Wastewater Treatment Analysis, Technology and Challenges in Sweden

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Abstract

Wastewater treatment is an efficient technique that increases the reclamation and reuse of wastewater for other productive uses, thereby, reducing the demand for freshwater resources, conservation of aquatic habitat, and sustainable utilization of water resources. Concerns for wastewater in Sweden began in the 1930s with only mechanical treatment but efficiently implemented in the 1960s as a result of significant eutrophication observed in open waters such as the Baltic Sea. Although prevailing wastewater treatment is fairly efficient, there is need to upgrade and improve existing treatment facilities (constructed in the 1970s) to mitigate potentially degradation of hygienic conditions due to the estimated increase in Swedish population.

Thus, this paper will critically analyse prevailing treatment of wastewater in Sweden, the technology used and possible challenges encountered in the process. Small scale treatment of wastewater particularly practiced for dwellings not connected to municipal treatment plant will be discussed including sludge management in Sweden. The report further presented the significant issues including regulations, challenges, health hazards and constraints associated with wastewater treatment and reclamation. In addition, background information relating to potential technology to meet future wastewater treatment in Sweden were highlighted because current wastewater treatment facilities were constructed in the 1970s to provide services to Swedish population at that time.

Keywords: *Water, Wastewater treatment, Grey wastewater, Sludge Management*

1. Introduction

Water is a fundamental resource that supports life forms and economic development in societies. There is approximately 1.4 billion km^3 (approximately 70%) of water existing globally with only 2.5% (3% of the total water) existing as freshwater and approximately 0.6% accessible for use, while the rest is locked up as ice in polar icecaps [1]. However, increase in population and rapid urbanization exerts significant pressure on freshwater resources thereby, subverting conservative practices and making water unfit for consumption [2; 3]. Accordingly, [4] observes that the efficiency to supplying uncontaminated water is perhaps the greatest developmental challenge of the 21st century. Thus, the treatment of wastewater has been a major challenge to societies particularly when they realized that discharging wastewater into surface waters enhances adverse impact on the environment. For instance, approximately 1 billion people in the 21st century lacks access to safe drinking water [2; 5; 6] and waterborne diseases such as diarrhoea is observed to be the second largest killer of children [7; 1]. Water related disease is further illustrated in Table 1.

CATEGORIES	DISEASE
Water borne diseases:- These are primarily spread through ingestion of water contaminated with faecal waste	-Cholera -Typhoid -Hepatitis -Giardiasis -Leptospirosis -Tularaemia
Water-washed diseases:- These are primarily infectious diseases as a result of poor personal hygiene. They depend on the quantity of water available, rather than the quality of water	-Typhoid -Cholera -Skin sepsis -Trachoma -Leprosy -Scabies -Conjunctivitis -Tinea -Ascariasis -Diarrhoeal
Water-based diseases:- These are diseases that affect people when they come in contact with dirty water harbouring disease causing organisms that have spent their life cycle inside	-Schistosomiasis -Dracunculiasis -Helminths
Water-related diseases:- Water supports the development of insect vectors by providing a favourable habitat that enhances their growth	-Dengue Trypanosomiasis -Elephantiasis -Onchocerciasis -Yellow fever -Filariasis -Malaria

Source: [8; 9]

Wastewater are liquid waste from homes, industries and public or commercial buildings channelled through drains to a treatment plants for processing. Prevailing wastewater treatment in developed nations is accomplished traditionally using biological, chemical and physical method, while the less developed economies due to the cost of maintaining sewage treatment plant discharges their wastewater directly into surface waters, degrading the aquatic ecosystem [10; 11]. Hence, sustainable management and efficient treatment of wastewater from an integrated perspective will be of immense benefit, enhancing adequate utilization of water resources.

1.1 Rationale for Wastewater Treatment

It is estimated that approximately 1.8 billion people will live in water stress regions in 2025, and approximately half of the entire population in 2050 as a result of increased demand of freshwater by a growing population especially in developing countries [12]. Accordingly, water is a finite resource and hence, the requirement to sustainably manage the supply to sustain life on earth [12; 13]. This can be achieved through efficient treatment and reuse of wastewater to lessen the impact of freshwater demand. It further contributes to adequate control of salt water intrusion and subsidence, and also enhances the replenishment of groundwater resources [14].

Conversely, although the advantages of wastewater treatment is identified, its infrastructures and associated technology remains scientifically unproven. For instance, [14] observe that wastewater treatment technology produces unevenness in water and alters nutrients and further modifies the natural hydrological and ecological systems. Similarly, wastewater treatment processes restricts nutrient recycling by enhancing the accumulation of sewage sludge, requires significant energy which in turn increases the concentration of GHG in the atmosphere, and transportation of wastewater requires considerable framework of infrastructures that distorts the hydrology of the ecosystem [4; 7; 11]. This indicates that treatment plants are major contributors to emerging contaminants in the hydrologic ecosystem if efficient technology that ensures social and economic development including environmental protection is not promoted. Nonetheless, wastewater treatment is an essential technique required to mitigate severe impact of water scarcity and pollution specifically generated from human activities, including preventing spread of disease and recycling of nutrient for other uses [6].

2. Sweden

Sweden is the third largest country in Europe with an approximated landmass of 450,000 square km and a total population of approximately 9.4 million people [15]. However, approximately 85% of the total population lives in cities with a population density of 21 people per square kilometre [15]. Stockholm (the capital city), has an average temperature of 18^0C in July and below freezing point in January and February. In addition, Sweden has significant amount of water with approximately 100,000 lakes accounting for approximately 9% of the country's total area [16]. Here, approximately 3% of the normal outflow from one of the lakes is abstracted to supply potable water to municipal areas [15].

2.1. Brief History of Wastewater Treatment in Sweden

Concerns for efficient treatment of wastewater in Sweden began in the 1930s (see Table 11 for trends in wastewater treatment in Sweden) with only mechanical treatment but efficiently implemented in the 1960s due to observed metals, chemicals and algae bloom in surface waters such as Baltic Sea as a result of high nutrient concentration [16; 17]. This led to the formation of Environmental Protection Agency (1967) and Environmental Protection Act (1969) which was later updated in 2006 to combat adverse impacts of wastewater discharge into surface water bodies with substantial emphasis on pollutant abstraction in wastewater before discharge into receiving waters [16; 11; 17]. In addition, between 1971 and 1979, the Swedish government invested approximately SEK 1.5 billion in municipal wastewater treatment plant construction and further gave allocations to industries to encourage efficient wastewater treatment practices [16; 17]. See Table 2 for trends in Swedish wastewater treatment.

Table 2: Trends in wastewater treatment in Sweden

Year	Challenges	Mitigation Strategies
From 1930	Visible pollutants	Mechanical treatment
From 1950	Reduced oxygen concentration in receiving waters	Secondary and biological treatment
From 1970	Eutrophication observed in lakes	Advanced and chemical treatment
From 1990	Eutrophication in marine environment	Extraction of phosphorus and nitrogen
Prevailing treatment and future potentials from 2010	-Reclamation and reuse of resources including phosphorus and energy -Sludge deposition containing un-desired materials	-Eco-cycling -Enforcement of Agenda 21 -Sustainable Technologies -Modified sludge handling -Increased public awareness, participation and responsibility -Development of new wastewater treatment technology

Source: [18]

2.2 Current Situation

In the 21st century, Swedish water supply and sewage disposal is primarily controlled municipally and approximately 95% wastewater treatment is accomplished using traditional biological and chemical methods with approximately 54% treated specifically to extract nitrogen and phosphorus [16; 19]. Here, approximately 2,000 water networks, 67,000km of mains, 2,000 sewage plants and 92,000km of sewers are used as infrastructure to efficiently provide water and dispose wastewater in Sweden [20]. In addition, major industries with the aid of government through the Local Investment Program for Sustainability, treat their wastewater to extract disease causing organism and chemical compounds in the plant before discharging into surface water bodies [14; 16]. Figure 1 below illustrates technological development in Sweden in relation to wastewater treatment in urban areas from 1940 to 2005.

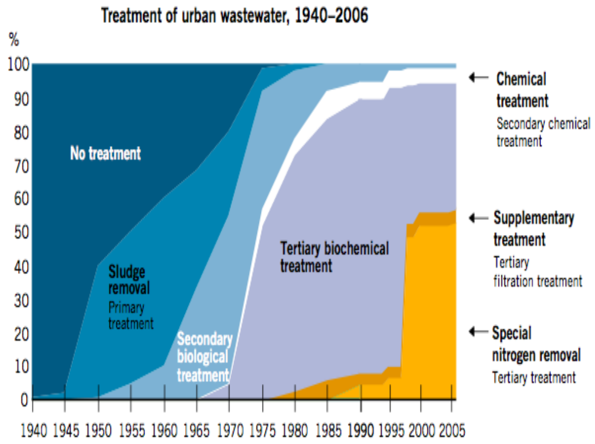

Fig 1: Treatment on urban wastewater in Sweden
Source: [16]

Efficient wastewater treatment in Sweden mitigates threat to the natural environment and human health by ensuring adequate disposal of sewage discharge from homes and effluent from industries [14; 21]. Accordingly, the Swedish national environmental objectives to wastewater treatment includes zero eutrophication, flourishing lakes and streams and good quality groundwater, and to recover 60% of phosphoric compounds from wastewater for other productive use by 2015 [16; 17].

2.3 Wastewater Treatment Legislations in Sweden

Sweden had efficient objectives regarding water quality before joining the European Union in 1995 and successfully incorporated EU water laws to consolidate prevailing water legislations [16]. For instance, the integration of Urban Waste Water Treatment Directive (1991) and the Water Framework Directive (2000) into Swedish regulations helps in combating environmental deterioration due to untreated wastewater discharge from cities and industrial activities. Swedish regulations governing wastewater discharge before and after joining the EU in 1995 is illustrated in Table 3 below

Table 3: Wastewater discharge regulations in Sweden

YEAR	REGULATIONS
Early 1940’s	Water Act was introduce to regulate discharge into the environment
1956	Swedish Water Inspectorate, formed to supervise lakes and other water areas
1969	Environmental Protection Act was enacted to regulated the disturbance and deterioration of outdoor environment including water
1995	Sweden joined EU and adopted the EU Urban Wastewater Treatment Directive
1999	Swedish Environmental Code was enacted to further regulated the disturbance and deterioration of outdoor environment including water
2000	Water Framework Directive was adopted
2008	The Marine Strategic Framework Directive was adopted to control discharge of wastewater into marine environment

2.4 Grey Wastewater Recycling and Reuse in Sweden

The reuse of grey wastewater has been practiced in many countries as a result of water scarcity, environmental sustainability, economic considerations and increased freshwater demands [23; 24]. The composition of water for different activities in a typical Swedish household is presented in Figure 2 below.

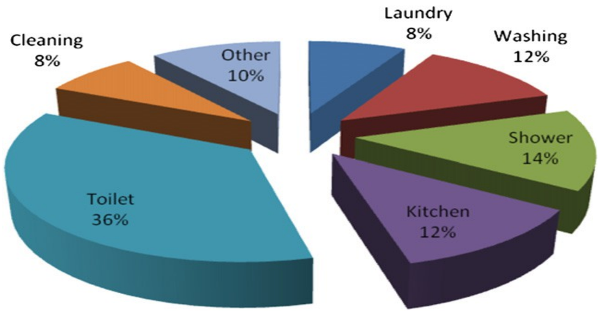

Figure 2: Water composition for different activities
Source: [25; 26]

However, grey wastewater is defined as wastewater obtained from showers, bathtubs, wash hand basins, and laundry machines accounting for approximately 75% of residential wastewater [23; 27]. In fact, grey water recycling contributes to approximately 43% savings of freshwater resources and reduces the adverse effect of environmental pollution [23; 24; 27]. Grey wastewater generally contains low organic matter and pathogens depending on the sources and quality of water supply and the lifestyle of the household, signifying that a considerable proportion of the pollutants are dissolved [24; 27; 28]. A typical composition of grey wastewater is presented in Table 4 below.

Table 4: Composition of grey wastewater

Sources	BOD (mg/l)	COD (mg/l)	Turbidity (NTU)	NH_3 (mg/l)	P (mg/l)	Total Coliforms
Hand basin	109	263	-	9.6[a]	2.58	-
Combined	121	371	69	1	0.36	-
Synthetic greywater	181	-	25	0.9	-	$1.5X10^6$
Single person	110	256	14	-	-	-
Single family	-	-	76.5	0.74	9.3	-
Block of flats	33	40	20	10	0.4	$1X10^6$

College	80	146	59	10	-	-
Large college	96	168	57	0.8	2.4	$5.2X10^6$

Source: [27]

2.5 Treatment Of Grey Water In Sweden

Various treatment alternatives have been established in Sweden primarily in small-scale. According to [27], the treatment and recycling of grey wastewater should enhance hygienic safety, environmental tolerance, aesthetics and technical economic feasibility. Thus, various approaches to grey water treatment in Sweden are illustrated in Table 5 below.

Table 5: Commonly used treatment processes of grey water in Sweden

PROCESSES	DESCRIPTION
SETTLING TANKS	Grey water is mechanically treated in settling tanks and larger solid particle settles to the bottom of the tank due to gravitational force. Pathogens attached to these particles are extracted. To extract phosphorus, precipitation chemicals are added to the wastewater and this further reduces approximately 93-99.6% of microorganism especially indicator organism
INFILTRATION UNITS	The conventional process of treating grey water in Sweden is by infiltrating the wastewater after the particles have settled to the bottom of the tanks. The extracted effluent is then distributed uniformly across a subsurface disposal system and sand filter with approximately 60-150cm of sands in a bed is used to further improve the quality of the water. A minimum of 3m of unsaturated soil underneath the disposal system and two months retention period is suitable to efficiently extract pathogens and organic materials from the water wells
ACTIVATED SLUDGE	This involves the introduction of microorganisms to feed on organic matter to reduce the BOD and COD substances present in the wastewater. Pathogens are reduced as a result of competition, digestion and sedimentation. Approximately 53-98% reduction of various microorganisms is achieved in Swedish treatment plants using activated sludge treatment process as observed in Vibyasen treatment plant
MEMBRANES	Semipermeable membrane and osmotic process are used to convey water as permeate across the membrane with captured dissolves solids as concentrate. Membranes, usually produced from organic polymers include ultrafiltration, microfiltration, nano filtration, and reverse osmosis, with varying size retention capacity. However, membrane bioreactors utilizes less energy, requires less space, adequately controls microorganism and organic material in the fluid process, and enhance improved quality of water. Conversely, the filter causes material build-up and impedes the flow of fluid across the membrane.
SAND FILTER TRENCHES, BIOFILTERS AND CONSTRUCTED WETLAND	Sand filter trenches, bio filters and constructed wetlands are used to treat and improve the quality of wastewater obtained from infiltration unit. Preliminary treatment in a bio filter aerates the wastewater and lessens the concentration of bacteria and BOD to obtain significant loading rate for further wetland or infiltration system
PONDS	Ponds are further grey water treatment method that enhances improved water quality after other

	types of treatment in Sweden. It reduces pathogens based on system design, time of retention and dilution, where bacteria and protozoa settles easily than viruses. Conversely, Swedish climate does not support pond treatment. In Kalmar treatment plant for instance, wastewater is treated in three connected ponds with an approximated retention time of one year including summer period. Vibyasen treatment pond is observed to reduce somatic coliphages and E. coli by 1.2 and 3.0 log respectively
DISINFECTION	Disinfection extracts various pathogens in wastewater and the commonly used method in Sweden is ultraviolet disinfection mainly used in wastewater streams with minor concentration of pathogens to enhance water reuse. For instance in Ekoporten and Norrkoping UV treatment plant, the Aquatron divides the fluid from the solid particles through centrifugal force and conveys the fluid to grey water treatment stream after UV disinfection

2.6 Funding Of Municipal Wastewater Treatment In Sweden

Municipal wastewater plants are publicly owned facilities by the local authorities, but its funding is primarily achieved through consumer charges and connection fees for water services. The charges, however, varies across the country. For instance in 2001, the charge for connection fee was between SEK20,000 and SEK137,500 and approximately 90% of local authorities charge between SEK40,000 and SEK100,000.

3. Wastewater Treatment In Sweden

Municipal wastewater treatment in Sweden undergoes mechanical treatment and approximately 95% are biologically or chemical treated to extract nitrogen and phosphorus [16]. Swedish nitrogen and phosphorus discharge tonnes in 2006 is illustrated in Figure 3 below.

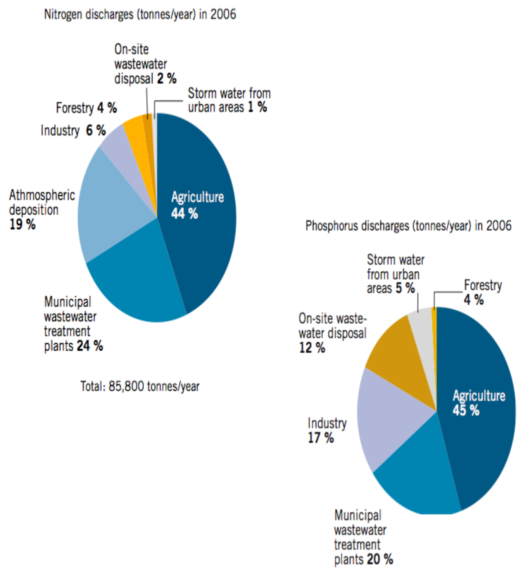

Fig 3: Nitrogen and phosphorus discharge tonnes in 2006 Source: [16]

However, the most common wastewater treatment and combinations in Swedish treatment plants are listed below.

i. Mechanical treatment
ii. Chemical treatment
iii. Biological treatment
iv. Nitrogen removal
v. Filtration

3.1 Mechanical Treatment

This stage involves the extraction of suspended solid particles such as grit (stones, sands, and gravel), piece of wood, paper, hair, textile, and plastics in the wastewater achieved through the use of screening, sand catchers and pre-sedimentation [16]. Here, wastewater is channelled through a bar screen to extract rags, and course debris, to avoid potential hitch in other treatment procedure [29]. The sand catcher (a basin-like chamber with a pocket) accumulates grit and other particles with significant weight, which are readily submerged to the bottom [24]. The submerged particles, however, will be extracted with pumps and the solid particles conveyed to landfill site [16]. Accordingly, escaped particles from screening or sand catcher are further extracted during pre-sedimentation. Here, particles with great weight falls to the bottom and scrappers collects and transport them to sludge pocket for further treatment [30].

3.2 Chemical Treatment

This is an essential component of wastewater treatment system in Sweden, involving the extraction of phosphorus from wastewater [16]. This is achieved through the addition of precipitating chemicals to the wastewater usually iron, aluminium or lime to enhance the precipitation of the dissolved phosphorus. Typical examples of plants where phosphorus treatment are carried out include the Kappala plants in Lidingo, Stockholm and Savsjo. This, however, leads to the generation of excessive sludge which will be further separated through sedimentation. Normally, this process extracts approximately 90% of phosphorus [16].

3.3 Biological Treatment

This involves the introduction of microbes to feed on organic substances in the wastewater after mechanical treatment to reduce its BOD content [16]. Through this procedure, approximately 90% of the organic materials dissolved in the wastewater will be removed. Thus, the major aim of biological treatment in Sweden is to reduce BOD content in the wastewater. Here, the organic materials are converted to cellular mass through metabolic process by the bacteria, and precipitated at the basement of the settling tanks or preserved as fungus on solid surface or vegetation in the system. Similarly, the microorganism consumes approximately 20% of nitrogen when feeding on the organic material, and further undergoes flocculation and separated in the sedimentation basins [16]. This is commonly known as activated sludge process.

3.4 Nitrogen Removal

This stage involves the extraction of nitrogen through biological oxidation from ammonia to nitrate (nitrification), and subsequently followed by the conversion of nitrate to nitrogen gas by denitrifying bacteria. The process of nitrogen extraction is relatively complicated and is commonly carried out in the large treatment plants before releasing into sensitive recipients. Here, the conveyance of the wastewater between different basins without or without O_2, enhances a conducive environment that supports diverse microorganisms. Thus, approximately 50-75% of nitrogen is expected to be extracted [16].

3.5 Filtration

This stage involves the extraction of residual suspended matter and sludge that were not earlier extracted in the sedimentary basins [16]. However, this is the final stage of wastewater treatment performed to enhanced adequate purification of treatment plants with rigorous specification. Furthermore, the stages of wastewater treatment in Sweden are further illustrated in Figure 4 below.

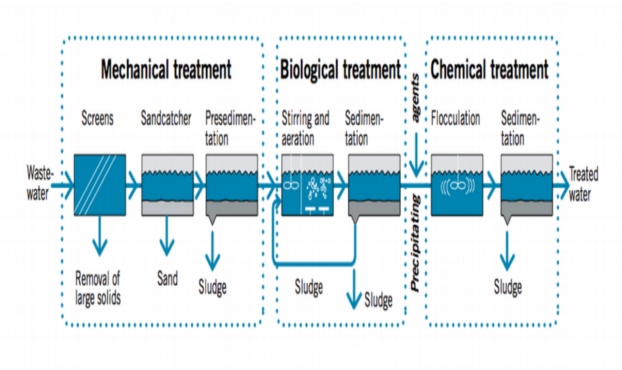

Fig 4: Stages of wastewater treatment Sweden
Source: [16]

4. Small Scale Wastewater Treatment And Sludge Management In Sweden

Approximately 0.5 household that are not connected to the sewage network treat their wastewater primarily through sludge separation. However, 50-60% of the dwellings are observed to treat wastewater contrary to the standards or requirement of Swedish Environmental Code for wastewater purification. Here, the conventional system apart from separation of sludge includes infiltration system, sub-soil filters and micro-treatment plants. Similarly, there are other systems although they are observed to treat wastewater below the acceptable standards. These include soak away, sand filter trenches, and resorption plants.

Furthermore, the sludge separation enhances a reduction in suspended solid particles, BOD and nitrogen through the diversion of urine if combined with sub-soil filter and local grey and black water treatment. Accordingly, micro-treatment plants efficiently extracts BOD, phosphorus and suspended solids materials if regularly monitored and managed by a competent personnel. On the other hand, the sub-soil filters and chemical precipitation systems are better alternate with regards to phosphorus and BOD extraction and are efficient structures for the removal of sludge and replenishment of required chemical for precipitation [16].

4.1 Sludge Management

Sludge generated at small treatment plants are usually conveyed to larger plants for dewatering and stabilization [31]. Generally, it is estimated that municipal wastewater treatment plants generates approximately 1 million m^3 dewatered sludge including dry solid content of approximately 180,000 tonnes. Furthermore, sludge is stabilised through anaerobic digestion (70%, usually in large treatment plants), aerobic digestion (3%), and composting (6%) [31]. See Appendix 6 and 7 for sludge disposal and treatment in Sweden.

Sludge with heavy metals are treated and conveyed to an intermediary deposition site of directly to landfill, while sludge obtained from domestic wastewater is treated and conveyed for usage in agricultural land to support the plant growth (;). Here, phosphorus in sewage sludge can act as fertilizers to fields or farmland, thereby forming part of the natural system, enhancing cost savings to farmers and a sustainable environment in general [16]. However, there can be significant eutrophication in seas, lakes and streams, if the sludge is not efficiently treated. Swedish treatment plants for instance, are constructed to extract and confined nutrient from the water phase in the sludge [32].

4.2 Potential Future Technology To Meet Wastewater Treatment In Sweden

Swedish wastewater treatment plants were constructed in the 1970s and approximately 70,000km sewage pipes and sand treatment plants were constructed [33]. Currently, wastewater from approximately 90% of the total Swedish population is treated centrally with the same designs [33]. Thus, these plants require improvement to meet prevailing specifications for phosphorus and bacteria discharge due to the new standards and increase in population connected to each plant. The target with regards to future wastewater treatment technology is to prevent the spread of disease by efficiently reducing nutrients and pollutants discharged into surface waters, and further recycles the nutrient for application in agricultural lands and this is famously expressed in Swedish Vision 2030 [34].

Furthermore, the Swedish Institute for Infectious Disease Control, the National Board of Health and Welfare, and the Swedish Environmental Protection Agency jointly presented a report stressing the need to enforce the polluter pay principle, and the requirement for Best Available Technology (BAT) to mitigate the rapid degradation of good hygienic conditions in Sweden [33; 34]. The BAT is estimated to enhance a reduction of approximately 90% phosphorus, 95% BOD, and in coastal areas, 50% nitrogen [33]. The technology is estimated to reach it goals in 2030, by decentralising wastewater treatment plant facility to efficiently treat and reduce domestic wastewater nutrient discharged into open waters [34]. In addition, new wastewater treatment technologies are currently being constructed in places such as Vadsbro, Stockholm and Norra Djurgardsstaden to allow efficient utilization of storm water for uses such as flushing of toilets and urinal, irrigation of green space and agricultural lands, and non-potable domestic needs to lessen the demand of freshwater resource in the country [35]. This technology is further estimated to control flooding by reducing storm water runoff which also pollutes surface waters.

Furthermore, Vision 2030 professes installation of water saving device in buildings to measure and reduce the consumption of water to 100 litres per person per day from the current 150 litre, and this will reduce the level of wastewater generated [36]. Adequate awareness has also been professed in Swedish environmental goals to educate Swedish citizens on the benefits of a healthy living conditions achieved from generating less wastewater because significant resources are used in treatment which may lead to other vulnerabilities [16; 36]. In addition, Sweden's target by 2030 is to have a functioning source separation facility in buildings for adequate separation of grey wastewater from black water to enhance a sustainable treatment procedure and Stockholm will construct a biogas plant to produce biogas from faecal waste [37]. Currently, Sweden generates approximately 600 GWh/year of biogas from wastewater treatment and could increase this figure to approximately 770-1000 GWh/year [37].

5. Conclusion

Water, a finite resource is fundamental to all life forms and economic development in societies. Increase in population and rapid urbanization however, exerts significant pressure on the available freshwater resources, leading to pollution which in turn enhances adverse impact on aquatic organisms, humans and the general environment. Such impacts include eutrophication of surface waters, pollution of groundwater, and high risk of water related disease observed when the contaminated water is consumed by man. Thus, sustainable management and efficient treatment of wastewater will be of immense benefit to mitigate the severe impact of water scarcity and pollution and enhancing sustainable utilization of water resources in societies.

References

[1] Human Development Report. (2006). Beyond Scarcity: Power, Poverty, and the Global Water Crisis. Retrieved May, 13, 2012, from http://hdr.undp.org/en/media/HDR06-complete.pdf.

[2] Hoffman, S. (2009). Planet water: Investing in the world's most valuable resource. Hoboken: John Wiley & Sons, Inc.

[3] Tarum, P. K., Chen, V. C., Corley, H. W. & Jiang, F. (2011). Optimizing selection of technologies in a multiple stage, multiple objective wastewater treatment system. Journal of Multiple-Criteria Decision Making Analysis, 48(2), 115-142.

[4] Spellman, F. R. (2009). Handbook of water and wastewater treatment operations. (2nd ed.). London: CRC Press.

[5] United Nations Children's Fund and World Health Organisation. (2012). Progress on Drinking Water and Sanitation. Retrieved May, 13, 2012, from http://www.designews.com/clients/Unicef/JMPreport_final.pdf.

[6] Vassallo, P., Paoli, C. & Fabiano, M. (2009). Emergy required for the complete treatment of municipal wastewater. Ecological Engineering, 35(5), 687-694.

[7] de Anda, J. & Shear, H. (2008). Challenges facing municipal wastewater treatment in Mexico. Public Works Management and Policy, 12(4), 590-598.

[8] Maksimovi, C. & Tajada-Guibert, J. A. (2001). Frontiers in urban water management: Deadlock or hope. Cornwall: IWA Publishing.

[9] World Health Organisation. (2001). Water quality: Guidelines, standards and health. Assessment of risk management for water related infectious diseases. Cornwall: IWA Publishing.

[10] Esquivel, K., Rodrigues, F. J., Arriaga, L. G., Camps, E., Duran-Mureno, A. & Luis, A. (2011). Photoelectrocatalytic wastewater treatment using TiO2/ITO bilayers prepared on optical fibers by pulsed lazer deposit. Journal of Environmental Engineering, 137(5), 355-362.

[11] Tomar, P. & Suthar, S. (2011). Urban wastewater treatment using semi-biofiltration system. Desalination, 282(1), 95-103.

[12] United Nations. (2011). Drylands: A UN System-Wide Response. Retrieved June, 4, 2012, from http://www.unemg.org/Portal/MG/LAND/report/Global_Drylands_Full_Report.pdf.

[13] Organisation for Economic Co-operation and Development. (2011). Benefits of Investing in Water and Sanitation: A OECD perspective. OECD Publishing http://dx.doi.org/10.1787/9789264100817-en.

[14] Muga, H. E. & Milhelcic, J. R. (2008). Sustainability of wastewater treatment technologies. Journal of Environmental Management, 88(8), 437-447.

[15] The Swedish Water and Wastewater Association. (2000). Facts on Water Supply and Sanitation in Sweden. Retrieved June, 7, 2012, from http://www.svensktvatten.se/Documents/kategorier.OmSvensktVatten/FactsonWaterSupplyandSanitationinSweden(English).pdf.

[16] Swedish Environmental Protection Agency. (2009). Wastewater treatment in Sweden. Retrieved May, 15, 2012, from http://www.naturvardsverket.se/Documents/publikationer/978-91-620-8416-5.pdf.

[17] Weiss, P., Eveborn, D., Karrman, E. & Gustafsson, J. P. (2008). Environmental system analysis of four on-site wastewater treatment options. Resource, Conservation, and Recycling, 52(10), 1153-1161.

[18] Plaza, E. & Trela, J. (2010). Present and future directions in Swedish research on wastewater handling. Retrieved June, 19, 2012, from http://www2.lwr.kth.se/forskningsprojekt/Publishproject/rep15/Plaza_Trela.pdf.

[19] Diggelman, C. & Ham, R. K. (2003). Household food waste to wastewater of solid waste? That is the question. Waste Management and Research, 21(6), 501-514.

[20] Paxeus, N. (1996). Organic pollutant in the effluents of large wastewater treatment plants in Sweden. Water Resource, 30(5), 1115-1122.

[21] Rodrigues-Garcia, G., Molinos-Senante, M., Hospido, A., Hernandez-Sancho, F., Moreira, M. T. & Feijoo, G. (2011). Environmental and economic profile of six typologies of wastewater treatment plants. Water Research, 45, 5997-6010.

[22] World Bank Institute. (2009). Improving Transparency, Integrity, and Accountability in Water

Supply and Sanitation. Retrieved May, 14, 2012, from http://www.oecd.org/dataoecd/1/49/44475062.pdf.

[23] Eriksson, E., Auffarth, K., Henze, M. & Ledin, A. (2002). Characteristic of grey wastewater. Urban Water, 4(1), 85-104.

[24] Revitt, D. M., Eriksson, E. & Donner, E. (2011). The implication of household greywater treatment and reuse of municipal wastewater flows and micropollutants loads. Water Research, 45(4), 1549-1560.

[25] Mourad, K. A., Berndtsson, J. C. & Berndtsson, C. (2011). Potential freshwater saving using greywater in toilet flushing in Syria. Journal of Environmental Management, 92(10), 2447-2453.

[26] Villarreal, E. L. & Dixon, A. (2005). Analysis of rainwater collection system for domestic supply in Ringdansen, Norrkoping, Sweden. Building and Environment, 40(3), 1174-1184.

[27] Al-Joyyousi, O. (2003). Greywater reuse: Towards sustainable water management. Desalination, 15(3), 181-192.

[28] Gunther, F. (2000). Wastewater water treatment by greywater separation: Outline for biologically based greywater purification plant in Sweden. Ecological Engineering, 15(2), 139-146.

[29] Official Publication of European Water Association. (2007). Water Reuse in Europe. Retrieved June, 19, 2012, from http://www.ewaonline.de/journal/2007_07.pdf.

[30] Eriksson, E., Andersen, H. R., Madsen, T. S. & Ledin, A. (2011). Greywater pollution variability and loadings. Ecological Engineering, 35(5), 661-669.

[31] Hultman, B. (2003). Trends in Swedish sludge handling. Retrieved June, 19, 2012, http://www2.lwr.kth.se/forskningsprojekt/Polishproject/JPS5s13.pdf.

[32] Jeppsson, U. (1996). Modelling Aspect of Wastewater Treatment Process. Retrieved June, 17, 2012, from http://www.iea.ith.se/publications/Theses/LTH-IEA-1010.pdf.

[33] SwedEnviro Report. (1999). Water Treatment in a Small Village: Options for Upgrading. Retrieved June, 19, 2012, from http://www.ccb.se/documents/WastewaterTreatmentSmallVillage-OptionsforUpgrading.pdf.

[34] European Union. (2007). Decentralised Wastewater Treatment. Retrieved June, 17, 2012, from http://spin-project.eu/downloads/2_SPIN_Project_waterbarrierefreireduced.pdf.

[35] European Spatial Development and Planning Network Intensive Programme. (2011). Assuring an Economic Viable Project for all the Stakeholders at Norra Djurgardsstaden. Retrieved June, 17, 2012 from http://esdp-network.eu/attachment/File/IP-2011/Students_reports/Report_EconSust1.pdf.

[36] Strategic Research Agenda. (2006). Water Research- A necessary Investment in our Common Future. Retrieved June, 16, 2012, from http://www.wsstp.eu/publisher/system/component_view.asp?LogDocId=732.

[37] Tjus, K. & Fortkamp, U. (2011). Bioenergy in Sweden 2010-2020: A Review of Amounts, Future Trends and Research. Retrieved June, 17, 2012, from http://spin-project.eu/downloads/o_SPINRootsibiogassitac=ustapaberveerbruar2011.pdf.