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Importance of Wastewater Management in Urban Areas

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Abstract— **At the beginning of the 21st century, the world faces a water quality crisis resulting from continuous population growth, urbanization, land use change, industrialization, food production practices, increased living standards and poor water use practices and wastewater management strategies. Wastewater management (or the lack thereof) has a direct impact on the biological diversity of aquatic ecosystems, disrupting the fundamental integrity of our life support systems, on which a wide range of sectors, from urban development to food production and industry, depend. It is essential that wastewater management be considered as part of an integrated, full life cycle, eco-system-based management system that operates across all three dimensions of sustainable development (social, economic and environmental), geographical borders, and includes both freshwater and marine waters.**
This study deals with the basic concepts of wastewater management; Case studies on different sustainable methods adopted in wastewater management such as the NEWater Technology in Singapore, Activated sludge method with waste stabilization pond in Avadi- Chennai and the sewage fed system which is an ecological sanitation approach of wastewater management in Kolkata; Comparing the three case studies, also compares the effluent standards of generated sewage in three case studies with the global and national sewage effluent limits and finally certain recommendations are suggested for developing a sustainable approach of wastewater management. From all these we can conclude that the sustainable approach will be the future of wastewater management systems that can efficiently use the wastewater generated and also promotes reuse and recycling of the wastewater, considering wastewater not as a burden but as a resource.

Keywords— **Effluent standards, Wastewater as a resource, Reuse**

I. INTRODUCTION

The world is facing a global water quality crisis. The continuing population growth and urbanization, rapid industrialisation, and expanding and intensifying food production are all putting pressure on water resources and increasing the unregulated or illegal discharge of contaminated water within and beyond national borders. This presents a global threat to human health and wellbeing, with both immediate and long-term consequences for efforts to reduce poverty whilst sustaining the integrity of some of our most productive ecosystems. There are many causes driving this crisis, but it is clear that freshwater and coastal ecosystems across the globe, upon which humanity has depended for millennia, are increasingly threatened. It is equally clear that future demands for water cannot be met unless wastewater management is revolutionized.

II. UNDERSTANDING DEFINITIONS

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[1].

Wastewater 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, stormwater and other urban run-off; agricultural, horticultural matter and aquaculture effluent, either dissolved or as suspended matter. (adapted from Raschid-Sally and Jayakody, 2008) [2].

Wastewater management is the process of taking wastewater and treating/managing it in order to reduce the contaminants to acceptable levels so as to be safe for discharge into the environment. There are effectively two basic types of wastewater treatment: centralised and decentralised. Centralized systems are large-scale systems that gather wastewater from many users for treatment at one or a number of sites, whereas decentralized systems are dealing with wastewater from individual users, or small clusters of users, at the neighbourhood or small community level.

III. NEGATIVE IMPACTS OF WATER POLLUTION

Dumping waste into water bodies can cause a multitude of problems. The impact of a specific type of waste depends on the attributes of the waste and receiving water body. Some of the few ways that water pollution can affect a community and the environment are mentioned below [3].

A. Biological Oxygen Demand (BOD)

In any water body that contains biological waste, a biochemical oxygen demand (BOD) exists (Defra, 2009). BOD is a measure of the amount of oxygen used by aerobic microorganisms when breaking down organic material. When the BOD is high enough, it can reduce the biologically available oxygen (BAO) to the point that the level of dissolved oxygen in the water cans no longer support aquatic life (Hooda, 2000).

B. Nitrogen and Phosphorous

Water contaminants can increase the nitrogen and phosphorous levels in water. High nitrate and phosphate levels can lead to increased algae growth and increased oxygen consumption, reducing the BAO in the water (Gonzalez, 1996; Hill, 1991). Excessive algae growth can cause algal blooms, which consume dissolved oxygen and block sunlight from reaching the bottom of the pond, river, or lake. This process is eutrophication, where excess nitrates and phosphorous in the ecosystem lead to an increase of algae growth reducing the BAO and killing aquatic organisms.

C. pH

Water that contains many contaminants may have its pH value altered. Extreme high or low pH values can cause damage to aquatic life and increase the toxicity of some pollutants, such as ammonium-N (Morrison, Fatoki, Persson, & Ekberg, 2001; Holmes, 1996). Ammonium-N is common in surface runoff and sewage. In basic water, ammonium-N breaks down into ammonia, which is extremely toxic to aquatic life in high concentrations. Acidic water can decrease the solubility of some elements that are essential for cellular function in animals such as selenium. It can also increase the solubility of toxic heavy metals such as cadmium and mercury that can cause reduced growth and development of children, cancer, and organ damage [4].

D. Turbidity

Wastewater that contains insoluble materials will introduce turbidity to the water body. Turbidity is a measure of the haziness of the water caused by the number of suspended solid particles in the water (Gonzalez, 1996). If water has high turbidity levels, the particles in the water can block sunlight and affect organisms living on the bottom of the river, lake or ocean. The lack of sunlight can cause plants and algae to die and remove a food source for fish and other animals higher on the food chain.

E. Pathogens

Most commonly, pathogens that are ingested from wastewater are bacteria, viruses, protozoa and helminthes (WHO, 1989; Ewemeje, 2014). Depending on the type of pathogen, an infection can be caused by as little as a singular organism entering the body. Wastewater from human wastes often contains bacteria such as E. coli, Listeria, Salmonella, Leptospirosis, Biyrio, and Campylobacter that cause infections such as diarrhea, dysentery, or skin and tissue infections. Ingestion of wastewater can also cause many microbial intestinal infections including cholera, typhoid fever and bacillary dysentery. Viruses are also often found in human wastes, and pose a risk of infection even though they cannot multiply without a host. Microbial pathogens have been found to cause chronic diseases such as degenerative heart disease and stomach ulcers. Helminthes can also be passed through untreated wastewater and include organisms such as roundworms, tapeworms and pinworms.

F. Reduced quality of Life

Polluted water areas contribute to a lower quality of life. On the Chesapeake Bay, for example, real estate values increased in areas with decreased levels of water pollution (Leggett, 2000). Areas that had higher water pollution had a corresponding drop in property values, indicating that areas that suffer from water pollution are less pleasant and desired locations to live. Polluted areas may suffer from unpleasant odors, murky water, algal blooms, and death of aquatic life, among other negative impacts. (ADB, May 2006)

IV. SEWAGE EFFLUENT DISCHARGE LIMITS

In the Global and National level, the concerned authorities have permitted certain scale up to which a sewage can discharged into the water bodies. The Global effluent limits and the national effluent limits specified the guideline limit for parameters such as pH, total suspended solids, Biological oxygen demand (BOD) and Chemical Oxygen demand (COD). The Global effluent Guideline limit and Sewage effluent discharge standard in India of each parameter is show in Table 1 and Table 2 [5].

Table 1 Global effluent standards of sewage generation

Traditional Parameters	Guideline Limit
pH	6.00 – 9.00
Temperature	≤ 37 °C
Total Suspended Solids (TSS)	≤ 30 mg/l
5-day Biological Oxygen Demand (BOD5)	≤ 30 mg/l
Chemical Oxygen Demand (COD)	Test required; limit currently not established.
Color	Offensive color not acceptable (visual observation); test required; limit currently not established. Test required using one of the following methods: (1) method producing results in ADMI units or (2) using spectrophotometry, measuring transmission at wavelengths 436 nm, 525 nm and 620 nm.

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Table 2 Effluent discharge limits in India

PARAMETERS	LOCATION	CONCENTRATION NOT TO EXCEED
pH	Anywhere in the country	6.5- 9
BOD	Metro Cities*, all State Capitals except in State of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Union territory of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and Lakshadweep .	20 mg/ l
	Areas/regions other than mentioned above	30 mg/ l
COD	Anywhere in the country	250 mg/ l

It is estimated that about 38,254 million litres per day (mld) of wastewater is generated in urban centres comprising Class I cities and Class II towns having population of more than 50,000 (accounting for more than 70 per cent of the total urban population). It is expected that, Gross wastewater generation (mld) by 2051 in India will reach to 120000 mld.

V. WASTEWATER AS A RESOURCE

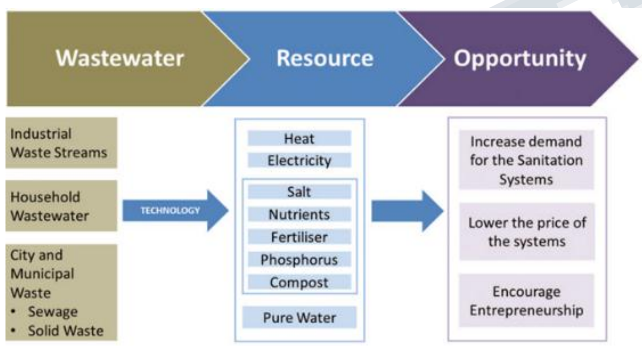

Figure 1 Opportunities for using wastewater as a resource

There are a number of opportunities for reusing wastewater and waste as a resource. The most important reuse techniques are:

A. Drought-resistant source of water

The use of reclaimed wastewater in agriculture can provide a reliable source of irrigation water for farmers. In developed countries, wastewater is often used to irrigate non-agricultural land, such as parks, golf courses and highway verges or to replace drinking water used for toilet flushing [13].

B. Source of nutrients for agriculture

Wastewater is nutrient-rich and can reduce the need for the application of chemical fertilizers. Human faeces, however, contains about 0.5% phosphorus by weight and recovery/reuse could improve phosphorus security and reduce pollution [13].

C. Soil conditioner

When faecal solids are properly treated and of good quality they can be used on agricultural land or gardens as a soil conditioner/fertilizer and are often termed 'biosolids'. Soil conditioner may be produced on a variety of scales from municipal wastewater treatments plants down to individual households practicing ecological sanitation [13].

D. Source of energy/heat

Anaerobic digestion is a bacterial decomposition process that stabilises organic wastes and produces a mixture of methane and carbon dioxide (known as biogas), which is a valuable energy source [13].

Figure 2 Potential added value of resource recovery in the city of Vientiane

The Figure 2 shows some estimates of the economic benefits that could become available from resource recovery, generated in an exercise in the Lao capital, Vientiane, as part of the CityBlues++ project (www. cityblues.la). (Sanitation, wastewater management and sustainability; From waste disposal to resource recovery, 2016) As the figure shows, improved management and recovery of waste resources could produce additional benefits in areas as diverse as natural water management, food security, renewable energy production and climate change mitigation. The city is having a population of 8, 20,940. Water saving potential with low-flush/waterless urinals: 13,700 m3 per day. Agricultural potential using biogas digestate and urine as fertilizers is 40,000 ha. of rice cultivation. Reduced CO2 emissions due to substitution of mineral fertilizer and diesel: 44,000 tons CO2/year. Energy potential for transport sector in the organic waste is 10,000 km of bus travel per day (adjusted for energy consumption due to increased transport in waste collection). [14].

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VI. KEY FACTORS IN THE DESIGN OF A WASTEWATER MANAGEMENT SYSTEM

For the resource recovery step, there may or may not be a different set of service providers with whom to engage, and who in turn can be public, private or community based. There are a number of factors that will influence the most suitable management model for a system with resource recovery. These cover the combination of four main factors such as the Legal and regulatory framework, Geographical factors, Financial and human capital and Political and social acceptance. The different parameters of concern in each of the factors are shown in Figure 3 [6].

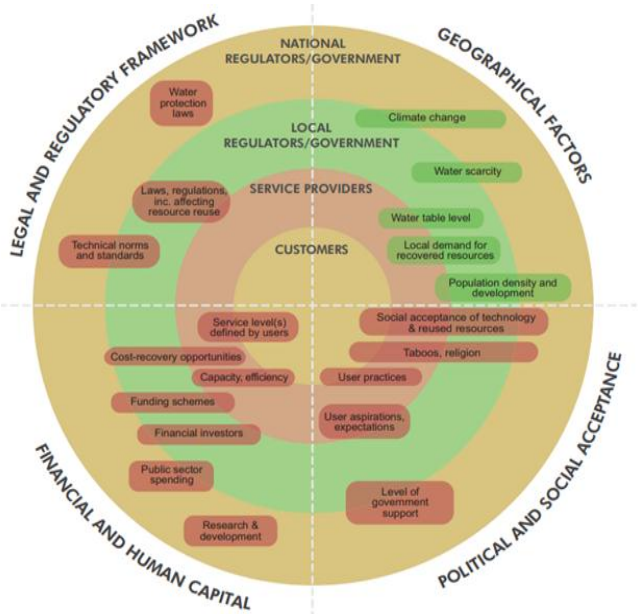

Figure 3 Factors influencing the design of wastewater management.

Another key factor is the selection of an appropriate system. Choosing the most appropriate technology can reduce the risk of problems and failures in the future. The two key issues in choosing a treatment technology are affordability and appropriateness. Affordability relates to the economic conditions of the community, while appropriateness relates to the environmental and social conditions. As such, the most appropriate technology is the technology that is economically affordable, environmentally sustainable, and socially acceptable mentioned in Figure 4 [6].

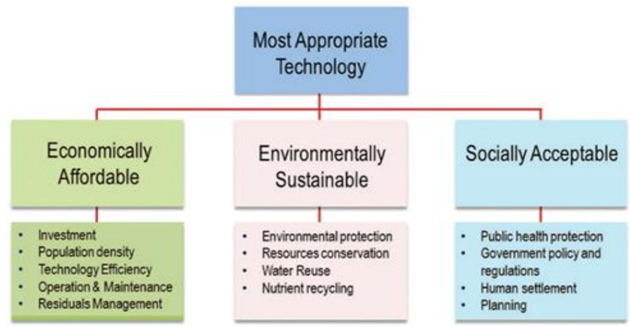

Figure 4 Method of Selection of an appropriate technology

VII. CASE STUDIES

A. NE WATER PROJECT IN SINGAPORE

1) BACKGROUND

Since its independence in 1965, water security has been a prime concern for the city-state of Singapore.1 Though Singapore receives about 2.3m of rainfall annually, land scarcity and a high population density mean there is limited land available for catchment and storage of rain water. Given such conditions, water reuse forms a critical component of Singapore's water sustainability strategy. This article describes Singapore's approach to water reuse, specifically with reference to NEWater – Singapore's brand of high-grade reclaimed water, and highlights factors that have played a critical role in the successful introduction and implementation of water reuse [7].

2) METHOD

Water reuse in Singapore takes two forms – Industrial water and NEWater. Industrial water which was first introduced in 1966, is a lower grade of reclaimed water and serves as an alternative water source for non-potable use in industries.

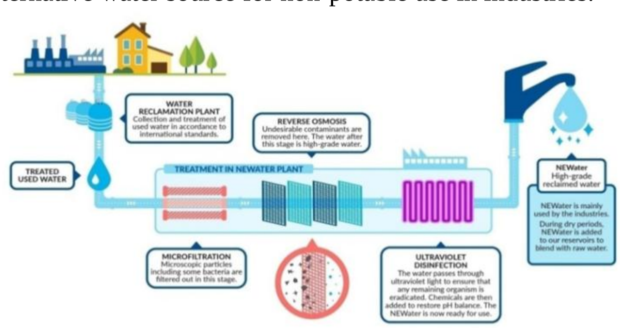

Figure 5 Treatment process at NEWater Plants

In 2003, high-grade reclaimed water, known as NEWater was introduced. NEWater is recycled from treated sewage ('used water') and produced using a rigorous 3-step purification process shown in Figure 5 involving

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ultrafiltration/microfiltration, reverse osmosis (RO) and ultraviolet (UV) disinfection. As compared to desalination, NEWater is more energy-efficient and cost-efficient to produce because of the lower salt content in treated used water, as opposed to seawater.

NEWater is used for both direct non-potable use (DNPU) and indirect potable use (IPU). DNPU is in the form of NEWater that is supplied to water-intensive industries such as wafer fabrication plants (fabs), power generation and petrochemical industries, commercial and public buildings for air-con cooling towers. The quality of NEWater surpasses WHO's as well as the US Environmental Protection Agency's water standards, thereby making it safe for potable use. However, it is not used directly. Instead, NEWater is injected into reservoirs to allow it to mix with rainwater before being collectively treated at the water treatment plants for potable use. This is done to be mindful of public attitudes and acceptance of reused water, as well as to provide an environmental buffer and allow for trace minerals to be reintroduced by blending with reservoir water. Over the years, PUB, Singapore's National Water Agency has expanded NEWater supply capacity to meet up to about 40% of Singapore's total water demand. Future plans aim to increase NEWater capacity to meet up to 55% of total water demand by 2060 [8].

a) Deep tunnel sewerage system

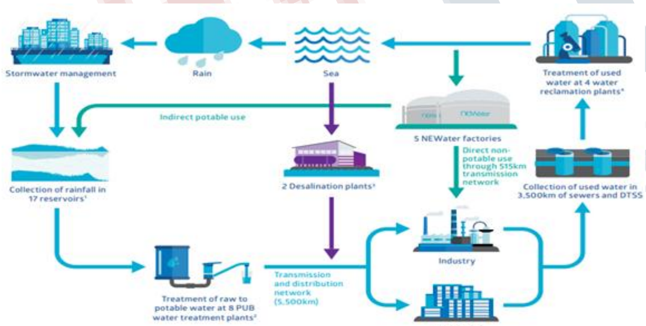

Figure 6 The Water loop

It is a massive integrated project being developed by the PUB in Singapore. The project involves the construction of two large tunnels, 6.5m in diameter and 80km long in total, located at 50m below the surface, to carry sewage to three centralised water reclamation plants (WRP). The WRPs will treat and purify the sewage into clean, high-grade reclaimed water to be supplied under the brand name NEWater. The treated effluent will be discharged through deep sea outfall pipes into the straits of Singapore [9].

3) FACTORS CRITICAL TO NEWATER'S SUCCESSFUL ROLL OUT AND IMPLEMENTATION

a) ***Strong governmental support:*** *Water sustainability had been a top priority for the government, right from the formation of the Water Planning Unit in 1971 under the Prime Minister's Office, with the 1972 Water Master Plan for local water resource development (including water reuse) receiving high levels of political attention.*

b) ***Technology demonstration in the local context, alongside comprehensive water safety assessments that were endorsed by experts:*** *In order to account for differences in the environment and the nature of used water, the technology was tested in local contexts through a demonstration plant. This served as a training ground for staff, and provided opportunities to solve operational issues and optimise design considerations. During this time comprehensive data on water quality and health effects was also collected by way of 20,000 test results from seven sampling locations in the demonstration plant. The results indicated microbiological parameters for NEWater that were better or comparable to regular PUB drinking water. There were also found to be no toxic and carcinogenic effects in mice and fish, or estrogenic effects on fish. An advisory panel of local and foreign experts from diverse fields such as engineering, microbiology, toxicology, biomedical science and water technology, also reviewed the test results, lending objectivity and helping increase credibility of the findings.*

c) ***Nomenclature:*** *The name 'NEWater' was carefully chosen to stress the high standards of treated water suggestive of it being 'as good as new'. In a similar vein the sewage treatment plants were renamed 'water reclamation plants and sewage or wastewater was termed 'used water', to draw parallels with the natural water cycle wherein used water could be recycled into NEWater and this could be done repeatedly.*

d) ***Extensive public and community engagement with a consistent message:*** *The technical rigor embodied in the development of NEWater, was complemented with extensive public and community engagement to increase its acceptability and convince Singaporeans it was safe to use. Members of Parliament and grassroots leaders were briefed to engage with the community about NEWater using exhibitions, posters, brochures and advertisements. Bottled NEWater was provided to the public to taste and distributed at community events and at the National Day Parades. The public communications message that followed*

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these activities was consistent and stressed the following – i) that potable reuse of water has been practised successfully around the world and is not something new; ii) the treatment process employed in its production is reliable and safe; iii) indirect potable use provides an additional environmental buffer; and iv) NEWater provides a sustainable water source for Singapore. This message continues to be conveyed in public education programmes in schools, at community events, and at the NEWater Visitor centre, which is another arm of the public engagement strategy. The NEWater Visitor centre opened in 2003 at one of the NEWater plants and allows visitors to view the treatment process from a gallery. In addition, the Centre organizes tours, workshops and features an interactive display, which are aimed at bridging the gap between public perception and the science behind NEWater.

e) ***Media engagement:*** *Prior to NEWater's introduction a study trip for journalists to visit overseas water reuse projects was organized in 2002. This was supplemented with visits to the demonstration plant that allowed journalists to witness the treatment processes first hand. Finally, a press conference with the panel of experts provided a platform for journalists to clarify their questions and understanding of the details.*

f) ***Organisational changes for integrated water management:*** *PUB was reconstituted in 2001, to have a single agency manage all aspect of the water cycle in an integrated manner. PUB took over the used water and drainage functions from the Ministry of Environment, removing the separation between water supply and used water treatment. This helped facilitate the implementation and expansion of the NEWater supply system.*

4) Conclusion

Over the past 15 years NEWater has successfully scaled up into a well-accepted solution capable of sustainably meeting more than half of Singapore's water demand in the long-run. NEWater improves Singapore's water security, increases its resilience to climate change, and also reduces the need for large water storage capacity as water is constantly recycled, thereby freeing up limited land for other uses. While technology makes the production of NEWater viable, strong political will, effective engagement (with the public, media, industry and experts), positive messaging and organisational changes have been instrumental in its successful implementation.

B. AVADI SEWAGE TREATMENT PLANT: SUSTAINABLE OFF-GRID SEWAGE TREATMENT IN CHENNAI

1) BACKGROUND

The lack of sewage treatment facilities was a major concern for residents of the police quarters in Avadi, a suburb of Chennai under the municipality of Thiruvallur district. The police colony, constructed by the Chennai Public Works Department (PWD) in 1966, occupies an area of 1,000 acres and houses approximately 12,500 residents from 2,000 households. However, as the Avadi area does not fall under Chennai city limits, it was not connected to the underground sewer system and had to dispose of its sewage through septic tanks. The problem with this arrangement was that the percolation of water from the septic tank to the subsoil was little, as the soil was largely clayey. This resulted in heavy stagnation of wastewater around the police quarter area, which became a source of foul odour and waterborne diseases, causing severe inconvenience to residents. The residents complained to the TNPHC, a state-level nodal body in charge of all police-related construction matters. After studying the area and the problems faced, a decision was taken to construct an off-grid STP that would transform waste into useful material [11].

2) IMPLEMENTING STRATEGY

The approach followed for implementation involved focussing on the basics initially, testing the essential viability of the project and then, if successful, scaling it up. Thus, the first goal of the project was to contain the existing damage and treat the sewage that was being generated. Emphasis was also placed on building a robust system that would be as maintenance-free as possible. Accordingly, the methodology of activated sludge control was chosen for deployment due to its simplicity and reliability. The method uses air and a biological floc composed of bacteria and protozoa to treat sewage. A contractor was selected through an open tendering process to construct the STP using this method. The different steps taken in the process in shown in Figure 7 [11].

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Figure 7 (Clockwise from top left): Collection well; clarifier; settling tank; pressure sand and activated carbon filter; sludge drying bed, and treated water pond with walking track.

Unplasticised Polyvinyl Chloride (UPC) material was used in construction, as it does not corrode easily and requires less maintenance. Phase I of the project began in 2003, with the target of treating 2 lakh litres of water daily and constructing a pond to store the treated water and use it to recharge the groundwater table. The project was completed in 2004. Phase II began in 2011 and had the target of treating 10 lakh litres of water daily. An additional STP was constructed for this purpose by 2012. After the construction of the treatment plant, its maintenance was handed over to the members of the police colony. Constables and pump operators were trained for three months by the implementing agency. The STP in Avadi is now almost maintenance-free. The process flow for the system is illustrated in Figure 8 [11]

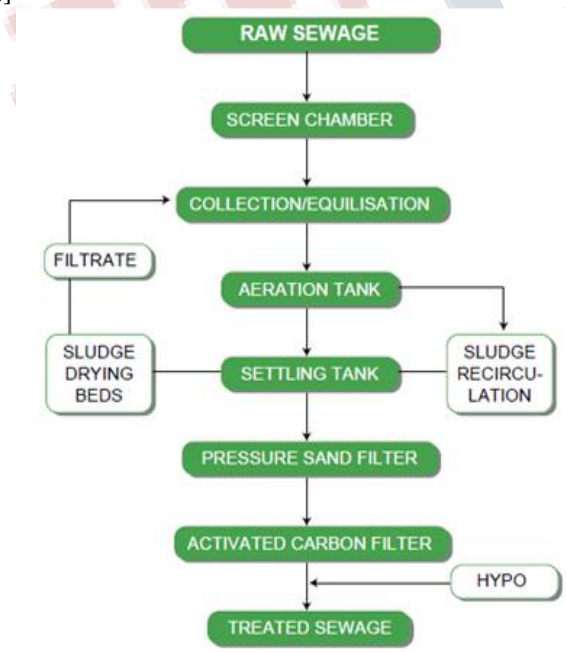

Figure 8 Process flow chart for sewage treatment.

3) IMPACT

Treatment of sewage, removal of odour and diseases: The immediate outcome of the STP in Avadi has been to treat 12 lakh litres of sewage every day with no negative discharge, produce manure, recharge groundwater, remove the source of foul odour and waterborne diseases, and beautify the area [11]

Production of economically valuable items: The water produced by the STP is being used for cultivation of bananas, coconuts and vegetables; fish like katla, kapis and logu; and beema bamboo, which is used in the production of furnace oil, paper, cloth, ornamental items and mats. This fast growing, thorn-free plant generates high levels of oxygen and also acts as a green boundary wall. The 1,000 beema saplings brought from Hosur, Bengaluru, will be ready for harvesting in five years. The products cultivated at the site are used in police canteens and are made available to the colony's residents at subsidised rates [11].

Figure 9 (Right) Cultivation of bamboo and (far left) bananas

4) CONCLUSION

The construction of the STP in Avadi shows how off-grid or isolated systems for sewage treatment can effectively manage sewage in a way that converts waste into useful products and also recharges the environment. Having already been replicated at several sites in Tamil Nadu, the model offers a proven strategy for responsible and productive sewage disposal.

C. SEWAGE FED AQUACULTURE SYSTEMS OF KOLKATA: A CENTURY-OLD INNOVATION OF FARMERS

1) BACKGROUND

Farmers around Kolkata city in India developed a technique of using domestic sewage for fish culture almost a century ago. This technique is widely used to meet the growing demand for fish in this thickly populated Indian city. The technique is considered to be unique and is the largest operational system in the world to convert waste in to consumable products [12].

The system appears to have started nearly a century ago although large-scale usage of sewage for fish culture began in the 1930s. Early success of fish culture in stabilized sewage ponds, which were used as a source of water for growing vegetables, provided stimulus for the large-scale expansion of sewage fed fish culture system. The area under this unique system of culture peaked at 12,000 ha, but in recent years there has been a steep decline in the area due to the increasing pressure from urbanization. Currently, the area under the sewage fed culture system has been reduced to less than 4,000 ha and the poor people dependent on these wetlands for their livelihood have been severely affected. However, even today, a considerable amount of fish consumed in Kolkata city is produced from this system. There are appeals to Government to declare the existing sewage fed aquaculture area as sanctuaries and to protect them from further encroachment by the rapidly expanding population of Kolkata city [12].

2) SEWAGE FED SYSTEM

The sewage fed ponds, which are locally called "Bheries" are usually large and can be as big as 40 ha in size, which is shown in Figure 3.7. Although these sewage- fed ponds are generally shallow and vary from 50 cm to 150 cm in depth. Though most of the sewage fed ponds are static in nature, with the increase in size, they tend to become lotic. In general, these ponds have five distinct phases covering pond preparation, primary fertilization, fish stocking, secondary fertilization and fish harvesting. Pond preparation is undertaken during cooler months (November- February) during which time the growth of carps is also reported to be slow. Whenever possible, ponds are drained, dried, silt is removed from the silt traps (perimeter canal dug along pond dike), the pond bottom is tilled and the dikes are prepared. Sewage from the canal is drawn in to the pond and allowed to stabilize for 15-20 days [12].

Figure 10 (Left)Sewage fed fishponds; locally called "Bheries" have a bamboo sluice structure to prevent the entry of wild fishes and escape of the stocked fishes, (Right) Open channel through which sewage is flown. Lush growth of Colocasia seen on either side of the channel.

The photosynthetic activity in the pond is the basis for biological purification of the sewage. Once the water turns completely green, stocking of fish is initiated. Before stocking fish, some are kept in hapas in the pond to test pond condition through survival. If the results are positive, large scale stocking is undertaken. Fish stocking takes place several times in a year depending on the intensity of operation [12].

Sewage fed ponds are operated both through individual (Jagrashisha Farm) operation as well as through cooperatives. Cooperatives have been largely successful in sewage-fed aquaculture systems and the poor are deriving good benefits from such systems [12].

3) CONCLUSION

Integrated resource recovery systems and waste recycling using peripheral wetlands around cities are some of the planning concepts suggested to maintain the good environment around urban areas. Unfortunately, Kolkata wetlands, which served as the best examples to the world on these concepts are slowly being lost due to the urban expansion without understanding the ecological, environmental and economic benefits of this sewage fed fish culture system. While there is a necessity to protect this unique system in Kolkata, there is a much more urgent necessity to understand the science behind the management practices evolved by farmers.

VIII. ANALYSIS AND FINDINGS

Table 3 Comparison of Case studies

PARAMETERS	SINGAPORE	AVADI- CHENNAI	KOLKATA
ISSUES	•High population density; •Lack of Land availability for the establishment of sewage treatment plants.	•Lack of sewage treatment facilities; •Percolation of water from the septic tank to the subsoil was little, as the soil was largely clayey; •Heavy stagnation of wastewater around the area, which became a source of foul odour and waterborne diseases, causing severe inconvenience to residents.	•Increasing population due to Urbanization. •Growing demand for fish in the city of Kolkota.
METHOD ADOPTED	NE Water Treatment	Method of Activated sludge with waste stabilization pond.	Sewage fed System
IMPLEMENTING AGENCY	Public Utilities Board (PUB)	Tamil Nadu Police Housing Corporation (TNPHC)	Initiated by the Farmers in East Kolkata
APPROACH	Sustainable	Sustainable	Ecological water treatment.
PRESENT STATUS	Functioning & Successful	Functioning and Successful	Properly functioning. (affected by increased urbanisation around)

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From the three case studies, it is clear that advanced and sustainable technologies and system lead to a successful approach of wastewater management.

Table 4 Comparing the standard of effluent discharge

PARAMETERS	pH	BOD (mg/ l)	COD (mg/l)
GLOBAL	6-9	<= 30	Limit currently not established.
NATIONAL	6.5- 9	20; 30	250
SINGAPORE	7- 8.5	20	60
CHENNAI	7	30	250
KOLKATA	8. 57	19. 78	139. 63

The effluent discharge values of the different elements of the three case studies are compared with the Global and the national standard value for sewage effluent discharge and shown in Table 4.2. From the table it is clear that the pH, BOD and COD of the discharged effluent in the three case studies satisfactorily meet the Global and the National Limits. Thus, we can say that the three different methods used in the three case studies are a sustainable and ecologically friendly approach of wastewater management which can be adopted in the future for achieving sustainable development.

A. RECOMMENDATIONS

Implement and Sustain the Education Plan

- The education curriculum will raise awareness of the dangers of wastewater and provoke the community to question the safety of their current wastewater management system.
- By educating children, we are educating tomorrow's decision makers and leaders of the community.

Organize Awareness programs

- Awareness must play a central role in wastewater management and in reducing overall volumes and harmful content of wastewater produced, so that solutions are sustainable.
- Awareness can also stop the resistance of people towards a new innovation.

Engage the public and private sector in planning process

- At local, national and transboundary scales in planning processes that provide an enabling environment for innovation, including at the community level.

Adoption of a sustainable approach to wastewater management

- Converting wastewater into something that can be reused (e.g: Biogas, fertilizers, proteins, etc), thereby reducing the quantity of wastewater discharge and reduced water pollution.
- Thus, considering wastewater as a resource.

Strong Governance

- Need for a strong governance for the implementation of Successful and sustainable management of wastewater that requires a cocktail of innovative approaches.

IX. CONCLUSION

Recycling or reusing wastewater results in less freshwater that must be abstracted from natural systems to meet human demand, contributing to environmental sustainability. Sustainable wastewater management could yield vast economic, social as well as environmental benefits for societies.

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