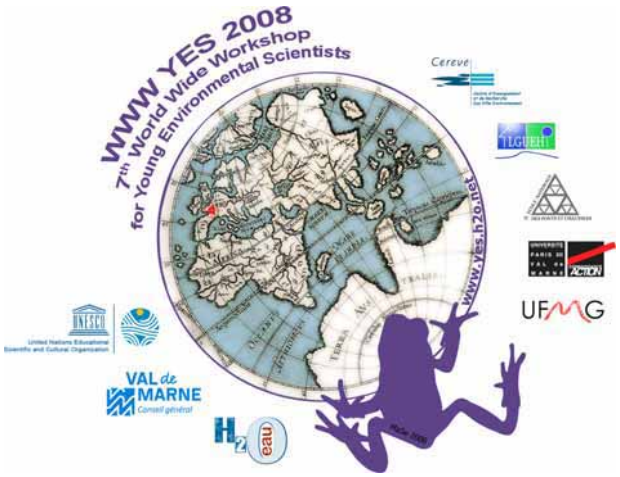

Urban waters: Resource or Risk?

WWW YES 2008

13-16 May 2008

Créteil – France

PROCEEDINGS

UNIVERSITÉ POPULAIRE DE L'EAU ET DU DEVELOPPEMENT DURABLE

Conseil Général du Val-de-Marne
Université Paris-Est

draft version
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PRELIMINARY PROGRAME WWW-YES 2008

DAY		SESSION		AUTHOR			REVIEUWER
13-MAY							
	10:00	Water policy/management	**1**	KHAROUF GAUDIG	Rana		*FULTON*
	10:40	Break					
	10:55	Water policy/management	**2**	FULTON	Julian		*KHAROUF G*
	11:35		**3**	NIEDERLAENDER	Julie		*STAUFER*
	12:15	Lunch					
	13:30	Water policy/urban development	**4**	STAUFER	Philipp		*NIEDERLAENDER*
	14:10		**5**	JALAIS	Savitri		*VIEIRA DE M.*
	14:50		**6**	VIEIRA DE MELLO	Rebeca		*JALAIS*
	15:30	Break					
	16:00	Integrated water management	**7**	SAMSON	Katelyn		*CORDIER*
	16:40		**8**	CORDIER	Mateo		*SAMSON*
	17:20		**9**	HETTIARACHCHI	Missaka Nandalochana		*ELFITHRI*
	18:00		**10**	ELFITHRI	Rahmah		*HETTIARACHCHI*
14-MAY							
	8:30	Water ressource/supply	**11**	BLANCHET	Thomas		*CARR*
	9:10		**12**	DOREA	Caetano		*CISSE*
	9:50		**13**	CISSE	Arona		*DOREA*
	10:30		**14**	SANDOVAL MINERO	Ricardo		*VELASQUEZ O.*
	11:10	Break					
	11:40	Waste water reuse	**15**	CARR	Gemma		*BLANCHET*
	12:20		**16**	VELASQUEZ ORTA	Sharon Belinda		*SANDOVAL M.*
	13:00	Lunch					
	14:00	Field visit					
15-MAY							
	8:30	Water quality/pollution	**17**	CAMARA	Papa Demba		*RAYA*
	9:10		**18**	PARKER	Alison		*PRIADI*
	9:50		**19**	PRIADI	Cindy R		*PARKER*
	10:30	Break					
	11:00	Water quality/pollution	**20**	SHAPIRO	Karen		*ZGHEIB*
	11:40		**21**	ZGHEIB	Sally		*SHAPIRO*
	12:20		**22**	RAYA	Rudra Bahadur		*CAMARA*
	13:00	Lunch					
	14:15	Research cooperation project: introduction					
	14:30	Research cooperation project: preparation					

	18:00	Night
16-MAY		
	8:30	Research cooperation project: summary preparation
	10:00	Break
	10:30	Research cooperation project: presentation preparation
	12:30	Lunch
	13:45	Research cooperation project: presentation & discussion
	16:15	Research cooperation project: classification
	16:35	Farewell drink
	18:00	End of workshop

SUMMARY WWW-YES 2008

1 Urban Water in Middle Eastern countries, development challenge : Legal Issues

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Abstract
The Middle East, which has been classified as a water-stressed region, is a zone conducive to water-related interstate tensions. The existence of water shortages, both in quantity and quality, crystallises particularly in big cities. The expansion of industrial estates around those big cities has for its part contributed to the deterioration of ecological conditions. In response to such a threat, national and international law is permanently adjusting in order to counter this critical situation.
Our intervention is a study of the data concerning water resources in a few Middle Eastern cities, whereby we focus on the role of the law as a factor of conflict resolution. In that sense, the analysis of legal provisions, both national and international, leads us to conclude that it is absolutely necessary to take scientific and technical means into account in order to counter the threat of fresh water shortage.
The example of these Middle Eastern case studies is characteristic of how difficult it is to manage waters in urban areas in developing and least developed countries.

Keywords
Development – Fresh Water – International Water Law – International Water Resources – Middle East – Urban Water – Water Rights – Water Law.

INTRODUCTION

This article is an attempt to explain the water management problems experienced by some Middle Eastern countries (Jordan, Syria, Lebanon, Israel, and the Palestinian Territories), mostly in big cities. It shows how the failure to prevent or resolve conflicts stems from the incoherence of the legal framework for the management of urban water in the Middle East, which there by becomes an obstacle to the development of the countries concerned.
In the first part, we talk about the increasingly critical water situation in several Middle Eastern big cities. In the face of worsening ecological conditions due to pollution on the one hand and population growth and the influx of people to urban areas on the other hand, big cities have a hard time balancing a limited offer and the increasing demand in drinking water. Indeed, as centres of human consumption and economic and industrial activity, they concentrate the critical factors that lead to water resources being threatened by both over-exploitation and pollution.
Middle Eastern countries being for the most part developing countries, sophisticated and often costly technologies meeting the requirements of sustainable development are not an option; this in turn, reinforces the water stress affecting the region.
The second part of the article focuses on the role of the law as a factor of conflict prevention and resolution. In response to increasingly scarce and deteriorating water resources, legal mechanisms were set up in national and international law for the purpose of regulating water management. These legal mechanisms, which reflect societal patterns, must be adapted to the new water usage and consumption figures.

At the beginning of the 21st century, the domestic laws of Middle Eastern countries need to evolve, as international water law is evolving, to preserve water resources and rationalise consumption.
In order to provide food security and meet the requirements of sustainable development in a region where big cities crystallise the seriousness of the water issue, the harmonisation of domestic laws and the development of multilateral regional agreements are a prerequisite before any water-related equilibrium can be attained in this difficult, when not downright conflictive context affecting regional and international security and peace.

Urban water management: A sustainable development challenge

Nearly all Middle Eastern capitals can serve as examples of the water stress situation which characterises the region. In Amman for instance, the population only has access to running water two or three days a week. In Damascus, water is rarely available all day long, so the population has to build up stocks.
The table below describes the availability of and needs in drinking water in the Syrian capital and its suburbs, taking into account the predicted population growth for the coming decades. In fact, the population of the Damascus urban area, which currently numbers 3.7 million inhabitants, will reach 5.2 million inhabitants in 2040. Such growth -which all Middle Eastern cities are expected to experience- could be faster still with the progressive liberalisation of the economy, attracting an increasing number of private investors and stimulating the whole area.

Table: Water production and needs in the Damascus urban area

	1995	2000	2005	2010	2020	2030
Local production	270	290	300	303	303	303
Area's needs	240	310	390	470	626	804
Area's shortage		20	9°	167	323	501
Potential transfers				1260	927	856
% of satisfaction of needs without regional transfer	112	94	77	64	84	38
% of satisfaction of needs with regional transfer				333	196	104

Source: Report of the *Fijeh* water utility, 2004, Damas.

On top of the issue of water scarcity and over-exploitation comes that of the deteriorating quality of water resources due to surface and groundwater pollution following the seepage of sewage on the one hand and poor industrial waste management on the other hand. Actually, given the unity of the water cycle and the interconnection of the various resources that are part of it, the consequences of overexploitation and pollution go beyond the geographical urban area and, can also affect rural areas, for example where they threaten the primary user of water resources, the agricultural sector, which uses up 67% of water in Lebanon, 63% in Israel, 44% in the Palestinian Territories, 64% in Jordan, and up to 90% in Syria (Bendelac, 2006 ; Clarke, King, 2004 ; Allan, 2001).

Urban water: economic and environmental stakes

In addition to the consequences of population growth and pollution, Middle Eastern cities are directly hit by climactic changes and the worsening of ecological conditions, notably in the form of increased drought. The Middle East, which is a semiarid region, is subject to irregular and on the whole insufficient rainfalls: concentrated on a quite short period, from November to March, with a good part evaporating at the surface or lost to the sea, they are in fact not sufficient to replenish groundwaters (ESCWA, 2005).

In that regard, it is most interesting to note that some big cities such as Damascus, Jerusalem, Ramallah, and Amman are mainly dependent on rain-fed groundwaters. In view of the insufficiency of rain waters, the use of unconventional resources (recycling, desalination, water transfers from less critical areas to harder hit areas) becomes unavoidable; however, such projects are subject to technical or financial problems which developing countries cannot easily overcome.
For instance, water desalination, which is the main source of fresh water in some Gulf countries, is much less important in the Middle East. Still, it remains the region's most common unconventional resource: in Israel, approximately 10% of consumption comes from desalinated water, and there are plans to increase this figure to 50% of household consumption, i.e. approximately 350 million cubic meters, by 2010 (Bendelac, (2006).

The development of this resource as of other unconventional resources is all the more essential as it will enable Middle Eastern countries to reduce their interdependence in water matters, as most conventional resources are often shared between riparian countries. For instance, the region's main surface waters are made up of international watercourses distributed as follows (where the percentage corresponds to the area of the basin in each country) (UNEP, 2002):

- Tigris – Euphrates – Shatt al Arab: Turkey 24.80%, Syria 14.73%, Iraq 40.48%, Iran 19.70%, Jordan 0.25%, Saudi Arabia 0.01%
- Orontes: Turkey 49.94%, Syria 44.32%, Lebanon 5.74%
- Jordan: Jordan 48.13%, Israel 21.26%, Syria 11.45%, Golan Heights 3.50%, West Bank 7.48%, Egypt 6.31%, Lebanon 1.33%.

In future, this interdependence must encourage countries to cooperate and show solidarity, which is absolutely necessary if we want to attain a regional equilibrium guaranteeing both water security and economic prosperity for the whole region. However, in the current conflictive context, with no true political will to share, concerted action in the common interest and balanced management are still a faraway prospect.
Thus, water resources today are governed by each country's domestic legal mechanisms, such management being deemed indissociable from the question of national sovereignty.

Water law: From sovereignty to the imperative of global management

Urban waters are an integral part of the national waters of the countries concerned. As a consequence, the management of such waters is governed by the state's general water strategy and is therefore subject to national and international policies. The purpose of urban water management is to regulate the use of water resources within society (consumers) and to impose penalties for violations.

Legal tools for proper water management

Existing water-related legal mechanisms in the Middle Eastern region take the form of legal texts of domestic law and international agreements handling the water issue according to

1- legal status (ownership),
2- management
3- protection against depletion or control of extraction and use on the one hand and protection against pollution on the other hand.

1- Water as public property

When water is publicly owned, or controlled by the state, the government has almost absolute authority as regards the way water resources are to be managed and utilised. Not so in case of private ownership, which limits the public authorities' control over the use of water, especially groundwaters.
When they attained independence after the Second World War, several Middle Eastern countries integrated some of the legal mechanisms contained in the *Ottoman Civil Code*, or *Mejelle* (Mallat, 1970) in their legal systems, including Syria and Lebanon where articles 1234 to 1328 on water management are still in force. In this text of Islamic tradition, water is defined as a common good whose ownership can only be private in certain specific cases. In accordance with article 1235, which provides that "Water flowing under ground is not the absolute property of any person", groundwaters are always deemed to be a public good. In Jordan and Israel, where the *Mejelle* was replaced by new legislation, this rule applies to all of the country's water resources, as asserted by the Water Authority set up by the Jordan Act (Jordan Act No. 18 of 1988, article 25): "All water resources available within the boundaries of the Kingdom, whether they are surface or ground waters, regional water, rivers or internal seas are considered State owned property".
Similar provisions were adopted in the Israeli Water Act of 1959 (article 5719, chapter one, preliminary, section 6), which provides that "The water resources in the State are public property; they are subject to control of the state and are destined for the requirements of its inhabitants and for the development for the country" (Trolldalen, 1998).
The special case of the Palestinian Territories (West Bank and Gaza Strip) should be mentioned here. Water ownership and management there had been governed since the beginning of the military occupation in 1967 by a series of Military Orders allowing Israel to acquire full control of the water resources. According to these Military Orders, which were adapted to the specificities of the West Bank and of the Gaza Strip, only the Israeli authorities had the power to grant drilling authorisations, forbid water extraction, or close down existing water installations (Van Edig 1999).
With the peace process, the water-related legal mechanisms in the Palestinian Territories have progressively evolved. For instance, the agreement of 4 May 1994 provides for a transfer of authority from the Israeli military government and the civil administration to the Palestinian Authority as regards drinking water and sewage management in the Gaza Strip and the Jericho Area[1]. These arrangements were broadened by the Interim Agreement of 28 September 1995 (Oslo II) which also includes new provisions relating to the management of the West Bank's water resources[2].
If we analyse the legal mechanisms relating to water management in the Palestinian Territories, we can see it constitutes a limited transfer of authority.

[1] Agreement on the Gaza Strip and the Jericho area, 4 May 1994, Annex II Protocol concerning civil affairs, Art. II § 31.

[2] Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip, Washington, 28 September 1995, Annex III, Protocol concerning civil affairs, Appendix 1, Article 40.

Even if the Oslo II text provides that "The Israeli side shall transfer to the Palestinian side, and the Palestinian side shall assume, powers and responsibilities in the sphere of water and sewage in the West Bank related solely to Palestinian"[3], several sub-articles limit the Palestinian Authority's action within its territories. For instance, the transfer of powers only concerns the Palestinians themselves, not the Israelis living in the colonies of the West Bank. Also, the transfer does not apply to the issues of ownership of water and of sewage in the West Bank (sub-article 5), for which arrangements shall be laid down only within the framework of the final negotiations (sub-article 4).
The institutions related to the Joint Water Committee (JWC), which is in charge of coordinating the common action of Israelis and Palestinians in matters of water resource management, are subject to other constraints. Notably, their role is to "deal with all water and sewage related issues in the West Bank" (sub-article 12), i.e. to manage the aspects excluded from the Palestinian Authority's competence by sub-article 5 and to settle any disagreements in that regard. Since the JWC is composed of an equal number of representatives from both parties and decisions can only be made by consensus, Palestinians' leeway for their action in the West Bank is again severely limited.
For instance, any Palestinian initiative relating to water management (licensing, drilling, increasing extraction) can be blocked by the simple opposition of the Israeli members pursuant to the committee's voting mechanism, even when the contemplated projects concern areas populated mainly by Palestinians, notably the Ramallah and Nablus urban areas. This "right of veto" also applies to decisions relating to proper Palestinian resources such as the Eastern basin of the Mountain Aquifer. Such failings become especially blatant when compared with the lack of any similar voting mechanism for the prevention of Israeli action regarding the exploitation of transboundary water resources such as the Western basin.
Yet some of the provisions of the Oslo II Agreement seemed to constitute a real advance towards the recognition of Palestinians' right to water. For instance, article 40 § I provides that "Israel recognizes the Palestinian water rights in the West Bank". However, these rights are not specified in the text, which simply announces that they will be taken into consideration in the final status negotiations. Worse, by stipulating that "both sides agree" to maintain "existing quantities of utilization from the resources" (sub-article 3 § IV), the text amounts to the legalisation of the existing situation resulting from the military occupation, which is characterised by the unfair use of water resources to the advantage of Israel, especially those of the Mountain Aquifer[4].
Another important shortcoming of the Oslo II Agreement is the lack of precision as regards the precautionary principle to be applied to the exploitation, management, and utilisation of water resources. Although article 40 § 3a recalls that both parties undertake to prevent the deterioration of water quality and take "all necessary measures to prevent any harm to water resources, including those utilized by the other side", this principle only takes the protection of the resource itself, not of the other party's rights, into account.
Lastly, the Oslo II Agreement emphasises that the water quantities allotted to Israeli military sites and colonies, both for household and agricultural usage, should be maintained.

[3] Annex III, article 40, § 4 of Oslo II.

[4] For instance, in the 1990s, an Israeli used up approximately four times more water from the Mountain Aquifer than a Palestinian (440 to 550 mcm/year for an Israeli and 116 to 121 mcm/year for a Palestinian). According to Nasser, Y., (2003), "Palestinian water needs and rights in the context of past and future development", in: Water in Palestine Problems-Politics- Prospects, Jerusalem, PASIS, pp .85-123.

The problems resulting from these legal shortcomings and the accompanying lack of any Palestinian territorial sovereignty are preventing the coherent management of all water resources in the occupied Territories.

Therefore, in the case of the Palestinian Territories, where the exercise of the Palestinian national territorial sovereignty is linked to the development of the peace process, the legal and administrative shortcomings arising from bilateral agreements are preventing the global management of all water resources. This was the ambiguous background for the passing of the Palestinian Act No. 3 on 17 July 2002. Its purpose is to increase the capacity of the Palestinian Territories' water resources and to improve their protection against pollution and over-exploitation risks. To that end, the Palestinian Territories' water resources are declared to be a public good and their utilisation and exploitation is from now on restricted. Any new extraction for commercial purposes must be authorised first.
Given the limited autonomy which, for the aforementioned reasons, Palestinians have in applying their water policy, this is in many cases a purely theoretical act. Therefore, it is not surprising that it should concern itself less with the water resources themselves than with the institutions charged with managing them, such as the National Water Council and the Palestinian Water Authority, author of the other two previous texts drawn up following the Oslo Agreements (Palestinian National Water Policy, 1995, and Water Resources Management Strategy, 1998).

During the French mandate, two texts (stemming, as with the *Mejelle*, from the pre-independence legal systems) were added to the Lebanese and Syrian legislations relating to water management. These two texts, *Order No. 144/S of the High-Commissioner* of 10 June 1925 and *Order No. 320* of 26 May 1926, give a definition of the public domain and provide for the protection and utilisation of water within this same domain[5]. These texts, which constituted the foundation for both countries' water legislations but were not exhaustive, were completed in 2005 in Syria with the Act No. 31 of 16 November relating to water, whose article 2 provides that watercourses, lakes, waterfalls, springs, and groundwaters are deemed to be a public good.

2- Regulation of the use of water resources

Although the development of the national legislations of Middle Eastern countries has led to water being branded a public good, when it comes to its management, it is necessary to differentiate between surface water and groundwater. Where surface waters (natural watercourses, canals, lakes, etc.) seem to be indissociable from the public domain, groundwaters, which are often exploited from private property (wells, drillings, etc.), may on the contrary evade control by the public authorities. In order to counter the resulting threat to this vulnerable, and for the region's big cities, essential resource, the respective countries' national legislations provide for a number of specific mechanisms intended to protect groundwaters from pollution and overexploitation. However, such mechanisms are the exception in national legislations which still only rarely differentiate between surface waters and groundwaters (Burchi 1999, Caponera 1992).

a) Protection against pollution

[5] Lebanese Republic, Official Journal no. 1998 (supplement)

The Israel Water Drilling Control Act of 1955 forbids any form of pollution, which it defines in a very broad manner. According to the Act, pollution includes "a change in the properties of water in a water resource in physical, chemical, organoleptic, biological, radioactive or other respect, or a change as a result of which water is dangerous to public health or likely to harm animal or plant life or less suitable for the purpose which it is used or intended to be used"[6].
In Jordan, the quality of water is controlled by the Ministry of Water and Irrigation[7]. The extraction authorisations granted by this administration entail an obligation not to cause any pollution to groundwaters.
In Lebanon, the By-Law of 1993 includes general provisions relating to the protection of groundwaters but falls short of proposing any specific measures.
In Syria, the Act No. 31 of 2005 includes the following provisions as regards the protection of groundwaters:
"- Public water quality control and pollution prevention are coordinated by various ministries and public institutions; the administration in charge of quality control, which belongs to the Ministry of Irrigation, carries out the controls.
- Any pollution identified according to the standards and criteria in force is notified to the Ministry of Environment and to the city in order to determine the cause of pollution.
- Administrative proceedings are then initiated and the pollution case processed within the framework of the Act No. 50 of 2002"[8]. For instance, deliberate pollution of a water spring or intentional damage to public irrigation works is punishable under criminal law by one to three years of imprisonment and a fine in amount of SYP 200,000[9].

Whether relating to groundwaters or surface waters, existing legal mechanisms relating to the protection of water in Middle Eastern countries only apply within the geographical territory of the state and are only rarely the subject of concerted action between states. This situation is all the more detrimental as the interconnection between the constitutive components of water basins facilitates the diffusion of polluting substances (industrial waste, salt water) beyond political borders. It is therefore in these countries' interest to harmonise the laws relating to the protection of water quality, especially as regards groundwaters, more critical because of their slow replenishment rate and their often hard to monitor mobility.

b) Protection against depletion (control of extraction and utilisation)

In the Jordan basin riparian states, groundwater extraction and exploitation is subject to domestic laws regulating the issuance of drilling authorisations on the one hand and quantity control on the other hand.
- Jordan: Underground Water Control By-Law (By-Law No. 85 of 2002)
- Israel: Water Drilling Control Act of 1955
- Lebanon: By-Law 14438 of 1970 organizing the prospecting and use of groundwater,
- Syria: Act No. 31 of 2005
Syrian law (the most recent) sums up the concerns shared by all riparian states regarding the difficult monitoring of this "hidden treasure". It notably provides that:

[6] Article 1 A, section 20A, chapter 2 of the Water Drilling Control Act 1955

[7] Article 4 A of Underground Water Control By-Law (By-law No. 85 of 2002), text available at the website of Ministry of Water and Irrigation in Jordan www.mwi.gov.jo, last accessed 22 March 2008.

[8] Article 50 of the decree relating to the Act No. 31 of 16 November 2005.

[9] Article 35A, chapter 7 of the Act No. 31 of 16 November 2005.

"- any extraction project is subject to prior authorisation
- extraction in protected areas (aquifer replenishment areas) is prohibited,
- the drilling of new wells is forbidden, unless exceptionally authorised by the Ministry,
- a specific administration equipped with modern technical means enforces these mechanisms,
- if the law is broken, serious penalties are provided for under criminal law"[10].

Even though these very strict mechanisms relating to the protection against depletion forbid new wells from being drilled and authorised water quantities from being exceeded, it has to be acknowledged that the drilling of unlicensed wells and non-abidance by the extraction limit have multiplied in the past few years. For instance, private Jordanian wells, which represent approximately 60% of the total number of wells, are not subject to control for the main part, or are equipped with broken water-meters (Stephan, 2007).
In Syria, the FAO estimates at 53,453 the number of unauthorised wells, i.e. approximately half the total figure for the country (FAO, 1997)[11].
In Israel, a report by the State Comptroller on the Management of the Water Sector of 1990 noted that over-exploitation of costal and mountain aquifers was the first cause of water quality deterioration. In the same report, emphasis was laid on the fact that, despite both aquifers undergoing depletion, additional extractions had been authorised by the Water Commissioner in charge of water management, in total contradiction with the new, alarming water figures (Adam 2000).

At this point, we can only note the continued over-exploitation of the water resources which the public authorities have difficulty controlling and acknowledge that, as things stand, it is not possible to check the dramatic deterioration and depletion of these resources.

CONCLUSION

In view of these over-exploitation and pollution issues, national law must meet the requirements of sustainable development by reinforcing water-related legal mechanisms.
It is also absolutely necessary to harmonise water-related national legislations if we want to be able to act efficiently against the threat to this vital and universal resource. International Water Law developments must take this target into account and encourage states to cooperate.
The most recently codified legal text pertaining to International Water Law - the Convention on Non-Navigational Uses of International Watercourses of 1997-, as well as the new draft articles on transboundary aquifers of 2008, emphasise the concept of the unity of water sources and the general principles of the obligation not to cause significant harm, of the equitable and reasonable utilization and participation, and of the obligation to notify, consult and negotiate. It is particularly urgent to put these principles into practice in the Middle East, where the current problems shared by all the countries cannot be settled fairly without cooperation and solidarity.
However, the persisting conflictive context which strengthens the states' attachment to the principle of absolute sovereignty (although that same sovereignty is lacking for Palestinians) makes fair management difficult to organise.

[10] Water legislation, Act No. 31 of 16 November 2005", Syrian Official Journal, *Techrin*, November 2005. Translated from the Arabic by the author.

[11] FAO, Aquastat, 1997, available at www.fao.org/nr/water/aquastat/main/indexfra.stm, last accessed 13 mars 2007.

In order for water to become a source of cooperation, provisional solutions must give way to a global, future-oriented strategy in compliance with sustainable development principles. Such a strategy must be founded on laws based on hydrological, economic, social and cultural studies, and its implementation needs to be guaranteed by harmonious policies coordinated by all riparian countries.
Taking all the elements of the water issue into account when making future decisions is the prerequisite for the sustainable management of resources. This concerns cities in particular, where, given the population density, stakes and are highest and the water issue is showcased in all its complexity.

The example of the Middle East and of its cities shows that the challenge of urban water management calls for new and sustainable methods to be implemented which, like the water cycle and the interconnection of its components, will bring all of the countries concerned together for the purpose of drawing up a coherent and harmonious legal framework.

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2 Privatization and Customer Attitudes in Conserving and Paying for Domestic Water

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Abstract
This paper explores the effects of water privatization on customers' attitudes towards conserving and paying for water. This version was written expressly for presentation and discussion at the World Wide Workshop for Young Environmental Scientists in June 2008.

Keywords
Privatization; Water Management; Decision-support systems

INTRODUCTION

There are several comparative and inter-temporal assessments of private vs. public water utilities, including customer satisfaction surveys (Davis, 2005). Less attention has been paid on how privatization changes the relationship between utility and customers and how this might affect customers' attitudes and utilities' policies. By water privatization we refer here to the change of ownership - or a long-term handover of management - of drinking water supply systems to private investors[12]. Qualitative case-studies from England and Wales suggest that after privatization water customers became less receptive, if not outright hostile, to calls for voluntary, self-restriction of water use during droughts (Haughton, 1998, Bakker, 2000). Water utilities also became more reluctant to use mandatory water restrictions, such as temporary, garden-hosepipe bans (Howarth, 2000). Anecdotal evidence from around the world suggests intense public reaction to water price increases by privatized water utilities and a return to public financing of infrastructure improvements (Hall, 2001). The question motivating this paper is whether such observations are unique and context-specific or manifestations of a more general, underlying relationship between privatization and customer attitudes.

This paper explores whether there is such a correlation between privatization and lowered willingness to voluntarily conserve or pay more for water. Section 2 presents the empirical research design, the methods used and the case-studies. Section 3 presents and analyses the

[12] Privatization might include different segments (e.g. treatment vs. distribution) and functions (e.g. capital investment, service provision) of the supply chain and be shorter (e.g. contract), longer (e.g. concession) or permanent (divestiture). By privatization we refer here to a permanent or longer term (>10 yrs) handover of management of the entity responsible for the core activities of drinking water supply, what we will call the "water utility".

results of the empirical research. Section 4 discusses the policy implications of our findings and section 5 concludes.

Hypotheses
This research aims to test empirically the following hypotheses:

Other factors equal, customers in privatized water utilities are less willing to:
i) conserve water voluntarily
ii) pay more for water
than customers in similar non-private water utilities.

MATERIAL AND METHODS

To explore links between privatization and attitudes to conservation and pricing, we developed a two-tiered methodology:

i) a telephone survey of customers in public and private water utilities,
ii) a comparative analysis of water usage before and after calls for conservation.

The telephone survey tested whether there are noticeable quantitative and qualitative differences in responses between customers in public and private utilities to the same set of questions concerning conservation and pricing. Because survey responses are statements of intention, and not actual practice, the analysis of actual water usage data helps to clarify the actual responsiveness of customers to calls for conservation. The utilities studied are all in the State of California, (Figure 1).

Figure 1: California, USA, with case study locations

Telephone Survey. The testing hypotheses of the survey are that other factors equal customers in privatized water utilities are less willing: i) to conserve water voluntarily, ii) pay more for water, than customers in public water utilities. To test these we designed a survey with two hypothetical scenarios under which respondents are asked by their utility: i) to cut back on water use during a drought; ii) pay significantly higher rates to cover infrastructure improvements. Their willingness

to do so was evaluated on a scale of 1 to 5 (see Appendix 1). Additional information was collected to facilitate interpretation and account for differences between respondents, including; i) information on whether the respondents are actually the ones paying the water bill (if not, as is often the case in tenant households, the "paying" question was omitted), ii) whether they have been practicing water conservation (this might affect their willingness to further conserve), iii) income level (which might affect ability to conserve or pay more). A question was also asked to verify whether the respondent knew if the utility was public or private.

100 people were interviewed in each utility. To avoid a demographically-skewed sample we distributed calls to different times of the day. The interviewer informed the respondents on the topic of the discussion only after they had committed to its 5-10 min duration (to avoid a skewed sample dominated by those with strong opinion on water issues). The hypothetical questions were asked before any reference to the question of ownership of the utility (Appendix 1), but the interviewer noted if the respondent referred spontaneously to the private or public character of the utility.

To explore links between attitudes to conservation and pricing and ownership of the utility, an open-ended question was posed after the hypothetical scenarios (Appendix 1) asking respondents whether their answers would change if the ownership of the utility was different. After a first round of conversations we developed a typology to classify responses to the open-ended question either positively or negatively. If the respondent stated that ownership did not affect responses, we did not pursue the discussion further.

Water Usage Data. If the telephone survey captured well people's intentions in the given hypothetical scenarios, it did not capture how people act in real life. With regards to testing *Hypothesis I,* the difference between *willingness to conserve,* as stated in the telephone survey, and *actual conservation,* as in real life, plays an important role. An obvious way then to test our *Hypothesis I* objectively is to look at actual conservation patterns in a real-life situation. (*Hypothesis II* cannot be tested objectively because an *unwillingness to pay* will usually result in disconnection, which is not an option for most people.)

2007 was a relatively dry year for California. The winter rainfall was far less than normal (reference), and by springtime water managers all over the state saw that supply would be low. While State agencies promoted conservation practice on a very general level, actual calls for conservation were left up to individual water utilities, depending on their specific resources. By the summertime many utilities, private and public, issued drought warnings and calls for domestic conservation. The requests were often voluntary and sometimes mandatory, but nevertheless customers were confronted with complying with the conservation measures or not.

Analyzing actual usage data from individual utilities before and after calls for conservation gives a picture of how customers responded in their daily practice. Domestic water consumption is tracked monthly by every water utility that meters its customers (all six cases in this study have metered household connections). When compared to historic data, we get a sense of whether or not an individual utility's call for conservation was effective. Other potential factors of influence such as demographic changes (household density, income levels, etc.) can also be controlled for.

Case Studies. To reduce the effect of geographical and socio-economic differences, we conducted the telephone survey in three sets of comparable utilities (a total of 6 water utilities), all in California (Table 1; Figure 1). Each set consists of neighboring utilities in the same geographical setting with different water system ownership structures. The sets differ in terms of utility size: set 1 includes two small-size town utilities, set 2 includes two utility districts in the same mid-size city, and set 3 the utilities of two big cities.

TABLE 1: The case studies

	Set 1	Set 2	Set 3
Investor-owned (private)	California American Water Company – Felton District	California American Water Company – Thousand Oaks/Westlake District	San Jose Water Company
Publicly-owned (public)	San Lorenzo Valley Water District – Ben Lomand	City of Thousand Oaks Department of Public Works	San Francisco Public Utility Commission

Sociopolitical factors are also considered in order to control for asymmetries in the case comparisons. For example political ideology can influence people's opinion of public or private organizations. Also current events and media coverage of those events can play an important role in the way people respond to surveys. In addition to basic information given for each case study (Table 2), background investigations were conducted to identify potential factors of influence in the survey responses.

TABLE 2: Information about the case studies (Felton and Ben Lomand missing)

	San Francisco - PUC	**San Jose - SJWC**	**Thousand Oaks - CTO**	**Thousand Oaks - CAM**
Socio-economic				
Population served	750,000	1,000,000 +	42,538	59,690
Population Change /yr.	0.43%	1.6% (City)	1.83% (City)	1.83% (City)
Income (2006 median)	$66,500	$73,804	$92,943 (City)	$92,943 (City)
Density(hab./sq.mi.)	15,867	5,118	2133 (City)	2133 (City)
Federal Voting	83% Democrat	61% Democrat	50% Democrat	50% Democrat
Water system				
Operator	City Department	Investor Owned	City Department	Investor Owned
Ownership	Outright Ownership	Outright Ownership	Outright Ownership	Outright Ownership
…Since	1932	1866	1947	1967
Source of water	85% Hetch Hetchy 15% Local source	60% Local sources 40% State Water	100% SWP Wholesale	100% SWP Wholesale
Domestic Consumption	62 gallons/capita/day	No info available	175 gallons/capita/day	150 gallons/capita/day
% domestic water to landscape irr.	audits are available on internal database	n/a	n/a	n/a
Price of water for Single Family 3/4" connection	$5.40 connection fee + $2.08/ccf (1 - 3 ccf) or $2.50/ccf (4 + ccf)	$14.02 connection fee + $2.22/ccf	$9.49 connection fee + $2.16/ccf	$13.70 connection fee + $2.21/ccf
Rate structure	Residential: 2 blocks	Flat Rate	Flat Rate	Flat Rate
Recent rate increase	5.6% in 2007	8.5% in 2007	14.90%	7.43% in 2007
Disconnect policy	Yes	yes	Yes	yes
Conservation programs	PUC Conservation Sec. Audit/Rebate Programs	Free Household Audits Wholesaler rebates	Website info and directs to MWD No rebates	Website info only

RESULTS AND DISCUSSION

Results are currently being processed, and will be presented at the WWW-YES workshop, May 13 – 16 2008. Some expectations that may corroborate the hypotheses are given here:

- Higher willingness to conserve and pay for water in public over private utilities (among respondents who know what their utility is) in all three sets.

- Lower differences in willingness to conserve or pay between respondents in public and private utilities who did not know what their utility is (compared to differences between those who knew).

- More in-promptu references to ownership by respondents in private utilities compared to respondents in public utilities.

- (In the open-ended question): More responses that they would conserve or pay more if the utility was public (when it was private) than the other way round.

- Indications in verbal responses (in-promptu and to the open-end question) to the "for profit" motive / customer relationship, and distance and lack of control.

- More pronounced differences in Set 1 because of small size (i.e. more direct control – less distance) – also higher numbers of respondents knowing what the utility is for Set

- Relatively higher willingness to conserve and pay for water in private utility of Set 3 (San Jose?) compared to other private utilities because of large size (and/or longer history of privatization).

CONCLUSIONS

The hypotheses would be supported by findings from the survey data and usage data, however additional sources of information will likely also be sought. An analysis of the signatories of California's Water Conservation Council's Memorandum of Understanding and the implementation of its best management practices provides some provisional support for our policy conclusions. Additionally, interviews with water managers in public and private utilities inform us of the relationships these agencies have with their customers.

A negative correlation between privatization and willingness to conserve voluntarily and pay more for water does not suggest that privatization works necessarily against water conservation. Voluntary participation of the customers is not an important factor in all types of conservation programs. There are also many other variables that might change positively after privatization and encourage water conservation.

Still, our findings are important since they suggest that: i) private utilities can tap less into a voluntary spirit of self-restriction during drought crises; this takes away from them an important policy tool; ii) there are contradictory forces in so far as privatization increases reliance on market-based (rather than voluntary or coercive) approaches to induce conservation behaviors, while customers' willingness to accept price increases may be decreasing as an outcome of privatization.

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APPENDIX 1
SURVEY

I'm a student at UC Berkeley, conducting a survey for research purposes.
Are you over the age of 18 and interested in participating?
No Yes

Is there someone at home over 18 who is available to talk?
No Yes

Wait…..

Do you have five to ten minutes to complete a survey with me?
No Yes

Sorry, I cannot conduct a survey with you due to OPHS regulations. Goodbye.

End Call

I will now read to you a consent agreement to participate in research.
Disagree Agree□

a Is your water bill paid for by a member of your household? No (skip dashed) Yes: ___

b OK, I will first pose a hypothetical scenario to you:
Your water utility claims to be facing a water shortage, so they are asking their customers to help by cutting back on water in the following ways, would you be willing to…
1. Take shorter showers?
2. Flush the toilet less?
3. Stop washing the car?
4. Water the garden less?
5. Stop watering the garden?
(Randomize these during survey)

c Have you recently taken these or any other measures in your household to conserve water?
No Yes: _____ …how about currently?: _____

d How would you feel if your utility made it mandatory for you to stop washing your car or restrict watering your garden? _____

e I will now pose another hypothetical scenario to you:
Your water utility claims to be facing increasing costs for infrastructure improvement.
They plan to ask their customers to help cover these costs by paying higher rates of 30%.
How willing would you be to help them, on a scale of 1 to 5, where 1 is unwilling, 2 is reluctant, 3 is neutral, 4 is somewhat wiling, 5 is willing? 1 2 3 4 5 N/A

f About how much do you pay for water per month to your utility? $ _____ N/A

g Do you know who your water provider is? Yes, Who?: _____ No

h Do you know if it is a private company or municipally owned? Yes (a): _____ No (b)

i Would your responses about *conservation* change if
(a) your water utility were (the opposite of last answer)? How? _____
OR (b) you did know whether it was private of municipally owned? How?

j Would your responses about *pricing* change if
(a) your water utility were (the opposite of last answer)? How? _____
OR (b) you did know whether it was private of municipally owned? How?

k One final question for demographic purposes:
In which of the following household income brackets is your household?
1. <$20k 2. >20k, <$50k 3. >$50k <$100k 4. >$100k <$200k 5. >$200k N/A

3 What territorial organization for a sustainable urban water policy? The French experience

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Abstract

Local urban water policy answering to questions related to technical, economic, social and environmental performance is a major task for local authorities.
In this research, the institutional framework is considered then 7 case studies in French local authorities are presented.
In the second part of the paper, we demonstrate that a work on the interactions and the reciprocal influences between the local services in charge of water and waste water public services and the basin systems is necessary for a better management of the water cycle.
In fact, urban water management is not only a technical issue but a systemic analysis with stakeholders and deciders. Three examples of a successful integration of environmental issues are presented and analyzed

Keywords
water cycle, sustainable urban water policy, metropolitan management, basin management, French experiences

INTRODUCTION

In France, the institutional water management system is complex. It is composed of several structures responsible for water, at different administrative scales (local, departmental, regional and national), or with the basin as territory. Despite this multitude of scales and stakeholders concerned, water management is above all a question of local policy. Already in 1790, the French law made the municipal power in charge of the local public health. And nowadays, the local authority is the perfect place for water management (Martin-Lagardette, 2004). It is responsible for water supply and waste water management and the mayor has an important police power in that field: "his place in the water policy is one of the key elements of the French system" (Nicolazo, 1997).

Local stakeholders have been confronted, during the last decades, to a significant evolution of stakes linked to water management. This evolution can be analyzed through the evolution of the institutional framework.

Water management has always implied technical and economical stakes. With the urbanization, it became necessary to realize water supply network and then, to evacuate waste water in order to answer to public health necessity. Then appeared the necessity (or not, depending on the type and the quality of the resource) to treat the water to answer to norms imposed by the European

Union[13], and the obligation to treat the waste water before rejecting them in the water natural environment[14]. Networks and treatments represent important investments.

Those technical and economical aspects have been completed by environmental and social stakes. In the environmental field, protection of water environment became a priority when the DCE imposed the good state for 2015. In the social field, the law SRU[15] introduced the individualization of the water supply contract. This confronts a number of economically fragile consumers with the necessity of paying a water facture which was diluted in the charges before. That forces the local authorities in charge of water to think of social purviews. The LEMA[16] adds, in its first article, that "every physical person, for his alimentation and hygiene, has the right to access to water in economical conditions that everyone finds reasonable" and let then an open door to social tariffing.

Local territories confronted to all those stakes often didn't have the means to answer to them. So different types of structures have been created by the legislator: the intercommunalities[17] for the technical and economical stakes and the basin agencies for the environmental stakes. But, at the local scale, no territorial organization is imposed: almost each local territory has its own one.

Moreover, the actual system clearly separates the water supply and waste water services, managed by classical administrations, from the environmental aspects of water environment protection, managed by specific basin structures. In such a complex situation, it is very difficult for local officials, confronted to those issues implied by a sustainable management of urban water, to choose their territorial organization.

The aim of our research is to help local officials in their decision by finding a territorial water management which permits to have a policy conciliating technical, economic, social, and environmental aspects. The output will be a coherent set of recommendations which could be adapted to local cases and used by them in order to be successful in their search of a sustainable water management.

METHODS

To find answers, several cases of French metropolitan have been analyzed. For each one, the context (political, technical, hydrological, economic…) was analyzed and people in each structures of the territory concern with water were interviewed:

- the responsible for water supply (technical and political)
- the responsible for waste water service (technical and political)
- the animator of the SAGE
- workers from the Agencies of Basin[18] in charge of the agglomerations

Sometimes, other people like the one in the agglomeration in charge of following the SAGE or in charge of environment were also interviewed.

[13] directive eau potable 80/778/CEE du 15 juillet 1980 and directive n°98/83/CE du Conseil de l'Union européenne relative à la qualité des eaux destinées à la consommation humaine du 3 novembre 1998
[14] directive n°91/27/CEE du Conseil relative au traitement des eaux urbaines résiduaires and directive n° 2000/60/CE ou directive cadre européenne
[15] loi Solidarité Renouvellement Urbain du 13 décembre 2000
[16] loi n°2006-1772 du 30 décembre 2006 sur l'eau et les milieux aquatiques
[17] We use the word "Intercommunality" (in French : intercommunalité) to design all type of groups of towns which manage one or several competences
[18] Basin Agencies (in French: Agences de l'Eau): the French territory is divided into 6 basins. On each basins, there is a structure, the Basin Agency, is responsible for the policy of water management.

Our first case of study is Nantes Métropole[19]. It permits to define the first elements of the analysis and to establish a version 0 of the approach. Then six other metropolises were selected: the Grand Toulouse[20], the Bordeaux Urban Community, the Strasbourg Urban Community, the Lille Urban Community, Grenoble Alpes Métropole[21] and the Grand Dijon[22] (figure 1).

Interviews were elaborated and tested with agents of Nantes Métropole during June 2007. The other interviews were from November 2007 to mars 2008.

To choose the metropolis, the first selection criterion was the population. We have restricted our research to urban centers between 250000 and 1 million of inhabitants in order to stay in the approximately same scale.

Figure 1 : Localisation of the urban centers chosen for the research

A second criterion was the singularity of the structure, the aim being to have the most different cases possible to study. The singularity depends on the type of the structure, the competences of this structure and the way environmental stakes and basin management are integrated (figure 2):

- We chose Lille Urban Community because it shares its competence of local authority for water supply with a big departmental syndicate[23]: the SIDEN. Another reason is the recent creation of a Eurométropole, which is the final point to a long history of cooperation which concerns water services too.
- The case of Bordeaux Urban Community seemed interesting because there is a very influent SAGE[24] in the region.
- The case of Strasbourg Urban Community was interesting because the urban community shares its water and a part of its waste water competences with a big departmental syndicate: the SDEA.

[19] Nantes Métropole is the name of the Nantes Urban Community
[20] Grand Toulouse is the name of the Community of agglomeration of Toulouse
[21] Grenoble Alpes Métropole is the name of the Community of Agglomeration of Grenoble
[22] Grand Dijon is the name of the Community of Agglomeration of Dijon
[23] A departmental syndicate is a group of several towns which manages one or several competences (in that case: water supply) instead of the towns.
[24] A SAGE is an orientation document produced at a basin scale by a CLE (Local Commission of Water composed of representatives of each stakeholders) and normally managed by a "structure porteuse"

- The Grand Toulouse was chosen because it has only the waste water competence and not the water supply, which could be the fact, even more if you know it could be a urban community considering its population[25].
- Grenoble Alpes Métropole was chosen for the same reason as the Grand Toulouse (considering the competences) and because of its long history in the field of water supply.
- The Grand Dijon was chosen because of the original structure they chose: a mixed syndicate[26].

Name of the structure	Type of structure	Water supply competence	Waste water competence	Integration of environmental stakes and basin management
Grand Toulouse	CA	NO	YES	
	considering its population, it could be a urban community			
Bordeaux Urban Community	UC	YES shares it with two syndicates	YES	SAGE Nappes Profondes
Strasbourg Urban Community	UC	YES shares it with a departmental syndicate	YES shares it in part with a departmental syndicate	
Lille Urban Community	UC	YES shares it with a departmental syndicate	YES	
		long history of cooperation with Belgian		
Grenoble Alpes Métropole	CA	NO	YES	
		long history in water supply management		
Grand Dijon	CA	NO	NO	
		managed by a mixed syndicate		

CA = Community of Agglomeration
UC = Urban Community

Figure 2: The urban centers chosen and their singularities.

RESULTS

A metropolitan[27] management coupled with a model based on the notion of organizing authority[28]: a way to answer to technical, social and economic stakes.

[25] Urban community can be formed when the metropolis has more than 500000 inhabitants
[26] A mixed syndicate (in French : syndicat mixte) is a group of town and groups of town which manages one or several competence instead of the towns and groups of towns which composed it
[27] We use this word to define a management by a group of towns or groups of town

The case of Nantes Métropole shows that a metropolitan management of water and waste water by the same structure on the entire territory of the metropolis, coupled to a clarification of stakeholders role, in particular the affirmation of the organizing authority and the introduction of the citizen, can lead to technically, economically and socially efficient public services.

A metropolitan management: several advantages

Nantes Métropole is a recent urban community, which has a metropolitan management of water and waste water. This situation presents several advantages.

First, it permits a real simplification of the landscape of stakeholders in water. Before the creation of Nantes Métropole, in 2001, water supply on the 24 towns composing Nantes Métropole was assumed by 6 SIAEP[29] and 3 towns (Figure 3). Collect of waste water was the responsibility of one syndicate (regrouping two towns) and 22 towns, and waste water treatment was the responsibility of 2 syndicates and 5 towns. Now there is only one public authority for all that: Nantes Métropole.

Intercommunality is also a way to have a larger covering perimeter and realize scale economies, to put in common means of all types (humans, financial, technical…) and to have means better and more structured.

All this is confirmed by a national study realized by the cabinet Claude Charier Consultants during first trimester of 1999 which shows that for the majority of the 500 towns who answered to the survey, the intercommunality tool appears like an efficient way to increase the financial margins from the member collectivities (Gazette des Communes, 1999). It is also confirmed by the different interviews. Even if some people think that a management of water in intercommunality is not an obligation, all of my interlocutors agreed to the fact that intercommunality brings some advantages such as a larger territory, technical and financial bigger basis and that this type of management is more efficient, in investment and in functioning, and more adapted to the actual restraints.

By the way, more and more local authorities transfer their competence to intercommunalities. Between 1998 and 2001, the number of local authorities in intercommunalities for the competence «water supply » increased from around 2% and the population concerned from 6% to reach a little bit more than 37 millions persons (IFEN, 2001). It went on between 2001 and 2004 with an increase of 4% for the population concerned by a management of water supply in intercommunality and an increase from 2% for the waste water management. In 2004, 66% of the French had their services managed in intercommunality (BIPE, 2006).

[28] The organizing authority (in French : autorité organisatrice) is a way to design the public local authority responsible of an urban service

[29] SIAEP are syndicates in charge of water alimentation

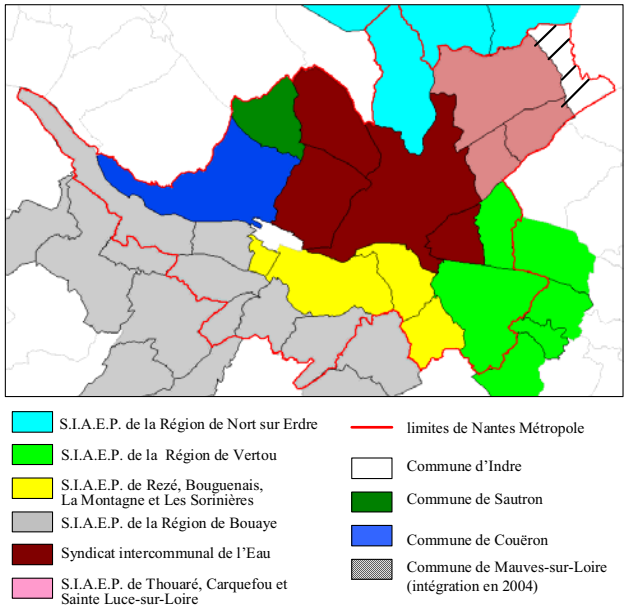

Figure 3: The public authorities in charge of water supply before the creation of Nantes Métropole (2001)

A model of organization which thwarts the classical disadvantages of intercommunality

So intercommunality brings some advantages non negligible but it also shows two major problems underlined by my different interlocutors. First, you can inherit from different situations depending on the town and so have a service non homogeneous on the territory and different prices, which is not such a big problem but is not very coherent if you want to speak of integration. For example, the Grand Toulouse, which has a metropolitan management of waste water, has inherited from the past of different types of contracts with different operators and so have different prices. They want to harmonize it but it is very difficult because that implies a lot of negotiations with the different operators. Secondly, in intercommunality, there is a lack of proximity with the citizen. The organization that Nantes Métropole chose to adopt is a way to solve those problems. In fact, Nantes Métropole adopted an organization model based on a triangle which links three stakeholders: the organizing authority, which is responsible for the general interest, the operator and the citizen-user (Lorrain D., 1995; Martinand C., 2001). This model defines the links between the three actors (figure 4).

At its creation, in 2001, Nantes Métropole inherited from a complicated situation in the field of management modes and operators. For example, there were 10 different contracts and one public corporation of a syndicate for the water supply. Rather than converging to an unique mode of management, which could have taken a long time (waiting till the end of each contract) or cost a lot of money (if they broke the contract before the end), they chose to conserve this different modes and to make an asset from it in order to have, for example, an emulation between the different operators. This was made possible by the triangle model and the affirmation of the organizing authority and its role. This permits to Nantes Métropole to impose itself as

responsible of the service delivered to the consumer and as the guarantor of the general interest and to impose certain restraints to the different operators to result in a harmonization of services and rates. Several additional clauses to the contracts permit to obtain an unique price of water on the first January of 2006, an harmonization which didn't penalized the habitants since, on the period 2001-2006, only 5% of the consumers have seen their facture increasing more than the inflation when 60% saw it increasing less than the inflation and 35% saw it sensibly decreasing (between 10 and 35%). Moreover, the signing, by the private and public operators, of a quality charter with 12 points of engagement permit the harmonization of the water supply service, in 2006 too (François M. & Marest P., 2006).

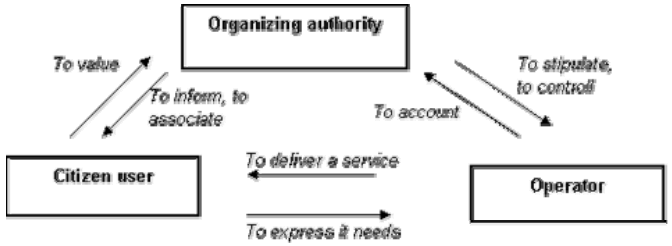

Figure 4: The triangular model adopted by Nantes Métropole

Moreover, if the triangle and the affirmation of the role of the organizing authority permit to solve the problem of harmonization, their putting into practice were accompanied by a analysis about, and a clarification of, every stakeholders role, in particular that of the citizen. The idea is to make him more places in a very technical domain and to introduce the participation of the citizen to the water management and policy. In fact, the role of the organizing authority is to inform the citizen and to make him participate to its local policy, and the citizen has to value the policy of the organizing authority. But this is only a theoretical model and the balance between the three stakeholders is very difficult to obtain: the link between the organizing authority and the citizen has to be reinforced. The real functioning of the CCSPL (French commissions of consultation which regroups the users of a public service) illustrated well this affirmation. This assembly is composed by 28 members (elects, consumers associations or environment associations) and meets two times a year to examine the annual reports of urban services. Despite the interest provoked by the themes linked to water supply (price, quality, economies of water…), we noted an important absenteeism which can reach 71%. This lack of participation can be explained by their lack of institutional and technical knowledge in the field of water and the absence of debates: subjects tackled are more technical than democratic.

Competences necessary to answer to actual stakes of water management

On the field of the competences that a structure must have, the comparison between Nantes Métropole and other cases illustrates the fact that it is better to have a whole competence on the whole territory. First, to have the whole competence, which means to be responsible of production and distribution in the case of drinkable water and to be responsible of waste water collect, transportation and treatment in the case of waste water, permits more coherence and a more global vision. This has been confirmed by people I interviewed and who worked in both situations. Secondly, it is an advantage to have the competence on the whole territory which is curiously not always the case. For example, Lille Métropole has to share its water supply competence with a big departmental syndicate which managed it on 23 towns. The Strasbourg

Urban Community is in the same situation with the SDEA which manages water supply on 15 towns. In such cases, it is difficult to have coherence in the policy on the whole territory. So people from two different towns of the same intercommunality can have different prices, different quality of services and, in particular, different orientations in the water policy.

Moreover, my interviews show that it is better to have water and waste water and other competences like urbanism and roads department. In fact, Nantes Métropole has those competences which presents some advantages for the coherence of the global public policy because water supply and waste water management are strongly linked to those elements of development or re-development of the territory. This coherence is more difficult to obtain in the case of the profession intercommunalities or even in the case of project intercommunalities[30] who didn't chose the competence of road department (non obligatory in the case of community of agglomeration or community of towns). In those cases, even if water or waste water management benefits from the advantages of intercommunality listed before, which is a perfect solution when the aim of the pooling is the putting in common of the means, this type of intercommunality is, depending on my interlocutors, a little bit overtaken by the transverse stakes of sustainable urban water management. So they can be confronted to difficulties of coherence with the other public policies conducted by their members and the restraints linked to the profession aspects remove them from those linked to territory development, which are more taking into account stakes from another order: social, economic or environmental.

The analyze of the model of Nantes Métropole and the comparison with other intercommunalities seem to show that a metropolitan management of water, waste water and other competences such as road department or urbanism on the whole territory of the intercommunality, coupled with the putting in practice from the triangular model, including the affirmation of the organizing authority and the introduction of the citizen, is a good way to answer to technical, economic and social stakes of urban water management : you can have the same services at the same price on your whole territory and control its development and try to conduct a more democratic policy by introducing the participation of the citizen. But to answer to the environmental stakes of sustainable urban water management is more difficult.

To work on links between administrative structures and basin structures: a way to answer to environmental stakes

The necessity of a more integrated water management

For water protection, the French model is based on a territory: the basin. This territory is presented as the natural territory for resource management and its legitimacy as a water management territory came naturally from its definition[31]. So the basin is « *praised as the ecological and economic management unit »* (Futuribles, mars 2000), seems to be *«the spatial unit logic to use »* (Maksimovic C., Tejada-Guibert A. & Roche P.-A., 2001) and *«the pertinent scale of planning* » (Launay J., 2003*).* It is institutionally recognized since two kinds of basin systems exist: the duo "Basin agency / Basin Comity", introduced by the French law of water of 1964 and the duo "CLE/ structure porteuse of SAGE" introduced by the French law of water of 1992. But even if the French model generally seems to be a good one for foreigner, especially for the UE who retake it in the DCE, it doesn't work so well in reality.

[30] Profession intercommunalities are in our case groups of towns which have only water or waste water management competences on the contrary to project intercommunalities (Urban Community, Community of Agglomeration and Community of Towns)

[31] The basin is a territory where all the waters (underground, surface water) flow out to the lowest point by following a naturally gradient and meet to form a river, a lake or an underground sheet of water.

« *If the basin notion can assume several ecological assets and impose itself through its apparent natural simplicity, it is another thing for the concrete organization of water management which stays a more complex business* » (Vieillard-Coffre S., 2001). The influence of the basin organisms on the water local policy still is limited. *« The basin agencies, [for example], fundamentally depend, for their interventions, on the goodwill of users liable to taxes, and so are reduced to certain inefficiency»* (Barraqué B., 1999). The basin organisms have no police power and no competence of contracting authority. Their influence is limited to the produced documents: SDAGE and programs for the basin agencies and SAGE for the CLE. The logics of the administrative and basin structures are very different: the ones are more on an economic and technical logic of services and networks management and the others, the basin structures, are on a logic of environment protection. So the problem is that the orientation documents often amount to list of good intentions. During my interviews, I met people who worked in the water field but totally ignored the existence of a SAGE on their territory!

But water environment is the receptor for waste water services and the resource for water supply and the local responsible are the principal contracting authorities of the actions proposed by the basin organisms. So a work on the bond between the different structures and on the influence that documents produced by the basin structures have on the local policy of water supply and waste water management is necessary for a more integrated management which is demanded by the DCE. During my research, I noticed three cases which can lead to a more integrated water management.

The agglomeration contract Neptune between Nantes Métropole and the basin agency Loire-Bretagne: an example of taking into account the whole water cycle

Nantes Métropole has the competences water supply and waste water management[32] but also the following ones: "actions for planning of waterways" and "prevention and management of natural risks and fight against the pollution"[33]. Since it also manages the rainwater, Nantes Métropole controls the entire water cycle. Nevertheless, the services managing water, waste water or waterways are clearly separated : in the organization chart (they belong to different general direction), financially (water supply and waste water services have their own budgets, in part financed by the consumers, when actions on the waterways and for rainwater are financed by the general budget) and in the logic adopted (logic linked to services for water supply and waste water management, and environmental logic for the waterways management). To have more coherence in the policy of water cycle and to rationalize its relation with the basin agency, Nantes Métropole has signed an agglomeration contract with the basin agency Loire Bretagne: the contract Neptune.

The contract Neptune, which concerns the whole cycle of water, is an old partnership, initiated in the beginning of the 90's. The first contract was on the putting of the waste water collect and treatment infrastructures which is classical for such a contract. But Neptune 2 already developed the idea of water environment restoration through actions by basin. And Neptune 3, the actual contract, is in the same logic with, moreover, a part about water supply. Neptune is piloted by a transversal service and so permits to rally services as different as water supply, waste water collect and treatment and waterways management. They all have the same aim: protection and management of water. The agents of Nantes Métropole consider Neptune as a project which forces them to recognize the limit of the basin and concerns a work and action scale which is

[32] Imposed by the article L 5215-20-I of the Code Général des Collectivités Territoriales
[33] Extracts of the statutes of Nantes Métropole

very interesting in the field of water environment. Neptune permits a work in common which was not possible before. Among the projects, we can quote the water capture of security in the Erdre. Nantes Métropole is nowadays alimented by only one resource: the Loire and requires so a second one, just in case of pollution in the Loire. So they have this project of water capture of security in Erdre which belongs to the project Neptune and is linked to the will of ameliorating the quality of the Erdre, another side of Neptune which implies measures in the field of waste water rejection and basin restoration.

The SAGE Estuaire of the Loire: an example of an upstream work on the links

The Sage Estuaire of the Loire was voted by the CLE in December 2007 and is now submitted to the public. It concerns Nantes Métropole. The principal stakes of this SAGE concern the quantitative management of water for the alimentation, the quality of waters and water environment, the overflow and the one which interest us: coherence and organization. This stake is the trademark of the SAGE Estuaire of the Loire.

The idea of the stake "coherence and organization" is to think about the future putting in practice from the project and about the financing of the actions and their contracting authorities, since the beginning of the project of SAGE. The organization will be on two levels:

- The first one is the level of the entire territory. On this territory, the CLE with an animation cell will be responsible of the pursuit of a certain number of debates and will be the referent in the field of water. It will bring homogeneousness and supply methods and watch out for the general coherence in the putting into practice.
-
- The territory of the SAGE is divided into several smaller territories called the under basins (figure 5). These under basins are the second level. For each one of these territories, one structure called the "referent structure" will be the relay of the animation cell on the territory. Those structures will have two missions: one of contracting authority for their competences and for the actions without contracting authority and one of animation of a co-ordination with the other contracting authorities and with all other stakeholders. They will be either existing structures which will maybe have to enlarge their competences or new structures. In all cases, the structure must have a pertinent territory, a competence linked to water management and don't have to take the competences of the other structures of the territory.

Moreover, the link between the SAGE and the financiers were also thought. For example, the basin agency will finance only if the askers put in place coherent programs fur a number of years and with a perspective at the basin scale.

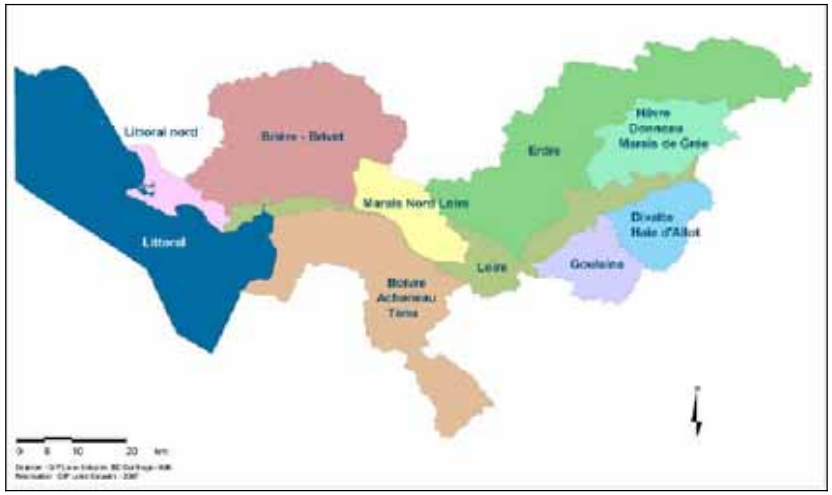

Figure 5: The territories of the referent structures of the SAGE Estuaire de la Loire

The SAGE Nappes Profondes of Gironde : an example of a work on the links during the whole project

The SAGE Nappes Profondes of Gironde is one of the two SAGE which concern the Bordeaux Urban Community. Its territory corresponds to the department of Gironde and concerns four aquifers: Miocène, Oligocène, Eocène et Crétacé. It represents 542 towns, that means 1227000 habitants. The Bordeaux Urban Community on its own represents almost 50% (637612). The principal stake is the quantitative management of water for alimentation, agriculture and industry. It came into effect the 25 November of 2003 and its aim is fixed for 2010.

There are two aims to combine: to do economies of water and to find new resources. As water for alimentation represents the biggest part of the samplings (74% against 17% for the agriculture and 9% for the industries), the majority of the actions logically concern water supply and its local responsibles. So the links between the SAGE and the local authorities or intercommunalities in charge of water supply are very strong. The Bordeaux Urban Community is particularly concerned since it represents the biggest part of the samplings (48,4% in 1998). By the way, the SAGE has been traduced in the contract between the urban community and its operator who is charged of putting in practice the SAGE, with objectives of samplings and economies of water. The policy of water of the Bordeaux Urban Community is the SAGE.

Since the beginning, they were conscious of the fact that they need means to function. So they put in place a specific tax. This tax is based on the principle of tax for dispensed services which consists of making financially participate those who made a project necessary and those who find an interest to it. It is modulated in function of the zones defined by the SAGE (in function of the available water quantity). It is tiny (some cents of euros by m3) but symbolic. It is used on several plans: for the contract between the actors of Gironde and the basin agency, to major the agency subventions, to aid to projects out of program upon acceptance of the CLE and as a compensation for those who are making efforts.
Moreover a territorial challenge has been signed between the basin agency, the CLE of the SAGE, the Bordeaux Urban Community and other structures for the protection and the improvement of the management of the underground water from the department of Gironde for the years 2003-2012

CONCLUSIONS

The analysis of the model developed by Nantes Métropole and the comparison to the other cases permit to find major principles for a territorial organization of water management which answers to issues implied by a sustainable urban water management :

- The management of water and waste water would be assumed by an intercommunality.
- This intercommunality would have adopted a triangular model based on the affirmation of the organizing authority with a real taking into account of the citizen.
- This intercommunality would also have other competences linked to water management as road department and urbanism.
- And, to take into account the environmental stakes, this intercommunality would have a contract with the basin agency including the whole water cycle or would participate to a SAGE who works on links between the different structures.

Those principles, stemed from a first analysis and mostly based on the case of Nantes Métropole, must be confirmed by an analysis of the other cases and must be taken as recommendations to adapt to each particular territory.

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4 Safeguarding urban areas confronting climate trends and extreme weather by means of a trans-disciplinary approach

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Abstract
With regard to the climate change an increase of storm water events combined with longer droughts is prognosticated subsequently resulting in growing discharges of sewage into receiving water bodies with harmful consequences for surfaces water. And second, longer dry weather periods and an increase of the annual average air temperature will produce a shift of water balance and a decrease of available water resources, with particular hazard for drinking water supply. Due to the currently foreseeable remodelling of settlement areas - not least activated by the looming population development in Germany and Europe - actions should be taken to counteract the consequences for water management out of the climate trends and the shift of extreme weather statistics. To meet these challenges an interdisciplinary competence network was formed including participants from urban planning, water resources management, drinking water supply and social scientists. The interdisciplinary cooperation shall assure that the prognosticated harmful outcomes on the urban water management not only can be attenuated but also be compensated by sustainable water sensitive methods. This paper deals with a first assessment of the primary issues, states scenarios to assess the range of change and to overcome lack of information and finally presents matrices containing adaptation measures.

Keywords
Adaptation; climate change; global warming; residential areas; water sensitive urban design

INTRODUCTION

Impacts of climate change to the hydrological cycle

The climate change will affect the temperature as well as the frequency, duration and intensity of storm water events. The hydrological balance of rivers and watercourses normally will rely on large-scale processes in time and space, while urban runoff depends on local storms and need to be modelled by higher temporal (minutes) and spatial (hectares) resolution.

The size of the shift in the water balance, however, differs greatly between the various climate zones of Europe. Nevertheless, the sensitive hydrological cycle is bound to react with
- a smaller groundwater recharge and lower groundwater level,
- rising water stress in areas which are already confronted with water shortage,
- an increase in the number of flooding due to storm water events and
- higher fluctuating discharges of water bodies throughout a year as a result of an increase of the occurrence of flooding (EEA 2007) and longer periods of low river-flows (Figure 1) in summer (EEA 2007, Jacob 2006, Lehner *et al*. 2001, Middelkoop et al. 2001).

As seen, the changes of the hydrological cycle of large areas and whole river basins will be severe. When these changes will be investigated in combination with impacts on the hydrological cycle that has already been modified by urbanization the outcome will be more hazardous. The processes involved in the hydrological cycle within urban areas react more quickly than those of pervious areas. Not only hydrological aspects but also water quality will be affected by the given changes.

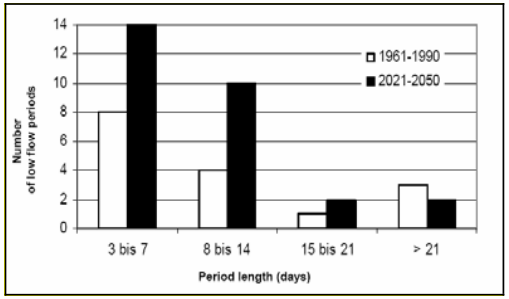

Figure 1: Rising number of low flow periods (Q < 750 m³/s) in River Rhine at Gauging station Kaub, Germany, based on the IPCC B2 Scenario (Jacob, 2006)

Migration, population and demographic changes

Urban planning as well as all infrastructure systems are designed for a certain population. If the population exceeds the infrastructures, e.g. water supply system or sewerage, has to be expanded. At least in European countries enlarging a given system is possible, because population growth goes together with economic growth. In contrast, at the centre of the current debate about future European water infrastructure systems more and more the decline of consumption as a result of declining populations is discussed, which often goes together with shifts in consumption patterns and reindustrialisation. This is a considerable driving force in the transformation process currently taking place in the water sector (Libbe and Moss 2006).

As much as we have to welcome a trend of saving water due to technical innovation, rising prices etc., with regard to environmental aspects, the consequences for the infrastructure systems are great, dimensioned on increasing demand and mass flow rate (Schiller and Siedentop 2005). Because of the longer amount of time that water and wastewater stay in the pipelines, there are deficits regarding the quality, transmissibility, odours, and corrosions as well as increasing deposits. If deposits are remobilised during storm water events, combined sewer overflows and wastewater treatment plants emit higher pollution loads into the receiving water bodies.

Furthermore, the infrastructure system is featuring an extremely long-term economical and technical lifecycle. The security connected with this comes with a path dependency and lack of flexibility of the system. With a decrease in the average utilisation but increasing operating costs a pitfall of fixed costs will occur: In order to generate the large fixed costs, higher unit prices have to be charged by fewer consumers. This will not only lead to a further fall in the consumption of water it also has a not to underestimate socio-political implication in structurally weak areas. The apportionment to the consumer is only partly politically enforceable.

Local Focus

By the use of river bank filtration the river Ruhr in Germany covers a significant amount of the water consumption. With regard to climate change, a network was formed to identify the most pressing issues. While including the "lessons learned" from the implementation of the water framework directive (WFD) it was reasoned that a trans-disciplinary approach is necessary. Thus water and wastewater managers cooperate within the established network "*Klimanet"* with town planners, the administration and local authorities as well as social scientist. The social scientists are up to the task to identify the risk awareness of the population and its willingness to take part in the change.

MATERIEL & METHODS

The study carried through was a first assessment of the problems arising in highly industrialised regions due to global warming, demographic changes and migration. Thus two objectives were pursued. Firstly, the major problems caused by the named anticipated developments have to be identified and qualitatively approximated. This was carried through with respect to the German technical guidelines and with linear or simple dynamic approaches, e.g. in case of sewer discharge by the rational method. For modeling the combined sewer overflows the hydrologic model Moment (BGS, 2002) was used. The scenarios were calculated with the approach of a "single central basin" (ATV, 1992). Furthermore, it needs to be mentioned that this approach does not consider static storage capacity within the sewer network. Detailed numerical surveys are planed for the future. Secondly, it was questioned, what level of involvement of the population and administration need to be carried out.

All developed scenarios are supposed to be dealt with by using water sensitive urban design (WSUD) measures. In order to distinguish this approach of already applied methods of "integrated water management" (Sieker, 1998, Sieker *et al*., 2005) we chose the systematic originated in Australia (Wong, 2005). The climate, the water infrastructure and local circumstances in Australia differ from Germany so consequently some fields and definitions had to be reshaped.

LOCAL CIRCUMSTANCES AND PREDICTIONS

The Ruhr area

The Ruhr area is located in western Germany and covers a space of about 4.435 km² with about 5.246 mio. inhabitants. The economy develops from formerly mining and steel-producing industries to services and high-end electronics. This economic development causes a decrease in population (-7 to -2 %) within the next 25 years. At best the cities will have a stable number of inhabitants (-2 to +2 %). A small number of cities will even have to encounter a loss up to 12 % of the population (Bertelsmann, 2006). However, studies from East Germany illustrate that a decrease in population not necessarily leads to a reduction of impervious area (Deilmann, 2007). More so, the impervious area rises across Germany at a rate of about 100 ha/d (UBA, 2003). Besides theses influences a slanting demographic pyramid will contribute to new challenges for the water sector and city planning. For instance, rising amounts of micropollutants from medicines may be expected within the sewage. These predictions will also cause many challenges for water and wastewater services.

Nevertheless, these challenges can also be understood as opportunity originating from former commercial and industrial areas of about 8.360 ha are presently available for development (RVR, 2006). The discharges from some of these surfaces need to be treated but many sites can either be disconnected or used for infiltration. Thus three structural scenarios were selected. The

first is placed in the city of Bochum where the population is supposed to decrease and a receiving water body would be threatened by increasing loads or concentration of pollutants from combined sewer overflows. The second scenario covers the transformation of former industrial sites with water sensitive measures or their transformation to retention facilities. Last and third structural scenario is the development of green areas within cities in order to combine the adaptation to climate change and simultaneously advance the districts appearance and its inhabitants well being.

Scenario for the assessment

Based on the well-known report by the IPCC (2007) and regional analyses by the German environmental agency (Zebisch *et al.*, 2005), the assessment lead to following settings for the climate scenarios.

Rain series

Since the future behavior of precipitation is currently only vaguely available, a time-series for the precipitation was designed. The assumptions made base on climate simulations by Zebisch *et al.* (2005) and the global economic scenario A2. While the total annular amount of precipitation remains constant, the time series reflects the shift of the water balance from summer to winter in an order of 15 %. Furthermore, the intensity of heavy storm water events was transformed by a factor of 1.15, too.

With respect to storm water events and the use of the rational method, it is postulated that the intensity of rainfall events with short durations less than one hour will convert such that a current "five year event" will become a "three year event. This procedure was chosen because reliable data or prognoses are currently not available for durations below 12 h. The *5to3-scenario* would lead from a former 15 min design storm of $r_{15,n=3}$ = 143,5 l/(s*ha) to a novel climate change design storm of $r_{15,\ n=3(cc)}$ = 159,8 l/(s*ha) (data from Kostra-DWD, 1997).

Sewer network

The modeled sewer network was set up on a real sewer with a total catchment area of 31 ha including 14 ha impervious area. The town has about 2.900 inhabitants and no major industrial or commercial inflows. The single combined sewer overflow is connected to a storage volume of about 935 m³ which corresponds to a specific storage volume of 66.7 m³/ha(i).

RESULTS AND DISCUSSION

Qualitative analysis for the Ruhr Area

These scenarios were checked against the current valid technical Guidelines. Examples are DWA A-118 (DWA, 2006), DIN EN 752 (DIN, 1996), and ATV A-128 (ATV, 1992). The vulnerability was evaluated of raw water quality for water supply, surcharges and operation of drainage systems as well as the special circumstances of combined sewers. With respect to sewer systems extreme weather in form of storm water events and longer dry weather periods will have a detrimental impact on the functionality of these systems. This results from increased runoff during extreme storm water events, which exceed the capacity of existing sewer systems. Longer dry weather periods will lead to increasing peak concentrations of first flush events (Arthur, 1996). These may contribute to increasing loads emitted by combined sewer overflows and increasing loads from wastewater treatment plants (Langeveld *et al.* 2003, Pinnekamp et al., in preparation). If such emission loads hit after long dry weather periods on low water in the

receiving water concentrations of ammonium and carbon (COD) may not be acceptable. These processes are valid for the separate system, too. The shift in water balance will cause more overflow events either by increased amount of rainfall per event or longer rain duration, although the total amount of annual precipitation maintains.

From case studies carried out in this area (Becker and Raasch, 2002, 2003; Becker *et al.*, 2006) it is known that two strategies have to be pursued. On the one hand administration, especially town planners and political consent are necessary. On the other hand conventional methods, e.g. bigger cross-sections that would be able to transport the runoff may worsen the processes that lead to extended sedimentation within the sewer system and would be too costly. However, if measures in the field of WSUD are applied in highly urbanized areas pollution characteristics have to be considers. Usually, this leads to smaller number of measurements that can be used, causing a need for End-of-Pipe solution that has to be minimized.

First quantitative assessment for combined sewer overflows

In order to have first insights in the order of magnitude of the changes numerical model was used to determine the average annual emitting load from a combined sewer overflow. Through different sets the total storage volume was varied to represent a wider spectrum of storage tanks. In Germany usually the specific storage volume, that represents the ration of storage volume and impervious area, is between 20 and 40 m³/ha(i). Values exceeding 40 m³/ha(i) are considered inefficient. If higher values are encountered, expansions and new developments were included in the design. Figure 2 shows the results of the calculations. With respect to the specific storage volume the specific emitted load by the cso of the climate change scenario is compared to current conditions (status quo). Furthermore, on the second y-axis the relative increase between the current and the climate change scenario is on display.

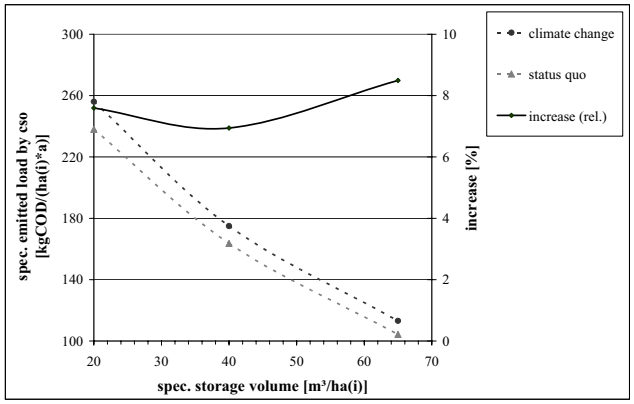

Figure 2 : Quantitative assessment of the impact of a change in the weather characteristic on emissions from combined sewer overflow

The results show that additional storage volume or equivalent measures will be necessary to maintain current emission standards. Within the suggested range between 20 and 40 m³/ha(i) the average increase of emitted load is 7 %. To attain this rise storage volume would have to be increased by about 10 %. With respect to rain intensity a 11 % increase would refer to a storm

water event with a duration of 15 min if the frequency would increase from one in three years to one in five years.

If one considers the large uncertainties, especially regarding evapotranspiration and the increasing annular temperature which have been neglected in the first assessment, further data and regionalized climate models are necessary. It needs to be stressed that this are preliminary results. However, the results show that the shift in the water balance and a change of the rainfall characteristics effect the emission loads. Derived from calculations with the rational method the order of magnitude of increased loads may be around 10 %. This indicates that adaptation measures will be necessary. In the same time it also shows that the adaptation can base on a good mixture of measure from the integrated urban water management or water sensitive urban design toolbox. That way very expensive End-of-Pipe solution, even increasing the transport capacities of the sewers, can be avoided. In order to include for example the methods of water sensitive urban design (WSUD) into urban planning, both the ideas and the way WSUD measures work have to be transported across disciplinary boundaries.

Identifications of interdisciplinary aspects and scales

The adaptation of the built environment will need at least the same great efforts as the implementation of the water framework directive (WFD) and has to involve people down to the individual level. The implementation of the WFD and the design of River basin Management plans (RMP) according to the WFD have shown that participation is very important to attain the goals of ecological good state. There is no reason to believe that in the process of adaptation fewer parties need to be involved. In a first step it is necessary to define the relevant people and groups, e.g. citizens, stakeholder of related organizations and industries, administration department and politicians.

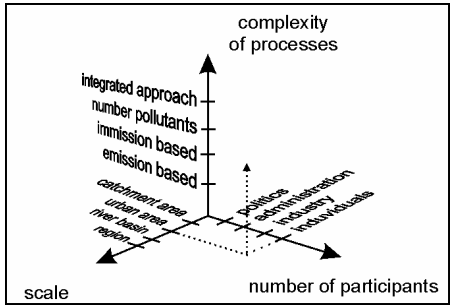

Figure 3: Space of complexity dealing with water sensitive urban design to adapt the built environment

In the next step the share of the individuals and the possibility to be affected by the changes related to the climate change has to be clarified. According to this the role of every participant has to be identified to face the predicted changes. Because of the complexity of the process (figure 3) a thoroughly analysis of stakeholders' and policy makers expectations and requirements with regard to the adaptation of urban water and wastewater management is following. Figure 3 illustrates the limiting effect of a broad participation process on the scale and the level of complexity. In order to be able to both disseminate results and carry out measures, model complexity has to be reduced. Moreover, the dependencies between risk awareness and a slowly changing weather pattern have to be investigated to be able to start long-term implementations of mitigation and adaptation measures. In order to increase the efficiency of

adaptation measures any planning of a town's future economic, social and environmental development should include both mitigation and adaptation measures.

The trans-disciplinary paradigm

Trans-disciplinarity as a principle of integrated research is a methodical procedure to combine scientific and practical knowledge. Within this understanding trans-disciplinary research starts out from social problem definitions, and meets the interdisciplinary approach of the WFD.

Each of the formulated issues going to addressed in detail need to consider all of the following:
- trans-disciplinary integration and transfer of knowledge across all stakeholder parties,
- implementation using processes on both levels emotional and cognitive,
- context related examples, participation of individuals and supervision of success,
- evolution of scenarios as subject for transfer of know-how and tuition concepts, as well as
- promotion of water sensitive urban design (WSUD).

Development scenarios (decision support framework)

With respect to the structural scenario in Bochum, where predominantly housing and commercial areas have to be adopted, the structure and architectural aspects have been analysed in a first step. Table 1 presents different types of developments. The used runoff coefficients originate from the German technical guideline DWA A-118 (DWA, 2006) and the technical data sheet ATV M-165 (ATV, 2004) (q.v. Butler and Davies (2004) for Great Britain).

Table 1. Existing types of development in Bochum, Harpen

Type of urban development	roof pitch	proportion of paved area about	Runoff coefficient[1)] (Ψ_s)
residential area			
– detached and semi-detached houses	40° - 50°	43 %	0.47
– row houses predominantly flat roofs	flat roof	45 %	0.41
– apartment buildings, administrative buildings / school buildings	flat roof	45 %	0.41
industrial park/ commercial sites	flat roof	78 %	0.70
parking places and parking garages	-	> 90 %	0.87
access road without important interconnecting residential Road – from 100 vehicles/h to 400 vehicles/h	-	> 90 %	0.87
following technical data sheet ATV M-165 and the technical guideline DWA A 118 (2006)			

It is reasonable to expect that with rising air temperature both infiltration rates and evapotranspiration rates will change, latter most probably increase. However, for this preliminary investigation was assumed that runoff coefficients remain the same. According to the *3to5scenario* and applying the rational method runoff has to be reduced by 11 %. This can be achieved by reducing the overall connected surface or by reshaping the surface so that the runoff coefficient falls. For many reaches at the beginning of the sewer system currently exiting cross-sections may be sufficient. The problems with regard to surcharge will arise further downstream. Those types of urban development listed in table 1 have been checked against different measures that might be useful to mitigate the impacts of higher rain intensities. Also have been assessed the effects on Urban Development, Water Management, Climate/Environment, Resident/Occupant/ Property Owner, and the community. The result is summarized in matrices that can be implemented into a toolbox as decision support framework. Exemplary, the appendix shows the matrix for the set of residential area (q.v. *www.klimanet.isa.rwth.de* (ISA RWTH, 2008) for more tables). Aims of the process are detailed surveys on the water flows of surcharging drainage systems.

CONCLUSIONS

From the investigation and discussions during the first phase of the Klimanet network the following conclusions have been drawn:
- Traditional solutions in concrete are not the most desirably methods. Economic and population changes demand flexible and sustainable solutions wherever possible.
- Adaptation will concern existing systems which are serving well for up to a hundred years.
- Points of interest have favourably to be located at the head to the sewer system. That way disconnection of surfaces, pollution control, retention and infiltration are more effective.
- A great number of decentralized facilities that attenuate the surface runoff are able to prevent damage caused by flooding from extreme storm water events.
- A *3to5-scenario* leads to an increase of max. discharge of 11%.
- If former 10-, 20- or even 50-year events become more often, the urban drainage master plan would need further extensions, e.g. emergency plans or detailed numerical surveys.
- Constrains
    - Being active on the individual level leads to a great number of participants that are located primarily on the private level, therefore any adaptation measures need political support.
    - The scale and the level of complexity of used models need to adapted to the way and the receptors of the dissemination
    - Rainwater treatment facilities need maintenance and emergency outlets.
    - Regionalization of climate models that can predict the change in the storm water characteristics for grids of hectares is currently not available.

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5 The river front of Benares : between 'sacred' waters and sewage water.

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ABSTRACT
The palaces of Benares, built along the river Ganges between the end of the 17th century and the beginning of the 20th century, appear as foremost references of monumental water-front constructions.
This paper explores the role played by these palaces in establishing a relationship between the Ganges and the city of Benares. These constructions integrate the river to the city while simultaneously protecting the city from the river. Were the palaces of Benares with their *ghats* (steps and landings leading to the water) and their foundations constructed to play this double role?
The foundations and *ghats* of these palaces have to be regularly repaired to counter the erosion of the running river water. However, these waters are not the only cause for damage as often drains running along the *ghats* leak and sewage flows over them before discharging into the Ganges. These palaces and their *ghats* will thus be studied in association to both the running 'sacred' waters of the river Ganges (in the forefront) and the sewage water of the city.

KEYWORDS
Water-architecture, river, sewage

INTRODUCTION

The palaces and *ghats* (steps and landings leading to the water) built along the river Ganges have consolidated the banks of the river and have protected the city of Benares from river currents and annual floods. Yet, most of these *ghats* and palaces have, in spite of their grandeur, collapsed and are today in a state of ruin. There are numerous reasons which explain the causes for the damages to these structures, including lack of means to maintain and renovate them. This paper will limit its study to the role of water as a cause for damage; running waters, river water, streams and rivulets, flooded tanks and ponds as well as percolating sewer.

I shall initially present the different palaces and *ghats* in their historical context followed by the techniques used in their constructions. I shall then proceed to place these structures in their geographical context so as to understand their position in relation to the river and to the drainage system of the city.

These structures will be questioned as to how effective they are and if during their construction they take into account the sources of running water which often happens to be the first cause for the crumbling of foundations. We shall discuss how on one hand the structure permits ready access to the river water, considered sacred and purifying for ablution; and on the other hand how the lack of efficient drainage structures pollutes this 'sacred' river.

Short history of the river front

The palaces of Benares give to the water front a magestic greatness and beauty. Soaring up five to six floors high, these palaces, constructed in sand stone, red, rose or orchre in colour, seem like fortresses. Actually, the first few floors have very little openings (a single entrance, and few tiny windows) or none at all, and serve only as a base for the more open and inhabited floors. This river front unfolds in an arc form, more than 6 kms in lenght, compared by Havell in 1905 to 'an amphitheatre, glittering in the sunlight'. These palaces and *ghats* are constructed facing the Ganges and the morning sun. The other bank being free from any construction, they have no vis-à-vis with other buildings but stand erect in front of the seemingly infinite horizon. During the monsoon season, the river overflows and pours partly on this opposite bank.

It is frequent to read that the ancient Kashi (the luminous) is the oldest continuously inhabited city. Historically, its date of origine is uncertain and there are doubts regarding the actual position of the ancient site and its correspondence with today's city. However, the city is mentionned in various ancient texts that confirm its importance as a cultural and religious site since 800 B.C. Till today, this city plays an important role as a religious and philosophical place as well as one of the most important pilgrimage sites in India.

The palaces and *ghats,* that form today the riverfront of Benares, were built in more recent times. Most were built, in the 18th and 19th century, when the city began to be reconstructed. A renewed economic and political stability (after 400 years of muslim rule) led to the construction of eminent residences and religious complexes. Rich personalities came from all over India and beyond, to build temples, palaces and shelters that would welcome pilgrims. It was prestigious for them to have a presence in the city and monumental constructions was a way to reaffirm their power.[34] They brought with them styles particular to their region and adopted techniques prevalent during the Mughal period in India. These numerous palaces, constructed between the rivulet Assi in the south and the river Varuna in the north, reflect the power not of a unique monarch nor of a single culture but of many contributions and individual wishes of minor kings, rich bankers and patrons from all over India[35].

The city of Benares is closely associated to the Ganges and to the religious character of the river. In the hindu conception, the water of the Ganges is sacred and purifying. The immersion and ablutions in its waters are an everyday practice for the inhabitants as well as for the pilgrims coming from all over India and beyond. The ghats constructed at the foot of these palaces enable an easy and clean access to the river. This water architecture, as pointed by Julia Hegewald[36], is a common practice all over India along sacred rivers, lakes, tanks and ponds. However, such a long stretch of *ghat* construction is particular to Benares.

These *ghats* also permit an easy access to the city constructed on a ridge of firm « kankar » (concentration of lime) filled clay. This high position is supposed to naturally protect the city from floods and the *ghats* constructed along the banks help to reinforce the banks. Was this *ghat* construction a tradition or a novelty when it was first built ? How did this tradition evolve and what are the current means to protect the city from the river?

The river has also for a long time played a crucial role in the economy and the evolution of the city. It had always been an excellent navigable route which explains partially the continuity of

[34] FREITAG, S., *Visualizing cities by modern citizens*, in GAENSZLE M., and GENGNAGEL J., *Visualizing space in Benares : Images, Maps and the practice of representation* ; Harrassowitz Verlag, Wiesbaden, 2006 ; pg. 244.
[35] Idem.
[36] HEGEWALD, J., *Water architecture in South Asia : A Study of Types,Development and Meanings*, Leiden, 2002.

the city in history. Part of the *ghats* were used as ports that harboured ships and boats exporting silk, diamonds and jewellerys, muslin and other manufactures of the city.

Techniques of construction

The foundations of these palaces and ghats are rarely visible as they are covered by the river and extend way below ground surface. One has to depend on different sources to have an idea about the forms and the materials used for their execution. As these palaces were built mostly in the 18th and 19th century, this paper focuses on the hydraulic constructions, often linked to bridges and sluices, built in the same period. Their foundations rested on piles of brick masonry, a tradition probably brought to India by the Mughals. Similar foundations must have been used for the construction of the palace foundations in Benares.

Another current way to imagine old foundations are by comparing them to those found in other cities. In Vrindavan, where the water of the river has reduced to a considerable length, *ghat* steps do not descend to the water edge and foundation piles are exposed undereath, enabling one to have an idea about the dimensions and forms of the foundations in Benares.

Medley in 1873 gives a brief description of foundations built along rivers[37]. According to him, wooden piles were rarely used as timber was scarce and was prone to rot. Instead cylinders of brick masonry was used, three to twelve feet in diameter, sunk to firm stratum and safe from river erosions. 'A sufficient number of wells are designed to carry the super-incumbent weight whether it be a house or the pier of a bridge, and the whole series being sunk to the required level, and as close together as possible ; the tops of the wells are arched over, the arches are all connected together by slabs of stones or other arches, and on this artificial platform the superstructure is raised'[38]. However, he does not give us any indication about drains linked to the structure.

Today, many of the new ghats being constructed or the old ones getting repaired use five meters high RCC (reinforced cement concrete) piles placed every two meters. To further protect these piles from the water currents, huge boulders are heaped up in front. On the other side, a mixture of sand, broken stone and cement cover the surface of the bank on which stone steps are arranged.

Stone steps or *Ghat* like structures are common today for the more important ghats (like Assi where stone is used for each step), however less known banks are often reduced to just a sheer expanse of steep retaining walls, now and then broken up into terraces. This kind of intervention is implemented to reduce expenses while at the same time insuring the protection of the *ghats*. Instead of stone, brick (much cheaper in cost and execution) is used on the surface.

A thorough survey on site will be needed to study more closely the structure of these *ghats* and palaces in their context. Primarily, it will be important to calculate how effective the new structures are and compare them to the old ones. Secondly, the permeability of the structure will be questioned in relation to the river and to the drainage and sewerage systems. Finally, one will have to question the structures in relation to the overflow of sewage.

Drainage and sewerage system in relation to the geographical context

[37] MEDLEY, J. G., India and Indian engineering, London, 1873.
[38] Idem. Pg. 15.

The city of Benares is built on a high ridge of *kankar* (lime concentration). It is assumed that the nature of this *kankar* renders the bank very stable. Actually, the banks are further stabilised by the construction of *ghats* and palaces.[39] Based on the map of Prinsep, Dr. R.L.Singh has drawn in his book a figure which illustrates the initial physiographic conditions of Benares. Along the river Ganges a high ridge of kankar can be seen, extending almost continuously from one end of the city to the other interupted only at Dasaswamedh *ghat* by the Godaulia *nala*[40]. This high ridge acts as a solid natural barrier protecting the city from the river.

The palaces and *ghats* of Benares have been constructed on this high ridge of *kankar* further consolidating the banks. They form the extremity of the city and are mainly designed in relation to the river water and are thus very different from the rest of the buildings found in the city. This river front seems to be constructed independent to the city that spreads out behind. In Prinsep's map of 1823, the level of land on the other side of the ridge slopes down slightly and a series of ponds and tanks are found all along the ridge. Initially, these tanks were supposed to collect the drainage and direct it either through the Varuna river or through the Godaulia *nala* into the river Ganges. However, with the densification of the city, most of these ponds and *nalas* have been filled up.

Till what extent were the construction of *ghats* and palaces linked to the infrastructure of the city? Actually, rich personalities were ready to pay large amounts for the development of religious structures in the city : *ghats*, temples, dharamshalas (shelters for pilgrims). To a certain extent, public welfare too was financed by the patrons of the city as an act of piety. However, the city spread in an unplanned way, and there lacked a powerful coordinating body that would effectively work on the management of large infrastructures. A committee did form for a very short period. It functionned from 1826-1829 and began various works for the developpement of the city. Prinsep, who was its secretary pointed out that « while resident pensioned noblemen and disinherited princes were embellishing the City in massive stone above ground the members of the committee would content to labour in humble brick underground ».[41]

Before the beginning of the 18th century Varanasi had an extensive system of underground drains meant primrily for carrying rain-water. These were large drains unsuitable for the flow of sewage as they were rectangular in shape with irregular gradients. Made of brick and rough stone work (from 1-6 ft wide and from 1-9 ft deep.) they ran at varying levels down the centre of the paved lanes, connected with courtyards of houses. They later played a role in the laying and development of a new sewer at their old site. Actually, the committee that worked for the improvement of the city in 1826 designed one main sewer, carrying the entire sewage of the city. It was built running down the stream and dropping the sewage into the Ganga near Rajghat.[42]

Around 1867 a municipal Board was instituted that introduced improved sewerage and drainage facilities. However, an entire sewerage system was introduced in the city only in 1891 and completed by 1917. This must have been the time when most of the tanks and *nallas* were filled up, either for construction of buildings or for establishing new roads (eg. The Godaulia *nalla* filled up to become the Dasaswamedh road).

[39] According to Singh, « just as the banks would most probably have been protected in the past thanks to the forest that covered this site, so today the stability of the bank is mentained by the construction of ghats and palaces », in SINGH R.L., *Banaras : a study in Urban Geography*, Banaras Hindu University, Varanasi, 1955, pg. 15.
[40] *Nala* : it can signify a big drain, a gutter, a rivulet or a watercourse.
[41] Swami Medhasananda, Varanasi at the crossroads : A Panoramic View of early modern Varanasi and the story of its transition; Ramakrishna Mission, Institute of Culture, Kolkata, 2002. Pg.435
[42] SINGH R.L., *Banaras : a study in Urban Geography*, Banaras Hindu University, Varanasi, 1955.

With time this sewage system installed became inadequate with the quickly expanding city. Furthermore, numerous leaks in the pipeline led to overflow of sewage directly into the Ganges at several places. There are several records of palatial houses collapsing because of these leakages. Already in 1955, Singh mentions that « the reconstruction and improvement of the ghats as also the improvement of the drainage system are interrelated problems and need to be tackled at the same time »[43].

In 1971, to prevent the pollution of the river at the important ghats, a new sewerage system was added. This system, constructed on the bank of the river, intercepted the sewage discharges to the river and was called the Ghat intercepting sewer. This sewage discharge came from a number of old drains between Meer ghat and Trilochan ghat. This interceptor sewer serves the ghat portion of the town and all the sewer that cannot be drained into the main sewer.[44]

Today, the scene of the ghats are much denatured by the presence of huge cylindrical often light pink coloured structures constructed along the entire river front, which are the pumping stations. These structures are supposed to pump out the sewer which is drained towards the ghats, and take it towards a treatment plant. Six major drains, that pass through densely populated areas of the city before discharging into the river, are tapped and pumped at the 5 pumping stations. The problem is that these pumps work on high electrical means which the city cannot afford to invest on. Therefore, during power cuts, which occur at regular intervals during the day, these pumps cease to function. The sewage then flows directly into the river over the *ghats*. In places where the river is used for domestic or ritual purposes there are some arrangements done to shift this same sewage, through pipes and manholes, a little distant off. But, this does not prevent the pollution of the 'sacred' river by the sewage water.

CONCLUSION

In a city of over 1.2 million habitants, the pollution of the river presents a health hazard specially to those who bath in it and drink its waters Many organisations have sprung up within the city to try and find a solution to the problems linked to the pollution of the Ganges. There is a contradiction in the fact that 'Ganga water' supposed to purify should have 'a fecal coliform count, in the religious bathing areas of the ghat, 10,000-100,000 times higher than acceptable level'45. This short presentation tries to associate the lack of adequate sewage facilities to the architecture of the river front. It invites to study documents elaborated by the different bodies responsible for the mentainance of the ghats, the drains, the sewer, and the water pollution of the Ganges and question the existing links between these different bodies.

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[43] idem, pg. 44.
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6 Representation of a sustainable city: the example on practice of urban planning in the rivers and estuaries borders in the City of Recife

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Abstract
In the search for the sustainable city, the relation between protection of waters and the occupation of its borders gain privileged space in the urban planning. However, speech and practice do not always walk together. In the city of Recife, Northeast of Brazil, the new public lines on the use of the borders of the rivers is a good example of the danger of the vulgarization of the term of sustainable development. The project of eradication of the precarious habitations on water considers the withdrawal of the families who inhabit wooden houses on stilts in these places and the restoration of the marginal zones. The local authorities legitimize such project alleging to act by the means of sustainable development; moreover, the real environmental impact in the area is rarely taken into consideration. Although the eminent risk of flood, it is from the rivers and swamps that this population takes off its sustenance.

Keywords
Urban water; resources, risk assessment, politics, sustainable development

INTRODUCTION

It is not new to say, after stated at the United Nations conference meeting about the environment of Rio de Janeiro 1992 (UNCED), that the implementation of a sustainable development in large cities has been introduced as one of the main commitments on their municipal managements. “The idea of sustainability recalls the logic of practice, where practical effects viewed as desirable are made to happen. […] When applied to urban space, the idea of sustainability has generated different representations and perspectives for managing cities” (Acselrad, 1999). An example of it in Recife is the incorporation of municipal Agendas 21, which holds as one of its main principle the line: "think globally, act locally" with leaflets and methodological guides that assist the town planners to put sustainable development into practice.

In spite of the fact that the rhetoric on those urban projects is in accordance with the speech of the urban sustainability - following the three dimensions: social, economic and the environmental – does it in *practice, really* represent a true change on the way of conceiving urban projects? Or may it only be some kind of "*greenwashing*", or even the vulgarisation of the term in itself, turning it banal and meaningless?

In the City of Recife, Northeast of Brazil, after the 90’s, urban projects have begun to integrate the perspective of a sustainable town development. Before it, urban planning was based on the preservation of the cultural heritage. This idea of the conservation of the city heritage for future generations was the first avatar on the urban sustainability. But, recently the city have begun integrate the environment perspective. Recife is conquering the spaces along the waters as the borders, rivers and humid zones. Although they have been situated in the common rivers’ estuary, the borders of water were until then ignored and had little integration with the city’s activities.

In this search for the implementation of the sustainable city, urban rivers and wetlands begin to have the meaning of natural patrimony to be preserved. “Water, it’s not only considers like an element of the environment, but as an essential component of the ecosystems to be protected, restores and emphasize” (Gauthier, Lepage, 2005). By the simple adequacy of the waters’ flow with urban necessities (rectification of banks, canalization of the streams, draining of the swampy zones, waterproofing of the borders), these projects try to integrate water and to respect its natural flow.

This paper intends to analyze the representation of a sustainable development in the recent urban planning of the City of Recife and the vulgarization of the green speech. In this way, we will verify a example of occupation of borders on superficial waters.

PROBLEMS AND CONTEXT:

For a better understanding of the case of Recife, it is necessary to highlight some social and natural characteristics of the place. Recife is situated in the tropical zone of Brazil, on the sea cost, common estuary of three river basins. This forms a complex fluvial system composed by five rivers and 66 canals. In low lands of the estuaries, there are the mangroves, that are swampy areas of transition between the river and the sea. The mangrove is a rich ecosystem, where we can find you a great variety of clams, fishes, crabs and birds. It is an important area for the ecosystem balance. Besides being a zone of reproduction of innumerable species, the zone is fundamental for the purification of the water and the absorption of rain waters, thus preventing floods and cyclic inundations. However, the mangrove is threatened by the water pollution and the constant embankment due to the urban growth towards the flooded zones.

It is in these muddy areas of the rivers banks where the poorest population installs their habitation. The sprouting of slum in these places comes to the fact that these uncertain zones between water and land do not possess commercial value. There are the last areas vacated by the city center, where this population can find work. With the highest GIP (2,04 to euros/per capita) of a metropolitan region of approximately 3,5 million inhabitants, Recife exerts a strong demographic attraction in the region. The flow of immigrants has two main origins: they run away from drought of the arid countryside or they come from other cities near the littoral to try their luck in the capital. Arriving in Recife, the majority find themselves without work. Thus they have no choice but improvise precarious shacks in the most devaluated areas. The slum shacks on the borders of the river are called *palafitas*, wooden houses on stilt.

Figure 4: Localization plan **Figure 2: Recife, plan of river basins**

The conflict between social dynamics and the environment preservation is a major problem of the great Brazilian cities. This conflict has its origins in the relation between the urban growth and the social inequality. The substandard housing in the cities is a frequent alternative of settlement of the population with low purchase power. The social inequality is consequence of the disparity in the income distribution. Without access to the formal market of the urban property, this part of the population occupies areas of environmental preservation, as fens and river sides. This type of housing generates two different situations. The first one would be the life risk that this part of the population is submitted, due to the fragility of the habitations against high tides and the exposition to illnesses because of a very unsatisfactory sanitary condition. The second deals with environment preservation, that generates the conflict between the individual right to occupy these spaces and the collective interest for preservation and protection of this environment.

The Town Hall estimates that more than 70 thousand people live on the rivers banks and canals in Recife in precarious ways. Out of this total, 50,000 people live in *palafitas*, (JC, 2006). The houses of *palafitas* are spread in 32 areas along the rivers and the estuary. Without access to the service of neither garbage collection nor water supply, the irregular habitations contribute for the water pollution. The families who inhabit the borders of the rivers are at the same time cause of the degradation of the quality of waters and victims. They represent the part of the population that is more exposed to the illnesses of water propagation, as leptospirosis.

Even if the town is surrounded by the water, the access to drinking water is becoming more and more difficult, which proves the deficiency of its supplying system. The Instituto Brasileiro de

Geografia e Estatística (IBGE, Brazilian Institute of Geography and Statistics) estimates that 88% of the domiciles are connected to the water supply net, but in the great majority of areas, water arrives to the taps each two days. Moreover, only 30% are connect to the used water evacuation net. Only 20% of this volume is treated, and the rest of it is rejected in rivers and canals without any treatment. The population perceives the river as an open air sewer that stinks and causes illnesses. Thus the city lives a paradox where the water is a major urban problem for its presence (polished state) or for its absence (potable state).

Figure 3; 4: Palafitas in the rivers banks of Capibaribe image of: Renato Spencer

METHOD AND MATERIAL

The method of research used understands the survey of the projects destined to the banks river and flooded areas, the study of the urban evolution and the analysis of urban projects dealing with the removal of the palafitas. From this survey, we could compare the official documentation (theoreticians) with the data observed in the local.

The projects that aim to withdrawal the families living in substandard housings in flooded areas in Recife is not properly a new kind of intervention inspired by an holistic vision of the sustainable development. The first projects for the flooded areas in the town date from the beginning of 20th century, motivated for the hygienists ideas. These projects consisted on the destruction of the precarious shacks, fill the flooded zones with earth and in the relocation of families for houses in the periphery.

In 2003, the city hall launches an ambitious project having as objective the eradication of the *palafitas* in ten years, called "*Recife sem palafitas*" Recife without palafitas. Such project of the city hall and the Ministry of the City acts in field of urban renewal of the flooded areas with *palafitas*, with the objective to relocated and build proper houses to this population. The city hall presents the project as being a set of urban, environmental, socio-economic and cultural actions.

The project of the eradications of the palafitas is integrated to other central project office called "*Capibaribe Melhor*" A better Capibaribe River. This project counts on the support of the World Bank. It's a integrated actions of urbanism that aims to promote the environmental requalification of the Capibaribe river basin.

Table 1: projects

	Theory referential	Projects objects	Actions
Project :Capibaribe Melhor Prefeitura da Cidade do Recife, URB, MCconsulnting	To improve social, economic and environmental conditions of the low-income population groups that live in the Capibaribe River Basin, with a view to ensuring the sustainability of their development and reduce environmental degradation of the canals and of the Capibaribe River itself caused by inappropriate use (sewage and garbage disposal) and human occupation of the river banks	***Integrated Urbanization***: a better quality of urban space along the Capibaribe River by creating and recovering the physical infrastructure associated with leisure, sanitation, macro and micro drainage, access and mobility.	▪ Parks and green areas ▪ Water and sewage macro-system ▪ Recovery of macro-drainage system ▪ Increased urban accessibility and mobility
		Social and economic development: development of participatory and economically entrepreneurial communities, and at the same time to instill in these communities the need to preserve and conserve the natural and built environment in places where they live and, by extension, throughout the city of Recife.	▪ Development of health and environmental education ▪ Support for employment and income ▪ Development of sporting and cultural potential ▪ Fostering urban operations ▪ Popular participation and social control
		Institutional Development: assisting the various departments within the Prefecture of Recife with direct responsibilities in the field of action of this Project to exercise their functions more efficiently and effectively.	▪ Municipal environmental management; ▪ Management, monitoring and evaluation of the project.

RESULTS

Through the confrontation between the project and the actions to eradicate the palafitas, it was possible to get to some results. Talking still about the project "A better Capibaribe" we can distinguish some positive points:

- The attempt to integrate the territory of the river basin with the a area of intervention of the urban planing seems to be an innovative action and a perspective of water resources management integrated in urban areas;

- The withdraw and transposition of the population from the border permit then to access a better conditions of housing;

- The implementation of the project of *integrated sanitation*: integrated actions of water supply, pavement, draining, improvement of sanitary services, intervention, sanitary and environmental education, garbage collection, control of illness and permanent maintenance of the systems.

However, with the relocation of a significant number of families who lived in risk areas, the free spaces have been transformed into ways for automobiles, instead of having its natural characteristics restored. No further action in the direction of ecological requalification of the ecosystem of the fen has been observed.

On the other hand, we have observed:

- The increase of the waterproofing by the rivers banks;

- The lack of elements that could facilitate the identity of the inhabitants with the river.

In the case of the project withdrawing its precarious habitations we have noticed two models of intervention. The first one is the relocation of the population to better places next to the old housings. The second one is about the urbanization of some of these slum areas. In this case, the biggest challenge is to find technical solutions for sanitary supplying, sanitation and garbage collection, adaptable to a flooded area.

The solutions techniques used in the construction of the urban project count on embankments and waterproofing of the ground, without presenting any innovation to reduce the ecological impact. From these observations, we can raise some perspectives for further research. That would be interesting to investigate the vision of the authors of the project on the water system. What reasons determined the choices for these techniques of urban management not very respectful to the environment.

The free space on the fens due to the relocation of these inhabitants could represent an opportunity to construction of a city in which the environment is dealt in a sustainable way. The rivers banks and swamps could be used for prevention of floods, for toxic retention of sediments, substances, for stabilization of the micro-weather, instead of the role as cultural patrimony. (Dunga, 1992, cit. in Coelho 2003) Despite the sensible environmental speech the analyzed projects do not present a regard for the insertion of these potential functions of the urban environment in its projects.

Finally, we can notice that in both projects the main interest seems to be the amplification of the road system of the city. The population of Recife counts on a deficient public transport service, and the use of the individual transport is the cause of continue traffic obstruction. The improvement of the road system is one of the main complaints of the elite. We can conclude that the term of sustainable development in the ecological speech of these projects is used only to legitimize elitist aims and ends out being little eco frinedly.

CONCLUSIONS

This paper underlines the vulgarization of the concept of sustainable development in the urban projects. In the case of Recife, we could observe an apparently strong effort of the municipality to construct a sustainable city. However this is not reflected on the usual techniques practices. As points Yves Guermond, the sustainable urbanism “is not what it believes to be (a new response for new problems), but essentially the resumption, the repetition of unconscious discursive configurations born at the previous century» (Guermond, 2006). Thus, it makes us to think that urban planners and managers lack a more holistic understanding of urban environment. At Recife, the sustainable development is used to legitimize projects that does not represent a deep change on classical employed solutions and that are far to have any real ecological consistency.

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7 Social Learning: A complementary approach to managing water at the catchment scale in Victoria, Australia.

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Abstract
While the Australian landscape is renowned as being old, flat and salty', water underpins the wellbeing of Australian society, its economic development and unique biodiversity. Despite this, legislation, policy tools and market driven strategies intended to protect and enhance Australia's natural water resources have been disjointed, predominantly used in isolation and remain insufficient to catalyze sustainable water management. Inspired by the limitations of commonly used policy tools and its successful use internationally, a social learning approach to managing water at the catchment scale is gaining prominence. Comprehensive evidence exists to suggest that, as a complementary policy tool, large scale individual and institutional change can be achieved through deliberate investment in social learning at the catchment scale. Drawing on the findings to date of a co-operative inquiry undertaken with the Corangamite Catchment Management Authority (CMA), in south-west Victoria (Australia), this paper will examine the conducive and constraining factors for using and facilitating a social learning approach as a complementary management tool for integrated catchment management in Australia. It will also discuss the extent to which, and in what ways enhanced social learning for catchment sustainability contributes to broader policy objectives such as building the social capital that underpins resilient and sustainable communities, and improvements in the conservation status of natural resources.

Key words
Social learning, integrated catchment management, multiple stakeholder processes, water policy, Australia.

BACKGROUND

The Australian landscape holds three million kilometers of rivers and creeks, at least 16 million hectares of nationally important wetlands and more than 1,560 estuaries. While these natural water assets underpin the wellbeing of Australian society, its economic development and unique biodiversity the ancient Australian landscape is in fact old, flat and salty. Currently, Australia is in the midst of a long cycle of water crises. The south eastern State of Victoria, specifically, is in its twelfth year of drought and is projected to become drier, endure more hot days and more storms (DSE 2004). Projections such as these serve to demonstrate that the relationship between Australia's water resources and its people is characterised by risk and uncertainty. As a result, significant community concern is emerging around the sustainability of Australia's water resources.

Blame for the current state of uncertainty surrounding Australia's water resources is being pointed in a number of directions. Those drawing from the pages of Australian history claim that

since European settlement, over two centuries ago, serious mistakes in environmental management have been made while attempting to alleviate concerns over Australia's water supply. As such, they place primary blame on the direct transfer of 'European principles of land and water management to a completely different geographic setting' (Mercer et al 2007). The impact of these 'mistakes' can be seen today as Australia's precious water resources are being placed under increased pressure from growing demands for agriculture, industry and a highly urbanised population with rising expectations about quality of life, the state of the environment, and the maintenance of a robust competitive economy (Pigram 2006). Others label Australia's Federal and State governments' performance in terms of water policy as 'fair to poor' and question whether the allocation of constitutional power between the Commonwealth and State governments is to blame or whether Australian citizens simply remain unconvinced that radical cultural change is required to conserve and manage Australia's water resources (Dumsday 2001).

Traditional policy responses prescribed to manage Australia's water resource dilemmas have included community-government-industry partnerships; community participation in water quality monitoring; integrated catchment management (ICM); environmental communication and education; social marketing; capacity building for individuals and local organizations; and market driven incentives and strategies including the establishment of new institutional arrangements for permanent water trading in many parts of the country. While these strategies have had some impact, they have often been dislocated, used in isolation, and inadequate to ensure sustainable water resources for the driest inhabitable continent on earth (Pigram 2006; Stafford Smith 2003). Several explanations have been offered to account for the limited success of Australia's water management strategies to date. Authors, such as Ison (2005), suggest that one of the most significant barriers to the success of environmental policies is that it is commonplace for environmental policy 'ends' or 'goals' to be pursued with little or no consideration for the process by which the ends are met. In other words they do not take account of new knowledge and the dynamics of social and economic systems or make allowances for the future (Ison 2005). Similarly, Lee (1993) argues that policy systems that seek to produce a particular end result have little relevance to the pursuit of sustainable development. Additional arguments include the failure to include civil society in democratic decision making processes; and the failure of regulatory legislation to inspire environmental citizenship (Dobson & Bell 2006).

The limited success of legislation, policy and programs to establish a culture of commitment to sustainable water management and conservation in Australia supports the notion that it is not viable to aim for 'everlasting' 'optimal' institutional arrangements for sustainable water management. In trying to do so, Australia's institutional arrangements have neglected the dynamic nature of managing Australia's water resources. In other words they have neglected the fact that change is constant in social-ecological systems. For example, human use changes water resource systems; water systems themselves undergo change processes; and human needs and interests in water resources change. While the continuous adaptation of management practices is promoted as the means to ensure the sustainable management of water resources, the question of whether and how this ongoing adaptation can be facilitated must be addressed (Maarleveld & Dangbegnon 1999).

From the dust of these 'mistakes' a new paradigm for water management has risen. At its simplest level, this new paradigm is based around the principles of equity; efficiency; and diverse knowledge integration (Pahl-Wastle et al 2008). It rejects merely boosting supply as the way to address water demands and instead prioritises more effective management of available water resources. Within this new paradigm, reform of water institutions and organisations is high on the agenda of federal and state governments, which brings to light the important role that

effective and adaptive governance plays in managing water resource dilemmas. Emphasis is placed on the integrated management of water resources and the devolution of water resource management to the catchment and regional scale. Additionally, water policy is scrutinised in daily media coverage and debated openly by concerned citizens (Pigram 2006, Pahl-Wastle et al 2008). Within this emerging paradigm, there is a strong case for enhancing social learning as a means for 'analyzing' and 'catalyzing' collective decision making in the management of Australia's water resources. This, Ison (2005) suggests, can be complementary to existing policy instruments by introducing in the policy some aspects related to the decision-making process itself rather than the end result.

The social learning approach to sustainable water management at the catchment scale

The concept of social learning is not new. Woodhill (1999) has described the way in which social learning was proposed by Dunn as the new paradigm for the social sciences in 1971; motivated by a concern for improved practice in economic and social development. Since then, general definitions of social learning describe it as a key cognitive process responsible for the acquisition of new knowledge by people being exposed to each other in a common environment. Conte and Paolucci (2001) suggest that many complex social phenomena lead to social learning; yet, imitation and social facilitation are highlighted as the most important. Today, however, social learning is increasingly viewed as another way of conducting public business 'alongside regulation, compensation, stimulations and the operations of the (free) market' (Ison 2005). Social learning has also been promoted in recent years as essential for the management of 'complex' natural resource problems and a key process of adaptive management (Ison 2005). However, when social learning is applied to or considered in the context of natural resource management (NRM), definitions such as the one above prove lacking.

In the context of 'good' NRM, Ison (2005) neatly describes social learning as 'the process of collective action and reflection among different actors directed toward improving the management of human and environmental interrelations'. In this context, social learning does not happen by accident; rather, it requires conscious design and facilitation. Accordingly, Woodhill (1999) proposes that social learning has two main concerns; 1) the ways in which different people or groups engage with each other to understand, contest, and influence the direction of social change; and 2) how society understands itself and its relation to the world around it. Social learning processes, therefore, allow societies to adapt their traditions, assumptions, beliefs, systems of social organization and approaches to problem solving in order to deal with external threats or achieve particular objectives (Woodhill 1999; Woodhill 2004; Bouwen & Thaillieu 2004; Maarleveld & Dangbegnon 1999; Ison 2005).

In 2001, the European Commission funded a multi-country project that aimed to investigate the socio-economic aspects of the sustainable use of water. The project title was SLIM, which stands for 'Social Learning for the Integrated Management of Water at the Catchment Scale'. The main focus of the SLIM research lay in understanding the application of social learning as a 'conceptual framework', an 'operational principle', a 'policy instrument' and a 'process of systemic change' (SLIM 2004; Ison et al 2004). The project ran in parallel with the implementation of the European Water Framework Directive (WFD) by all European Union member states (Ison 2005 in Keen et al 2005). The WFD, published in 2000, is a legally binding document that requires all member states to implement water management strategies that will achieve good overall water quality for European water bodies within fifteen years (Steyaert & Ollivier 2007). The WFD has significant implications for social learning especially given the mandatory nature of public participation and demands for transparency in decision making (Ison 2005), which necessitates what Williams (2001 in Ison 2005) describes as 'a joined up strategy'

to bring all affected stakeholders together. The twelve SLIM case studies were undertaken by thirty researchers from six countries in four European countries, namely France, Italy, the Netherlands and the UK. SLIM researchers studied social learning or determined the factors that enhanced or constrained the social learning process as a 'purposeful policy and praxis option' (Ison 2004, Ison 2005 in Keen et al 2005). Evidence from the analysis of these case studies indicates that deliberate investment in social learning, or 'multi-stakeholder learning partnerships' at the catchment scale achieves the necessary change in individual and institutional behavior at the large scale. This, Ison (2005) suggests, occurs due to the fact that the social learning approach 'provides a context for a dynamic decentralized process, and, in the case of large watersheds, for concerted parallel processes'. As such, SLIM researchers propose that social learning processes should be seen as complementary governance mechanisms (Ison 2005).

The SLIM research was undertaken in part as a process of co-learning between researchers and case-study partners and action research. The SLIM project sought to understand and reflect on the role that social learning processes played in the transformation of situations towards concerted action for sustainable water management at the catchment scale. While the study focused on one particular approach to social learning, namely the 'co-construction by interdependent stakeholders of a resource management issue and of ways to resolve or improve it' (SLIM Introduction 2004), the study illustrated the variety of ways in which an inquiry based around social learning as a complementary catchment management tool can be designed and undertaken.

The SLIM researchers engaged three methodological positions in their case studies. The first entailed 'researcher as observer', which is considered traditional case study research in the sense that it provides the researcher with the opportunity to reflect, understand and consequently learn. The second concerned 'researcher as facilitator' through the use of tools, skills, data and the involved others learning. The third methodological position involved systemic action research through co-research and revolved around 'co-constructing knowledge-in-action with stakeholders in a joint process with shared responsibility' (SLIM Introduction 2004). The SLIM researchers engaged a combination of these methodologies in each of the twelve case studies.

The final product of the SLIM project was a conceptual framework for 'organizing, analysis and action in situations of complexity, connectedness, controversy, multiple perspectives and uncertainty, such as water catchments' (Ison 2005). The framework was developed by SLIM researchers so that others can understand and promote the use of social learning for integrated catchment management and more broadly for addressing 'complex' natural resources issues (Ison 2005; SLIM Framework 2004).

Applying the social learning approach for sustainable catchment management to Australia

Today, key social learning thinkers in Australia suggest that the case for enhancing social learning in catchment management is built around the need for equitable learning partnerships between the combined expertise of communities, professions and governments; learning platforms that enable interdependent individuals and groups concerned with common environmental issues to meet and interact in forums to resolve conflicts, learn collaboratively and take collective decisions towards concerted action (Roling 2002 in Keen et al 2005); and a recognition that social change requires a transformation in our thinking and in the learning values that underpin learning processes (Keen et al 2005). Keen, Brown and Dyball (2005) highlight five key components of the social learning approach, which they describe as the 'braided strands'

of social learning; these are: reflection, systems orientation, integration, negotiation, and participation.

The social learning approach to managing water at the catchment scale is particularly applicable to Victoria's commitment to integrated catchment management (ICM), which theoretically underpins the Victorian State Government's approach to managing Victoria's water resources. Table 1, below, summarizes the six principles that govern the way catchment management is implemented by Victoria's ten Catchment Management Authority.

Table 1: Summary of the Victorian Catchment Management Structure.

1. Sustainable Development Victoria's whole of catchment approach to natural resource management seeks to deliver social, economic and environmental outcomes for the community and reduce our ecological footprint.
2. Community Empowerment Catchment management is a partnership between community and Government. Planning and implementation of natural resource management programs should maximize opportunities for community engagement.
3. Integrated Management Management of natural resources should recognize the linkages between land and water and that the management of one component can impact on the other.
4. Targeted Investment Government and community need to ensure that resources are targeted to address priorities and deliver maximum on-ground benefits.
5. Accountability Those making decisions on natural resource management should be clearly accountable to Government and the community, both in a financial sense and for biophysical outcomes.
6. Administrative Efficiency To maximize on-ground results catchment management structures should facilitate more efficient procedures and practices.

Source: DSE 2004.

In 2004 the Victorian Government, through the Department of Sustainability and Environment (DSE) released a White Paper titled 'Securing Our Water Future Together'. In an effort to ensure the future of Victoria's water assets, the White Paper set out a fifty-year strategy for the integrated management of Victoria's water resources. A number of 'Sustainable Outcomes' were identified within the strategy. This study is being undertaken to particularly contribute to two community-related outcomes identified within the strategy, namely:

- "Communities that truly appreciate all the services that water provides, that are able to make considered choices about how those services are delivered; and
- Communities that have a stronger ethic of water conservation".
  (DSE 2004)

While these community-related outcomes represent the 'human dimension' of water management (Pahl-Wostle & Hare 2004), their achievement depends on a number of factors that entail social learning for sustainable catchment management. Some of these include development of knowledge and understanding of water management issues; positive experiences that clarify and promote a water sustainability ethic, ethical discernment to integrate personal wishes and

community needs in judgments about water issues, and commitment and skill to act, both individually and as part of a wider community (Lee 1993, Fien & Skoien 2002, Woodhill 2004, Keen, Brown and Dyball 2005).

METHODS

At its most basic level, this study is being undertaken to determine whether a social learning approach can help achieve these outcomes as a complementary management tool for catchment management in Victoria. In doing so, the study aims to contribute to the Victorian state government's agenda of ensuring sustainable water resources; and the broader agenda of social learning for sustainable catchment management by producing:

- Practical guidelines for ensuring that social learning complements other policy instruments and is integrated into a comprehensive approach to managing catchments sustainably; and
- Practical guidelines for developing the organizational frameworks and training programs needed to ensure that local communities are effective participants in planning and decision making for sustainable catchment management.

The study is also seeking to identify the ways in which social learning can complement other policy instruments to encourage an integrated approach to managing water sustainably. It is analyzing the strategies for, and the drivers and barriers to, facilitating the kinds of social learning that can develop the understanding, commitment, ethical discernment and purposeful individual and collective action needed for successful public appreciation of the importance of water issues and catchment management needs. Additionally, it is evaluating the extent to which, and in what ways, enhanced social learning for catchment sustainability contributes to broader policy objectives such as building the social capital that underpins resilient and sustainable communities, and improvements in the conservation status of natural resources.

The Pennyroyal and Deans March Creeks restoration project has been selected as an ideal case study to investigate social learning as a complementary approach to water management at the catchment scale in Victoria. The Pennyroyal Creek and its major tributary, Deans Marsh Creek, are situated within the Corangamite catchment in south west Victoria. The catchment region covers an area of 13,340 km^2 and is populated by 330,000 people living within regional cities, coastal and inland towns, and rural farming districts. Important water assets of the region include the estuaries of the Great Ocean Road, which are considered some of the most diverse in Australia. (DSE 2005). The Pennyroyal Creek is considered the most connected Creek to the Barwon River, which flows into the Lake Connewarre estuary system, a wetland of international significance listed under the Ramsar International Convention. The lower reaches of the Pennyroyal and Deans Marsh Creeks have been channelized and are incised. The Creeks are affected by bank erosion as a result of bed incision and other factors such as riparian vegetation loss, willow infestation[46], uncontrolled live stock damage, and fluctuating water quality. The restoration project is being managed by the Corangamite Catchment Management Authority (CCMA) and is being undertaken in partnership with the Upper Barwon Landcare Network, the local Water Authority Barwon Water, and local landholders.

This study is being undertaken using qualitative research techniques. As an interpretive study, a phenomenological approach is being used to understand and explore the experience of social learning amongst stakeholders of the Pennyroyal and Deans Marsh Creeks restoration project. It

[46] Willows are listed in Australia as a 'weed of national significance'.

seeks to uncover a deeper meaning of the phenomenon of social learning. This study does not rely on measurable variables, but adopts a more open-ended approach, allowing 'truth' to emerge through use of in-depth interviews and the analysis of personal experiences through narrative.

The method underpinning this research is known as 'enthusiasm'. The 'enthusiasm' method is an approach to case study research and involves listening to people, especially to their stories of the past and present, and provides them with the opportunity to voice their hopes and wishes for the future. As such, it involves creating opportunities for dialogue from which learning and personal, social and/or environmental change may result. Whilst relatively uncommon, the enthusiasm method has been successfully used and championed by researchers such as Ray Ison; for example during participative rural development projects in New South Wales (Ison & Russell 2000).

The 'enthusiasm' method is underpinned by the biological and theoretical understanding of the enthusiasm 'drive' itself. The key to using enthusiasm as a research method is that the researcher does not re-direct a participant's energy – rather it is the researcher's initial task to discover where a participant's energy lies. Ison suggests that this can be done by asking the 'right' sorts of questions. Some of these questions could include 'what do you want to do…?' or 'why are you involved with…?' or 'what is it you get out of this activity that you find satisfying?'. Ison recommends that engaging participants with this sort of conversation requires respect for the individuality of participants and acceptance that whatever they are going to say is valid. This, he suggests, is based on the notion that it is the god within a person that has to be respected. In giving the participants the opportunity to be actively listened to they will have the opportunity to tell the story of where their energy comes from, how they see it expressing itself and what they consider as obstacles to the manifestation of their energy. Underpinning all this is the ethical implication that research participants' have 'control of the process (Ison & Russell 2000).

The following features foster the use of enthusiasm as a research method:

- Active listening and cultivation of stories;
- Space for facilitated participation;
- Avoidance of imposed practices that enforce consensus;
- Collective responsibility, transparency, and rituals which create a sense of common purpose.

A case study is being used to inform this inquiry as it gives the researcher great opportunity for insight, analysis and interpretation (Merriem 1988). Three key research techniques are being used to collect rich, meaningful data in the case study. In-depth, unstructured interviews with open ended questions are being undertaken with approximately thirty stakeholders of the Pennyroyal and Deans Marsh Creek restoration project. These interviews allow the research participants to explore and explain their experience with the social learning process; and give the researcher the opportunity to understand the interviewees' experiences with the phenomenon of social learning and the phenomenon itself. Facilitation of the learning process in workshop settings engages research participants with opportunities for social learning. Observation of the social learning process allows the allows the researcher to reflect upon and make sense of the process of social learning through first hand experience and allows the researcher to judge whether a social learning approach is an effective complementary management tool for catchment management. Relatively informal data gathering techniques are also being used. For example, casual conversations and incidental observations also provide a rich source of information to validate or provide a different perspective from interview responses and set the context of the study. Data

collected in this way is building a picture of the role that social learning plays in contributing to the restoration of the Pennyroyal and Deans Marsh Creek.

The case study is being undertaken in six clear stages. Table 2 below outlines the events of each stage, the data collection and analysis techniques and how the data is being validated.

Table 2: Case study stages

Stage	What happens	Data Collection /Data Analysis	Validity/Ethics
1	Engage the CCMA to establish an 'invitation' to conduct the study in their region. Establish a relationship of mutual interest/benefit; to prevent the feeling of being invaded or exploited by the researcher; and to prevent power imbalances.	Participant observation (becoming an insider)	
2	Conduct a systems analysis and construct a systems map of the Corangamite catchment region to identify the major water stakeholders; projects being undertaken; and perceived problems in the catchment region.	Interviews Systems Analysis	Face validity Triangulation
3	Conduct an historical analysis of the CCMAs' practices to determine whether social learning is being used to engage stakeholders in decision making processes for water management, i.e. do they already use social learning without knowing it?	Document analysis Interviews	Face validity Triangulation
4	Identify social learning already occurring in the Pennyroyal and Deans Marsh Creeks restoration project.: • What sort of social learning is occurring? • Who is facilitating? • Who is learning? • What impact is social learning having, i.e. changes in social capital, ecological capital, or learning processes?	Document and data analysis Interviews Facilitation of learning process Participant observation In-depth unstructured interviews	Face validity Triangulation
5	Identify co-researchers within the CCMA; test the SLIM framework to analyse social learning processes in the Pennyroyal and Deans March Creeks Restoration Project.	Participant observation	
6	Develop a locally-contextual social learning model for catchment management in Victoria.	Thematic analysis	Face validity

CONCLUSION

There is increasing concern associated with water security in Australia. While Australian Federal and State government's have implemented several new strategies that address water management, using market driven, regulatory, educational and incentive based approaches, none have adequately provided for true participatory and integrative approaches. The need to fill this

gap and implement true participatory and integrative approaches to managing water sustainably is becoming ever more important as the social face of water management gains prominence. The SLIM research undertaken in Europe has demonstrated that a social learning approach can be an effective complementary tool for water management at the catchment scale. Preliminary findings from this research, based around a creek restoration project in south west Victoria, indicate that, as in Europe, a social learning approach can provide stakeholders with an opportunity to become truly involved in the decision-making process. Further, this research indicates that the effectiveness of this approach is reliant on effective facilitation of the learning opportunities and institutional arrangements designed to provide an integrative and adaptive environment.

It is anticipated that this study will be completed in March 2009. The outcomes from this research will include practical guidelines for ensuring that social learning complements other policy instruments and is integrated into a comprehensive approach to managing catchments sustainably; and practical guidelines for developing the organizational frameworks and training programs needed to ensure that local communities are effective participants in planning and decision making for sustainable catchment management.

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8 Economic and environmental foresight as a tool for integrated coastal zone management

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Abstract
The PhD "economic and environmental foresight as a tool for integrated coastal zone management" started very recently in December 2007. It aims at building a methodological framework for economic analysis as a tool for integrated coastal zone management processes. It relies on economic and environmental foresight methodologies. The later might be defined as a mean to analyze the scientific knowledge for the benefit of the society, with the aim to foreseen the various possible futures. The Seine estuary will be used as study case and the following environmental issues will be studied in order to illustrate the potential of our methodology : heavy metals, eutrophication and climate changes. The first step will consist in a characterization of the study zone in economic and environmental terms. Regional economic accounting methodologies – NAMEA, green input-output tables – as well as the construction of sustainable development indicators will be the methodologies used to carry out this task. The second part of the work relates to modeling, i.e. parametrising as fine as possible relationships between economic components of the system and their impacts on the environment. The third step is about foresight strictly speaking, which means simulating management scenarios. Each scenario will be assessed in terms of environmental goals, implementation costs, related benefits, and distribution of benefits and costs among stakeholders.

Keywords
Input-output matrix; NAMEA; satellite accounts; green accounting; sustainability indicators; coastal zones, integrated management, ICZM, deliberation tool, scenarios, Le Havre, Seine watershed, France.

INTRODUCTION

The PhD started very recently in December 2007 and is going to end in December 2010. It is supported by C3ED-UVSQ, in partnership with CEESE - ULB, Département d'Economie Maritime from IFREMER and Centre de Droit et d'Economie de la Mer from Université de Bretagne Occidentale. Their aim is to develop economic evaluation tools for ecological economic foresight as a support to Seine estuary management.

The choice of this PhD topic originates from the massive production of scientific knowledge funded by the research program Seine-Aval in Northern France. However this knowledge suffers a lack of integration with local and regional economic issues. This is the reason why our work will be highly transversal by gathering knowledge from various scientific disciplines and promoting integrated coastal zone management (ICZM) by integrating modeling and scientific knowledge into governance processes.

Problems of natural resources overexploitation and degradation, negative externalities leading to economic losses and social conflicts, and *in fine*, sustainability issues, partly originate from the intensification of human use of natural coastal resources. ICZM, as a governance process in the framework of sustainable development, aims at integrating in decisional processes all the stakeholders in order to plan and implement preservation and development measures of coastal systems and resources.

Scientists are needed in ICZM processes in order to bring their knowledge in environmental and economic evaluation as well as propositions for decision support. A multidisciplinary transversal and integrated approach, would allow answers to be found for complex questions relating to social and environmental issues. Indeed, each discipline alone would not be able to answer such kind of issues. In that context, this PhD starts from ecological economic foresight with the aim to build a methodological framework for economic analysis in support to ICZM processes. Foresight might be defined as a mean to structure and analyze scientific knowledge in order to help society to foreseen different possible futures. It starts from present and past observations and use modeling tools. To achieve that, relationships between human activities and their environmental impacts will be schemed as a system. This system will be the basis for the analysis of complex relations between land and resources uses, environmental dynamics and governance processes. One of the goals of foresight methods is to influence future dynamics of socio-ecological systems in order to drive them towards sustainable development schemes.

The Seine estuary has been selected as study site because of the high interactions between human and nature existing in its interface land/sea that has been highly modified from its initial morphology. This estuarine ecosystem is rich in terms of environmental functions (hydrodynamic and sediment control in the Seine watershed, high faunal and floral biodiversity, specific fish habitats, etc.) and economic functions (tourist and marina activities, natural resources exploitation, industrial and harbor activities, etc.). The intensification of human uses due to demographic increase in the Seine watershed, heavy polluting industry development, increase in agricultural pollution from intensive cropping and breeding and morphological modifications resulting from harbor development in Rouen and Le Havre, are the main causes to environmental degradation of the studied area. The impacts of this list of human activities on the Seine estuary are eutrophication processes during summer, increases in chemical and microbiological contaminations, etc., and finally, quantitative and qualitative decreases in natural areas as well as their ecological functions.

The environmental issues to be studied are the followings: heavy metals will be the main issues selected to illustrate the potential of our methodology. Climate changes will be an additional issue to be quantified, and eutrophication will be considered first in a qualitative way, and secondly in a quantitative way if time constrains allows it. Contacts should be done with scientists from Sisyphe at the Paris-Jussieu university who have written on those three topics (Thévenot, Meybeck, Garnier, Billen, Ducharne, etc.).[47]

[47] Meybeck et al. (2007), Thévenot et al., (2007), Ducharne et al. (2007), Garnier et al. (2007), Billen et al. (2007), etc.

MATERIEL & METHODS

The foresight analysis will be based on three pillars. They are described below.

Ecological and economic characterization of the studied area

The economic and ecological characterization of the studied coastal area, will be carried out with "regional green economic accounting" and sustainable development indicators. The work will consist in the economic system description via national accounting derivate methods. We selected the NAMEA (National Accounts Matrix including Environmental Accounts) as the central method, which is an accounting frame expressed in physical and monetary unit allowing environmental accounts to be linked to input-output matrices (table 1) and to be broken down for each economic sector. The basic principle of NAMEA is to expand the conventional national accounting system used to compute GDP, economic growth and other traditional economic aggregates, by directly adding environmental data. That kind of green accounting enables *DPSIR* (causality chain of Driving forces-Pressure-State-Impact-Response) environmental pressure indicators to be built and to be integrated to economic data. NAMEA and classical input-output techniques allows us to go backward until the origin of pressures, i.e. to economic sectors responsible of pollutant emissions, as well as to the final demand category responsible for direct and indirect pollution due to its consumption behaviors.

The goal of this first pillar is to extrapolate national accounting methodologies toward a local framework allowing the characterization of economic systems on smaller geographical scales and the adaptation to ICZM processes. The approach leads to find answers to questions such as the relevance of analysis scales and aggregation levels of the variables analyzed.

TABLE 1: Example of a classical NAMEA table (CBS, 2006). Cells shaded in green are environmental accounts expressed ni physical units. White cells are conventional economic accounts in monetary units.

ACCOUNT (classification)	Goods and services (product-groups)	Consumption of households (purposes)	Production (industry)	Generation of income (value added categories)	Distribution of income and consumption (sectors)	Capital	Taxes (types)	Rest of the world, current	Rest of the world, capital	Subsidences	Environmental themes	TOTAL
Goods and services (product groups)		Consumption of households	Intermediate consumption		Consumption of government	Gross capital formation		Exports (fob)				Use at purchasers' prices
Consumption of households					Consumption of households					Emission of pollutants by consumers		Consumption of households
Production	Output at basic prices						VAT not handed over to the government	Compensation of employees from r.o.w		Emission of pollutants by producers		Output at basic prices
Generation of income (value added categories)			Net national value added	Net national generated income	Property income and current transfers		Taxes less subsidies	Property income and current transfers from r.o.w				Origin of generated income
Distribution of income and consumption				Consumption of fixed capital	Net national savings				Capital transfers from r.o.w	Other changes in volume of pollutants and changes in natural resources		Current receipts
Capital						Natural net lending (+) / net borrowing (-)						Capital receipts
Financial balance					Current taxes on income and wealth			Current taxes on income and wealth from r.o.w				Tax payments (less subsidies)
Taxes (types)	Taxes less subsidies on products		Other taxes less subsidies on production		Property income and current transfers to r.o.w		Current taxes on income and wealth to r.o.w		Subsidy of the nation on current operations	Cross border pollution flows r.o.w		Current payments to the rest of the world
Rest of the world, current	Imports (cif)			Compensation of employees to r.o.w		Capital transfers to r.o.w		Current receipts from the rest of the world	Capital receipts from the rest of the world			Capital payments to the rest of the world
Rest of the world, capital												Destination of subsidences
Subsidences			Abatement by producers			Environmental investments					Contribution to environmental themes	
Environmental themes							Tax receipts (less subsidies)	Current receipts from the rest of the world		Origin of subsidences	Theme equivalents	Theme equivalents
TOTAL	Supply at purchasers' prices	Consumption of households	Input at basic prices	Distribution of generated income	Current expenditures	Capital expenditures						

Formulation and parametrization of relationships between economic and environmental systems

Based on preceding descriptions of economic and environmental systems in the first pillar, the second pillar of the PhD will consist in formulation and parametrization as fine as possible of relationships between economic components of the system as well as their environmental impacts. The approach enables any system modification and its subsequent impact on economic activities and the environment to be modeled and analyzed.

These relationships will be modeled via input-output (I-O) methodologies (table 2 shows an example of an I-O matrix). Such methodologies, in a first stage, enable a table to be built, showing the exchanges of inputs between the various economic sectors, as well as the final output produced by each sector for final consumption by households and other final demand categories. Such tables enable to determine the amount of goods and services required from sector *j* in order to produce the final output of sector *i*. This leads to the calculation of the so-called technical input coefficient. The NAMEA is an example of an environmental application of I-O table (table 1). Such tables, also called "green I-O matrix", enable the impact of environmental policy scenarios to be modeled. They contribute to characterize the pollutant flows transferred from an economic sector to another or to final consumption as well as to determine :

- the impact of environmental policies on the total level of pollutants rejected in waters by each sector,
- the total amount of pollution due to final demand from households,
- the direct and indirect impact of environmental policies on the economic production level,
- the direct and indirect impact of environmental policies on employment as well as on good and services' prices.

In the framework of this PhD, ecological economic systems modeling aims at its integration in ICZM processes, which includes interactions between the local level, supported by co-construction approaches and social participation, and the global level with other economic, environmental and governance systems.

Figure 1 below shows our global approach. It shows that the environmental impact on economy is assessed by the difference between green scenario PIB and *business as usual* scenario PIB (estimated by Input-output calculations). The economic impact on environment which cannot be monetarily assessed is estimated through indicators in physical units.

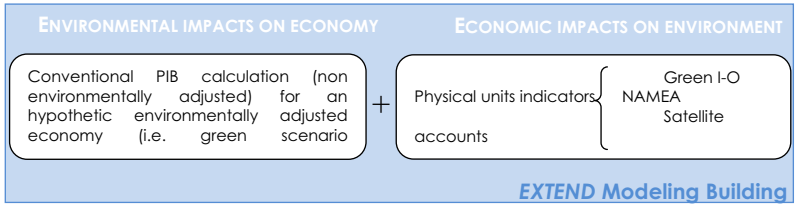
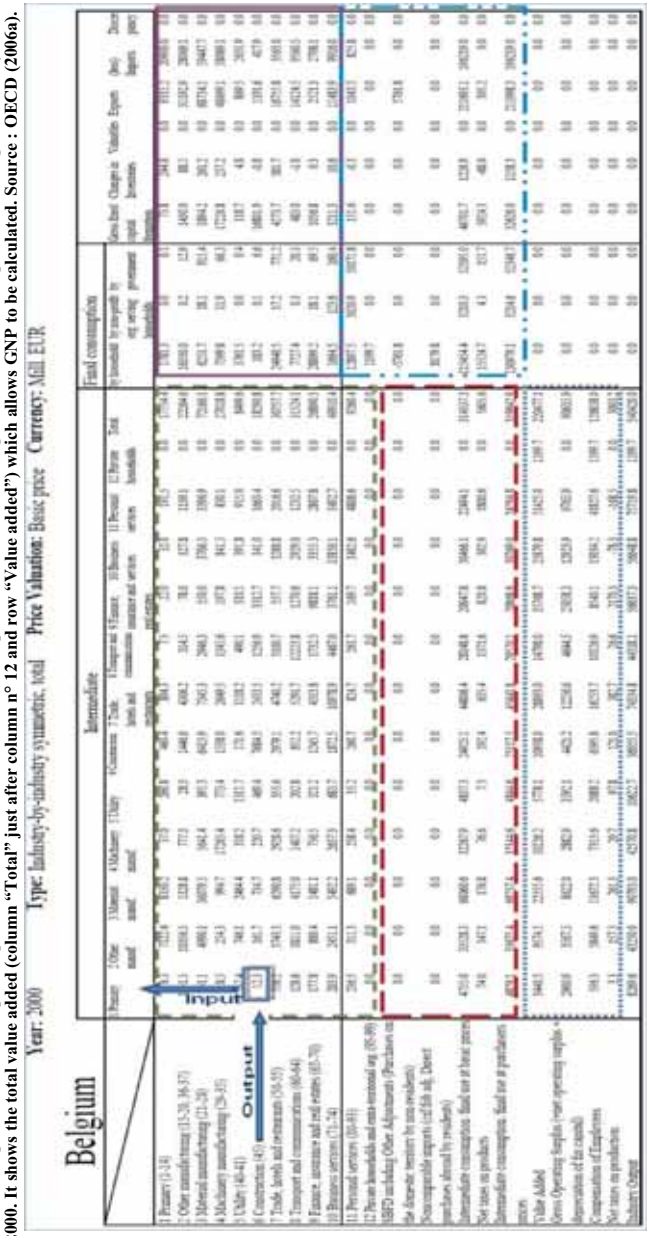


Figure 1. Global description of our methodology. The green input-output method for PIB calculation under environmental measures (inside green scenarios) is completed by physical unit indicators.

TABLE 2: Example of a classical Input-output matrix. I-O matrices are the central part of NAMEA tables (figure 2). This matrix represent the Belgian economy in the year 2000. It shows the total value added (column "Total" just after column n° 12 and row "Value added") which allows GNP to be calculated. Source : OECD (2006a).



Key (OECD, 2006):

= **First quadrant :** Domestic intermediate demand matrix that provides data on the interactions between domestic suppliers and domestic users of domestically produced raw materials, industrial components and services. It is a square matrix of an equal number of supplying and user industries.

= **Second quadrant :** rows showing the adjustments required to derive *total* intermediate inputs used in production *at purchaser's prices*. These include imports of intermediate goods and services; any taxes less subsidies (net taxes) on intermediate products; and any VAT and import duties paid on intermediate products.

= **Third quadrant :** rows that make up added value (at basic prices) such as wages and salaries and gross operating surplus.

= **Fourth quadrant :** supplies of goods that are not consumed by domestic industries. The columns therefore include such categories as final consumption (both by households and general government), gross fixed capital formation (investment) and exports.

= **Fifth quadrant** imported goods for final use, and the required taxes less subsidies associated with transactions in these products (and those shown in quadrant 4) can be added to quadrant 4 to provide total final use *at purchaser's prices* (quadrant 5).

(1-14) = Industry classification according to OECD I-O Database.

Figure 2 shows the systemic architecture of our model and the place where the Input-output table is embedded inside the DPSIR causality chain. The dashed arrows show where the quantification of links in the causality chain might suffer a lack of robustness due to the non-deterministic relation between the economy and the environment, namely the link between *Pressures* (e.g. pollutant emissions) and *State* (e.g. concentration of pollutants in the environment). This is why we might focus our work on links between *Driving forces* (good and services production such as metallic goods production) and *Pressures*, as well as between *Response* (environmental measures enabling environmental services to be improved) and *Impacts* on the economy. Links between *Pressures* and *State* will be investigated and quantified but we may encounter some difficulties and lack of robustness.

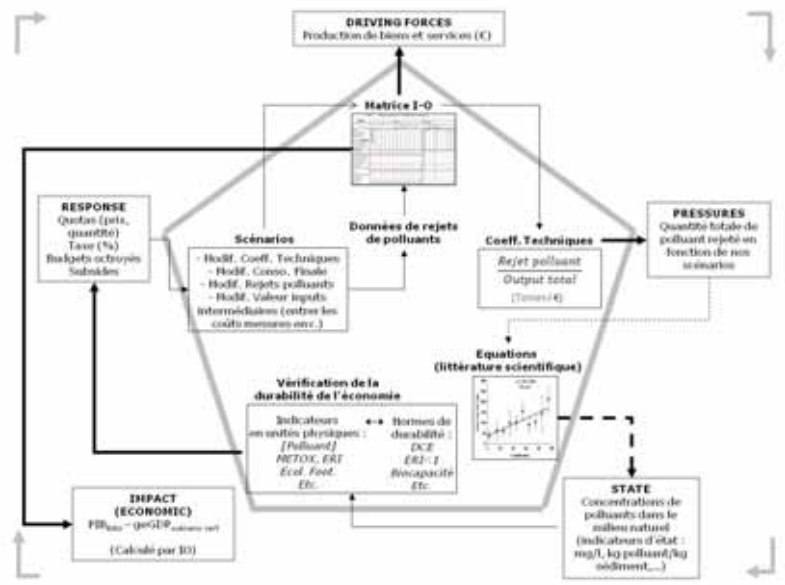


Figure 2. Systemic analytical architecture of our model, showing the place of the Input-output matrix inside the *DPSIR* causality chain analysis.

Simulation of environmental management scenarios

The third pillar of the PhD relates directly to the foresight approach and is based on environmental management scenarios simulation methods. The aim is to explore the various plausible futures based on the model constructed in the second pillar and on the system dynamic studied in first and second pillars as well as on the existing management possibilities in the studied area. The economic analysis will allow each management scenario to be assessed in terms of environmental goals effectiveness, implementation coast of measures, and subsequent benefits. The distribution

of benefits and costs between stakeholders groups (or sectors) will be studied as well. This approach is elaborated with the aim to integrate the existing knowledge inside dialogue and decision processes relating to environmental policies or management of resource exploitation. Taking into account governance is required to construct relevant methodology and tools and guarantee their legitimacy.

The PhD will also explore territorial governance modes in the Seine estuary, which take place in a sharp economic competition context between demographic and economic centers from Rouen and Le Havre. Both highly depend on environmental conditions in the watershed (harbor development, cropping, tourism, etc.). They enter also in interaction with worldwide sectors such as maritime transportation. The governance modes will highlight sustainability conditions of land management in the estuary according to common goals shared by all the stakeholders.

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9 Integrating multidisciplinary information for urban flood control through proper management of wetlands: A Case Study of Kolonnawa Marshlands (Sri Lanka)

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Abstract: This paper presents a preliminary study done on a selected segment of the Colombo Wetland System (Sri Lanka) to develop a method of integrating essential information on the wetlands multipurpose use in flood control activities. This is done as part of a larger research project on the "Sustainable Use of Water Services Offered by the Colombo Wetlands" at the department of Chemical & Process Engineering, University of Moratuwa Sri Lanka, under funding from International Foundation of Science.

Keywords; Urban Floods, Wetland Rapid Assessment, Integrated Information,

INTRODUCTION

Urban Floods are becoming more and more commonplace around the world at present due to many reasons. In most cases urban floods are invariably bound with degradation of natural eco-systems – especially wetlands. Degradation of natural resources in urban settings is more intense in Developing Countries due to reasons such as ineffective Environmental Governance, poor Environmental Awareness among stakeholder communities, poor Environmental Monitoring, Un-participatory nature of Environmental Decision-making etc. All the above drawbacks are associated in one way or the other with lack information, weaknesses in the flow of information to stake holders or decision-making based on incomplete or false information. But it has been observed in many countries that lot of environmental data is available in scattered sources which could be used for effective decision making and awareness building (Martha et al, 2006). Therefore in a developing country context integration of the available information in a simple and presentable manner for multipurpose use is very important.
Colombo (Commercial Capital of Sri Lanka) has a vast necklace of natural wetlands along its western boundary. These wetlands are unique eco-systems which offer a range of water and environmental services to the City and Suburbs. Due to the rapid urbanization trend of the past 15-25 years Colombo is fast loosing this precious natural resource. About 30% of the extent had been encroached or degraded (Wetland Site Report, 1994). During the past 15 years the Greater Colombo area suffered from a series of major and medium urban flood situations. There is enough evidence to directly attribute these events to degradation of urban wetlands.

Study Area

The study area selected for the proposed preliminary research was a 214.5 ha segment of the main wetland system commonly known as the Kollonawa Marsh. The study site is located between Lat. 6^0 52' 55''- 6^0 52' 45'' and Longt. 79^0 52' 35''- 79^0 55' 15''. This wetland is a riverine marsh associated with the stream the "Kolonnawa Ela". It has a local basin of 10 km^2. (Wetland Site Report, 1994). For the ease of study the area was divided into two zones, Fringe Area (area within 200m from the boundary of the marsh) and Upper Basin (area beyond the fringe)

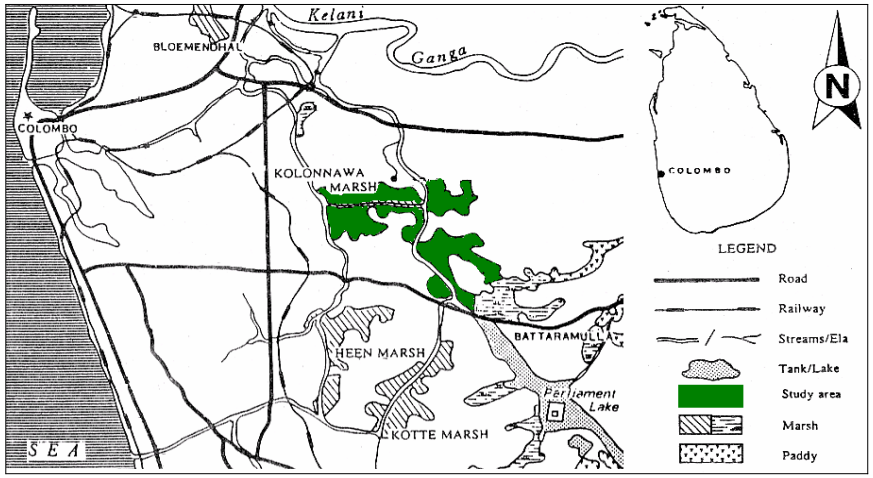

Figure 01: Map of the study area

MATERIAL AND METHODS

Literature Survey

Initial part of the research was mainly carried out in the form of literature survey where available information on Kolonnawa Marsh at different sources was gathered. Information of wetland assessment methods used in other counties were also reviewed during this stage.

Desktop studies and site survey on the condition of wetlands

Regular site survey and desktop studies were done on following aspects of the wetland

1. Monthly variation of water quality at different stations for following parameters: BOD, pH, TDS, Temperature, DO, Nitrates, Phosphates, Fecal Coliform Count and Turbidity
2. Study of the percentage cover of different vegetation in a set of selected plots in the marsh
3. Study of diversity and abundance of fish and bird species a set of selected plots in the marsh

4. Study of wetland extent variation with Arial Photographs of 1982, 1994, 1999 and 2000 using GIS.
5. Social Survey: Around 150 people from stakeholder communities in the “Fringe Area” and government organizations involved in wetland management or disaster mitigation were interviewed using structured questioners

RESULTS AND DISCUSSION

Table 01, 02 and 03 summaries the available sources of wetland-related information and ongoing regular data collection programs of the study area. Table 04 provides an overview of the prevailing quality of each type of information.

Overview of the Available Information

TABLE 01: Existing maps and images of the area

Map / Image	Prepared by	Basic Information Provided	Importance in flood control	Public Accessibility	Drawbacks / Gaps
1:50,000 topographical map of Colombo	Survey Department	Land-use, Transport, Hydro, Contours	For overall view of the larger basin	Easy	Scale two large Some features are missing last revision ….
1:2000 topographical map of Colombo	Survey Department	Land-use, Transport, Hydro, Contours, Buildings, Spot Levels	Very useful in identifying inundation areas, wetland boundary demarcation	Difficult	Not field verified Last revision in 2001
1:50,000 Geological Map	GSMB	Rock types, Geological structures	No direct use	Easy	
1:10,000 map of South Colombo Flood Control System	Irrigation Department	Layout of Canals, positions of head works	Obtaining the positions and sizes of major head works	Very Difficult	Map was last updated in 1964

TABLE 02: Previous reports and documents with flood and wetland related information on the study area

Document Name	Prepared by	Basic Information Provided	Importance in flood control	Public Accessibility	Drawbacks / Gaps
Colombo Flood Protection Scheme Report, **1937**	Irrigation Department	Details of Flood Protection Headworks	Overall view of existing flood protection scheme	Very Difficult	Outdated information
Hydrology – Reclamation of Swamps in Colombo, 1966	Irrigation Department	Detailed Hydrology of the area	Advanced hydrological analysis	Very Difficult	Outdated information
Wetland Site Report : CFDA Wetlands, 1994	CEA	Climatic, Geological, Ecological and Social Data	Overall view of the study area	Easy	Not readily usable in analysis
Environmental Status Report of Sri Lanka	MOFE	Environmental Information	Ecological condition assessment	Easy	Not readily usable in analysis
Greater Colombo Canal Drainage System Rehabilitation Project; Review Report, 1992	NWS&DB	Hydrological aspects of the Wetlands and Canals	Advanced hydraulic & hydrological analysis	Very Difficult	
Environ Management Strategy for Colombo Area, 1983	UDA	Govt. Policy and Development plans Proposed Management Plan	Soft measures affecting the floods	Very Difficult	Not site specific

NWS&DB: National Water Supply & Drainage Board, **UDA:** Urban Development Authority, **GSMB:** Geological Survey and Mines Bureau; **CEA:** Central Environmental Authority, **MOFE:** Ministry of Forestry and Environment

TABLE 03: Regular data collection and testing carried out in the area (on Wetlands or Floods)

Type of Data	Collected by	Parameters	Frequency and (Period of data collection)	Public Access	Drawbacks / Gaps
Water Quality	SLLRDC	BOD, EC, pH, TDS, Fecal Coli., NO_3, PO_4	Monthly (2-3 Years)	Very Difficult	Monitoring is not regular Inadequate spatial and temporal coverage
Ecological	None	N/A	N/A	N/A	N/A
Socio Economic	Divisional Secretariat Office	Income Employment	Annual (> 35 years)	Difficult	Record keeping is poor
	Dept. of Census and Stat.	Demographic Data	Every 5 years (>50 years)	Easy	
Hydrological	SLLRDC	Water Level at main bridges	Not clear	Very Difficult	Monitoring is not regular Inadequate spatial and temporal coverage
Climatic	Department of Meteorology	Rainfall Ambient Temp Pan Evaporation	Daily (>50 years)	Easy	
Flood Related Statistic	Divisional Secretariat Office	Cost of Damage	Not clear	Difficult	Low Reliability

TABLE 04: Quality of existing information on wetlands

Type of Information	Merits	Demerits
Ecological	• Existing information is of good quality and reliable	• Data sources are few • No regular data collection • Spatial coverage of data is poor
Water Quality	• Intermittent effort have been made to collect data regularly and methodically • Proper parameters to be tested have been identified	• Public accessibility to information is very limited • Some values are not reliable • Collection of data is still intermittent
Climatic	• Very reliable good quality data • Freely available	• Spatial Coverage of data is poor
Hydrological	• Infrastructure to measure some parameters are available	• Public accessibility to information is very limited • Collection of data is still intermittent • Data resolution not adequate for flood prediction
Demographic	• Very reliable good quality data • Freely available	• Frequency of data collection is inadequate
Socio-economic	• Data is regularly collected	• Some data is not reliable • Record keeping is poor (Data lost with time)
Flood related statistics	• A mechanism to collect data is available	• Some data is unreliable • Data collection is not methodical & Regular • Record keeping is poor (Some data is lost with time)

Site Trials for data collection

The calculation of wetland extent using aerial photographs of 1982,1994,1999 and 2000, revealed that there had been approximately a 22% reduction in wetland extend between 1982 and 2000. Table 05, 06 and 07 summarizes the water quality, ecological and socio-economic data collected during the field trials as stated in Material and Methods. The tables only give the average, maximum and minimum values for some parameters tested, whereas the data was collected in a much wider spatial and temporal spectrum.

TABLE 05: Water quality

	BOD (mg/l)	pH	Fecal Coliform (nos in 100ml)	NO_3 (mg/l)	PO_4 (mg/l)	DO (mg/l)	TDS (mg/l)
Average	35	6.5	4700	0.7	0.33	5	134
Maximum	64	7.5	23000	1.9	0.94		230
Minimum	8	6.1	40	0.01	0.01	0.5	90

TABLE 06: Ecological condition

	Chlorophyll Content (mg/l)	Number of endangered macro-fauna species recorded in a station	% coverage of invasive plants species in a plot	No of invasive fish species recorded in a station
Average	*1.5*	Not significant	55-45	2
Maximum	*2.6*	2	>90	5
Minimum	0.23	0	<20	1

It is observable from the tables 05 and 06 the condition of the wetland shows a high level of disturbance and degradation. Water quality in open sources has highly deviated from national standard for quality of open water sources for human use (SLS 722). Ecological parameters show a high possibility of algal growth and excessive presence of both faunal and floral invasive species.

TABLE 07: Socio-economic condition

Parameter	Value
Percentage of households effected by flood	60.0%
Percentage of households effected by water related diseases	35.5%
Percentage of households without a hygienic lavatory or wastewater	10.5%
No of households directly discharging wastewater into the wetland	52.5%
No of houses without proper solid waste collection or disposal method	39.5%
No of households that are dependent fully or partially on the wetland for their livelihood	34.5%

The socio-economic data reveals that a majority of households in the Fringe area of the wetland effected by floods and related events. In turn they contribute largely in further degrading the wetland.

Existing Information Gaps

Although there are several sources of information and regular data collection programs on deferent aspects of Kolonnawa Marsh, none of them reflected the actual level of overall degradation indicated by the field trials. Based on the results of the field trials we identified the following as the most notable weaknesses and gaps in the present sources of available data;

- Information available is scattered
- Updating of information is poor
- Level of information on some aspects is insufficient both spatially and temporally
- Some data are unreliable
- Public accessibility to information is limited in many cases
- No common criteria of comparison and interpretation of information for assessment of wetland condition

Therefore it is clear that a method for integrating and presenting the available information for multi-purpose use is essential.

Overview of the Available Methods for wetland Assessment

Principally there are three approaches for analysis and presentation of wetland data; Inventory, Assessment and Monitoring (Ramsa, 2005). The task of this research was to develop a method to assess the condition of wetlands in the study area for flood management purposes. The are many existing methods for integrating multi disciplinary information developed for different purposes such as regulatory decision making, wetland management, wetland monitoring, public awareness etc. according to the level of information required for the purpose, the complexity of the method and the resources required may change significantly. According to Martha et al (2006) the complexity and resource requirement of a wetland assessment method increases with the intensity of assessment and scale of assessment. For example a semi-quantitative assessment of a wetland at site level will need much less resources than a quantitative assessment of a group of wetlands in a whole river basin. Complexity of an assessment method is more related to the intensity of assessment whereas the resource requirement is highly connected with the scale. Only the following five methods were considered in this overview; 1. Hydro-Geomorphic Method (MGM); 2. Index of Biotic Integrity Method (IBI) 3. State of Ohio Wetland Rapid Assessment Method (ORAM) 4.California Rapid Assessment Method (CRAM) and 5. Ramsa Guideline for Rapid

Assessment of Wetlands (Ramsa). References for above are, Mark Bisnon (1995), Ramsa Resolution IX.1 (2005), Mark (2001), Collins (2007). Table 08 gives a summery of the features of each method. The purpose of the assessment method required in this research is to assess the sustainability of wetland functions that are useful in flood management. Given the limitation of resources and the urgent need of integrated information, the method developed should have the following characteristics;

1. Direct applicability in flood related decision making, regulatory work and awareness building
2. Minimum requirement of human and financial resources
3. Simple method that can be implemented even without high quality technical expertise at field level
4. Quantitative and objective as possible
5. Applicable at site level

TABLE 08: Summery of the reviewed wetland assessment methods

Method	Assessment End-point	Geographic Scope (Scale)	Resource Requirement		Level of Intensity	Applicability in Flood Mgt.
			Time	HR & Other		
HGM	Condition of Wetland Functions	Site Level	Time intensive	High	Quantitative	Detailed assessment of hydraulic functions
IBI	Biotic Integrity	Site level	Time intensive	High	Quantitative & Hypothesis testing	Determining ecological health as an indicator of hydraulic functions
ORAM	Required Level of Statutory Protection	Site level	Rapid	Low	Semi-Quantitative	Rapid determination of wetland condition
Ramsa	Condition of Bio-diversity	Site level Basin level Eco-region	Moderately time intensive	High	Semi-Quantitative	Determining ecological health as an indicator of hydraulic functions
CRAM	Ecological condition	Site Level	Rapid	Moderate	Semi-Quantitative	Rapid determination of wetland condition

Although HGM approach is specifically designed for assessment of wetland functions and tally with the endpoint requirement of this research, the fact that it is time and resource intensive makes it unsuitable for the purpose. Therefore it was decided that a rapid approach is best suited. The approach followed in both ORAM and CRAM can be applied with modifications in developing a method for assessing flood related functions of wetlands that suits the resource levels and needs of the study area.

Applicability of a Rapid Assessment Method (RAM) for integration of flood-related information

Both ORAM and CRAM are semi-quantitative methods which convert both qualitative and quantitative inputs of the field observers (assessors) in to standardized scores or indices using interpretation matrices. The process is made fairly objective by providing detailed manuals and guidelines for conversion of field data and qualitative judgments into scores and indices. Once

converted into indices the information can be used objectively as a simple indicator for many purposes. Table 09 and 10 gives the conceptual breakdown of the two methods. ORAM is a method specifically developed to determine the level of statutory protection required for the assessed wetlands, where CRAM serves a broader target of assessing the wetland conditions for multi-purpose use (Martha et al. 2006).

TABLE 09: Summery of CRAM

Attribute	Matrics / Parameter
Landscape Context	• Habitat connectivity • Percentage of wetland with buffer • Average Buffer Width • Buffer Condition
Hydrology	• Sources of water • Hydro-period • Hydrologic connectivity
Physical Structure	• Physical Patch Type • Topographic Complexity
Biotic Structure	• Organic matter accumulation • Biotic patch type • Vertical structure • Interspersion and zonation • Native plant species richness • Present Invasive plant species
	•
	•

TABLE 10: Summery of ORAM

Attribute	Matrics / Parameter
Wetland size	None
Upland buffers and surrounding land-use	• Average Buffer Width • Surrounding land-use
Hydrology	• Sources of water • Duration of inundation or saturation • Modifications to the natural hydraulic regime • Maximum water depth • Hydrologic connectivity
Habitat alteration and development	• Substrate dispersion • Habitat Development • Habitat alteration
Special wetland communities	None
Vegetation, Interspersion, Mcrotopography	• Wetland vegetation communities • Horizontal vegetation interspersion • Presence of invasive species • Mcrotopography

Source: Mark (2001)
Source: Collins (2007)

According to Martha et al following are the main steps involved in developing a wetland rapid assessment method.

1. Organize RAM development by identifying the intended applications, assessment endpoints, and geographic scope of the RAM and forming appropriate teams to advise and review the development process and its products
2. Build a scientific foundation for method development by conducting a literature review, choosing a wetland classification system, building conceptual models, and identifying the major assumptions underlying the model
3. Assemble the method as a system of attributes and metrics that describe a full range of conditions
4. Verify the ability of the method to distinguish between wetlands along a continuum of conditions
5. Calibrate and validate the method against sets of quantitative data representing more intensive measures of wetland condition
6. Implement the method through outreach and training of the intended users

Both methods are designed to cover significant amount of information related to flood control/management function of a wetland, such as average buffer width, surrounding lands use, maximum water depth, duration of inundation etc. Although ORAM is specifically developed for decision making in statutory protection of wetlands, it incorporates more direct information on anthropogenic modification of the wetland in the scoring system than the CRAM. A method developed for the purpose of flood management should incorporate more direct information on flood related damage and socio-economic attributes that may effect the flood management function of the wetland. Such an attribute is not available in both CRAM and ORAM.

CONCLUSION

The review of existing sources of information reveals that there are many gaps and weakness that has to be filled and corrected for effective use of this information in flood related decision making and awareness building in the study area. Considering all the factors such as resource limitations, urgent need for action and level of expertise pertaining to the study area a Rapid Method to Assess the Condition of Flood Related Wetland Functions is the best approach to integrate the information for above purposes. The Wetland Rapid Assessment methods developed in some states of USA such as CRAM and ORAM will be useful guidelines in developing such a method for the study area.

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10 Collaborative Decision Making within the Context of Integrated Water Resources Management in Langat River Basin, Malaysia

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ABSTRACT
This paper explained the study on Collaborative Decision Making (CDM) that has been done in Langat River Basin, Malaysia. This study looks at several issues on CDM among agencies that are related to water resource management in Langat Basin, by using the Integrated Water Resources Management (IWRM) as an approach towards sustainability governance. This study analyses the structure and the inter-relations between some characteristics of collaboration and local capacity; to investigate the decision making process that is related to water resources management in Langat Basin; and to assess the potential and the problems of CDM among agencies that are related to water resources management in Langat Basin, Malaysia. There are some factors that influenced the application of CDM in this basin that need to be given more attention and actions. The concept of CDM is also need to be clearly understand and well known as an important mechanism in water resources management.

Key words: collaborative, decision making, integrated, Langat, management, water resources.

INTRODUCTION

The concept of Integrated Water Resources Management (IWRM) was already recognized in agenda 21 of the United Nations "Earth Summit" on Environmental and Development that was held in Rio de Janeiro in 1992. At the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, the international community has also took an important step towards more sustainable patterns of water management by develop IWRM and water efficiency plans with support to developing countries (Mokhtar, et al, 2004).

The World Summit on Sustainable Development has identified several key issues and challenges and proposed many actions to meet the challenges, with increasing focus on water supply and sanitation as well as the need for improved frameworks for Integrated Water Resources Management (IWRM) and water governance at all levels (WEHAB Working Group, 2002).

IWRM may be defined as "*a process that promotes the co-ordinated development and management of water, land and related resources in order to maximise the resultant economic value and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*" (GWP-TEC, 2004). IWRM is a comprehensive approach to the development and management of water, addressing its management both as a resources and the framework for provision of water services.

IWRM includes social, economic, and environmental factors in the planning, development, monitoring and protection of land and water resources. Hence, IWRM is not limited to addressing just physical relationships or water resources characteristics. It also includes water as an integral part of the ecosystem, a finite natural resource, and a social and economic good (Davis & Hirji, 2003).

IWRM planning process takes a more flexible and dynamic approach to planning the development and management of water resources (GWP-ToolBox, 2003). National IWRM plans include actions necessary to develop an effective framework of policies, legislation, financing structures, capable institutions with clearly defined roles and a set of management instruments. The purpose of such framework is to effectively regulate the use, conservation and protection of the water resources, balancing requirements for broad economic development and the need to sustain ecosystems. The emphasis here is on the process of establishing priorities and actions for IWRM, which include ecosystem protection and conservation.

Integrated River Basin Management (IRBM) as a sub-set of IWRM deals with management at the basin level involving aspects like water allocation, pollution control, flood control, etc (Clausen, 2000). IRBM defined as the coordinated management of resources in natural environment (air, water, land, flora, fauna) based on river basin as a geographical unit/area, with the objective of balancing man's needs with necessity of conserving resources to ensure their sustainability (Keizrul, 2000). It means that river basins need to be managed in an integrated and holistic manner (IRBM).

Water Governance is about local change and reform, and strategies that need to be developed as part of the IWRM plans that are required under the WSSD target. Making Water Governance more effective requires change and reform in line with the law. The governance and administration of water resources in Malaysia involved several departments and agencies that operate dependently or independently of one another according to the specific responsibilities assigned to them.

Governance covers the manner in which power is balanced in the administration of a country and embraces the traditions and institutions by which authority is exercised, where Water Governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services at different levels of society (Hall, 2003). Water Governance can only be successful if accompanied by required decision making powers, resources and capacity at the lower levels.

The key challenge for water policy and management is to move from competition and conflict to co-operation. Water knows no political boundaries, and its optimal management is best achieved when done at the basin level, across political boundaries where necessary. Co-

operation is thus a critical element in regional water management, when inter-basin water transfers may in certain cases be a preferred option. Quantity and quality must be considered simultaneously and jointly when thinking about co-operative or co-ordinated management of water among users and across political boundaries (UNESCO, 2002).

Changing water practices to achieve goals of IWRM and of IRBM requires change of attitudes in individuals, institutions, professionals and organisations within civil society. The key to encouraging an IWRM and IRBM oriented civil society lies in the creation of shared visions, through joint diagnosis, creation of options, implementation, and monitoring. This itself requires broad stakeholder participation in water planning and operating decisions, and is another strong tool for encouraging such new civil orientation (GWP-ToolBox, 2003). Towards this, the CDM involving all stakeholders that are related to water resources management is suitable mechanism in achieving IWRM goals in Langat Basin.

COLLABORATIVE DECISION MAKING (CDM)

Collaborative Decision Making (CDM) is an important mechanism in water resources management because of its potential in improving the present water resources management system. The definition of CDM is a joint effort among government agencies, private sectors, NGOs, the public, universities and other relevant stakeholders aimed at improving the present management system through increased information exchange among the various parties in the community and improved decision support tools (Elfithri *et al*., 2002, 2004a,c; Mokhtar *et al.,* 2004).

CDM offers an opportunity for more proactive and collaborative approaches to resolving environmental problems, and it can be used in water resources management related issues. In turn, this will require the participation and involvement from stakeholders within a larger context of shared understanding. Particular attention is paid to the issues that emerge as a result of multiple stakeholder involvement within environmental problem situations. **Figure 1** show the key elements of CDM.

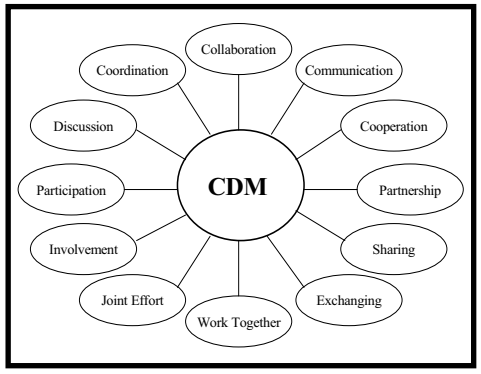

Figure 1. Key Elements of CDM (Source: Elfithri 2006)

CDM is an appropriate and best way to practice collaboration among agencies that can be done through consensus and consultation. The participation and involvement of related stakeholders in water resources management, including the relevant federal and state agencies, private sectors, Non Governmental Organisations (NGOs), universities, public and local authorities are needed to incorporate their data and information into decision making process in the CDM mechanism (Mokhtar & Elfithri, 2005).

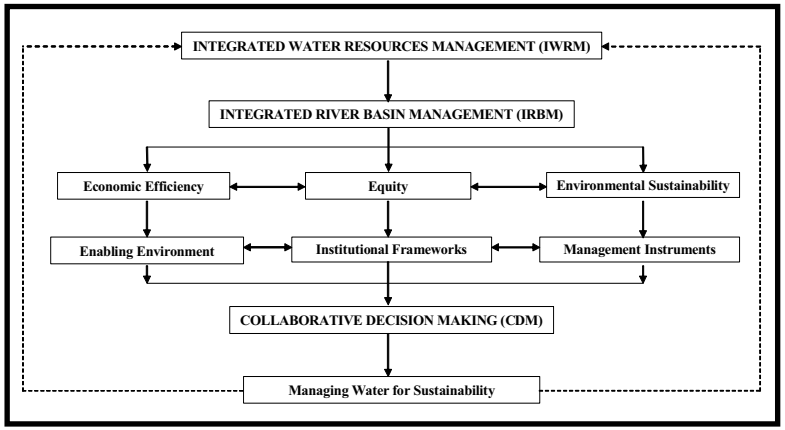

Figure 2. Framework of IWRM and IRBM that showed the importance of CDM (Source: Elfithri 2006)

CDM is needed in order to improve the existing water management system, where the agencies and other related bodies have to sit together to discuss about the settlement of the issues together. CDM is a suitable and appropriate way within framework of IWRM and IRBM where CDM is needed as enabling environment towards IWRM, mechanism of CDM allow and provide institutional frameworks, at the same time CDM can also become a tool for management instruments (**Figure 2**).

The concepts of CDM are being used and applied in several countries involving many aspects of natural resources management. Several groups are pursuing collaborative approaches to natural resource management and their experiences offer valuable insights into the process, the people, the successes, and the pitfalls. This study use CDM within the context of IWRM as a comprehensive approach to the development and management of water that needs the involvement of various stakeholders, especially in Langat River Basin, Malaysia.

CDM IN LANGAT RIVER BASIN

The Langat River Basin, administratively involves two states and a federal territory viz. Selangor State, Negeri Sembilan State and the Putrajaya Federal Territory. Therefore this study has been carried out by taking into account the agencies and institutions that are related to water resources management in three areas within the basin and focus on how they are communicate, cooperate and collaborate among each other.

This study uses a combination of quantitative and qualitative methods in assessing the CDM in Langat Basin, based on the concepts of structure and agency by Giddens (1984). A total of 40 agencies that are related to water resources management in Langat Basin have been interviewed that include some of the federal and state government agencies, Local Authorities (LAs), private sector and Non Governmental Organisations (NGOs). Indepth-interviews have also been carried out on five representatives of agencies in Langat Basin.

Under the Malaysian Constitution, water is a state matter. Nevertheless when it comes to water resources development, utilization and management, both the federal and state governments are involved. This is because the responsibility for water resource administration is fragmented and is shared among a number of federal and state agencies, each of them have their own specific involvement in water related issues (Welch & Lim, 1987). Their interest in water related matters could be viewed as from any one or more of the following three aspects:

- The planning, development and management of water resources aspect;
- The protection and conservation of water aspect;
- The land-use control and watershed management aspect.

The Langat Basin is an area that drains by the Langat River in the state of Selangor, Malaysia. The Basin is currently the fastest developing area in the country. A number of large scale social-economic projects have either currently taking shape or are already completed in the Basin. This include the new township of Putrajaya (new Federal Government Administration Center), Multi-Super Corridor (MSC) for the information technology industry, the BioValley for biotechnology research/industry, the Kuala Lumpur International airport and several other institution of higher learning including universities. The rapid urbanisation in the Basin has led to a large influx of people into the region. The sudden increase in population has exerted a number of stresses on the Langat River. One of the main problems is river pollution from sewage and suspended solids resulted from land clearing and discharge of untreated or incompletely treated sewage. The problem is a concern of many including government, non-governmental organisations and the public as the Langat River is the main potable water resource for the whole Langat Basin and the Klang Valley (Kuala Lumpur) nearby where almost a million people depend on the Langat for drinking water. Many solutions and activities have been carried to arrest the deterioration of the Langat River water quality but few have achieved success. The root to the problem is the absent of a truly integrated management system of water resources in the Basin (Elfithri, et al, 2004b). **Figure 3** shows the map of the Langat River Basin.
There are a number of government agencies, private sectors, local authorities, NGOs and universities that are involved in managing water resources in the Langat Basin and had initiated to a certain degree activities pertaining to realization of goals of an integrated water resources management approach (Elfithri et al., 2004b). A study on CDM in Langat River Basin is carried out to analyse the current organizational structure in the basin and also to look at several issues on CDM involving several agencies and institutions and the need of CDM to be applied in this basin. The purpose of the research is also to seek common grounds from which the diverse agencies can collaborate in managing the basin as well determining areas of conflict.

Figure 3. Map of the Langat River Basin, Malaysia

RESULTS

This study found that there is selective collaboration among agencies that are related to water resources management in Langat Basin, in form of (i) meetings among agencies, (ii) process in making decision together, (iii) handling issues together, (iv) sharing the data and information, and (v) joint research projects among agencies.

The level of application of CDM in Langat Basin have been assessed and found that most of agencies had more involvement in term of management and administration (80%) and making decision together (80%), rather than handling issues together (67.5%), sharing the data and information (65%), and joint research projects among agencies (40%).

The collaboration among agencies is influenced by the factors of structure and agency. It is found that the factor of structure of administration and management is the main factor that drives and limits the collaboration process when compared to the factor of preparedness and capacity of agency. Where it is found that the level of application of CDM in Langat Basin in all form of collaborations in Langat Basin are drives by the factor of structure of administration and management rather than the factor of preparedness and capacity of agency.

The level of application of CDM in Langat Basin in form of management and administration, handling issues together and joint research projects among agencies are also limits by the factor of structure of administration and management compared to the factor of preparedness and capacity of agency. But not in form of making decision together and sharing the data and information that limits by the factor of preparedness and capacity of agency itself.

This study also found that there is no involvement from NGOs in water resources management of Langat Basin (0%), lack of involvement from private sectors (40%), minimal involvement from government agencies in Federal Level (52%), and quiet enough involvement from

government agencies at State Level in Negeri Selangor (78.6%) and Negeri Sembilan (84%), as well as at Local Level (90%).

CONCLUSIONS

Proper management of river basins is important in reducing the water being polluted which not only causes degradation upstream but also downstreams as well as coastal and estuarine areas. River basin management should take into consideration the integration of the role played by various agencies (both government and private sectors), land use development activities and protection of vital ecosystems. Strong coordinated national actions are required to integrate legislation and also all the related agencies that are related to river and water resources management. The integration will take into account the coordination in decision making among different levels of government and among various sectoral departments and agencies within government, private sectors, NGOs, communities and also universities or research institutes. It is also the integration in terms of holistic approach management that looking at overall development in the river basin to avoid conflict among users. The task of the integrated approach will include the setting up of water quality standards, regulation and control of pollution. Coordination among various agencies will help prevent conflict and duplication of functions and roles.

Water managers need to develop an understanding of the concept of IWRM, its potential benefits and how best to put it into practice. In addition, water professionals need to acquire skills to apply specific (often sectoral) management tools, to make regulations, to set up financing systems, etc. Specialist training courses in such topics as social assessment, designing and running participatory and gender sensitivity processes, dispute management and consensus building, institutional design, policy profiling, and working with the media can be valuable.

CDM is a concept, but it seems to become important and compulsory to be adopted and applied in management of water resources as an approach towards IWRM.

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11 How useful is the Berlin Centre of Competence for Water for the urban management of water supply? A contribution to an inter-organisational analysis in the field of sustainable innovation.

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Abstract : Like many towns in East Germany, in 1999 Berlin sold a 49, 9% share of its water supply to a consortium composed of two international multi-utility: RWE and the current Veolia-water. In this Framework in 2001 Veolia built the Berlin Centre of Competence for Water, a cooperation of the private French investors (Veolia) and the Berlin Group comprising the Berliner Water Utility, the Technique University of Berlin, some State Ministries of Berlin and some locals research institutes. Through the analysis of different reports of the Berlin Centre of Competence for Water and the interviews with employees I will try to shed the light on two phenomena: On one hand, I will explain how the cooperation works using methods of Organisation studies i.e. sociology of Organisation and Organisational Learning and Knowledge. On the other hand, I will show on the basis of the theory of innovation how such cooperation can be a useful contribution for the urban water management of Berlin.

Keywords: decision support, inter-organisational management, public private partnership, sustainable development, urban water, water privatisation

Introduction: The context of privatization of the Berlin water supply company

The management of urban services in recent decades has known a great wave of privatization. This phenomenon is the direct consequence of the liberalization process of the water sector, which called into question the monopoly of historic operators by introducing competition (Allouche et al., 2007). This process was largely encouraged by international bodies (International Monetary Fund, World Bank, European Union). The "privatization" of the public sector "has become one of the watchwords of a neo-liberal management in Europe on behalf of the lower costs of management and performance" (Bonin, 2005: 62). The opening of the markets to foreign operators was the decision that would enable the consumers to have a free choice in a service or a product (Kleinpeter, 1994). Even if the privatization of water management is not the placing of the resource in the hands of private operators but rather another form of management (Kluge and Scheele, 2003), there were some operators who took advantage of this wave of liberalization to internationalize their activities. Three of them are French, namely Veolia, Suez and SAUR and another German, RWE Thames Water. These companies belong to powerful multinational groups specialized in urban services and that it is customary to designate as *multi-utility firms.* These companies, as highlighted Dominica Lorrain, belong to the group of big enterprises that play a leading role in their countries, which have internationalized and intervene in different sectors, namely water, energy, public transport and waste (Lorrain, 1995: 202). The two biggest are Veolia Water and Suez-Lyonnaise des Eaux. Veolia Water is No. 1 worldwide in water services: it serves drinking water and sanitation to 110 million people, had in 2004 a turnover of 9.8 billion Euros, is

active in 55 countries on five continents and employs nearly 67800 employees. The Lyonnaise des Eaux, a subsidiary of Suez, is No. 2 on the global water market. The group supplies 80 million people with drinking water and 50 million with sanitation around the world. The turnover of the subsidiary water company was 5.9 billion Euros for 2005. More than the success of a few firms some observers see the achievement of a management model, requiring the introduction of private operators in a field which had remained till now firmly in the public sector. Further to the liberalization of the markets the firms, through competitive bidding, have obtained the opportunity to cooperate with local and public operators to improve urban water management. How do the different actors cooperate? Does this cooperation result in an improvement of urban water management?

The traditional water management in Germany

To answer the questions I will take the example of the water management in Berlin and focus more precisely on the Berlin Centre of Competence for Water. I will question whether and how these institutions contribute to improve water management in Berlin. But first of all, if we want to understand how water management works in Berlin, we have to shed some light on the specific context of traditional water management in Germany. All public operators are small or medium and there is no exception for the German operators. Apart from R.W.E. and E.on., two giants of electricity which have also invested in the water sector, all companies in German water management are communal or grouped into an association of communes (Zweckverbände). There are more than 3000 German companies responsible for delivering water management nationwide. "German local authorities manage directly or through public water supply and sanitation" (Drouet, 1988: 43). In general, these companies are called transversals because of their management of gas, electricity, waste and public transport. Municipalities play a central role in that they have a degree of autonomy and control over the various urban services including water management: "The most remarkable feature of the German management is the existence of municipal urban services "multi-utility", the *Stadtwerke*. These are companies in their own right, but under the control of the town" (Boué et al., 2000: 14). The shareholding of these firms is mostly composed of public entities, i.e., the town or community of towns. In general, even when the private sector moves into these companies, the majority shareholding remains in public hands. "Municipal compagnies, writes Drouet, are publicly owned or mixed, municipalities still holding the majority, and often the entirety of the shares" (Drouet, 1988: 45). The precarious situations of German municipalities associated with the infrastructure cost of water management are a good foundation for the arrival of change in this sector. Some international companies, like Suez which is the German subsidiary Eurawasser, and Veolia, and its German subsidiary Veolia Wasser, are also based in Germany, particularly in the former East Germany. They are in charge, in cooperation with the municipal water management, of the local management of water, i.e., "pumping, processing, distribution, wastewater collection, reprocessing and rejection" (Lorrain, 2003: 70), in different German cities.

The case of the Berlinerwasserbetrieb

Like many towns in east Germany, in 1999 Berlin sold a 49,9% share of its water supply to a consortium composed of two international multi-utility companies : RWE and the current Veolia-water. That partial privatization is part of a broader wave of privatization concerning the utility companies of the town and was the subject of much controversy. Initially this privatization was created in order to improve the social, environmental and technological aspects of the city of Berlin in the field of water. In this context, a number of agreements were made: protection of jobs, increase in prices limited… one of these agreements was the creation

of the Berlin Centre of Competence for Water (Moss and Von Schlippenbach, 2007: 3). The Centre was established in December 2001 by the company Veolia and has been incorporated in January 2003 into a network of water research and cooperates with local universities, including the Technical University of Berlin. The main actors involved in this institution are Veolia, the *Berlinerwasserbetriebe* (the Berlin communal water management company), the Technology Foundation of Berlin (TSB), whose objective is to support innovation and, the Technical University of Berlin. Its official target is the establishment, receipt and dissemination of knowledge on the theme of water. An analysis of such an institution, which will be the starting point of my study will describe the mechanisms underlying the activities of the latter and of the actors who contribute to its functioning. More generally, it will focus here on the scope such cooperation can have between various actors in general research on the sustainable management of water. Indeed, the case of this organization argues very well for the institutionalization of cooperation between the technical sphere and the scientific sphere, each with specific knowledge and skills.

Method: theoretical background and data-gathering

Before highlighting the method I will use to analyse this subject, I have to explain the theoretical framework. This is composed of two main theoretical currents. On the one hand the organisation theory will permit us to understand how the institution and the cooperation between the different organisations that are implicated in this Centre works. After that, I will use the theory of innovation as theoretical framework to try to understand how this institution could help Berlin to improve its Water management and furthermore how it could improve the general way of sustainable water management.

Inter-organizational cooperation and knowledge management

The organizational analysis of the subject will be studied through two inputs: on the one hand, the sociology of organizations will allow us to clarify the arrangement and relationship of the various players in this institution. On the other hand, the contribution of the theory of organizational learning will give us the opportunity to better understand the movement and the creation of knowledge within and between different institutions. The sociology of organizations will therefore give us the keys to reading, to describing and analyzing the formation and operation of this institution, as well as coordination of the various actors involved in it. It will detect certain power relationships that can play the role of constraint with regard to the development of new knowledge. It will also be interesting to update the strategies of the various actors in this institution. All this will enable us to understand the general organization of the cooperation between institutions of a different nature. Finally, we will have to focus more specifically on the interweaving of research and industry within the same institution, forcing on the one hand to expansion of organizational analysis in the composition and functioning of actors forming that institution and on the other, pointing to the cooperation of two different categories of actors: engineers and researchers (Vinck, 2007). What we will learn from the theory of organizational learning is how to form the new knowledge through the relationships between different actors within the same organization or between organizations. First it will be to identify different forms of knowledge and then analyze how they contribute to the creation of new knowledge. To do this, we will call on categorizations made between different forms of knowledge, i.e., *tacit knowledge*, who “is deeply rooted in actions, commitment, and involvements in a specific context” and *explicit knowledge*, that is transmittable in formal, systematic language” (Nonaka, 1994: 16) and between the forms of transmission of this knowledge through the various processes of socialization, combination,

internalization and externalization (Nonaka, 1994). The theoretical contribution of organizational learning will, in general, be a prerequisite for understanding the phenomenon empirically studied.

How can be sustainable innovation defined and analyzed?

Then we will try to highlight the scope and limits of such cooperation in the contribution to the innovation process in the sustainable management of water. Broadly speaking, we consider that innovation, collective process allowing the creation of an economic value, is derived from the interaction between different actors whose knowledge exchange enable to impose change. From a theoretical point of view, innovation has been studied since Schumpeter in many ways and by many schools of thought. Despite the differences of views adopted by the researchers, it appears that a consensus has formed on the fact that innovation is the result of a collective work (Rosenberg, 1983; Freeman, 1987; Callon, 1994; Alter (ed.), 2002) and not of an isolated actor. Taking into account the issue of sustainable development within the logic of innovation, is actually to add a constraining dimension. Indeed, the problem of sustainable development could therefore arise in these terms: how can prolonged economic growth be supported in the long term by nature while allowing growth to benefit everyone. In other words, it is "reconciling the economic (growth), social (equity) and environmental (respect for nature) dimensions of the human development” (Slim, 2004: 28). Therefore, analyzing sustainable innovation lies not only in taking into account the impact of the economic benefits but also the impact on nature. On the other hand, having put forward the demands of sustainable development as well as the properties of innovation, we can understand why the latter can play a very important, if not decisive role, in the approach of the goals set by this concept. If innovation is the engine of economic growth, it must, in the context of sustainable development, also work to be beneficial, or at least neutral toward the natural and human environment. It is essential to make a difference between environmental innovation that could be characterized as a subset of the novelty aimed at reducing the use of environmental services and sustainable innovation that brings with it the three dimensions of sustainable development (Tauchmann et al, 2006). These definitions will help us to better understand the scope of the institution's activity studied.

The qualitative analyze of the subject

Concerning the method, we will rely mainly on a comprehensive approach that is to say, try to understand how the institution works and therefore we will base our study on various methodological tools. First of all we will use semi-structured interviews with members of the Berlin Centre of Competence for Water, as well as some members of Veolia Wasser and the *Berlinerwasserbetrieb*. To better appreciate the conditions of the creation of this institution, there will also be interviews conducted with representatives from the city who participated in negotiations with Veolia. These interviews will have essentially a comprehensive goal and they will therefore focus on the justification of the players to better understand "the nature of the devices in which they deploy their action" (Amblard et al., 1996). These interviews will draw a link between the action of the players, their motivation and the context in which they operate. Then we will proceed to a compilation and an analysis of the scientific output of the Berlin Centre of Competence for Water. As the Centre involved in many projects and organizing numerous scientific events, it will be interesting to note the players directly involved in the scientific life of this institution. It will also highlight the characteristics of the scientific production centre to try to analyze the extent that it may have. It will also be worth to describe the organizational structure of this institution in order to push forward the

development of power relations between the different institutions. Finally, researching into the legal documents (to the extent possible), and above all the contracts signed between Veolia and the city of Berlin, will enable us to understand a little better the conditions of entry of the French company in Berlin. In addition to the first two methodological tools, we will support the collection of data by direct observations in the Centre, and more specifically at events organized by it. This will enable us to highlight the staging organized to meet the players and will complement our description of the diffusion or not of scientific facts. On the other hand, these observations allow us to draw a link between the speech and the action of the actors.

Results: what resources for what results?

The first results of the analysis will lead us to consider the scope and limits of the Berlin Centre of Competence for Water, on the one hand in terms of inter-agency cooperation and on the other hand in terms of innovation, both being naturally linked. In the words of Nonaka: « Innovation can be better understood as a process in which the organisation creates and defines problems and then actively develops new knowledge to solve them" (Nonaka, 1994: 14). The problem here is largely defined by the various players involved in the Centre as the quantitative and qualitative preservation of water resources necessary for survival (KWB, 2003: 2; KWB, 2006: 4).

The organization of the cooperation: goals and resources

We have already pointed out, that the official goal of this institution is to federate innovation between companies and scientific institutions. To that end, it has to identify the items requiring an effort to coordinate research and projects aligned to these topics (KWB, 2001: 2). The various projects are divided into different areas: information technology in water economics, sustainable management of water resources and technological innovation in the field of wastewater treatment. These fields, dividing themselves into 30 projects jointly run by employees of Veolia and the *Berlinerwasserbetrieb*, must in general contribute to the reduction of the costs of water management and the increase of the quality of drinking water (KWB, 2001: 4). The protocol set out by the Berlin Centre of Competence for Water to complete the various challenges is the following: to identify the important points of research and development, contribute to the transfer of information and technology in the field of sustainable water management, present results of research in public through publications and communications, offer training, organizing conferences and seminars of experts, create a network of small and medium-sized businesses through the different projects. In order to complete this project, Veolia Water has offered the sum of 50 million Euros for the 10 years that followed its creation (KWB, 2001: 23). We see therefore through the provision of different resources (money and people) a genuine intention to contribute to the improvement of water management through innovation. Finally, the federation of research and businesses in a common goal of innovation is characterized by the networking of different small and medium enterprises, both contributing to innovation and profiting from it.

The organization of the KWB as a resource of knowledge creation

From an organizational point of view, it could be an initial thought that cooperation between institutions of various kinds such as Veolia (private French company and global player) and the *Berlinerwasserbetrieb* (public enterprise, local and German), both following two different paths for several decades, is a constraining factor for the development of innovation. However,

when looking more closely at the Berlin Centre of Competence for Water, we can detect an inter-organizational cooperation, which could contribute to the development of innovation. The activity of this institution and the cooperation underlying it becomes clearer when based on the theoretical work of Nonaka. We see in fact how different bodies of knowledge accumulated by the various players are remitted to contribute in the formation of new knowledge. It is clear that this knowledge is essentially created and transported by work groups involved in the Centre and would thus refer to a model of middle-up-down Management. Contrary to the Top-down and Bottom-up models, « the middle-up-down model takes all members as important actors who work together horizontally and vertically. A major characteristic of the model regarding knowledge creation is the wide scope of cooperative relationship between top, middle and lower managers" (Nonaka, 1994: 30). We find in this institution, the different movements of knowledge translation developed by Nonaka. The *socialization*, corresponding to the passage of tacit knowledge to tacit knowledge, is found in the application of new technologies and the shared work of the engineers, researchers and technicians from the different institutions. This mutual socialization or not is the result of this inter-organizational cooperation, to the extent that everyone learns from each other by working directly with each other. For example projects are usually conducted by teams of the various institutions. Therefore employees of a project will learn new knowledge from he other and integrate it in a more or less unconscious way of doing things. The *combination*, passage of explicit knowledge to explicit knowledge, can be found in various symposiums and work groups organized by the Centre. It is for example the case of the « Berlin Water Workshop », whose goal is "to promote the information exchange among water experts from the Berlin and Brandenburg region" (KWB, 2004 : 26). It takes place every two mounts since autumn 2004. The *internalization*, passage of an explicit knowledge to tacit knowledge, is reflected in training of different natures offered by the Center. It not only offers training for managers in the field of water management and scholarships for doctoral students but also set up in cooperation with the TU the Chair of water management (KWB, 2004: 25-26). Finally, the *externalization*, namely passage of a tacit knowledge to explicit knowledge, is found in the publications produced by the Centre. Thus, the Centre seeks to publish results on the completion of various projects, particularly through the *Schrifftenreihe Kompetenzzentrum Wasserberlin* (KWB, 2004: 21; KWB, 2005 : 24). With regard to this organizational analysis, it can be said that this institution has already set aside to contribute to the creation of new knowledge in the field of sustainable water management. However, can we say that to the extent that knowledge will contribute to the development of sustainable water innovations?

The innovation process between local and global developments

Concerning the innovation process, it has already found that many resources were made available to foster innovation. But this is not enough to be able to say that the availability leads to results. An initial result which can be argued is that, far from being opposed, and to be a brake on innovation, the local and global nature of the various institutions seems to complement each other quite well and thus contribute to the development of innovation. Indeed, we can see a double movement on the one hand ranging from the global to the local and on the other hand from the local to the global, that seems to foster innovation and to benefit the various players investing in the Berlin Centre of Competence for Water. In other words, it is questionable whether the interweaving of different scales of action in this institution would not be a means to promote innovation. It could be argued that on the one hand the global benefits the local level. For example, the project *Mobile IT Service Field Operations* for introducing the use by employees of PDA (Personal Digital Assistant) enabling them during their field work, to have real-time access to all the data they need to solve the

problem is a process that was developed in France and then having been exported to be tested in Berlin. We see therefore an innovation developed by Veolia, a global player, with a local application and therefore benefiting the city of Berlin. There is therefore the overall development of an innovation and a local application in Berlin (KWB, 2001: 18). This is also true of the "Membrane Development for Urban Sewage Purification" responsible for conducting research on the development of membranes MBR technology for the treatment of wastewater at the local level (KWB, 2005: 17). On the other hand, the movement from the local to global is characterized by the willingness of internationalization of innovation. To this extend, the local would take some advantages of the global. Berlin, through the Center, is a test city for many innovations before it can be then applied to other cities, regions, and countries. This is particularly true of the project NASRI (Natural and Artificial Systems for Infiltration and recharge), to improve conditions for reprocessing of groundwater. This project started, which ran from 2002 till 2005, has been developed in Berlin and has then to be internationalized. It is a development of a model for optimizing filtration devices from banks, which will then be applied on a global scale (KWB, 2002: 6). Thus this project gave rise to a new project entitled “Filtration Bank in India”. It is the implementation of what has been developed in Berlin to the region of Delhi. "In this Project, which was started in 2005, the overall process of understanding Bank Filtration that was gained in the NASRI project is to be verified and further developed at an entirely new test site. The Capital Region of Delhi in India has been selected as the future investigation area "(KWB, 2005: 13).

What bring the KWB to the different actors involved in it?

Thus, it would appear that this double imposition movement of innovateion would benefit both the city of Berlin and its *Berlinerwasserbetrieb* and Veolia. For the first, the innovation would bring it opportunities for extension of its contract to the international and a renowned name in the field of water research. Veolia would also benefit from it by obtaining legitimacy not only locally but also nationally and internationally. This cooperation also enables both companies to be connected to the research in the field of water management and as well as to enjoy a wide network (Moss, von Schlippenbach, 2007: 11 - 12). This institution helps to accelerate the transition from one scale to the other and therefore also to facilitate the transition of innovation. To summarize, Veolia in cooperation with the group of water management in Berlin found, through the Berlin Centre of Competence for Water, many resources to promote innovation in sustainable development of water. However, two boundaries should be put in place. Firstly, at this stage of research, it seems rather difficult to say if these innovations are carriers or not of sustainable development. On the other hand, it is also difficult to say exactly who benefits from the fallout of innovations. These limits are linked to certain factors. First of all this Centre has existed only since 2001, and it is therefore difficult to really analyze the scope of its activities in terms of sustainable innovation. In addition to this, it is essential to emphasize the dual challenge of social scientist to interfere in technical and entrepreneurial fields. Then, to try to analyze a technical discipline, where the researcher is a neophyte, is a formidable challenge and calls firstly for a long process of understanding technical activity. Finally, the researcher faced with the world of business is often confronted with the difficulty of access to empirical data.

Conclusion: limits and possibilities of the analyze

To conclude, I would like to address two points relating to innovation. First, it would be interesting to know who really benefits of the different innovations. In referring to an analysis of the “technico-economic networks” developed by Michel Callon, it might at first glance say

that Veolia because of the position within the network of innovation is the actor, who would enjoy most of the benefits of innovation. Indeed, this actor, part of its central location, seems to have established an ascent relationship vis-à-vis other actors becoming indispensable within the network. Therefore it can more easily impose its interests and contribute to the irreversibility of the innovation network, by excluding a step backwards (Callon, 1991). However, a more detailed analysis of innovation network would be needed to verify this assertion. Finally, an analysis would be interesting to study the factors contributing to a possible blocking of sustainable innovation. The purpose of this paper is to demonstrate how the KWB is helping to develop sustainable innovations. Therefore, it would be interesting to reflect on the reasons that may contribute to the failure of this policy to promote sustainable innovation. To do so it would be in my opinion necessary to rely on the theory of path dependence, thereby showing, to what extent the historical evolution of the institutions contributing to innovation would be an impediment to the development of it (Foxton, 2002). Whether the assessment of the activity of Centre is positive or negative, this institution provide still the advantage to reflect on the conditions for the creation of new institutions and their imposition of new agenda of research on the environment. In addition, an assessment of its institution would also be very successful on the one hand to improve its efficiency, but also to develop a model of cooperation that can be applied to other locations.

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12 "Appropriate technologies" for drinking water supply in developing countries.

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Abstract
In order to ensure maximum consumer benefits (e.g. public health, livelihood), drinking water supply technologies in developing countries should be adopted taking into consideration locally available skills, resources as well as cultural and environmental settings. This paper presents case-studies from several developing countries in different geographical regions of water supply projects utilizing methods ranging from biological treatment offered slow sand filtration systems to chemically-assisted clarification. These examples reveal successes and lessons learnt in several research projects conducted under different settings (e.g. international development and humanitarian emergencies). In addition, the importance of capacity building for successful implementation of water treatment technologies is also illustrated.

Keywords
Appropriate technology; coagulation; development; emergencies; slow sand filtration; water treatment

INTRODUCTION

Health risks associated with drinking-water, particularly microbial, are a major concern in water treatment. Particularly in developing countries where resources for a minimally adequate and reliable water supply are many times lacking. Therefore, drinking water treatment and supply projects should make the most of the accessible resources by adopting the most adequate technologies available. The term "appropriate technology" is commonly used in the context of water treatment and supply in developing countries to refer to water purification techniques that can be implemented (sometimes), operated, and maintained by the beneficiary community.

Appropriate technology usually refers to situations where there is a relative stability and time for the involvement and capacity building of the local community (i.e. development projects). Locals are consulted on their preference of technology and factors such as locally available skills and resources are taken into consideration together with the cultural and environmental settings. However, in situations such as humanitarian emergencies an appropriate technology may refer to water treatment methods that can be quickly and easily implemented (usually by a foreign aid agency) in locations with limited resources (e.g. energy source, chemical supply, spare parts).

Three case studies are presented on use of appropriate technologies for water treatment in developing countries, varying from rural community slow sand filtration systems to chemically-assisted emergency water treatment kits. Both successes and lessons learnt are illustrated in each case study from varied geographical locations (i.e. Sub-Saharan Africa, South Asia, and South-East Asia) and contexts (i.e. development and humanitarian emergency).

CASE STUDY 1: MULTI-STAGE FILTRATION IN RWANDA

Multi-stage filtration

Slow sand filtration (SSF) has been well established as a biological process for drinking-water treatment that can achieve significant improvements in water quality. However, it is sensitive to influent waters of high turbidity. This limitation has the implication of hindering the reliability of the process in terms of continuity or negative effects on the biological activity. This shortcoming to SSF can be dealt with the incorporation of pre-treatment stages. Gravel (or roughing) pre-filters are units filled with gradually finer graded media with varying bed depths (or lengths). They have been used together with SSF due to their effectiveness, simplicity, and reliability as pre-treatment, providing (together with SSF) a multiple-barrier system; otherwise know as multi-stage filtration (MSF) systems. Such a treatment approach relies on more than one purification stage (or barrier) during the treatment process progressively removing contaminants and consistently producing safe and wholesome water (Galvis et al., 1994).

Study area

The study area is situated in the communities of Nyabwishongwezi and Ntoma in northeast of the country bordering Uganda and Tanzania. The two multi-stage filtration (MSF) water treatment plants (WTPs) are located in a hilly terrain and utilize the river Umuvumba that runs through the boarder of Uganda and Rwanda. The Nyabwishongwezi WTP is a multi-stage filtration plant consisting of four parallel storage tanks followed by two parallel two-stage gravel (roughing) pre-filters and four parallel slow sand filter units. Choice of such treatment system was based on the inadequacy of groundwater as a source in terms of quality and quality (i.e. high iron content). This WTP was designed for a population of 18000, mainly returnees from the 1994 genocide. The neighboring Ntoma WTP was commissioned by a different non-governmental organization (NGO) shortly after the construction of the Nyabwishongwezi WTP. It is said to have been a "blueprint copy" of the Nyabwishongwezi WTP; mainly differing in the fact that the water is pumped from the river intake to conventional rectangular (horizontal-flow) sedimentation basins, in contrast to the batch (i.e. fill-draw) storage tanks of the Nyabwishongwezi WTP. This is followed by two-stage up-flow gravel pre-filters and slow sand filters.

Field visit outcomes/findings

Despite having no terminal disinfection, the finished water produced by the MSF system in Nyabwishongwezi was substantially better in terms of turbidity and microbiological quality in comparison to the polluted source water (Figure 1). The water quality assessment was done in conjunction with the plant operating staff that received water quality training during the first field visit to the system in 2002. However, some design/operational problems were also noted (Bertrand et al., 2003; Dorea et al., 2004), some of which could be simply remedied (e.g. floating outlets to storage tanks, drainage system for gravel pre-filter cleaning); while others would require a substantial investment (e.g. adequate intake structure, insufficient number of gravel pre-filter units).

Figure 1: Improved water quality along MSF system (samples from: raw water, settling tank, pre-filter, slow sand filter – left to right).

Subsequent visits to the Nyabwishongwezi WTP in 2003 and 2004 saw improvements with regards to the simple deficiencies. It was also noticed that the continuing operation of the WTP was being affected mainly by issues relating to the tariff system. There was a low revenue collection due to seasonally low water usage (i.e. rainy season). Notably, the tariff system (by demand of local authorities to comply with National tariff model) did not factor the depreciation and replacement of items (e.g. diesel pump). Moreover, by 2003, the increase in fuel costs, attributed to the events occurring in the Middle East, was already affecting the community's capacity to purchase diesel to run the pumps. A final visit to the system revealed that the Nyabwishongwezi system was not operational due to the breakdown of the pumps.

The Ntoma WTP shared as well many similarities in terms of design shortcomings that could have been avoided with consultation. Most notably was the choice of sedimentation basin. Conventional rectangular (horizontal-flow) settling basins require a constant flow in order to be effective. However, due to the positioning of the WTP and the topography of the region a constant supply of water would require a non-stop pumping regime; which is unfeasible for this type of rural scheme. Unfortunately, no information on the operation of this water treatment plant was available, as it is said to only have operated for the two days in which the implementing NGO was present (Dorea et al., 2004)!

CASE STUDY 2: EMERGENCY "CLARIFIER" IN INDONESIA

Oxfam Field Up-flow "Clarifier"

The supply of safe drinking water during disasters can be compromised and is one of the top priorities in public health interventions that must be reestablished to prevent the spread of disease. When the speedy establishment of adequate water supplies is beyond the capacity of local authorities, emergency response and equipment from external relief agencies can often provide timely interim solutions while more durable long-term repairs are being planned. The Oxfam Field Up-flow Clarifier Kit is an emergency water treatment kit that is one type of treatment option deployed to emergencies in the event of disasters (Dorea et al., 2006). The Clarifier relies on the principles of up-flow blanket clarification and is driven by a single pump; requiring only fuel and aluminum sulfate, which are typically widely available. Detailed description and performance of the Clarifier is available elsewhere (Dorea et al., 2007).

Study area

Following the Asian Tsunami of December 2004, two Clarifier units were deployed to the affected villages of Lamno and Meulaboh on the island of Sumatra (Indonesia). In Lamno, pre-coat (diatomaceous earth) filters were being used for emergency relief water supply. Yet, the effectiveness of these units was being compromised by the increasing turbidity of the source river, due to the approaching of the monsoon season. This prompted the installation of an Oxfam Field Up-flow "Clarifier" Kit to aid in the water production in May 2005 (Dorea et al, 2007). In Meulaboh a unit had already been installed, but required optimization and operator training.

Field visit outcomes/findings

Operator training was provided for the unit installed in Lamno before being handed over to the local Public Health Engineering. It was later reported that high turbidities could be effectively reduced to the recommended potable drinking water limits (i.e. below 5 turbidity units), as per Sphere Project (2004). Such unit was still running for more than two years when it was last visited in 2007. On that occasion it was noticed that the (unskilled) operators had been successfully running the Clarifier with only the training received when the unit was installed (Figure 2). The unit installed in Meulaboh was also visited and optimized. Operators there received training in field jar-testing for coagulant dose determination, as explained by Dorea (2007). Simple concepts delivered in the training proved to be effectively assimilated by the operators. A sign of this was that during a 103 day (unsupervised) period following the training, the logged Clarifier performance revealed that the treated water turbidity was always below recommended potable drinking water limits (Dorea et al., 2007).

Figure 2: Operator training on simplified jar-test procedures for coagulant dose determination.

CASE STUDY 3: EMERGENCY BATCH WATER TREATMENT IN PAKISTAN

Emergency batch water treatment

Batch mode emergency water clarification is usually carried out in storage tanks by adding the coagulant (e.g. alum) the incoming water. Once the tank is full, the water is left to settle; after which the settled water is then decanted, stored, and disinfected prior to distribution. Despite limited process control, turbidities in the hundreds can be reduced to what is considered to acceptable by the Sphere Standards, i.e. < 5 NTU. This is a simpler (in comparison to the Clarifier) and most common form of emergency water treatment (Dorea, 2007).

Study area

In the aftermath of the October 8 2005 earthquake in Pakistan two rural filtration systems were visited in the Jehlum Valley region near Muzaffarabad (AJK, Pakistan). Both plants were similarly designed and operated by the local governmental water authority. Of the two, the Gahri Dupatta WTP was the worst hit; having its pumping station, settling basin and slow sand filters structurally affected. Further upriver, the Hattian Bala WTP was still operational relying on an undamaged slow sand filter bed. Both systems relied on river abstraction by pumping in to plants consisting of baffled hydraulic flocculators followed by conventional rectangular sedimentation basins and slow sand filters. Whilst the rehabilitation of the Gahri Dupatta treatment plant was being commissioned, the damaged settling basin was by-passed and alum-assisted batch emergency sedimentation tanks were used for the emergency relief efforts (Figure 3).

Figure 3: Emergency batch sedimentation tanks used in Gahri Dupatta.

Field visit outcomes/findings

A few design issues were observed, particularly with regard to the choice of sedimentation basin and pre-treatment method for the slow sand filters. Similarly to what was observed in Ntoma, the location of the WTP on a hillside should have proscribed against the choice of settling basin. The electric pumps operated intermittently due to the constant power shortages experienced in the region (even before the earthquake). Such operating regime most likely would have caused the stirring up and carry over of previously settled particles into the slow sand filters every time the flow was started; thereby shortening the duration of the filter runs. In addition, the choice of an alum-based pre-treatment method was perhaps not ideal considering the rural settings and availability of other non-chemical pre-treatment techniques (i.e. gravel or roughing filtration). Anyhow, it was noticed that operators in both plants assimilated well the simplified jar-test procedures for coagulant dose determinations, as had been observed previously in Indonesia. Prior to the training sessions, the operators would add the entire daily coagulant "requirement" was added at once directly into the incoming flow of water in the baffled flocculator. Noting that the alum "requirement" was arbitrarily decided depending on the perceived color of the river.

SUMMARY AND CONCLUSIONS

The case studies presented give abridged descriptions of research/field work with appropriate technologies for water treatment in developing countries. In the field visits where rural supply schemes were encountered (Rwanda and Pakistan), the importance of proper design and adequate choice of treatment unit processes (e.g. sedimentation basin) is illustrated. Such examples of *by-the-book* designs are great, but only if they fit within the local context and can be properly operated as recommended *by-the-book*! In the context of areas with limited resources, coagulant-based water treatment processes are not viewed as appropriate technologies; such was the case observed in Pakistan. However, experiences also indicated that in extreme circumstances, such as in the aftermath of disasters, local (and mainly unskilled) operators can successfully operate coagulant-based processes. Noting that these were short-term measures only utilized whilst a supply of chemicals was available from the implementing aid agency. The main key to the successful operation of these systems in emergencies was the adequate training and capacity building of operators. Finally, another non-technical factor to take into account when selecting a technology is the cost-recovery of the running expenditure. This should include in the tariff system for the successful long-term operation of a water supply scheme.

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13 Decentralized cooperation and management of urban services in southern countries: an application on water supply services in Senegal.

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Abstract
Drinkable water crisis is since the seventies a concern shared worldwide, especially in developing countries urban areas.
Since the early eighties, international organisations and non-governmental organisations (NGO) are leading several initiatives trying to solve the problem within frameworks involving central states (between developed and developing countries), and by the early 90' between local authorities in the framework of decentralized cooperation.
The goal of this paper is to show that public-private partnerships model involved by the World Bank and the IMF in developing countries have shown their limits in urban services management, drinkable water particularly. We assume that an alternative model based on decentralized cooperation and a strengthening of local authorities capabilities may widen quality water access in low prices, especially for poor citizens.
Our analysis will be organized around institutional economics and collective action theories in order to analyse socio-economics dynamics in drinkable water issues for developing countries.

Keywords:
Urban services, drinkable water policies, decentralized cooperation

INTRODUCTION

This thesis work follows our master's dissertation in which we analysed ten years of public-private partnership in urban water management in Senegal. We shown that even if the efficiency's goal was attempt, social and spatial discrimination increased during this period. In this frame our interrogation was how authorities can improve water access for poor people living in poor parts (not always illegally) of developing countries cities? Therefore, decentralized cooperation and its proximity-based model interested us as a new way to reinforce solidarities and knowledge transfers as stated in 3rd World Water Forum in Kyoto.

Since the late 70's the issue of urban planning and services access in developing countries is at the heart preoccupations of various agencies and actors at diversified levels of interventions from national to the international area.

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Today, the issue continues to interest political and theoretical debates because cities in developing countries records most raised demographic rates in the world (today's tendencies are around 4% per year). Because of their high population growth these countries are facing institutional and material difficulties to assure access to urban services to the people, drinkable water[48] especially. According UNDP projections, by the year 2020 more than the half of African population will live in urban areas, and authorities will face growing problems if nothing is done.

According to some authors (Jaglin & Dubresson 1993; Jaglin 2004; Dubresson 2004) problems that faces cities in developing countries can be understood under two ways: demographic pressure, due to both natural growth rate and the phenomenon of rural population exodus to cities on one hand, on the other to the urban territories sprawling as a result of population growth which that the size of the African cities does not stop increasing.
These phenomena coupled with the lack of regulatory authorities in these areas often located in suburb facilitate for us, the disorganization of urban space and network services in developing countries.

To face the issue of network services access in developing countries, drinkable water and sanitation in particular, several programmes were thought by countries and international organizations. In the early 80's, an ambitious programme (*International Drinking Water Supply and Sanitation Decade*) involving states and several international organizations (governmental and non governmental) tried to ensure access to water "for all" by the year 1990. However, the results of this vast programme have not been commensurate with the investments made, what some authors (Breuil, 2004) attribute to a bad coordination between the evolution of structures and institutional reform within the framework of this project and those who follow.

By the early 90s, the speech of international organization is going to change; the objective is not any more to assure the access to water for all, but trying to insure access for the largest number (Baron, 2006). This situation constitutes according to us a backing on behalf of states and international organizations in front of the scale of the problem.
The failure of the drinking water and sanitation decade goals' and the disappointment of developing countries national government, subjected to rigorous structural adjustment programmes[49], changed urban policies in developing countries.

Since the 90s, Bretton-Woods institutions (IMF and World bank) and other partners of developing countries focused their speeches around decentralization. It's in this context that will be launched in 1992, the Municipal Development Programme between the developing countries and donor organizations. This new strategy oriented towards decentralization is seen by some (Stern, 1991) as a way to find new financial resources and a more efficient scale of intervention after the depletion of previous strategies.

[48] Access to drinkable water is characterized by domestic connection to the network or modes of collective supplies (standpipes or other water sources) available on a reasonable distance from home, estimated at 200 meters (Jaglin, 2001).
[49] Period of budgetary austerity imposed on developing countries by the Bretton Woods institutions to "consolidate public finances and bring fiscal stability in highly indebted states. Some authors These programmes are institutional process resulting from the adoption of economic and financial agreements by developing countries with Bretton-Woods institutions. Developing countries accept reforms programme in exchange of financial assistance...

This work's aim is to analyse the interaction between local policies of water accessibility management and international decentralized cooperation and its consequences on urban territories organization and water access improvement. Decentralized cooperation refers to the international action of local governments in North/South or South/South exchanges and projects run by international NGO subsidized by local governments.

Method and hypothesis

Our work will consist in analysing this frame of action where speeches and practices on urban areas are in perpetual evolution, to see how the actors situated at different levels of intervention, going of the international to the premises, coordinate their strategies to produce a policy tending to resolve the imbalance existing in the access to the drinking water on urban segregated territories (Baron, 2006).

It will also ask how local actors appropriate, adapt or throw back imported models so called " ready to manage " by Dubresson (1993), proposed by donors (IMF, World Bank) or local partners in the North, but their efficiency leaves sceptic some (Damiba, 1996).

The research method includes a bibliographic review, official documents analysis, interviews and questionnaires to relevant actors. The expected result is an evaluation of decentralized cooperation stakes and above all a discussion on new opportunities of collaboration between developed countries local governments and those of developing countries in urban services improvement, especially water accessibility.

We shall try to report this phenomenon through the literature of these last twenty years on the problem of the access to the urban services in developing countries, in Africa in particular, their stakes in spatial engineering (Jaglin, 2004) and of reorganization of the urban space in search of a " good urban governance " (Baron, 2006); but also the modalities of price determination of the water which, for some, has to be made by the market to reflect the real cost of the water and allow an effective allocation of the resources (Thobani, 1995; Camedessus, 2003), whereas for the others (Shiva, 2003) this trade drift is on the base of the disparities in access to water services which must be considered as a public good (Patrella, on 2003; on 2004).

Participatory mechanisms will be analysed in their implementation in the context of the daily ways that communities (NGO's and users association) organize themselves and local governments international cooperation practices for water management. The goal is to identify new ways of collective action and new institutional organization that make it possible to integrate decentralized cooperation in water issues solution.

We shall try to confirm or deny certain assumptions in this work:

- Does decentralized cooperation at the same time it allows communities to improve the water access management is not going to be a way of accentuation of existing disparities between urban spaces and populations, on territories already characterized by an mosaic form of organization (Baron, 2006)?
- How the decentralized governments, within the support of international cooperation, can improve the participation of the local actors (who have a deeper insight of populations' difficulties) in establishing a solution to the problems of access to water in a " bottom up " model?

Evolution of water sector policies

The reforms that followed the structural adjustment policies lead to the end of free service in water and national government's subsidizes. This change in the management of drinking water services in developing countries joined the concerns of the World Bank which considers within

the framework of Global Water Partnership that water is an economic good that it is necessary to value and to distribute by taking into account granted investments and profits removed from equipments.

The International Conference on Water and Environment (Dublin 1992) stated: "for all its different uses, water has an economic value and should be recognized as an economic good". According to this report, "the non-recognition in the past of the economic value of water drove to wasting and harmful practices for the environment of the resource…."

It's on the basis of this principle that developing countries led changes in their water policies with the establishment of public-private partnerships (PPP).

The emergence of a new model of public management

The "depressed" context of post-Washington consensus (Petiteville, 1995) in developing countries allowed to local authorities the opportunity to put in profit their new attributions in foreign actions and engage North/South decentralized cooperation relationships.

The increasing openness of the international relations to non-governmental actors (after the fall of Berlin Wall) and the broadcasting of decentralization model as well as in northern and southern countries participated to the spread of decentralized cooperation [example: French Law of 1992 that legitimised international actions of local authorities and Britain's "Local government overseas assistance" Law in 1993]. These legal devices will permit local governments to become more emancipated from national authorities and to set up economic strategies in their field of competence.

In Africa, the trend towards decentralization is carried by International organizations such as World bank to ensure on one hand a more efficient management of public services and on the other hand to reduce public deficits by transferring at the same moment some revenue and expenses to local authorities.

In a context of spreading of "local governance" concepts (World Bank, on 1992), several African countries under structural adjustments constraints subscribed to this model heavily recommended by international financial partners; that will be the case of Mali (by a law of February 11th, 1993 determining conditions of the free administration of regions and their autonomy) and Senegal by the adoption of Local Government Code in 1996.

It is important to wonder about the impact of transformations intervened since the early 90's (which are ongoing) both in speeches and practices on the urban territories in developing countries, especially dealing with water sector.

This period (the 90s) is also that of the circulation of a "hybrid" model of public management: the *New public management*, which associates public and private stakeholders in public-private partnerships (PPP). The generalization of this model is going to follow in the importance, which was given - at the end of the year's 80- to the participation of users in costs recovering of water services and in commons generally. Thus, international community in New Delhi (1990) and Dublin (1992) conferences on water and environmental stated:

- The diversification of services (a little for all is better than a lot for little)
- The association of users and decision-makers at all levels of decision
- The end of the free services, giving the water an economic value…

It's in this circumstance that at the World Water Forum in Kyoto (2003) public assistance is put at the centre of improvement of water policies, especially in developing countries. After the market regulation and less state model advocated in the 90s shown its limits, it was

necessary to find a balance between the market and the State (or the decentralized communities) to assure fair access water for populations, particularly for the poor. According to the recommendations of the Forum, this solution has to go through a strengthening of international solidarity that must be manifested by the development of decentralized cooperation in water sector, support NGOs and associations' actions, and Private sector engaged in developing countries.

Decentralized cooperation and water services management improvement

To us, decentralized cooperation can help local authorities of developing countries to reinforce their management capacities, especially in water services supply for poorest citizens.

For example in France, local governments have already competences in the management of urban services and space too. And in the frame of Oudin Law (2005), which allow them to engage international actions in water access and sanitation programmes, they can help developing countries local authorities to improve their technical and political skills in urban territories management.

We will try to show how decentralized cooperation can help northern countries, local authorities especially, to anticipate on problems that they might face in the future, as water resources allocation will generate more and more competition between territories and populations usage (household, industries, agriculture…).

According to Graham and Marvin (2001) splintering urbanism is a consequence of the less state model that strengthens urban networks fragmentation and the failure of state regulation. Decentralized cooperation, bye the close relations it creates between partners can help developing countries to overcome these issues and lead toward social and spatial equilibrium in cities services access, especially drinkable water.

CONCLUSION

Water access services is one of the most discussed issue in international meetings nowadays. This research tries to bring a new comprehension of international practices in water management, especially how developing countries can improve their urban management to guarantee a fair access to water services.

By the combination of theoretic framework (collective action and institutions economics) we will discuss the consequences of decentralised cooperation in urban services management in developing countries. We also try to show how decentralized cooperation can favour the emergence of new collective action both at local and international scales.

In this research we assume that to ensure fair access to drinkable water at low cost (as declined in the Millennium Development Goals) to urban population, it should be necessary to strength local actors "capabilities" (in the sense of Amartya Sen, 2000) so that local governments would be able to regulate socio-spatial organization of urban services, access to water in particular. For us, public-private partnership model has shown its limits and a new model with a stronger role for public institutions is essential to ensure social investment and spatial equilibrium.

The results of ongoing research (literature review, interviews and land practices observation) will allow us to confirm or deny our presumptions.

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14 Strategic management tools and governance structures in urban water services – a research proposal for Mexico

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Abstract
Urban water supply in developing countries poses a growing challenge for the complexities of the processes involved, as well as for the extent of the potential consequences of the persistence of the ongoing problems. In the case of Mexico, during the last decades, a set of changes and adjustments in terms of the institutional environment can be identified, which however have led to the emergence of a set of varied institutional arrangements in the local level. In this paper, a research project is proposed. First, a brief hystorical analysis is proposed, in order to identify possible traces of the institutional environment's evolution, in reference to the different responses implemented within the States and Municipalities. Secondly, a more detailed analysis is suggested, in order to explore the role of performance evaluation as a means for ensuring internal and external transaction efficacy, where the operator's management performance as an agent should be assessed in terms of the effective, equitable and sustainable attainment of the system's objectives; the conception and implementation of a strategic performance management tool is proposed, both as a governance enabling device and as a learning tool for the researcher and the organization.

Keywords
Management; new institutionalism; decision support systems; sustainable development; developing countries.

INTRODUCTION

Urban water provision poses a major challenge in developing countries, since a large part of the population lives in medium-sized and bigger cities, whose water sources are becoming each day more scarce and menaced by pollution and competition with other users. There is a need for building new infrastructure – mainly for waste water collection and treatment –as well as for substituting older installations and equipments; in general, investment costs and even operating ones are not sufficiently recovered and administrative practices don't always lead the systems to a sustainable operation; the lack of both career stability and competitive remuneration prevents the consolidation of a strong work force in this sub-sector; organizational structures and regulations don't always support good management practices; water users and citizen's concerns are also usually disregarded, leading to vicious circles of distrust and lack of support and attention. Simultaneously, the lack of adequate practices for land use development, solid waste management and risk prevention, complicate the urban water system's environment. In this context, facing the challenges introduced by the need for moving towards an integrated urban water management model, which should adequately incorporate sustainable development issues, would pass through the improvement of management practices, even for revising urban water governance structures.

The challenge of urban water supply in Mexico

Mexico is a federal, representative and democratic republic, with elected authorities in the Federal Government, 31 State governments, the Capital city – *Distrito Federal* – and 2438 Municipalities. By the Constitution, water belongs to the Nation and the federal authority – through the National Water Commission (CNA, for its Spanish acronym) – concentrates the most relevant jurisdiction attributions, both in water management and in water supply regulation, while State authorities show very different capacities, structures and scopes in this field. Since 1983, the Municipalities are supposed to be primarily in charge of the operation and development of every water supply and sanitation system, in urban and rural settings – including the nearly 190 000 population centers or *localidades*, 98% of which have less of 100 people and are located in rural dispersed areas –, with the subsidiary help of State authorities, theoretically in exceptional cases.

Presently, 550 cities house more than 15 thousand inhabitants each, accounting for 62.8% of total population in the country; amongst them, 123 cities have a population over 100 000 inhabitants, where 11 cities house more than a million people (INEGI 2005). Institutional arrangements for urban water supply and sanitation are quite heterogeneous. Since the transferal of operating responsibilities to the municipal authorities, the possibility for the State authorities to take charge of the systems remained, when justified by the lack of local capacities, but in some states the process had different outcomes. Presently, in about two thirds of the 31 federated states it is the State authority that rules and manages urban water systems; in the other, these services have been transferred directly to the municipalities more than 10 years ago; some urban areas have inter-municipal utilities and in some other, state dependent public operators are in charge of local urban water systems; very few systems have been delegated to a private operator and even a mixed firm exists. Federal government, by means of the CNA, still keeps control of some relevant budgetary and normative levers, while State authorities strive for gaining wider normative, supporting or even operating capacities.

Institutional diversity in urban water management in Mexico could be seen as the result of a series of successive implementation of policies facing a rapid urbanization process – Mexico's population grew from less than 25 millions in 1950, of which only 47% lived in cities with more than 2500 inhabitants, to more than 103 millions in 2005, with 76.5% of urban population (CNA, 2007b). Influence of different policy paradigms, remarkably those of "new public management" in late 80's, introduced policies seeking to implement decentralization, private sector participation, market mechanisms, as well as better accountability and social participation mechanisms. The most important reform undertaken, the constitution of municipal operators structured as semi-independent public enterprises – with their own accounting, assets and governing bodies –, has shown very uneven results, while CNA has kept a double role, in one hand as a "counterpart" of Municipalities and States in setting up the "master plans" and co-financing related investment actions, which were expected to improve water supply's efficiencies and coverage, and in the other, as the regulatory agency in charge of inspecting users' practices and enforcing law for water rights administration and water quality control, among many other functions. Attempts to implement private sector participation have failed, remaining very limited in number and scope and mainly being promoted for financing long-term supply and treatment facilities (Pineda-Pablos, 2002; Castro, 2007).

In terms of results, even when urban water and wastewater collection coverage is rather high – over 95% for cities with more than 2500 inhabitants, while 94.7% for sewage connections–, less than a half of the population has continuous supply (BM, 2006), while wastewater

treatment accounts for only 36.1% of collected flows, with very variable efficiency levels (actually removing less than 24% of total DBO generated); besides, invoice collection is estimated around 81% of total billed consumption and unaccounted-for water is calculated in 42%, which renders a global efficiency under 50% (CNA 2006, 2007a). Sustainable provision of water services is threatened simultaneously by the financial, administrative and technical weaknesses of municipal operators and by the rapid reduction of reliable water sources, the deterioration of watersheds – in 30 years, the number of overexploited aquifers has tripled, potentially affecting 60% of groundwater sources in the country, while 47.8% of surface waters are considered as polluted or heavily polluted in terms of their COD levels (CNA, 2007a) –, the growth in conflicts between users, the reduction of subsidies and the growing competition for financial resources. It is expected that, in the year 2030, 53% of the population will live in 35 cities with more than 50 000 inhabitants, mostly concentrated in the central and northern parts of the country (CNA, 2007a) – where sources are becoming scarcer and conflicts more frequent; in the future, more than 100 million people would be affected if the present condition persists in the urban water supply sector. The need for setting up a proper integrated urban management model seems to be a difficult task but also a potential tool for sorting out from this complex situation.

One research question that could be posed is why, under similar institutional environments, so many different institutional arrangements have emerged throughout the country. In some states, as Guanajuato, water supply is under the jurisdiction of each of the 46 Municipalities; in some others, as Querétaro, the State authority operates water supply systems throughout its territory, with the exception of one city; in others, like Baja California, there is a State-dependent operator in charge of the city of Tijuana – one of the best managed water supply systems in Mexico – while in others, like Nuevo León, the inter-municipal operator of the capital metropolis, Monterrey, is growingly taking part in the development of services in other cities in the State, including rural ones. Talking about private sector participation, the failure of this policy – in terms of its objectives of attracting investment capitals, extending services to the poor and liberating public funds while improving efficiencies in concessioned systems (Castro, 2007) – could have been a matter of a failure from the part of regulating bodies, a consequence of the difficulties for implementing new tariff structures or of the paralysis facing the sharing of risks (Breuil & Nakhla, 2003), but a more detailed analysis could be worthy. Specifically, the very different nature of institutional environments from the countries whose models have inspired the private participation schemes from the 80's, in terms of their stability and the relative simplicity of their operation should be analyzed – since those models aren't probably well suited to face problems like urban development lawlessness or the need to build extensive infrastructure, circumstance which could perhaps explain the good performance of privatization schemes (such as in England) or leasing contracts (such as in France) in those settings. Disregarding the public or private nature of the capitals involved in the extension and the operation of urban water systems, it is true that municipal operators, in spite of the reforms implemented in the 90's aiming to transform them into public enterprises, are now jammed in a system of overlapping relationships of normative, supporting, cooperative and subordinating nature dealing with its federal, state and local counterparts. As Breuil (2004) describes it, public urban water supply is characterized by the absence of a formal contractual framework and thus of specific objectives, where self-control predominates and a strong political interference remains in price setting. Moreover, if dissecting water supply and politics has been seen as naïve (Schwartz & Schouten, 2007), due to "water sector realities" in developing countries, from the figures and perspectives presented, the need for finding alternative ways for improving governance structures and institutional settings seems well justified.

Understanding the origin and dynamics of the institutional diversity in the Mexican water sector, both from the national context and from the local specificities, in particular for trying to identify some clues or paths from the analysis of the institutional arrangements in place in different settings, seems to be instrumental for opening ways to the design of innovating public policies in this sector. By its own nature, as well as because of the long-term questions raised by the quest for integrated or sustainable management of urban systems, two kinds of questions can be posed. First: Is there a relationship between the evolution in the institutional environment, the governance structures and the systems' capacity to ensure a sustainable provision of water services in the urban context? And second: Is there a place for strategy formulation and strategic management within such a complex setting as the one we have in developing countries? In other words, what have been the feasibility, the role and destiny of strategy formulation and implementation in this context? Would the implementation of a strategic performance management process help to improve learning about the issues linked to the transformation of a governance model in sake for improving the system's sustainability? In this paper, a research proposal is outlined for addressing these issues.

THEORETICAL FRAMEWORK AND METHODS

Rationale and proposed methodology

The primary aim of this research is to analyze the relationship between governance structures and performance in the context of a set of Mexican urban water supply operators, specifically focusing on the role of information and strategic performance management processes and tools. In a first stage, a thorough revision of the origins and characteristics of a selected set of urban water supply governance structures within the country would be undertaken. Then, since urban water supply is a long term subject, the actual and potential role of strategic management processes – or, eventually, the absence or the obstacles for implementing such kind of processes – would be studied. In a second phase, the implementation of tools for strategic performance management – a strategic scorecard, dashboard or control panel, developed through a participatory and recursive process of selection of indicators, evaluation and feedback – is envisaged as a potential mean for exploring the main issues affecting governance in urban water supply, both from an environmental as from an internal institutional approach.

New institutional economics is proposed as the basic theoretical framework for this research (Williamson, 1996; Powell & DiMaggio, 1991; Ménard, 2003), complemented with the exploration from a cognitive approach to contract theory (Girin, 1995) and strategic management (Bouvier, 2004) and from stakeholder theory (Freeman, 1985). A specific approach of *intervention research* is suggested, where the presence and eventually the implementation of management tools is considered as a structuring and learning device capable of revealing unattended knowledge about "organizational operation, the piloting of transformation and the exploration of new [courses of action]" (Moisdon, 1997; 2006). In this case, the eventual implementation of an adaptation of a *Balanced Scorecard* (Kaplan and Norton, 1992) or *tableau de bord* kind of management tool is being considered *a priori* as a potential pivot for a second phase of the field exploration; a specific process for the implementation of a strategic performance management tool would be used to analyze the transit towards a different governance model, in which an adequate consideration of stakeholders' criteria and priorities should be incorporated, as well as the proper sustainable development criteria.

In terms of a definition of the problem, an adequate articulation between its components should be attained. First, departing from a historical and a field analysis from a neo-institutionalist approach, some hints and orientations about the relationship between governance structures, institutional arrangements and environment should be obtained, from the exploration of how the different transaction classes identifiable within the Mexican water sector are translated into governance structures, partially as a response to the implementation of sector-wide policies, as well as specific to each local setting. Secondly, the actual and potential role of information sharing, performance assessment and strategic management would be explored more deeply in at least one case, taking into account the cognitive and relational aspects of the issue. A general model for setting up a strategic management tool would be proposed, with the triple objective of incorporating sustainable development and integrated management criteria, allowing stakeholders participation in the systems construction and operation, as well as considering a flexible form for elucidating preferences and aggregating performance indicators, according to the multi-user, multi-criteria nature of this kind of system.

It most be pointed out that previous works have shown the potential of new institutional economics for the analysis of urban water supply's issues, mainly around the evaluation of reforms where the collectivity has the choice (or has been given the choice because of the reforms) between public management and delegation to private operators (Breuil, 2004; Fauquert, 2007; Guérin-Schneider 2001; Ménard and Shirley 2001; Ménard and Saussier 2002). These are valuable sources for the construction of an analytical grid, without loosing sight of the more general intention of this project, in terms of the scope of institutional arrangements that are envisaged to be studied.

Building an institutional analysis grid

The construction of the analytical grid is in process to the date this proposal is being written. In general terms, new institutional economics would furnish a conceptual grid which should be useful to analyze, through a historical exploration as well as through an in-depth field analysis, the relationship between the changes in the institutional environment – mainly those related to the evolution in the resources related to urban water provision and the implementation of specific policies, projects, organizational structures and constraints –, and the local responses in form of specific institutional arrangements, from which a set of transaction and assets characteristics, as well as their contractual implications, would be proposed (Baudry, 1995).

For characterizing the kinds of transaction present in urban water supply and sanitation, a model for identifying the nature of the agency relationships would be proposed from the cognitive approach of J. Girin (1995), in which each kind of mandate – whether it is clear or difficult to make explicit – and each kind of task – according to its inherent degree of difficulty – calls for a different interaction between the agent and the agency – that is, a different transaction kind – which implies different follow-up devices and different suitable indicators (Table 1).

We propose to characterize as different transactions each of the main functions to be performed by the urban water operator as an agent, where the nature of the task and even the kind of mandate would vary according to the institutional environment and arrangements. That is, one specific function which would correspond to a clear mandate for performing a simple task in a specific institutional environment can turn into a *confuse* function (difficult to make explicit) or involve a more difficult task in another institutional environment or even in another moment in institutional environment's or in the agency's relationship evolution – perhaps because of the cognitive structure or the information imbalances between the parties, the

complexity of information sharing procedures and decision making rules, the gap between present and required capacities and the nature of the assets involved in the performance of the task.

In terms of transaction costs economics, the kind of mandate and the nature of the task are related to the simultaneous presence of bounded rationality and opportunistic behavior (since a complex task and a confuse mandate would perhaps leave more space to agents for getting informational rents), and thus, each urban water function could be related to different levels of transaction costs and, for each setting, indicate whether an institutional arrangement would leave more or less place for failures in the system's governance.

A very important requisite for performing this kind of exploration is to test a definition of specific agents, functions, means – conceived as the set of resources available to each agent to perform the required task – and communication channels for interacting with the principal. An agent transforms resources into service outputs while being subject to a set of constraints, and leading the organization to a different state of value as perceived by its stakeholders. Another fundamental dimension for the analysis is the extent to which reliable data will be available, in order to allow a numerical analysis of the transaction costs which should ideally lead to effectiveness and efficiency analyses, including the effects of the delays related to performing tasks of similar complexity under different institutional settings.

TABLE 1: Relationship between kinds of mandate, difficulty of the tasks, transaction interactions and suitable numerical indicators.

	Kind of mandate			
	Clear		Confuse [a]	
Nature of task:	*Simple*	*Complex*	*Simple*	*Complex*
Initial interaction	Precise specification of mandate		Vague declaration of mandate. Responsibility limitations. Definition of means.	
Intermediate interaction	State of advancement	Intuitive estimates of advancement	Precise accounts and reports. Evaluation of committed means.	Simplified accounts and reports. Evaluation of committed means.
Final interaction	Results evaluation		Precise accounts and reports. Eventually, construction of results.	Simplified accounts and reports. Construction of results.
Numerical indicators	Advancement. Results.	Results.	Activity	

a. Difficult to be made explicit.
Source: adapted from Girin (1995).

In principle, it seems to us that this kind of analysis would help explaining why some contractual models work right in stable environments linked to precise definitions of means and expected results, even when the tasks involved are complex, while in other settings they tend to fail or lead to institutional deadlocks. It seems worthy to undertake an exploration of the communication processes having place between citizens, urban water users, mediating parties, municipal authorities, the directive council, the operator's management and even the State and Federal legislative and executive branches of government which take part in some of the core management processes for urban water services provision – such as tariff setting and approval, budget allocation, demand for information, legal inspection and evaluation activities.

Moreover, it could be useful for exploring the cognitive issues linked to the principal-agent relationship and, instrumental for the purposes of this research, for assessing the potential role of information and management tools and systems within governance models, necessarily conceived as contingent to the local cognitive and institutional characteristics.

Strategic Management Tools and Governance

As it was suggested before, the conception and implementation of a tool for piloting the strategic performance management of a urban water supply system is considered as a potential way for bringing out a deeper learning on the way the related management process are structured within the organization's operation, on how the transformation takes place and even on how new emerging issues can be dealt with, within an intervention research model oriented to the revelation of unattended aspects of the processes under study, rather than trying to verify a specific hypothesis (Moisdon, 2006).

Nevertheless, from a previous exploration of these issues, it has become apparent that conceiving performance piloting tools could contribute to the construction of a consistent governance model, in terms of its capacity for reacting to external and internal constraints, "mobilizing a panel of tools belonging to three key dimensions: the contractual, the institutional and the social ones", while satisfying the system's overall objectives (Breuil, 2004, p. 272). From an initial exploration stage, setting up a tool similar to the Balanced Scorecard (Kaplan and Norton, 1992) would seem appropriate to take into account the objectives different from the value of the firm that can be suitable in the case of a water operator, being a monopoly which must fulfill several performance criteria under a set of constraints. For instance, facing the arguments of the stakeholder theory (Freeman, 1984), it has been proposed to utilize an "enlightened balanced scorecard" to bring the agent an aggregated measure of performance, so to allow him to better choose the appropriate levers for improving performance (Jensen, 2001). Of course, the way the strategy is elicited for incorporating it to such a kind of a scorecard, the issues related to the aggregation of performance measures and stakeholders preferences' elicitation processes, the inclusion of sustainable development objectives – perhaps even beyond the preferences of present stakeholders – are issues that must be explored, specially after a first field research stage will have been performed. Moreover, taking into account the usual effects of the implementation of any management system within an organization, even the professional and identity processes should be addressed and analyzed.

A sustainable development framework

In principle, a working definition for incorporating sustainable development to strategic management in urban water services can be that proposed by the ECLAC (1991, 24-25): "[Sustainable Development implies] a dynamic balance between all capital forms or assets that participate in the effort of economic and social development of the countries, in such a way that the resultant use rate of each capital form does not exceed its own reproduction rate [...] Among the most important capital forms, the following can be highlighted: the *human* capital (where people also represent the development subject), the *natural* capital, the *institutional* assets (decision systems), the *cultural* assets, the *physical* capital (infrastructure, machineries and equipment) and the *financial* capital"[50]. In spite of trying to analyze the consequences of the operator's activities on a set of economic, social and natural environment indicators, we propose to explore the tracking of the state, pressures and dynamic response of these resources categories, as they appear to the operator's as being available and behaving in their system's environment and as they would be consumed or transformed within it; the rationale would be that, as long as the utility can dispose of these resources in a sustained way, while not contributing importantly to their imbalance for the rest of the organizations belonging to the same system's environment, its chances to perform in a sustainable way will be greater.

[50] In (Sandoval & Palombo, 2007), the use of this definition is proposed as a reference for performing a self-assessment exercise of a urban water supply system's sustainability.

For the rest of the project, a fundamental orientation could emerge from this model, in terms that the agent would be expected to perform the set of tasks defining urban water services in a specific context – some of which would be likely to be expressed in precise terms, some of them not – making use of a set of resources and subject to the constraint of not depleting or increasing/restoring some of these related resources. In terms of the analysis of the consistency between means and expected results, this definition can furnish an analytic grid, useful for assessing the associated difficulty degree and, at the same time, since the fulfillment of the objectives of the system is related to the extent to which the agent satisfies the stakeholders' expression of an aggregated "function".

In terms of the implementation of a scorecard or a dashboard, it can be noted that there have been prior attempts to use the Balanced Scorecard to incorporate the evaluation and alignment of social and environmental concerns to the long term strategic management of a firm (Figge *et al.*, 2002). Indeed, the "four perspectives" proposed in the Balanced Scorecard model can be identified with the set of sustainability resources from the ECLAC's definition. The problem lies on the procedure for assessing whether the firm's performance has effects on its economic, environmental and social value in a balanced way. Regarding the participatory nature of a shared construction of a strategy, a self-evident requirement if an alignment between the agency's and the principal's objectives is to be attained, it has also been proposed to explore different methods for incorporating tacit knowledge from expert workers into the strategy formulation to be integrated in the scorecard (Abernethy *et al.*, 2005), which could also be useful to include the external stakeholders perceptions into the model. Anyway, the relevance and appropriateness of building and implementing such a model in the context of the proposed resarch remains to be tested and defined during the process of analysis.

INITIAL INSIGHTS FOR THE DEFINITION OF THE RESEARCH FIELD

The institutional environment

At a first stage, some basic elements of the institutional environment in Mexico's water supply sector should be identified. The field of research would consist, in an initial phase, of the analysis of the evolution of water supply institutional environment and the identification of the emergence of different institutional arrangements in some specific local settings. Figure 1 shows a graphic inter-linkage between the emergence of the different administrative public bodies which were expected to take

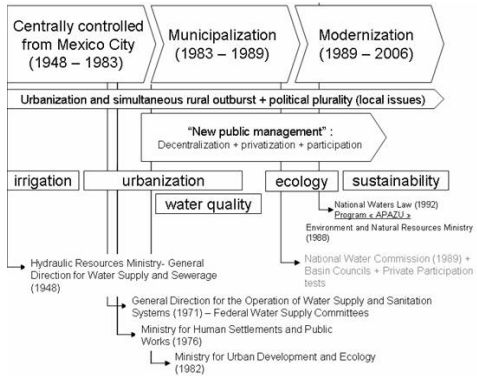

Figure 5 **Institutional evolution in Mexican water supply sector** (author's construction based on Pineda-Pablos 2002)

charge of urban water infrastructure development, as long as urbanization and political plurality grew throughout the country, while different external frames of reference were also were exerting a strong influence in policy making, which was being mainly conceived and implemented from the federal offices in charge of the issue (Pineda-Pablos, 2002).

An emphasis should be put on analyzing the last 25 years, from the municipalization wave and the related public tax and expenditure reforms. The rationale and the policies implemented to create and promote the evolution of municipal operators built as public firms, with a participatory governing body and a supporting scheme of master plans and financing programs would be analyzed in terms of their impact on investment in the sector and the evolution of a set of different cities. Although there are no homogeneous and complete sources of information on the different public and private investment in urban water supply for that period (1983-1989), at least a set of general trends would be sought. For the last period, the adaptation of the chosen cities and States to the evolution in demographic variables, socio-political and financial environments, related to their outputs and performances, is expected to reveal some key processes regarding the role of the structuration of the relationships between collectivities and operators. A detailed exploration should be made in order to elucidate whether some public policies can be considered as *institutions* in terms of their stability, degree of abstraction and generality and their normative character; their implementation devices and processes should also be analyzed.

A possible set for analyzing the proposed evolution would include:

- Querétaro State, where state authority still operates water supply systems in every municipality but one; the capital city's performance is amongst the best in the country.
- Coahuila State, where there is a supporting state authority, as a mediator between federal and local authorities; the city of Saltillo has now a private participation scheme based on the constitution of a mixed enterprise with interesting outputs.
- Morelos State, where a supporting state authority has recently been created
- Aguascalientes State, whose capital was object of the first important integrated concession of water services to a local partner of Véolia
- Quintana Roo State, where the state authority still controls municipal water supply, with the exception of Cancún, where there is a concession to a local partner of Ondeo.
- Baja California State, where the city of Tijuana, operated by a state-dependant operator, is reputed to be the best managed water utility in Mexico.

A detailed analysis in terms of the performance indicators available, the institutional characteristics and comparability criteria would help to approach this analysis with more pertinence and precision.

After a first stage, where the evolution of public policies in terms of their institutional consequences and the emergence of local arrangements would be analyzed, in a second stage some elements would be sought to study which of these local responses have led to a more effective attainment of social goals. An identification of the core concepts for an institutional analysis would be instrumental, that is, the principal-agent relationship, the governance structures, institutions or micro institutions (Ménard, 2003), the rules and the implementation devices constituting the institutional environment. A selection of three representative cases – for instance, one where water supply would have been mantained under the centralized control of the State authority, another one where municipalities rule the services and a third one having a mixed structure – is envisaged to delimit the research's scope.

Inherent to the idea of exploring alternative governance structures in terms of their comparative effectivenes for attaining social goals, there is the idea of defining in a broader fashion a urban water supply system's objective structure, taking into account the expected outputs in terms of quality and reliability of services, but also its performance *vis-à-vis* sustainability issues, that is, the way in which the system affects the resources whose utilization right is exerted by the agent and the internal equilibria concerning the utilization and complementarity of those resources, based on the definition presented in the previous section. This formulation leads to the idea that the agent should need, in order to guide his decisions towards a better overall long-term integrated performance of the system, an aggregated way for evaluating the consequences of those decisions. The existence (or the absence) of information systems or procedures leading to this kind of integrated evaluation of performance is considered as a potential analytical pivot for exploring governance mechanisms, as they imply internal and external transactions and interactions with internal agents and with external stakeholders. Therefore, the implementation of a strategic management tool could serve as an auxiliary research learning device to explore and follow-up how the effectiveness of transactions could be improved in a specific case. The collaboration with a consulting firm to conceive and set up a model of Balanced Scorecard for water utilities is envisaged, in which consensual bottom-up evaluation of performance and specific performace criteria, related to water supply sustainability, would be sought[51].

EXPECTED RESULTS

This research project could show different outputs:

- It is expected to shed light on the origin of governance structures for urban water supply, whose diversity facing a similar policy context calls for an thoughtful exploration
- A relationship between different local governance structures and performance, in terms of the transactional facilitation leading to effective, equitable and efficient results, in a sustainable fashion, would be sought
- The role of performance monitoring in internal and external agency relationships would be explored, if possible undertaking a process of "governance engineering" by the conception and implementation of a strategic dashboard as a tool for revealing a deeper learning of the organizational implications of performance steering in relation to effective governance.
- Ultimately, a more general model for the analysis of governance structures in urban water supply and sanitation, even a specific proposal of a model linked to the implementation of a strategic management tool could be proposed.

CONCLUSIONS

New institutional economics, in one hand, seem to furnish a powerful analytic grid to explore whether some institutional arrangements show a greater effectiveness and, in that sense, if some kind of orientation in terms of public policy conception and implementation can be obtained. In the other hand, reflecting on the implications of embedding sustainable development issues in the definition of the overall objectives of a urban water supply system, thus constituting the broad "mandate" to the operator, conceived as the agent, leads us to the exploration of strategic performance management as a way to improving transactions effectiveness and, in principle, as a possible device for reaching a deeper learning on how agency relationships occur within the organization and in its interactions with the external

[51] In González *et al*., 2006, a model proposed for a South American water operator is proposed.

stakeholders. Being at an initial stage, this research can still be better outlined, specially when fieldwork comes.

Urban water supply in Mexico, for the challenges it poses to the Nation's development, can help raising important questions about the ways public policies can favor institutional environments enabling more effective transactions towards the sustainable fulfillement of social goals. Performing the proposed exploration can shed a light to overcome the complex problem of ensuring an efficient long-term provision of urban water services, which affects a very large part of the population of the country.

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15 Urban wastewater reuse for irrigated agriculture in Jordan: Soil sustainability, perceptions and management

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Abstract
Jordan is a country with very limited water resources and urban treated domestic wastewater offers a valuable contribution to the country's water balance. Water reuse is particularly well-suited to irrigated agriculture, for which water is in constant demand. The physical characteristics of the water (high organic content and solute loaded) mean that suitable soil management strategies, such as periodic leaching and nutrient management are required to maintain soil productivity and prevent the accumulation of plant toxic solutes. The effect of water reuse on soil sustainability was investigated by means of soil sampling and analysis combined with interviews with farmers and organisations involved with water reuse. The results reveal that the perception and knowledge of the water is important in the process of decision making as to the relevant management strategy to be applied. The research stresses that maintaining soil sustainability when reusing water is imperative for agricultural development in Jordan and achievable through water management both on and off the farm.

Keywords
Perception; sustainable development; urban water; water management; water re-use

INTRODUCTION

Water scarcity is a growing problem across the world as greater pressure is placed on the available water resources. Rising populations require more freshwater for drinking, domestic uses and particularly for food production. Irrigated agriculture is essential to sustain the increasing populations and in arid and semi-arid lands it commonly absorbs a majority share of the freshwater resources. The countries of the Middle East are facing some of the greatest water shortage problems in the world. The available resources are significantly lower than the potential demands placed on them by industry, agriculture, tourism and domestic uses. Jordan, at the centre of the Middle East, is one of the most water scarce countries of the world. With only 497 cubic metres per person per year (FAO Aquastats, 2008) it is well below the official criteria for water scarcity of 1000 cubic metres per person per year (Winpenny, 2000).

There are three principle ways which water scarcity can be alleviated. Firstly, through the development of new resources through the construction of dams, desalination of sea water or by exploiting deep groundwater resources. Such schemes typically involve hard engineering and technological developments and tend to be expensive. Secondly, through water demand management which aims to lower the demand for water by encouraging water saving devices and reducing water use in the home, in industry and in agriculture. Thirdly, by reusing urban domestic wastewater after it has been treated. Treated wastewater is particularly well suited for agriculture as it often contains significant quantities of plant essential nutrients like

nitrogen, phosphorus and potassium. The strong psychological aversion to reallocating used water to domestic needs also drives the use of treated wastewater for irrigated agriculture.

In Jordan water reuse is taking place on a grand scale. 65 per cent of households are connected to a central sewage system (Water Authority of Jordan, 2007) which means that about 80 million cubic metres (MCM) of wastewater are produced annually (Vallentin, 2006). This constitutes just under 10 per cent of Jordan's 850 MCM of renewable water annually. The majority of this is produced at the Kirbet As Samra treatment plant located 30 km east of Amman (the capital of Jordan). Figure 1 is a schematic diagram showing the domestic to waste to irrigation water pathways in north-west Jordan. It shows that the majority of the wastewater coming from Amman is sent to the Kirbet As Samra treatment plant. After treatment the water is released to the Zarqa River, where it flows down to the King Talal Reservoir. From the reservoir it is then released as required to be used for irrigation in the Jordan Valley (a major agricultural area). The use of the water is split between that consumed directly around the treatment plant and that used indirectly (after significant transportation and the seasonal addition of natural surface runoff) in the Jordan Valley.

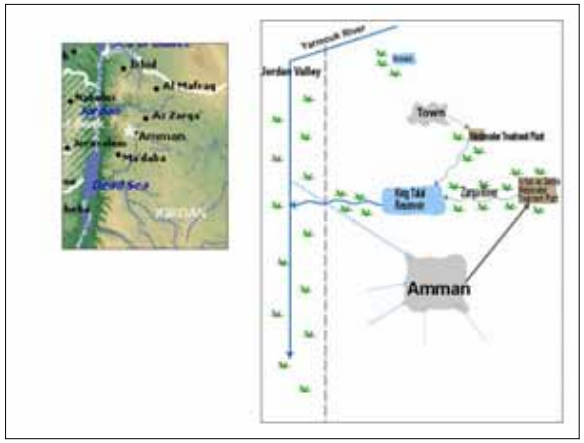

Figure 1 Schematic diagram and corresponding map of the water pathways in north-west Jordan

Water has been reused successfully in Jordan for several decades and the aim of this research is to investigate the sustainability of this practice in terms of both the effects on soil and the ability of people to manage and mitigate these effects. Water management is increasingly emphasising the importance of an holistic and interdisciplinary approach to overcome the water challenges of the 21st century. The need to incorporate social considerations with technical planning is frequently discussed, yet in reality it is often limited or lacking. This research seeks to emphasise that combining research from the social and physical sciences is both easily accessible and highly profitable in terms of research findings for water management issues.

METHODS

To reflect the interdisciplinary nature of the work several different research methodologies

have been utilised. These included soil sampling and laboratory analysis, mathematical modelling to further understand the processes affecting the soil and semi-structured interviews with stakeholders involved with water reuse.

Soil and water sampling and analysis

In this work it was hypothesised that soil irrigated with treated wastewater would have a greater quantity of ions such as sodium (Na^+), chloride (Cl^-) and boron (B^+) which are plant toxic in high quantities. These solutes enter the water through the use of domestic cleaning products in which NaCl and B are often present (Patterson, 2001; Reuben, 2004; Reuben, 1965). The limited availability of domestic water in Jordan leads to high concentrations of solutes which are not removed by standard treatment methods, and so when applied to the soil with the irrigation water over time, they can accumulate. Accumulation leading to soil salinisation is of particular concern in arid and semi-arid regions because the high rates of evapo-transpiration require large quantities of water to be applied to meet the crop water demand. The water is used by the plants or evaporated from the soil surface resulting in large quantities of salts becoming deposited in the soil. The accumulating ions can only be removed through the application of excessive quantities of water and the subsequent dissolution and transportation of the salts down through the soil profile. The accumulation of salts in the plant root zone jeopardises plant health and productivity and it may reduce the quality of the soil structure and lead to reduced soil fertility. The careful management of saline waters is required to prevent high levels of salts accumulating which threaten the sustainability of the soil system.

Soil sampling was conducted at several localities in Jordan to compare sites with higher and lower precipitation rates, with different qualities and quantities of irrigation water and with the application of management methods such as leaching. Soils were sampled from a number of depths in the soil profile down to 50 cm. Water samples were also collected at the same localities as the soil sampling in order to compile corresponding data on water quality.

Analyses were conducted to determine the salinity and pH of the soil through saturating a known quantity of soil with ultra-pure water and then removing this water by suction following the method suggested by Rowell (1994). The removed liquid (the soil saturation paste extract) could then be analysed to determine the overall salinity (electrical conductivity) of the extract (ECe), the pH, the quantity of major cations (e.g. sodium, potassium, calcium, magnesium and boron) using ICP-AES, and the quantity of anions (e.g. chloride, bicarbonate, phosphate, sulphate) using ion chromatography. The EC and pH of the water samples were measured in the field using hand held instruments and sub-samples were also collected for analysis using ICP-AES and ion chromatography.

Mathematical modelling

Modelling soil salinity changes through the use of treated wastewater offers a way to determine the sustainability of agriculture. The Hydrus model (Šimůnek et al, 2005) is currently being applied to identify long-term salinity changes, leaching water requirements and therefore determine the overall water requirement for maintaining soil productivity.

Semi-structured interviews

Extensive semi-structured interviews were conducted with 56 farmers and 29 organisations who work with treated wastewater. The aims of the farmer interviews were to gauge the perceptions of the water, to identify perceived and real problems and benefits and to document local knowledge of how the water is managed to minimise adverse effects on crops and soil. To investigate the differences in perception and management between farmers reusing the water directly close to the treatment plants and those using it indirectly in the Jordan Valley time was spent interviewing farmers in three different locations. In the Jordan Valley, around Kirbet As Samra wastewater treatment plant and around Ramtha wastewater treatment plant (in the northern highlands). At each locality a variety of farmers were selected with an even distribution of those managing large farms with access to secure export markets through to those cultivating small holdings producing crops for the local market. The interviews were conducted in the field via a translator with advanced knowledge of Jordanian agricultural systems. Notes were taken during the interviews and often a tour of the farm was given to clarify and explain management methods and issues. The interview notes were typed up and expanded according to memory immediately after the interviews. Each data bit (piece of information) within the interview transcript was then coded and grouped according to its code. This method meant that similarities and discrepancies between the farmers became clear and factors that were frequently mentioned or ignored became highlighted (Kitchin and Tate, 1999).

The organisation interviews were held with individuals working actively in the field of water reuse in the private sector, governmental, non-governmental and research institutions in Jordan. These interviews focussed on the perception of wastewater, but also covered wider management and implementation challenges, priorities for future research and management directions. These interviews were conducted in English and were either recorded or notes were taken during the interview. They were transcribed immediately after the interview with additional observations and comments. For analysis they were coded according to various themes and the coded data was analysed to identify similarities and differences between the individuals and the organisational groups. Quotes were identified for each theme and compiled together in order that narratives could be developed on water reuse from the perspective of the organisations.

RESULTS

Water quality

Table 1 shows the composition of water samples collected in 2006 and 2007 from Kirbet As Samra research station. The electrical conductivity (EC) is used as a measure of salinity and the treated effluent in Jordan typically has an EC of 2 dS m^{-1} which guidelines suggest gives the water a slight to moderate restriction to use (Ayers and Westcott, 1985). Of greater concern is the concentration of chloride in the water, which can reach 400 mg l^{-1} and which exceeds a recommended maximum concentration of 350mg l^{-1} (Ayers and Westcott, 1985).

TABLE 1: Selected parameters of the water samples from Kirbet As Samra and the Jordan Valley

Location	Month and year of sampling	Solutes detected in the water (mg l^{-1})			Additional Parameters			
		Chloride (Cl)	Sodium (Na)	Boron (B)	Electrical Conductivity (EC) dS m^{-1}	pH	Sodium Adsorption Ration (SAR)	Total Organic Carbon (TOC) ppm
Kirbet As Samra	Nov 2006	440.05	253.30	1.03	2.04	8.12	5.64	n/a
Kirbet As Samra	May 2007	174.25	265.31	0.84	1.68	7.83	6.68	10.97
Jordan Valley - Deir Alla	May 2007	299.54	173.21	0.55	2.09	7.50	4.12	9.45

Soil sustainability

Results from sites irrigated with reclaimed water for known lengths of time reveal that salts do accumulate from water reuse. Figure 2 shows salinity data from an experimental site irrigated with known quantities and qualities of water for two consecutive years. The data show that after one year of irrigation the salinity of the soil increased dramatically relative to a non-irrigated control. However, at the end of the second season the salinity dropped. This is probably a result of the greater number of higher magnitude rainfall events in the second year which contributed more freshwater over a shorter time, leading to increased solute leaching.

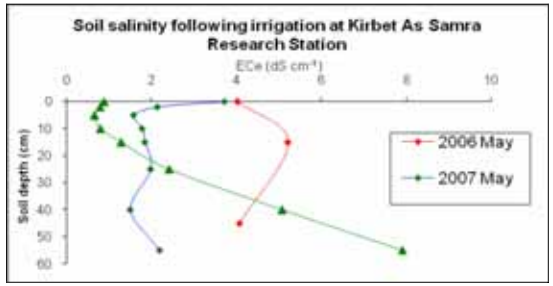

Figure 2: Soil salinity (ECe) at Kirbet As Samra research station

From the experimental data, especially those collected after just one year of irrigation, it could be hypothesised that soil salinity rises with wastewater irrigation and that rainfall is essential in maintaining suitably low soil salinities in the plant root zone. Yet figure 3 shows data collected from a farm irrigated with reclaimed water for almost 3 decades. These data have been collected from a locality that has had no freshwater input for 28 years, yet the soil salinity has been maintained at a level very suitable for crop production. These data emphasise that with good management, soil solute accumulation can be avoided. For comparison, soil salinity data from an olive plantation irrigated for 18 years is shown. This shows higher soil salinity in the top 50 cm than in the site irrigated for 28 years, which demonstrates that the soil salinity will rise if leaching is not practised. The deeper rooting depth of the olive trees mean that such high salinity in the soil surface is not detrimental for the plant productivity.

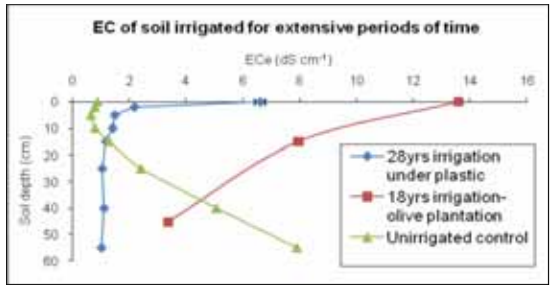

Figure 3 The salinity of soil from farms irrigated with wastewater for extensive periods of time

Interviews

Farmer interviews. The results of the soil analysis emphasise the importance of management methods in maintaining soil productivity and the farmers interviewed were all asked about the management strategies they employed. It was clear during the interviews that there is a distinct difference in the perception of the water and the use and management of the land between the direct water re-users and the indirect re-users.

A typical comment from a direct re-user was, "*I like the wastewater because before the treatment plant there was no water for supplementary irrigation. I make more money now.*" Directly around the treatment plants the water is being used for the continuous production of fodder crops such as barley, clover and maize. The yield is sold to diary farms in Jordan and can earn the farmers a substantial income. All farmers around the treatment plants were aware of the beneficial plant nutrients within the water and said how they usually did not add additional chemical fertilisers to the soil which gave them considerable financial savings. It also became clear during the interviews that the farmers felt able to speak with the staff of the wastewater treatment plant if they required any information about the water or if they had any concerns. One example was frequently given of how large amounts of chlorine were previously being added to the wastewater before it was released from the treatment plant. The chlorine was damaging the crops and so the farmers spoke with the plant manager to ask him to reduce the quantity of chloride. Action was taken to reduce the chloride additions and irrigation was able to continue successfully without detrimental effects on the crops. No farmers reported any soil salinity issue and most associated the management of this potential risk to the use of flood irrigation around the treatment plants. This results in large quantities of water being applied to the soil regularly giving plenty of leaching of solutes down through the soil profile.

By comparison, the indirect water re-users had a more negative opinion of the water. Typical comments such as, "*The water has bad things in it for the plants, there are no good things.*" "*The water quality is bad. There is a high pH and there are many soil born pathogens that come with the water and attack the plants.*" These negative opinions may occur for several reasons. Firstly, the Jordan Valley has historically been irrigated with freshwater from the Yarmouk River. As more and more of this water is redirected to Amman for domestic purposes the freshwater has been replaced by the treated wastewater coming from Kirbet As Samra. Older farmers therefore remember the past when good quality freshwater was available. Secondly, the land of the Jordan Valley is mainly used for the cultivation of high value vegetable and fruit crops. Soil pathogens are both common and very costly to farmers through lost productivity. Any potential for increased risk to the crop, however unscientifically proven, is understandably viewed negatively.

The management methods in the Jordan Valley primarily involve leaching and soil solarisation (a method of sterilising the soil using the suns radiation during the summer). Most farmers spoke of the importance of leaching to maintain soil productivity and they said how they aimed to leach annually prior to planting at the start of the season. However, they also said that they rarely have enough water to leach adequately and so are forced to leach either only a small section of their land or to abandon leaching altogether. The low availability of water when it is needed was attributed to both the very limited water resources of Jordan and the weak management of the available resources by the responsible government agency. Farmers were asked if they are able to save money on chemical fertilisers because of those contained within the water. Few farmers recognised any benefits in the form of nutrients coming from the water. Even those who had been trained about the nutrient value of the water admitted to adding chemical fertilisers so as to ensure a good harvest. The cultivation of nutrient demanding vegetable crops in the Jordan Valley and the intensity of cropping also leads most farmers to the decision to add chemical fertilisers, sometimes in excessive quantities.

Organisations interviews. The interviews revealed that 50 per cent of organisations recognised

that damage to soil was a risk from water reuse yet none of the organisations considered that water management to reduce this risk was a priority for sustainable development of agriculture using wastewater. The organisations instead spoke frequently of the importance of monitoring to check for adverse effects from irrigation with wastewater. They spoke of a need to train farmers how to manage this water and of the need for more research to provide information to decision makers. All the organisations considered water reuse to be important because of the limited availability of water and its corresponding importance for Jordan's water strategy. Only 7.5 per cent of organisations spoke of the positives from water reuse such as the nutrient benefits.

An issue of considerable importance in Jordan is the allocation of water to different agricultural types and geographical localities and particularly the potential conflict between the direct and indirect water re-users. This was identified by several of the organisations working to develop agriculture in the international and NGO sector.

> *"But then there's another challenge coming up. Because the (waste) water quality is better the farmers upstream are more interested in it so it could happen that the water doesn't even reach the Jordan Valley. Although the farmers (in the JV) have their water rights. This is a bad thing for the livelihoods of the farmers, and also you have to ask why invest in uphill farming when there's no farming there at the moment. This threatens groundwater resources and damages the good market advantage that the Jordan Valley has during the winter. Because the uphill farming is summer farming. They don't get as much money as the farmers in the Valley as there's a market gap there. It's always an economic decision what or where the water is used. And if they come up with these ideas of growing industrial crops it would be a disaster."*

> *"The water that comes from the Kirbet As Samra means that agriculture can continue in the Middle Jordan Valley. And if this stops the situation will be very bad, I cannot imagine, because there is no water for agriculture. And even from a social and economic point of view, water here, is the only guarantee for the sustainability of agriculture."*

It would seem that the topic of water allocation between the indirect and direct agriculture is worthy of serious discussion by planners and decision makers.

CONCLUSIONS

The interdisciplinary work allows us to draw several conclusions with regards to the sustainability of water reuse. The soil analysis has shown that water reuse for irrigation does alter the soil salinity but it is very important to notice that the salinity changes are highly dependent on several factors such as the quantity of water applied, the rainwater inputs and especially the management methods used on the farm. For this reason it is very important that laboratory results and field experiments are not extrapolated directly to the farm. It is essential that the farmer's knowledge, his perception of the water and the management methods that he chooses to apply are considered when assessing the effects of water reuse on soil. The decisions make by stakeholders away from the farm are also very important in the sustainable management of water reuse and it seems that many organisations do not realise their role in maintaining soil productivity through water management off the farm. It is expected that water reuse for irrigation will increase in the future as greater volumes of urban wastewater are produced, collected and treated. The allocation of this water between direct reuse around treatment plants and indirect reuse at distance from the plants is worthy of considerable discussion as there are disadvantages and benefits of each system.

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16 Evaluation of industrial wastewater properties and microbial diversity to improve power generation in Microbial Fuel Cells

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Abstract
Microbial Fuel Cells can be used to generate electricity from organic matter present in industrial wastewaters. This study compared four different types of industrial wastewaters (bakery, brewery, paper and dairy) for bioelectricity generation. The relationship between wastewater characteristics, bacterial diversity and power output was determined. Paper wastewater produced the highest current yield (0.25 mA), at least five times higher than dairy (0.05 mA), brewery and bakery wastewaters (0.02 mA). Such high current production was independent from the substrate degradability measured as chemical oxygen demand. A comprehensive study was conducted to determine the key difference driving current production for the paper effluent versus others. Results from the microbial diversity revealed that bacteria specifically developed in MFCs according to the type of wastewater used. Electrochemical analysis by cyclic voltammetry showed than the MFC operated using paper wastewater produced an electron shuttle compound with a red-ox potential of -0.12 V vs NHE. It was also proven that the paper wastewater bacteria producing the electron shuttle compound were able to be transferred to MFCs using brewery and dairy wastewater resulting in a six times improvement in current generation.

Keywords
Industrial wastewaters, anaerobic treatment, electron shuttle mediator, microbial fuel cells, microbial diversity

INTRODUCTION

Wastewater treatment is a worldwide requirement to ensure community sanitation and conservation of natural resources. It is reported that over 10 billion litres of wastewater are daily produced by England and Wales requiring approximately 6.34 Gigawatt hours of energy (POST, 2007). As wastewater production increases and discharge standards become stricter, conventional wastewater treatments demand more energy. The application of technologies that can generate energy from sewage is a possible solution to reduce energy consumption and increase sustainability.

Wastewater is potentially useful for generating energy since it is rich in organic matter. Obtaining methane as biogas from sewage or sludge is a widely-practised technology for energy production (Lastella et al., 2002, Aiyuk et al., 2006). Other alternatives that have been explored are hydrogen or ethanol production from sewage (Venkata Mohan et al., 2007, Hipolito et al., 2008). An alternative wastewater treatment technology to directly generate electricity from wastewater is Microbial Fuel Cells (MFC). MFC have the advantage to overcome storage and further processing of fuels (methane, hydrogen or ethanol) decreasing number of operations. However their application is regarded as to complement rather than

substitute other anaerobic treatment processes (Pham et al., 2006). MFC technology uses microorganisms as catalysts, to produce electrons from organic matter. The reactor configuration used is similar to a fuel cell system with a proton exchange membrane dividing an aerobic and anaerobic chamber. Each chamber contains an electrode called “anode” for the anaerobic chamber and “cathode” for the aerobic chamber. Wastewater flows through the anaerobic chamber where microorganisms oxidize the organic matter producing electrons, protons and carbon dioxide. Electrons are collected by the anode of the MFC, and protons migrate to the aerobic chamber through the proton exchange membrane (Rabaey et al., 2004, Lovley, 2006). Electrons pass through an electrical circuit generating energy, and merge in the cathode with oxygen and protons generating water (Davis and Higson, 2007). By-products of the process are mainly: water and carbon dioxide.

MFC have proved to be able to produce energy from wastewater effluents with high organic matter content, such as sanitary wastes, food processing wastewater, swine wastewater and beer processing wastewater (Du et al., 2007) indicating that MFC are suitable to treat a variety of sewages. However, very little attention has been given to the MFC limitations imposed by the substrates used and direct literature comparisons are difficult, due to the different reactor conditions used. Wastewater characteristics affect the rate of organic matter degradability and the microbial ecosystem; as a consequence the rate of bacterial electron transfer and the overall MFC process efficiency are defined. The determination of how wastewater characteristics affect the anaerobic chamber mechanisms will increase the understanding of the mechanisms affecting electron shuttle rates and will allow exploring alternatives for the MFC control and optimization according to the type of wastewater used.

In this work we studied and compared the effect of using different industrial wastewaters (bakery, brewery, paper and dairy) in bioelectricity generation from MFC using identical single chamber reactors. The relationship between different wastewater characteristics, bacterial diversity and power output was determined.

MATERIALS & METHODS

MFC assembly and operation

Eight novel single chamber MFC reactors were constructed. Reactors consisted of a 45 ml anaerobic chamber with a carbon cloth anode in one side of the chamber. In the opposite side the cathode was assembled with an open gate to use oxygen from air. The cathode was made of 20% wet proof carbon toray paper coated with a gas diffusion layer consisting of Ketjen Black (1.5 mg/cm^2) and 10%wt PTFE, and, a layer of Pt (5 mg/cm^2). A proton exchange membrane was assembled to the cathode by hot-pressing (130^{o}C, 1500 kg/cm^2) for 5 min. To collect electrons and protons a stainless steal mesh was used in the cathode external side. Anode and cathode were connected using a stainless steal wire and an external resistor box fixed at 1000 ohms (closed circuit). Before use, all reactor components were autoclaved and/or sterilised for at least 15 min. MFC were sampled and refilled using a sterile syringe, through a septum installed in the top of the reactors. MFC were operated all the time in batch mode and at closed circuit except when polarizations and cyclic voltammetry experiments were done (cells were at open circuit). Samples collected from reactors were immediately stored at -20^{o}C.

Inoculum and wastewater samples

Experiments were done in duplicates using four different effluents sampled from bakery, brewery, paper and dairy industries located in the North East England, UK. Immediately after collection, wastewater samples were stored at -4^{o}C. Before use, wastewater samples were adjusted in terms of COD (around 600 mg/L) by diluting some wastewater streams with

autoclaved tap water. After COD calibration, wastewater samples were analysed for anions using ion chromatography (Dionex ICS-1000). Then, pH was adjusted to neutrality using either HCl or NaOH (1M) solutions. Table 1 shows the final characteristics of the wastewater samples used in MFC reactors. Wastewaters were flushed with nitrogen for 15 min before being added to MFC reactors.

The source of inoculum used was anaerobic sludge since microbial diversity investigations have shown that mixed cultures achieve greater power densities than pure cultures (Logan et al., 2006). Anaerobic sludge was collected from an anaerobic digester at Hexham Municipal Sewage Treatment Plant, Northumberland. One millilitre of sludge was added for batch 1-5 (microbial enrichment period).

Table 1: Wastewater Characteristics

Wastewater	Dilution	COD	Anions (ppm)				Conductivity
	(ww/totalw)	(mg/L)	Fluoride	Chloride	Phosphate	Sulphate	(µS/cm)
Dairy	2.5/10	700	n.d.	138	6	31	832
Bakery	0.65/10	651	12	11	6	8	79.6
Brewery	0.65/10	661	1.3	5	3	10	180.6
Paper	10/10	600	n.d	189	n.d.	241.3	1397

n.d.= non detectable

Laboratory Analysis

Electrochemical Measurements: MFC current generation was recorded every 5-15 min using a data acquisition system (ADC 16, Pico Technology Ltd, UK) connected to a personal computer via a BS 232 Pico high resolution analogue cable. During the experiment MFC reactors were polarized using a variable resistor box (starting at 1 mega ohm and finishing at 50 ohms) by decreasing the resistance stepwise, pausing at each resistance for about 1 min. The current density and power densities were calculated according to the literature (Logan et al., 2006). To determine the electroactivity of the MFC system, cyclic voltammetry (CV) was performed in all reactors using a potentiostat (Autolab Potentiostat PGSTAT303, The Netherlands) interfaced to a personal computer, in the potential range of -500 to 0 mV. The MFC anode was used as the working electrode, the cathode as the counter electrode and Ag/AgCl as reference electrode. Prior to analysis, background currents for the individual elements of the MFC were studied at the scan rates used (working electrode, electrolyte and inoculum at 25 mV/s, 10 mV/s, 5 mV/s and 1mV/s); no peaks were found for all samples.

Chemical Measurements: The pH was determined using a digital pH meter (Model 20, Denver instruments Ltd). Concentrations and soluble chemical oxygen demand (COD) were estimated according to standard methods. Volatile fatty acids (VFA) were quantified by gas–liquid chromatography (Unicam 610 Series Gas Chromatograph with auto-injector and PU 4811 computing integrator). GC conditions were as follows; carrier gas - nitrogen at 20 mL min^{-1}; column temperature - 140°C, detector temperature - 180°C, injection port temperature - 180 °C; column dimensions - 2000 mm long × 2 mm internal diameter; glass packed with 10% AT-1000 on 80/100 Chromosorb W-AW; detector - flame ionisation detector.

Bacteria Community Analysis: Anode biofilm was sampled using a sterile spatula and resuspended in 1ml of sterile potassium phosphate buffer (100 mM, pH 7.0) 250 µl of the anode biofilm suspension was preserved by addition of an equal volume of absolute ethanol and stored at -20°C until analysis. Total DNA was extracted from the fixed samples, using a Fast DNA Spin Kit (BIO 101, Q-BioGene, UK). After DNA extraction, polymerase chain reaction (PCR) was conducted in 50 µl reaction volume containing 47µl of PCR mega mix blue (Microzone Ltd., UK), 1 µl of Vf-GC GC-clamp CCT ACG GGA GGC AGC AG, 1 µl of Vr ATT ACC GCG GCT GCT GG and 1 µl of DNA (Muyzer et al., 1993). PCR amplification was performed in an automated thermal cycle (Hybaid, Omn-E). Then, bacterial community profiles were obtained using denaturant gradient gel electrophoresis (DGGE) (Curtis and Crane, 1998). Stained gels were viewed and documented using a Fluor-S Multilmager (Bio-Rad, Hercules, CA, USA). Images obtained were processed using the Bionumerics software package (version 3.5, Applied Maths, USA). Bionumerics was used to determine the position and intensity of bands in DGGE profiles in relation to markers run alongside samples in the gel. Dice cluster analysis was performed for MFC reactors using bakery, brewery and paper wastewaters (Verseveld and Roling, 2008).

RESULTS & DICUSSION

MFC reactors were operated at closed circuit using different types of wastewaters (bakery, brewery, paper and dairy) for approximately 300h (Figure 1). Maximum current outputs were achieved after 200 h of electrochemical bacterial enrichment, equivalent to five process batches (Figure 1). For the two batches after enrichment, there was a high difference in current output between MFC using paper wastewater (0.25 mA) and all other wastewaters (less than 0.05mA). Interestingly, COD removal measured in the last batch was very similar for dairy (81.6% ± 0.03), brewery (85.2% ± 0.07), bakery (85.5% ± 0.04) and paper wastewater (77.5% ±0.02). This suggests that while secondary reactions (e.g. bacterial growth) are taking place in all reactors, electrochemical processes are being favoured in the reactor containing paper wastewater.

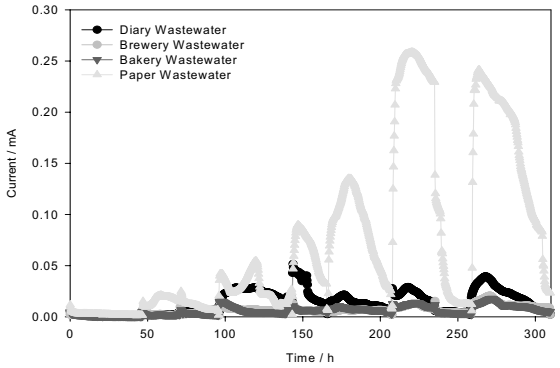

Figure 1: Current Production in MFC reactors using different types of wastewaters

The degradation of organic compounds in wastewater through MFC is analogous to an anaerobic digestion where hydrolysis, fermentation (or acidogenesis) and methanogenesis are the key stages (Metcalf and Eddy, 2003). Hydrolysis is related to complex substrate degradation. For this experiment, hydrolysis can be linked to COD removal results to discard this step as being a limiting factor for energy production. After hydrolysis, substrates are further degraded by fermentative pathways. Fermentation produces partially oxidized compounds known as volatile fatty acids (VFA). Results for the last batch indicated that VFA were not accumulated through time for any MFC reactor (Figure 2). This behaviour can be explained through methanogenic bacteria using VFA to generate methane or electroactive bacteria consuming VFA to generate electricity, as recent literature suggests (Lee et al., 2007).

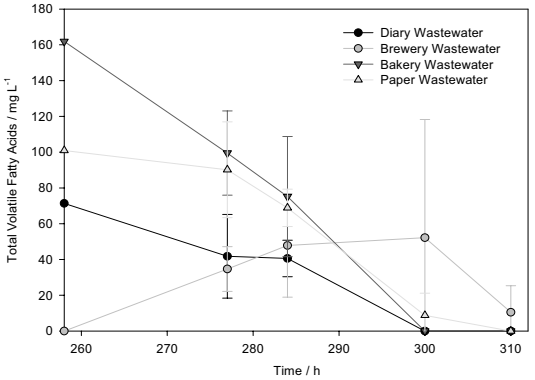

Figure 2: Total Volatile Fatty Acids produced by MFC fed different Industrial wastewaters.

An open circuit experiment was conducted after the closed circuit ones were finalized, to obtain the maximum power output and voltage losses (Figure 3). Paper wastewater produced the maximum voltage (500 mV) indicating a high electroactivity. It also produced the maximum power density (60 mW/m^2) during polarization and had a constant rate of voltage fall. For all other reactors there was a steep voltage drop implying a higher polarization/ electron transport resistance hence low power densities were obtained. This confirmed the low electrochemical activity in MFCs using other substrates than paper wastewater.

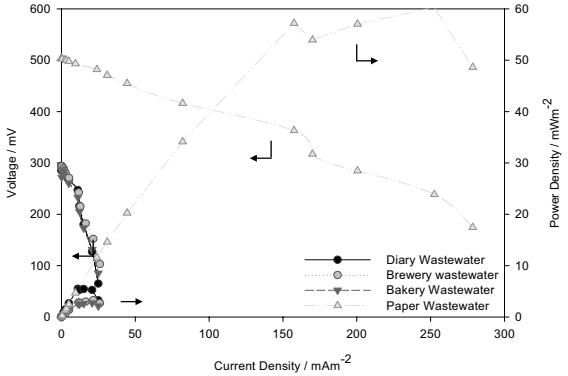

Figure 3: Power densities and voltage losses for MFC reactors using different types of wastewaters.

To determine whether the different wastewaters conductivities (refer to Table 1) were affecting the current output further experiments were performed at closed circuit. Prior to reactor feeding, wastewaters were conditioned with phosphate buffer (PBS) to a concentration of 50 mM. This increased and normalized wastewaters conductivity to 7100± 300 µS/cm. As a consequence, all MFC reactors increased their current production by 0.02 - 0.04 mA (Figure 4, b). This showed that current output increases by decreasing the resistance of the anaerobic chamber electrolyte (wastewaters) which is consistent with previous studies (Cheng and

Logan, 2007). Moreover, these results proved that conductivity was not the cause of the current differences within the different wastewater types used.

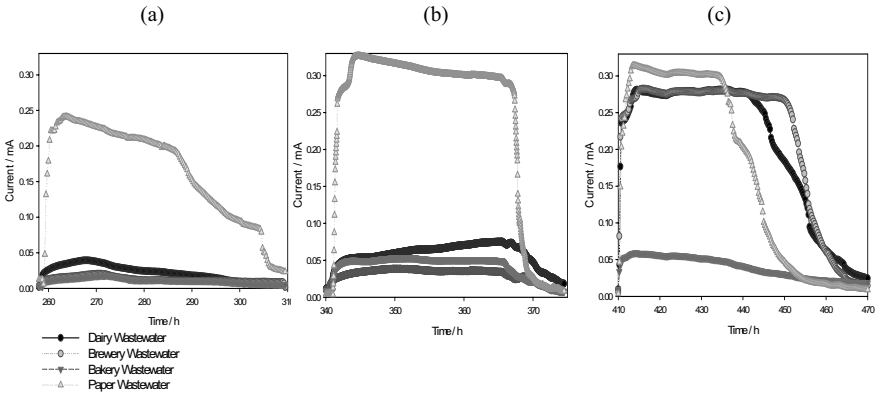

Figure 4: Comparison of MFC current outputs with modified electrolyte (wastewater) conditions. (a) Initial MFC batch with no changes in wastewaters; (b) MFC batch using PBS conditioned wastewaters; (c) MFC batch using PBS conditioned wastewaters after conditioning reactors with paper wastewater for one batch.

Although all MFC reactors were inoculated with identical anaerobic sludge as source of bacteria, the system was also enriched by the bacteria naturally present in wastewaters. DGGE analysis revealed differences in the bacterial diversity for the different wastewaters used (Figure 5). DGGE fingerprints for bacteria biofilms, developed in MFC reactors, were clustered according to the type of wastewater used. There was at least 80% similarity between microbial community profiles for MFC reactor duplicates. On the other hand, DGGE profiles from bacterial communities developed with bakery wastewater were 60% distinct from the communities developed in brewery wastewater. Moreover, communities from both bakery and brewery wastewaters were significantly different from communities developed under paper wastewater (less than 30% similarity). These results along with the current outputs obtained (Figure 1) indicate that biofilm microorganisms specifically developed in the MFC using paper wastewater were possibly promoting a higher electron shuttle rate to the anode.

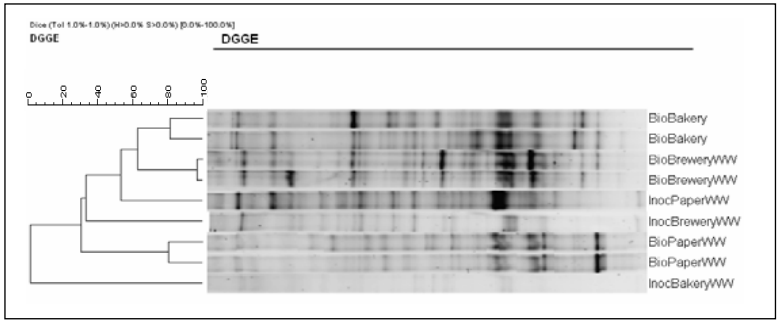

Figure 5: Cluster analysis of microbial biofilms formed in MFC reactors using different wastewaters. Clustering analysis was done on DGGE fingerprints obtained by the bacteria present in the MFC biofilms (Bio), and initial inoculums (Inoc) for the different wastewaters (WW).

Cyclic Voltammetry was used to determine the electrochemical activity of bacteria developed in the different MFC reactors. This technique is able to identify the presence of electron shuttle compounds, which could be naturally produced by bacteria to increase the rate of electron transfer (Rabaey et al., 2005, Von-Canstein et al., 2008). The electron shuttle compounds so called "mediators" are stable molecular weight molecules that have the ability to be continuously reduced and oxidized (Lens et al., 2005). They accept electrons (reduction) from the bacterium cell, transport those electrons to the electrode surface where they drain them off (oxidation) and start the cycle again (Ieropoulos et al., 2005). Paper wastewater presented an oxidation and reduction peak with an overall red-ox potential of -0.325 V vs Ag/AgCl (-0.13 V vs NHE) (Figure 6) while the other MFC cells did not present red-ox activity. As can be seen in Figure 6, the oxidation peak is higher than the reduction peak which implies that the oxidation reaction was more favoured than the reduction reaction. These results provided strong evidence that bacteria developed in MFC reactors using paper wastewater produced an electron shuttle compound that increased the rate of bacterial electron transfer to the anode and explains why current outputs from the MFC reactors using paper wastewater were higher than for other MFCs.

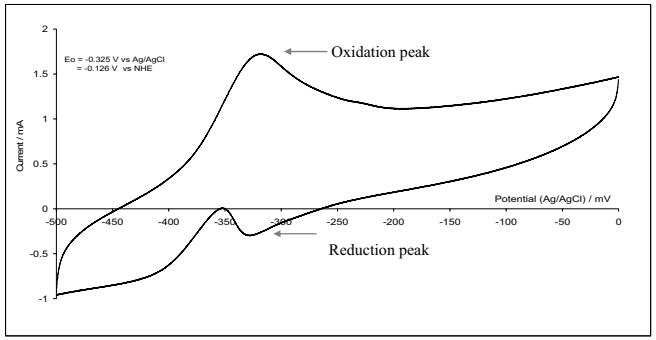

Figure6: Cyclic voltammetry of MFC operated using paper wastewater. Scan rate 10 mV/s, W = 0, 3rd cycle at room temperature.

Finally to evaluate the ability to use bacterial communities present in paper wastewater for other substrates. MFC reactors operated using other substrates where conditioned for one batch with paper wastewater and 50 mM of phosphate buffer. After this conditioning period, for all subsequent batches, MFCs using dairy and brewery wastewaters increased their current output to values between 0.25 and 0.30 mA (only previously obtained by MFCs using paper wastewater and 50mM phosphate buffer) (Figure 4, c). This indicated that the electroactive communities were able to be transferred to MFCs operating in other anodic conditions and increase the current outputs using other types of wastewaters. However MFCs using bakery wastewater did not increased the current output. Presumably microbial communities present in this reactor inhibited the development of electrochemical bacteria.

CONCLUSIONS

The present study determined how wastewater characteristics affect current output in MFC. All MFC systems achieved high COD removal rates although only MFC fed with paper wastewaters developed a high current output. MFC microbial biofilm communities differed according to the wastewater type. Bacteria specifically developed in MFCs using paper wastewater were electrochemically active and were able to produce an electron shuttle compound. The mediator producing bacteria were found to be able to use different types of wastewaters to shuttle electrons. These findings enhance our understanding of the interactions taking place in the microbial fuel cell anode. Further work will be conducted to establish the type of electron shuttle compound produced and the microbial electroactive communities responsible for the enhancement of the current output.

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17 Problem of land use and water supply in urban area: the case of the city of Touba, Senegal.

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Abstract
This study focuses on the relation between land use and water supply. It results from direct observations coupled by semi-structured interviews with local actors. In urban areas of Senegal, water is drawn from two sources, from the drinking water network and from traditional wells. Our study focuses on the city of Touba, a city which is singled out by its recent character (new city) and by her religious inclination (religious city). The naturals conditions are unfavorable: low rainfall, depth of the groundwater with wells brought up rates in salt and fluorine. Two types of land use have been identified in the city: a traditional occupation and modern occupation. They have real consequences on water supply. A city of 700000 inhabitants, Touba hosts two millions pilgrims every year. Water quality and the quantity have always been the main problem for the people and pilgrims. The first consequence of water lack is unhealthy. Water-borne diseases caused by pathogen agents appear in this city so endemic.

Keywords
lack, pathogens, quality, water borne disease, water supply, well

INTRODUCTION

The galloping demography of black Africa countries and the exponential urbanization of some cities of the continent so disparaged just after independence (1960) that it does not seem to be ready to stop. At the beginning of the 3rd millennium, a new urban mapping is taking shape: we talk about urban revolution. Next to the ancient city, some new cities came into existence, the same case with Touba Senegal, very recent city. The cities of second generation contribute certainly to ease congestion in capitals and to readjust the urban mapping. But like the old cities the new cities also have certain problems such as poor planning systems, anarchic land use, deficient water supply, no sewerage systems etc.

This essay is about the relationship between the systems of drinking water and land ownership in urban areas. This is not an exhaustive essay because it needs more research for the problems to be identified and because of the time constraints it is difficult to do the thorough analysis. The study carries reconciliation, generally speaking, on the concept of sustainable development between fast economic growth and the environment. But in this particular context, we are talking about the relationship between population growth in Africa and its environment. Indeed, in countries with low economic development, demographic weight drastic affect on the environment.

This study in the first part describes the city of Touba, what makes its prominent, is the way the space is occupied and used. Touba the religious city suffers from the problem of limited water supply. Touba is a holy city, but because of contaminated water it seems literally "mucked up". This study will try to cover this subject in the second part, and finally, the last part will focus on inherent health problems associated with the water in Touba.

MATERIEL AND METHODS

This work examines the relations between land usage and water supply in urban areas. It results from direct observations coupled by semi-structured interviews with local authorities, people and doctors. We visited some drillings, health centres and interviews some families. Basically our methodology can be broken down into three steps:

Documentary research:

It allowed the collection of secondary data and guided us to visit the chosen places and interview the most likely affected families.

Semi-structured interviews

Our study is based on a qualitative approach purpose of which is get from the locals first hand information. Thus we discovered that it is in the relations of one-to-one debate that the locals devote themselves more and we benefited from their personal experience.

Observation

Our presence in the field has enabled us to witness what the locals face to get basic supply of water. Easy access to water is not an easy mean in Touba. The locals travel about 20 miles to get access to drinking water which might not be clean water.
Keep in mine that this study was made easier by the various people whom we met during our field visit and was able to provide us with accurate information we need for this research. We like to take this opportunity to thanks them for all their support and wish them all the best.

TOUBA: BETWEEN TRADITION AND MODERNITY

Located around 200 km east of Dakar, Touba is a Muslim holy city of the mourid brotherhood. The city of Touba was founded in 1887 by Sheikh Ahmadou Bamba. In just few years of urbanization, Touba has become the second biggest city in Senegal after the capital Dakar. With an area of over 20,000 hectares, its urbanization was mainly facilitated by a paternalistic land system, based on donation or a free attribution of plots, but also marked by speculation. The development of the city is link to the great pilgrimage which celebrates every year the departure into exile of the founder of the mourid brotherhood, Sheikh Ahmadou Bamba. This pilgrimage called "magal" means, celebration in Wolof. The intersection between the town and

the village makes Touba in between tradition and modernity. So that is one foot in the city, an other one out. This gives to the city a mixed configuration.

Located in the Senegalese peanut basin, Touba is facing a growing desertification hence the drop in profitability of agricultural activities. Rainfall is increasingly weak; it varies between 300 and 600 mm of rain per year. Due to its geographical location, the city of Touba has Sudano-sahelian climate hot and dry. In the dry season, it is subject to the influence of hot and drying harmattan in the daytime and cool at night. Temperatures range between 27 and 46 °C. The soil type is Dior, very sandy therefore very often degraded and washed. Its water retention capacity is very low. The depth of the water table is 25 m.

In 2007, according to official estimates, Touba has about 700,000 people. The religious inclination of this city makes the population can increase up to 2 millions people during the "magal" annual religious appointment due to pilgrim from around Senegal. Touba record the strongest population growth of settlements of Senegal, more than 10%. According to an unofficial source, this growth would increase by 19% in 2020. This growth is owed to the influx by the migration of villagers and even some city dwellers to the city of Touba. Most of the villages around the city are almost empty due to this migration.

Two types of land use have been identified in the mourid city. The first said traditional rhythm with the patterns of life of the occupiers. The voluntary migration of rural people toward Touba driven to an anarchic occupation of the area. According to our interlocutor, the country population which migrate to Touba has tendency once installed in the city, to rebuild their own environments and to extend the same socioeconomic practices. This is due to socioeconomic reasons.

Indeed, the new urbanites justify their arrival in town by the difficult living conditions for their place of origin. They come in effect from villages hit by an impairment climate, with a weak rainfall and combined with the drying of wells. But these people are in danger by living in the outskirts of Touba. Because they are not too keen of hygiene while the quality of water which they use doubtful. These add to the low endowment in health infrastructures. These rural newly installed in urban areas, are not used to visiting the hospital quickly in the event of occurrence of the first symptom of disease. As long as they are not seriously ill, they won't see a doctor. They are therefore at the mercy of water-borne diseases because, in the lack of treatment started quickly, cholera for example can create a quick and strict desiccate.

The second type of occupation says modern is a form of contemporary occupation. Residents are building modern houses. It is urban dweller's fact in retirement or immigrants who are in developing countries. This rush toward Touba of dwellers from other cities is due to religious factor, the majority of people who migrate to Touba consider their trip as an impetus to the rapprochement of the great holy city. In the individual and collective representation of these people, this rapprochement is a religious accomplishment. Unlike the old rural, they are more attentive to the basics of hygiene. They tend to bleach for example watershed water before consuming it. In addition, in case of demonstrations symptoms of diseases they rushed to hospital. Anyway, this migration has real consequences on the health plan. Often located in the urban fringe, these newcomers do not have easy access to the drinking fountains and they have no tap at home. While living in an urban environment they travel thousands of meters to obtain water. Because in the city of Touba, networks drinking water do not cover the whole urban area, the paradox is that the infrastructure of drinking water and as well as sanitation systems do not evolve at the same pace as the city. The offer is becoming increasingly lower than demand. This is the paradox of Touba.

WATER FROM TOUBA: AWARE OF DANGER

Can the rural water supply provide for the urban environment? That is unfortunately the peculiarity of this city. Despite its rapid urbanization and its high population growth false, water supply is always provided through the drillings and wells. Touba is synonymous with lack of water; and also rhymes with waterborne epidemics. Since, 20 years this "City of God" suffers from the lack of water. If it is not the lacking of the quantity so, the quality will be problematic; however water of Touba has always had a bitter taste. Indeed, the city is still confronted with a problem of salinity. Most capture groundwater wells with high levels of salt and fluorine. Generally higher than those recommended by the WHO (World Health Organization): 1.5 g / l for salt and 0.5 to 1.5 m / l for fluoride.

Despite the existence of 17 drillings in the city and over 150 linear kilometres for the supply, the water supply is worst during "magal", because during "magal" the city dropped abruptly to 60000 cubic metres of water daily to 600000 cubic meter because people have switched from 700 000 to 2 000 000 people. During this period, water is placed under surveillance in the city because whenever there is water shortage, the local population and the pilgrims use the pools open and wells. In Touba during watershed people use the wells or the basins, a kind of tank to cope with water shortages. For the magal administrative and religious authorities ensure lot of water. In case of disruption of supply, they are trucks away from supplying the city during this period to prevent the population and pilgrims to consume water from the basins. During a visit to a house on the outskirts of Touba we asked the mother "*how long this water remained in the basin?"* She answers, *"Since 9 days." "Are you going to drink this water whenever there is water shortage?"* She answers again, *"Yes we are going to drink it. It is used whenever there is water lack. You know Touba is a dry zone, we run out of water very often is why we are taking our precautions."*

Epicentre of cholera Touba is also the breeding ground for water-borne diseases. According to the point of view of doctors, the water problem is the hub of the spread of cholera vibrio in Touba. All patients hospitalized with cholera in the department of infectious diseases have been to Touba during the magal. This revelation is from the head doctor of Infectious Diseases of Dakar. Each year, more than 50 cases of cholera were hospitalized at the department of infectious diseases. *'When an individual does not have access to drinking water, he drinks anything. And all cases received the services of Infectious Diseases have in common the fact that they consumed water from wells, the water that comes from the watershed, a kind of open wells. But, warns the head of Infectious Diseases, 'until there managed the water issue in Touba and the problem of septic tanks every year, we may have to cope with outbreaks of cholera* '.

In water diseases, as soon as there gathering of people and there is no access to drinking water, there is a risk of cholera. The problem of cholera is not a medical problem, but a problem of quality of life. It is a health problem; the environment is an issue of environmental sanitation, access to clean water, live in conditions that have latrines, and so on. And for the prevention of this disease, there must be drinking water available to the people, sensitise them to respect the basic rules of hygiene such as washing hands before touching food. Touba is also an unhealthy city. There is acute a real problem of waste management. Indeed,

the city has neither adequate sewerage system even less of an efficient service for the collection and disposal of garbage. This is reflected by a proliferation of wild depots near homes and the disposal of domestic sewage on the public highway. The city is characterized also by the absence of a network of storm water and sewage. The sewerage system missing and cesspits built mostly in the streets without adherence to standards sealing and sizing, expose people to a serious health and environmental problems. In terms of aesthetics, the city presents a face not at all bright with runoff water valves along the narrow streets. These waters loaded mostly viruses and bacteria seep into groundwater causing his infection. According to a hydraulic officer of the city, except one drilling on 17, all others have revealed the existence of pathogens so, each drilling need a kit for detecting microbes to better secure but before that he adds, people should make effort have to bleach water from drilling before use. According to a study, from 2005, 3.8% of households emptied the contents of their septic tanks in the courtyard of their homes, 9.5% in the street, 2.4% were not emptying.

Conclusions:

The urbanization of African cities across all exceeded their willingness and openness. But this urban dynamic is only demographic. Precisely, it is the population growth that has changed the face of Touba. To better enjoy the city, African countries must control their population because an uncontrolled population will lead to uncontrolled urbanization therefore doomed to failure. Controlled urbanization means to supply the area with good quality and sufficient water. It is also provided the adequate sanitation facilities.

In essence, the problem of water is still the first and main problem for cities dwellers. In Touba, as in most of Senegalese urban areas, the water problem is seen as the main factor of vulnerability to multiple repercussions. The first problem of this water lack is notorious unhealthy found especially in urban areas. This unhealthy also has a profound effect on people's health. So there should be a better balance between land use and water supply. In Touba, water is a risk, a real risk. Worse water from the city of Touba is a danger, a danger that has claimed many victims. Because the networks of safe drinking water may not cover the whole urban area and there is also the quality of water infected largely due to the absence of inadequate sewerage. Yet in this city, water can become a resource if local authorities and government take necessary measures. Who said water is priceless?

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18 Measuring groundwater parameters to improve modeling and regulation

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Abstract
Groundwater forms 70% of the world's freshwater supply, and is typically much cleaner than surface water supplies. It is therefore a key water resource that needs to be carefully managed. In urban areas, groundwater can be overexploited by industry, leading to degradation in quality. In order to regulate groundwater use, an understanding of the key parameters that control groundwater flow is required. This paper focuses on methods of measuring some of these parameters, so more accurate groundwater flow models can be created. The results from standard techniques are compared to other, lower technology methods. The Chalk aquifer of East Yorkshire in the UK is used as a case study. It is hoped that the lessons and principals learned by groundwater regulators in the UK and other developed countries can be used to avoid similar problems in the developing world as urban populations increase.

Keywords
water resources, contaminants, pollution, modelling, quality

INTRODUCTION

In the UK, groundwater provides about 40% of the drinking water supplies (UK Groundwater Forum, 1998). By 2002, 10% of aquifers had urbanized land directly above them. Whilst there is an increasing trend for abstracting water in rural areas and pumping it to the cities, (Morris et al, 2007), many public water drinking supplies are still pumped from aquifers in urban areas. In addition many industries are based in the cities, and their private abstraction wells put additional pressure on groundwater. Groundwater is usually considered to be much cleaner than surface water, and often requires little or no treatment before it can be used for drinking. However, overabstraction can lead to deterioration in quality, as low quality water is drawn in from neighboring sources, including other aquifers, rivers or the sea. Urbanization brings additional threats to groundwater quality from sources like petrol filling stations, waste disposal, leaking septic tanks, leaking sewers and the removal of any protective confining aquifer layer during construction works (Aldrick et al 1999). Urban drainage can also decrease soil infiltration rates, so rainfall never enters the aquifer. In the UK, land use and groundwater abstraction rates are now regulated by the Environment Agency in order to maintain high groundwater quality.

In order to be effective regulators, the Environment Agency maintain a series of groundwater flow models which can predict the impact of changes in abstraction rates, and track potential contaminants. Whilst many of the input parameters for these models are well known, some are much harder to measure, including hydraulic conductivity.

Hydraulic conductivity is defined as "the rate at which water flows through a rock", and together with the pressure gradient, controls the speed of groundwater flows, which ultimately controls how much water can be abstracted and the speed and dilution rates of any potential contaminant plumes. Whilst the methods for measuring an average value of hydraulic conductivity over the depth of the aquifer are standard, methods for establishing the variations in hydraulic conductivity with depth are still being developed. It is important to understand these variations. For example, where the horizons with high hydraulic conductivity are all situated near the top of the aquifer, drilling expensive, deep wells is unnecessary. In addition, contaminants can travel faster through a few thin zones of high hydraulic conductivity than a thick zone of low hydraulic conductivity, and are hence the contaminants will be less diluted.

This paper presents several different methods of measuring the vertical distribution of hydraulic conductivity including impeller flow logging and dilution testing under both pumped and ambient conditions.

METHODS

Pumped well methods

The principal of these methods is illustrated in figure 1 and is best described by Molz et al (1989). A pump is set up at the top of the borehole, so that the water flows radially towards the borehole, and then up the borehole towards the pump inlet.

As depth down the borehole increases, fluid speed decreases as each producing zone is passed. If there is no ambient flow, the derivative of this log is proportional to hydraulic conductivity.

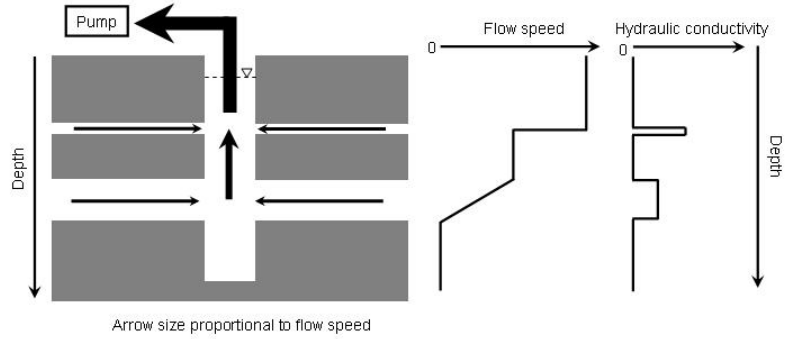

Figure 1 : The basic prinicples of a pumped test

Overall transmissivity (product of hydraulic conductivity and thickness summed over the full aquifer thickness) can be measured using a pumping test (detailed in, for example, Kruseman and de Ridder 1990). It is found by measurign the fall in water level in the well induced by pumping. This value is then multiplied by a log of fluid flow speed derivative versus depth to obtain absolute hydraulic conductivity values for each individual layer.

There are several ways of measuring fluid flow speed in a borehole, two of which are described below:

Impeller flow logging. The impeller flowmeter has a spinner whose rotation is proportional to flow speed. As the impeller is lowered down the hole, it measures the sum of the flow speed of the water, plus the speed of the flowmeter (line speed). Line speed is subsequently subtracted during calibration.

Pumped dilution testing. This is described by West and Odling (2007). A hosepipe is lowered down the borehole, and filled with salt solution. The hosepipe is then removed from the borehole, so the borehole is filled with water of a greater conductivity than the surrounding aquifer water. As this water is drawn into the borehole by a pump, the resulting pattern of dilution is observed by measuring the electrical conductivity of the borehole fluid. From this the vertical fluid flow profile can be found.

Ambient methods

Sometimes, it is impossible to pump water from a borehole, perhaps due to time and cost constraints, or very large lifts (i.e. the depth to the rest water level is large). In this case, the ambient well flows can be measured. Ambient flows occur up or down a borehole due to pressure differences between two different conductive horizons intersected by the borehole. The vertical flow velocity between the layers depends on both the pressure difference and the hydraulic conductivity of each layer. As the pressure difference between layers is unknown, a quantitative hydraulic conductivity profile cannot be obtained, but the ambient flows indicate where the layers of high hydraulic conductivity are located and the direction of flow (upwards or downwards) in that part of the aquifer.

RESULTS

The results here are examples from the Chalk aquifer of East Yorkshire, which is a fracture flow aquifer. Fractures are subsequently enlarged by the dissolution of the carbonate rock matrix. Both of these factors mean that hydraulic conductivity varies considerably with depth. The aquifer has both confined and unconfined zones, with glacial clay till acting as the confining layer. Most boreholes in the aquifer are open to the Chalk, but are cased through its uppermost layers, and the till where present. All depths are in metres below ground level. Ordnance Survey National Grid references are given for location.

Pumped methods

Impeller flow logging. A pumped impeller flow log from Wilfholme Landing (TA 062 472) on the confined Chalk is shown in figure 2. The position of the base of the well casing is indicated. The measured data are noisy due principally to turbulence in the borehole set off from rugosities in the borehole wall, and variations in borehole diameter. A regression technique was developed which fits straight lines to the noisy plot. This is described in detail in Parker et al (under review). The modeled flow shows two zones where flow decreases rapidly, an upper zone between 24 and 32m, and a lower zone between 41 and 43m. The hydraulic conductivity profile found from this flow log is shown in figure 3, which also shows the magnitude of the hydraulic conductivity for the two zones described above. The regression technique gives an indication of the confidence of the model fit; 95% confidence limits are shown on this profile.

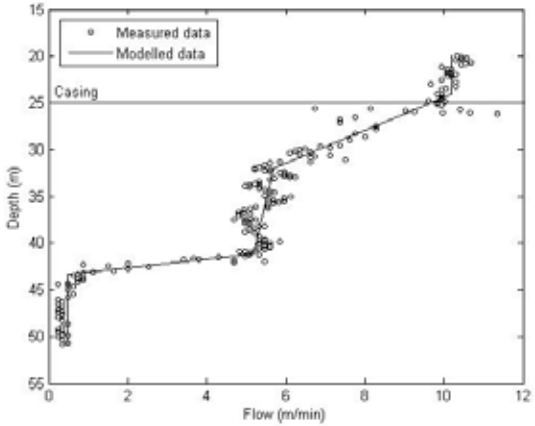

Figure 2: An impeller flow log from Wilfholme Landing, showing the measured data and the regression model fit. The depth of the base of the casing is indicated.

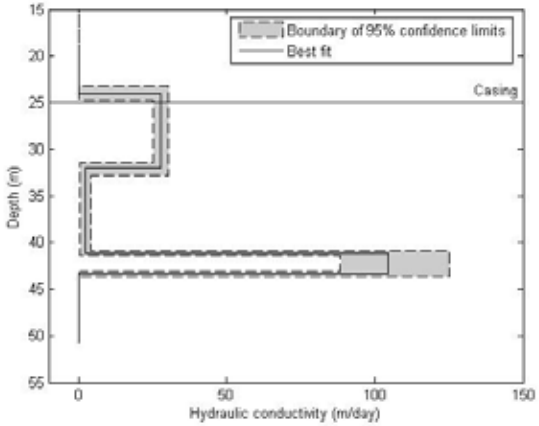

Figure 3: The hydraulic conductivity profile produced from the impeller flow log from Wilfholme Landing. The depth of the base of the casing is indicated.

Dilution testing. The results from a pumped dilution test for the same borehole at Wilfholme Landing are shown in figure 4. The pump inlet was at the bottom of the hole. The salt concentration profiles at several different times are plotted, and the concentration can be seen decreasing with time after injection. Inflows seem to be at 25 and 42m. Modelling of the salt concentration curves (using the technique of West and Odling, 2007) suggests that the well bore flow between 25 and 42m is 3m per hour, and the velocity from 42m to the pump outlet is 6m per hour, suggesting that half the inflow enters at 25m and half at 42m. This corresponds to the hydraulic conductivity profile from the impeller log, shown in figure 2 (i.e. the areas enclosed by the square sections representing the two conductive layers are similar).

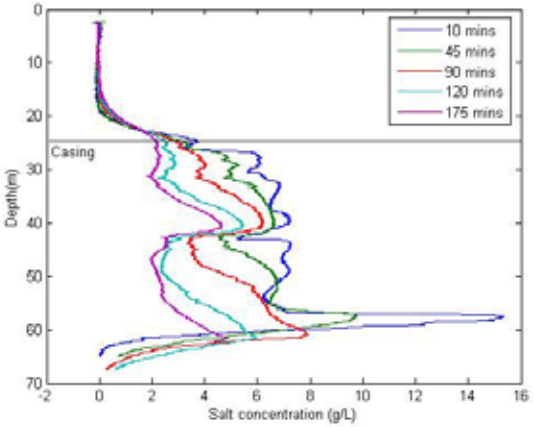

Figure 4: Salt concentration profiles through the duration of a pumped dilution test at Wilfholme Landing. The pump inlet was at the bottom. The base of the casing is indicated.

Ambient methods

Impeller flow logging. Figure 5 shows an ambient impeller flow log from a borehole at Henpit Hole (TA 025 658), on the unconfined Chalk. The resting water level in this borehole is below the casing. This borehole has a blockage at about 30m, below which the impeller cannot pass. However, the flow log indicates that flow is coming from beneath this blockage and leaving the borehole between 21 and 14m depth. It leaves most rapidly at 18m, suggesting this is the location of a high hydraulically conductive layer, possibly even a single conductive fracture.

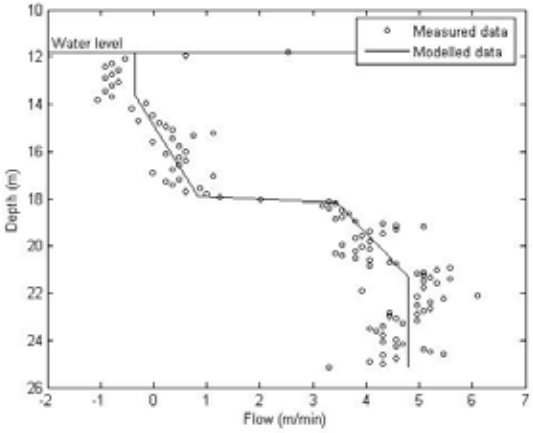

Figure 5: An ambient flow log from Henpit Hole, showing the measured data and the regression model fit.

Dilution testing. Figure 6 shows an ambient dilution test from a well at Weaverthorpe (SE 981 702) on the unconfined Chalk. Salt concentration profiles at several different times are plotted, and the concentration can be seen decreasing with time after injection. The profiles show there is an inflow at the top of the water column; this water flows down the borehole and leaves at 35m depth. There is another inflow at 40m. Water from here flows up the borehole and leaves at the same depth of 35m. The salt concentration in the bottom of the borehole remains constant throughout the duration of this test, suggesting that below 40m there are no ambient flows. Analysis of the salt concentration curves suggest that the upper ambient flows are 4 times faster than the lower flows. This suggests there are highly conductive horizons at the level of the water table (22m), and also at 35 and 40m depth.

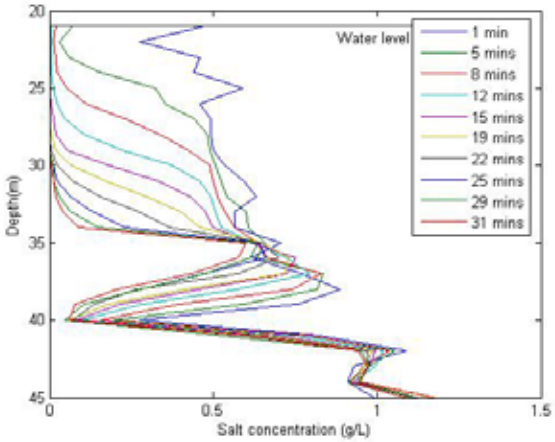

Figure 6: Salt concentration profiles through the duration of an ambient dilution test at Weaverthorpe.

DISCUSSION

Four different methods are presented here for establishing the variation of hydraulic conductivity with depth are presented here. Each has its advantages and disadvantages.

Impeller flow logging under pumped conditions gives the most comprehensive results, giving both the depths and magnitudes of hydraulic conductivity, and also an indication of the certainty of those values from the confidence limits. However, it requires the most complicated and expensive equipment – not only the logging equipment but also a high capacity pump.

Pumped dilution testing provides exact depths of layers of high hydraulic conductivity, with a more approximate estimate of their magnitude. The conductivity can be measured using an inexpensive handheld conductivity probe. A much lower capacity pump can be used (for example a swimming pool pump running from a generator), although as the distance of the resting water level below the ground surface increases, the disturbance induced by pumping will decrease. If large ambient flows are present, they will swamp the efforts of a low capacity pump meaning the data is very hard to interpret; in this situation it would be better to carry out an ambient dilution test.

Ambient tests give a clear indication of the location of the layers of high conductivity, but cannot give any information of their magnitude. Dilution tests are the cheapest to carry out as the only specialist equipment required is the conductivity probe. Their only limitation is in boreholes with high ambient flow, where it becomes necessary to use the impeller to measure flow speed as it can measure much faster flows, but again, the equipment is expensive.

CONCLUSION

Four different methods of characterizing the vertical hydraulic conductivity distribution within an aquifer have been presented. In general as cost decreases, data quality is compromised, although there are some other physical constraints (the magnitude of ambient flows and the distance below the ground surface of the resting water level), and even the lowest cost method provides some very useful information about the aquifer.

The methods presented here can be used to better define groundwater flow model input parameters. The more accurate the model, the better the regulator will be able to predict the effects of changes to the aquifer, for example, the effect of installing a new abstraction well, or the contamination risk presented by a change to industrial land use, as well as the long term effects of increasing urbanization and climate change.

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19 Identification of particulate heavy metal pollution sources in urban river sediment using scanning electron microscopy coupled with energy dispersive spectrometer (SEM-EDS)

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Abstract
Scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) was used to develop a protocol for the identification of trace element carriers in the Seine River. Various Pb, Ni, Zn, V, Cr, and Cu bearing phases were identified on the sediment of the Seine River. Lead and nickel were found to be preferentially bound with iron sulfide particles. This phase is known to be a significant trace metal carrier in a reducing environment. Association of vanadium and calcium was identified which would be a product of road surface runoff. Zinc was also found associated with barite, possibly indicating an urban-related contamination source. Microscopic particle analysis shows to be a powerful tool in the characterization of their different sources and their eventual mobility in the environment.

Keywords
Heavy metal carrier; binding phase; Seine; sediment; Scanning electron microscopy; Energy Dispersive spectrometer; source tracing

INTRODUCTION

The European Water Directive obliges all the water bodies in their territory to fulfill certain water quality criteria. This includes heavy metal concentration, which remains a main concern in anthropogenic watersheds. The ever-growing uses of metal in urban, agricultural and industrial activities have resulted in multiple contaminations in the environment and eventually to living beings. It is a great concern since metals are known to bio-accumulate and can cause long-term health effects. Thus, the understanding of metal cycle in the environment is an important aspect in water basin management.

Metal toxicity is generally defined as bio-available metal, including dissolved and labile metal fraction. The particulate phase plays an indirect, but nevertheless important role because it serves as a binding phase for dissolved metal, thus lowering metal bioavailability. Moreover, this phase may also be a source, acting as temporary storage where metal may be released to the water. It occurs during evolution in physical and/or chemical conditions, such as water discharge, pH and dissolved oxygen. Consequently, the study of particulate phase is important in the understanding of the global metal cycle.

The common sediment phases that exist in the rivers are the following:

- Iron and manganese oxide; this phase is well documented as a metal binding phase in the environment (Horowitz, 1991). These oxides may also exist as thin layers on minerals.
- Carbonate; in a calcareous basin such as the Seine, the carbonate may constitute an important binding phase were metal may be adsorbed on its surface and then incorporated in its crystalline structure on the long term (Elzinga *et al.*, 2006).
- Clay; due to the large specific area, its surface is an important host to precipitation
- Quartz; this phase is not necessarily a binding phase but it serves as sites for precipitation and flocculation of organic matter and secondary mineral.
- Biologic and organic matter; organic matter is known to concentrate up to 10 percent of its volume in metal (Swanson et al., 1966 in Horowitz, 1991).
- Sulfide; in reducing condition, sulfide plays an important role as a binding phase

Aside from association on sediment phases, dissolved metals may also precipitate with anions forming carbonate, hydroxide, sulfate or sulfide particles.

Associations between metal and its binding fraction may take place in various points throughout the particle's pathway. It may be bound from the source, during the transport (dry or wet), in the water treatment plant, or in the river itself. Trace metal carriers in deposited sediments and suspended particulate matter carry morphologic and geochemical signature that can be linked to specific natural, industrial or urban sources. Studies on these particles, its form and association would allow us to understand its history, including sources and formation. Further observations may help to define metal mobility thus gaining a bigger understanding on their toxicity.

Sequential extraction procedure (Tessier *et al*., 1979) is widely applied in studies of particulate heavy metal where samples are usually digested with several reagents. Five classes are normally identified, including exchangeable, bound to carbonates, bound to Fe- and Mn-oxides, bound to organic matter and residual fraction. Unfortunately, it is widely known that metals may migrate to different binding fractions during extraction, thus resulting in questionable results and low reproducibility (Garnaud *et al.*, 1999, Webb *et al.*, 2000).

The development of analytical microscopic technology has increased their usage in geosciences. Recent application on urban particles (Bibby and Webster-Brown, 2005, Clozel *et al.*, 2006, El Samrani *et al.*, 2004) show promising results in understanding the binding phenomenon. Although this type of technology demands a longer analysis and interpretation period, the results carry more information and understanding on the particles' past and composition.

The Seine River Basin is a sedimentary basin which serves as a perfect example of an anthropogenic river which includes agricultural, industrial, and urban sources. Among the large range of potential anthropogenic activities, only mining activities are not presented in the Seine River basin. This study aims to develop a method of direct particle analysis targeted especially for the Seine watershed in order to characterize different natural anthropogenic sources and possible mechanism of formation.

MATERIAL & METHODS

Among a few hundred samples available in the laboratory, sediments taken from 2 sites on the Seine River situated a few km downstream from Paris were chosen (*Figure 6*). The first one, labeled A, is located right on the outlet of a waste water treatment plant (WWTP) with a depth

of 12-14 cm. The second site is approximately 3 km downstream on a dead river branch, labeled B. We analyzed two different sediments in this second site, one from a depth of 25-30 cm, the second was from a depth of 45-50 cm. These depths were chosen due to their high level of Cesium-137 indicating recent deposit (i.e. younger then 1986). The metal concentrations on the samples were assured as to fulfill the criteria of the limit of detection of the following microscopic analysis by applying total digestion to the samples and analyses on ICP-MS.

Figure 6 Sampling site on the Seine River for this study

Previously freeze dried samples were grounded on agate mortar. Bulk samples, samples <50 micrometer and magnetic samples (samples separated magnetically) were dispersed in alcohol and filtered on a 0.5 µm nucleopore carbonate filter and posed on a carbon sample holder with a diameter of about 1 cm. The amount of the sample dispersed is approximately 100-200 µg. Prepared filter was checked under microscope to confirm that the particles were evenly dispersed to facilitate the microscopic analysis that follows. Finally, a thin layer of carbon was coated on the filter to allow high electron conductivity during analysis.

Samples were analyzed using a Scanning Electron Microscope (SEM) JEOL JSM 840 coupled with an X-Ray microanalysis system from Princeton Gamma Tech (PGT). A ray of generated electrons of the size of a few angstroms is scanned over a randomly located field. A numerical image is produced from the backscattered electron beam with particles ranging from 0.2 to 20 µm. X-ray spectrum generated from these particles are then acquired (Figure 7) using a high purity Germanium (HPGe) detector and digital pulse processing from PGT. Hundreds of spectrums of particles per sample were analyzed automatically to assure that results are qualitatively representative.

The spectrum is analyzed by the energy dispersive spectrometer (EDS) and then classed according to the pre-defined sediment, as well as metal phases. Predefined sediment phases included various iron and manganese oxides, calcium, SiO_2, pyrite and barite. These sediment phases were chosen according to the capability of the SEM-EDS to identify particles and analyze spectra. Organic matter and amorphous iron oxide are not defined since these phases can not be detected by the SEM. On the other hand, metal classes consisted of zinc, lead, chrome, copper, and vanadium. These metals were chosen due to their high quantity which allows them to be detected on the spectrometer.

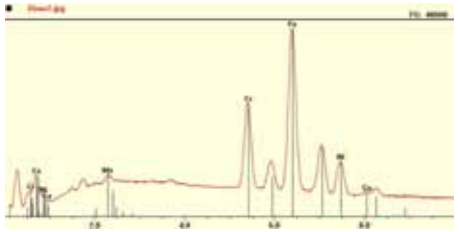

Figure 7 An EDS Spectrum of stainless steel

A manual check was done by randomly observing spectra and particles to confirm that they were correctly classed. Interesting particles was further analyzed by producing morphological images and chemical maps of the particles.

RESULTS AND DISCUSSION

To assure the statistical quality of the results, only samples where more than 100 particles analyzed are shown. Due to the statistical limitations that may be caused by microscopic analysis, the results herein will be discussed qualitatively and semi-quantitatively. Graphs are shown only to facilitate results presentations. The horizontal axis indicates the different predefined binding phase. The vertical axe gives the percent value of a certain metal associated with a certain phase. Each color indicates a certain sample (marked on the legend of each figure) and the number in parenthesis next to each sample label indicates the number of particles analyzed containing a given metal. We take for example the Ni association on iron sulfide (Figure 8, left). Twenty-eight Ni particles were located during the automatic analysis of sediment sample A 12-14 cm. Out of the 28 particles, 26 particles, or 93 %, were found to be associated with iron sulfide.

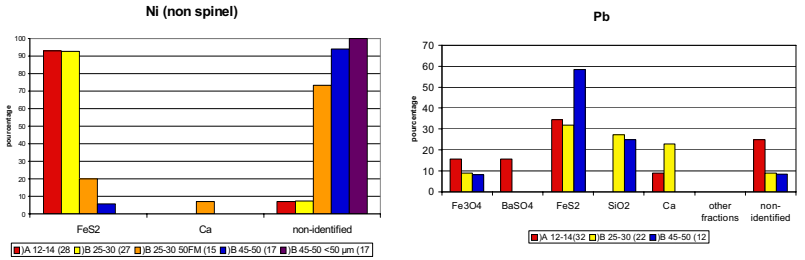

Figure 8 Distribution of nickel binding phase (left) and lead binding phase (right) analyzed by SEM-EDS

Iron sulfide seems to be a preferable binding site for Ni and Pb (Figure 8). Given the fact that these sediments were once anoxic, this is a very possible condition as iron sulfide is known to be an important binding fraction in reducing condition. Although the samples were not kept in anoxic conditions, the pyrite may partly oxidize in surface, while the rest remains reduced. This would explain the extraction of the pyrite during the magnetic separation. The association between Ni and iron sulfide was also noted on coastal fresh water lake sediment (Canavan *et al.*, 2007) where Ni and Co is notably associated with pyrite. Sulfide was also observed as a main heavy metal carrier in combined sewer overflow samples (El Samrani *et al.*, 2004)

Analysis on fine fraction (< 50 µm and magnetic fraction of <50 µm) shows a whole different trend where Ni are mostly associated with non-identified phases. Further analysis on the fine fraction (<50 µm) B 45-50 cm shows a 100% association with non-identified phases. This may indicate that Ni is associated with the organic fraction or fine amorphous iron oxide particles a phenomenon also observed by Canavan *et al*.(2007). This fact may be supported by the analyses of the magnetic fraction of the same sediment. More than two-thirds of the Ni-containing particles in this fraction are also found associated with the non-identified phase, possibly indicating bond with iron oxide, a fairly magnetic particles.

The Paris water treatment plant has been studied by various authors ((Buzier *et al.*, 2006), (Thévenot *et al.*, 2007a) . They cited that due to the moderate removal efficiency for Ni and the addition of Ni-containing chemical during the treatment process, the labile and dissolved Ni concentration from the plant outlet may be comparable to Ni concentrations coming from the outlets upstream. The water on the outlet may create a reducing condition due to the high organic matter content which may promote respiration thus diminishing oxygen level. This reducing environment may promote the formation of sulfides. The high dissolved and labile Ni ions coming out from the WWTP may be found to associate with sulfide particles in the river. Organic matter association is also possible due to this high OM content. In this case, associations would be formed in the WWTP before entering the river. The difference in the formation momentum of these associations is interesting to note when determining choices in source reducing methods.

Figure 8 on the right, shows distribution of Pb on various binding phase. Here, we may note that Pb is also preferentially bonded on pyrite. Pb also show to have a certain affinity for the sulfide fraction and even higher rates as the sediments get deeper. Metal bearing sediment is not stable and the association evolves with time and changing condition. They will have a tendency to migrate from isomorphous replacement into crystalline lattice (Emerson *et al*., 1983 in (Huerta-Diaz *et al.*, 1998)). The SEM has a weaker capacity in detecting amorphous structure. This may explain that there are higher non-identified phase in the Q 12-14 cm layer, and a higher pyrite associated Pb in the deeper 45-50 cm sediment.

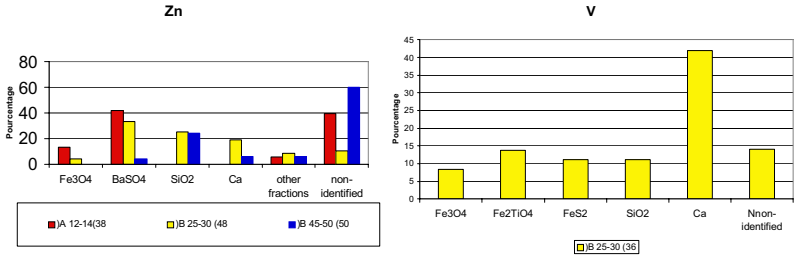

Figure 9 zinc (left) and vanadium (right) binding phase analyzed by SEM-EDS

Results of Zn association shows less preferential site (Figure 9, left). We may though observe an important fraction bound with barite, which was less observed for other metals. A recent metal budget was established based on calculations in an urban sewage system from urban and

domestic waste in the Seine river watershed by (Thévenot *et al.*, 2007b). It underlined an important portion of Zn deriving mostly from roof runoff (55 %) where rooftops and rain gutter in Paris are mostly made from Zn. Detailed studies on the runoff by (Gromaire-Mertz *et al.*, 1999) showed that the percentage or Zn bound to particles ranges from 0-73 %, with a median of 9 %. Further "downstream", street runoff measured 44-96 % of particle-bound Zn, with a median of 75 %. While barite in urban surfaces may derive from the usage of brake in automobiles (Osterle *et al.*, 2001), we may hypothesize that during a rain event, Zn may be washed off from surfaces in a dissolved form at high concentrations. During the flow, the dissolved Zn would associate with particles washed off from road surfaces carrying barite. The association may also well be formed in the sewage system. Similar association between barite and lead were observed in mine wastes where Pb is mobilized in dissolved form (Courtin-Nomade *et al.*, 2008)

The vanadium may also be an indicator of an anthropogenic contamination. SEM observations allowed us to localize specific association between V and calcium (Figure 9, right). V and calcium is produced as slag in steel production. The slag is frequently reused in road construction (Chaurand *et al.*, 2007). This association may indicate the effect of runoff on urban surface which may carry these particles during rainy periods. Another possibility is that V is bound to the calcite in the Seine, which is abundant do the calcareous nature of the watershed. Further comparison with particles directly recovered from road surfaces will be necessary to confirm this hypothesis.

Associations between metal and binding phase may seem complicated as there are an endless variation of metal and binding phase, but surprisingly recent studies in soils by extended X-Ray absorption fine structure spectroscopy have shown a certain restricted uptake mechanism thus restricted associations with phyllosilicates, Fe(oxyhydr)oxides, and Mn-oxides (Manceau *et al.*, 2000). Observations by Transmission Electron Microscopy (TEM)-EDS and SEM-EDS by El Samrani et al. (2004) also support this finding in sewer sediment studies by adding sulfides as an important trace metal carrier. These studies supports the observation as we identify that certain metals seem to be preferentially associated with a certain sediment phase.

A few limitations of this analysis to note is certain undetected phases including the organic matter. This will be compensated in the future by analyzing particles with the TEM. Further detailed study on defined metal bearing phase will also be carried out using local analysis such as EXAFS and XANES to detail the chemical association on the molecular scale and understanding the mobility of the particles.

CONCLUSIONS AND PERSPECTIVES

Scanning electron microscopy proves to be a powerful method in understanding different associations between heavy metal and its carrier phase. Particle analyses of The Seine River bottom sediment downstream of Paris are shown to be effective in determining the sources of contamination. Lead and nickel were found to be preferentially bound with iron sulfide particles. Association of vanadium and zinc indicated an urban-related contamination source through runoff during rainy period.

Its application in the future will be used in understanding monthly, weekly, and even daily dissolved metal variability in the Seine. As the variability seems to be linked to biological activities and changes in redox condition, interesting binding fraction to be analyzed would be the iron and manganese oxide. Calcite bound metal would make an interesting observation as the Seine river system is known to be controlled by its calcium carbonate balance.

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20 A quantitative approach for detection of *Toxoplasma gondii* oocysts and surrogate microspheres in water: New methods for investigating zoonotic pathogens in urban runoff

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Abstract
Waterborne toxoplasmosis is a significant health concern in both developed and developing countries. Current limitations on the detection of *Toxoplasma gondii* oocysts and a lack of understanding of their transport and fate in watersheds are impeding efforts to recognize contaminated water sources and implement effective management strategies to reduce exposure in people. Here we assess the ability of hollow fiber filtration to concentrate tap and environmental water spiked with oocysts and fluorescent microspheres that were developed in our laboratory as surrogate particles to study the transport and fate of *T. gondii.* Detection of oocysts and microspheres in concentrated retentates was performed using molecular methods (conventional and TaqMan PCR) and membrane filtration followed by epifluorescent microscopy. Membrane filtration performed better than molecular methods for detection of *T. gondii* oocysts and provides a rapid, cost-effective, and quantitative approach for detection of *T. gondii* oocysts and surrogate microspheres. Concentration of water using hollow fiber filtration followed by particle detection via membrane filtration may improve efforts to detect *T. gondii* in water sources implicated in toxoplasmosis outbreaks. This approach also offers quantitative recovery of surrogate microspheres from water which provides a novel tool for evaluating the transport behavior of *T. gondii* oocysts in watersheds and for assessing parasite removal efficiency of water treatment processes.

Keywords
Zoonotic Pathogen*;* Microspheres; Surrogate; *Toxoplasma gondii*; Water pollution; Waterborne disease

INTRODUCTION

Waterborne toxoplasmosis is emerging as a significant health concern worldwide. The causative agent of toxoplasmosis is *Toxoplasma gondii*, a zoonotic, single-celled protozoan parasite. Outbreaks of acute infections with *T. gondii* have been documented in human populations in Panama, Canada, Brazil, and India (Aramini et al., 1999 1999 #44; Bahia-Oliveira et al., 2003; Benenson et al., 1982; Palanisamy et al., 2006). The prevalence of *T. gondii* infection in some human populations is higher than 90% as documented in a study

performed in Brazil, where the risk of exposure was associated with urbanization and drinking unfiltered water (Bahia-Oliveira et al., 2003; Boia et al., 2008). In immunocompetent people, infection with *T. gondii* is often asymptomatic or results in flu-like symptoms. However infection in immunosuppressed patients can result in fatal disseminated toxoplasmosis from uncontrolled multiplication of the parasite in muscle, lungs and nervous tissue. Primary infection of pregnant women can also lead to abortion and devastating health impacts due to congenital fetal infection through the placenta (Jones et al., 2003). Waterborne transmission of oocysts to expectant mothers is believed to play an important epidemiological role in congenital disease (Elsheikha, 2008). Severe birth defects, mental retardation, and vision defects are serious sequelae in children born with congenital toxoplasmosis; less obvious clinical outcomes can also take years to manifest and include ocular disease, learning difficulties and mental illness such as schizophrenia (Jones et al., 2003; Mortensen et al., 2007).

Toxoplasma gondii is an incredibly successful parasite that can infect virtually all warm-blooded animals as intermediate hosts, including humans, wildlife and domestic animals. However, only felids are known to serve as definitive hosts for *T. gondii*, in which the parasite can undergo sexual multiplication in the gut epithelium, resulting in fecal shedding of high numbers of oocysts after primary infection (Bahia-Oliveira et al.; Dubey, et al., 1970). *Toxoplasma gondii* oocysts are the environmentally resistant stage of the parasite and can survive months to years in soil and water under various ambient conditions (Kuticic and Wikerhauser, 1996; Lindsay et al., 2003; Yilmaz and Hopkins, 1972). In people, waterborne transmission of *T. gondii* occurs following accidental ingestion of oocysts in contaminated water supplies. Numerous studies have demonstrated that methods commonly employed in water treatment including chlorination, iodine tablets, ozone, UV irradiation, and radio frequency are ineffective in complete inactivation of *T. gondii* oocysts (Benenson et al., 1982; Wainwright et al., 2007; Wainwright et al., 2007).

While the importance of waterborne toxoplasmosis is becoming more apparent, tracking the transport mechanisms of *T. gondii* in aquatic systems and identifying sources of contaminated water remains difficult due to the lack of standardized methods for *T. gondii* detection in the environment (Dumetre and Darde, 2003). To date, only one study described successful isolation of *T. gondii* from water implicated in a waterborne outbreak. However, the methods utilized in this study relied on bioassays in chickens and pigs (de Moura et al., 2006). While generally sensitive and specific, bioassays are time consuming, costly and qualitative rather than quantitative. In a second study, Isaac-Renton et al. attempted to use cartridge filtration based on a United States EPA protocol for concentration of related protozoa followed by bioassay for detection of *T. gondii* from a reservoir implicated in a waterborne outbreak in British Columbia; however, identification of the parasite in that study was not successful (Isaac-Renton et al., 1998).

The goal of our study was to develop new methodology that is rapid, cost-efficient, and quantitative for detection of *T. gondii* oocysts in drinking and environmental waters. In addition, we recently evaluated two types of fluorescent polystyrene microspheres that have similar surface chemistry as *T. gondii* oocysts for use as surrogate particles in transport studies. The two microspheres were selected based on their different but complementary surface charge and hydrophobicity properties. The application of both microspheres in transport experiments theoretically provides a range of transport potential that is similar to that of *T. gondii* oocysts through aquatic systems (Shapiro et al., in review). This study describes the use of hollow fiber filtration (HFF) to concentrate spiked tap and environmental water and

subsequent detection of *T. gondii* oocysts and surrogate microspheres in concentrated retentates via PCR and membrane filtration followed by epifluorescent microscopy.

MATERIALS & METHODS

Particle Preparation

Toxoplasma gondii. To produce *T. gondii* oocysts, two 10-week-old kittens were fed brains of Swiss-Webster mice previously inoculated with culture-derived tachyzoites of a Type II isolate of *T. gondii*. Feces were examined daily by zinc sulfate double centrifugation to detect shedding of oocysts, and unsporulated oocysts were collected from fecal samples by flotation in saturated saline of specific gravity (s.g.) 1.18 on days that oocysts were shed. Oocysts were washed twice in deionized water to remove saline, and then suspended in 2% sulfuric acid. Sporulation was achieved by aeration at 25°C over 7-10 days after which oocysts where suspended in fresh sulfuric acid and placed at 4° C until use. Prior to filtration experiments, sulfuric acid was removed by washing oocysts twice in PBS and twice in MilliQ water to achieve a pH between 6 and 7. Oocysts were resuspended in approximately 1.5ml MilliQ water and placed within a heating block set at 80 degrees Celsius for 15 minutes for inactivation. Oocysts were then counted using a hemacytometer chamber and epifluorescent microscopy with a DAPI filter.

Microspheres. Ten and 8 micron surface-modified polystyrene microspheres were obtained from Bangs Laboratories (Bangs Laboratories, Inc., Fishers, Indiana). To attain fluorescence capabilities while allowing the two beads to be differentiated, microspheres were infused with a green (10 um microspheres) or blue (8 um microspheres) fluorochrome. An aliquot of beads from the stock suspension was diluted in MilliQ water, sonicated for 10 minutes in a water bath, and counted using a hemacytometer and epifluorescent microscope.

Water Sample Preparation and Filtration

The two water types tested were tap water which was obtained directly from the laboratory faucet, and surface water which was collected from Tembladero Slough (TS), a creek that drains surface and agricultural runoff from the north western portion of the Salinas watershed in central California. An aliquot of both tap and TS water was reserved for water quality analyses. Parameters tested included salinity (Sybon Refractometer), pH (Accuemet pH meter), dissolved organic carbon (Shimadzu TOC/TN analyzer), total suspended solids (TSS), TSS-N and TSS-C (Carlo Erba NC1500). Ten liter volumes of tap and TS water were measured and *T. gondii* oocysts, green microspheres and blue microsphere were added to achieve a final concentration of 1000, 100, or 10 particles/liter. Spiking levels were tested in triplicate for both water types. Water was concentrated via hollow fiber ultra filtration (HFF) by continuously pumping ten liter samples through a recirculating small volume HFF system until the volume of retentate was reduced to approximately 50 milliliters (Rajal et al., 2007). The retentate was collected from the outflow port, and the filter was removed from the system apparatus and flushed back and forth with 50 ml of glycin solution using two 60 ml syringes. The glycin wash was combined with the collected retentate and the exact volume of this final retentate recorded. The retentate was then divided into two portions with one designated for TaqMan and conventional PCR and the other for membrane filtration.

Particle Detection

Membrane Filtration. Membrane filtration was performed using MicroFil filtration funnels (Millipore) placed on a 1000 ml flask connected to a vacuum hose. Ten milliliters for tap retentates and 5 ml for TS retentates were vacuum filtered onto membrane filters and the filters mounted on glass slides. A drop of glycerol was placed upon each filter and a round 25 mm cover slip applied. The entire filter was scanned using epifluorescent microscopy at 100X and

the numbers of *T. gondii* oocysts, green microspheres and blue microspheres were recorded. For each retentate, triplicate membranes were prepared and counted. For each retentate, the number of each particle type was averaged across the three membranes and the percent recovery calculated as follows:

Number of particles counted / Number particles expected X 100,

Where expected particle count =

[Number of total particles spiked / final retentate volume (ml)] X volume of retentate applied to membrane filter (ml)

TaqMan PCR. A one-tube TaqMan RT-PCR was used to determine the gene copy numbers of *T. gondii* oocysts after filtration and extraction. Twenty-five microliters of reaction contained 10mM Tris–HCl (pH 8.3), 50mM KCl, 5mM MgCl2, stabilized passive dye ROX (Applied Biosystems), 800nM each of dATP, dCTP, dGTP, and dTTP, 800nM of the forward primer, 400nM of each of four reverse primers, 80nM of the TaqMan probe, 6U MMLV-RT (Applied Biosystems), 1.25U of AmpliTaq Gold DNA polymerase, and 10 ml of the nucleic acid. Cycling conditions were 30 min at 48° C, 10 min at 95° C, followed by 40 cycles at 95° C for 15 sec and 60° C for 1 min using an ABI Prism 7000 (Applied Biosystems). Cycle threshold values were calculated with a threshold set to 0.09, with a baseline of 3 - 15 cycles. Retentates were processed in duplicate and determined to be positive if an exponential amplification signal was recorded by the instrument.

Conventional PCR. For each retentate, DNA was extracted from 1.5 ml in triplicate using one freeze/thaw cycle followed by the protocol described by QIAamp Tissue kit (Qiagen). DNA amplification was performed according to a previously described nested PCR protocol that targets a repetitive element sequence (Homan et al., 2000). Primary and secondary PCR reactions were carried out in 50µL reaction volumes containing $MgCl_2$ (15mM), dNTP (2.5 mM), forward primer (50pM/µl), reverse primer (50pM/µl), BSA, Taq Polymerase and 10 µL DNA template for external reaction and 2µL DNA amplicon for internal reaction. The secondary amplification products were detected by gel electrophoresis in 2% agarose gel containing ethidium bromide. PCR products were visualized under UV-illumination and photographed.

RESULTS & DISCUSSION

Water quality parameters for tap water and Tembladero Slough are summarized in Table 1.

Table 1. Water quality parameters of tap and Tembladero Slough water used in hollow fiber filtration experiments.

	Water Type	
Parameter	**Tap Water**	**Tembladero Slough**
Salinity (ppt)	< 0.5	1
pH	8.26	8.61
TSS (mg/L)	< 5	112
Turbidity (NTU)	0.247	108.33
DOC (mg/L)	0.46	8.4
TSS-C (mg/L)	<0.2	1
TSS-N (mg/L)	<0.05	0.13

In both tap and Tembladero Slough (TS) water samples, *T. gondii* oocysts and microspheres were detected across all spiking levels using membrane filtration followed by epifluorescent microscopy (Figure 1). The percents of particles detected in TS waters were much lower than in tap water, and in all water samples recoveries of green microspheres were higher than both blue microspheres and autofluorescent *T. gondii* oocysts. Overall, detection of green microspheres ranged between 36 and 54 percent in tap water and between 8 and 11 percent in TS water. For the blue microspheres, percent of spiked particles detected ranged between 26 and 29 percent in tap and between 2 and 8 percent in TS water. Detection of *T. gondii* oocysts was similar to blue microspheres, ranging between 15 and 30 percent in tap and between 2 and 4 percent in spiked TS water.

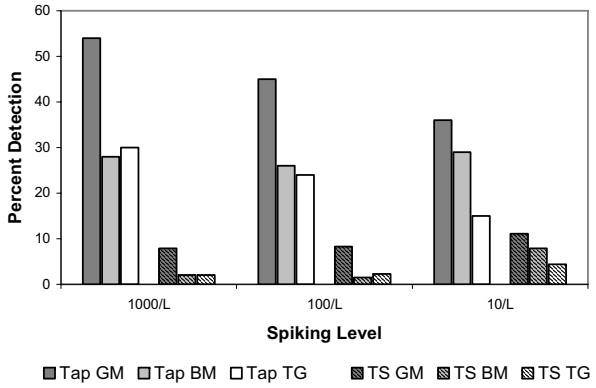

Figure 1. Percent of spiked particles detected via membrane filtration and epifluorescent microscopy in retentates of tap and Tembladero Slough (TS) water that was concentrated using hollow fiber filtration. Full bars represent tap water and hatched bars represent TS water. (GM = Green Microspheres, BM = Blue Microspheres, TG = *Toxoplasma gondii* oocysts).

In all retentates from tap water spiked with 1000 oocysts per liter, conventional and TaqMan PCR detected *T. gondii* DNA. In tap water spiked with 100 oocysts per liter, detection of *T. gondii* was achieved in all samples using TaqMan and in 8 out of 9 triplicate samples using conventional PCR. In retentates from tap water spiked with 10 oocysts per liter, only 4 out of 6 duplicate samples and one out of 9 triplicate samples tested positive for *T. gondii* DNA using TaqMan and Conventional PCR, respectively. Both PCR methods failed to detect *T. gondii* DNA in any of the TS retentates, in spite of oocysts being visualized on membrane filters from the same samples.

The approach described using hollow fiber filtration to concentrate samples followed by detection via membrane filtration represents the first described methods for quantitative detection of *T. gondii* oocysts in drinking and environmental waters. Several studies report that HFF is a more sensitive method for recovery of waterborne pathogens than the commonly employed capsule filtration method recommended by the U.S EPA, especially in environmental water (Kuhn and Oshima, 2002; Simmons et al., 2001). However until now, there have not been previous attempts to utilize HFF for the recovery of *T. gondii* from water. Autofluorescent properties of *T. gondii* oocyst wall allowed visualization of the parasite in

HFF retentates using epifluorescent microscopy even in very turbid surface water and at low concentrations. In this study, visual detection of oocysts following membrane filtration provided a more sensitive method for detection of *T. gondii* in concentrated environmental samples than molecular methods. Inhibition of PCR reactions by constituents such as dissolved organic carbon was likely a significant factor in the inability of these methods to detect *T. gondii* DNA in spiked TS water (Wilson, 1997). Other researchers have reported successful detection of *T. gondii* using PCR in concentrations as low as 1 oocyst/liter, however those results were obtained in spiked 100 liters of deionized water that likely had lower levels of PCR inhibitors (Villena et al., 2004).

Quantitative detection of surrogate microspheres using HFF and membrane filtration also provides a new tool for investigating the transport of *T. gondii* in aquatic habitats as well as for evaluating the efficacy of water treatment processes for removing this pathogen from drinking water. Use of microspheres as surrogates for other zoonotic protozoan parasites, including *Cryptosporidium* and *Giardia,* has been described in numerous studies (Dai and Hozalski, 2003; Emelko and Huck, 2004; Harvey et al., 2007). While caution must be taken in extrapolating results from experiments performed with surrogates, particles that are carefully chosen as surrogate particles based on similarity of surface chemistry with the pathogen in question offer several advantages. Unlike *T. gondii* oocysts, polystyrene microspheres are easy to obtain, safe to release, and depending on the fluorochrome used are also easier to detect in concentrated water samples. This latter factor was apparent in our results as the microspheres infused with a dragon green fluorochrome had a detection efficiency that was in some samples more than double that of the microspheres infused with a glacial blue fluorochrome. In addition, most autofluorescent background debris has a purple-blue appearance that is very similar to *T. gondii* oocysts and blue microspheres, making visualization of these two particles more difficult than green microspheres.

One limitation of our study is that a relatively small volume of water was processed (10 liters). The larger volumes of water often collected during monitoring procedures in water treatment plants as well as for detection of pathogens in environmental samples will likely lead to concentration of more debris that may reduce detection efficiency of both oocysts and microspheres using microscopy. Nonetheless, the recovery of surrogate microspheres from 10 liters of water is sufficient for estimating the concentration of particles during release studies for evaluation of the transport potential of *T. gondii* oocysts in aquatic environments.

CONCLUSIONS

Concentration of water using hollow fiber filtration followed by membrane filtration and epifluorescent microscopy offers a rapid, cost-effective, and quantitative approach for detection of *T. gondii* and surrogate microspheres in turbid water. The techniques we describe provide new methodology for concentrating *T. gondii* in drinking and environmental water and may improve detection of the parasite in water sources implicated in waterborne toxoplasmosis outbreaks. The same methods offer a tool for the recovery of surrogate microspheres in release studies for evaluating the transport and fate of *T. gondii* oocysts in watersheds and through water treatment processes.

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21 Monitoring of urban stormwater pollutants in both particulate and dissolved phases in separate sewers

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Abstract Organic and minerals pollutants are nowadays part of urban environment. They are ubiquitous in every component: soil, air, water, sediments. During a rain event, stormwater quality as well as the contaminant loads are affected by atmospheric deposition and the types of impervious urban surfaces, on which runoff occurs. Studies have shown that the variety of contaminants is related to the land use of each urban watershed. As a consequence, three sites in Paris and its suburb, whose watershed land use differs, were investigated. A screening of 88 stormwater pollutants will be carried out on samples collected at the outlet of these sites on both the dissolved and the particulate phases. In this paper, we will present a description of these three sites and of the monitoring strategy. As a consequence, this study will provide an original set of data for a large number of stormwater pollutants, both in the dissolved (µg.l-1) and the particulate (µg.g-1) phases for urban areas with different land use pattern.

Keywords Priority pollutants; runoff; screening; urban watershed; water frame directive

INTRODUCTION

Land development increases stormwater runoff volumes and pollutants concentrations. Impervious surfaces, such as rooftops, driveways and roads, prevent infiltration of rainfall and runoff into the ground and degrade the runoff quality. Urban runoff volume can be affected by different factors: the quantity of rain and the extent of impervious surfaces connected to a stream or drainage system. However, urban areas can be equipped with three types of sewers: sanitary or separate sewers, storm sewers and combined sewers. Each of these types has specific properties related to sewer processes. In case of separate storm sewer, the residence time of stormwater is quite short, and in general it ends up in watercourses without treatment. Stormwater quality becomes a crucial issue and an improved knowledge of its contamination is required.

Besides, the European Water Framework Directive (WFD) n° 2000/60/EC (EC 2000a) requires, a progressive reduction of discharges of priority substances into water bodies and the cessation of discharges of priority hazardous substances. The European Parliament decision n° 2455/2001/EC (EC 2001) highlighted on a list of 33 priority substances that must be reduced by 2015 or eliminated by 2020. Industrial and agricultural effluents as well as urban water (wastewater and stormwater, water from separate and combined sewer systems, etc) are concerned and should be analysed and quantified in order to define priorities for actions of urban water management approach. But the main limitation of this list is, the choice of these substances was relevant with respect to their specific industrial sources since they were

identified using the COMMPS approach (Combined Monitoring-based and Modelling-based Priority Setting). Thus, this list need to be expanded in order to include those carried from urban areas.

This paper focuses on stormwater pollution. One of the interesting features of our work is to extend the list of the 33 priority pollutants in order to include those specific to urban stormwater. An innovative screening methodology of this extended list will be done at the outlet of three separated storm sewers. A fully description of the screening methodology, precautions from sampling to analyses and the land use of each watershed are detailed in this paper.

The main objective of this research is to propose an appropriate list of urban stormwater pollutants which is able to be monitored on both the dissolved and the particulate phases. This screening can lead to asses the kind of pollutant generated from three watersheds having different land use pattern. The results can be used by managers in order to optimise the best management water practices and to contribute to reach the WFD goals.
This research is performed within the framework of the third phase of the OPUR (Observatory of Urban Pollutants) research programme, which aimed at improving knowledge of the origin, the characteristics and the transfer of pollutants in urban watersheds during dry and wet weather.

SELECTION OF URBAN PRIORITY POLLUTANTS

After an international literature review on monitoring programs and sources of urban pollutants, we have established a new list of 88 individual chemical substances including, also, the ordinary water quality parameters (to evaluate the general pollution). These substances should be monitored to prevent any future problems of pollution with respect to their urban sources. The choice of these substances was based on three different approaches: Sources of pollutants in an urban area, literature review of pollutants lists and European Directives. These approaches are detailed as follow:

Sources of urban pollutants

A number of studies have linked specific pollutants in stormwater runoff with their sources (Allen Burton *et al.*, 2001). For this reason, firstly we have investigated the sources; the uses and the production of some pollutants in urban areas. Then, we have looked to their toxicity degree, their bioaccumulation and their persistent in the environment.
Indeed, during precipitation, urban contaminants may be removed from air by either rain-in or washout (Gill *et al.*, 1983) and their load, can also be affected by the types of impervious urban surfaces on which runoff occurs. As a consequence, a large number of constituents, both organic and inorganic, may be present in stormwater (Eriksson *et al.*, 2002), runoff or wastewater (Allen Burton *et al.*, 2001, Garnaud, 1999, Gromaire-Mertz *et al.*, 1999) or even in stormwater at the outlet of a watershed. The measured concentrations may vary from event to event and from site to site (Gromaire-Mertz *et al.*, 1999), underlying the unique site-specific.
In this paper, we have considered four urban sources of pollutants that could be, generally, found on an urban watershed. These sources and the kind of pollutants load are as follow:
- Atmospheric deposits: organic substances (such as HAPs, PCBs, pesticides & alkylphenols); volatiles substances (BTEX & COHV); flame retardants (PBDEs, PCBs, chloroalkanes).
- Traffic: metals (Zn, Cu, Pb, Pt, Cd); alkylphenols; HAPs.
- Gardens: pesticides and their additives (alkylphenols, organotins).
- Buildings: metals; nonylphenols; PBDEs; phtalates.

Literature lists of pollutants

Some authors such as (Eriksson *et al.*, 2007), have established a list of pollutants called SSPPs (selected stormwater priority pollutants), to provide a clear statement on the need tackle of non-point source pollution in urban areas. The choice of pollutants in this list was based on a theoretically assessment of the stormwater pollutants presence called the CHIAT (Chemical Hazard Identification and Assessment Tool) methodology. It was developed within the 5th European Framework Project named Daywater (Thévenot *et al.*, 2005) to develop an adaptation decision support system for integration of stormwater source control into sustainable urban water management strategies to support stormwater managers. The aim of this list was to give a valuable support for stormwater managers regarding the comparison of various stormwater management strategies. However, its limitation is that it hasn't been yet experimentally screened on a stormwater sample.

European Water frame directive

On term of European Union rules, different lists were established since 1976. The two first lists were included in the Directive 76/464/EEC (ECC, 1976), on pollutants that caused pollution into the aquatic environment of the Community. Then in 2000, the EU has established a list for priority substances in the water policy field (EC 2000b) for which quality standards and measurements for the emission controls reduction will be set at Community level. This list includes 33 priority substances identified as substances representing a significant risk to or via the aquatic environment at EU level. But these pollutants were identified with respect to their industrial source without considering the urban ones.

Choice of the 88 urban pollutants

We found, that it seems important to evaluate not only the 33 priority pollutants of the WFD but also we have to expand this list to include other pollutants that could be loaded in urban areas. So we have defined a list of 88 urban pollutants included those of the WFD priority substances list (2000/60/CE), those of the List 1 of dangerous substances Directive (76/464/ECC) (ECC, 1976), as well as those chosen within the others lists as described above (Eriksson *et al.*, 2007) and those deriving from urban areas. For many organic substances of our list, there is no information available about the concentrations in both the dissolved and the particulate phases in the urban environment. In fact, data about priority substances in stormwater remain scarce so far worldwide. The scientific literature within this field has focused on quality parameters (Kafi- Benyahia *et al.*, 2008), heavy metals (Davis *et al.*, 2001, Garnaud *et al.*, 1999, Herngren *et al.*, 2005, Rule *et al.*, 2006b, Sabin *et al.*, 2005), polycyclic aromatic hydrocarbons (PAHs) (Ngabe *et al.*, 2000, Polkowska *et al.*, 2000), or on a given family of priority substances [PBDEs for (Kierkegaard *et al.*, 2004, Wang *et al.*, 2007), organotins for (Berto *et al.*, 2007), alkylphenols for (Fries *et al.*, 2004, Remberger *et al.*, 2003)]. Only a few surveys deal with all the substances of the priority list on bulk samples of wastewater or runoff (Rule *et al.*, 2006a, Rule *et al.*, 2006c).

So, a screening of these latter substances (88 substances, from 13 different chemical families) will be done on stormwater samples for the first time, and it will provide a concentration for each water phase: the dissolved and the particulate. This list is detailed in table 1 (annexed). While, the pharmaceuticals and personal care products (PPCPs), which refer to prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances and cosmetics, were purposely excluded from our work.

EXPERIMENTAL SITES

Monitoring campaigns for urban stormwater pollutants are carried out at the outlet of three experimental watersheds in Paris and its suburb, which are a part of the OPUR research programme (figure 1). Each watershed presents different land use cover. These sites are equipped with stormwater separate sewer system:

- Tolbiac-Massena is a 0.64 km² urban dense area in Paris centre with an impervious surface coefficient (ISC) of 0.80 (figure 2),
- Sucy-en-Brie is a 2.61 km² residential area in Paris suburb (Val de Marne) with an ISC of 0.27 (figure 3),
- Noisy-le-Grand is a 2.30 km² urban centre area in Paris suburb (Seine Saint Denis) with an ICS 0.65 (figure 4).

Sampling procedure

All watersheds are equipped with two similar specific sampling devices. Stormwater samples are collected at the outlet of each watershed by refrigerated automatic water samplers (Bühler 1029) to preserve sample integrity (figure 5). They are programmed to provide a mean rain event sample. Each is equipped with 12 bottles of 1 litre. In order to avoid any interactions between sampling devices and pollutants to be measured, samplers are configured as follow:

- For organic pollutants, samples are collected in Pyrex amber glass bottles with Teflon sampling tubes.
- For minerals substances and ordinary water quality parameters, samples were collected in polyethylene (PE) bottles with PVC tubes.

For each targeted analyses, these bottles are washed with a specific laboratory protocols. Glassware is previously thoroughly washed with TFD4 (a detergent), to remove any trace of organic contamination, then rinsed with deionised water and finally heated at 500°C prior to use. To avoid any metallic contamination, bottles are cleaned according to the following method: 24 h in a detergent bath (Extran, 5%), to remove any organic traces, then 24 h in a nitric acid (5%, Normatom) bath and finally 24 h in another nitric acid (5%, Normatom) bath. Between all bathes, bottles are rinsed with ultra-pure water (MilliQ system, Millipore).

All sites are equipped with ultrasonic transit time flowmeter capable of accurate measurement of depth and velocity in sewers to measure the flow variation. In order to catch the whole rain event, data from Meteo-France are used to gauge the sampling frequency. In addition, all sites are equipped with pluviometer to gauge exactly the quantity of precipitation on each (*i.e,* figure 6).

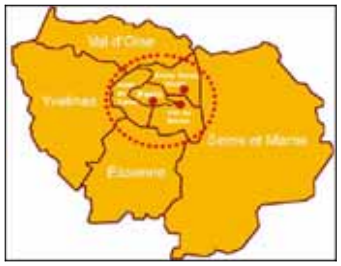

Figure 1. Location of experimental sites

Figure 2. Tolbiac-Massena watershed

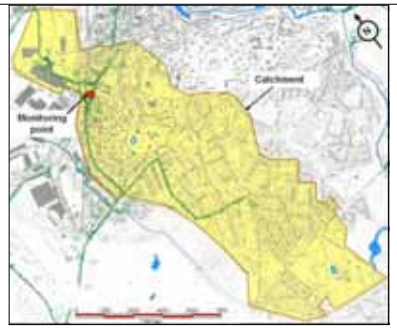

Figure 3. Sucy-en-Brie watershed

Figure 4. Noisy-le-Grand watershed

Figure 5. Two automatics samplers Bühler 1029

Figure 6. Pluviometer at Sucy

SCREENING METHODOLOGY

All the analyses are carried out by a certified laboratory. This laboratory was chosen among 10 laboratories that answered to our specifications and its capacity to carry analyses on these 88 substances in both the dissolved and the particulate phases.

Generally, when suspended solids (SS) concentration is above 500 mg/l analyses are made on these phases separately after filtration.

In most cases, analyses were made on bulk water sample without any specific analyses on suspended solids. This case can generate a misinterpretation of the results:

- Analyses carried out on unfiltered samples will provide poor-quality data with regard to the representativity of the contamination in water and also poor comparability between data from different laboratories (Coquery *et al.*, 2005),
- For organic pollutants having log Kp > 3, their concentration should preferably be measured in SS rather than in the bulk water sample or dissolved phase. As a matter of fact, solvent extraction of bulk water samples with high SS concentrations will be much less efficient for those substances than if performed on the SS itself, using extraction methods designed for solid phases, such as sediment or soil (Coquery *et al.*, 2005).

So, the results of dissolved and SS pollutant concentrations should be given separately, as such data are often lacking from monitoring databanks. These pose some interesting challenges for analytical testing laboratories:

- Water samples with low SS concentrations need large volumes, up to 10 litres to be filtered to get a suitable mass to perform reproducible analyses on solids,
- In some cases, analytical methods have not been fully validated for the solid phase in certified laboratories whereas they are analysed in routine in research laboratories.

So, this research attempt at performing a whole innovative screening of the 88 listed urban pollutants on stormwater on both the dissolved and the particulate phases. For samples with low SS, large volume of water samples, (i.e., 24 litres) will be filtrated to collect enough particles for analyses. Finally, in order to compare the analyses on both dissolved and particulate phases to the current analyses (i.e., on bulk samples), these two procedures will be carried out on the same sample.

Screening preparation samples

After a rain event, samples are collected, and bottles are mixed to get a mean sample of the event. From plastic bottles, sample is targeted to ordinary quality parameters and metals analyses while the bulk samples from glass bottles is also mixed, filtrated in a glass filtration unit in order to get the dissolved phase for organic contaminants. This latter is sent to the certified laboratory for analysis within 24 hours. Filters with suspended solids are deep-frozen, then lyophilized and stored at 4°C prior to analysis.

The analytical procedures used by the laboratory follow the existing French (AFNOR) or international (ISO) standards. When no standard was available, the laboratory has developed and validated its own methods. During analysis and in case where other substances are identified we will attempt to quantify them. In addition, field blanks will be done on automatic water samplers and on the whole analytical procedure.

CONCLUSION

This research work started in November 2006 within the framework research programme OPUR. All sampling equipments are installed on three separated sewer networks in Paris Centre and its suburb. Sampling procedures have been validated. The innovative screening methodology is described for the 88 urban pollutants on both the particulate and the dissolved. Analyses will be carried out by a French certified laboratory which has validated its analytical procedures in order to analyse for the first time stormwater samples, not only on bulk sample but also on both the particulate and the dissolved phases. Additionally, the screening of the 88 urban pollutants can be applied on different types of water samples such as wastewater from combined sewers collected at the outlet of urban watersheds, but also runoff from the different types of urban surfaces. Effective monitoring campaigns have started on these sites. In a first attempt, stormwater from storm sewers will be investigated followed by wastewater and runoff. So, this research will provide the first database concentrations for the 88 pollutants in dissolved and particulate phases for different kind of urban water samples collected from sites with different land uses pattern.

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Annexe Table 1. List of urban pollutants

Family pollutants name	Reference number	Parameters	CAS Number
General water quality parameters		Temperature	-
		pH	-
		Conductivity	-
		Total NTK	-
		Total Phosphor	-
		Suspended solids (SS)	-
		COD	-
Organotins	**1**	Tributyltin [TBT]	36643-28-4
	2	Dibutyltin [DBT]	1002-53-5
	3	Monobutyltin [MBT]	78763-54-9
Metals	**4**	Cadmium	7440-43-9
	5	Lead	7439-92-1
	6	Mercury	7439-97-8
	7	Nickel	7440-02-0
	8	Platinum	7440-38-2
	9	Chromium	7440-47-3
	10	Copper	7440-50-8
	11	Zinc	7440-66-6
Polycyclic Aromatics Hydrocarbons (PAH)	**12**	Benzo(a)Pyrene	50-32-8
	13	Benzo(b)Fluoranthene	205-99-2
	14	Benzo(g,h,i)Perylene	191-24-2
	15	Benzo(k)Fluoranthene	207-08-9
	16	Indeno(1,2,3-cd)Pyrene	193-39-5
	17	Anthracene	120-12-7
	18	Naphtalene	91-20-3
	19	Fluoranthene	206-44-0
	20	Acenaphtylene	208-96-8
	21	Fluorene	86-73-7
	22	Phenanthrene	85-01-8
	23	Pyrene	129-00-0
	24	Benzo(a)anthracene	56-55-3
	25	Chrysene	218-01-9
	26	Dibenzo(a,h)anthracene	53-70-3
	27	Acenaphtene	83-32-9
Polychlorinated Biphenyls (PCBs)		**PCB (sum of congeners)**	1336-36-3
	28	PCB 28	
	29	PCB 52	
	30	PCB 101	
	31	PCB 118	
	32	PCB 138	
	33	PCB 153	
	34	PCB 180	
	35	PCB 194	
Chlorobenzenes	**36**	Hexachlorobenzene	118-74-1
	37	Pentachlorobenzene	608-93-5
		Trichlorobenzenes	12002-48-1
	38	1,2,4-trichlorobenzene	120-82-1
	39	1,2,3-trichlorobenzene	87-61-6
	40	1,3,5-trichlorobenzene	108-70-3
Benzene Toluene Ethylbenzene Xylene (BTEX)	**41**	Benzene	71-43-2
	42	Ethylbenzene	100-41-4
	43	Isopropylbenzene	98-82-8
	44	Toluene	108-88-3
	45	Xylenes (Sum o,m,p)	1330-20-7
Volatiles organics compounds (VOCs)	**46**	1,2-dichloroethane	107-06-2
	47	methylene Chloride	75-09-2
	48	Hexachlorobutadiene	87-68-3
	49	Chloroform	67-66-3
	50	Carbon tetrachloride	56-23-5
	51	Tetrachloroethylene	127-18-4
	52	Trichloroethylene	79-01-6
Chlorophenols	**53**	Pentachlorophenol [PCP]	87-86-5
	54	4-chloro-3-methylphenol	59-50-7
Alkylphenols	**55**	Nonylphenols	25154-52-3
	56	4-(para)-nonylphenol	84852-15-3
	57	para-tert-octylphenol	140-66-9
	58	4-n-octylphenol	1806-26-4
	59	4-tert-butylphenol	94-54-4
Brominated Diphenylethers	**60**	Pentabromodiphenylether	32534-81-9
	61	Octabromodiphenylether	32536-52-0
	62	Decabromodiphenylether	1163-19-5
Pesticides	**63**	Alachlor	15972-60-8
	64	Aldrin	309-00-2
	65	Endrin	72-20-8
	66	Dieldrin	60-87-1
	67	DDT-2,4'	789-02-6
	68	DDT-4,4'	50-29-3
	69	Isodrin	465-73-6
	70	Endosulfan alpha	959-98-8
	71	Endosulfan beta	33213-65-9
	72	Lindane	608-73-1
	73	alpha Hexachlorocyclohexane	319-84-6
	74	Chlorfenvinphos	470-90-6
	75	Chlorpyrifos	2921-88-2
	76	Trifluralin	1582-09-8
	77	Atrazine	1912-24-9
	78	Desethylatrazine [DEA]	6190-65-4
	79	Desethylsimazine	1007-28-9
	80	Simazine	122-34-9
	81	Diuron	330-54-1
	82	Isoproturon	34123-59-6
	83	Metaldehyde	108-62-3
	84	Aminotriazole	61-82-5
	85	Glyphosate	38641-94-0
	86	AMPA	83654-13-1
others	**87**	C10-C13 chloroalkanes	85535-84-8
Phtalates	**88**	Di(2-ethylhexyl)phtalate [DEHP]	117-81-7

22 Impact of Land Use on Water Quality of Phewa- Lake Pokhara,Nepal

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Abstract

The principle recent change in rural land use in the Pokhara valley of Nepal is that rural area are being absorbed into growing town and cities . this conversion of rural in to urban land has several impact on lake water quality because of development such as industrial instillations and so many hotel and restaurant which are located along the bank of environmentally vulnerable lake .Phewa Lake which is a major tourist destination of Nepal is at present facing high human pressure at both its urban and rural watershed areas .in the absence of proper sewage system in Pokhara city. High sedimentation rate of the lake has half reduced its size since 1956.The prime objective of the water quality monitoring is to characterize the water quality of Phewa Lake over a long time frame. The water quality monitoring is mainly based on quantitative determination of selected physical and chemical parametric values that present in the water where various intervention have been implemented. Since the concentration of pollution level distribution at fhewa lake is heterogeneous in nature, the stratified random sampling technique is adopted.

And to provide reliable data about sedimentation in the Phewa lake , which could then be used to estimate and predict sedimentation rate lake storage capacity ,and its expected life span .The eco sounding , aerial photo and photo monitoring have given a clear picture of the sedimentation in the silt trap area . Phewa Lake is mesotrophic to eutrophic status .most of the analyzed physo chemical parameters are destructive as found in natural surface water bodies.In such situation ,if the lake continuous to be polluted and fill up by sediment at present rate ,its recreational and aesthetic value as well as national economy of Pokhara ,Nepal will be diminished .

Key word: water quality, land use, pollution, sedimentation, watershed,

1. Introduction

1.1 Background

Nepal is renowned in the world on account of her natural beauty, geographical / biological diversity and culture heritage. In adequate management and unwise utilization of these resources, despite there high potential has been undergoing several environment degradation. As a result, they may reach to a critically threatening point if adequate measures are not taken. One of such important natural area is Phewa lake in Pokhara valley .The Phewa Lake is one of the most beautiful place in Nepal and attracts a large number of tourists from all over the world. By the virtue of its natural beauty, the lake contributes significantly in local and national economy through tourist industry.

1.2 Objective of the study

To identified the concentration of pollution in the lake
To estimate and predict sedimentation rate, lakes storage capacity and its expected life span.

1.3 Problem statement

However the lake and its watershed has been under immense and exhaustive pressure due to excessive human intervention since last couple of decade.

2. MATERIALS AND METHODS

2.1 Study area

Fig 1 Nepal

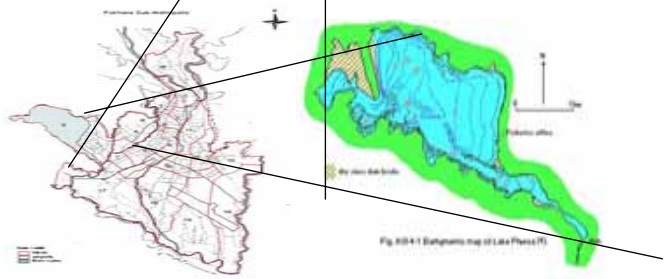

Fig 2: Pokhara valley **Fig3: Phewa lake**

2.2 Method of water sampling

Water samples were taken twice in a month, i.e. first and last week, from 5 stations located in different part of lake namely Anadu, Khapaudi, Hallan Chowk, Inlet and Outlet. Water samples from Anadu were collected from 0m, 2.5m, 5.0m, 7.5m, 15m and 20m. Khapaudi site permitted samples were taken only from surface and 1m depths. Water temperature, pH and secchi disk validity were measured in situ. Water samples for dissolve oxygen was fixed at the site and measured by Wrinkler's method. Nutrient analysis of water began immediately after collection of the samples in the laboratory. The standard methods involved in the nutrient analysis of water were: chlorophyll-a by SCOR/UNESCO (1960), ammonium-nitrogen (NH_4-N) by Bower and Hansen (1980), nitrite +nitrate-nitrogen (NO_2+ NO_3-N) by Dowens (1978) and phosphate-phosphorus (PO_4-P) by Murphy and Rilay (1966).

2.3 Method of sedimentation survey

2.3.1 Echo sounding survey

The sedimentation survey of March 2006 is used as the base line information on the lake bed with reference to the high water level 794.15 m .The depth of the water in the lake is measured from a rowboat with an echo sounding instrument. The measured water depth is related to the reference water level (i.e.974.15m).
It continuously record depth to the bottom of the lake as boat moves along survey line. The positioning of the survey line is fixed by stretching a rope between benchmark so that measurement can be made along the same fixed line repeatedly. The rope is marked at every 25 meters interval and these positions are recorded in the chart during the echo sounding survey. This ensures the location of the measurement with reference to the benchmark. When the water depth was less than 2-3 m and the profile was not clear , the water depth was measured manually using measuring rod or rope with stone and incorporated with the eco sounding graphs for the analyze .

2.3.3 Aerial photo graph

The survey utilizes also the aerial photo graph from 1983,1998,2001,2002 and 2004 to review the growth of the delta over a long time period. The photo graph help to understand the sedimentation process near the river mouth and over a longer time period, show visually the growth of the delta.

3. RESULT AND DISCUSSION

3.1 Water Quality of Sampling Sites

Season: Pre-monsoon

Parameters	**Observed value**				
	Inlet	**H.Chowk**	**Outlet**	**Khapaundi**	**Anaudi**
Physical					
Water temperature (^{0}C)	25.4	24.9	27.8	24.5	24.3
visibility(m)	3.1	3	2.9	4.1	5.9
Chemical					
Dissolve oxygen (mg/L)	8	6.5	6.6	7.5	7.3
Biological oxygen demand (mg/L)	2.9	3.5	4.6	4.5	4.3
Chlorophyll (mg/m^3)	4.6	5.0	1.0	4.6	2.6
Nitrate nitrite (mg/L)	0.100	0.200	0.100	0.100	0.200
Ammonia (mg/L)	0.040	0.020	0.030	0.006	0.006
Total phosphorous (mg/L)	36.0	83.0	31.0	24.0	29.0
pH	5.0	8.1	6.0	5.7	5.8
Biological					
Heterotrophic bacteria (cells/ml)	$4.435*10^6$				
Heterotrophic Nano flagellates(cells/ml)	$0.832.10^3$				
Phytoplankton abundance (cells/ml)	227	1083	622	722	976
Zooplankton density (No/L)	51	233	374	478	836
Water hyacinth coverage (Eye estimate)	10%				

Table 2: water quality parameter of Phewa Lake at pre-monsoon period

Season: Monsoon

Parameters	**Observed value**				
	Inlet	**H.Chowk**	**Outlet**	**Khapaundi**	**Anaudi**
Physical					
Water temperature (^{0}C)	20.0	23.5	24.1	20.5	21.5
visibility(m)	2.8	2.9	2.1	2.3	2.7
Chemical					
Dissolve oxygen (mg/L)	7.0	9	8.7	7.6	8
Biological oxygen demand (mg/L)	4.5	3.2	3.8	4.2	4
Chlorophyll (mg/m^3)	6.0	13.6	20.4	19.6	30.0
Nitrate nitrite (mg/L)	0.186	0.060	0.164	0.06	0.154
Ammonia (mg/L)	0.080	0.030	0.009	0.032	0.004
Total phosphorous (mg/L)	77.0	58.0	35.0	34.0	40.0
pH	6.5	7.6	7.3	6.8	7.0
Biological					
Heterotrophic bacteria (cells/ml)	9.02×10^6				
Heterotrophic Nano flagellates(cells/ml)	0.9444×10^3				
Phytoplankton abundance (cells/ml)	446	739	317	2091	414
Zooplankton density (No/L)	291	394	87	420	92
Water hyacinth coverage (Eye estimate)	8%				

Table 3: water quality parameter of Phewa Lake at monsoon period

Season: Post monsoon

Parameters	**Observed value**				
	Inlet	**H.Chowk**	**Outlet**	**Khapaundi**	**Anaudi**
Physical					
Water temperature (^{0}C)	18.0	22.5	18.5	19	19.5
visibility(m)	2.7	2.2	2.4	3.4	4.4
Chemical					
Dissolve oxygen (mg/L)	7.7	9.69	7.0	7.4	7.3
Biological oxygen demand (mg/L)	4.2	3.7	4	3.9	3.5
Chlorophyll (mg/m^3)	2.0	10.5	3.3	2.9	1.6
Nitrate nitrite (mg/L)	0.054	0.037	0.017	0.030	0.040
Ammonia (mg/L)	0.007	0.002	0.003	0.001	0.002
Total phosphorous (mg/L)	43.5	75.0	28.0	26.0	42.0
pH	5.6	6.5	6.1	6.2	6.2
Biological					
Heterotrophic bacteria (cells/ml)	$10.33x10^6$				
Heterotrophic Nano flagellates(cells/ml)	0.738×10^3				
Phytoplankton abundance (cells/ml)	379	1217	909	1443	1729
Zooplankton density (No/L)	738	685	271	458	218
Water hyacinth coverage (Eye estimate)	6%				

Table 4: water quality parameter of Phewa Lake at post-monsoon period

3.3 Sedimentation

Generally, Phewa Lake has broad and gentle sloped lake bottom except at the gorge portion. The sedimentation distribution is quite thin and in many places is beyond the accuracy of the instruction for the sediment computation on annual basis. The sedimentation up to January 2004 had been computed by the department of soil conservation. Therefore, here the sedimentation in the lake between the January 2004 and February 2006 is computed. The deposition or erosion of sediment is computed by multiplying the mean of the average water depths of two cross-section by the area of the reservoir surface between those two cross sections. The average sedimentation rate in the Phewa lake for the period of March 2000 to Feb 2006 is about 180000 cu. m. and in the silt trap area (1), it about 94000 cu. m. annually.

3.5 Lake's Storage Capacity

The gross capacity of the reservoir is computed by multiplying the mean of the average water depths of two contour lines by the area of the reservoir surface between those two contour lines using the bathymetric map (method II). During the highest water level, the area of lake is 439 ha and the total capacity of the lake is estimated to be 42.2 million cubic meters (February 2006). About 74% of the coverage area and 87% of the water volume are in the main reservoir area(II). Similarly 10% of the coverage area and 8% of the water volume are in the river channel (III). Only 16% of the coverage area and 5% of the water volume are in the silt Trap Area .

3.8. Life spans of the lake.

The capacity of the lake is estimated as 42.18 million cu. m. with highest water level of +794.15 m. if the lake is considered to be dead, when 80% of the silted up and if the average sedimentation rate about 180000 cu m. continue, the lake will be dead in about 190 years.The sedimentation rate in the silt trap area for the period of 4 year (2000 to 2004) was about 120000 cu. m. annually for the period between 2004 to 2006, it was only about 67750 cu. m. therefore, and the average sedimentation rate for the period from 2000 to 2006 in the silt trap area is about 94000 cu. m. With the annual average sedimentation of about 94000 cu. m. in the silt trap area about 68 ha. (I.e. 16 % of the lake area) it will be completely filled in 24 years. However, the result depends on how the Harpan Khola shifts with in the deltas. If the sedimentation rate of 67750 cu. m. continues in a silt trap area, it will be completely filled only in the next 33 years. The growth of the delta at the rate of about 2 hectares per year also indicate that in about 33 years the silt trap area (I) of about 68 hectare will be completely silted up.

4. CONCLUSION

The water quality parameter of the three seasons in Phewa Lake suggest its eutrophic status. Among many station Hallan Chowk input highest amount of phosphorus due to this area direct discharge solid waste . If the average annual sediment rate about 180000 cu. m. contain 80% of Phewa lake storage capacity will be silt up in the next 190 years virtually making the Phewa lake useless there fore the silt trap area depending up on the situation of Harpan Khola will be completely fill up in between 24 to 34 years reducing the 16 % of the lake area .

Sediment monitoring is a tool to guide the concerned agencies for the formulation of necessary strategy to protect the lake from sedimentation. Similarly study to understand the relationship between climates; erosion processes in the watershed and sedimentation in the lake are needed.

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