An Overview of Performance Evaluation of Sewage Treatment Plant

Ankit[1], S.K. Singh[2]
[1, 2] Environmental Engineering, Delhi Technological University, Delhi, India

Abstract

Sewage whether treated or untreated, ultimately discharge in lakes, rivers, streams, and oceans. We consider groundwater as pure, but unfortunately, sewage is one of the major reason behind wastewater associated diseases. Nearly 78% of the water flows back to the environment without any treatment. This can lead to a numerous health and environmental problems so it is better to treat wastewater before disposal and further proper management can help in meeting the public's water demand. As per today's scenario, number of innovations are required to operate treatment plant at high efficiency because of increasing domestic, commercial, and industrial waste. And this rise is taking place due to several reasons – urbanization, increasing population, economic development, and improved living conditions etc. Nowadays people of both urban and peri-urban areas are using waste water to irrigate their crops, often because they do not have any alternate source of irrigation water. New technologies are continuously being introduced in sewage treatment plant to exhibit good performance. The paper focuses on reviewing the various sewage treatment methods and their results.

Keywords – STP, Wastewater, Removal Efficiency, Characteristics

1. Introduction

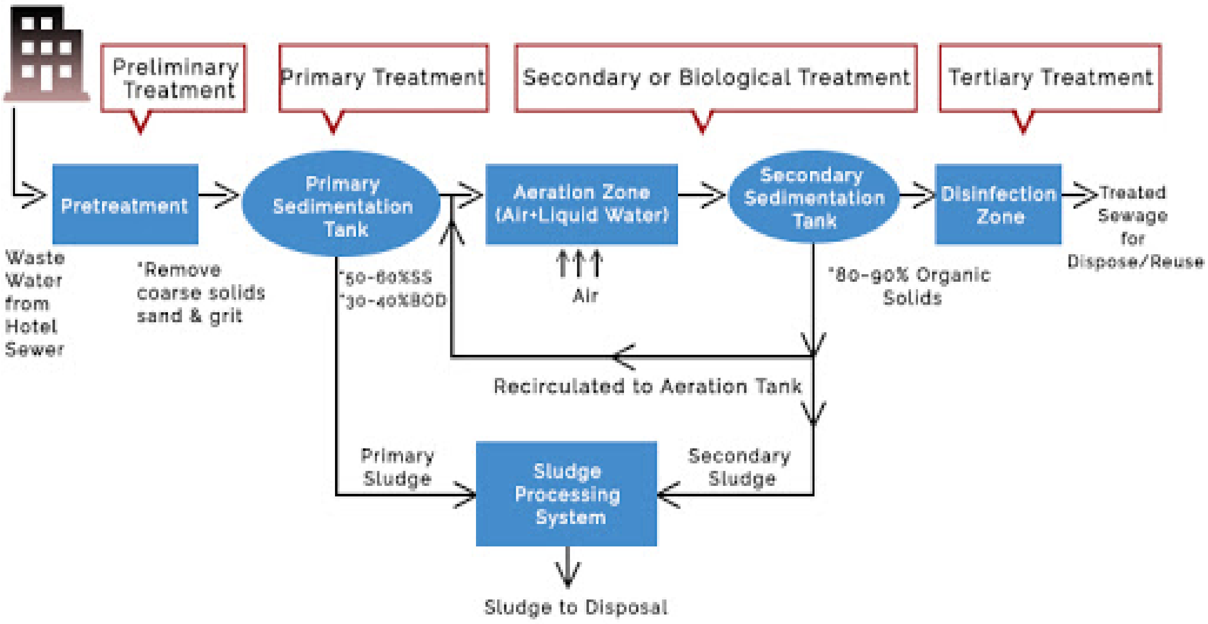
Water is the most significant resource in the world, and now is in danger due to urbanization, increasing population, inadequate rainfall, climatic change, and economic development etc. Water is required to be used efficiently due to its increasing demand [1]. This can be achieved by using existing sources of water with proper management and adopting both traditional and modern approach for improving efficiency such as ground water recharge, conservation of water, and reuse of waste water etc. Among all the methods, reuse of waste water has become the most important for both economic and environment reasons. Earlier wastewater after treatment was used in agricultural activities but nowadays it is intensifying its applications in urban, industrial and construction industry. The important pathways for reuse of waste water contains surface water replenishment, irrigation, ground water recharge, and industrial use [2]. The volume of water carried through each pathway depends on degree of water utilized for different purpose, climatic factors, watershed characteristics, quantity of direct and indirect water reuse. Also water problems are in need of immediate assistance because of increasing environmental hazards to human health.

1.1 Sewage Treatment Plant

Sewage is the waste produced from institutional, industrial, residential, and commercial establishments. Sewage treatment involves number of stages for eliminating the contaminants from household or industrial sewage water [3]. Sewage treatment plant treats the waste water/sewage before its disposal into the water body so that it can be used in domestic or agricultural activities safely. Sewage consists of high quantity of inorganic and organic wastes. It becomes very important to treat sewage appropriately before letting into any source of water.

1.2 Working of Sewage Treatment Plant

Sewage treatment involves several stages in treatment process and is mentioned below:



- **Preliminary Treatment:** This is the initial stage/ first stage of wastewater treatment which includes removal of large materials or coarse solids usually found in raw water. This treatment consists of filtering screen which helps in breaking the large objects to prevent blockage in treatment process. Preliminary treatment stage also includes flow measurement devices.
- **Primary Treatment:** This treatment takes place after preliminary treatment which aims to reduce any kind of heavy solids that are settled at the bottom due to sedimentation while light solids like oil and grease float over the surface by skimming [3]. After removing the both floating and settled materials the remaining liquid is discharged to next stage of treatment. The efficiency of primary treatment is to remove around 60% of suspended solids from sewage.
- **Secondary Treatment:** This treatment takes place after removal of floating and settled materials from the sewage which aims at removing suspended and dissolved biological matter. Secondary sludge which is removed during secondary sedimentation is generally mixed with primary sludge for sludge processing. This treatment involves a separation process for removal of microorganisms from treated water before moving to next stage of treatment. The efficiency of secondary treatment is to remove around 90% of suspended solids from sewage.
- **Tertiary/Advanced Treatment:** This treatment takes place after secondary treatment and aims at removing those sewage constituents which were not removed in prior

stages. Sometimes treated sewage is disinfected physically or chemically before its discharge into the ecosystem (river, sea, wet lands, lake, ground, etc.

LEVEL OF TREATMENT REQUIRED FOR DIFFERENT PURPOSES

Sr. No.	Purpose/Use	Level of Treatment
1	Direct use	Sixth level treatment with RO
2	Indirect potable use	Fifth level treatment
3	Industrial non potable use	Fourth level treatment
4	Restricted Urban use	Tertiary treatment
5	Irrigation	Secondary treatment

2. Literature Review based on variation of different parameters in Sewage Treatment Plant

2.1 Dissolved Oxygen and Biochemical Oxygen Demand

Hassan et al. (2015) conducted study on BOD, COD, and DO of sewage treatment plant, which recorded 7.78 mg/l at receiving point and 7.82 mg/l at outlet [4]. The research on water quality assessment of sewage treatment plant is conducted by Agyemang et al. (2013) which gave 3.6±0.6 mg/l DO at receiving point and 5.7±0.6 mg/l DO at outlet [5]. Bhagwatkar et al. (2017) conducted a study of decentralized sewage treatment which stated DO at receiving point is lower than detection limit and greater than 2 mg/l at outlet [6]. Also a Bhaarat et al. conducted a study on wastewater of pharmaceutical industry which resulted in 1.4 mg/l DO at receiving point and 4.5 mg/l at outlet [7].

Rajkumar (2016) performed a study on interpretation of biological method for the sewage treatment and found 225mg/l BOD at receiving point and 9mg/l at outlet [8]. A study on water quality assessment of sewage treatment plant was conducted by Agyemang et al. (2013) which recorded 1118.6±182.5 mg/l BOD at receiving point and 45.7±35.2 mg/l at outlet [5]. Patil et al. (2018) performed a study on design of sewage treatment plant units which stated BOD of 189.78 mg/l at receiving point and 30-150 mg/l at outlet [9]. The outcome of study conducted by Bhagwatkar et al. (2017) on decentralized sewage treatment reported 100-200 mg/l at receiving point and less than 5 mg/l at outlet [6]. Dahamsheh and Wedyan (2017) performed a study on interpretation of performance of sewage treatment plant which recorded BOD of 335.7 mg/l at receiving point and 15.5 mg/l at outlet [10]. Sahu and Negi (2015) studied performance evaluation of waste water treatment plant which recorded BOD of 200.46 mg/l at receiving point and 22.6 mg/l at outlet [11].

Author	DO (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Agyemang et al. (2013)	3.6±0.6	5.7±0.6	21% increase in DO.	[5]
Bhagwatkar et al. (2017)	BDL*	> 2	Dissolved Oxygen level improved	[6]
Hasan et al. (2015)	7.78	7.82	Organic matter was oxidized.	[4]

Bharat et al. (2013)	1.4	4.5	Increased up to 5ppm level.	[7]
Author	**BOD (mg/l)**		**Remarks**	**Ref.**
	Inlet	**Outlet**		
Agyemang et al. (2013)	1118 ±192	45.7±35.2	93% BOD Reduction.	[5]
Patil et al. (2018)	189.78	30 –150	Treatment contained solely in separating the suspended materials.	[9]
Bhagwatkar et al. (2017)	100-200	<5	Self-reliabale sanitation solution.	[6]
Sahu and Negi (2015)	200.46	22.6	Post ultra-filters quality of treated water.	[11]
Rajkumar (2016)	225	9	Paper board industry sewage treatment operation and removal performance.	[8]
Dahamsheh and Wedyan (2017)	335.7	15.5	93.7- 96.6 % of BOD lowered	[10]

Review based on variation in DO and BOD in STP plant

2.2 Conductivity and pH

A study on water quality assessment of sewage treatment plant was conducted by Agyemang et al. (2013) which results in conductivity of 1748.6±20 µS/cm at receiving point and 840±48 µS/cm at outlet. Durga et al. (2013) performed the study on treatment efficiency of algae based waste water treatment plant which stated conductivity of 987 µS/cm at receiving point and 1080 µS/cm at outlet [12]. The outcome of study conducted by Khushwah et al. (2012) reported conductivity of 2.323 µS/cm at receiving point and 1.423 µS/cm at outlet [13]. And Khushwah et al. (2011) performed a study on seasonal variation of physiochemical parameters of sewage and found conductivity of 1.815 µS/cm at receiving point and 1.235 µS/cm at outlet [14].

Kulkarni et al. (2016) performed a study on waste water quality and found pH of 6.2-6.9 at receiving point and pH of 7.1-7.5 at outlet, batch reactor mode process increased the pH value [15]. A study on sewage water management system was conducted by Ashok et al. (2018) for design of decentralized waste water treatment which stated pH of 6.5-8.5 at receiving point and 6.5-8.5 at outlet [16]. The research on water quality assessment of sewage treatment plant is conducted by Agayemang et al. (2013) which stated pH of 10.6-11.4 at receiving point and 7.7-8.7 at outlet. The pH decreased because of sulphuric acid used in the treatment process. Sahu and Negi (2015) conducted a study on performance evaluation of waste water treatment plant which recorded pH of 7.5 at receiving point and 7.1 at outlet [11]. Rajkumar (2016) performed a study on interpretation of biological method for the sewage treatment and found pH of 7.20 at receiving point and 7.5 at outlet [8].

Review based on variation in conductivity and pH in Sewage Treatment Plant

Author	Conductivity(µS/cm)		Remarks	Ref.
	Inlet	Outlet		

Durga et al. (2013)	987	1,080	Higher algal abundance.	[12]
Agyemang et al. (2013)	1750±20	840±48	The sewage obtained after treatment records unsatisfactory results.	[5]
Khushwah et al. (2012)	2.323	1.423	32.37% of reduction and sewage quality did not appear to comply with electrical conductivity.	[13]
Khushwah et al. (2011)	1.815	1.235	Defined domestic usage limits.	[14]

Author	pH		Remarks	Ref.
	Inlet	Outlet		
Kulkarni et al. (2016)	6.2 to 6.9	7.1 to 7.5	pH value increased because of cyclic activated treatment process.	[15]
Ashok et al. (2018)	6.5 to 8.5	6.5 to 8.5	pH value remained constant	[16]
Agyemang et al. (2013)	10.6-11.4	7.9 to 8.9	pH value decreased because of sulphuric acid	[5]
Sahu and Negi (2015)	7.50	7.10	pH value decreased, water after treatment obtained at outlet was found to be suitable for irrigation purposes.	[11]
Rajkumar (2016)	7.20	7.5	Determined feasibility of particular sample.	[8]

2.3 Chemical Oxygen Demand

Dahamsheh and Wedyan (2017) performed a study on interpretation of performance of sewage treatment plant which recorded COD of 314.6-356.4 mg/l at receiving point and 50.2-55 mg/l at outlet [10]. Durga et al. (2013) performed the study on treatment efficiency of algae based waste water treatment plant which stated COD of 455.7 mg/l at receiving point and 206 mg/l at outlet [12]. Chen et al. (2018) performed a study on technology choice for municipal waste water treatment which recorded COD 250 mg/l at receiving point and 55mg/l at outlet [17]. Rajkumar (2016) performed a study on interpretation of biological method for the sewage treatment and found COD of 930 mg/l at receiving point and 55 mg/l at outlet [8]. Sahu and Negi (2015) conducted a study on performance evaluation of waste water treatment plant which recorded COD of 455.50 mg/l at receiving point and 25.58 mg/l at outlet [11]. The values of COD obtained from various papers is listed below in table.

Review based on variation in COD of Sewage Treatment Plant

Author	COD (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Dahamsheh and Wedyan (2017)	314.6-356.4	50.2-55.0	83.3-85 % reduction in COD.	[10]
Durga et al. (2013)	455.7	206.0	55% Removal.	[12]

Chen et al. (2018)	250	55	82% Removal.	[17]
Rajkumar (2016)	930	55	Conventional aeration treatment decreased COD value by 876.	[8]
Sahu and Negi (2015)	455.50	25.58	Recommend use in flushing purpose or construction activities.	[11]

2.4 Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

Bhagwatkar et al. (2017) conducted a study of decentralized sewage treatment which stated TSS of 100-200 mg/l at receiving point and <10 mg/l at outlet [6]. A study on water quality assessment of sewage treatment plant was conducted by Agyemang et al. (2013) which recorded TSS of 85±25 mg/l at receiving point and 175±110 mg/l at outlet [5]. Sahu and Negi (2015) conducted a study on performance evaluation of waste water treatment plant which stated TSS of 235 mg/l at receiving point and 13 mg/l at outlet [11]. Hangargekar and Takpere (2015) performed a case study on sewage treatment plant and common sewage treatment plant which recorded TSS of 240 mg/l at receiving point 80 mg/l at outlet [18]. Dahamsheh and Wedyan (2017) conducted a study on interpretation of performance of sewage treatment plant which resulted in TSS of 264 mg/l at receiving point and 46.1 mg/l at outlet [10]. Rajkumar (2016) performed a study on interpretation of biological method for the sewage treatment and found TSS of 755 mg/l at receiving point and 12 mg/l at outlet [8].

Hangargekar and Takpere (2015) performed a case study on sewage treatment plant and common sewage treatment plant which recorded TDS of 3300 mg/l at receiving point and 2500 mg/l at outlet [18]. A study on assessment of sewage water treatment plant was conducted by Agayeamang et al. (2013) which results in TDS of 860±55 mg/l at receiving point and 830±58 mg/l at outlet [5]. Sahu and Negi (2015) conducted a study on performance evaluation of waste water treatment plant which recorded TDS of 498 mg/l at receiving point and 430 mg/l at outlet [11]. A study on interpretation of biological method for sewage treatment was conducted by Rajkumar (2016) which stated TDS of 1595 mg/l at receiving point and 1945 mg/l at outlet [8]. Durga et al. (2013) performed the study on treatment efficiency of algae based waste water treatment plant which resulted in TDS of 780 mg/l at receiving point and 850 mg/l at outlet [12]. The values of TSS and TDS obtained from various papers is listed in table below.

Review based on variation in TSS and TDS of STP plant

Author	TDS (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Hangargekar and Takpere (2015)	3300	2500	Very small reduction observed in dissolved solids.	[18]
Agyemang et al. (2013)	860±55	830±58	Reliable with the EPA Ghana Guideline for beverage industries discharging into water bodies.	[5]
Durga et al. (2013)	780	850	Microbial growth.	[12]
Sahu and Negi (2015)	498	430	Recommend use in cooling towers.	[11]
Rajkumar (2016)	1595	1945	Reduced values using RO plant.	[8]

Author	TSS (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Bhagwatkar et al. (2017)	100-200	<10	Load on intermediate sewage treatment units decreased.	[10]
Hangargekar and Takpere (2015)	240	80	Efficient reduction.	[18]
Agyemang et al. (2013)	85±25	175±110	Partial sludge settlement	[5]
Sahu and Negi (2015)	235	13	Chlorination is required before using this water.	[11]
Rajkumar (2016)	755	12	Removal of the pollutants.	[8]
Dahamsheh and Wedyan (2017)	264	46.1	79- 85.6 % decrease in TSS.	[10]

2.5 Turbidity and Colour

A study on sewage water management system was conducted by Ashok et al. (2018) for design of decentralized waste water treatment which stated turbidity of 122 mg/l at receiving point and <0.1 mg/l at outlet [16]. The research on water quality assessment of sewage treatment plant was conducted by Agyemang et al. (2013) which recorded turbidity of 45.6±3.6 mg/l at receiving point and 92.6±65.4 mg/l at outlet [5]. Kesalkar et al. (2012) performed a study on physiochemical characteristics of sewage from paper industry and recorded 13 hazen units at receiving point and 18 hazen units at outlet which did not lie in the permissible limits [19]. Wang et al. (2013) performed a study on textile industry sewage for colour removal which stated 70 hazen units at receiving point and 140 hazen units at outlet [20]. The study on water quality assessment of sewage treatment plant was conducted by Agyemang et al. (2013) which obtained 75.8±35 hazen units at receiving point and 100±40 hazen units at outlet [5]. Sivakumar (2014) performed a study on textile industry sewage for colour removal and recorded 30 hazen units at receiving point and 1.62 hazen units at outlet [21]. This might be due to application of constructed wetland using Lemna minute L. Uysal and Biligic (2017) conducted a study on colour removal from sewage by using aerobic filter reactors which recorded 425 hazen units at receiving point and 62 hazen units at outlet [22].

Review based on variation in Turbidity and Colour

Author	Turbidity (mg/l) and Color (Hazen)		Remarks	Ref.
	Inlet	Outlet		
Ashok et al. (2018)	122	<0.1	Complex technical solutions.	[16]
Agyaemang et al. (2013)	45.6±3.6	92.4±65.6	Turbidity value lies in the range of 30-220.	[5]
Kesalkar et al. (2012)	13	18	Do not lie in the permissible limits after treatment.	[19]
Agyemang et al. (2013)	75.8±35	100±40	92% of removal in color, by biodegradation of organic matter.	[5]

Wang et al. (2007)	70	140	Color level is increased.	[20]
Uysal and Bilgic (2017)	425	62	30 to 54% color removal.	[22]
Shivakumar (2014)	30	1.62	94 % color removal.	[21]

2.6 Total Phosphorus

Sahu and Negi (2015) conducted a study on performance interpretation of waste water treatment plant which recorded 1.50 mg/l of total phosphorus at receiving point and 1.20 mg/l at outlet [11]. Prachi et al. (2014) performed a study on performance interpretation of 25MLD waste water treatment plant and found 4.0 mg/l of total phosphorus at receiving point and 1.5 mg/l at outlet [23]. A study was conducted by Vitez et al. (2012) for interpretation of efficiency of sewage treatment plant which stated 1.08 mh/l 0f total phosphorus at receiving point and 1.00 mg/l at outlet [24]. Shiilton et al. (2006) performed a study on phosphorus removal and found 8.5 mg/l of total phosphorus at receiving point and 8.8 mg/l at outlet [25]. The variation in values of total phosphorus is shown in table.

Review based on values of Total Phosphorus

Author	Total Phosphorus (mg/l)		Remarks	Ref.
	Inlet	Outlet		
Prachii et al. (2014)	4.0	1.5	72.79% of total phosphorus is removed.	[23]
Sahu and Negi (2015)	1.50	1.20	Treatment with Ultra Filters.	[11]
Viteaz et al. (2012)	1.08	1.00	Reducing efficiency is about 7%.	[24]
Sheilton et al. (2006)	8.5	8.8	Reducing efficiency is about 70%.	[25]

2.7 Microbial Count

Xiuhua et al. (2014) conducted a study on different dose of disinfectant and recorded 70 microbial at receiving point and 2 at outlet [26]. Chabi and Acour (2014) performed a study on disinfection of drinking water constraints and found 0.05 microbial at receiving point and 0.0005 at outlet [27]. Also Hong and Chiing (2009) performed a study on design of MBR type waste water treatment plant, which records 1.24×10^7 microbial count at receiving point and no value got detected at outlet [28]. The variation of microbial count is shown in table below.

Review based on Microbial Count

Author	Microbial (MPN/100ml)		Remarks	Ref.
	Inlet	Outlet		
Hong and Chiing (2009)	1.24×10^7	Not- Detected	MBR technique found to be effective in almost 100% removal of microbial.	[28]
Chabi and Acour (2014)	0.5	0.005	99% of the removal of microorganisms is due to the application of chlorine.	[27]

Xiehua et al. (2014)	70	2.2	Found statistically significant in recovering microbial count.	[26]

3. Conclusion

The paper focuses on reviewing the various sewage treatment methods and their results. An effort is put to comprehend how the concentrations of different parameters change with change in treatment method. After going through various papers it was found that final value of conductivity obtained at outlet do not match with the standard values. Sewage treatment plant when investigated for determining efficiency of treatment recorded moderate level of treatment with 90% removal of BOD. The results of both influent and effluent TDS were found to be consistent.

Sewage after treatment in STP can be used as an alternative to fresh water in gardening, flushing and many other activities. The level of treatment is based on the purpose which will help in deciding the technology to be used. If sewage is permitted to enter water bodies without any treatment, it will be hazardous. Hence it is recommended to treat before releasing into the ecosystem.

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