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A Review on Working, Treatment and Performance Evaluation of Sewage Treatment Plant

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ABSTRACT
Wastewater, treated or untreated, eventually ends up in rivers, streams, lakes, and oceans. We often assume that groundwater is pure, but unfortunately, well water contaminated by sewage is a common cause of outbreaks of wastewater related diseases. Almost 80% of water supply flows back into the ecosystem as wastewater without any treatment. This can be a critical environmental and health hazard if not treated properly but its proper management could help the water managers in meeting the city's water demand. Ensuring proper wastewater treatment and disposal is as important for protecting community health as waste water treatment, and immunization programs. Untreated wastewater can spread disease and contaminate drinking water sources. Operational efficiency is always of utmost importance in treatment facilities and this has driven innovation in the sector for quite some time. The volume of wastewater generated by domestic, industrial, and commercial sources has increased with population, urbanization, improved living conditions, and economic development. The productive use of wastewater has also increased, as millions of small-scale farmers in urban and peri-urban areas of developing countries depend on wastewater or polluted water sources to irrigate high-value edible crops for urban markets, often because they have no alternative sources of irrigation water. By implementing new technology in treatment of sewage treatment plant (STP), it is in treating and exhibiting good performance in further usage. The aim of the present study is to give an insight over the various treatment methods and performance achieved in Sewage treatment plant.

Keywords – Characteristics, Removal Efficiency, STP, Wastewater

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I. INTRODUCTION

Water is the most valuable resource in the world, and is now under threat due to human population and technical development. Since water is under demand to the human race, it has to be used efficiently [1]. One quarter of the world's population is affected by economic water scarcity. Due to the growth of population, consumption of water resources is more and availability is less, so the demand for water is increasing [2]. Wastewater treatment is a process of intensive use of resources, mainly energy, which accounts for 15 to 40% of the operating costs in conventional wastewater treatment systems. With the expected demographic increase and the restrictive trend in quality standards for effluent discharge, the energy consumption tends to increase further if there are no changes in the processes [3]. Wastewater is liquid waste discharged by domestic residences, commercial properties, industry, agriculture, which often contains some contaminants that result from the mixing of wastewater from different sources [4]. The water discharged is found highly organic in nature with high COD consisting of easily biodegradable sugars, soluble starch, ethanol and volatile fatty acids [5]. Various types of reactors are in use for the treatment of wastewater sources. Fluidized Bed Biofilm Reactor (FBBR) is one of the recent methods used in this field [6]. Considering the increased milk demand, the dairy industry in India is expected to grow rapidly and have the waste generation and related environmental problems are also assumed increased importance [7].

Wastewater also accounts as the by-product of municipal, agricultural and industrial activity. The chemical composition of wastewater reflects the origin from which it comes, and also known as environmental forensics [8]. Sustainable wastewater treatment technologies are gaining attention of policy-makers and industries for meeting the required pollution guidelines laid down by the regulators of the countries and conservation of natural resources [9]. Also the zones of pollution and recovery in stream may be lengthened materially, to the disadvantage of other industries of communities [10]. However, a typical sewage treatment plant flow diagram is represented in Fig. 1.

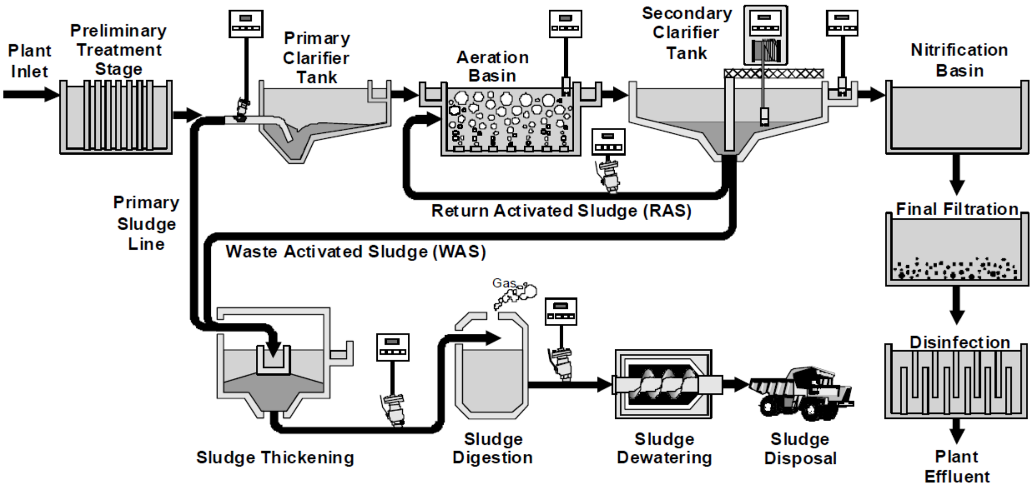

Fig.1: Typical sewage treatment plant flow diagram [2]

The aeration basin effluent (also called "mixed liquor") is transferred to the secondary clarifier. Here the activated sludge settles to the bottom and the clear effluent is pumped to a nitrification basin. Controlling waste sludge rates helps the plant run more efficiently. This can be accomplished many ways, but most plants choose to keep their mixed liquor suspended solids (MLSS) concentration in within the specific concentration range. The nitrification basin effluent flows into a mix tank where aluminum sulfate (alum) is added to precipitate phosphorus. This is followed by adding polymer and flocculent to improve settling characteristics. The effluent is then polished by a gravity filtration process typically consisting of anthracite coal and/or sand filters. The effluent from the gravity filters is disinfected with chlorine and aerated to increase the dissolved oxygen in the water.

Finally, it is de-chlorinated with sulfur dioxide and released from the plant. Wastewater has physical characteristics such as temperature, solids, odour and color. However, the chemical characteristics are nitrogen, phosphorus, dissolved oxygen, BOD, and COD as well as others that may affect its composition and pH rating. Bacteria, viruses, and parasites make up the biological characteristics of wastewater. Wastewater contains vast quantities of bacteria and other organisms which may cause impact on the environment if not treated before discharge into the natural system.

VARIATION OF DIFFERENT PARAMETERS IN STP

pH and Conductivity

Kulkarni et al. (2016) have conducted studies on sewage quality and states that the pH at the inlet is 6.2 to 6.9 and at the outlet is 7.1 to 7.5, pH increased by analysis of batch reactor mode process [11]. The study result of grey-water management systems as design for efficient and decentralized grey-water sewage treatment by Ashok et al. (2018) states that the pH at the inlet is 6.5 to 8.5 and at the outlet is 6.5 to 8.5, pH remained constant by the analysis of flow characteristics and specific energy consumption of a membrane bio-reactor (MBR) [12]. Agyemang et al. (2013) have conducted studies on water quality assessment of a wastewater treatment plant, and states that the pH at the inlet is 10.8 to 11.6 and at the outlet is 7.9 to 8.9, pH decreased by dosing of sulfuric acid to the influent in treatment process [13]. The study result of performance evaluation of sewage treatment plant at and cost effective measures in treatment process conducted by Negi and Sahu (2015) states that the pH at the inlet is 7.89mg/l and at the outlet is 7.42mg/l [14]. RajKumar (2016) has conducted study on evaluation of biological approach for the effluent treatment, and states that the pH at the inlet is 7.19 and at the outlet is 7.5 [15]. Agyemang et al. (2013) have conducted studies on water quality assessment of a wastewater treatment plant in a beverage industry, and states that the conductivity at the inlet is 1750.1±100.6 µS/cm and at the outlet is 842.8±58.8 µS/cm [13]. The study of treatment efficacy of algae-based sewage treatment plant by Durga et al. (2013) tabulates the results as conductivity at the inlet is 978 µS/cm and at the outlet is 1,082 µS/cm [16]. Khushwah et al. (2012) have study on water quality assessment of raw sewage, and stated as conductivity in the inlet is 2.232 µS/cm and at the outlet is 1.438 µS/cm and the effluent quality does not appear to be compliant with the regulation for electrical conductivity [33]. Khushwah et al. (2011) have study on seasonal variation of physicochemical parameters of waste water, and stated as conductivity in the inlet is 1.914 µS/cm and at the outlet is 1.325 µS/cm and the effluent quality stated as regularity limits for domestic use [34]. A review of variation in pH and conductivity is represented in Table 1.

Table 1: Review of variation in pH and conductivity in STP plant.

Author	pH		Remarks	Ref.
	Inlet	Outlet		
Kulkarni et al. (2016)	6.2 to 6.9	7.1 to 7.5	pH Increases, due to the cyclic activated sludge treatment Process System is operated in a batch reactor mode.	[11]
Ashok et al. (2018)	6.5 to 8.5	6.5 to 8.5	pH remains same, since water effluent quality has higher energy and operational costs.	[12]
Agyemang et al. (2013)	10.8 to 11.6	7.9 to 8.9	pH decreased, and could be attributed to the dosing of sulfuric acid to the influent wastewater.	[13]
Negi and Sahu (2015)	7.89	7.42	pH decreases, water quality at SBR outlet is found to be good enough for irrigation purposes.	[14]
Rajkumar (2016)	7.19	7.5	Determines the feasibility of a particular sample.	[15]
Author	**Conductivity (µS/cm)**		**Remarks**	**Ref.**
	Inlet	**Outlet**		
Durga et al. (2013)	978	1,082	Higher algal abundance.	[16]
Agyemang et al. (2013)	1750±10	842±58	The effluents wastewater was unsatisfactory.	[13]
Khushwah et al. (2012)	2.232	1.438	35.57% of reduction and the effluent quality do not appear to be compliant with the regulation for electrical conductivity.	[33]
Khushwah et al. (2011)	1.914	1.325	Stated as regularity limits for domestic use.	[34]

Biochemical oxygen demand (BOD) and Dissolved oxygen (DO)

Agyemang et al. (2013) has conducted studies on water quality assessment of a wastewater treatment plant, and states that the BOD at the inlet is 1116.8±192.7 mg/l and at the outlet is 49.8±32.9 mg/l [13]. The study of design of sewage treatment plant units, by Patil et al. (2018) tabulates the results as BOD at the inlet is 198.67mg/l and at the outlet is 30 –200mg/l [17]. Rajkumar (2016) have conducted study on evaluation of biological approach for the effluent treatment, and states that the BOD at the inlet is 225mg/l and at the outlet is 9mg/l [15]. The study result of decentralized wastewater treatment conducted by Bhagwatkar et al. (2017) reported that the BOD at the inlet is 100-200mg/l and at the outlet is less than 5mg/l [18]. Negi and Sahu (2015) have conducted studies on performance evaluation of sewage treatment plant and cost effective measures in treatment process, and states that the BOD at the inlet is 201.48 mg/l and at the outlet is 20.17 mg/l [14]. Dahamsheh and Wedyan (2017) have conducted studies on evaluation and assessment of performance of wastewater treatment plants, states that the BOD at the inlet is 325.8 mg/l and at the outlet is 16.6 mg/l [19].

Agyemang et al. (2013) have conducted studies on water quality assessment of a wastewater treatment plant, states that the DO at the inlet is 3.6±0.6 mg/l and at the outlet is 5.7±0.6mg/l [13]. The study result of decentralized wastewater treatment facility conducted by Bhagwatkar et al. (2017) states that the DO at the inlet is below detection limit and at the outlet is greater than 2mg/l [18]. Hasan et al (2015) has conducted studies on effect of DO, BOD and COD of wastewater treatment plant, tabulates the results as DO at the inlet is 7.80 mg/l and at the outlet is 7.88 mg/l [20]. The study of reduction of ammonia and turbidity in wastewater of pharmaceutical industry by Bharat et al (2013) tabulates the results as DO at the inlet is 1.5 mg/l and at the outlet is 4.9 mg/l [21]. However, a review of variation of BOD and DO in STP is represented in Table 2.

Table 2: Review of variation in BOD and DO in STP plant.

Author	BOD (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Agyemang et al. (2013)	1116 ±192	49.8±32.9	93% BOD Reduction.	[13]
Patil et al. (2018)	198	30 –200	Treatment consists of solely in separating the floating materials.	[17]
Bhagwatkar et al. (2017)	100-200	<5	Self-reliable sanitation solution.	[18]
Negi and Sahu (2015)	201.48	20.17	Post ultra-filters quality of treated water.	[14]
Rajkumar (2016)	225	9	Paper board industry wastewater stable operation and removal performance.	[15]
Dahamsheh and Wedyan (2017)	325.8	16.6	93.7- 96.6 % in reduction.	[19]
Author	**DO (mg/l)**		**Remarks**	**Ref.**
	Inlet	**Outlet**		
Agyemang et al. (2013)	3.6±0.6	5.7±0.6	21% increase in DO.	[13]
Bhagwatkar et al. (2017)	BDL*	> 2	DO level has been improved.	[18]
Hasan et al. (2015)	7.80	7.88	Oxidizing the organic matter.	[20]
Bharat et al. (2013)	1.5	4.9	Increased up to 5ppm level.	[21]

*BDL = Below detection level.

Chemical oxygen demand (COD)

Dahamsheh and wedyan (2017) has conducted studies on evaluation and assessment of performance wastewater treatment plants and states that the COD at the inlet is 315.1 to 365.6 mg/l and at the outlet is 51.2 to 56.0 mg/l [19]. The study of treatment efficacy of algae-based sewage treatment plant by Durga et al. (2013) tabulates the results as COD at the inlet is 458.7 mg/l and at the outlet is 208.0 mg/l [16]. The study result of technology selection for municipal sewage treatment, conducted by Chen et al. (2018) states that the COD at the inlet is 252 mg/l and at the outlet is 60 mg/l. Therefore, the process is technically feasible and economically rational [22]. The study result of performance evaluation of sewage treatment plant and cost effective measures in treatment process conducted by Negi and Sahu (2015) states that the COD at the inlet is 456.50mg/l and at the outlet is 25.58mg/l, due to post filtration method process [14]. Rajkumar (2016) has been conducted study on evaluation of biological approach for the effluent treatment of paper boards industry, and states that the COD at the inlet is 932mg/l and at the outlet is 56mg/l [15]. A brief review of COD removal in STP is presented in Table 3.

Total dissolved solids (TDS) and Total suspended solids (TSS)

Hangargekar and Takpere (2015) has conducted a study on wastewater treatment plant, common effluent treatment plant (CETP) and states that the TDS at the inlet is 3300 mg/l and at the outlet is 2500 mg/l [23]. Dahamsheh and Wedyan (2017) have conducted study on water quality assessment of a wastewater treatment plant in an Industry, and states that the TDS at the inlet is 862.2±56.1 mg/l and at the outlet is 839.8±59.3 mg/l [19]. The study result of performance evaluation of sewage treatment plant at and cost effective measures in treatment process conducted by Negi and Sahu (2015) states that the TDS at the inlet is 497.78mg/l and at the outlet is 434.01mg/l [14]. Rajkumar (2016) has conducted study on evaluation of biological approach for the effluent treatment of paper industry, and states that the TDS at the inlet is 1599mg/l and at the outlet is 1946mg/l [15]. The study of treatment efficacy of algae-based sewage treatment plants by Durga et al. (2013) represents the results as TDS at the inlet is 782 mg/l and at the outlet is 859 mg/l [16]. A brief review of TDS and TSS removal is presented in Table 4.

Table 3: Review of variation in COD in STP plant.

Author	COD (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Dahamsheh and Wedyan (2017)	315.1 to 365.6	51.2 to 56.0	83.3-85 % reduction in COD.	[19]
Durga et al. (2013)	458.7	208.0	60% Removal.	[16]
Chen et al. (2018)	252	60	85.1% Removal rate.	[22]
Negi and Sahu (2015)	456.50	26.58	For flushing purposes in the group housings and for construction activities.	[14]
Rajkumar (2016)	932	56	Due to conventional aeration treatment, COD value decreased by 807.	[15]

Table 4: Review of variation in TDS and TSS in STP plant.

Author	TDS (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Bhagwatkar et al. (2017)	100-200	<10	Decreased load on central sewage treatment units.	[18]
Hangargekar and Takpere (2015)	245	80	Efficient reduction.	[23]
Agyemang et al. (2013)	87.7±27	176.7±114.3	Attributed to incomplete sludge settlement during the sedimentation stage of SBR.	[13]
Negi and Sahu (2015)	238.20	13.19	Algal growth therefore chlorination is required to control algal bloom before using this water	[14]
Rajkumar (2016)	756	12	Due to removal of the progressive accumulation of pollutants.	[15]
Dahamsheh and Wedyan (2017)	264	46.1	79- 85.6 % reduction in TSS.	[19]
Author	**TSS (mg/l)**		**Remarks**	**Ref.**
	Inlet	**Outlet**		
Hangargekar and Takpere (2015)	3300	2500	Very small reduction observed in dissolved solids.	[23]
Agyemang et al. (2013)	862.2±56	839.8±59	Consistent with the EPA Ghana guideline for beverage industries discharging into water bodies.	[13]
Durga et al. (2013)	782	859	Microbial growth and MCRT.	[16]
Negi and Sahu (2015)	497	434.01	For use in cooling towers of air conditioned residential and commercial buildings	[14]
Rajkumar (2016)	1599	1946	Reducing purpose using RO plant.	[15]

The study result of decentralized wastewater treatment facility, conducted by Bhagwatkar et al. (2017) states that the TSS at the inlet is 100-200 mg/l and at the outlet is <10mg/l [18]. Agyemang et al. (2013) have conducted studies on water quality assessment of a wastewater treatment plant in a beverage industry, and states that the TSS at the inlet is 87.7±27.8 mg/l and at the outlet is 176.7±114.3 mg/l [13]. The study result of performance evaluation of sewage treatment plant at and cost effective measures in treatment process conducted by Negi and Sahu (2015) states that the TSS at the inlet is 238.20mg/l and at the outlet is 13.19mg/l [14]. Hangargekar and Takpere (2015) has conducted, a case study on wastewater treatment plant, common effluent treatment plant (CETP) and states that the TSS at the inlet is 245 mg/l and at the outlet is 80 mg/l [23]. Rajkumar (2016) have conducted study on evaluation of biological approach for the effluent treatment of paper boards industry, and states that the TSS at the inlet is 756mg/l and at the outlet is 12mg/l [15]. Dahamsheh and Wedyan (2017) has conducted studies on evaluation and assessment of performance of wastewater treatment plants and states that the TSS at the inlet is 264.8 mg/l and at the outlet is 46.1 mg/l [19].

Turbidity and Color

The study result of integrated grey-water management systems for efficient and decentralized sewage treatment, conducted by Ashok et al. (2018) states that the turbidity at the inlet is 124 mg/l and at the outlet is <0.1 mg/l [12]. Agyemang et al. (2013) have conducted studies on water quality assessment of a wastewater treatment plant in a Beverage Industry, and states that the turbidity at the inlet is 46.8±3.8 mg/l and at the outlet is 94.8±67.8 mg/l [13]. A brief representation of variation of turbidity and color in STP is presented in Table 5. Kesalkar et al. (2012) has gone through a study on physico-chemical characteristics of wastewater from paper industry, and stated that 13 hazens unit in inlet and 19 hazens unit in outlet and are not upto the permissible standards [24]. The study result of water quality assessment of a wastewater treatment plant in a beverage industry, conducted by Agyemang et al. (2013) states that the color at the inlet is 77.8±36.0 hazen unit and at the outlet is 100±41.3 hazen unit [13]. Wang et al. (2013) have conducted studies on color removal from textile industry wastewater, and states that the color removal at the inlet is 75 hazen units and at the outlet is 150 hazen units [25].

Table 5: Review of variation in Turbidity and Color in STP plant.

Author	Turbidity (mg/l) and Color (Hazen)		Remarks	Ref.
	Inlet	Outlet		
Ashok et al. (2018)	124	<0.1	Robust technological solutions.	[12]
Agyemang et al. (2013)	46.8±3.8	94.8±67.8	Turbidity value is in the range of 32 and 225.	[13]
Kesalkar et al. (2012)	13	19	Does not meet the permissible standards after treatment.	[24]
Agyemang et al. (2013)	77.8±36.0	100±41.3	93% of removal in color, by biodegradation of organic matter process.	[13]
Wang et al. (2007)	75	150	Increased level in color level.	[25]
Uysal and Bilgic (2017)	426	63	40 to 64% color removal.	[26]
Sivakumar (2014)	32	1.72	94.6% color removal.	[35]

The study result of color removal from wastewater by using aerobic filter reactors, conducted by Uysal and Bilgic (2017) states that the color at the inlet is 426 hazen units and at the outlet is 63 hazen units [26]. Sivakumar (2014) have conducted studies on color removal from textile industry wastewater, and states that the color removal at the inlet is 32 hazen units and at the outlet is 1.72 hazen units. This may be due to the application of constructed wetland using Lemna minuta L [35].

Microbial count

Achour and Chabbi (2014) have conducted studies on disinfection of drinking water-constraints and optimization, states that the microbial at the inlet is 0.05 and at the outlet is 0.0005 [28]. The study result of study on disinfection effect of different dose of rapid hand disinfectant by Xiuhua et al. (2014) states that the microbial at the inlet is 73 and at the outlet is 2, which indicate a statistically significant in recovered CFUs / microbial [29].

Ching and Hong have conducted study on design and operation of MBR type sewage treatment plant, states that the microbial at the inlet is 1.22×10^7 and at the outlet is non-detected [27]. A brief representation of variation of microbial count in STP is shown in Table 6.

Total Phosphorus

Prachi et al. (2014) have conducted study on performance evaluation of 25MLD sewage treatment plant (STP), and states that the total phosphorus at the inlet is 4.5 mg/l and at the outlet is 1.0 mg/l [30]. The study result of performance evaluation of sewage treatment plant and cost effective measures in treatment process conducted by Negi and Sahu (2015) states that the total phosphorus at the inlet is 1.55 mg/l and at the outlet is 1.22 mg/l [14]. The study result of evaluation of the efficiency of selected wastewater treatment plant conducted by Vitez et al. (2012) states that the total phosphorus at the inlet is 1.09 mg/l and at the outlet is 1.01 mg/l [31]. Shilton et al. (2006) have conducted study on Phosphorus removal by an active slag filter and states that the total phosphorus at the inlet is 8.6 mg/l and at the outlet is 8.9 mg/l [32]. A representation of variation in total Phosphorus is shown in Table 7.

Table 6: Review of variation in Microbial count in STP plant.

Author	Microbial (MPN/100ml)		Remarks	Ref.
	Inlet	Outlet		
Ching and Hong (2009)	1.22×10^7	Non-Detected	MBR technique proves almost 100% removal of microbial.	[27]
Achour and Chabbi (2014)	0.05	0.0005	99% of the removal of MO due to the application of chlorine.	[28]
Xiuhua et al. (2014)	73	2	Indicating a statistically significant in recovered CFUs / microbial.	[29]

Table 7: Review of variation in Total phosphorus in STP plant.

Author	Total Phosphorus (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Prachi et al. (2014)	4.5	1.0	71.79% of removal in total phosphorus	[30]
Negi and Sahu (2015)	1.55	1.22	Treating with the Ultra Filters polishing.	[14]
Vitez et al. (2012)	1.09	1.01	Reduction efficiency is about 6.9%.	[31]
Shilton et al. (2006)	8.6	8.9	Reduction efficiency is about 72%.	[32]

II. CONCLUSIONS

A brief review on the various techniques for wastewater treatment has been considered in the present study. An attempt was also made to understand how the concentrations of various parameters change in different treatment techniques. The pH decreases by dosing sulfuric acid, and the water treated from the SBR can be used for irrigation purpose. The conductivity parameter is unsatisfactory since there is no effective change in the outlet, when compared with the standard drop values. The post ultra-filter, reliable sanitation solution and stable operation help in decreasing and removal of the BOD parameters effectively in the outlet. The investigations on the treatment efficiencies of the STP showed moderate treatment levels with 90% BOD removal. Total dissolved solids consist of both the organic and inorganic molecules and ions present in the true solution of the wastewater. It was noted that both average influent and effluent TDS results were consistent. This may be due to, the use of conventional treatment techniques. Conventional aeration treatment provided a high reduction of TSS. The high mean effluent, TSS value could be attributed to incomplete sludge settlement during the sedimentation stage of SBR. Self-reliable sanitation solutions are some of the well-known techniques. Decreased load on central sewage treatment units helps in efficient treatment process. Zero discharge norm for colonies, recycling and reuse of water for various purposes.

Use of waste water as a resource can help out in consuming fresh water for gardening, flushing, and curing of concrete. Tertiary treatment of wastewater is required to reuse it for various applications. Also, the appropriate technology should be judiciously being chosen for a particular degree of treatment. The treated water based on its final quality can be further decided for different applications. Due to improper sewage treatment system, many of the institutions discharge there wastewater directly to the surroundings. If they are released into the environment without any treatment, our natural water bodies will be severely affected. As we cannot deny the contribution of educational institutes, the wastewater must be treated before releasing into the environment, however the final quality must be checked before discharge into any system.

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