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Energy efficiency and Reuse of STP Treated water

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Abstract: *Sewage generated from household need to be treated before it enters into any water body. The importance of water treatment and supply is not given to sewage though it is about 80% quantity of water supply. To achieve the SDG goals of water supply and sanitation and also life below water, it is essential to treat the sewage and also reuse after treatment to reduce the overall demand of fresh water being used. One of the main causes is sewage treatment plants are power intrinsic and requires lot of funding for operation and maintenance of STPs. The old STPs in operation are consuming more power and need of the hour is to renovate and refurbish the plants with latest developments in the field. Improving the energy efficiency of the plant need to be studied and implemented for making the STPs viable for operation.*

The sewage generated will vary with the time of consumption during the day. The peak flow which is 2 to 3 times the average flow, average flow and lean flow which is half of the average flow. Peak flow exists for 5 to 6 hours in a day. Average flow exists for 6 hours a day and lean flow exists for 12 to 13 hours in a day. Sewage coming from under ground drainage network or open nallas will reach the treatment plant premises at a depth of minimum 5 to 6 m below natural ground level which necessitates pumping for further treatment . Sewage pumping is almost 40% of the power consumed in treatment scheme. Number of measures are to be taken for decreasing power consumption. A) using number of small size pumps to decrease the power consumption and also use suitable pumps based on the flow regime during the day B) Using variable frequency drives for optimal power consumption C) Use of level sensors and SCADA controlled operation for timely starting and stopping of the pumps for using minimum energy

Another power consuming component of treatment plant is aeration. Dissolved Oxygen levels are to be continuously monitored and the oxygen requirements are to be modulated using variable frequency drives for the blowers. By using online oxygen uptake rate as a tool for monitoring and controlling the status of the plant during aeration phase of the treatment plant. Oxygen requirements vary as per the inlet BOD and oxidation need to

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be adjusted in the process. Using turbo blowers in the system will increase the efficiency and less power consumption. Twin lobe , Tri lobe blowers can also be used with proper preventive maintenance coupled with VFD for adjusting the oxygen transfer efficiency. Online monitoring and using SCADA for knowing the real time DO levels will reduce the power consumption by about 30%. The efficiency of the selected blowers will be high at design parameters like discharge and head which will vary during the cycle time of aeration and also as per the level in the reactor. It is very crucial to supply oxygen as per the treatment phase and as per input BOD levels.

Secondary treatment plants can be converted into tertiary treatment units by providing gravity disc filters there by reducing the BOD less than 5 mg/lit which make the water fit for reuse of Indirect potable use. This water can be used for industrial applications like cooling, recirculation and other non process water. This will ensure to meet the SDG goals efficiently. By providing number of case studies where the water reuse has been effective and economically viable, the use of the same for many more applications will increase.

Waste to wealth concept can be discussed further by promoting the bi-products from STP meeting the sustainable Development goals.

Keywords: *Energy efficiency of STPs, Reuse, Byproducts, Circular economy*

Introduction

Most of the cities are developed along the rivers or near water bodies. Source of the drinking water is available in near vicinity. But over the period of time with rapid urbanization, the drinking water sources are getting polluted with the domestic sewage entering into the water bodies with or without proper treatment. This condition has made both under ground and above ground water not fit for direct use. This is making the difference in selecting a source of water away from the developed habitations. For all major cities water is brought from far away sources making the water costlier due to large pumping and conveying mains. The sewage generated is directly proportional to the water supply availability and consumption. That is the reason in metropolitan cities , menace of sewage is more compared to small villages / habitations. The water supply for metro cities is about 150 LPCD there by generating 80% of the same as sewage ie. 120 LPCD. There are seasonal variations as well as diurnal variations in the quantity and quality of the sewage. Peak factor for different capacities of STP is as per Table 1 . The main parameters for assessing the quality of raw sewage are pH, BOD, COD, TSS , TKN, P and coliform present in the sewage. The parameters shall be as per Table 2.The source of sewage and its collection by piped network or open nalas will be the crucial factor for design of the appropriate system. Storm water entering in to nala will have adverse effect of more flow though with less concentration as the STP plants are to be designed for higher capacity and capacity utilization will vary in dry season. Entering of any industrial effluents in to the nala or pipeline needs to be studied before designing.

[1]**Table: 1:** Peak factor based on population

Sl. No	Population	Peak factor	MLD of STP
1	Up to 20, 000	3	2.16
2	20,000 to 50,000	2.5	5.4
3	50,000 to 7,50,000	2.25	81
4	Above 7,50,000	2	>81

Ref: [1]CPHEEO Manual- 3.2.5 Flow assumption on sewage and sewerage treatment – 1993

Raw sewage characteristics based on the organic load is tabulated with range of Biological oxygen demand (BOD) in mg/lit, Chemical oxygen Demand (COD) in mg/lit, operating pH values, Total suspended solids (TSS) in mg/lit, fecal coliform in Most probable number in 100 ml (MPN), Total Nitrogen(NH_4N) and Total Phosphorous (TP) in mg/lt are tabulated in Table 2. With limits of treated effluent after treatment.

Table 2 : Characteristics of raw sewage and treated effluent:

Sl. No	Parameter	Raw Sewage	Treated Effluent
1	BOD (mg/l)	250 - 400	<10
2	COD (mg/l)	425 - 600	<50
3	pH	6.5 - 8.0	6.5 – 9.0
4	TSS (mg/l)	375 - 700	<10
5	Fecal Coliform (MPN/100ml)	$5x10^7$ MPN/100ml	<230
6	NH_4N (ppm)	32.50	<5
7	TP (ppm)	7	<1

Objective

Objective of this paper is to assess the status of existing STPs and identify need for a detailed performance assessment which will result in preparing proposals for modernising existing STPs to conform to latest technology adopting emerging concepts like Net-zero emission and self-sustaining carbon-neutral, Improving energy efficiency, Climate resilient, Zero discharge sewage treatment plant and Circular economy

Methodology

The existing technologies include Activated sludge process , Upflow anaerobic Sludge Blanket Reactor (UASBR), Extended Aeration, Moving Bed Bio Reactor (MBBR) , Membrane Bio reactor (MBR) and Sequential Batch reactor (SBR) etc. Basically the process is either anaerobic / aerobic or combination of both. The power requirement of the process varies and the lowest power consumption with reference to the quality of the treated water shall be the basis of the selection of technology of STP apart from the foot print and also the sludge production and handling. Conventional treatment facilities can be upgraded by providing additional media for improving the MLSS / MLVSS for better efficiency. The quantity of sewage handled or capacity of the STP can be enhanced by modifying the media and process parameters. IFAS is one of the recent developments in increasing the plant capacity without much modifications to the civil structures.

Main power consumption in a sewage treatment plant is attributed to pumping of raw sewage and aeration requirements. By providing variable frequency drives to the pumps and blowers , the energy requirements can be lowered . Also maintaining the required Dissolved Oxygen levels will lower the power consumption.

Conventional treatment plants are designed for higher BOD values of treated water as per the then effluent standards . However, the effluent standards are being made stringent and lower BOD values are to be achieved and also part of the treated effluent shall be reused as per the Swatch Bharat Mission guidelines in India. Reuse of treated sewage will enable the reduction in clear water requirement as it can be uitilized for non potable use / indirect potable use.

The stress on availability of drinking water sources is increasing and reuse of treated water is the alternative solution and getting initiatives across the globe.

Another important point in most of the existing sewage treatment plants is bio nutrient removal system is not part of the process and the same can be incorporated by nitrification and de nitrification and also phosphorous removal. The norms of total nitrogen less than 5 mg/lit and total phosphorous less then 1 mg/lit shall be met mandatorily in the treated sewage as per the latest norms.

Proposing the tertiary treatment to the secondary sewage treatment will enhance the willingness to reuse the treated water. Proper disinfection methods like vacuum feed chlorination / UV disinfection will enhance the quality of treated water and meet the faecal coliform of less then 230 MPN as per USFDA standards.

Emerging concepts

A zero-carbon emissions sewage treatment plant, or a net-zero carbon wastewater treatment plant (WWTP), aims to achieve net-zero greenhouse gas (GHG) emissions by offsetting carbon footprint through various strategies, including energy optimization, process modification, and renewable energy integration.

Improving energy efficiency in sewage treatment plants (STPs involves implementing strategies to reduce energy consumption while maintaining effluent quality, potentially leading to 20-30% energy savings and lower operating costs.

To build a climate-resilient sewage treatment plant, integrate strategies like resilient infrastructure design, flood protection, stormwater management, and energy efficiency, while also considering nature-based solutions and decentralized systems.

A zero discharge sewage treatment plant (ZLD STP) is a wastewater management system designed to treat sewage to a level where all treated water is reused within the plant or evaporated, ensuring no discharge into the environment

A circular economy approach to sewage treatment plants involves treating wastewater as a resource, recovering valuable materials and energy, and minimizing waste, promoting a closed-loop system.

There is a need to assess the status of existing STPs across India. Jal Hi Amrit initiative has already started across India to assess and give incentives for upgrading the STPs. The main parameters are treated water quality, innovative systems, reuse of treated water, co – treatment of Faecal sludge, utilization capacity etc.

Advanced measures recommended for present STPs

Power consumption is given utmost importance as the same will affect the cost of O&M. Variable frequency drives are used to regulate the power consumption based on the conditions in case of submersible pumps, blowers, decanters. Providing power factor correction panels, Capacitor banks for maintaining PF as 0.99. Dissolved Oxygen (DO) Sensors are used to know the oxygen requirement and to vary the production of air from blowers . Turbo blowers are used to have more efficiency and life even when they are costlier to Twin lobe or trilobe blowers. Noise levels are to be reduced to less than acceptable limits. Chlorination is replaced with UV disinfection to have more reliability of E Coli present in the treated outlet. Optimal use of poly electrolyte in sludge decanters like centrifuges to conserve the nature and environment. Less foot print area is preferred as the land availability in urban areas is most critical. Solar panels installation in sewage treatment plants to generate captive power and reduce the overall power requirement from the grid. Odour control systems are to be provided to reduce H2S concentration in the ambient air in treatment plant areas. This will reduce the pollution of aerosols and there by health of the operators as well as neighbouring communities.

Providing SCADA and instrumentation to monitor and operate the sewage treatment plants in optimum efficiency. Nowadays CPCB is insisting for OCEMS (Online Continuous Effluent Monitoring System) by providing sensors for measuring pH, BOD, COD, TSS and Residual Chlorine on real time basis and uploaded to the CPCB server for ensuring the plants under operation are meeting the prescribed standards. These standards are prescribed based on the end use of treated effluent.

Conclusion

This paper deals with the parameters to be considered in design of sewage collection, treatment and advanced techniques to improve the efficiency of treatment plants and concept of reuse and utilizing the by products from sewage treatment plant like biogas /grit / sludge to be used as manure or for preparation of blocks/land fill. Nutrient removal (N, P) is to be planned for all treatment plants to avoid eutrophication and growth of algae and plankton in the lakes where treated effluents are disposed. Parameters to be assessed for arriving at type of technology are effluent quality, coliforms removal, nutrient removal, land requirement, energy recovery and life cycle cost of STP. Need for a detailed performance study which will result in proposals for modernizing STP’s to conform to latest technology adopting emerging concepts like Net-zero emission and self-sustaining carbon-neutral, improving energy efficiency, Climate resilient, Zero discharge sewage treatment plant and Circular economy.

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Declaration

The data provided in this paper is only based on my work and reference available . There is no conflict of interest in this paper

There is no conflict of Interest in submitting this paper