

# EFFECTIVE MANAGEMENT OF WASTEWATER FOR ENVIRONMENT, HEALTH AND WEALTH IN NIGERIA

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**ABSTRACT:** Improving and safeguarding wastewater management and water quality are vital for all three dimensions of sustainable development. Demand for water is growing at twice the rate of population growth. Without effective strategies to manage wastewater production, its treatment and reuse, development will be constrained and the resulting negative impacts, particularly on water-scarce economies, will arrive sooner than predicted by current approaches.

Reducing unaccounted-for-water, or making beneficial use of water which is reused or recycled, are the most readily available ways to preserve water resources and to reduce the demand on finite freshwater resources. Preventing and removing pollution is essential to maintain the renew-ability of a renewable resource. For most uses of water, quality is as important as quantity. Many water resources are rapidly degraded by poor disposal of wastewater and in some case the economic cost of treatment makes them unsuitable as a source downstream.

## INTRODUCTION

### 1.0 PREAMBLE

Any water that has been adversely affected in quality due to human activities can be regarded as wastewater (Burton and Stensel, 2003). It includes domestic liquid waste from residences, industries or agriculture. It encompasses a wide range of contaminants which can be potentially harmful or concentrations that can lead to degradation in water quality. These potential contaminants include soaps and detergents from bathrooms, food scraps and oil from kitchens and other human activities that involve the use of water. Potable water becomes wastewater after getting contaminated with all or some of the above mentioned potential contaminants.

Wastewater that comes from human waste (feces, urine or other body fluids), also known as black water, includes water from lavatories, septic tanks or soak away, and washing water; while grey water is wastewater that comes from urban rainfall runoff from roads, roofs, and sidewalks. Wastewater can be contaminated with different components which mostly include pathogens, synthetic chemicals, organic matter, nutrients, organic compounds and heavy metals. These occur either in solutions or as particulate matter.

If wastewater is not properly managed it could become a point source of pollution which could be a hazard for the health of human populations and the environment. The environmental impact of wastewater degradation may result in physical changes to receiving waters, increased level of dissolved oxygen, bioaccumulation in aquatic life, release of toxic substances and increased ground water quality (Mahmood and Maqbool, 2006). Diseases caused by bacteria, viruses and protozoa are the most common health hazards associated with untreated wastewater. Many microbial pathogens in wastewater can cause chronic diseases with long-term effects such as degenerative heart disease and stomach ulcer (Paillard et al., 2005). These debilitating ailments can be fatal and have been known to impair human productivity. Wastewater also consists of vast quantities of bacteria, most of which are harmless to man. However, pathogenic forms that cause diseases such as typhoid, dysentery and other intestinal disorder may be present in the wastewater (Absar, 2005).

### 1.1 STATEMENT OF THE PROBLEM

Wastewater – spent or used water from farms, communities, villages, homes, urban areas or industry may contain harmful dissolved or suspended matter. Unregulated discharge of wastewater undermines biological diversity, natural resilience and the capacity of the planet to provide fundamental ecosystem services, impacting both rural and urban populations and

affecting sectors from health to industry, agriculture, fisheries and tourism. In all cases, it is the poorest that are the most severely affected.

## 1.2 JUSTIFICATION OF RESEARCH

Global populations are growing rapidly, particularly so in urban areas where the rate of urbanization far outstrips planning and wastewater infrastructure development. Existing wastewater infrastructure of most cities is decaying or no longer appropriate and in slum areas there is no planning and few facilities. Management of wastewater in the urban context must be adapted according, not only to the size, but also to the economic development and governance capacity of the urban area. By working together, and cooperating across municipalities the challenges of addressing wastewater management can be met and potential benefits realized.

## 1.3 AIM OF RESEARCH

To proffer a better solution on how to effectively manage wastewater for health and public use

## 1.4 OBJECTIVES

The objectives of this research are:

- To improve the effective management of wastewater for sustainable economic development and growth.
- To mitigate the hazards of agricultural, industrial, and municipal by-products
- To provide the most promising and potentially profitable strategy for wastewater management utilizing it in processes for algae biomass production
- To stimulate the necessity for clean water and renewable energy

## 1.5 SCOPE

The research is done to proffer an effective method of managing wastewater in Nigeria to prevent environmental hazard.

## 1.6 RESEARCH METHODOLOGY

The methodologies used in this research work include:

- Collection of primary sources (sampling)
- Collection of secondary sources (published information and data from government agencies)

## 1.7 SIGNIFICANCE OF RESEARCH

Global populations are growing rapidly, particularly so in urban areas where the rate of urbanization far outstrips planning and wastewater infrastructure development. Existing wastewater infrastructure of most cities is decaying or no longer appropriate and in slum areas there is no planning and few facilities. Management of wastewater in the urban context must be adapted according, not only to the size, but also to the economic development and governance capacity of the urban area. By working together, and cooperating across municipalities the challenges of addressing wastewater management can be met and potential benefits realized.

## 1.8 CONTRIBUTION TO KNOWLEDGE

Water is an important requirement in many industrial processes, for example, heating, cooling, production, cleaning and rinsing. Overall, some 5–20 per cent of total water usage goes to industry (WWAP, 2009), and industry generates a substantial proportion of total wastewater. If unregulated, industrial wastewater has the potential to be a highly toxic source of pollution. The

vast array of complex organic compounds and heavy metals used in modern industrial processes, if released into the environment can cause both human health and environmental disasters. Industry has a corporate responsibility to take action to ensure discharged water is of an acceptable standard, and accept costs of any required clean up. The most cost-effective solutions usually focus on preventing contaminants from ever entering the wastewater stream or developing a closed system of water use. Industry can also benefit from access to cleaner water resources with fewer impurities, as impurities can add costs to the production processes.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 HISTORY OF WASTEWATER MANAGEMENT**

Throughout history, waste has been generated by humans. In areas with low population density waste generation may have been negligible. In higher population areas even largely biodegradable waste had to be dealt with. Sometimes this was released back into the ground water with environmental impact like Nor Loch. The Maya of Central America had a fixed monthly ritual, in which the people of the village would gather together and burn their rubbish in large dumps. Land application of wastewater, sludge and excreta is a widespread practice with a long tradition in many countries around the world. For centuries, farmers in China used human and animal excrements as fertilizers. Wastewater and sewage sludge, just as manure, have also been used by the northern European and Mediterranean civilizations; for instance, wastewater was reused in the 14th and 15th centuries in the Milanese Marcites and in the Valencian huertas, respectively (Soulié and Tréméa, 1991). In many European and North American cities, wastewater was disposed of in agricultural fields before the introduction of wastewater treatment technologies to prevent pollution of water bodies. In Paris, for instance, the use of partially treated wastewater was common until the second part of the 1900s (Asano et al., 2007). In developing countries like China, Mexico, Peru, Egypt, Lebanon, Morocco, India and Vietnam,

wastewater has been used as a source of crop nutrients over many decades (AATSE, 2004; Jiménez and Asano, 2008).

Therefore, agricultural use of untreated wastewater has been associated with land application and crop production for centuries (Keraita et al., 2008). However, over the years, it has become less popular in developed countries with the improvement of treatment technologies and increased awareness of the environmental and health issues associated with the practice; by contrast, in developing countries, due to a variety of factors described later, farmers use it extensively, even drawing advantages to improve their livelihoods. The oldest references to the use of excreta come from some Asian countries, where it was used to increase fish production through aquaculture (World Health Organization (WHO), 2006). Sludge management has only recently become an issue, even for developed countries, because the densely populated areas are producing such large amounts of sludge and excreta that natural assimilation into the environment is not possible, while space for stockpiling is limited (United Nations Human Settlements Programme (UNHSP), 2008). Moreover, management is complex and there is a lack of social support: people prefer to ignore what happens to excreta after it is disposed of into latrines – and they are uncomfortable if it is brought to their attention, be it in developed or developing countries (Snyman, 2008). Thus, wastewater is defined as “a combination of one or more of:

- Domestic effluent consisting of blackwater (excreta, urine and faecal sludge) and greywater (kitchen and bathing wastewater); .
- water from commercial establishments and institutions, including hospitals;
- industrial effluent, storm water and other urban run-off;
- Agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter” (Corcoran et al. 2010).

Although, using this definition, the term ‘wastewater’ clearly encompasses domestic, commercial, industrial agricultural components and also faecal sludge, these are sometimes covered separately in order to clarify or highlight the importance of the individual components or wastewater streams.

## **2.2 WASTEWATER QUALITY: THE BASIC TREATMENT PROCESSES**

Municipal sewage treatment involves the main processes (WELL, undated) illustrated below but extensive definitions are not provided here as they can be found in specific engineering texts. In addition, it is beyond the scope of this report to include discussions on lagoons and extensive treatment systems.

- Preliminary: screening and grit removal to remove coarse solid and other large materials often found in raw wastewater. It includes coarse screening and grit removal.
- Primary: sedimentation – simple settlement of solid material in a primary settling tank. Solid particles settle at the bottom, and oils and greases rise to the top. This material is removed as sludge, for separate treatment.
- Secondary: the further removal of common pollutants, usually by biological processes to remove dissolved organic material. Wastewater from primary treatment flows into an aeration tank, to which micro-organisms are added to consume the remaining organic matter. Following aeration, the mixture is clarified. The residue is removed as sludge, for separate treatment and disposal.
- Tertiary: involves the removal of specific pollutants, e.g. nitrogen or phosphorus, or specific industrial pollutants. The effluent may then be disinfected to kill harmful micro-organisms by chlorination or ultraviolet disinfection. The residual chlorine is then removed.
- Processing of solids and sludge: solids from the primary and secondary processes are sent to a digester which produces by-products including methane and water. The final residue is sent to landfills or incinerators, or used in agriculture for fertilizer or soil beneficiation.

Wastewater management should consider the sustainable management of wastewater from source to re-entry into the environment ('reuse/disposal' in the sanitation service chain) and not only concentrate on single or selected areas or segments of the service provision process. Many of today's poorly thought-out and badly managed systems (section 3) overload natural processes that purify water and maintain soil structure. It is clearly important to design wastewater management systems that "work with rather than against natural ecosystem processes" (Laugesen et al., 2010) and, thus, understanding these processes before designing infrastructure/artificial systems is fundamental for choosing a sustainable wastewater management approach. Different management approaches are required depending on whether the

area is urban or rural, the size and density of the population, level of economic development, technical capacity and system of governance in place. Approaches can also vary according to the quality required for end users or that required for safe disposal and thus “wastewater management should reflect the community and ecological needs of each downstream ecosystem and user” (Corcoran et al., 2010).

### **2.3 CENTRALISED VERSUS DECENTRALISED**

Wastewater management can be conducted through centralized systems (which are large-scale systems that gather wastewater from many users for treatment at one or few sites) or decentralized systems (typically on-site systems, dealing with wastewater from individual users or small clusters of users at the neighbourhood or small community level). Traditionally, much of the urban wastewater management in developed countries has relied on centralized systems. Industrial effluent in developed countries is generally treated on-site, although some may also be sent to centralized municipal systems following pre-treatment on-site (UNEP, 2010). The choice between centralized (sewered) or decentralized (on-site/neighbourhood-level) wastewater management systems will depend upon a number of factors, but it is important that full consideration be given to both options rather than the situation that has existed in the past where sewerage is often considered to be the only ‘proper’ form of urban sanitation (Hawkins et al., 2013). The flip side of this mindset is that on-site systems are often seen as temporary or stopgap solutions and primarily for illegal or informal settlements, which may then be reflected in local building regulations and/or technical standards which fail to specify appropriate on-site systems but are based on the assumption that new housing will be provided with networked sewerage (Peal et al. in press b). Whichever approach is preferred, there needs to be an emphasis on continued management aspects; no system has the capability to be ‘fit and forget’. There is a need for appropriately trained staff and capacity (financial, technical etc.), irrespective of wastewater management system. Traditionally the operation and maintenance of many on-site systems has been left to homeowners or local authorities, leading in many cases to system failure due to lack of, or improper, maintenance. The effectiveness of the decentralized approach could therefore be improved by an enforced regulatory framework that includes incentives and sanctions and the establishment of a management program that ensures the regular inspection and maintenance of the system (Massoud et al., 2009).



## 2.4 TREATMENT

The aim of treatment is to reduce the level of pollutants in the wastewater before reuse or disposal into the environment, the standard of treatment required will be location and use-specific. The year 2014 marks the centenary of the publication of the seminal paper on activated sludge which provided a basis to treat sewage by biological means (Ardern and Lockett, 1914). Since then there have been extensive developments in both scientific knowledge and processes to treat wastewaters of all types. There are now many aerobic, anaerobic and physicochemical processes that can treat wastewaters to almost any standard of effluent from the simple removal of gross solids to membrane systems that can produce drinking water quality. They vary from the very simple to the highly complex and each has its own characteristics in terms of efficiency, reliability, cost, affordability, energy consumption, sludge production, land requirements and so on. Treatment strategies range along a continuum from high technology, energy-intensive approaches to low-technology, low-energy, biologically and ecologically focused approaches (UN Water, 2011). Starkl et al. (2013b), for example, explored the potential of natural treatment technologies (i.e. those based on natural processes that use attenuation and buffering capacity of natural soil aquifer and plant-root systems, where the process of contaminant removal is not aided by the input of significant amounts of energy and/or chemicals) including waste stabilization ponds, duckweed and hyacinth ponds and constructed wetlands for wastewater management in India. In an examination of 12 cases they found that performance varied widely and that institutional and organizational issues were very important for sustainable system operation.

## 2.5 ADVANTAGES

Where vegetables are the main commodity produced with wastewater, there can be a significant aggregate benefit for the society in terms of a more balanced diet. In the case of Accra, for example, more than 200,000 people eat vegetables produced with wastewater every day (Amoah et al., 2007). On the other hand, this is also the group potentially at risk as the possible adverse health effects to farmers and consumers are well established (WHO, 2006). As part of the urban food-production systems, urban livestock contributes to cities' food security by providing meat and dairy products (Bonfoh et al., 2003; Wolf et al., 2003). In semi-arid countries, livestock production relies mainly on natural pasture, which is often limited or decreasing due to low

precipitation. In Sahelian countries (i.e. Burkina Faso, Mali, Senegal), forage biodiversity has decreased over time and plant species with lower nutritive value and palatability are becoming predominant (Bonfoh et al., 2003 and 2006; Food and Agriculture Organization of the United Nations (FAO), 2006; Sanon et al., 2007; Toutain et al., 2006). At the same time, however, the demand for dairy in cities is increasing with urbanization and changing diets. For example in Asian countries, the demand for dairy products is growing by a factor of 3.5 per year (Moran, 2005). Reusing wastewater or faecal sludge for fodder production appears an important and comparatively low-risk avenue which can contribute to enhancing the resilience to climate changes and food insecurity especially of small and middle-sized cities in developing countries (Koné, in press).

Another well-established advantage of wastewater and sludge reuse is their nutrient content. Even when treated, wastewater recycles organic matter and a larger diversity of nutrients than any commercial fertilizer can provide. Bio-solids, sludge and excreta in particular, provide numerous micronutrients such as cobalt, copper, iron, manganese, molybdenum and zinc, which are essential for optimal plant growth. It is estimated that 1000 cubic metres of municipal wastewater used to irrigate one hectare can contribute 16–62kg total nitrogen, 4–24kg phosphorus, 2–69kg potassium, 18–208kg calcium, 9–110kg magnesium, and 27–182kg sodium (Qadir et al., 2007). It therefore can reduce the demand for chemical fertilizers especially where the wastewater is not diluted, i.e. make crop nutrients more accessible to poor farmers. In the light of the global phosphorus crisis, excreta and wastewater can be critical sources of phosphorus (Rosemarin, 2004). On the other hand, excessive concentrations of nitrogen in wastewater can lead to over-fertilization and cause excessive vegetative growth, delayed or uneven crop maturity and reduced quality (Jiménez, 2006; Qadir et al., 2007). Excessive concentrations of some trace elements may also cause plant toxicity and sometimes become a health risk for crop consumers.

Few studies have quantified the economic gains from nutrients in wastewater under actual field conditions. In Guanajuato, Mexico, the estimated saving arising from using wastewater to supply the required nitrogen and phosphorus for crops was US\$135 per hectare (Keraita et al., 2008). A study comparing vegetable production using freshwater and untreated wastewater in Haroonabad, Pakistan, found that the gross margins were significantly higher for wastewater

(US\$150 per hectare), because farmers spent less on chemical fertilizer and achieved higher yields (van der Hoek et al., 2002).

In a cost–benefit analysis of grey water reuse systems constructed in residential schools in India, the internal and external benefits far outweighed the costs (Godfrey et al., 2009). Although studies conducted to quantify economic returns are still few and lack a uniform methodological approach, they consistently report significant gains among farmers with access to wastewater. The annual income reported in such studies performed in India, Ghana, Senegal, Kenya and Mexico varied from US\$420 to \$2800 per hectare per year (Keraita et al., 2008). According to studies in Ghana, the greatest factor influencing farmers' profits is not so much the yield obtained, but the ability to produce crops that are in high demand and low supply, at the right time, the result being that they can be consistently sold at above average prices (Cornish et al., 2001). The profitability of the business is also reflected in farmers' decisions to pay more for (especially nutrient-rich) wastewater than normal water. In the Mezquital Valley, Mexico, the availability of wastewater instead of freshwater as irrigation water caused land rents to increase from US\$170 to \$350–950 per year (Jiménez, 2005). In Quetta, Pakistan, farmers paid 2.5 times more for wastewater than for freshwater (Ensink et al., 2004).

The land application of wastewater, sludge and excreta for agricultural use constitutes a low-cost disposal method and a land-treatment system that uses the soil to attenuate contaminants. If carried out under controlled conditions, it can also be safe. Wastewater use can also recharge aquifers through infiltration or reduce the impact on surface-water bodies, as wastewater is 'treated' in the vadose before reaching them (Jiménez, 2006). Several wastewater constituents are subject to processes that remove them or significantly reduce their concentration. Reduced costs to society are also noteworthy, in view of reducing the use of fossil fuels to produce fertilizer.

## CHAPTER 3

### 3.1 METHODOLOGY

The effluents generated from domestic activities or wastewater constitutes the major sources of the natural water pollution load. This is a great burden in terms of wastewater management and can consequently lead to a point source pollution problem and could also introduce a wide range of pollutants and microbial contaminants to water sources (Eikelboom and Draaizer, 1999). This includes groundwater pollution in wells and boreholes. This has created negative environmental impacts and increased the health risk of the residents. Wastewater that is directed to the environment is the prime breeding sites for mosquitoes, houseflies, rodents, and other vectors of communicable diseases such as dysentery, diarrhea and. The two fundamental reasons why wastewater should be properly managed includes the prevention of pollution of water sources and the protection of public health by safeguarding the environment against the spread of diseases. Wastewater management is presently poorly done or even nonexistent in Nigeria and most other developing countries.

The quality of domestic wastewater effluents is one of the main causes of degradation of the receiving water bodies such as rivers, lakes, streams etc. The potential health hazards of polluted wastewater effluents on the quality of receiving water bodies are many and depend on the volume of the wastewater discharge, the microbiological and chemical concentration of the effluents. It also depends on the type of discharge, for example, the amount of suspended solids or hazardous pollutants like heavy metals or organic matter (Owuli, 2003). By extension, using the water for recreational purposes and anyone else coming into contact with the degraded water is at risk, children playing around contaminated wastewater are most vulnerable to getting infected with diseases. The impact of such degradation may result in physical changes to receiving waters, release of toxic substances, decreased levels of dissolved oxygen, increased nutrient loads and bioaccumulation in aquatic life (Environmental Canada, 1997). Several indicators have been developed to measure the relative scarcity of water (Kumar and Singh, 2005; Falkenmark and Widstrand, 1992).

A summary of two common indices is shown in Table 3.1. The Water Scarcity Index, based on per capita availability of renewable fresh surface water and groundwater, represents the potential usable water per person without regard for existing water infrastructure or economic usage. The Water Intensity Use Index expresses the amount of surface water and groundwater withdrawals as a percentage of internal actual renewable water resources available for a region. The distribution of these indices by country is illustrated in Figures 3.1(a) and 3.1(b). As of 1995, about 41 percent of the world's population, or 2 300 million people, lived in river basins under water stress (that is, having a Water Scarcity Index below 1 700 m<sup>3</sup>/capital/year)

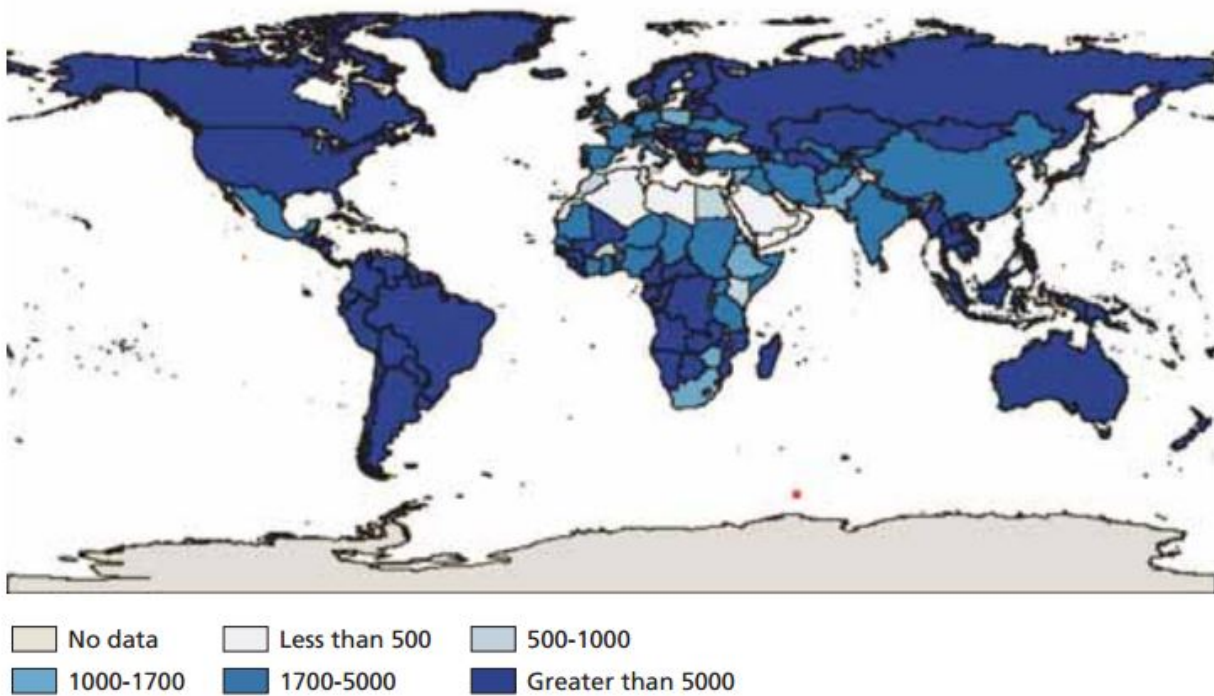
**Table 3.1-** Water scarcity index

**Threshold values used to characterise water stress within a region**

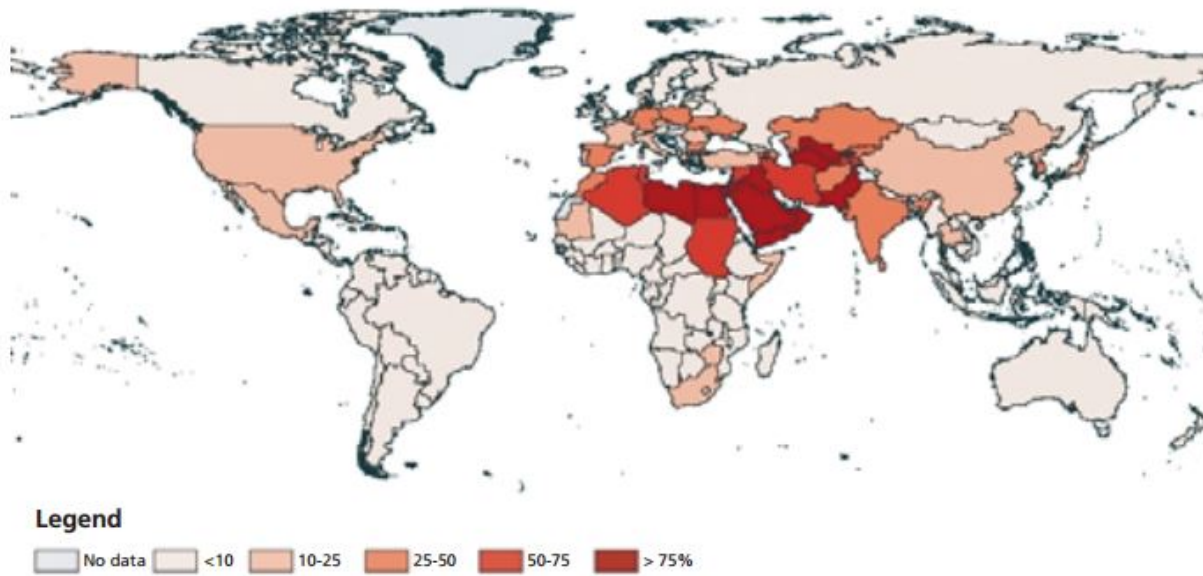
Characteristic	Threshold	Situation
<b>Water Scarcity Index, m<sup>3</sup>/ capita-yr</b>		
Water stress	<1 700	The region begins to experience water stress and the economy or human health may be harmed
Chronic water scarcity	<1 000	The region experiences frequent water supply problems, both short and long-term
Absolute water stress	<500	The region completes its water supply by desalting seawater, over-exploiting aquifers or performing unplanned water reuse
Minimum survival level	<100	Water supply for domestic and commercial uses is compromised, since the total availability is not enough to fulfil demand for all uses (municipal, agricultural and industrial)
<b>Water Intensity Use Index</b>		
Water stress	>20%	The region is experiencing severe water supply problems that are addressed by reusing wastewater (planned or not), over-exploiting aquifers (by 2-30 times), or desalinating seawater

Source: Adapted from Jiménez and Asano (2008b)

Even within countries with apparently abundant water, there are regions of scarcity or regions without the infrastructure to gain access to the available water resources. Areas of water withdrawals approaching or exceeding sustainable limits, for example, 75 percent or more of renewable water resources, are described as areas of physical water scarcity. On the other hand, economic water scarcity can occur where water resources are abundant, but deficiencies in human, institutional, or financial capital limit the access to it.



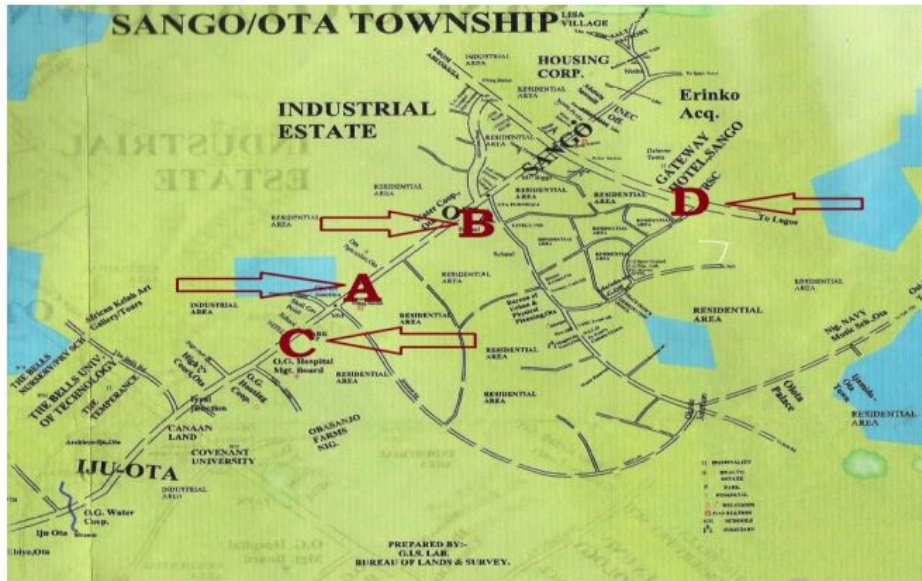
**Figure 3.1(a)** - Actual renewable water and groundwater resources per inhabitant in 2005  
(m<sup>3</sup>/year)



**Figure 3.1(b) - Water intensity use index by country (around 2001)**

The increasing release of domestic wastewater containing hazardous substances and the lack of adequate finances for treatment may likely cause an increase in the incidence of water borne diseases as well as more rapid degradation of the environment. Wastewater more often than not forms stagnant pools in the neighborhood since mostly the drainage channels are either nonexistent or blocked. Poorly drained wastewater could collect at the foot of buildings, commonly along fence lines, building frames and foundations leading to cracks and eventually collapse of the structure.





**Figure 3.2-**Water distribution in Sango/Ota Township

The most common health hazards associated with domestic wastewater includes disease caused by viruses, bacteria and protozoa that may get washed into drinking water supplies or receiving water bodies (Kris, 2007). Microbial pathogens have been identified as critical factors contributing to numerous waterborne disease outbreaks. Many of these pathogens found in domestic wastewater can cause chronic disease with long term health effects such as stomach ulcer and degenerative heart disease.

The detection and identification of the different types of microbial pathogens in domestic wastewater are always difficult, expensive and time consuming. To overcome this problem indicator organisms are commonly used to determine the risk of the possible presence of a particular pathogen in wastewater (Paillard et al., 2005). Chronic exposure toxins produced by these organisms can lead to health problems like liver damage, gastro-enteritis, skin irritation, nervous system impairment and liver cancer in animals (Eynard et al., 2000). According to Toze 1997 and Okoh et al., 2007, viruses are considered as been among the most important and

potentially most hazardous pollutants in domestic wastewater. They found out that they are generally more resistant to treatment; most infectious, more difficult to detect and require smaller doses to cause infections. Bacteria are also one of the most common microbial pollutants in domestic wastewater. They cause a wide range of infectious diseases such as dysentery, diarrhea, skin and tissue infection etc., such bacteria found in wastewater include E. Coli, Salmonella, Leptosporosis, etc. These cause mostly dysentery and typhoid fever which is very endemic in the developing world Nigeria inclusive.

### **3.2 DISADVANTAGES OF UNTREATED WASTE WATER**

Among the disadvantages of using untreated or partially treated wastewater, sludge or excreta, the most obvious are the health risks from pathogens. These have been discussed extensively elsewhere (WHO, 2006). Firstly, it should be stated that diseases are linked to the nature of the pathogen in the wastewater and thus vary locally following the local public-health pattern. Secondly, risks are not limited to farmers, but can be observed in four groups: agricultural workers and their families; crop handlers; consumers of crops or meat and milk coming from cattle grazing on polluted fields; and those living on or near the areas where wastewater, sludge or excreta is used. Within these groups the most vulnerable sections of the population are children and the elderly. Thirdly, observed responses may vary considerably between developing and developed countries. This is because pathogen distributions and concentrations, to which these groups are exposed, are very different, as are the living conditions and the level of resistance to disease between developing and developed countries (Jiménez, 2007; Jiménez and Wang, 2006). Furthermore, the statistics on food safety are unreliable because laboratory standards are so low in most developing countries.

Pathogens contaminate crops mainly via direct contact, though some cases of uptake by plants have been recorded (Hamilton et al., 2007). Beside pathogens, wastewater and sludge can also be a source of high levels of heavy metals and organic toxic compounds (Abaidoo et al., 2009; Hamilton et al., 2007). Contamination can occur, in the case of metals and some organic chemicals, through absorption from the soil, which strongly depends on the location (possible contamination sources), the environmental conditions (particularly the soil), bio-availability (in the case of some contaminants), type of plant and agricultural practices (quantity of water applied and irrigation method) (Jiménez, 2006).

There is relatively good knowledge concerning the allowable amounts of heavy metals that crops and soil can be exposed to when wastewater, sludge or bio-solids are applied to soil (Page and Chang, 1994; UNHSP, 2008; WHO, 2006). Moreover, for both developed and developing countries, the content of heavy metals in wastewater, excreta and sludge from domestic sources is generally low enough to allow their use for crop fertilization (Jiménez and Wang, 2006; UNHSP, 2008; WHO, 2006). However, there are always cases where care has to be taken, for example, close to tanneries or mining areas (Abaidoo et al., 2009).

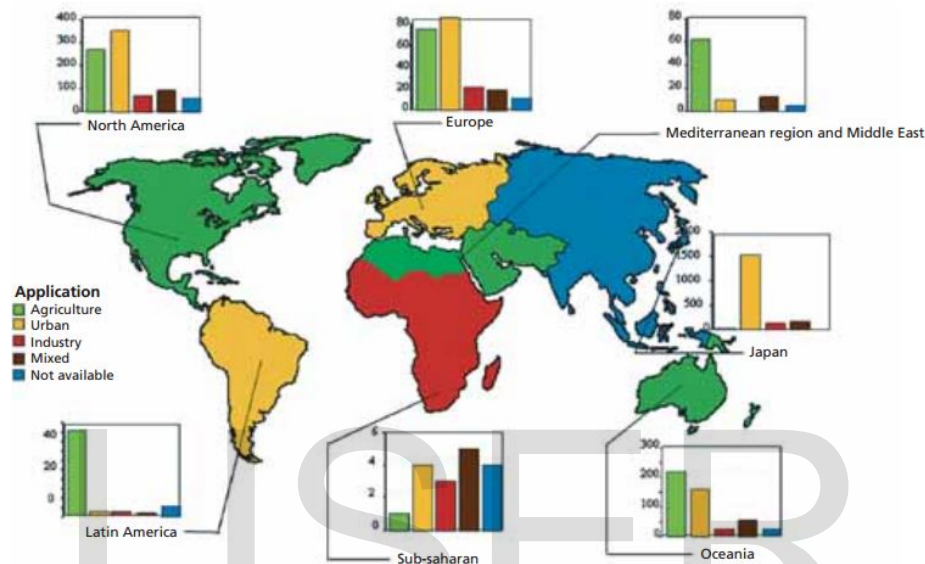
The risk from organic components derived via wastewater is in general much lower than via direct pesticide application. In comparison with pathogenic health risks, pesticide levels on vegetables, even if elevated, were considered to be of secondary importance in the context of a developing country (Amoah et al., 2006).

As described above, the use of wastewater, bio-solids and excreta implies benefits but also risks. Frequently, experts recommend simply banning this unsafe practice and 'properly' treating wastewater, sludge and excreta. Such recommendations besides being nearly impossible to

implement in most developing countries for both economic and social reasons, would also result in the removal of components from these 'waste' products that are not acting as pollutants but, conversely, are beneficial. Therefore, in practice, there has to be a trade-off between the advantages and disadvantages and the best solution for each situation should be sought, even if this is considered unconventional, especially from a developed country perspective. From a technical point of view, the solution will basically consist of finding a way to supply soils and crops with water, nutrients and organic matter. This should take advantage of the assimilation capacity of the soil, so that pathogens or heavy metals do not cause harm, while putting in place additional measures to deliver safe food to consumers. These and other alternative options for health-risk reduction are supported by the Guidelines of WHO (2006) where conventional wastewater treatment fails for whatever reason.

However, wastewater may be a more reliable year-round source of water than other sources available to farmers, though this is dependent on the primary sources of urban water also being reliable. The value of recycled water has long been recognized by farmers not only as a water resource, but also for the nutrients it contains for plant growth and soil conditioning properties. Currently, the total land irrigated with raw or partially diluted wastewater is estimated at 20 million hectares in fifty countries, which is approximately 10% of total irrigated land (FAO Wastewater Database). Recycling and reuse of wastewater can relieve pressure on water resources due to abstraction from surface water or aquifers, provided that its impact on downstream flows is manageable. Figure 3.3 shows the number of municipal water reuse schemes across different regions of the world according to field of reuse application. Applications are arranged in four main categories: agriculture, urban, industrial and mixed (multipurpose). It is estimated that, within the next 50 years, more than 40% of the world's

population will live in countries facing water stress or water scarcity. Growing competition between the agricultural and urban uses of high-quality freshwater supplies, particularly in arid, semi-arid and densely populated regions, will increase the pressure on this ever scarcer resource.



**Figure 3.3-Municipal water reuse**

The relationship between available water resources and their utilization can be established using the water scarcity index (Smakhtin et al., 2004; Kumar and Singh, 2005). When this index signals potential water scarcity, the country concerned would need to take measures to alleviate the situation, involving either or both of demand management and supply augmentation. The resources to be developed could be conventional (surface or groundwater) or non-conventional. Increasingly, the development of new conventional resources is not feasible on grounds of cost, or faces opposition from conservationists or others who prefer the status quo. On the other hand, some non-conventional resources are also questionable on grounds of sustainability problems (e.g. desalination in terms of brine disposal and high energy costs). Problems such as these increase the relative attractiveness of reclaimed water, though this has problems of its own.

Environmentalists are concerned that reuse in the upper part of basins can reduce the availability of water for ecosystems further downstream. There are also public health risks from the use of reclaimed water, and its prolonged use could impact soil salinity depending on treatment level, though it may also enhance soil fertility and organic matter content. However, there are ways of mitigating any harmful impact on agriculture, e.g. using good quality water in the initial growing period and poorer quality water later - this practice can even increase the quality of certain fruits (Oron, 1987; Hamdy, 2004). Communities reliant on direct precipitation and natural surface water supplies are at the mercy of the availability of these supplies over time and space. They are also susceptible to flooding and drought. Groundwater is less affected by short term weather conditions but is vulnerable to long-term overdraft, resulting in increased pumping costs, and salinization from seawater intrusion and long residence time in contact with minerals, and subsidence.

The growth of urbanization and irrigated agriculture weakens the bond between naturally available water supplies and the timing and geography of demands. This has necessitated an infrastructure of canals or pipes to transport water and dams to capture river flows for later release when the demands occur. In developing countries the costs of such infrastructure can be prohibitive. In developed countries, the most cost-effective locations of dams and other schemes of water development have already been taken. Further water development not only is more costly but also competes with the needs for environmental protection of water quality, fisheries, and wetlands. In some cases, limitations have been placed on historic extractions of ground and surface waters to prevent further environmental damage or to restore the sustainable yield of groundwater.

As the development of conventional surface and ground water resources become increasingly expensive and difficult, the use of nonconventional resources or demand management are receiving increasing attention. One such source, seawater desalination, remains a relatively expensive option for irrigated agriculture despite progress in membrane technology. Achieving more efficient water use amongst urban and agricultural users through the various forms of demand management has great potential and remains one of the lowest cost alternatives to align supply and demand. The use of better technology to reduce leaks in urban water distribution networks and localized irrigation can also improve the Water Intensity Use Index.

To characterize reclaimed water use as “nonconventional” is not to imply that wastewater is uncommon or unproven as an effective water supply source. Domestic wastewater has been used for centuries in agriculture, and the use of treated wastewater is at least a century old. Its nonconventional status reflects the fact that it is only in the last 30 years that the use of reclaimed water has become prominent in water resources planning. With adequate treatment, wastewater is suitable for many urban, industrial and agricultural uses. Though still not approved in many countries, reclaimed water is used for drinking in some locations, such as Namibia (Lahnsteiner and Lempert, 2007).

### **3.3 THE CASE FOR REUSING WASTEWATER**

Reusing wastewater is an important option for Integrated Water Resources Management (IWRM) which is concerned with managing all aspects of the water cycle, and with optimizing the use of water in all its aspects. The World Summit on Sustainable Development in 2002 called for all countries to develop IWRM and water efficiency plans. This approach includes the following elements, amongst others:

- assessment of water needs in collaboration with end users;
- examination of all the water sources available; and
- Matching water supplies to needs based on the quantity, quality and reliability required for the various purposes and the costs of supply relative to the benefits in each case.

The reclamation of wastewater and its reuse in agriculture is gaining wider acceptance in many parts of the world. In many water-scarce countries, wastewater has become important in bridging the demand and supply of water in different uses.

The drivers of wastewater reuse are somewhat different in developed and developing countries, but there are common problems of increasing population and food demand, water shortages, and concern about environmental pollution. All these forces make reclaimed water a potentially valuable resource. Water reuse does, however, entail changes in the traditional frameworks for water allocation, funding structures, fixing of water-quality standards, regulatory frameworks, and institutional mandates. It involves good governance at all levels in order to develop a holistic approach and sets of consistent policies for water allocation meeting multiple user needs.



## CHAPTER 4

### 4.0 ANALYSIS AND RESULTS

Wastewater is an under-utilized resource. Reuse or recycling can combine an effective environmental and health protection strategy with the recovery of water, nutrients and energy

The term “resource” is used based on the presence of certain substances which often have value in their own right. The only reason they are not reclaimed is the cost or practicality of recovery.

Domestic wastewater is a good example. It contains the nutrients required for agriculture in correct proportions. The only problem is the cross contamination with pathogens or traces of toxic chemicals. The same consideration applies to industrial wastes. Even toxic substances such as cadmium or mercury have a value. Good examples of resource recovery include the extraction of precious metals from mining wastewater and Struvite from urine.

Technologies are advancing and there are increasing examples of where resource recovery becomes financially viable.

The key to effective reuse therefore lies in minimizing the costs associated with its carriage and treatment. In some settings the use of domestic or “black water”, is constrained by the taboos associated by some cultures with the reuse of faecal material. This is sometimes related to the health aspects but also embedded in social customs and norms. These issues need to be addressed by supporting communities to overcome these fears and embrace reuse, through awareness creation and behavior change.

Ignorance of people in terms of waste collection causes environmental pollution. This can also decrease the aesthetic value of the environment. Waste bins should be allocated at different parts

of the road. Also, there should be thorough waste compaction and collection to avoid littering the environment with waste. This can cause pollution in water during rainy season as the waste is mixed with water from the rain which runoff to the drainages. Figure 4.1 shows littering of waste around the environment and Figure 4.2 shows a well compacted waste bin.



**Figure 4.1-** Littered waste



**Figure 4.2-** Well-structured waste

Wastewater should be treated properly to avoid water-borne diseases which can damage human health. Active management of wastewater can prime to a clean environment which would be good for human health and recycling of wastewater can provide income for people.

#### **4.1. UNDERSTANDING THE SCALE AND URGENCY OF THE PROBLEM IN LIGHT OF DEMOGRAPHIC CHANGES**

Wastewater production and its management and disposal remain un-quantified despite the fact that it is such a significant component of the water cycle. Understanding the importance of wastewater and its opportunities is woefully lacking in any of the current development goals.

Global changes impacting on the use of water resources are the reality and recognizing that urbanization will exert a greater impact on human activity compared to climate change, at least up until 2050, requires urgent action. Wastewater pollution has the potential to contaminate scarce water resources, thus exacerbating the problem and bringing a potential crisis to water-short economies, far sooner than currently envisaged. The inclusion of a wastewater management and pollution control target is therefore an essential component of any future water Sustainable Development Goal. Such a goal should monitor and stimulate national actions on progress towards collection, treatment, reuse and disposal of wastewaters on a collective and individual basis. The importance of minimizing the generation of wastewater, through low-volume flush toilets, water saving faucets and also through improved industrial and agricultural water-use efficiency should also be part of the strategy.

Targets should be applicable and adaptable to all countries and cover the main sources including domestic, industrial and agricultural. There is a need to set up monitoring systems at national and sub-national level to understand the problems and inform clear policy decisions on action.

#### **4.2. PROMOTE WASTEWATER COLLECTION, TREATMENT AND REUSE FROM THE RESOURCE RECOVERY PERSPECTIVE**

In order to meet the growing demand for water from the finite resources available, it is sensible to ensure the successive uses of water by different users in the same catchment. This can be done by reducing pollution and by collecting and treating used water to enable its subsequent use by others. Formalizing reuse should be a first priority above disposal, so as to conserve the available water resources. Managing water pollution and treating used water is essential to reduce freshwater abstraction and use globally.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATIONS

The negative health impacts of poor wastewater management are somewhat empirical and are not quantified to the level where they can provide meaningful economic arguments. There have been many catastrophic impacts of poor wastewater management, but by and large they are unseen or, as is often the case, occur downstream from the places where the pollution originated. In many high-density urban settings, inadequate wastewater and surface water management results in significant intra-urban differences in relation to environmental health impacts.

The impacts on health affect both on the wealthy and the poor. In many large cities, the market crops irrigated with untreated wastewater and the fish from polluted coastal sites are consumed by rich and poor alike.

Wastewater, including polluted surface water, is one of the main causes of water-borne disease. These include both communicable disease, non-communicable disease (such as those related to long-term chronic exposure to toxic substances) and vector-borne diseases.

Urbanization is one of the most critical issues governing the production and use of wastewater. It will need more attention than climate change up until 2050 (OECD, 2012). Large urban areas, but particularly unplanned smaller urban centers present the biggest threat, but also the biggest opportunity for introduction of sustainable approaches to managing resources. Understanding the process of urbanization and the patterns that exist can give a good insight to the likely impact of production and treatment. Critical to many elements of the water cycle is the juxtaposition of human settlements, agricultural and industrial activity. This implies that urban planning and the design of efficient and effective urban space needs much more attention. This includes developing

and operating systems that collect and channel used water flows and enable these to be treated to restore their potential as a resource.

There is clearly a need to consider an overarching goal for water/wastewater in development goals. Wastewater is such a key component of the water cycle and its understanding is critical to future water management strategies.

It is without doubt that a goal associated with wastewater will further unify the debate on water, sanitation, solid waste and wastewater management. However, an integrated approach is necessary, which although existing on paper, often finds very little practical application in reality. In this respect the goal must be politically attractive and inspirational and capable of being easily understood and communicated.

A specific target for managing pollution and treating wastewater is called for, but must be measurable and time-bound. In addition, it must have applicability to countries at all levels of economic development and be easily adaptable in a way that does not impact negatively on economic development. The target should not be perceived as standalone and must be coherent with other proposed development goals

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