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Study of Wastewater Treatment Reuse and Disposal of Sludge

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A B S T R A C T

Residential building, hotels, industrial establishments and institutions which house or employ a huge number of people, use great quantities of water daily in toilet, bath, laundry and kitchen. This water, known as sewage, after having served its purposes, is charged with organic matter, grease, soap and other impurities, which will, when exposed to the air, putrefy and become a source of nuisance, unless provision is made for adequate treatment. The population of hotels, institutions, etc., is concentrated on a few acres of ground so that the sewage must of necessity be discharged in comparatively large quantities. Careful consideration as to location on ground available for sewage treatment purpose, is of first importance. Isolation from the institution, public highways, present and future residence sections, is highly desirable. The matter of economical arrangement of units to take up but a minimum ground area, and yet provide for future enlargement. Both package sewage treatment plant and MBBR technology provide efficient sewage treatment with a minimum ground area. Compactness not only saves ground space and cost of construction, but it aids efficient operation. The sludge, or the settled-out solids from the raw sewage as it flows through the settling tanks, must be removed at regular intervals and disposed of. In conclusion, the results can indicate that MBBR with polyethylene media as Biofilm carrier and package sewage treatment plant may possess great potential to be used for contaminants removal from wastewater. This study can be helpful to check possibility that the moving bed Biofilm process and package sewage treatment plant may be used as an ideal and efficient option for the total nutrient removal from municipal wastewater.

Keywords: Wastewater, MBBR, PSTP, Biogas, Sludge

1. Introduction

Urbanization has encouraged the migration of people from villages to the urban areas in India. With exponential growth in urbanization, a number of environmental problems have emerged. For improving standards of life, running water-supply has been established in most of the cities/towns and even in some villages over the past three decades in India. This has, in turn, led to flush-latrines and much large use of water in homes for bathing, washing of clothes utensils etc., generating significant amount of wastewater. Use of soaps, detergents and amounts of various food materials going to the sink have also grown with improved life standards. Unfortunately, due to paucity of resources sewerage or improved sanitation did not get much attention. Hence sewerage has lagged far behind water supply. A large number of the cities/towns either do not have any sewerage system or the sewerage system is overloaded or defunct. Even where sewers exist, they often leak or overflow, releasing their contents to storm water or other surface drains or percolate in to soil to reach ground-water. Thus, a bulk of pollution gets retained on land to percolate, leach or get washed-off to streams or groundwater. The performance of a sewage treatment plant may be defined as its efficiency to remove/reduce the potential harmful contaminants or pollutants from raw sewage and to discharge the treated effluent into the natural environment with compliance to specific discharge limits.

The main biological parameters which are used to classify the pollutant load in the municipal raw sewage are Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS). The other parameters, considered are Chemical Oxygen Demand (COD), Faecal Coliform, Nutrients like Nitrogen (N) and Phosphorous (P) etc. Physical parameters like pH and Temperature may also be important in some cases. Therefore, the performance of a Sewage Treatment Plants is associated with the efficient removal of the aforesaid parameters from the raw sewage.

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The treatment technology, involved in the treatment process also plays an important role in the overall performance of the STP because the selection of appropriate technology depends upon many factors like quantity and quality of the raw sewage, availability of space, cost criteria, environmental status of the receiving body, existence of proper operation and maintenance facilities, availability of energy, utilization of treated effluent and sludge by-products etc.

A successful project must satisfy certain criteria like economic viability, social responsibility, environmental reliability etc. especially after its implementation. In this aspect, the performance of a Sewage Treatment Plant can be considered as a measure of the sustainability of the sewage treatment project. The better is the performance of a plant, more is its useful life, more is the project sustainability. Therefore nowadays, the performance of a STP has become a very important factor in taking part in the overall development of the community as well as the development of the country.

The one important aspect associated with the performance of Sewage Treatment Plant is its regular operation and maintenance (O&M). The level of O&M actually determines the efficiencies of the different treatment units of the plant. More is the regularity and quality of O&M, more will be the efficiencies of the treatment units and consequently better is the performance of the treatment plant. Again, in order to maintain the level of O&M to the desired extent, factors like regular flow of fund, plant management, laboratory and training facilities, plant personnel, co-ordination amongst the implementing authorities, reputation of O&M agencies etc. are also necessary.

1.1. Water Supply, Wastewater Generation and Treatment

In India, water quality has deteriorated steadily with time. With increase in population, the demand of fresh water also increased which in turn, led to the increased generation of wastewater. Rapid urbanization in the last century has led to the Metropolitan and other bigger cities getting choked with myriad environmental problems such as water supply, wastewater and solid waste generation and their collection, treatment and disposal. A study conducted by the Central Pollution Control Board in 2003-04 indicates that about 26,254 million litres per day of waste water are generated in the 921 Class I cities and Class II towns in India (having more than 70% of urban population) with treatment facilities available for about 7044 million litres per day only.

1.2. Water Pollution

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

Water pollution affects plants and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and populations, but also to the natural biological communities.

1.3. Reuse of Wastewater

Water scarcity and water pollution pose a critical challenge in many developing countries. In urban areas, it is becoming difficult for the authorities to manage water supply and wastewater.Strategies for water and wastewater reuse can improve urban water management. The important aspects to minimize public health risks are identified as: 1.Wastewater Reuse for Agriculture 2. Wastewater Reuse for Industry 3. Urban Applications 4. Wastewater Reuse for Environmental Water Enhancement 5. Groundwater Recharge

The capacity building policy-making, institutional strengthening, financial mechanisms, and awareness rising and stakeholder participation are vital to implement these strategies for wastewater reuse.

1.4. Zero Discharge Technology

Zero discharge means that no wastes are discharged, that everything is recycled and no pollutants are being discharged into the environment. Another term for this is Totally Effluent Free(TEF) Evolution of treated wastewater discharge standards is a complex process requiring thorough expertise. Zero Discharge is one such standard / requirement of pollution control authorities.

1.5. Importance and Usefulness of Wastewater Treatment

The purpose of wastewater treatment is to remove the organic and inorganic solids. The organic solids are decomposed by microorganisms and inorganic solids that are inert are removed by sedimentation. The treatment of sewage consists of primary, secondary and tertiary treatment. The primary treatment units are screen chamber, grit chamber, and primary settling tank. The secondary treatment units are aeration tank and secondary settling tank. The tertiary treatment units are rapid sand filtration or slow sand filtration and nutrient removal by various methods. The domestic sewage is the major source of pollution for surface as well as ground water. The water becomes unfit for various uses and causing waterborne diseases. There are frequent outbreaks of diseases due to unsanitary living conditions. The discharge of untreated wastewater into the aquatic environment is the main cause of diarrhoea diseases. As the quantity of wastewater discharged into the rivers/water bodies exceeds the self-cleansing capacity of rivers the dissolved oxygen in the water reduces and the aquatic life will starts disappearing. As the rivers are the major sources of drinking water needs, the treatment of wastewater becomes necessary.

The waste water treatment systems are very essential for the following reasons:

- To reduce human disease and to promote public health
- To eliminate gross water pollution effects and
- To achieve levels of water quality that allows native marine organisms / aquatic life to return to normal growth patterns and allows full human recreational use.
- Removal of Suspended Solids by Clarification (In Sedimentation Tank) & Decomposition (By providing Suitable conditions for bacteria)
- Removal of Organics by Decomposition (By providing Suitable conditions for bacteria) & Provide conditions for separation of the wastewater from the Bacteria.
- Removal of Residual bacteria present in separated wastewater by adding powerful oxidants such as Chlorine.

1.6. Standard for Treated Wastewater

The standards for treatment of wastewater decided by the regulatory authorities [which in the case of India is the Central Pollution Control Board (CPCB) along with the various State Pollution Control Boards (SPCB's)] and the application for which the final effluent from the treatment plant is to be utilized/ disposal method used for the final effluent.

2. Literature Review

One of the most pervasive problems afflicting people throughout the world is inadequate access to clean water and sanitation. Problems with water are expected to grow worse in the coming decades, with water scarcity occurring globally, even in regions currently considered water-rich. Addressing these problems calls out for a tremendous amount of research to be conducted to identify robust new methods of purifying water at lower cost and with less energy while at the same time minimizing the use of chemicals and impact on the environment. Sewage/Wastewater treatment is a vital process in the modern industrial world, alongside this, more than 97% of water is stored in Saline (Oceans) and only 3% in fresh water, however only less than 1% is available for consumption [1]. Sewage/Wastewater treatment uses chemical, physical, and biological processes to cleanse wastewater in order to protect the environment and public health. Wastewater treatment is a modern practice, while ancient Romans used to create sewers for removing the foul-smell of the used water; now days, the main reason for constructing sewages is to remove or decrease the dangerous pollutants such as nutrients, carbon, inorganic and organic elements [2]. Domestic wastewater is the main reason for designing a proper wastewater treatment plan and building sewers in the cities. The domestic pollutants characteristics in wastewater can be physical, Chemical or industrial with physical characteristics consisting of colour, temperature and weight. The colour of wastewater which has been produced recently is grey, however as time goes by it changes to black, the reason why is the suspended solids which cannot dissolve or settled in the waste water. In addition, the solids increase the weight of the wastewater which has been measured 1,000,000 grams in one cubic meter in the wastewater [3].

There are a lot of pollutants and wastes in the wastewater such as, nutrients, inorganic salts, pathogens, coarse solids etc., which are really dangerous for ecology and human, for removing these pollutants, different processes have been exposed. There are specific processes and unit operations in sewage/wastewater treatment, the primary goal of these processes is to reduce the pollution of the water the polluting starting point until the end of the treatment process which can be disposal or refusal and these reduction processes can be chemical, physical or biological.

Chemical unit processes are playing an important role in advanced cleansing. [7]mentioned that chemical unit processes are the procedures that cause reactions in wastewater components such processes are used while the physical and biological processes are in action. There are quite a lot of different chemical processes, such as precipitation, coagulation, neutralization and stabilization, ion exchange, oxidation and advanced oxidation that may be added to sewage water during the purifying procedure [9].

Physical unit operations are some treatment methods which cleanse the wastewater by using the physical forces such as flocculating, floatation, mixing, filtration, screening and gas transfer.

Biological unit processes is the procedures that break down the grease/oil, Suspended solids, organic matter, nitrogen and phosphorus by bacteria which grow naturally in abiological reactor. The bacteria consumes the carbon-based material in the sewers, also the primary goal of this treatment is to decrease the biological elements in wastewater [10].

The processes and operations which were mentioned are being used in different stages of treatment; Preliminary, Primary, Secondary and Advanced wastewater treatment which are perusing different objectives in the treatment process.

The objective is to remove the large materials like coarse solids which are being frequently seen in wastewater. Furthermore, it separates the floating materials which are being carried by water flow. Preliminary treatment procedures usually contain grit removal, coarse screening and comminution of large objects. In addition, this treatment helps in removing the greases and oils. This process decreases the wastewaters BOD, by approximately 15 to 30% and the devices which are being used during this treatment are Grit chamber and Comminutor: This device consists of a screen to prevent the large materials from accessing further into the following treatment processes and some cutters are also installed after the screen to chop the solids which had made it through the screen [8].

Grit chamber: its objective is to remove the oils and semi-liquid elements. There are two kinds of Grit chamber; Aerated and Vortex [8]. The objective of the primary waste water treatment is to remove solid components of wastewater by sedimentation, these components can be organic elements such as, phosphorus, nitrogen, and metals connected to solid components. On the other hand, colloidal and dissolved elements will remain and not be affected. The waste from primary sedimentation units is known as primary effluent and the wastes which have been produced by this process is called Primary effluent [12].

Sedimentation tank and clarifiers: “Up flow clarifiers and Rector clarifiers are two types of sedimentation tanks, perform very well if both the raw water is characteristics and the hydraulic loading rates are constant” [8].

Overall, a sewerage system primarily receives the wastes which have been released from industrial or domestic sources, and then the treatment procedures take place in the system and it finally releases the left-over pollutants into the environment. Furthermore, the sewerage system can transfer the water in critical situation like heavy rain falls; as a result, the flood does the minimal damage to the citizens and domestic areas [6]. There are some important factors which have to be considered before designing a sewerage treatment network, these consist of:

Environmental factors are concepts related to environmental situations such as the quality of the groundwater and surface water, public health considerations [15]and odour and insects disturbance which affect public health and land values.

Engineering factors should be considered and observed by experienced engineers to prevent any critical phenomena. The engineers who work on these projects should consider sewer penetration, groundwater depth, risks of segregating, recycling or reusing of sewage within the houses [4], bearing capacity of the soil, topography of the site and hydraulic calculations, especially for the coastal discharge [10].

Cost consideration is related to a financial analyser who should anticipate which beneficial aspects are the most beneficial for use in the sewage/waste water treatment system. The analyser should pay attention to the costs included in the project which consist of maintenance, repair, electricity, fuels, staff, chemical and should also consider the general costs for equipment, construction and land expense [5].

Disposal or reuse is the final procedures in sewage/wastewater treatment which should be designed in a way which pleases economic and scientific goals and procedures. There are two main groups of disposal systems which differ in their use in terms of where they are situated and how they are to function; On-site and Off-site (Public) disposal/reuse systems. On-site system is being used in an area which has minimal pollution production and also where there are only a couple of houses in a wide geometric range. In this case, this disposal system is even more beneficial in terms of economics, in comparison to using a system for collecting, transferring and treating the wastewater [3]

In a public system, wastes are being collected in an area and then carried to other locations through transporting systems for final disposal. In addition, public disposal systems can be very useful in critical situations like flooding or storms by containing the water in the off-site facilities or carrying out the huge proportion of the water [11].

3. Research Methodology

3.1 Working Principle of Sewage Treatment Plant

Treatment of sewage is essential to ensure that the receiving water into which the effluent is ultimately discharged is not significantly polluted. However, the degree of treatment required will vary according to the type of receiving water. Thus, a very high degree of treatment will be required if the effluent discharges to a fishery or upstream of an abstraction point for water supply. A lower level of treatment may be acceptable for discharges to coastal waters where there is rapid dilution and dispersion.

A Sewage Treatment Plant consists of all the operational units where proper collection, treatment and disposal of sewage are undertaken with respect to the characteristics of influent sewage and the status of the water bodies receiving the treated effluent.

3.2 Unit operation and process of sewage disposal

Waste water is a complex matrix of physical, chemical and biological contaminants and therefore the treatment can also be classified as physical unit operations, chemical unit processes, and biological unit processes, although these operations and processes occur in a variety of combinations in treatment systems, but the basic principles involved in the treatment do not change.

3.2.1 Physical unit operation

These are the treatment methods in which the application of physical forces predominates. Screening, mixing, flocculation, sedimentation, floatation, filtration, and gas transfer are examples of physical unit operations.

3.2.2 Chemical unit operation

In these treatment methods, the removal or conversion of contaminants is brought about by the addition of chemicals or by other chemical reactions. Coagulation, ion exchange and pH adjustment are examples of typical chemical processes.

3.2.3 Biological unit operation

These treatment methods are associated with the removal of contaminants which is brought about by biological activities. Biological treatment is used primarily to remove the biodegradable organic substances (colloidal or dissolved) in wastewater. Basically, these substances are converted into gases that can escape to the atmosphere and into biological cell tissue that can be removed by settling. Biological treatment is also used to remove nutrients (nitrogen and phosphorus) in wastewater.

3.3 Selection of sewage treatment technologies

An understanding of the nature of waste-water is fundamental for the design of appropriate wastewater treatment plants and the selection of effective treatment technologies. Waste-water originates predominantly from water usage by residences and commercial and industrial establishments, together with groundwater, surface water and storm water .Consequently, wastewater flow fluctuates with variations in water usage, which is affected by a multitude of factors including climate, community size, living standards, dependability and quality of water supply, water conservation requirements or practices, and the extent of meter services, in addition to the degree of industrialization, cost of water and supply pressure.

3.4 Technological operation for sewage treatment

In India, apart from the common unit processes such as pumping, screening, grit removal, plain sedimentation, chemical precipitation, chlorination etc, different biological treatment technologies have been adopted for the treatment of sewage. Here we are going to discuss in details about the two of the waste water treatment technology that are following:

- Moving bed biofilm reactor
- Decentralised waste water system (package sewage treatment plant or PSTP)

Moving bed Biofilm Reactor

The MBBR system consists of an aeration tank (similar to a activated sludge tank) with special plastic carriers that provide a surface where a biofilm can grow. The carriers are made of a material with a density close to the density of water (1 g/cm^3). For example, high-density polyethylene (HDPE) which have a density close to 0.95 g/cm^3. The carriers will be mixed in the tank by the aeration system and thus will have good contact between the substrate in the influent wastewater and the biomass on the carriers. MBBR technology employs thousands of polyethylene biofilm carriers operating in mixed motion within an aerated wastewater treatment basin. Each individual biocarrier increases productivity through providing protected surface area to support the growth of heterotrophic and autotrophic bacteria within its cells. It is this high-density population of bacteria that achieves high-rate biodegradation within the system, while also offering process reliability and ease of operation.

The MBBR system is considered a biofilm process and has following advantages compared to other conventional biological treatments.

1. Compact units with small size.
2. Increased treatment capacity.
3. Complete solids removal.
4. Improved settling characteristics.
5. Operation at higher suspended biomass
6. Concentrations resulting in long sludge retention times.
7. Enhanced process stability.
8. Low head loss.
9. No filter channelling.
10. No need of periodic backwashing.
11. Reduced sludge production and no problems with
12. Sludge bulking
13. MBBR processes are an excellent solution for common wastewater applications including Nitrificationand total Nitrogen Removal
14. MBBR systems doesn't need a recycling of the sludge, which is the case with activated sludge systems.

4. Results and Discussion

4.1 MBBR Technology

Total amount of waste water treated = 1000 KLD.

The average ranges of physical, chemical and biological characteristics of waste water quality are experimented and found as follows:

Source: golmuri plant, Jusco Jamshedpur, Jharkhand, India

Table 1- Test Results of Wastewater

Characteristics	Range
pH	7.8 to 8.01
Turbidity	10 to 120 NTU
BOD	30 mg/l
COD	200 mg/l
TSS	10 mg/l
Oil & Grease	5 mg/l
Chloride	3.5 to 120 mg/l
Alkalinity	15 to 80 mg/l
Total Iron content	0 to 3 mg/l
Zinc content	0.1 to 2 mg/l

4.2 Modifications

There are the following modifications, that can done in the existing sewage treatment plant in golmuri:

As the population of golmuri area is growing, the sewage discharge also increasing and hence we can increase the treatment capacity and the extra treated water can be further treated so that it can be used for drinking.

In rainy season where there is less amount of treated water is required for irrigation of golf course, some amount of treated water can be used for water harvesting.

We can also form a sludge tank in which dried sludge is fed and its digestion can be done which release biogas like methane, can be used for cooking.

Instead of filter press which having comparatively high cost we can also use sludge drying bed. But the sludge drying bed require more area than filter press. The sludge drying bed has also low maintenance cost.

The gas produced can be stored in a tank and the solid residue can be used as fertilizer as it contains organic material.

4.3 Result of Package Sewage Treatment Plant

Table 2- Properties of Package Sewage Treatment Plant

Parameter	Inlet sewage	Outlet Sewage		Remarks
		Sample 1	Sample 2	
PH value	5.5 to 9.0	7.6	7.4	alkaline
TSS(mg/l)	600	25	22	Can be used for irrigation
BOD(mg/l)	350	< 30	< 30	Can be used in industries
Turbidity(NTU)	500	20	25	Can be used for irrigation, washing

5. Conclusion

There is a need to generate water from all available resources including wastewater by recycling, reuse, recharging, and storages. There is urgent need to plan strategies and give thrust to policies giving equal weighting to augmentation of water supplied as well as development of wastewater treatment facilities. Municipal wastewater collection, treatment, and disposal are still not a priority by the municipality/ state government as compared to water supply. In the absence of sewer lines, untreated wastewater is flowing into storm water drains and poses health hazards to the citizens inhabiting the areas near the drain. The O&M are not satisfactory due to lack of proper power supply/ backup power; municipal authorities do not have the money for spares and payment of electricity bills; there is a lack of skilled manpower and most of the plants are under-loaded due to lack of proper sewer lines. Although municipal wastewater treatment is given impetus under National River Conservation Plan of Ministry of Environment and Forest, Government of India to provide sewage treatment plant to cities discharging wastewater to rivers, in spite of all these effort and various schemes, the gap between generation and treatment is still large. There are various issues with treatment technology in addition to management aspects. The primary requirement for wastewater treatment is adequate supply of electricity which is a deterrent in the present context in almost all the states of the country. Treatment technology selection for different sizes of urban settlements is another issue due to the constraint of land availability. The waste stabilization ponds (oxidation ponds, maturation ponds, and duckweed ponds) are most appropriate for small towns having land availability for treatment plants and demand for treated wastewater in agriculture. In large urban settlements with land scarcity for the establishment of STPs and less demand for treated sewage for farm application, mechanical treatment systems viz. activated sludge process, trickling filter, UASB, and aerated lagoons are appropriate and produce good results. There are success stories of treatment plants producing reasonably good quality water which is being used in the industrial sector for processes as well as cooling purposes thereby reducing the industrial demand for fresh water.

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