Caribbean Regional Fund for Wastewater Management

CReW

International Best Pratices

International Overview of Best Practices in Wastewater Management

CEP Techinical Report 65

International Overview of Best Practices in Wastewater Management

INTERNATIONAL BEST PRACTICES

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Promoting development with the environment in mind……securing a sustainable future

Project on Testing a Prototype Caribbean Regional Fund for Wastewater Management (CreW)

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Acronyms

BOD	Biochemical Oxygen Demand
CEPT	Chemically Enhanced Primary Treatment
CMA	Catchment Management Agency (South Africa)
COP	Code of Practice
CReW	Caribbean Regional Fund for Wastewater Management
CWA	Clean Water Act (USA)
DTSS	Deep Tunnel Sewerage System (Singapore)
EPMA	Environmental Protection and Management Act (Singapore)
EST	Environmentally Sound Technology
EU	European Union
GEF	Global Environmental Facility
IADB	Inter-American Development Bank
IBP	International Best Practice
IWRM	Integrated Water Resource Management
MINAS	MInimal NAtional Standards (India)
NEA	National Environment Agency (Singapore)
NGO	Non-governmental Organization
NPDES	National Pollutant Discharge Elimination System (USA)
NRA	National Rivers Authority (England and Wales)
NWSDB	National Water Supply and Drainage Board (Sri Lanka)
O&M	Operation and Management
PUB	Public Utilities Board (Singapore)
RAS	Restroom Association of Singapore
SDA	Sewerage and Drainage Act (Singapore)
SIDS	Small Island Developing State
TSS	Total Suspended Solids
WCR	Wider Caribbean Region
WHO	World Health Organization
WOP	Water Operators Partnership

Introduction

The decline in the quality of surface and groundwater resources from industrial discharges and poor sanitation is a major concern especially where cities are growing rapidly. As well as being a finite resource, domestic water supplies and aquatic ecosystems are at increasing risk of pollution. This increases the scarcity of good quality water and harms habitats.

According to the IRC (2004), professionals working in domestic water supply and sanitation are faced with a range of critical questions as populations and demands on water resources continue to grow: How to develop reliable sources with sufficient water for domestic supplies? How to ensure adequate water quality, and protect sources from pollution? How to minimize the impacts of water abstraction and wastewater pollution on other water users? Finding answers to these questions, and putting in place processes that lead to sustainable solutions, is of increasing importance as we continue to see more conflicts over access to water affecting domestic supplies, more systems failing due to resource problems, and rising infrastructure and treatment costs.

The United Nations Environment Programme Caribbean Environment Programme has partnered with the Inter-American Development Bank (IADB) and the Global Environmental Facility (GEF) to develop a prototype regional revolving fund which will provide sustainable financing for environmentally sound and cost-effective wastewater management projects in the Wider Caribbean Region. The fund is being piloted as a possible modality for providing sustainable financing for wastewater management projects in the region while also addressing key capacity constraints within existing legal, institutional, policy frameworks for wastewater management.

To assist in designing the most effective intervention, technical input is to be provided for the development of the full GEF project proposal for a Caribbean Regional Fund for Wastewater Management (CreW) by implementing the following tasks:

- Conducting a situational analysis of wastewater management in the Wider Caribbean Region, with particular emphasis on wastewater technologies, policy and legislation for wastewater management;
- Preparing a gap analysis to be derived based on the situation with respect to the management of wastewater in the Region and international best practices related to wastewater management with an emphasis on small island developing states (SIDS);
- Examining knowledge, attitudes and practices regarding wastewater management as well as the modes of information dissemination within the Wider Caribbean region. This analysis will inform the development of a public education and communication strategy on wastewater issues in the Region.

Purpose of Study

This International Best Practice study provides some of the technical input required to prepare the gap analysis to determine the needs of countries in the Wider Caribbean Region (WCR) regarding wastewater management. The study highlights some best practices in wastewater management from a variety of throughout the world. Best practice examples can provide models for countries in the WCR and can illustrate complexities in accomplishing certain goals and demonstrate how challenges can be overcome. The countries highlighted included developed and developing countries, large countries as well as small island states in order to provide a cross-section of solutions and to meet the needs of all countries in the region, which are at different levels of development and face different challenges.

Definitions

According to BNet Business Directory, "best practice" can be described as:

- The most effective and efficient method of achieving any objective or task.
- A well-defined procedure that is known to produce near-optimum results.

With respect to wastewater management, the concepts of effective, efficient and near-optimum have specific meaning. Best practice in wastewater management is more fully defined below.

Water and wastewater management is concerned with providing potable water to households and industries and the collection, transmission, treatment and disposal of wastewater. Sanitation refers mainly to the facilities and hygiene principles and practices related to the safe collection, reuse and/or disposal of human excreta and domestic wastewater.

For the purposes of this study, domestic wastewater is considered to be the liquid waste produced by households, schools, hotels, and small commercial establishments commonly combined in town or city sanitary drainage systems. Industrial wastewater is considered to be liquid waste from manufacturing plants for a variety of industrial products.[1] Domestic wastewater can be divided into two categories:

- greywater: wastewater from the shower, bath, basins, washing machine, laundry troughs, and kitchen — also referred to as sullage
- sewage[2]: all wastewater including greywater and toilet waste (also known as blackwater)

[1] This is in line with the report, "Appropriate Technology for Sewage Pollution Control in the Wider Caribbean Region" which identifies the most appropriate wastewater treatment technologies and water quality standards for the Wider Caribbean Region (WCR).

[2] Note that, technically, sewage is wastewater that is contaminated with faeces or urine, but is often used to mean any waste water.

The physical infrastructure, including pipes, pumps, screens, and channels used to convey sewage from its origin to the point of eventual treatment or disposal is termed sewerage.

Best practice examples in wastewater management should demonstrate initiatives which integrate water resource management, coastal zone management, environmental management, waste management and human health issues; stakeholder participation in the development of policy and practice; public education and awareness in wastewater management and general environmental management and/or sanitation and hygiene; innovative technologies used in treatment plants; culturally acceptable technologies and practices for wastewater management in households and industry; high levels of clean technologies in industry; high capacity of entities that deal with wastewater; a cohesive institutional framework for delegating responsibilities and management; innovative and sufficient financing for wastewater management; and a holistic approach to training and development of human resource capacities.

Structure of the Report

This report presents guiding principles for wastewater management and discusses the emerging concept of Integrated Water Resource Management (IWRM). The report describes general principles and criteria for best practices in the full spectrum of wastewater management: in the areas of legislation, policy and institutions; standards and guidelines; technologies and practices; public education/communication and clearing house mechanisms.

IBP

Following the discussion in each area, the report presents specific International Best Practice examples – denoted by the “IBP” symbol.

Also, the report presents an example of one country whose holistic wastewater management system is considered exemplary: a national best practice example.

Guiding Principles for Wastewater Management

The following guiding principles provide a suitable basis for sound management of water pollution.

1. *Prevent pollution rather than treating symptoms of pollution*
   Past experience has shown that remedial actions to clean up polluted sites and water bodies are generally much more expensive than applying measures to prevent pollution from occurring. Although wastewater treatment facilities have been installed and improved over the years in many countries, water pollution remains a problem, including in industrialized countries. In some situations, the introduction of improved wastewater treatment has only led to increased pollution from other media, such as wastewater sludge. The most logical approach is to prevent the production of wastes that require treatment. Thus, approaches to water pollution control that focus on wastewater minimization, in-plant refinement of raw materials and production processes, recycling of waste products, etc., should be given priority over traditional end-of-pipe treatments. In many countries, however, an increasing proportion of water pollution originates from diffuse sources, such as agricultural use of fertilizers, which cannot be controlled by the approach mentioned above. Instead, the principle of "best environmental practice" should be applied to minimize non-point source pollution. As an example, codes of good agricultural practice that address the causes of water pollution from agriculture, such as type, amount and time of application of fertilizers, manure and pesticides, can give guidance to farmers on how to prevent or reduce pollution of water bodies. Good agricultural practice is recognized by the United Nations Economic Commission for Europe as a means of minimizing the risk of water pollution and of promoting the continuation of economic agricultural activity (UNECE, 1993).

2. *Use the precautionary principle*
   There are many examples of the application and discharge of hazardous substances into the aquatic environment, even when such substances are suspected of having detrimental effects on the environment. Until now the use of any substance and its release to the environment has been widely accepted, unless scientific research has proved unambiguously a causal link between the substance and a well-defined environmental impact. However, in most cases it takes a very long time to establish such causal links, even where early investigations suggest clear indications of such links.

When, eventually, the necessary documentation is provided and action can be taken to abandon the use of the substance, substantial environmental damage may already have occurred. Examples of such situations include a number of pesticides which are now being abandoned because contamination of groundwater resources has been demonstrated. The examples clearly show that action to avoid potential environmental damage by hazardous substances should not be postponed on the grounds that scientific research has not proved fully a causal link between the substance and the potential damage (UNECE, 1994).

3. *Apply the polluter pays principle*

   The polluter pays principle, where the costs of pollution prevention, control and reduction measures are borne by the polluter, is not a new concept but has not yet been fully implemented, despite the fact that it is widely recognized that the perception of water as a free commodity can no longer be maintained. The principle is an economic instrument that is aimed at affecting behaviour, i.e. by encouraging and inducing behaviour that puts less strain on the environment. Examples of attempts to apply this principle include financial charges for industrial waste-water discharges and special taxes on pesticides. The difficulty or reluctance encountered in implementing the polluter pays principle is probably due to its social and economic implications. Full application of the principle would upset existing subsidized programmes (implemented for social reasons) for supply of water and removal of wastewater in many developing countries. Nevertheless, even if the full implementation of the polluter pays principle is not feasible in all countries at present, it should be maintained as the ultimate goal.

4. *Apply realistic standards and regulations*

   An important element in a water pollution control strategy is the formulation of realistic standards and regulations. However, the standards must be achievable and the regulations enforceable. Unrealistic standards and non-enforceable regulations may do more harm than having no standards and regulations, because they create an attitude of indifference towards rules and regulations in general, both among polluters and administrators. Standards and regulations should be tailored to match the level of economic and administrative capacity and capability. Standards should be gradually tightened as progress is achieved in general development and in the economic capability of the private sector. Thus, the setting of standards and regulations should be an iterative and on-going process.

5. *Balance economic and regulatory instruments*

   Until now, regulatory management instruments have been heavily relied upon by governments in most countries for controlling water pollution. Economic instruments, typically in the form of wastewater discharge fees and fines, have been introduced to a lesser extent and mainly by industrialized countries. Compared with economic instruments, the advantages of the regulatory approach to water pollution control is that it offers a reasonable degree of predictability about the reduction of pollution, i.e.

it offers control to authorities over what environmental goals can be achieved and when they can be achieved (Bartone et al., 1994). A major disadvantage of the regulatory approach is its economic inefficiency. Economic instruments have the advantages of providing incentives to polluters to modify their behaviour in support of pollution control and of providing revenue to finance pollution control activities. In addition, they are much better suited to combating nonpoint sources of pollution. The setting of prices and charges are crucial to the success of economic instruments. If charges are too low, polluters may opt to pollute and to pay, whereas if charges are too high they may inhibit economic development. Against this background it seems appropriate, therefore, for most countries to apply a mixture of regulatory and economic instruments for controlling water pollution. In developing countries, where financial resources and institutional capacity are very limited, the most important criteria for balancing economic and regulatory instruments should be cost-effectiveness (those that achieve the objectives at the least cost) and administrative feasibility.

6. *Apply water pollution control at the lowest appropriate level*

   The appropriate level may be defined as the level at which significant impacts are experienced. If, for example, a specific water quality issue only has a possible impact within a local community, then the community level is the proper management level. If environmental impacts affect a neighbouring community, then the appropriate management level is one level higher than the community level, for example the river basin level. On a wider scale, the appropriate management level may be the national level for major water bodies where no significant water pollution impacts are anticipated for neighbouring states. Where significant impacts occur in several nations, the appropriate management level is international (e.g. an international river basin commission). The important point is that decisions or actions concerning water pollution control should be taken as close as possible to those affected, and that higher administrative levels should enable lower levels to carry out decentralised management. However, in considering whether a given administrative level is appropriate for certain water pollution control functions, the actual capacity to achieve these functions (or the possibility of building it) at that level should also be taken into account. Thus, this guiding principle intends to initiate a process of decentralisation of water pollution control functions that is adapted to administrative and technical feasibility.

7. *Establish mechanisms for cross-sectoral integration*

   In order to ensure the coordination of water pollution control efforts within water-related sectors, such as health and agriculture, formal mechanisms and means of cooperation and information exchange need to be established. Such mechanisms should:

   - Allow decision makers from different sectors to influence water pollution policy
   - Urge them to put forward ideas and plans from their own sector with impacts on water quality

- Allow them to comment on ideas and plans put forward by other sectors. For example, a permanent committee with representatives from the involved sectors could be established. The functions and responsibilities of the cross-sectoral body would typically include at least the following:
    i. Coordination of policy formulation on water pollution control
    ii. Setting of national water quality criteria and standards, and their supporting regulations
    iii. Review and coordination of development plans that affect water quality
    iv. Resolution of conflicts between government bodies regarding water pollution issues that cannot be resolved at a lower level

8. *Encourage participatory approach with involvement of all relevant stakeholders*

   The participatory approach involves raising awareness of the importance of water pollution control among policy-makers and the general public. Decisions should be taken with full public consultation and with the involvement of groups affected by the planning and implementation of water pollution control activities. This means, for example, that the public should be kept continuously informed, be given opportunities to express their views, knowledge and priorities, and it should be apparent that their views have been taken into account. Various methods exist to implement public participation, such as interviews, public information sessions and hearings, expert panel hearings and site visits. The most appropriate method for each situation should take account of local social, political, historical, cultural and other factors. In many countries in transition, for example, only professional and scientific experts usually participate and other groups have mostly been excluded from the process. Public participation may take time but it increases public support for the final decision or result and, ideally, contributes to the convergence of the views of the public, governmental authorities and industry on environmental priorities and on water pollution control measures.

9. *Give open access to information on water pollution*

   This principle is directly related to the principle of involvement of the general public in the decision-making process, because a precondition for participation is free access to information held by public authorities. Open access to information helps to stimulate understanding, discussions and suggestions for solutions of water quality problems. In many countries, notably the countries in economic transition and the developing countries, there is no tradition of open access to environmental information. Unfortunately, this attitude may seriously jeopardize the outcome of any international cooperation that is required.

10. *Promote international cooperation on water pollution control*

   Trans-boundary water pollution, typically encountered in large rivers, requires international cooperation and coordination of efforts in order to be effective. Lack of recognition of this fact may lead to wasteful investments in pollution load reductions in one country if, due to lack of cooperation, measures are introduced upstream that have counteractive effects. In a number of cases (e.g. the Danube, Zambezi and Mekong rivers), permanent international bodies with representatives from riparian states have been successfully established, with the objective of strengthening international cooperation on the pollution control of the shared water resources.

Integrated Water Resources Management

It has become internationally recognized that wastewater management should be part of the larger framework of Integrated Water Resource Management (IWRM). IWRM has emerged during the last decade as a response to the widespread concern that the planet's freshwater resources are coming under increasingly unsustainable pressure from rising populations, growing demands for water and increasing pollution. IWRM is based on the Dublin Principles that came out of the 1992 International Conference on Water and the Environment, and which emphasize a holistic approach, decentralized control, and respect for the environment.

The Dublin principles

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2. Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
3. Women play a central part in the provision, management and safeguarding of water.
4. Water has an economic value in all its competing uses and should be recognized as an economic good.

IWRM is still an evolving concept and, while several definitions are used, all definitions include the core elements of equity, efficiency and sustainability. The most widely used definition is from the Global Water Partnership:

> IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (IWA, 2009).

IWRM aims to:

- promote more equitable access to water resources and the benefits that are derived from water in order to tackle poverty
- ensure that scarce water is used efficiently and for the greatest benefit of the greatest number of people
- achieve more sustainable utilization of water, including for a better environment

The water sector is divided into many sub-sectors (agriculture, urban and rural water supply and sanitation, industry and mining, environment and tourism, fisheries, energy, transport, etc.). All these water users (and polluters) have the potential to impact upon each other, both positively and negatively. Increasing demand and water pollution coupled with reduced water resource availability requires a holistic, integrated philosophy.

IWRM requires a change from traditional sub-sector based approaches (sanitation, irrigation, industry, etc) to a more holistic or integrated approach to water management based upon a set of agreed key principles. The principles offer a framework for analyzing and managing multiple uses of water in situations of increasing competition and conflict and where water resources are scarce (or polluted). IWRM also provides a framework for the sanitation sector to better consider and manage their impacts on other water users, especially inadequate sanitation and wastewater treatment (IRC 2004).

There is now wide acceptance of the merit of Integrated Water Resource Management. However, practical implementation of IWRM and infusing the IWRM principles into worldwide water management practice still requires a massive international effort ranging from reforms of water management laws, institutions and regulatory systems to capacity building in a wide variety of areas.

At the implementation level, this integrated form of management is best accomplished at the watershed or river basin or catchment level. However, IWRM can also be adopted at other physical and institutional scales. Real and significant improvements in water management can be made at all levels – from the household to the international basin - by individuals and institutions applying the Dublin principles in the context of their own abilities and opportunities. The application of IWRM principles and best practice in sub-sector projects and programmes, and the promotion of bottom-up multiple stakeholder management will go a long way in improving water and wastewater management.

Ideal Policy Framework

As discussed above, integrated water resource management requires the involvement of all stakeholders, including policy makers (governments), investors (governments/private sector companies), managers (public and private sectors) and users (communities/community organizations) within a coordinated system that establishes clear responsibility and authority.

Governments have generally final jurisdiction and responsibility in water and wastewater management by setting overall policy, whether they are involved in performing the management functions or not. Many government departments play crucial roles in the management of wastewater. Public health departments have jurisdiction over the maintenance of public health. In an integrated system a public health department has responsibilities in monitoring, inspection and enforcement of public health and in general hygiene promotion. Public works departments have jurisdiction over large infrastructure projects involving wastewater and stormwater. They have the responsibility for operating and maintaining centrally operated wastewater and/or stormwater systems, and oversee the systems operated by private contractors.

Often, environmental departments assist in providing policy input in water and wastewater management as wastes can seriously impact on the environment. They formally assess environmental impacts of major infrastructure projects. These departments can play a significant role in the coordination of major stakeholders in an IWRM system. Often the above jurisdiction and responsibilities are devolved to provincial or municipal governments with the central government setting general policies and planning parameters. With many stakeholders involved, the crucial factor is the coordination of all the major stakeholders. Responsibility and authority, including final responsibility for decision making, need to be clearly spelt out.

Private sector companies provide a range of services ranging from being contractors to government in conducting feasibility studies, community consultation, developing master plans for wastewater and stormwater infrastructure, to constructing the infrastructure and operating wastewater and stormwater facilities. Private sector companies operate with the aim of making a profit. Unlike governments they do not have direct responsibility in maintaining public health or quality of the environment. Pressures on government to reduce taxes have resulted in privatization of services such as wastewater and stormwater management.

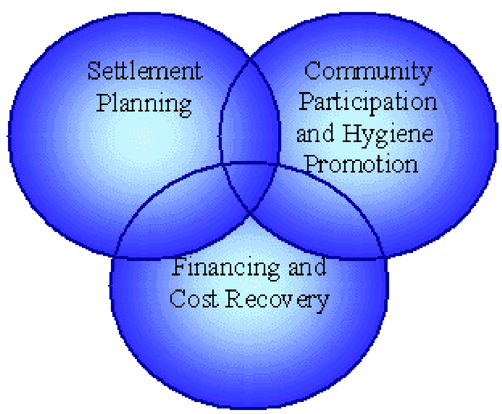
It is important to have involvement of users of wastewater and stormwater management services to ensure that the services are what they desire and are able to pay for to ensure the long-term sustainability of the services. Community participation can be facilitated by community-based organizations or non-government organizations in the area.

Communities without legal status of land they occupy in rapidly growing peri-urban areas present a special problem. These communities usually require urgent sanitation services because of serious local public health threats as well as downstream impacts of the wastewater. These communities have inadequate resources and may not be able to afford to pay for any form of sanitation service. Because of the threat to public health generally as well as on-site and downstream impact of wastewater from these communities, a case can be made for governments to provide the most basic sanitation services. The involvement of the stakeholders already operating in these communities is crucial to ensure the contribution of users through the provision of labour and cash to the operation and maintenance of systems appropriate to their situation.

Planning for Wastewater Management

From examining how sanitation problems develop in a community, it becomes obvious that they are related to population density relative to the ability of the environment to cope with the wastes generated, and the ability of the community to respond to the problems that arise. Thus, besides the public health and environmental aspects that have been discussed, there are the social and institutional dimensions that have to be taken into account. These refer to the way communities organize themselves to manage their common affairs, such as arranging collection of household wastes, laying of sewer pipes, and financing these activities. Each community has generally developed means of carrying out these tasks, which may be unique to a particular community or communities in a region. The institutional arrangements in a community evolve with time to meet changes in culture and technology, and may or may not cope with external changes. One such change is rapid urbanization, which leads to rapid population growth in a relatively small area, leading to severe sanitation problems. Figure 1 illustrates the issues associated with how communities manage wastewater and stormwater.

Figure 1. Major cross-cutting issues of planning, community participation and finance



Source: UNEP GPA 'Recommendations for decision making on municipal wastewater' / UNDP/WB 'Resource Guide in Urban Environmental Sanitation'

Settlement Planning

Planning appears to be a major and key issue for a community to address. Ideally, settlements should be planned ahead of their occupation. Areas should be set aside for treatment and disposal of solid wastes which cannot be recycled or reused. Easement should be provided in the plan if wastewater is to be collected through a sewerage system, or if on-site treatment is chosen, lot sizes should be able to adequately accommodate the treatment system. Planning should also take into account the natural drainage of the landscape to enable stormwater run-off to flow freely by gravity and minimize flooding. Water reuse should also be carefully planned. Generally a sufficient area must be set aside for water reuse, which can take the form of water for agriculture, aquaculture, tree plantations or for irrigation of public parks and gardens.

New approaches to planning to achieve long-term resource sustainability for wastewater and stormwater management should be considered in a planning process. Stormwater infiltration at source to reduce heavy downstream run-off is an example. Water conservation measures can reduce wastewater volume, and dry sanitation, where appropriate, merits consideration. In a rapid urbanization process and with illegal settlements occurring, the situation is far from ideal. Decisions have to be made based on the existing far-from-ideal situation. In most cases, no action is taken until the legal status of the land occupation is clarified, and this can take quite some time. In the meantime, temporary measures need to be taken to provide sanitation services to prevent disease outbreak as well as on-site and downstream environmental problems. In the first instance, piped water may be provided from standpipes. If no corresponding measure is taken to provide for wastewater collection, then invariably poor sanitation conditions result. This illustrates an important point in planning and integrated waste management that when water is provided, wastewater disposal should be considered at the same time, because provision of water means wastewater is simultaneously generated. Simply disposing the wastewater into stormwater drains is clearly not satisfactory. The problems arising from the provision of water may be negated by the problems caused by the wastewater.

Community participation and hygiene promotion

The whole community should be involved in provision of sanitation services to ensure that any service that is provided is what the community wants. This will help ensure the viability of the service and its long-term sustainability. The need to involve women has been emphasized, because women are generally responsible for the day-to-day management of wastes at the household level. How far community participation can be implemented depends on the social, cultural and political practices within the community.

The decisions taken by a community are influenced by its knowledge base. One aspect that may be lacking is the awareness of the relationship between illnesses and lack of hygiene and sanitation. This may be reflected in the low priority given to provision of sanitation services. Promotion of hygiene is therefore an important issue that has to be addressed. The promotion materials should include not only the relationship between health and sanitation services, but also the correct choice of sanitation hardware, and in its maintenance and operation. It is known that sound hygiene practices, even with inadequate sanitation provision can improve health outcomes. It is, however, preferable to have sound hygiene practices go hand in hand with environmentally sound sanitation hardware.

Financing of sanitation services and cost recovery

Sanitation services require investment and continuing costs of operation and maintenance. The level of investment is dependent on the technology that is chosen. The technology also determines the costs associated with its operation and maintenance. A community may be able to provide in-kind contribution such as labour towards the construction of a wastewater collection system. With a simple on-site wastewater system, the community may be able to do most of its construction. Knowledge of technology options is therefore essential to a community to decide which one to choose, because in the end they have to pay for both the investment and operating costs if the service is to be sustainable in the long term.

Institutional Arrangements

Institutions are defined as the “rules” in any kind of social structure, i.e. the laws, regulations and their enforcement, agreements and procedures (UNEP 1997). Organizations are a particular type of institution and are composed of groups of people with a common objective. Organizations can be formalized, such as “official” sector organizations with operational objectives, their own budget and professional staff (such as water departments in Government Ministries, Water Boards, Environmental Protection Agencies, laboratories, consultant companies) or they can be informal and less well described (such as “the public”, the “customers” who pay for a water service, the socio-economic distinct groups in a village or town community).

The success achieved when implementing a government’s policy for water pollution control primarily depends on the suitability of the chosen institutional arrangement. Other factors are also important prerequisites, such as availability of capital, of technology and of human resources (expertise). Generally, however, the maximum benefit can only be generated from available resources by an “optimum” institutional arrangement that makes the resources work effectively for the sub-sector. This “optimum” depends on the characteristics of the sub-sector, which differ from those of other water-using subsectors, such as water supply or hydropower, and the requirements of the country. Good institutional arrangements are essential to liberate and to develop resources further, for example to make more finance available by increasing the willingness of customers and citizens to pay for sewerage services or to educate and train the professional staff.

The wastewater sector can only prepare and manage its programmes properly if all institutions are appropriately involved in the three main phases; planning, implementation (construction), and operation and maintenance linked with cost recovery. Although this is normal for formal organizations such as government departments, it is also true for all other institutions that are indirectly implicated and will affect, in one way or another, the wastewater management programme. Examples of such institutions are:

- *Policies and regulations that determine tariff-setting and taxation.* These commonly fall outside the jurisdiction of pollution control organizations, although their success depends on their financial strength. Responsibility for decision-making commonly lies with the Ministry of Finance, in municipalities or amongst the politicians.
- *Enforcement of regulations and laws*. Any pollution control law is only as strong as the will and the capability of the law enforcement institutions.

- *Human resources and development of expertise.* Pollution control is technically complicated and, therefore, education and research institutions must be able to support a national pollution control policy.
- *Mechanisms to render organizations more responsive to customer demands, flexible and accountable.* This generally requires devolution of decision-making and financial autonomy to the most appropriate, lower levels of administrative government. It can also lead to the inclusion of private partners. Rules that stifle initiative and good performance should be removed (deregulation) and replaced by other regulations that, typically, are based more on performance. Again, the required institutional framework is determined outside the environmental or water sector.
- *Mechanisms that enable the definition of the economic value to the nation of good water quality.* This requires a full appreciation and understanding of water uses and their significance for the nation's long-term sustainable development. A crucial institution to the success of water pollution control is the group of people that will "benefit" from it. World-wide, numerous water supply and sanitation schemes have failed completely, or partially, because the designated users (and financial supporters) of the new infrastructure were not consulted about whether they valued the initiative and would be willing to contribute for its proper operation. Thus, inadequate involvement of the users during the planning phase created a situation with a lack of demand. Provision of a service, such as a clean environment, is not merely a question of meeting a presumed demand from customers. Without a clearly expressed demand, customers are not committed to the infrastructure and they will fail to use it properly or to pay a reasonable amount for it. An existing demand may be insufficiently developed, for example, because prospective customers have not recognized the long-term benefits of the service (good public health or education) or because they may prefer "purchasing status" (increasing their consumer goods) rather than investing in the long-term benefits. Consequently, demand may need to be developed.

No fixed, optimum model for institutional arrangements exists that would suit all countries, at all times. The organizations that would fulfill the requirements best in a given country and in a particular period of its development, depend on the local characteristics, i.e. the hydrogeology and topography, industrialization, culture, economy and the natural environment. The institutional arrangement of the wastewater sub-sector will have to adjust continuously because the institutional environment around the sub-sector changes so much. Preferably this arrangement should prepare for and facilitate continuing change. Inevitably, institutional arrangements are very case specific; what works for one country in a given period may be detrimental to another. Nevertheless, experience suggests that good arrangements consist of a number of standard institutional components (e.g. organization types, financial measures) that perform well in different arrangements.

Prioritizing functions and setting mandates of organizations

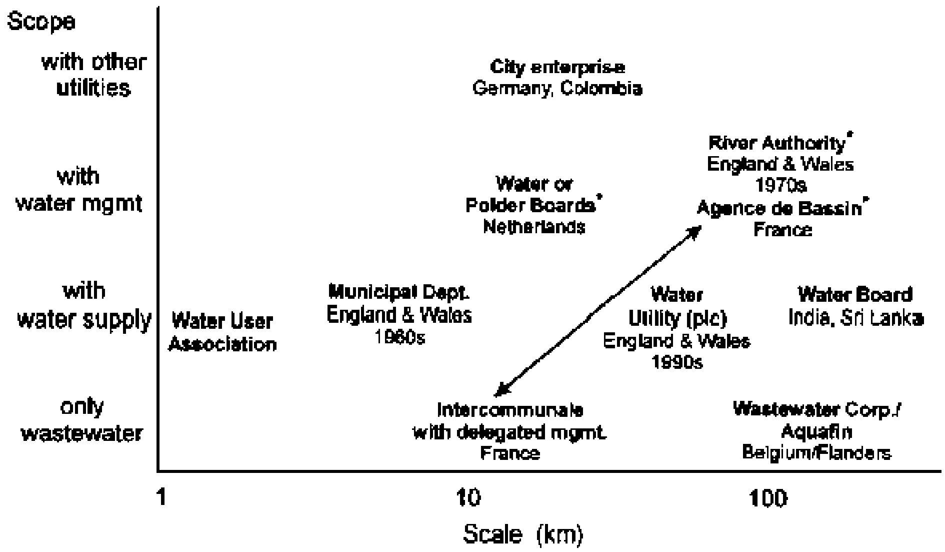
First of all, the priority issues for water pollution control in the medium term (with a planning horizon of 10-20 years) need to be determined. Countries with a high population density and high industrial output require a different approach from others which are predominantly rural and less industrialized. In the same way, arid regions may put a high priority on water conservation and re-use. Other regions may have to cope with the diverse effects of wastewater constituents that have long-term deleterious effects, sometimes at locations very distant from the discharge point. Institutional arrangements must reflect environmental priorities.

A second major consideration concerns the prioritization of investment (construction) or operation and management (O&M). Sustainability is served by institutions that ensure the infrastructure serves a long, active life. Well-operated and maintained devices minimize resource losses due to spillage, breakage and leakage. Poor O&M also leads to a poor service to the consumer. Clogged drains and pumps, and treatment works that are out of order, provide an unreliable and low-level service that severely reduces the consumer's and citizen's willingness to pay. In many countries, the O&M of the water infrastructure is very weak. This is cause for concern because it renders many water organizations unable to recover the costs (including asset depreciation) of their water supply operations, let alone their sewerage operations.

The consensus of opinion suggests that, in a healthy sub-sector, the water organizations should be able, in the long run, to recover full costs from their consumers. This is rare in practice for many reasons. Wastewater infrastructure, in particular, is an unpopular item on the budgets of authorities and citizens alike. Operation and maintenance (O&M) is an expensive, yet unforgiving, item on the budget of any enterprise and is often neglected at the expense of the cost recovery performance shown in an enterprise's accounts. Often, a concentrated investment effort necessitates setting up a devoted organization for a specific time period, for example, under the Holy Ganges project in India and Aquafin in Belgium (see below).

The required sector organizations can be of different scale and scope. The scale reflects the typical size of the area for which the organization has a mandate. This can range from small, such as a city quarter or village, to very large, the size of a country or state of over 100 million inhabitants within the country, e.g. India. The scope of the organization defines whether it concentrates on (an aspect of) water pollution control or whether it also covers other utilities such as wastewater, water supply, drainage, water quality management, river basin management, power generation and/or distribution, public transportation, or environment protection. Importantly, because much O&M and cost recovery is physically associated with fine-detailed reticulated networks and individualized households, decentralization or devolution of responsibilities to the lowest appropriate administrative level is an important guideline (ICWE, 1992). Part of the local network or infrastructure can then be entrusted to a local water users association. Determining the preferred scale and scope depends on the local characteristics of the water sector, the possible interactions with developments in other sectors such as power, and the identified priorities.

Examples of scale and scope of the organization responsible for wastewater management



Organizations with a purely regulatory function are excluded. The water quality management function is covered by the organizations marked with an asterisk. The double arrow connects, for France, the two complementary organizations that together cover the sector

Institutional architecture should from one perspective ensure consistency of policy over the whole territory, and from the other it should allow for sufficient flexibility, particularly in order to respond to local issues and demands and to adapt to changing conditions in the country. The first requirement calls for a centralized, top-down approach, with adequate control from the top. The second, however, tends to put more responsibility at the local levels and calls for more local and sub-sectoral autonomy. While accepting that much of the work needs to be carried out by a variety of organizations at different levels, governments tend to keep control by means of regulations. For example, governments define national health and environmental quality standards and personnel structures in the public service, decide on the targets for pollution control achievements, set price structures and may attribute the market mechanisms a major or minor role and, importantly, decide on who will take the important decisions. Experience over the past decades has shown that too much regulation is inefficient, it creates its own distortions and stifles initiatives for improvement.

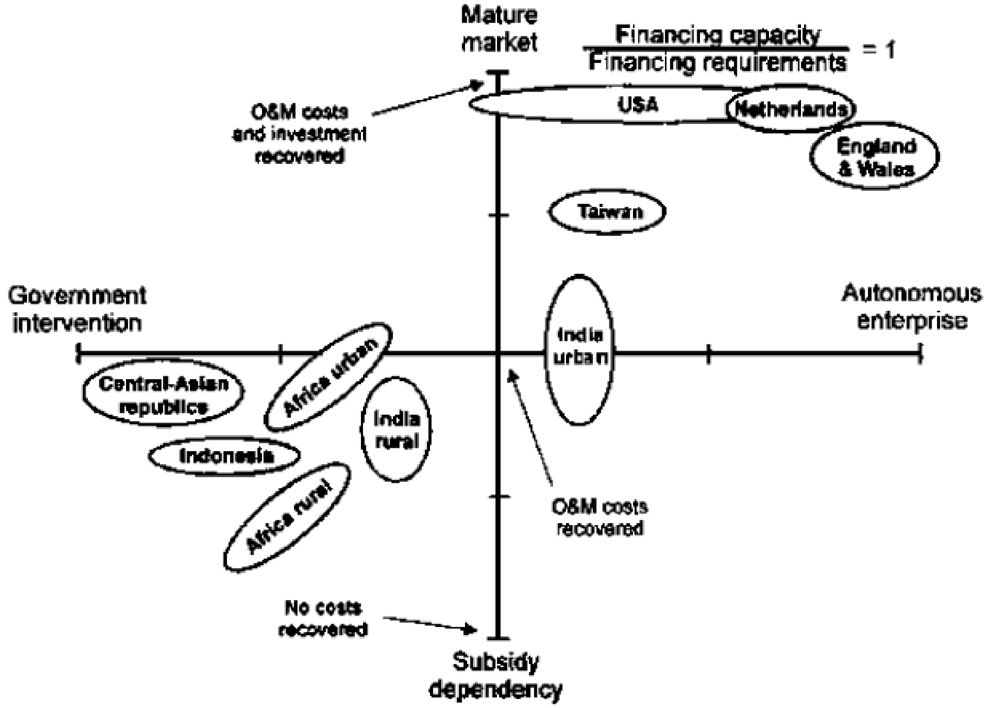
Mechanisms to reduce the level of top-down regulation include:

- Decentralization and devolution of decision making to lower administrative levels, including the right to raise finance (e.g. through tariffs)
- Wastewater utilities, and in some cases water quality management organizations, allowed to operate as autonomous entities, i.e. they can decide on tariff structures and personnel management without explicit interference by the local or central government
- Involve private partners to carry out (part of the) management, bring in finance, or buy the assets (infrastructure, land, the organization) and operate them as a private company. These alternatives, with increasing private sector involvement, are called leasing, concession and privatization
- Identify (waste)water rights and allow their owners to trade them on the basis of their market values
- Avoid introduction of measures such as subsidies or taxes that may distort the price value ratio of the water as it is perceived by the water user
- Apply financial (dis)incentives rather than inflexible command-and-control regulations to control, for example, waste discharges

Although the purpose of deregulation is to allow decision-making outside direct government control, national government does retain an important policy making and monitoring function and, in particular, is responsible for the functioning of the sectoral organizations. Deregulation, therefore, must be compensated by other types of regulation. Typical regulations include:

- Installing mutual control amongst the organizations by creating open competition, such as by tendering out all government contracts to private, as well as to semi-governmental, enterprises.
- Installing mutual control amongst the organizations by creating watchdog organizations and balancing the power of one organization with that of another; for example by putting a powerful, objective regulatory agency in place. An executive organization should be prevented from empowering and regulating itself because this creates internal conflicts of interest.
- Ensuring that utilities which benefit from a higher degree of autonomy are also more accountable to their clients, to their shareholders (commonly local government) and to the national government with respect to their support for achieving national goals.
- Preventing monopoly and cartel formation. Recent European Union (EU) legislation forbids cartel formation and attempts to break up monopolies, including those of the water services.

Figure 2 - The relationship between national water sector organizations as a function of their autonomy and the development of the water services "market"



A "mature" market implies that the willingness-to-pay of the consumers balances the financing requirements.

The degree of desired autonomy for an organization is related to the "maturity" of the market, i.e. the willingness of the consumers to pay for the service. Figure 2 charts the relationship of a number of national institutional arrangements with respect to the degree of autonomy in their wastewater sector organization and the maturity of the market. Proportionality becomes apparent where local organizations are more autonomous where the market is mature and the demand is more developed. Arguably, England and Wales have the highest degree of autonomy, because their organizations are privatized and operate as independent companies. Most probably, maturity and autonomy must be developed in a coordinated fashion and must mutually reinforce each other. An organization which is suddenly cut off from regular subsidies has no option other than to educate its consumers. Autonomy is measured by the absence of political interference in an organization.

Capable organizations and capacity building

Sector organizations can only perform well if they are properly managed, guided and staffed. This implies that:

- Management must offer leadership, to ensure that the organization and its staff have a clear and shared view of their purpose and how this will be achieved.
- Staff must be adequate and with the right combination of levels of expertise.

- Personnel management must be dynamic, stimulating loyalty and minimizing operational cost.

Instruments to further this include career development and salary measures to motivate staff to improve their performance, education and training, and management consultancy. In France, it is argued that the system of delegated management allows municipal governments to concentrate on policy making and essential tasks, while technical management is left to private organizations that are more expert and better equipped for this purpose.

Sustainable institutions, in addition, possess built-in capacity to monitor critically the overall contribution of the sub-sector to the achievement of the nation's goals, and to influence these goals for the better, for example by introducing the economic replacement value of water and environmental quality in national economic planning, and by demonstrating the economic value of water for sustainable economic development. Such institutions possess the internal mechanisms that enable them to review the management performance and the effectiveness of the separate organizations and institutional measures. Ideally, an organization should be allowed to operate in an institutional environment such that, without government interference, it gives maximum performance under its present mandate, it learns from errors and improves on its weaknesses, and it is able to identify the future requirements of the sector and to propose the new concomitant institutional arrangements (even if that means abolishing the organization and replacing it with another).

Capacity building in the water sector starts from three premises (Alaerts and Hartvelt, 1996):

- Water is a finite resource, for which numerous users compete, most notably the waste dischargers (who lower the usefulness of the water)
- Water is essential for a healthy economy as well as for the environment and, therefore, it is a resource that should be managed in a sustainable way
- Institutional rather than technical factors cause weakness in the sector

Capacity building, therefore, takes a comprehensive look at the sector, analyses its physical and institutional characteristics in detail, defines opportunities and key constraints for sustainable development, and then selects a set of short- and long-term action programmes. Very often the water sector performs poorly because of inappropriate or rigid institutional arrangements. If these can be improved, structural constraints are removed. Water is a finite resource and, therefore, demand management rather than new development is necessary because any additional supply created from a new water development is soon fully used and creates even more demand, which can no longer be fulfilled.

Countries must build "capacities" in order to achieve the goal of good sector development, which is effective in service delivery, efficient in resource use and sustainable. Through the Delft Declaration, the United Nations Development Programme (UNDP) developed the following definitions of the aims of capacity building which are applicable for the water sector (Alaerts et al., 1991):

- Creating an enabling environment with appropriate policy and legal frameworks
- Institutional development, including community participation
- Human resources development and strengthening of managerial systems

A number of instruments can be applied in capacity building. These are:

- Technical assistance for sector analysis and programme development. Since 1992, UNDP has developed "water sector assessments" which analyze comprehensively national water sectors and which develop a priority action programme. Other agencies, such as The World Bank and the Asian and European Development Banks, are also engaged in similar exercises. Such analyses need to be performed by an interdisciplinary team.
- Technical assistance for institutional change. The expertise for this will differ depending on the institution that is under consideration and it may relate to policy, micro or macro-economic structures, management systems, and administrative arrangements.
- Training for change at different levels, including decision-makers, senior staff and engineers with managerial assignments, junior staff and engineers with primarily executive tasks, technicians and operators, and other stakeholders (such as care-takers and people in local communities who have undertaken to operate or to manage community-based systems).
- Education of prospective experts who will play a role in the sector. This encompasses physical and technological sciences, as well as financial and administrative management, and behavioural sciences. The water pollution control sub-sector is so complex and develops so fast that in most developing countries not more than 10 per cent of the required technical expertise (as university graduates) is available. Many graduates are inadequately prepared for the tasks in their country (Alaerts, 1991).

International Best Practices in Legislation, Policy and Institutions

Laws generally provide the overall framework within which regulations provide the more detailed guidance. There is a variety of laws that address wastewater management, including environmental legislation, public health laws and planning laws. Regulations are rules or governmental orders designed to control or govern behaviour and often have the force of law. Regulations for sanitation can cover a wide range of topics, including the practices of service providers, design standards, tariffs, discharge standards, environmental protection and contracts. These regulations, and especially design and discharge standards, have to be carefully adapted to local conditions. National agencies may also issue official guidelines that serve to define policies.

There are fundamental elements that create a holistic legislative wastewater management regime. These include:

- Legislation and the supporting regulations for:
  - management of urban waste (especially important for the expanding urban areas in the Caribbean)
  - protection of waters against nutrient pollution caused by agricultural sources
  - defining good agricultural practices
  - governing the use of pesticides in agriculture
  - determining various levels of treatment standards e.g. primary or secondary treatment
  - marine areas especially waters containing fish
  - reducing contamination by specific pollutants
  - the inclusion of public education in the promotion of sound wastewater management practices
  - integrated water resources management
  - addressing industry by type
  - handling stormwater runoff
  - creation of marine protected areas and prohibition of discharges to these areas or the use of greater restrictions for discharges to these areas
- Standards and emission limits for:
  - sewage treatment plants that discharge pollutants into fresh and marine waters

- municipal wastewater
- construction and operation of wastewater treatment plants

- Guidelines and codes of practice for:
  - use of recycled water
  - management of septic tanks
  - management of public toilets
  - environmental management systems in industries

Integrated Water Resource Management

Integrated Water Resource Management (IWRM) principles used as the foundation of a country's water and sanitation sector will be infused within that country's legislation, policies and institutions.

As defined by the Global Water Partnership (2000), the working principles for the water and sanitation sector within an IWRM framework are:

1. Catchment management and source protection are essential to ensuring sustainability of supply
2. Water use efficiency and demand management must be addressed to minimise the need for new source development
3. Multiple uses of water should be acknowledged and encouraged
4. All stakeholders should be involved in decision making, but particular emphasis should be put on the active participation of users
5. Gender and equity issues must be addressed throughout the project cycle
6. Water provision should be priced so as to discourage wasteful use, while ensuring the right to access of a necessary minimum for all

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South Africa

South Africa adopted a new National Water Act in 1998 based upon IWRM principles and is in the long-term process of establishing new institutions at the water catchment level to manage water resources. The act included novel concepts aimed at protecting resources for basic domestic water supply and the environment. Around the same time the 1997 Water Services Act provided a new framework for the provision of water and sanitation services to which people are entitled. These two acts thus provide a comprehensive framework covering water management and domestic water and sanitation as well as setting out rights for everyone to basic water and sanitation services and to access water resources.

The key change introduced in the South African National Water Act is that custodianship of all surface and groundwater resources is vested in the state, with access and entitlement to water resources to be allocated to users according to licenses agreed by new Catchment Management Agencies (CMAs), one for each of the 19 water management units defined in the country. A

CMA manages water resources and coordinates functions of other institutions involved in water related matters within the water management units. The CMA governing board must represent the relevant interests in a water management area and must have appropriate community, racial and gender representation.

Equity is a key issue in South Africa due to the historical legacy of racially skewed patterns of land ownership, which also mean that previously disadvantaged racial groups have less riparian access to water. A system of compulsory licensing will enable more equitable access to water. More efficient use of water is being promoted especially through economic instruments i.e. charges for water. Also, a more sustainable water environment is ensured by recognizing the importance of a healthy environment and protecting the resources upon which aquatic environments including wetlands depend.

A key instrument for implementing IWRM is an effective planning, monitoring and decision-making platform – the Catchment Management Agencies -- with mechanisms to develop binding catchment management strategies and plans. In South Africa, these strategies are developed based upon a national water resources management strategy and 'local' consultation and decision making. These plans focus mainly on 'water resources' issues but a high-level of importance is also given to sanitation issues through links to other planning processes.

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The EU Water Framework Directive

Taking over ten years to develop, the 2000 EU Water Framework Directive is the most significant legal instrument in the water field to emerge in Europe for some time and will have a profound effect on how water is managed over the next 25 years (EU 2000). The Directive requires that all surface waters and groundwater within defined river basin districts must reach at least 'good' status by 2015. It will do this for each river basin district by:

- Defining what is meant by 'good' status by setting environmental quality objectives for surface waters and groundwater
- Identifying in detail the characteristics of the river basin district, including the environmental impact of human activity
- Assessing the present water quality in the river basin district
- Undertaking an analysis of the significant water quality management issues.
- Identifying the pollution control measures required to achieve the environmental objectives
- Consulting with interested parties about the pollution control measures, the costs involved and the benefits arising

- Implementing the agreed control measures, monitoring the improvements in water quality and reviewing progress and revising water management plans to achieve the quality objectives

Legislation and Regulations

Although regulatory means are discussed here, it should be remembered that the development of financial systems of charging for pollution to encourage the adoption of good practices, or to provide incentives against over-production of potential pollutants and over-use of treatment facilities, must be considered alongside, or even in advance of, regulation.

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Australia: Water Services Act

Following the trend to consolidate legislative approaches to wastewater management, in 2007 Australia enacted the Water Services Act. Major legislative revisions have been provided for in the new law which incorporates a comprehensive review, update and consolidation of all existing water services legislation and facilitates the establishment of a comprehensive supervisory regime to ensure compliance with specified performance standards (Department of the Environment, Heritage and Local Government, 2007).

In summary, the Act includes provision to:

- Consolidate water services law into a single modern code, for ease of access and application
- Introduce a licensing system to regulate the operations of group water services schemes
- Amend the Environmental Protection Act 1992 to assign responsibility for supervision of sanitary authority water supplies to the Agency
- Strengthen administrative arrangements for planning the delivery of water services at national and local level
- Place duties of care on users of water services in relation to water conservation, protection of collection and distribution networks, and prevention of risk to public health and the environment

Specific provisions relate to the provision and supervision of water services by other persons, in accordance with any prescribed standards, for domestic and non-domestic requirements in its functional area, taking full account of the following aspects of public policy, namely:

(a) proper planning and sustainable development in its functional areas
(b) protection of human health and the environment
(d) relevant regulations made by the Minister for Health and Children
(e) Relevant policy directions issued by the Minister under this Act or any other enactment

(g) Sustainable management of water resources

(h) Relevant development plans, regional or spatial planning guidelines, housing strategies or special amenity area orders, as appropriate, made under the Act of 2000

(i) a water quality management plan or a programme of measures made under the Local Government (Water Pollution) Acts 1977 to 2007 for the area to be covered by the water services strategic plan

(j) a waste management plan under the Act of 1996

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USA: Environmental Bond Bill

Very often, the challenge to proper wastewater treatment is simply lack of financial resources. In 2008, as part of the Environmental Bond Bill, Massachusetts, USA passed landmark wastewater legislation – An Act Relative to Water Protection – that will provide critical funding assistance to Cape Cod communities to build the wastewater treatment systems needed to improve water quality in estuaries and bays (Cape Cod Water Protection Collaborative). This bill will help to protect the economy, job base and property values of the entire Cape. The new law provides Cape Cod communities with the legal and financial tools needed to arrest and reverse the degradation of its precious coastal waterways. The major threat to water quality is excess nutrients. By targeting enhanced financial assistance to communities implementing projects intended to reduce nutrient impacts on surface and drinking water, the new law provides an important focus on an ongoing threat. The bill provides an opportunity for communities to access no interest funds from the State Revolving Fund to move quickly to address this issue.

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USA: Clean Water Act and National Pollutant Discharge Elimination System (NPDES) permit programme

The 1972 Amendments to the Federal Water Pollution Control Act (Public Law 92- 500, known as the Clean Water Act (CWA), established the foundation for wastewater discharge control in the United States. The CWA's primary objective is to "restore and maintain the chemical, physical and biological integrity of the nation's waters." The CWA established a control program for ensuring that communities have clean water by regulating the release of contaminants into the country's waterways. Permits that limit the amount of pollutants discharged are required of all municipal and industrial wastewater dischargers under the National Pollutant Discharge Elimination System (NPDES) permit programme. In addition, a construction grants programme was set up to assist publicly-owned wastewater treatment works in building the improvements required to meet these new limits. The 1987 Amendments to the CWA established State Revolving Funds to replace grants as the current principal federal funding source for the construction of wastewater treatment and collection systems (USEPA 2004).

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USA: Stormwater Phase II Final Rule

While the Clean Water Act resulted in a significant improvement in the quality of water in the USA, it was recognized that there were still degraded water bodies largely due to polluted runoff. Phase I of the Stormwater programme used the NPDES programme to control runoff from larger municipal, industrial and commercial activities[3]. Subsequently, the Stormwater Phase II rule was promulgated and expands Phase I, requiring additional operators of systems in urbanized areas and operators of small construction sites, through the use of NPDES permits, to implement programmes and practices to control polluted stormwater runoff. Phase II institutes the use of controls on the unregulated sources of stormwater discharges that have the greatest likelihood of causing continued environmental degradation (USEPA 2000). This rule includes specific minimum requirements for:

- Public Education - to inform individuals and households about ways to reduce stormwater pollution
- Public Involvement – to involve the public in the development, implementation, and review of a stormwater management programme
- Illicit Discharge Detection & Elimination - to identify and eliminate illicit discharges and spills to storm drain systems
- Construction - for construction site operators to address stormwater runoff from active construction sites
- Post-construction - developers, and property owners to address stormwater runoff after construction activities have completed
- Pollution Prevention/Good Housekeeping - to address stormwater runoff from their storm sewer system facilities and activities

Policy

It is widely accepted that wastewater management within a country should be guided by a national policy on sanitation and that the political will must exist to ensure that this policy is fully implemented once developed. Policies clearly define institutional roles and responsibilities and are seen to be an important motivating force for focused programme planning on sanitation. National sanitation policies can serve as a key stimulus to local action by including local initiatives in the overall strategy. In most countries, wastewater management is deemed secondary in importance to water provision. By articulating needs and promoting the importance of sanitation, an effective national policy can promote the setting of priorities and mobilize resources for addressing sanitation needs at different levels.

[3] (1) “medium” and “large” municipal separate storm sewer systems (MS4s) generally serving populations of 100,000 or greater, (2) construction activity disturbing 5 acres of land or greater, and (3) ten categories of industrial activity.

Good sanitation policies should address the following key elements:

- *Political will* - the support given to policies by politicians, government officials and representatives of influential organizations
- *Inclusion of all stakeholders in policy development* – involvement of political leaders, government officials, donor representatives, the private sector, NGOs and CBOs and men and women in the general public
- *Legal framework* – anchoring the policy within a legal basis: laws, legislative acts, decrees, regulations and official guidelines
- *Population targeting* – ensuring that the policy serves the needs of specific population groups with focus on urban poor in large cities, residents of small towns, and most of the rural population
- *Recognition of dimensions of gender and poverty* – to ensure equitable access by the poor and to meet the different needs of men and women who often have different roles to play and who have different interests vis-à-vis sanitation.
- *Levels of service* – determined by availability of water, costs, the economic status of communities and households, and the willingness of users to pay for or otherwise contribute to the installation
- *Health issues* - policies should address identified sanitation-related health concerns and should raise awareness among the public about the link between proper sanitation practices and good health.
- *Environmental considerations* – seeking to protect water and land resources for social, health and economic reasons
- *Financial issues* – addressing the costs associated with implementing national sanitation policies: capital costs required for sanitation infrastructure and facilities; recurrent costs required to operate and maintain the facilities and; programme costs for such aspects as training, institutional development, community organization and hygiene improvement
- *Institutional dimensions* – clearly identifying the roles and responsibilities of the institutions and groups responsible for sanitation, including the interactions among these organizations

Each of these elements, if well-addressed in policies, will help define an enabling environment for sanitation improvements.

There are few national sanitation policies in the region or in other developing countries where this need is great. One notable example of a national policy is in South Africa. This example demonstrates key components and levels of sanitation policy and shows how a national sanitation policy can be used as a starting point for a national effort to improve access to sanitation services. Although it is a national policy, larger countries should also consider subnational policies for local implementation, for it is at the local level that these policies will largely be implemented.

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South Africa: Sanitation for a Healthy Nation (2001)

The policy development process began in 1994 with development of a White Paper on Water Supply and Sanitation in which the importance of developing a national sanitation policy was highlighted. The National Sanitation Task Team was then formed and in 2001 published a National Sanitation Policy. The policy defines sanitation, discusses the sanitation problem in South Africa, lists 12 clear policy principles, articulates strategic interventions, identifies the importance of community participation in policy implementation, clarifies the institutional arrangements at all levels of government, and describes the roles and responsibilities of all stakeholders: householders and communities (of "first and foremost" importance); local government and community-based contractors; national and provincial government; and NGOs and the private sector (Department of Water Affairs and Forestry 2001). The policy addresses the promotion of health and hygiene awareness and practices, stresses the development and use of local resources and makes provisions to prioritize communities with the greatest need. The document promotes the adoption of a common approach and agreement on implementation models and technical options for use throughout the country. It describes sources of financing and discusses the importance of monitoring and evaluating policy implementation. Importantly, the policy states that the Sanitation Plan is a component of the Water Services Development Plan (WSDP) which is a component of the country's Integrated Development Plan (IDP).

Institutions

As discussed earlier in this study, the appropriate institutional arrangements must be determined for each country according to its particular needs. However, there are some commonly held ideas about what would constitute a good institutional system.

Ramon Alikpala[4] uses the term "national water apex body" which typically formulates and coordinates policies, programmes and standards relating to the water and wastewater sector; and regulates and monitors water/wastewater utilities. He states that these "apex bodies" are generally policy making and coordinating bodies but that their mandate should not be limited to these. It is equally important that they define specific and time-bound targets in water resources management, and ensure that these targets are enforced and attained. To gauge whether an apex body has indeed attained its mandate, it should be seen if its policies are translated into action at all levels. Water issues cut across a number of departments/ministries, and therefore the apex body should have representations from the highest levels of government and should be multi-sectoral in nature.

[4] Executive Director of the Philippines National Water Resources Board at the workshop on Sharing Best Practices in Water Supply and Wastewater Management held in 2008

An apex body requires the participation of the entire water sector, including water users, to facilitate the implementation and coordination of policies. While an apex body should have the support of the highest levels of the government and other sectors, its regulation requires independence from users or implementers for it to be effective.

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England and Wales

In recent years, England and Wales have gone through four phases of institutional arrangements. Before 1972, water pollution control infrastructure was under the responsibility of, and was owned by, local government departments, and was often combined with the water supply sub-sector. This led to serious inefficiencies because each municipality had its own small treatment plant and there was no critical mass of technical expertise and financial support. Regulation and water quality management rested with Inspectorates and the River Authorities (one for each of the nine major river basins).

Between 1972 and 1982, nine Water Authorities were created and all infrastructure, with the exception of local sewerage, was transferred to the new authorities in order to increase the scale of the organizations and to bring all water management functions into single entities. This led to the merger of many sub-sectors, including drainage and river management, and brought the regulatory and executive functions together, thus broadening their scope. The newly created organizations proved too large and unfocused, struggling with internal conflicts of interest, and unable to generate sufficient investment to meet increasing environmental quality standards.

Between 1982 and 1989, the Water Authorities were made more business-orientated in order to increase their efficiency as well as their effectiveness. In addition, they were placed primarily under the supervision of the national environment ministry. Preparations were made for privatization. After 1989, the Government sold the water supply and wastewater infrastructure of the Water Authorities to public and private investors. These private enterprises remain operating in the same river basins. One of their main tasks is to generate finance for the overdue expansion and modernization of the water and wastewater infrastructure in order to meet the strict EU environmental directives. As a result, tariffs have been raised. The regulatory and water quality management functions were taken over by the National Rivers Authority (NRA), which is also responsible for river management, and by the Inspectorates of the environment and of health. The enterprises are allowed to operate as monopolies within their region and, therefore, the new Office of Water was created as a financial regulator (under the Ministry of Environment) to ensure that water companies meet government policy, and that they do not exploit their monopolistic position at the expense of the citizens or the nations.

In 1996 the water quality regulatory function of the NRA was merged with air and soil quality regulatory functions from the Inspectorates to create an American-style environmental protection agency (known as the Environment Agency).

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France

In 1982, the French state structure was fundamentally altered by a decentralization law that devolved a substantial part of the central government to local government. Traditionally, France had been strongly centralized, but the municipalities were now attributed more responsibility for infrastructure planning and financing. In addition, economic development and water management required a new regional approach with more integration between sectors. Thus, the new law allowed municipalities and Départements (counties) to develop appropriate institutions.

Wastewater collection and treatment is the responsibility of municipalities, which commonly make joint-ventures (intercommunales) to execute this task. However, in most cases the actual management (operation, maintenance and cost recovery) is delegated to private enterprises. Five such companies operate in France and compete with each other during the frequent public tendering of contracts, for example for operation and maintenance, all over the country. Such contracts are very specific, stipulating what the municipality wants the contractor to achieve in a given period of time (5-20 years) and the associated performance parameters. A water price is agreed, from which the contractor has to recover costs and pay a lease fee to the municipality. The contractor can carry out management tasks on the infrastructure owned by the municipality (lease), or it can also provide financing for investment which reverts after a suitable period to municipal ownership (concession) (Lorrain, 1995). Water quality management and regulation is carried out by the Agences de Bassin (river basin boards) which carry out planning, collect fees for abstraction and pollution of the water resources, and also provide subsidies to local government for wastewater infrastructure (Chéret, 1993). Quality standards are developed by the Ministry of Environment.

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Germany

Wastewater management is the responsibility of the municipalities in Germany. If they are too small to address the financial and technical complexity of this task, the municipalities form Verbände (inter-municipal joint-venture autonomous enterprises) or, in the case of cities, the various utilities are amalgamated into one Stadtwerke (City Enterprise) encompassing water supply, power distribution, district heating, (often) sewerage and wastewater treatment and, importantly, public transport. The shares of such municipal enterprises are in the hands of the municipalities. The management has a large degree of autonomy, although critical decisions need approval by the board in which the representatives of the municipal enterprises have a majority. The enterprise is subject to taxation on any profits. However, because public transport and sewerage typically lose money, whereas power distribution and water supply commonly yield a benefit, the net profit is zero and taxation is avoided.

Depending on the local topography and pollution load, joint-ventures may be created, based on river basins, to manage water and wastewater, including the operation of treatment works. The Emscher Genossenschaft (Treatment Association for the Ems River) in the industrial heartland of the Ruhr region has an unusual arrangement, insofar as local municipalities (in proportion to their population), industries and other partners form a fully autonomous “water parliament.” This “water parliament” undertakes to collect all domestic, and part of the industrial, sewage in the basin and, after pretreatment, to treat it centrally near the mouth of the Ems in the Rhine. Regulation and part of the water quality management are carried out by the Land's (State) Environment Department and in the Federal Ministry of Environment.

IBP

The Netherlands

Historically, The Netherlands has been very much influenced by the need to safeguard its low-lying lands from flooding from the sea or large rivers (Rhine, Meuse and Scheldt). Seventy per cent of the territory needs infrastructure to protect against floods, and the large areas of polders require continuous drainage and meticulous water management.

Since the 12th century, Polder Boards have been operational. These were unusual because they represented a separate line of local government; the councils of these boards were, and still are, composed of representatives elected by ballot by all those with a commercial or residential interest within the confines of the polder area. In return, all these groups pay a substantial contribution for dike maintenance and water management. After the 1950s, the task of water quality management and wastewater management, with a few exceptions, automatically became a new mandate of the newly named Water Boards. The local sewerage remained the responsibility of the technical departments of municipalities. The boards cover an area of half to one full province, typically with half a million inhabitants. A move towards an increase in scale (mergers) started recently, in order to pool technical expertise and financial strength, and to allow a more integrated approach for complete water systems (e.g. inter-related canals, lakes).

The present water boards are not owned by local or national government, but have built up their own financial resources and institutional position. All polluting units in the country (households, industries and farms) pay a waste-water conveyance and treatment contribution which is added to the water supply bill and allows full cost recovery of all wastewater infrastructure. The boards also serve as water quality managers and, as such, report to the

Ministry of Transportation and Water Management. Regulations are issued by this Ministry as well as by the Ministry of Environment.

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Belgium: Flanders

Since 1986, Belgium has been a federal country, of which Flanders is the northern region. Flanders consists of five provinces with approximately five million inhabitants. In the early 1950s, a comprehensive pollution control law was adopted investing the municipalities with the responsibility to treat sewage. However, although most industries gradually installed treatment works, reduced their pollution production or closed down, most domestic wastewater remained untreated due to the lack of institutional mechanisms to make municipalities cooperate, and due to the lack of financial means and political will. In the 1970s, two regional governmental agencies were set up by national and provincial authorities to combine water quality management and wastewater management. This attempt again failed to produce more than a small proportion of the badly needed investments, partly because the country as a whole was in a state of re-organization (with devolution of power to the regions) and partly because the government agencies could not generate the required finance. In 1989 the two agencies were reorganized into a “mixed” autonomous investment organization, known as Aquafin, in which the regional government (responsible for 51 per cent) and a private partner cooperate, and into a Regional Wastewater Corporation (which became the Flemish Environmental Agency after 1992) for water quality management and operation of infrastructure. The private partner is one of the English private water companies which contributes technical expertise and substantial finance, for which it is compensated through tariffs. National and regional ministries of environment are responsible for regulation.

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India

India must address the deficient sanitary conditions of the poor rural areas and urban squatter zones simultaneously with the industrialized and urbanized regions. Institutional analysis shows an allocation of mandates as illustrated in the table below.

Table - Typical mandate allocation amongst organizations for sanitation and wastewater management in India

	Regulation	Integrated planning	Construction	Operation of cost recovery
Rural and peri-urban	-	-	State Water Corp./Board	State Water Corp./Board; Local Govt
Urban	State PCB; CPCB	Min. Urb. Constr.; Min. Water Res.; State Water Corp./Board	State Water Corp./ Board	Local Govt
Industrial	State PCB; CPCB	-	Industry	Industry

PCB: Pollution Control Board; CPCB: Central Pollution Control Board

Regulation and standard setting have achieved much progress and can be considered well organized. The Central and the State Pollution Control Boards were already functional by the 1960s. In the 1970s, a basic comprehensive water quality standards system (MInimal NAtional Standards - MINAS) was established which, among other things, specifies quality standards depending on the intended use of the water, and sets discharge standards that are specific for each industrial sector. These boards also regulate air and soil quality and monitor quality trends. The boards have been instrumental in forcing large factories to install primary or more advanced treatment, although they will not take any responsibility for the execution of the treatment programmes. Their effectiveness can be attributed, in part, to their clear, simple focus and well demarcated tasks, and to the relatively small size and high degree of professionalism which facilitate their management.

In the large cities, such as New Delhi, Bombay, Madras and Calcutta, city departments or corporations are responsible for drainage, sewerage, sanitation and sewage treatment. In the rest of the territory this responsibility falls with the state water boards or corporations, such as the Jal Nigam in Uttar Pradesh, and the Panchayat Raj Engineering Department in Andra Pradesh. However, these state organizations are primarily structured and equipped to develop and execute new construction schemes.

Water supply and wastewater infrastructure for the larger towns, once built, are handed over to local government for O&M (local government is also supposed to take care of cost recovery). In the rural areas the state agencies retain responsibility for O&M.

In 1986 the then Prime Minister, Rajiv Gandhi, launched a high-profile and devoted programme to “clean up the Holy River Ganges” which would involve the construction of numerous municipal and industrial sewage treatment plants in the river basin. In the wake of the programme, several integrated urban environmental sanitation programmes were developed, made up sewerage infrastructure as well as water supply, and assistance by government agencies to industry to advise them on the options for minimization and prevention of waste discharges. This Ganga Action Plan has a limited-time mandate and is centrally financed and guided by a special Project Directorate in the Ministry of Environment and Forests, although it is executed by the state and local authorities. One of its components, focusing on one of India's largest and most polluted cities, Kanpur, includes substantial institutional development. The success of the Ganga Action Plan has led to the development, in 1993, of the Yamuna and Gumti Action Plans, and will be expanded into a National Rivers Action Plan. Operation and maintenance cost recovery is claimed to be complete, although these figures often hide an underestimation of the true costs, such as for major repairs, warehouse stocks, and for qualified and well-paid staff. Plans are being developed for improving cost recovery while at the same time spending more funds on better O&M. At the same time, several promising initiatives are being taken, particularly those involving the local urban communities in planning and operational phases. In addition, the tendering of concessions to private companies and non-governmental organizations (NGOs) for the installation and operation of blocks with lavatories and bathing facilities are being relatively successful.

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South Korea

South Korea went through rapid changes in its institutional arrangement between 1985 and 1995. This was spurred by the country's rapid economic development and the associated pollution pressure. In addition, the country is comparatively poorly endowed with freshwater resources, all of which are intensively used. The development process led to increasing scale and scope within the water pollution control organizations and necessitated an integral water management concept.

In 1985, urban wastewater collection and treatment were mandated exclusively to the municipalities. These were faced with the need for major investments. The typical subsectoral approach (with limited vision on long-term sustainability) taken at that time is illustrated by, for example, the hydraulic design guidelines for sewers and sewage works. These were based on a projected linear increase of water consumption from 100 to 440 litres per capita per day. However, it was not recognized that the available water resources would not be able to sustain this level of consumption beyond the foreseeable future. Similarly, the ensuing treatment works would be so costly that, at best, only secondary sewage treatment would be possible, followed by discharge to coastal waters (because most cities lie close to the coast). However, the coastal ecosystems which supported the harvesting of sea kelp (an important economic activity) would be badly affected by the nutrient-rich effluents from the secondary treatment plants.

To integrate water and wastewater planning and management more effectively, a National Water Improvement Program was developed at national level in 1990. In 1992, region-specific Catchment Water Quality Master Plans were drafted by the Ministry of Public Works and in co-ordination with other ministries. The plans attempted to avoid resource losses and minimize expenditure. This regional planning and co-financing of infrastructure works is administered by Catchment Authorities that direct and complement municipal initiatives. As a consequence, as of 1994, the cities of Kwangju and Seoul envisaged the application of more modest hydraulic design guidelines, with the full reuse of sewage in nearby agriculture, the avoidance of any nutrient disposal in coastal waters, and with much lower investments in wastewater infrastructure.

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Sri Lanka

Between 1985 and 1991 the United States Agency for International Development assisted a major institutional development programme with the National Water Supply and Drainage Board (NWSDB) (Edwards, 1988; Wickremage, 1991). This Board was functioning reasonably well in terms of construction of new schemes, but performance was less than satisfactory in operation and financial viability. In 1983, for example, collections covered only 12 per cent of O&M costs. The basic problem with NWSDB was that it had not been able to adjust to the significant differences brought about by its change from a government department to a public corporation. The new role demanded that its attention be changed from capital projects to O&M and the consumers.

Deficiencies included minimal commitment to financial viability, negligible budget discipline, lack of corporate planning, little attention to communities and users, and oversensitivity to political pressures. These deficiencies could not be overcome without a change in staff attitude supported by new staff skills and organization procedures. Major objectives of the institutional development programme were:

- Decentralization of management to regional offices in order to put it closer to the consumers
- Change of organizational structure and attitudes in order to make O&M the most important mission of NWSDB
- Close cooperation with Ministry of Health, NGOs and communities to provide coordinated support to public health programmes

The process consisted of consultations, practical and formal training sessions, organizational analysis, and changes in the administrative organization and procedures.

In doing this, a large degree of ownership by the staff was created. The most notable changes were decentralization of financial responsibilities (including setting up an accountability and management information system), management skill development, corporate planning (including setting up a Corporate Planning Division), financial viability (including tariff reform and collection efficiency improvement), human resources development (especially in basic management and accounting skills, and exposure programmes abroad), and community participation. The incentive structure for engineers was also revised.

At a cost of US$ 14 million the whole organization was restructured in six years. After the programme, the performance of NWSDB was vastly improved on all accounts, and it showed a high degree of commitment to public water and health services. Importantly, its managerial system now ensured “institutional sustainability.”

International Best Practices in Standards, Guidelines and Codes of Practice

Standards and Guidelines

Standards and guidelines for municipal waterworks, wastewater and storm drainage facilities an integral part of a country or state's regulatory program directed at ensuring public health and environmental protection. Standards are mandatory requirements that must be followed. However, guidelines are not mandatory requirements, but they usually include standards that have been developed for the particular aspect of water management and often include best practices.

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Alberta, Canada: Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems

Alberta Environment (AENV) is responsible for the Drinking Water and Wastewater Programs for large public systems in Alberta. AENV has established a comprehensive set of standards and guidelines for municipal waterworks, wastewater and storm drainage facilities (Alberta Environment 2006). AENV's objective is to develop comprehensive and scientifically defensible standards and guidelines that are effective, reliable, achievable and economically affordable. To facilitate an open and transparent process in the development of these standards and guidelines, AENV invited recognized waterworks experts within the province to participate in the initial development and drafting stage. Representatives from the municipalities, engineering consultants, academia and other government departments participated in an Advisory / Working Group to guide and direct AENV in this process.

Standards and guidelines for all components of the water and wastewater sector are included as indicated by the sections that comprise the document. These sections are:

- Section 1: Waterworks System Standards – details all the critical elements of the drinking water program and the associated design and/or performance standards.
- Section 2: Waterworks System Guidelines – intended to provide general guidance on how to achieve a certain level of system performance or reliability.
- Section 3: Wastewater Systems Performance Standards – must be adopted by the system owners
- Section 4: Wastewater Systems Design Standards – must be adopted by the system owners

- Section 5: Wastewater Systems Design Guidelines – may be adopted at the discretion of the system owners
- Section 6: Stormwater Management Guidelines – may be adopted at the discretion of the system owners
- Section 7: Wastewater Systems - Operating and Monitoring (Requirements and Guidelines)

The scope of coverage of the standards and guidelines can be seen by examining the Table of Contents of the document, included here as Annex I.

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World Health Organisation Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture

The WHO Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture were published in 1989 and are widely used internationally as the base for developing specific country standards (WHO 1989). The guidelines took into account all available epidemiological and microbiological data. The faecal coliform guideline (e.g. =1000 FC/100ml for food crops eaten raw) was intended to protect against risks from bacterial infections, and the newly introduced intestinal nematode egg guideline was intended to protect against helminth infections. The exposed group that each guideline was intended to protect and the wastewater treatment expected to achieve the required microbiological guideline were clearly stated. Waste stabilization ponds were advocated as being both effective at the removal of pathogens and the most cost-effective treatment technology in many circumstances. Note that In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account and the guidelines modified accordingly. The guidelines are presented in the table below.[5]

[5] From A Review of Policy and Standards for Wastewater Reuse in Agriculture: A Latin American Perspective

The 1989 WHO guidelines for the use of treated wastewater in agriculture[a]

Category	Reuse conditions	Exposed group	Intestinal nematode[b] (arithmetic mean no eggs per litre)[c]	Faecal coliforms (geometric mean no. per 100ml)[c]	Wastewater treatment expected to achieve the required microbiological guideline
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks[d]	Workers, consumers, public	≤ 1	≤ 1000	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees[e]	Workers	≤1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure to workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by irrigation technology, but not less than primary sedimentation

[a] In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account and the guidelines modified accordingly.
[b] *Ascaris* and *Trichuris* species and hookworms.
[c] During the irrigation period.
[d] A more stringent guideline (≤ 200 faecal coliforms per 100 ml) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact.
[e] In the case of fruit trees, irrigation should cease two weeks before fruit is picket, and no fruit should be picked off the ground. Sprinkler irrigation should be used.

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Tasmania: Environmental Guidelines for the Use of Recycled Water

The *Environmental Guidelines for the Use of Recycled Water in Tasmania* are the primary reference for the effective management of wastewater reuse systems in Tasmania (Environment Division 2002). The guidelines were produced for wastewater producers, consultants, and regulators when designing and assessing the environmental impacts of water recycling projects. These Guidelines are designed to be consistent with the section of the State Policy on Water Quality Management 1997 diffuse source management framework that addresses reuse of wastes by land application. They are intended to provide a framework to allow the sustainable reuse and recycling of wastewater in a manner which is practical and safe for agriculture, the environment and the public in a manner consistent with industry standards and best practices of environmental management. The Guidelines are reviewed periodically to take into account the experiences and knowledge gained through their implementation, and to incorporate new research data.[6]

In the Guidelines, wastewater means any domestic and industrial effluent that has been treated to an appropriate standard to enable it to be safely re-used under the management arrangements proposed. The aims of the document are to:

- foster awareness and encourage the beneficial use of treated wastewater;
- provide guidance on best practice environmental management for managers and operators of sewage or wastewater treatment plants for the planning, design, operation and monitoring of wastewater re-use systems involving land application in a manner that minimizes risks to public health and the environment; and to
- outline the procedures required for the environmental assessment and approval of a re-use system.

Codes of Practice

A code of practice is a systematic collection of rules, standards and other information relating to the practices and procedures followed in an area and generally demonstrate best practice. Codes of practice have been developed for various aspects of wastewater management.

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New Zealand: Code of Practice for Management of Domestic Wastewater

Under the Environment Protection Act 1970, a Code of Practice (COP) is prescribed for the management of domestic wastewater (Ministry for the Environment n.d.). This COP applies to all types of on-site systems treating up to 5,000 litres of wastewater per day and covers various design elements for on-site wastewater management. The COP applies to on-site systems that treat and dispose of, or recycle, domestic wastewater at unsewered sites and on-site systems that treat and recycle domestic grey-water for garden irrigation, toilet flushing and use in washing machines.

The code applies to all systems, as defined above, at premises such as:

- Single houses
- Residential complexes including units, apartments and clusters of homes
- Accommodation establishments including motels and hotels
- food businesses
- Community and recreation facilities including sporting facilities, halls and public amenities
- Schools including pre schools, commercial and industrial sites, shopping centres and camping areas.

[6] Environmental Guidelines for the Use of Recycled Water in Tasmania, 2002

The Code identifies the treatment of domestic wastewater as having four stages.

1. Discharge sewage offsite to a reticulated sewerage system.
2. Partially treat sewage onsite, then discharge the primary or secondary treated effluent offsite via a reticulated sewerage system for further treatment and/or recycling.
3. Treat and dispose of or recycle sewage onsite.
4. Treat and recycle greywater on-site and discharge blackwater as well as any excess greywater offsite to a reticulated sewerage system (or, if in an unsewered area, to an onsite wastewater treatment system).

The code also provides options for wastewater treatment and disposal/recycling in unsewered areas as well as options for recycling treated greywater in unsewered areas.

International Best Practices in Technologies and Practices

Wastewater technologies address the following aspects: collection, treatment – on-site and decentralized; reuse; disposal systems; residuals management; zero discharge. Also included are systems for managing industrial wastewater. Wastewater practices include those at wastewater treatment facilities such as plant operation and maintenance as well as the practices of the general public in waste disposal and reuse.

Improper wastewater management (e.g. overflows, poor infrastructure maintenance, insufficient treatment, over-irrigation, inadequate lagoon lining) could lead to surface and groundwater pollution. The lack of adequate treatment prior to storage or irrigation could also lead to odour generation.

The general criteria for the selection of best practices in technology are:

- *Average, or typical, efficiency and performance of the technology*. This is usually the criterion considered to be best in comparative studies. The possibility that the technology might remove other contaminants than those which were the prime target should also be considered an advantage. Similarly, the pathways and fate of the removed pollutants after treatment should be analyzed, especially with regard to the disposal options for the sludges in which the micro-pollutants tend to concentrate.
- *Reliability of the technology*. The process should, preferably, be stable and resilient against shock loading, i.e. it should be able to continue operation and to produce an acceptable effluent under unusual conditions. Therefore, the system must accommodate the normal inflow variations, as well as infrequent, yet expected, more extreme conditions. This pertains to the wastewater characteristics (e.g. occasional illegal discharges, variations in flow and concentrations, high or low temperatures) as well as to the operational conditions (e.g. power failure, pump failure, poor maintenance). During the design phase, "what if scenarios should be considered. Once disturbed, the process should be fairly easy to repair and to restart.
- *Institutional manageability*. In developing countries few governmental agencies are adequately equipped for wastewater management. In order to plan, design, construct, operate and maintain treatment plants, appropriate technical and managerial expertise must be present. This could require the availability of a substantial number of engineers with postgraduate education in wastewater engineering, access to a local network of research for scientific support and problem solving, access to good quality laboratories,

and experience in management and cost recovery. In addition, all technologies (including those thought "simple") require devoted and experienced operators and technicians who must be generated through extensive education and training.

- *Financial sustainability*. The lower the financial costs, the more attractive the technology. However, even a low cost option may not be financially sustainable, because this is determined by the true availability of funds provided by the polluter. In the case of domestic sanitation, the people must be willing and able to cover at least the operation and maintenance cost of the total expenses. The ultimate goal should be full cost recovery although, initially, this may need special financing schemes, such as cross-subsidization, revolving funds, and phased investment programmes.
- *Application in reuse schemes*. Resource recovery contributes to environmental as well as to financial sustainability. It can include agricultural irrigation, aqua- and pisciculture, industrial cooling and process water re-use, or low-quality applications such as toilet flushing. The use of generated sludges can only be considered as crop fertilisers or for reclamation if the micro-pollutant concentration is not prohibitive, or the health risks are not acceptable.
- *Regulatory determinants*. Increasingly, regulations with respect to the desired water quality of the receiving water are determined by what is considered to be technically and financially feasible. The regulatory agency then imposes the use of specified, up-to-date technology upon domestic or industrial dischargers, rather than prescribing the required discharge standards.

Any best practice must be decided based on the particular characteristics of the country. For example, in dry countries and regions, "using precious water to float human excreta down sewers is increasingly seen as wasteful and inappropriate" (GWP 2000) and on-site solutions such as septic tanks, and various forms of dry disposal are more suitable.

Within the context of waste management, the terminology that is used to refer to best practices is embodied within the term Environmentally Sound Technologies (ESTs).

ESTs encompass technologies that have the potential for significantly improved environmental performance relative to other technologies. Broadly speaking, these technologies:

- protect the environment
- are less polluting
- use resources in a sustainable manner
- recycle more of their wastes and products
- handle all residual wastes in a more environmentally acceptable way than the technologies for which there are substitutes

Furthermore, as presented in Chapter 34 of Agenda 21, Environmentally Sound Technologies are not just "individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures." This requires both the human resource development (including gender relevant issues) and local capacity building aspects of technology choices. There is also the need to ensure that ESTs are compatible with nationally determined socio-economic, cultural and environmental priorities and development goals.

In the complex relationship between development and the environment, technology provides a link between human action and the natural resource base. Faced with limited global natural resources, the people of the world must seek to achieve more sustainable forms of development. As a result, the application of new, resource efficient ESTs has become crucial for both development and the environment. Technology cannot compensate for or mitigate the deep-rooted social causes of environmental problems or the short-comings of political and social policies, but the need for sustainable development in the world today is real. The availability of ESTs via cooperative technology transfer depends largely on political willingness at the international level to pursue an innovative environmental agenda as we approach the new millennium.

The dynamics of technological change will not be limited to one technology for developed countries and another for developing countries. Instead, cutting-edge and traditional technologies will coexist across the globe. In order for developing countries to make the best use of ESTs, however, they must increase their ability to assess, analyze and choose technologies based on their own needs and development priorities, and then adapt these technologies to specific local conditions. Technology in its new role, will be an essential factor on the path towards sustainability.

ESTs and Agenda 21

34.1. Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes.

34.2. Environmentally sound technologies in the context of pollution are "process and product technologies" that generate low or no waste, for the prevention of pollution. They also cover "end of the pipe" technologies for treatment of pollution after it has been generated.

34.3. Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures.

This implies that when discussing transfer of technologies, the human resource development and local capacity-building aspects of technology choices, including gender-relevant aspects, should also be addressed.

Environmentally sound technologies should be compatible with nationally determined socio-economic, cultural and environmental priorities.

Source: UNEP International Environmental Technology Center

In most situations, the process of planning wastewater treatment involves ten major steps (Ringskog 1997):

1. Determine the flow of wastewater
2. Determine the composition of wastewater
3. Determine standards for disposing or reusing effluent
4. Identify objectives and alternative processes for treating effluent before disposal or reuse
5. Determine the quantity and quality of sludge for each process
6. Determine standards for disposing or reusing sludge
7. Identify alternative processes for treating and reusing sludge
8. Identify alternative sites for treating, disposing, or reusing effluent and sludge
9. Determine the need for pilot studies and industrial pretreatment programmes
10. Evaluate the technical and economic feasibility of each alternative and select the most attractive scheme.

Some of these steps are straight-forward, such as determining the flow and composition of wastewater. Others are much more involved and require considerable expertise, such as determining the appropriate standards and examining alternative technologies for treating wastewater and the sludge produced during the liquid treatment.

Wastewater Treatment

Stormwater and domestic wastewater management are impacted by solid wastes and wastewater produced by industry. In many instances these may not differ in characteristics from domestic wastes, consisting primarily of biodegradable organic substances. Industry, however, produces numerous types of wastes that may be toxic to the bacteria that are utilized to treat domestic wastewater. Best practice is for industrial wastes not to be disposed with domestic wastes. Also, it must be remembered that human excreta and wastewater also contain pathogens. Treatment and reuse of the wastes must ensure that public health is maintained.

This section will focus on proven environmentally sustainable technologies that may be appropriate for the Caribbean. Detailed descriptions of the technologies are included in the report, *Assessment of Wastewater Management Technologies in the Wider Caribbean Region*, prepared as part of this consultancy. All the technologies presented here have been deemed to be "culturally acceptable" within the Caribbean.

On-site wastewater treatment systems

For domestic wastewater the suitability of various sanitation technologies must be related appropriately to the type of community, i.e. rural, small town or urban. Typically, in low-income rural and (peri-)urban areas, on-site sanitation systems are most appropriate due to the following reasons:

- they are low-cost (due to the absence of sewerage requirements)
- they allow construction, repair and operation by the local community or plot owner
- they reduce, effectively, the most pressing public health problems

Moreover, water consumption levels often are too low to justify conventional sewerage.

On-site treatment relies on decomposition of the organic wastes in human excreta by bacteria. This can take place in a simple pit in the ground or in specially designed tanks to promote the bacterial decomposition of the wastes. Unless re-use of the wastewater is specifically intended, the overflow from the pit or tank is allowed to soak into the ground. Further bacteriological decomposition and soil filtration, absorption and purification processes take place in the soil. The potential for groundwater pollution, however, exists with on-site treatment and disposal systems, because not all pollutants (e.g. nitrate) are removed by these processes.

Pit latrines, pour flush latrines, composting toilets, and septic tanks are the major types of on-site treatment systems, with each type possessing advantages and disadvantages. Pit latrines and composting toilets are "dry" options: they do not require water and are simple to construct. However, pit latrines may result in soil contamination. While composting toilets can produce valuable soil conditioner, they require more responsibility and careful maintenance to handle the finished product. With the use of the pit latrine, composting toilet and pour flush latrine, greywater (sullage) has to be separately treated. Greywater can be reused directly or after treatment. Septic tanks are easy to easy to construct and can be made using a variety of construction materials. Also, greywater can be treated together with toilet waste

On-site versus off-site options

In densely populated urban areas the generation of wastewater may exceed the local infiltration capacity. In addition, the risk of groundwater pollution and soil destabilization often necessitates off-site sewerage.

The unit cost for off-site sanitation decreases significantly with increasing population density, but sewering an entire city often proves to be very expensive. In cities where urban planning is uncoordinated, implementation of a balanced mix of on-site and offsite sanitation is most cost-effective. For example, in Latin America the population density at which small-bore sewerage becomes competitive with on-site sanitation is approximately 200 persons per hectare (Sinnatamby et al., 1986). The deciding factor in these cost calculations is the cost of the collection and conveyance system.

Off-site centralized treatment technologies

There is a large variety of off-site treatment technologies. The selection of the most appropriate technology is determined, first of all, by the composition of the wastewater flow arriving at the treatment plant and also by the discharge requirements. Questions for assessing the expected composition and behaviour of the sewage to be treated include:

- To what extent is industrial wastewater included?
- Will sewerage be separate, combined or small-bore?
- Is groundwater expected to infiltrate into the sewer?
- Are septic tanks removing settleable solids prior to discharge into the conveyance system?
- What is the specific water and food consumption pattern?
- What is the quality of the drinking water?

Off-site ESTs include lagoons, land-based treatment and anaerobic digestion.

Ponding or lagooning is effective in treating wastewater and can reduce BOD and SS to the same levels as mechanical treatment plants (e.g. Activated Sludge Treatment). In addition because of the longer residence time of wastewater in the lagoon (days), removal of pathogenic bacteria and viruses by natural die-off is greater than in an activated sludge treatment plant (residence time usually several hours). Cysts of parasites and helminth eggs are also usually removed through sedimentation in the lagoons.

Land-based treatment of wastewater relies on the action of soil bacteria to degrade the organic wastes in the wastewater. Raw wastewater can be used in land-based treatment systems provided that the application rate is small. Settled wastewater needs to be used for higher rates of application. Land application treatment systems work well in arid or semi-arid regions, where the soil is generally not saturated with water over much of the year, and reuse of wastewater for agriculture is attractive. Particular attention has to be given to public health requirements.

Constructed wetlands lie in-between lagoons and land-based treatment systems. They are based on natural wetlands, which act as a water filter and purifier. They are suitable for treating domestic sewage as well as other forms of wastewater such as contaminated groundwater and agricultural and animal waste. Constructed wetlands are particularly of interest in low-income areas as they are simple to construct, operate and maintain, usually by trained local people. This keeps the both the capital and operating costs low.

Anaerobic treatment is more suited to wastewater high in BOD. It is used to treat the sludge from an activated sludge treatment or biological filtration process. In households where there is cottage industry (such as food processing to supply restaurants or food market) the wastewater may be high in BOD. Wastewater high in BOD may also be generated when water conservation measures result in less water being used.

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New Zealand: slow-rate land application system

In 'slow-rate land application systems' wastewater is applied to land of a slightly inclined ground through channels in the upper part of the gradient and treated wastewater is collected in channels in the lower part of the gradient. The organic substances in the wastewater are biodegraded by soil bacteria at the surface of the soil and during percolation through the soil. Vegetation is usually part of the treatment process. It takes up nutrients (nitrogen and phosphorus) released from the degradation of the organic substances. The vegetation (usually grasses) is harvested by grazing animals (cattle or sheep). In New Zealand, treated wastewater is successfully disposed by spray irrigated into forests and crops. The trees and crops take up the disposed nutrients and use then to promote growth. This is mainly for disposal purposes and not for re-use. Crops (usually grass) are harvested as silage and then fed to live stock. This disposal system is referred to as “cut and carry” as the livestock do not graze the irrigated paddocks. The silage is of good quality and there is a demand for it. Sub-surface irrigation disposal of wastewater for silage is also being promoted.

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Chemically Enhanced Primary Treatment (CEPT)

CEPT is a recent innovation that can be used to enhance the first step in urban wastewater management. CEPT is a superior choice because:

- CEPT uses small doses of coagulant salts and flocculant polymers to produce a highly efficient, single stage treatment process that is superior in terms of suspended solids and organic carbon removal to conventional primary treatment alone, but also, in terms of phosphorus removal and energy consumption, to conventional primary plus activated sludge.

- CEPT, because of enhanced settling, results in increased treatment capacity and removal efficiency. As has been demonstrated by retrofitting some of California's largest conventional primary plants, CEPT provides a low-cost way of quickly upgrading overloaded plants.
- New CEPT plants can take advantage of enhanced settling to increase the surface overflow rate and reduce the number of settling tanks. When Hong Kong's new plant switched from conventional primary to CEPT, in the design stage, the number of settling tanks was reduced to two-thirds. In Mexico City it is estimated that capital and O & M costs for CEPT would be about 55% of the cost of conventional primary and secondary biological treatment, including sludge handling.
- CEPT effluent, in contrast to conventional primary effluent, can be effectively disinfected. This is important in controlling public health problems caused by water supply contamination by contact with raw or inadequately treated wastewater.
- CEPT sludge is readily dewatered and processed. The amount of CEPT sludge is generally only 10 to 15% greater than that produced by the removal of suspended solids.
- CEPT is an effective and appropriate first stage treatment process, it may be followed by biological treatment if the incremental effluent improvement, the risk of toxic upsets of the biological process and increased biosolids disposal can be justified and afforded. Subsequent biological treatment plants will be smaller and more efficient because of reduced organic load and increased solubility of the CEPT effluent.

While CEPT is already being applied in mega-cities, it is appropriate for small cities as well. Ongoing studies are aimed at reducing the cost and increasing the efficiency of wastewater treatment lagoons frequently used in small cities by combining CEPT and lagoon treatment technologies. CEPT tanks can be used as a pre-lagoon treatment to reduce solids and BOD loading to lagoons or coagulants can be added directly at the lagoon inlet.

There are now a growing number of examples of CEPT being tested and implemented in the developing world. Their objective is to protect public health, in a cost-effective manner, by first building the minimum level of wastewater treatment that permits effective removal of pollutants and deactivation of pathogens. Because of the increased surface overflow rate compared to conventional primary treatment, CEPT provides the minimum cost per unit volume of wastewater treated. There is no constraint on future biological upgrades; in fact, CEPT technology ensures that any subsequent biological treatment, if it can be justified, will be more efficient and smaller in both size and cost.

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Brazil: Use of CEPT

Bench-scale and full-plant CEPT demonstration tests have been successfully completed, first in Sao Paulo, under the sponsorship of the state wastewater agency. (SABESP, 1996) Next, in Rio de Janeiro, in 1997, the World Bank requested a demonstration of CEPT technology at an existing treatment plant. The objective was to show whether CEPT technology should be used in future treatment plants designed to solve severe eutrophication problems within Guanabara Bay. One of the major treatment objectives is low-cost phosphorus removal, the limiting nutrient controlling the large algal blooms that cause oxygen depletion and odors in the Bay. Tests of CEPT showed that it is possible to remove about 90% of the phosphate as well as high levels of TSS and BOD. (Harleman and Murcott, 1998) The first two CEPT treatment plants in Rio have been constructed by CEDAE, the state agency, and have begun operation.

The CEPT experience was tested on municipalities which have overloaded and poorly functioning plants. In Brazil, most wastewater treatment in medium size cities is by open lagoons at the edge of the urban area. The usual method of upgrading existing lagoon performance and treatment capacity is by cleaning and reconstructing the lagoons and installing surface aeration units. However, in addition to the initial costs, most cities cannot afford the large annual costs to run and maintain the aerators. Two CEPT alternatives were tried and compared with models to predict the performance of the wastewater treatment lagoons for a city which had planned to upgrade existing lagoons by installing aerators (Chagnon, 1999)

In the first treatment upgrade alternative, a small CEPT tank is placed in front of the first lagoon. This reduces the solids and BOD load on the lagoons and eliminates the need for aerators. The second alternative used an in-lagoon CEPT concept whereby chemical coagulants are added directly at the inlet of the first lagoon, again eliminating aerators. This type of CEPT lagoon performed well in the warm climate of Brazil. A comparative cost study showed that both alternatives were less expensive, in capital and O & M costs, than the original aerated lagoon design. (Cabral, et al, 2000)

Wastewater Reuse

Wastewater should be considered a potential resource in a country's water management system. There needs to be a shift in thinking – from seeing waste as a drain on resources to seeing it as an economic and environmental opportunity. Sewage, household grey water and wastewater contain potential sources of fertilizer and energy. Treated effluent can replenish water courses or be reused directly for many purposes. Better management of wastewater would contribute to a solution to water scarcity as well as water pollution.

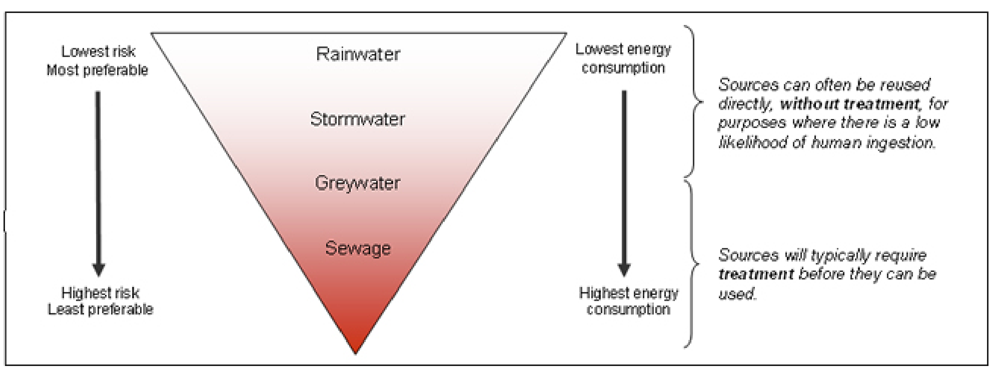
Human excreta and wastewater contains useful materials. These are water, organic carbon and nutrients and should be regarded as a resource. In their natural cycles they are broken down by micro-organisms and become useful to plants and animals, thus sustaining natural ecosystems. However, when improperly disposed these substances can cause pollution, because the organic materials exert oxygen demand, and the nutrients promote algal growth in lakes, rivers and near-shore marine environments.

Also, human excreta and wastewater contain pathogens. Treatment and reuse of the wastes must ensure that public health is maintained. Reuse of treated wastewater for irrigation of crops, for example, will need to meet standards for indicator pathogens, as well as plant requirements for water, nitrogen and phosphorus. WHO and others have developed standards for reuse of wastewater for various purposes.

Public outreach and education programmes are an essential component in water reuse programmes. Transparency, information sharing and involvement of water (re)users and local communities are critical to ensure acceptance of reuse projects. In the case of water reuse in agriculture, farmers need to be educated on safe irrigation and post-harvest practices, and consumers need to be informed about the safety of agricultural products irrigated with well-managed reclaimed water. Water quality data must be widely available and freely shared with customers for the water and the general public.

Figure 3 shows the hierarchy of wastewater reuse options. The level of treatment before wastewater can be reused depends on the source and nature of the wastewater.

Figure 3 – Risk and Energy Use for Water Reuse Options



Wastewater reuse for agriculture

Treated wastewater from off-site treatment plants can be reused for irrigation of parks and gardens, agriculture and horticulture, tree plantation and aquaculture, if these exist or can be established not far from the wastewater treatment plants. For these purposes the wastewater should generally be treated to secondary wastewater standard (< 20 mg/L BOD and < 30 mg/L

SS). Total coliforms should be < 1000 organisms per 100 mL for irrigation by spraying. When sub-surface irrigation is used this requirement may not be necessary. A period of non-entry to irrigated sites may need to be observed, particularly for wastewater-irrigated parks and gardens. Irrigation of vegetables for direct human consumption requires a much stricter guideline.

Because requirement of wastewater for plant growth is governed by climatic conditions, soil and plant type, there may be a need for storage of the wastewater. An alternative to storage, if land area is not available for this purpose, is to dispose of wastewater that is excess to requirement. A combination of wastewater for irrigation and aquaculture (see below) is also an option that can be considered.

Land application for treatment of wastewater and grass filtration, when combined with growing of grasses for grazing by sheep or cattle can properly be considered as treatment and reuse of wastewater.

Wastewater reuse for aquaculture

Wastewater reuse for aquaculture has been practiced in many countries for a considerable period of time. It has the potential of wider application in the tropics. There is great diversity of systems involving cultivation of aquatic species, (mainly fish) and plants (mainly aquatic vegetables such as water spinach).

Farmers and local communities have developed most reuse systems; the primary motivating factor has been reuse of nutrients for food production rather than wastewater treatment, and with scant attention to either waste treatment or to public health. In most aquaculture systems, wastewater is not reused directly in aquaculture and the nutrients contained in the wastewater are used as fertilizer to produce natural food such as plankton for fish. These nutrients, mainly nitrogen and phosphorus, are also taken up directly by large aquatic plants such as duckweed which is cultivated for animal feed, and aquatic vegetables such as water spinach and water mimosa cultivated for human food.

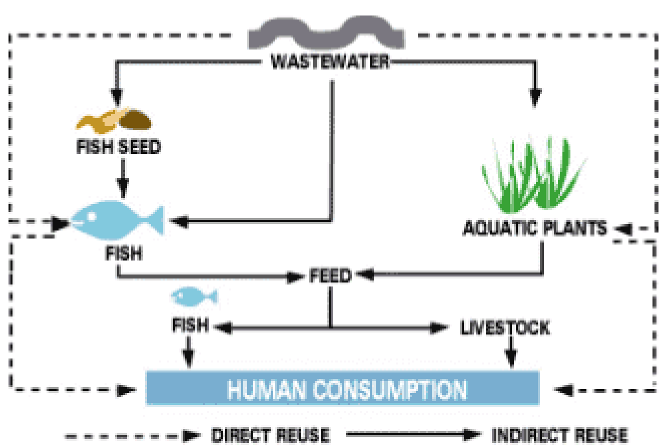
As wastewater provides a source of nutrients for aquaculture, it is technically feasible to link it up with most sanitation technologies, providing that land is available at reasonable cost. Farmers have learned by experience how to culture fish, first in static-water nightsoil-fed ponds and more recently in conventional wastewater-fed fishponds. Research has provided a scientific basis for the key parameters in wastewater-fed aquaculture practice developed earlier by farmers.

There are a number of constraints to wastewater-fed aquaculture and they need to be considered where the practice is considered to be an option. They include:

- lack of knowledge of aquaculture as a technical option in wastewater treatment and reuse
- limited available sites in peri-urban areas where wastewater is available for reuse
- rapid urbanization in developing countries threatens the existing wastewater-fed systems
- rapid eutrophication from both urbanization and industrialization
- improved sanitation reduces the availability of nightsoil for agriculture and aquaculture
- rapid industrialization contaminates nutrient-rich domestic wastewater with industrial wastewater
- social and cultural acceptance of wastewater-fed fish
- climate - wastewater-fed aquaculture involves the farming of warm water organisms

Despite the constraints listed above, there is considerable potential for the reuse of wastewater in managed aquaculture in the tropics. A correctly managed system would limit public health risks and wastewater should never be reused without prior treatment if the produce (fish or aquatic vegetables) is intended for direct human consumption. **Error! Reference source not found.**4 presents strategies for the reuse of wastewater through aquaculture.

Figure 4 - Schematic of wastewater reuse strategies (Edwards 2000)



There are a number of situations where wastewater-fed aquaculture has significant potential for incorporation into existing and proposed improved sanitation schemes:

- Developing countries that cannot afford mechanical wastewater treatment schemes. Although aquaculture in stabilization ponds requires more land, it produces significant benefits such as increased employment for local people and revenue from sale of produce which, in turn, can be used to subsidize the wastewater treatment.

- Arid and semi-arid countries have an increasing need to reuse water as well as nutrients contained in wastewater. Pilot projects on culture of fish in treated stabilization pond effluents have been successfully completed in arid areas in Egypt, the Middle East, Peru and in Latin America.

Wastewater reuse for industry

Treated wastewater can also be used for industrial purposes if suitable industries are not far from the treatment plant. Industry's requirement for water quality ranges widely, from very pure water for boilers of electricity generation to lower water quality for cooling towers. Treated wastewater can fulfill the lower range of this requirement, e.g. water for cooling towers. Secondary-treated wastewater after chlorination may be adequate for this purpose.

With off-site treatment plants reuse of wastewater may be limited by the need to pipe treated wastewater to where it is needed. To implement wastewater reuse in houses for toilet flushing, watering of gardens and other purposes which do not need drinking quality water, a third pipe-reticulation system is required, that is in addition to the reticulation to provide drinking water and the sewer to collect the wastewater. Care is also needed to prevent cross-connection between drinking water and treated wastewater.

"Sewer mining" is the term given to the withdrawal of wastewater from a sewer for reuse near to the point of withdrawal. This provides an opportunity for reuse without having to pipe treated wastewater from the centralized treatment plant. Wastewater needs to be treated to the standard required for the reuse, and may duplicate the function of the centralized treatment plant.

Reuse of wastewater from on-site systems

Many options are open to a householder who wishes to reuse wastes on-site. One option is separation of all wastes. Urine can be separately collected and stored for later use as a liquid fertilizer, rich in nitrogen, phosphorus and potassium. Toilet wastes can be composted and used as a soil conditioner, rich in organic carbon, nitrogen and phosphorus. Greywater can be treated in a constructed wetland and used for sub-surface irrigation of the garden beds. This option may be suitable for a householder who is interested in managing wastes for beneficial uses in the garden. Sufficient garden area needs to be available for this purpose.

Another option is the use of an evapotranspiration system for growing shrubs and trees. This is a passive system, not requiring household attention on a regular basis, except desludging of the septic tank every 3 to 5 years. There is a fairly wide choice of shrubs and trees to choose from depending on local soil and climatic conditions.

Trinidad & Tobago: Water Reuse Project to Boost Supply to Domestic Customers

The wastewater reuse project earmarked for the new Beetham Wastewater Treatment Plant provides some 20 million gallons per day of high-quality industrial water for use by the Point Lisas Industrial Estate (WASA n.d.).

Effluent from the new Beetham Wastewater Treatment Plant

This project involves the polishing of the already high-quality effluent from the Beetham Wastewater Treatment Plant, transporting it via submarine transmission pipeline to Point Lisas in the short term, and expanding as necessary to San Fernando and Point Fortin. The multi-million dollar new Beetham Waste Water Treatment Plant was completed in April 2004. It treats approximately 20 million gallons of wastewater a day, of which 95 percent is discharged into the nearby lagoon. The wastewater undergoes several processes to ensure that it is environmentally friendly. One of the first processes is the removal of solid material. Later on this wastewater, free of solid material is sent to the Grit Chambers which consist of zones that destroy aerobic and anaerobic bacteria and allow for the survival of Facultative Bacteria.

This type of bacteria is important for the destruction of nitrogen which can encourage algae growth in the discharged effluent. Other processes include clarification and ultra violet disinfection which ensure that microorganisms are destroyed and water appears clear.

The system to be used in the wastewater reuse project involves the polishing of the already high-quality effluent and will allow for the potable water that is currently used for machinery cooling and other inputs to be distributed to households that do not now receive a regular water supply.

An estimated 20 million gallons of water is discharged each day.

A survey was conducted to find out the public's reaction to the wastewater reuse project. The findings were that generally, the citizens interviewed welcomed the project. However, their major concern was the quality and safety of the treated water, even for industrial purposes, and the possibility that cross contamination could occur.

WASA has invited tenders to bid for prequalification to Build/Own/Operate/Transfer (BOOT) Wastewater Reuse project.

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Melbourne, Australia: Reusing sewage

The public water company, Melbourne Water, manages 54% of its wastewater in 11,000 ha of ponds, wetlands and grazing fields – that is 500,000m3 of wastewater per day. Cattle and sheep graze on 3,700 ha of pastures irrigated with raw or sedimented sewage and 3,500 ha non-irrigated pastures. The livestock yields a substantial return of about 3 million Australian dollars per year, which significantly reduces the cost of sewage treatment for the city (Melbourne Water 2001).

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Tunisia's National Water Reuse Programme

In Tunisia's national water reuse programme, which was launched in the early 1980s, treatment and reuse needs are combined and considered at the planning stage. Reclaimed water is being used for industrial purposes, groundwater recharge, irrigation of forests and green areas along highways, and for wetlands development. By 2020, the annual volume of reclaimed water is expected to reach 290 million m^3, and it is planned to extend the area irrigated with reclaimed water up to 20,000-30,000 ha, i.e., 7-10% of the overall irrigated area. Inter-departmental coordination and follow-up commissions with representatives from the different ministries and their respective departments or agencies, the municipalities, and representatives of the users (Water Users' Associations) have been set up at national and regional levels to bridge the gaps between the needs of different parties, ensure the achievement of development objectives, and preserve the human and natural environment (Melbourne Water 2001).

International Best Practices in Public Education/ Communication and Clearinghouse Mechanisms

Public participation has gained wide recognition as a key principle for modern environmental resource management. In water management, according to the Dublin Statement (second principle): "Water development and management should be based on a participatory approach. … Decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects" (The Dublin Statements, 1992).

Raising public awareness and close involvement of the public into decision making often results in less costly and more effective water protection because people understand the relationships between their activities and the impacts of it on water bodies. The decisions are of better quality since the interests of various stakeholders should be balanced as much as possible and local knowledge of problems together with local experience should be reflected in decisions. Perhaps most importantly, citizens feel more empowered and committed when involved in all stages of water management – from identifying the issues to developing plans to implementing the solutions.

Public education/communication programmes include public awareness campaigns and educational programmes designed to raise awareness about water and sanitation issues and to implement good water conservation and protection practices. Increased public awareness can also to generate demand and public support for efforts to expand sanitation services. Communication and education techniques can enhance the effectiveness of people or groups seeking to participate.

Good communication programmes awaken communities to dangers facing their members and their environment, build local capacity to understand and analyze situations, arouse a sense of responsibility to face the issue, promote appropriate attitudes and behavior, and can teach appropriate techniques and practices. Education and communication programmes must endeavour to change behaviour. According to Monroe, Day, Grieser (2000), "Knowledge alone doesn't harm or help the environment. Human attitudes don't harm or help the environment. Human behaviours, have greatly harmed, yet hold a great deal of hope for helping, the environment." Changes in behaviour are, of course, facilitated by increased knowledge and appropriate attitudes.

In this digital age, websites and electronic clearinghouse mechanisms are increasingly being used to share information with the general public as well as with individuals who have specific responsibilities within the wastewater management system – from lawmakers to technicians to business owners.

Public Education and Communication

There is a wide variety of public education techniques. The method selected will depend on the target audience, timeline, available resources and the actual objective of the particular intervention. Some key public education techniques are described below (NEEC 1999).

Discussion - an oral exchange of ideas and information usually considering points for and against an issue. Variations include: buzz groups in which 2-3 persons talk for a few minutes and brainstorming in which ideas flow freely from all group members

Focus group - a planned discussion among a small group of people on a specific topic. Obtained information is asked on social interaction, and the group setting allows individuals to use the ideas of others as cues to more fully elicit their own views

Debate - a discussion about different sides of an issue

Simulation - a contrived activity that models aspects of the real world. It is a simple representation of a complex natural situation. A simulation can take the form of a game or an imaginary field trip, for example. Simulations allow participants to ask "what if" questions

Role play - a type of simulation in which individuals act out roles to better understand how others feel about given issues and to appreciate the complexity of real life problems

Moral dilemma - presentation of a moral conflict situation that allows participants to wrestle with their own beliefs and values and to experience higher level moral reasoning skills

Citizen's Jury - a randomly selected panel of citizens, which meets for 3-5 days to carefully examine an issue of public significance through discussions, examinations of information, and questioning of witnesses. The members of the jury are given the chance to hear views and receive information from a variety of expert witnesses. Finally, the jury presents their recommendations to the problem issue

Art forms - creative expressions of how people feel, think and act in forms such as drama, dance, music, song, poetry, proverbs and literature

Field trip - a unique outdoor, first hand, concrete experience

These small-scale education techniques often complement large-scale mass communication media campaigns that relay key messages to the general public or specific target audiences using products such as posters, brochures, flyers, newspaper ads, articles and radio and television programmes and features.

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Estonia: River Dialogue Public Participation

The EU funded research project River Dialogue sought to identify the best approaches to increase public participation in the implementation of the EU Water Framework Directive[7] in the Emajõgi river basin, Estonia (IWRM Toolbox n.d.).

Focus groups were conducted on water management issues with the all major stakeholder group in the Emajõgi river basin, Estonia. To determine who the relevant stakeholders were, interviews were conducted with environmental organizations, schoolchildren, owners of the recreation homes, fishermen, farmers, officials from local authorities, water recreation groups, NGOs and with people from the water tourism companies. These meetings concentrated on understanding the possible influence of different stakeholders on water management issues. Focus groups then included representative stakeholders from these groups, using mostly existing networks of interest groups – for example, the meetings of fishermen, NGO representatives, farmers and schoolchildren. The topics discussed in the focus groups dealt how the participants understand water management, what the situation in the River Emajõgi area was like and which environmental problems there were. Participants were asked to comment on some articles about water and express their opinion of the availability of information on water problems. Focus groups proved to be an effective approach that could be used on the water management planning stage to collect opinions of stakeholders about major issues in a river basin. Focus groups also helped to increase an awareness of water issues among participants and empowered the participants by giving them an opportunity to voice their opinions.

A Citizen's Jury in Emajõgi River region was organized on the topic "Water transport on River Emajõgi in the Alam-Pedja Nature Reserve. What would be the compromise between the interests of environmentalists, entrepreneurs and local inhabitants?" based on the results of the focus groups and several discussions with environmental authorities of the region. The idea behind Citizens´ juries is that given enough time and information, ordinary people can make decisions about complex policy issues. The citizens' jury allows the participants to learn in depth about one or a number of issues relevant for the public. The important aspect of this public participation method is that it promotes political dialogue aimed at mutual

[7] The EU Water Framework Directive is described as an International Best Practice example in the Section on Institutions.

understanding, which does not mean that people will agree, but rather that they will be motivated to resolve conflicts by argument rather than other means.

The citizens' jury took place for two days with randomly selected participants. It is important to use random selection of participants rather than voluntary involvement. Participants listened to the presentations of witnesses from different sectors and stakeholder groups, involved on the issues regarding the development of water transportation on the River Emajõgi – from River Port, public authority, environmental NGOs, local businessman. The idea is to give the overview of the problem form very many different and even conflicting interest and organizations. After each presentation people had a chance to give questions and give their own concerns and arguments about the topic. The session concluded with recommendations prepared by the citizens. Participants were pleased – and surprised – that "officials" were interested in their opinions and stressed the advantage of having the specialists from various fields in one room. The citizens' jury proved that people, when thinking together in a pleasant constructive atmosphere, can prevent conflicts and, by way of compromises, reach solutions.

This example shows how two specific participatory methods of citizens' involvement - focus groups and citizens' juries – can enable local people, who are not specialists, to take part in discussions and decision making process of complex environmental issues. Citizens react positively to being invited to become involved in the planning and decision-making processes around issues that affect their lives. In addition, their participation in innovative discussion and education methods increases their own capacity to share and discuss information.

Clearinghouse Mechanisms

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USA: National Menu of Best Management Practices (BMPs) for Stormwater

The US EPA maintains a National Menu of Best Management Practices (BMPs) for Stormwater Phase II that provides BMP information for all aspects of the Stormwater Phase II Rule (public education, public involvement, illicit discharge detection & elimination, construction, post-construction, pollution prevention/good housekeeping) (USEPA n.d.).[8] For each aspect, the website provides background information, fact sheets, guidelines, legal requirements, and resources. For example, the BMP page for public education includes guidelines for conducting an outreach strategy, classroom education, interacting with the media; information for homeowners and businesses on how to reduce pollution of water emitted by their establishments; case studies of public education programmes; and communication resources such as videos, flyers, fact sheets and other outreach materials.

This website also provides access to a number of other tools. The Urban BMP Performance Tool provides easy access to approximately 220 studies assessing the performance of over 275 BMPs

[8] See section on Legislation above, for more information on this rule.

of low impact BMP types, including retention and detention ponds, biofilters, grassed filter strips, porous pavement, wetlands, and others. Users will also find a series of essays aimed at improving understanding of BMP performance and the importance of volume reduction/ infiltration in these assessments.

Stormwater Case Studies help operators of municipal storm sewer systems regulated under the Phase II stormwater regulations develop or improve their stormwater management programs. Users can search the case studies by minimum measure, case study location, or keyword. Additional resources and tools for each case study and minimum measure are provided. The National Management Measures to Control Nonpoint Source Pollution from Urban Areas helps municipalities and citizens in urban areas protect water bodies from polluted runoff resulting from everyday activities. These scientifically sound techniques are the best practices known today. The guidance helps municipalities implement their Phase II stormwater permit programs, and states implement their nonpoint source control programs

Water Operators Partnerships

The Hashimoto Action Plan, launched in March 2006 at the 4th World Water Forum in Mexico City, identifies actions for achieving breakthroughs in vital areas of water management, water supply and sanitation (UN 2006). The Plan calls for a collaborating mechanism among water operators, recognizing that the greatest capacity to improve the delivery of water and sanitation services is found in the operators themselves. Partnerships between operators present a way to improve and extend basic water and sanitation services to all consumers. A Water Operators Partnership (WOP) is defined as any form of simple or structured partnership aimed at capacity building on a not-for-profit basis (IWA 2009). The WOPs initiative is led by the Global Water Operators' Partnerships Alliance – an international network of concerned partners hosted by UN-HABITAT.

A distinctive characteristic of the WOPs mechanism compared to some other forms of external support is the linking of 'mentor' operators (the organization with demonstrable experience and expertise) and 'recipient' operators who request assistance with the mentor assuming a coaching role in the partnership. Thus, the added value of the WOPs approach is in enabling the operator itself to sustain an improvement over the longer term. The main services offered by WOPs are knowledge development and dissemination, connecting mentoring and recipient water operators, and capacity development.

Based on experience from the implementation of a variety of WOPs there are several basic requirements to be met to achieve success. These include:

- a demand driven approach – the recipient operator has to clearly express demand for a WOP and spell out their need for a partnership.
- a willing and enabling environment – frequently a partnership will give rise to suggestions for change

- formulate and agree on clearly defined and specified targets to guide the partnership and to keep it on track
- incorporate flexibility in order to adjust partnership activities to the needs and demands of the recipient operator
- agree to open communications, a common language, and transparent financial systems as base conditions for a trustworthy partnership relationship

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Waterlinks: Linking Water Operators throughout Asia

A web portal, WaterLinks[9], has been established for the WOP programme in Asia. WaterLinks is a regional network that supports partnerships between water and wastewater utilities in Asia to promote improved access to safe water and basic sanitation. WaterLinks develops and implements three principal activities, each of which draws on a range of partner resources and capabilities to achieve tangible results in terms of expanded or improved access to safe water and sanitation and increased capacity. These activities are described below.

- *Twinning Activities*: Twinning activities include peer review, technical assistance in developing and implementing improved policies and practices, specialized on-the-job training, technology demonstrations and information exchange. Twinning partners develop memoranda of understanding and work plans that identify specific commitments, activities, resources, timelines and outcomes. WaterLinks development partners facilitate and co-fund twinning activities.

- *Regional Capacity Building*: WaterLinks supports regional capacity building of Asian water and wastewater operators through the development and implementation of training programs and toolkits and applied research. As part of its capacity building efforts, WaterLinks highlights the results of twinning partnerships through its training programs and toolkits.

- *Information Sharing and Networking*: WaterLinks disseminates best practices via publications and the website. It also organizes regional networking events to share twinning partnership results and broker new partnerships.

An example of a twinning agreement is the recent partnership between King County in Washington state, USA and the Wastewater Management Authority of Thailand (King County 2009). Under the agreement, wastewater managers from King County and Thailand will share best practices for wastewater treatment plant maintenance and operation, financing and public education. The twinning agreement will to not only enable Thailand to learn from King County, acknowledged as a as an international leader in the fields of wastewater treatment, climate change and public health, but will also enable King County to better understand and serve their own communities thereby improving local service delivery.

[9] http://www.waterlinks.org/

Country Case Study - Singapore

Background

Singapore is characterized by abundant rainfall, high temperature and high humidity. Coupled with high population density, waterborne diseases can spread easily and quickly unless a high standard of public health is maintained. The country recognizes that proper collection, treatment and disposal of domestic and industrial wastewater is therefore necessary to prevent the pollution of watercourses, reservoirs, rivers and the sea, and thus, the spread of diseases. To meet the environmental demands associated with continued economic and population growth, Singapore sought to replace the nation's entire sanitary services infrastructure with one that can handle wastewater needs for the next 100 years. Currently, Singapore provides 100% of its citizens with access to potable water and to sanitation services.

Singapore has been awarded a number of international awards for its holistic water management system – integrating the management of both water and wastewater to provide its citizens with clean water and proper sanitation and to protect the quality of the country's inland and coastal waters. In 2007, the country's Public Utilities Board was awarded the Stockholm Industry Water Award in 2007 which recognizes innovative corporate development of water and wastewater process technologies as well as contributions by businesses and industries that help improve the world water situation (Ministry of the Environment and Water Resources 2008).

Singapore has been very successful in managing its water and wastewater because of its concurrent emphasis on supply and demand management, wastewater and stormwater management, efficiency and equity considerations, institutional effectiveness and creating an enabling environment, which includes strong political will, effective legal and regulatory frameworks, public sector and private sector participation and an experienced and motivated workforce (Tortajada 2006). This management scenario which reflects strategic national interest and economic efficiency is derived from the Singapore Green Plan 2012, a ten-year national blueprint drawn up in 2002 to preserve, protect and enhance the environment for future generations (Ministry of the Environment and Water Resources 2008).

Singapore is one of the very few countries that looks at its supply sources in their totality. Singapore is considered to be a water-scarce country not because of lack of rainfall, but because of the limited amount of land area where rainfall can be stored. In addition to importing water, it has made a determined attempt to protect its water sources (both in terms of quantity and quality on a long-term basis), expand its available sources by desalination and reuse of wastewater and stormwater (Lee & Nazarudeen, 1996) and use technological developments to increase water availability, improve water quality management and steadily lower production and management costs. This is embodied in the "Four Taps" concept: Tap 1 (local catchment), Tap 2 (imported water), Tap 3 (reclaimed water – "NEWater"), Tap 4 (desalinated water).

Currently, the public sewerage system serves all industrial estates and almost all residential premises in Singapore. All wastewater is required to be discharged into the public sewerage system.

Institutions

The overall governance of the water supply and wastewater management systems in Singapore is exemplary in terms of its performance, transparency and accountability. The Ministry of the Environment and Water Resources has overarching responsibility for environmental sustainability in Singapore along with its two statutory boards, the National Environment Agency (NEA) and the Public Utilities Board (PUB), the national water agency.

The PUB now manages the entire water cycle of Singapore. Earlier, PUB was responsible for managing potable water, electricity and gas. In 2001, the responsibilities for sewerage and drainage were transferred to PUB from the Ministry of the Environment. This transfer allowed PUB to develop and implement a holistic policy, which included protection and expansion of water sources, storm water management, desalination, demand management, community-driven programmes, catchments management, outsourcing to private sector specific activities which are not core to its mission, and public education and awareness programmes. The PUB therefore manages Singapore's water supply, water catchment and used water in an integrated way. At this time, the name of the Ministry itself was changed from the Ministry of Environment to the Ministry of Environment and Water Resources in recognition of the strategic importance of water management to the country.

The Public Utilities Board has implemented a competitive remuneration, incentives and benefits package. The salary and benefit package is generally benchmarked against the Civil Service, which, in turn, benchmarks against the prevailing market. It provides strong performance incentives that are commensurate with the prevailing pay packages for the private sector. In addition, its pro-family policies, commitment to train its staff for their professional and personal development, and rewarding good performers, ensure good organizational performance and development. PUB has a comprehensive Corporate Social Responsibility program, focusing on corporate philanthropy, community volunteering, socially and environmentally responsible business practices and international responsibility.

A problem in many cities has been that the process of setting tariffs is primarily controlled by elected officials, who mostly resist increases because of perceived vested interests. PUB has been able to increase water tariffs in progressive step through the years because of its high level of autonomy and solid political and public support. This increase not only has reduced the average monthly household water demand but also has increased the income of PUB, which has enabled it to generate funds not only for good and timely operation and maintenance of the existing system but also for investments for future activities.

Tariffs and fees
PUB collects a water conservation tax and a water-borne fee, a statutory charge prescribed to offset the cost of treating used water and for the maintenance and extension of the public sewerage system. It was shown that the new tariffs had a notable impact on the behaviour of the consumers, and have turned out to be an effective instrument for demand management. Average monthly household consumption steadily declined during the period 1995 – 2004. In terms of equity, the government provides specially targeted help for lower-income families. Households living in 1- and 2-room flats receive higher rebates during difficult economic times. For hardship cases, affected households are eligible to receive social financial assistance from the Ministry of Community Development, Youth and Sports.

Legislation and Regulations
The management of water and wastewater is governed by the pieces of legislation and regulations described below. While many other developing countries have similar requirements, the main difference is that, in Singapore, these regulations are strictly implemented. Singapore's laws can be easily found on the website, Singapore Statutes Online[10].

Public Utilities Act
This act establishes the PUB whose functions encompass management of the entire water cycle in the country, as described above.

Environmental Protection and Management Act (EPMA) and the Environmental Protection and Management (Trade Effluent) Regulations
The EPMA regulates licences for discharge of trade effluent, oil, chemical, sewage or other polluting matters; plants for treatment of trade effluent; penalties for discharging toxic substances or hazardous substances into inland waters; and the power of Director-General to require the removal and cleaning up of toxic substance or trade effluent, oil, chemical, sewage, hazardous substance or other polluting matters. The discharge of wastewater into open drains, canals and rivers is regulated by the EPMA and the Environmental Protection and Management (Trade Effluent) Regulations. The EPMA and its Regulations are administered by Pollution Control Department within the Ministry of the Environment and Water Resources.

Sewerage and Drainage Act (SDA) and Sewerage and Drainage (Trade Effluent) Regulations
The SDA governs the provision, operation and maintenance of Singapore's sewerage system. The treatment and discharge of industrial wastewater into public sewers are regulated by the SDA and the Sewerage and Drainage (Trade Effluent) Regulations. All trade effluent to be discharged into the public sewerage system must be done so with the written consent of the Public Utilities Board in accordance with the Act and Regulations.

[10] http://statutes.agc.gov.sg

Cattle Act
In response to the problem of wastes from pig farms contaminating surface waters, the Cattle Act was legislated to restrict the rearing of cattle to certain areas in the interest of public health. This also protects the water catchments from animal wastes generated from the cattle farms.

Environmental Public Health Act
The EPHA regulates sanitary conveniences, drains, sewers and wells, including public toilets and sanitary conveniences in work premises or the work place.

Technology and Practices

NEWater
Singapore is supplementing its water supply through the collection, treatment and reuse of wastewater. This reclaimed water, is known as "NEWater" - high-grade reclaimed water produced from treated used water that is purified further using advanced membrane technologies, making the water ultra-clean and safe to drink. NEWater meets the water quality standards of the Environmental Protection Agency of the United States and the World Health Organization and the level of acceptance within the country is high. With a 100% sewer connection, all wastewater in the country is collected and treated. Wastewater is reclaimed after secondary treatment by means of advanced dual-membrane and ultraviolet technologies[11]. In 2001, the six sewage treatment works were renamed as Water Reclamation Plants (WRPs) to emphasize their new role of not only treating used water, but also to reclaim water for non-potable use.

NEWater is used for industrial and commercial purposes, even though it is of drinking water quality. The cost to produce NEWater is significantly less than the cost of desalinated water. It is expected that by 2011, 15% of the country's water needs will be met by NEWater. With more industries using NEWater, water saved is being used for domestic purposes.

Deep Tunnel Sewerage System
The Deep Tunnel Sewerage System (DTSS) is an efficient and cost effective solution to meet Singapore's long-term needs for used water collection, treatment and disposal (PUB n.d.). Completed in 2008, Phase I of the DTSS comprises a 48km long deep tunnel sewer running from Kranji to Changi, a centralized water reclamation plant at Changi, two 5km long deep sea outfall pipes and 60km of link sewer. The heart of the DTSS, the Changi Water Reclamation Plant, is a state-of-the-art used water plant capable of treating 800,000 cubic metres (176 million gallons)

[11] NEWater involves a three stage process comprising of filtering out elements - bacteria, viruses, and solids, passing the water through a semi-permeable membrane, and then exposing the water to ultraviolet light. The first two stages involve stringent purification and treatment processes using an advanced dual-membrane technology (micro filtration followed by reverse osmosis). Micro filtration is necessary to remove particles and bacteria larger than 0.2 microns in size. This prevents the reverse osmosis membrane from clogging. Reverse osmosis in turn removes and filters out particles as small as 0.001 microns. This includes viruses, salts, and dissolved organics. Alkaline chemicals are then added to restore the pH balance. And the membranes are cleaned with citric acid every sixty days. -- Water Management Issues in Singapore

of used water a day to international standards. The treated used water is then discharged into the sea through deep sea outfall pipes or channelled to the Changi NEWater factory where it is further purified into NEWater. Crowned ‘Water Project of the Year’ at the Global Water Awards 2009 in Zurich, Switzerland, the DTSS was selected as the water project with the most significant contribution to water technology and environmental protection.

The implementation of the DTSS will have far-reaching effects beyond wastewater treatment and reuse. Land comes at a premium in Singapore, and the decommissioning of old pumping stations and wastewater treatment plants will free up valuable land for other uses.

Sewerage system
The current sewerage system is designed based on a 'separate system' whereby used water is collected separately in a network of underground sewers that lead to a treatment plant whereas stormwater and surface runoff are collected in open drains and channelled to rivers and reservoirs. This reduces the amount of pollution that gets into the waterways and helps ensure that the quality of the water harnessed from the catchments is of good quality.

Research and Development
The Public Utilities Board (PUB) has an in-house Centre for Advanced Water Technology, with about 50 expert staff members who provide it with the necessary research and development support.

Standards, guidelines and codes of practice
Given Singapore's limited water resources, it is critical that water pollution and quality are carefully monitored and regulated. The responsibility for this belongs to the National Environment Agency (NEA), which regulates water pollution and quality in Singapore's sewerage system, as well as inland water bodies and coastal areas (NEA). The Agency maintains comprehensive records of air, water and weather conditions in order to detect changing conditions and trends in air and water quality, and assess whether current regulations are sufficient to ensure a safe environment for all in Singapore.

Standards for Trade Effluent Discharge to Sewer/Watercourse/Controlled Watercourse
Specific standards exist for the treatment of industrial wastewater before being discharged into a sewer or watercourse (if the public sewer is not available) (NEA Water Pollution). Additionally, industries generating large quantities of acidic effluent are required to install a pH monitoring and shut-off control system to prevent the discharge of acidic effluent into the public sewer.

The trade effluent discharged must not include:
1) Calcium carbide
2) Petroleum spirit or other inflammable solvents
3) Materials that may give rise to fire or explosion hazards
4) Materials that may be a hazard to human life, a public nuisance, injurious to health or otherwise objectionable

5) Refuse, garbage, sawdust, timber, or any solid matter
6) Pesticides, fungicides, insecticides, herbicide, rodenticide or fumigants
7) Radioactive material

The trade effluent shall be analyzed in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater published jointly by the American Water Works Association and the Water Pollution Control Federation of the United States (PUB 2000a).

Industries may apply to PUB for permission to discharge their trade effluent that contains biodegradable pollutants, as determined by their biochemical oxygen demand (BOD) and total suspended solids (TSS) loading that exceeds the allowable standards, directly into the public sewers on payment of a tariff.

Codes of Practice

Codes of practice (COP) relevant to wastewater management have been developed and are mandated to be followed by supporting regulations. These codes of practice include:

- COP on Environmental Health – provides design criteria for building public toilets to meet environmental health requirements[12];
- COP on Pollution Control – for handling wastewater from food processing factories and laboratories and for wastewater treatment plants;
- COP on Sewerage and Sanitary Works[13] – specifies the minimum requirements in the design and construction of sewerage and sanitary works;
- COP on Surface Water Drainage – specifies basic planning, design and procedural requirements for surface water drainage
- COP for Water Services – provides guidance on the design, installation, fixing and testing of potable water service installations in all residential, commercial and industrial buildings or premises

Building Plans

Building plans and detailed plans are required for buildings works as well as related building services such as solid waste, sewerage, surface water drainage and pollution control systems. These plans ensure that the development complies with environmental requirements stipulated in the codes of practice (COP) and relevant regulations.

Guidelines pertaining to public toilets

Promoting clean and well-maintained public toilets is an important aspect of NEA's public health efforts. NEA provides owners of public toilets with operating and maintenance guidelines and requirements. Design guidelines for public toilets can be found in the Code of Practice on Environmental Health. NEA, in collaboration with the Restroom Association of

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[12] The code of practice emphasizes the objectives to be achieved rather than the means to achieve these objectives. In this way, qualified professionals such as architects, professional engineers and developers, as well as members of the public, can exercise flexibility and creativity in their building designs.

[13] In addition to the minimum requirements, some good engineering practices in the planning, design and construction of the sanitary and sewerage system are also given in this code. See the Code Of Practice On Sewerage And Sanitary Works

Singapore, has published a guidebook titled 'A Guide to Better Public Toilet Design and Maintenance' that covers topics such as design, layout, ventilation, maintenance and user education. Public can also download educational posters on public toilets from NEA's website.

Recreational Water Quality Guidelines

Singapore's recreational water quality guidelines for recreational beaches and fresh water bodies are adopted from the World Health Organisation (WHO) standards (2003). In 2008, the NEA studied the WHO guidelines, collected data for the past few years and, in consultation with other organizations[14], established Singapore's guidelines. The revised guidelines were based on the microbial indicator, enterococcus which corresponds better with the health risks associated with the use of recreational beach water.

Written permission for disposal of sludge residues at landfills

Solid residues such as sludge from wastewater treatment facilities may contain toxic contaminants such as heavy metals. Such wastes must be treated to comply with leachate test standards before disposing of at an approved landfill site. Application for written permission to dispose of such wastes must be accompanied by a recent report of analytical results from leachate tests carried out on the wastes. The report must be from an accredited laboratory.

Guidelines to handle contamination of wastewater by pesticides

NEA has published a document for pest control operators, "Measures to Prevent and Control Water Pollution from the Use of Termiticide," which sets out the minimum requirements for the prevention and control of water pollution from the use of termiticide. The document states that preparation of termiticide for application should be carried out in such a manner that it would not be spilled/ discharged to the open drain or a public sewer. Any wastewater contaminated with termiticide must not be discharged into a septic tank, an open drain or the sewer. Such wastewater may be reused or should be disposed of properly by licensed toxic industrial waste collector.

Public Education and Training

Environmental Training

The National Environment Agency (NEA) offers environmental training to NEA staff, government officials, businesses and the public through the Singapore Environment Institute. Courses range from those required to meet industry regulations for businesses, to general environmental awareness courses for the general public.

Public Education

Singapore has an extensive and innovative national public education program that includes initiatives by government, NGOs, schools and communities. These initiatives focus on all

[14] Ministry of Health, Public Utilities Board, Maritime and Port Authority of Singapore, the National University of Singapore, the Nanyang Technological University

environmental aspects including climate change, littering, energy use, water conservation etc. The initiatives highlighted here focus on water and especially sanitation issues.

The Singapore International Water Week is a premier annual water event that focuses on best practices, successful case studies and practical applications of water innovation and technologies. It is an event for senior government officials, top industry leaders, leading water specialists and practitioners to meet and discuss policies, business solutions and water technologies. Comprising the Water Convention, Water Leaders' Summit and Water Expo, it culminates in the presentation of the Lee Kuan Yew Water Prize, a prestigious international award to recognize an individual or organization for outstanding contributions towards solving the world's water problems by applying innovative technologies or implementing policies and progress that benefit humanity. The inaugural Singapore International Water Week was held in June 2008 (Ministry of the Environment and Water Resources 2008).

The NEWater Visitor Centre showcases the use of advanced membrane and water purification technologies for the production of NEWater. The centre includes experienced guides, multimedia displays and interactive exhibits that are interesting educational tools for informing people about the country's important product.

To raise consciousness among the young on the importance of good hygiene habits and practices, NEA developed the Environmental Health Educational Kit for pre-schoolers between ages four and six to educate them on the key aspects of environmental health education – from proper toilet habits, good personal hygiene habits to how to keep the environment clean and litter-free. Since its implementation in 2005, the kit has been used in 1,008 (out of the 1,306) pre-schools in Singapore.

The Restroom Association of Singapore (RAS) is a key NGO partner in promoting clean public toilets. The association's 'Happy Toilet' programme, sets benchmarks for various types of toilets and encourages owners of public toilets to reach the standards through improvements in toilet design/maintenance system, training of toilet cleaners and/or revision of cleaning schedule. It grades Singapore's public toilets on a scale of three-, four- or five-star rating. To inculcate good toilet etiquette and habits among the young, RAS has also introduced the 'Happy Toilet School Education' programme in primary, secondary and pre-schools.

The NEA website has various brochures with useful information regarding sewage management, including: *A Guide for Eating Establishments on Good Practices and the proper maintenance of private sewerage systems and grease traps*; *Safeguarding our sewerage infrastructure at construction sites*; and *Taking care of your private sewers*.

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Annex I – Alberta Standards and Guidelines

STANDARDS AND GUIDELINES FOR MUNICIPAL
WATERWORKS, WASTEWATER AND STORM DRAINAGE SYSTEMS
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