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Comparative Study of Different Technologies Involved in Small Sewage Treatment Plant

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***Abstract*—The present paper discuss the different technologies of Waste water Treatment for small size Sewage Treatment Plant (STPs) in India. Wastewater treatment technologies are gaining attention of policy makers and industries for meeting the required pollution control guidelines laid by the pollution board of the country and to make waste water fit for various usage and therefore leading to conservation of water resources for near future. The article provides comparison of various technologies commonly used in small size STPs. various aerobic treatment technologies viz. Moving Bed Biofilm Reactor (MBBR), Membrane bioreactor (MBR), Sequencing Batch Reactor (SBR), Activated Sludge Process (ASP), Up flow Anaerobic sludge blanket (UASB) Reactor, suitable for treating waste water have been considered for comparative analysis.**

***Index Terms*—Sewage Treatment Plant, Cost Effective Technology, Wastewater, Small size waste water plant**

I. Introduction

Sewage treatment plant is the procedure for removing contaminants from the wastewater from the domestic, commercial and industrial sewage. It has to undergo the chemical, physical and biological procedure to remove these contaminants and give out an environmentally safe treated effluent.

Available statistics reveals that India habitats 1/6th of the total world's population on 1/50th portion of the land and just with 1/25th of the total water resource. This depicts the need to treat and reuse waste water by taking effective measures for sustainable development. The annual per capita utilizable surface water has gone down from 1911m^3 in year 1951 to 575m^3 in year 2011, mainly because of ever rising population. Sewage generation is growing with rapid urbanization. In India it has facility to treat only 33% of total sewage generated. It is estimated that by 2050, sewage generation quantity can meet around 10% of total irrigation water demand. The challenge for next decade is not only to bridge this huge gap in treatment capacity but also to develop suitable and cost effective treatment facilities for not only waste water treatment but its recycling also.

II. Types of Technology Used in Sewage Treatment Plant

The study is for waste water treatment technologies which has capacity of STPs ranges of 200 to 500 KLD i.e. small size sewage treatment plants. Various technologies used are:

A. Extended Aeration (EA)/ Activated Sludge Process (EAS)

The activated sludge process is the most widely used biological water and waste water treatment. Suspended growth microorganisms are applied to breakdown wastes.

An extended aeration system includes capabilities for aeration & mixing, settling, return of activated sludge and solids removal, this lasts in the form of biomass known as waste activated sludge. Basically, it takes raw sewage directly into an aerated mix tank for 8 hrs. or more to provide bacteria with optimum condition to consume the BOD present in wastewater. The effluent from this mix tank goes to a sedimentation tank where the flocculated colonies or organism are settled to produce clear flow. This method of treatment is particularly suited to plants that have low concentration of settable solids in the raw sewage. It minimizes the number of unit operations involved in smaller plants.

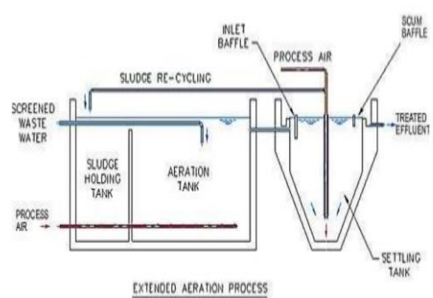

Fig. 1. Extended aeration process

B. Sequencing Batch Reactor (SBR)

SBR is a special form of activated sludge treatment, where all treatment take place in reactor tank and clarifiers are not required. Process treats the waste water in batch mode. Each batch is sequenced through series of treatment stages. SBR system has two tanks which operate fill and draw basis. Sewage from main pumping station (MPS) filled in to tank; after desired treatment mixed liquor get settled and clarified water is drawn out from tank. SBR treatment cycle contains five phases Fill, React, Settle Draw and Idle, having defined time period (Depend on aeration and mixing pattern) for each phase.

Aeration times vary according to the plant size and the composition/quantity of the incoming liquor, but are typically 60 to 90 minutes. Aeration supports formation of Nitrogen from its reduced ammonia in the form of nitrite and nitrate. To remove phosphorous compounds from the liquor, ammonium sulphate (alum) is generally added during this period.

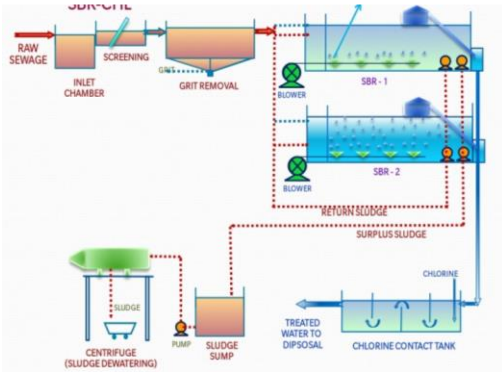

Fig. 2. Sequencing batch reactor

C. Membrane Bioreactor (MBR)

MBR is a Process where a perm-selective membrane, e.g. microfiltration or ultra-filtration, is integrated with a biological process – specially suspended growth bio reactor. This process is based on use of submerged membranes for liquid separation; it uses membrane as filter, rejecting the solid materials which are developed by the biological process, resulting in a clarified and disinfected product effluent. The process provides high quality effluents, higher volumetric loading rates, shorter retention time and less sludge production. But it also has disadvantage, including higher energy costs, the need to control membrane fouling problems, and potential high costs of periodic membrane placement.

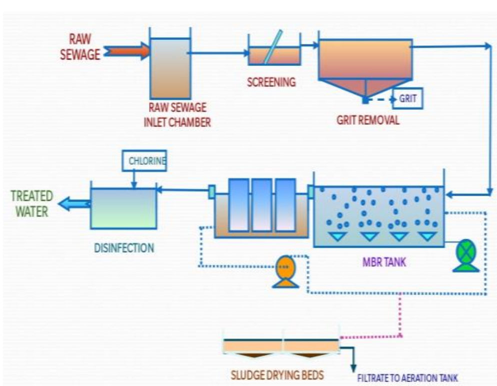

Fig. 3. Membrane bioreactor

D. Moving Bed Biofilm Reactor (MBBR)

MBBR Technology employs thousands of polyethylene biofilm carriers operating in fixed motion within an aerated waste water treatment. Each individual bio carrier's increases productivity through providing protected surface area to support the growth of heterotrophic and autotrophic bacteria within its cells.it utilizes floating high capacity Microorganism Biochips media within the aeration and anoxic tanks. The microorganism consumes organic material. It is this high density population of bacteria that achieves high rate biodegradation within the system, while offering process reliability and ease of operation

The technology provides cost effective treatment with minimal maintenance since MBBR processes self-maintain an optimum level of productive biofilm. The biofilm attached to the mobile bio carriers within the system automatically responds to load fluctuations. MBBR system provides a flexible, cost effective and easy to operate means to current waste water requirement and the expandability to meet future loads or more stringent discharge requirements within a compact design. MBBR process is an useful solution for waste water applications including BOD reduction, nitrification, total nitrogen removal.

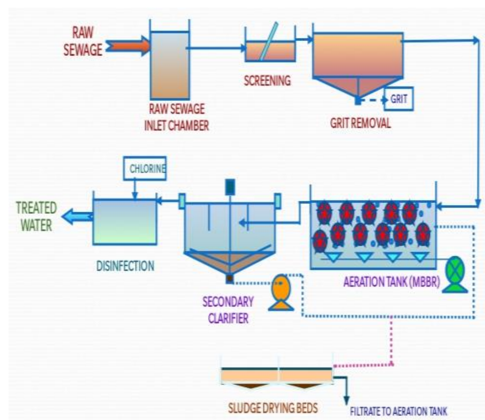

Fig. 4. Moving bed biofilm reactor

E. Up Flow Anaerobic Sludge Blanket (UASB) Reactor

UASB is a single tank process. Waste water enters the reactor from the bottom and flow upwards.

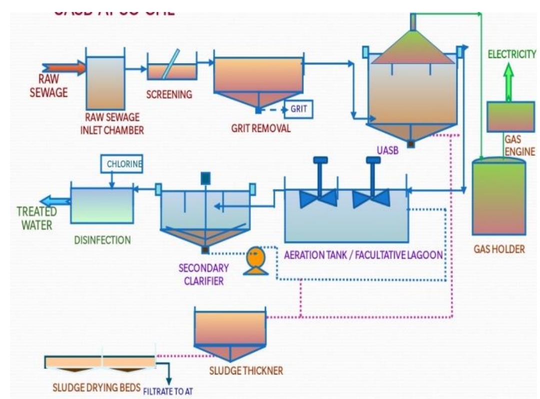

Fig. 5. Up flow anaerobic sludge blanket

A suspended sludge blanket filters and treats as the waste water flows through it. Pre sedimentation anaerobic wastewater treatment and final sedimentation including sludge stabilization are essentially combined in one reactor making it most attractive high rise waste water treatment option. The up flowing sewage itself forms millions of small granules of sludge which are in suspension and the excess sludge is removed and taken to sludge pump house. To produce by products like methane enriched biogas and nutrient rich sludge.

The aerator provides the oxygen to be decomposed along with water by providing huge surface area. The resulting induction of oxygen reduces BOD load by further 75%.

III. Methodology

Comparison of different technologies on the basis of:

A. Cost Definition

The land cost is not considered as it varies with and within the cities. The area of requirement of STP been analysed to determine the footprint area of STPs required for various technologies. The fixed cost includes civil construction cost of various STP units i.e. equalization tank, screen, grit chamber, settling tank and biological reactor tanks, supernatant water tank and treated tank for reuse and electro-mechanical cost such as piping, screen, tube media, FAB media, motors, pumps, sludge dewatering system, etc.

The O&M costs are based on cost of electricity, chemicals, salary of manpower and maintenance of electro-mechanical parts only. Repair and maintenance for mechanical and electrical equipment are estimated on annual basis at certain percentage i.e. 5% (extended aeration), 6% (MBBR, SBR, and USAB) and 7% (MBR). The effective life of the mechanical and electrical equipment is considered as 10 years. The replacement cost was included in the repair cost. The service lives of small STP were considered 20 years.

B. Foot Print Area

Foot print area requirement varies from 1m^2/KLD to 0.48m^2/KLD. It is important to mention here that these STPs are very compactly designed therefore the foot print area is much less than the conventional municipal sewage treatment plants. All STPs have facilities up to tertiary treatment level including pressure filter, activated carbon filter and treated water storage tank. It is found that the foot print area per unit discharge becomes nearly constant with the capacity above 200 KLD.

C. Bio-Chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS) Removal Efficiency

Biochemical Oxygen demand (BOD) is dissolved oxygen demanded by aerobic biological organism to break down organic material present in waste water. COD is the amount of specified oxidants that react with the sample under controlled conditions. TSS is the dry weight of suspended particles that are not dissolved, in wastewater and can be trapped by the filters.

Various parameters of wastewater are observed which includes Mainly BOD, COD and TSS content. The removal efficiencies in respect of mentioned parameters of each technology is analysed.

The study discuss the BOD removal efficiency varied in the order MBR > SBR > UASB > EA > MBBR. The COD removal was in the order MBBR > MBR > SBR > EA > USAB and the TSS removal efficiency followed the order USAB > MBR > MBBR > SBR >EA

Therefore, it is implied that comparison of removal efficiencies of the individual parameter in these reactors may not be yield reliable information for decision making.

As such, removal efficiency of individual process parameters cannot be considered as the sole basis for selection or comparison of these technologies.

IV. Conclusion

In this study, attempt was made to generate a general basis for comparison of technologies used in STPs based on EA, SBR, MBR, MBBR, and UASB for discharge varying from 50 to 750 KLD and that is the range of capacity of most of the small STPs in India.

Cost should be considered as a potential tool for the comparison of the STPs. The cost effective wastewater technology has been driven by systematic evaluation of installation cost and present value of operation and maintenance cost. The cost wise hierarchy found is: MBR < USAB < EA < SBR < MBBR. It is found that MBBR requires the least and MBR requires the highest cost.

The foot print area, MBR requires the least foot print i.e. 0.48 m^2 per KLD. Therefore, if area is major constraint then it could be better option. EA > USAB > SBR > MBBR > MBR

The performance of all the technologies in respect to BOD, COD, and TSS was almost comparable and were not significantly varying. As such comparison of the treatment efficiencies in respect of the removal efficiencies of routine monitoring parameters may not provide sufficient information which will facilitate their selection.

So in terms of overall investment, area and removal efficiency it has been concluded that SBR is most economical and efficient technologies for small sewage treatment plant and followed by MBBR.

SBR, MBR and MBBR are the most effective technology for the biological treatment of sewage in India.

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