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Performance and Evaluation of Sewage Treatment Plant Based on UASB

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Abstract:

The present study deals with the evaluation the performance of 339 million liter per day (MLD) Sewage Treatment Plant located at Amberpet, Hyderabad which is based on Up-flow Anaerobic Sludge Blanket Process (UASB). Performance of this STP is an essential parameter which was measured by the quality of treated effluent discharged into Musi River. Sewage samples were collected from the influent and effluent of the treatment plant and analyzed for the physico-chemical and microbiological parameters, such as pH, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand, total suspended solids, volatile fatty acids, alkalinity, sulphate, sulphide and fecal coliforms as per standard methods. The effluent sample showed more than 90% of impurities removal by UASB technology, which indicates the better efficiency and performance of the STP.

Keywords: Efficiency, Performance, Pollutants, Sewage, UASB Process, Water Quality

1.0 Introduction:

The treated water management objectives of sewage treatment are related with the efficient removal of pollutants and to preserve and protect natural water resources. Human health protection from the pathogenic organisms present in the sewage prior to the treated effluent being discharged to the receiving water bodies is of specific concern. The purpose of sewage treatment is to remove the organic and inorganic solids where the organic solids are decomposed by microorganisms and inorganic solids due to sedimentation. As the rivers are the major sources of drinking water, the treatment of sewage becomes necessary before discharging into the rivers (Ansari, 2013). Sewage is grey water, in suspension or solution that is intended to be removed from a community which is also known as wastewater. This wastewater consists of 99% water and is characterized by volume, physical condition, chemical and toxic constituents, and the bacteriological organisms. It consists mostly of grey water (from sinks, tubs, showers, dish and clothes washers, and toilets) and the human waste that the toilets flush away; soaps and detergents; and toilet paper (less so in regions where bidets are widely used instead of paper (Singh, et al., 2011).The main function of wastewater treatment plants is to protect human health and the environment from excessive overloading of various pollutants. Due to industrial development, domestic effluent and urban run-off contribute the bulk of wastewater generated in Hyderabad city. Sewage from domestic source comprises of spent water from kitchen, bathroom, lavatory etc. The factors which contribute to variations in characteristics of the domestic sewage are daily per capita water use, quality of water, supply, type, condition, extent of sewerage system and habit of the people (Rooklidge, et al., 2003).

Domestic wastewater is one of the largest sources of pollution by volume. Domestic wastewater normally receives treatment in sewage treatment plant before being released into the environment. The higher the level of the treatment efficiency and performance provided by a wastewater treatment plant, the cleaner the effluent and the lesser the impact on the environment (Aslan, et al., 2007).Despite domestic sewage treatment some pollutants remain in treated wastewater which is discharged into surface waters. Treated domestic wastewater may contain grit, debris, disease-causing bacteria, nutrients and many chemicals such as those in drugs and in personal care products like shampoo and cosmetics. Nowadays, society demands that all processes, products or services must be analyzed from an environmental point of view. Therefore it is necessary to analyze the system to determine the overall pollution associated to these activities. Rapid growth and urbanization of city over past few decades has given rise to innumerable problems and one among is domestic sewage. One of the major problems is the deterioration of water quality in Musi River due to more or less unrestricted disposal of large volumes of domestic and industrial wastewater (Bartamas, et al., 2013).

2.0 Materials and Methods:

2.1 Study Area:

Hyderabad is the capital city of the Indian state of Telangana. Greater Hyderabad has an estimated metropolitan population of 6.7 million, making it an A-1 status city and the second largest (in terms of area) in the country. It is also the 6^{th} largest metropolitan area in India. Hyderabad is known for its rich history, culture and architecture representing its unique character as a meeting point for North and South India, and its multilingual culture, both geographically and culturally. Situated on the Deccan Plateau, Hyderabad has an average elevation of about 500 meters above sea level (1640 feet). Most of the area has a rocky terrain. The rapid growth of the city, along with the growth of Secunderabad and neighboring municipalities has resulted in a large and populous metropolitan area. Hyderabad has a tropical wet and dry climate, with hot summers from March to June, the wet monsoon season from July to October and warm dry winters from November to February with an annual precipitation around 79 cm (Govindswamy, et al., 2006).

2.1339 MLD Sewage Treatment Plant, Amberpet:

Most of the treatment schemes using UASB technology include grit chamber as preliminary treatment unit and one-day retention time pond as the terminal polishing unit which is depicted in Figure 1. Operationally, this treatment scheme is one of the most economical ones, as it merely requires passing the sewage through treatment scheme, with an added advantage of biogas generation. Ideally, this makes UASB technology as the most suited for cities of all sizes (Palamthodi, et al., 2011).The STP built in Amberpet is the largest in the country and also one of the biggest plants in Asia and its salient features is highlighted in Table 1. The STP with UASB (Up Flow Anaerobic Sludge Blanket) Technology in terms of capacity (339 MLD) is tapped from combined chamber. Pretreatment unit consists of 4 mechanical screens, 2 manual screens to prevent floating materials and conveyor belt for disposing screened materials and 4 degritting units of 56.5 MLD capacities for removal of grit. Grit is disposed through rake classifier mechanism. 226 MLD sewage from these new units and 113 MLD sewage from the existing plant is collected in wet well of pump house and pumped to reactors by 12 pumps (12 Working + 6 Standby) of 160 Kw (210 HP) capacity to a head of +17.0 Mts over a length of 1.5 Km through 2 lines of M.S. 1800 mm diameter pipe lines. UASB Reactors (24 nos of each size 32 Mtsx 28 Mtr x 5.8 Mtr Liquid depth) is the place where the separation of gas, liquid and solids stakes place. The reduction of BOD is 75% in reactors.

In this process the whole waste is passed through the anaerobic reactor in an upflow mode with a Hydraulic Retention Time (HRT) of 8.8 Hrs. The up flowing sewage itself forms millions of small granules or particles of sludge which are in suspension and provide a large surface area on which organic matter undergo biodegradation which is depicted in Figure 2. The high solid retention time (SRT) of 33 days occurs within the unit. Excess sludge is removed and taken to sludge pump house and pumped to Belt Press where moisture is removed and it is formed into sludge cakes, which can be used as Manure (165 Cum/day). Organic compounds get anaerobically biodegraded converting it into methane – enriched biogas. Biogas consists of methane CH_4, carbon dioxide CO_2, hydrogen sulfide H_2S and traces of ammonia NH_3 and nitrogen N_2.The hydrogen sulphide is removed in gas scrubbing unit and methane gas is fed to pure gas engines of capacity

625 Kwh to generate electricity (0.6 to 0.9 MW) The effluent from UASB reactors is further treated in Facultative Aerated Lagoon (FAL) by aeration. 24 aerators of 50 HP capacities are operated out of 30 aerators and resulting induction of oxygen reduced the BOD load by further 75%. The detention period in FAL is 24 Hrs. Sewage is then led to polishing pond with 3 baffle walls to increase the length of flow with a detention period of 12 Hrs, where any remaining suspended solids are removed. Disinfection using chlorine is done to reduce the fecal coliforms before discharging the treated effluent to River Musi. The important treatment processes of 339 MLD STP, Amberpet are as follows is depicted in Figures 2 and 3.

Table 1: Salient features of 339 MLD STP, Amberpet

Sr. No	Process	Units
1	Average Inflow	3.92 Cum/Sec
2	Peak Flow	7.84 Cum/Sec
3	**Screen Channel**	
	Units	6 Nos 2.5 M wide
	Liquid Depth	0.8 M
	Head Loss	0.3 M
4	**Detention tank**	
	Units	4 Nos
	Size	12.25 X 12.25 M
	Liquid Depth	0.7 M
5	**Grit Channels**	
	Units	4 Nos
	Size	24 M X 2.5M
	Liquid Depth	0.87 M
6	**Main Pumping Station**	
	Size	40 M X 40 M X 12 M
	Pumps	18 Nos
	Discharge	2360 Cum/Hr, Head–17 M
	Capacity	160 KW or 210 HP
	Detention Time	5 MIN
7	**UASB**	
	Reactors	24 Nos
	Size (in Mtr)	32x28x5.8 LD
	Solids Retention Time	33 Days
	Upflow Velocity During Avg. Flow	0.65 m/hr
	During Peak Flow	1.3m/hr
	Angle of GLSS	50^0
	Hydraulic Retention Time	8.88 Hrs (Avg), 4.44 Hrs (Peak)
8	**Sludge Produced**	
	Wet Sludge	1380 Cum/Day (82780 Kg/Day)
	Manure	165 Cum/Day
9	**Facultative Aerated Lagoons**	
	Detention Time	1 Day
	Size (in Mtrs)	450 X 300 X 3.8 m LD
	Aerator	30 Nos 50 HP
10	**Polishing Pond**	
	Detention Time	½ Day
	Size (in Mtrs)	450 X 200 X1.7 m LD

11	**Chlorination (Disinfection)**	
	Chlorinator	2 No's
	Booster Pumps	2 No's
	Chlorine Mixers	4 No's
12	**Sludge Pumps**	
	Pumping Station	3 Nos
	Sludge Pumps	3X 2 = 6 Nos
	Capacity	160 Cum/Hr
	Head	18 M
13	**Filter Belt Press Dewatering Equipment**	
	Filter Belt Press	5 Units
	Capacity	20 Cum/Hr. Each
	Excess Sludge Generation	1380 Cum/Day
	Sludge as cake	165 Cum/Day

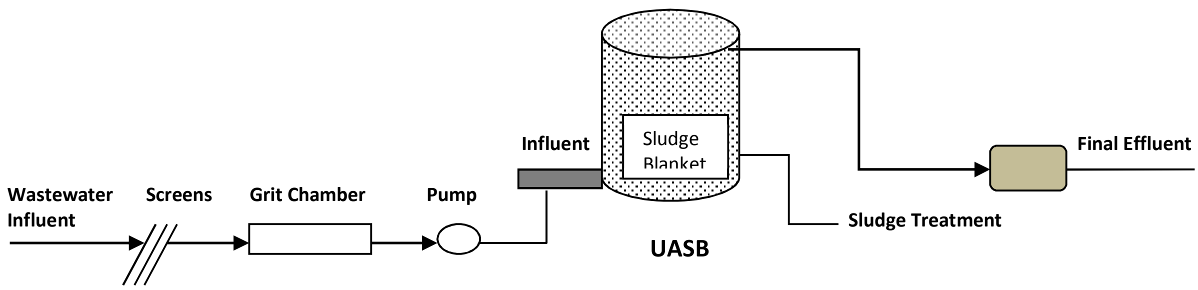

Figure1: UASB treatment process flow diagram at 339 STP Amberpet

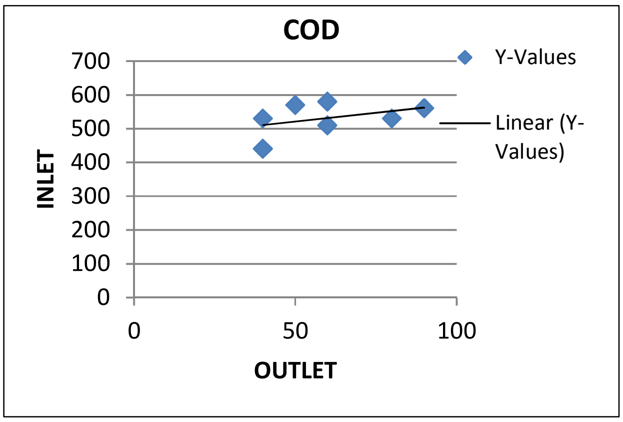

Figure 2: UASB Reactors	Figure 3: COD Removal Efficiency

2.2 *Methodology:*

The study was conducted for studying performance and evaluation of 339 MLD STP. The various physico-chemical parameters of the sewage from the influent and effluent from the Amberpet Sewage Treatment Plant (STP) were analyzed for a period of 7 days by using American Public Health Association (APHA) method (APHA, 2005). The influent and effluent samples were collected in 1000 ml plastic sampling bottles. The samples were immediately brought to the laboratory for further testing of physic-chemical analysis, within 24 hours the samples were analyzed for physico-chemical parameters by following APHA-2005 standards. The chemicals and glassware used in the laboratory are borosil and merck.

2.3 Sample Collection:

The sewage samples were collected from two points of STP which are as follows: Inlet of STP (Influent) and Outlet of STP towards Musi River (Effluent). The sewage samples were analyzed for physico-chemical parameters such as: pH, Temperature, TSS, DO, COD, BOD, Alkalinity, Sulfate, Sulfite, Volatile Fatty Acids and Fecal Coliform. The physico-chemical characteristics of influent and effluents from STP were analyzed which is shown in Table 2.

Table 2: Parameters and methods used for analysis

S. No.	PARAMETER	METHOD USED	APHA STANDARDS (2005)
1	pH	pH Meter	5.5 - 9.0
2	Temperature	Thermometer	-
3	Dissolved Oxygen	Probe Method	-
4	Total Suspended Solids	Spectrophotometric	<50.0 mg/l
5	Volatile Suspended Solids	Muffle Furnace	-
6	COD (Total)	Rapid dichromate oxidation method and Digestion	<250.0 mg/l
7	COD (Filter)	Rapid dichromate oxidation method and Digestion	-
8	BOD (Total)	Incubator at 27^0C for 3 days	<30.0 mg/l
9	BOD (Filter)	Incubator at 27^0C for 3 days	-
10	Alkalinity	Titration	<200.0 mg/l
11	Sulphate	Barium Chloride Method	-
12	Sulphide	Spectrophotometric	<2.0 mg/l
13	Volatile Fatty Acids	Spectrophotometric	-
14	Fecal Coliform	Incubator	<10000 MPN/100ml

3.0 Results and Discussion:

The present study has been undertaken to evaluate performance efficiency of the 339 MLD STP. The physico-chemical parameters of the influent and effluent of the STP were analyzed. The results are shown in Table 3.

Table 3: Physico-chemical analysis of influent and effluent of 339 MLD STP

S.No	Sampling Point	Parameters										
		pH	DO	TSS	VSS	COD	BOD	Alkalinity	Sulphate	Sulphide	VFA	Faecal Coliform
1	Inlet	7.13	0.31	393	140	580	266	406	85	0.941	116	512000
	Outlet	7.71	4.18	23	7.56	60	9.94	350	62	0.04	23	2460
2	Inlet	7.18	0.27	391	132	530	262	388	90	0.891	120	548000
	Outlet	7.69	3.99	25	8.23	80	10.3	360	64	0.038	26	2820
3	Inlet	7.16	0.28	355	116	440	270	380	83	0.794	103	396000
	Outlet	7.68	3.91	20	6.76	40	10.4	358	63	0.033	24	2040
4	Inlet	7.09	0.32	395	128	560	274	400	92	0.976	126	492000
	Outlet	7.66	4.05	24	7.92	90	10.2	352	65	0.037	27	2240
5	Inlet	7.17	0.26	375	118	510	271	396	81	0.763	99	506000
	Outlet	7.71	3.98	15	4.86	60	10.2	356	59	0.035	25	1980
6	Inlet	7.11	0.3	391	124	570	276	408	97	0.842	119	601000
	Outlet	7.74	4.06	17	5.46	50	10.5	360	60	0.032	26	2160
7	Inlet	7.15	0.28	373	118	530	267	404	90	0.796	121	496000
	Outlet	7.76	4.12	13	4.2	40	10.5	360	62	0.03	28	2060
8	Mean Inlet	7.14	0.29	381.9	125	531.42	269.4	397.42	88.28	0.857	115	507285.7
	Mean Outlet	7.70	4.041	19.57	6.42	60	10.29	356.57	62.14	0.035	25.57	2251.43
9	SD Inlet	0.03	0.02	13.68	8.13	43.89	4.46	3.81	5.17	0.07	9.25	1.82
	SD Outlet	0.03	0.08	4.33	1.47	17.72	0.18	9.48	2.24	0.00	1.59	275.23
10	Efficiency Percentage	-	-	94.87	94.86	88.70	96.18	39.64	29.61	95.91	77.73	99.55

3.1 pH: It is the measure of the intensity of acidity or alkalinity and measures the concentration of the hydrogen ions in the water. Influent and effluent samples were measured immediately after its collection by pH meter. Extreme values of pH of wastewater are generally not acceptable as it causes problems to survival of aquatic life and it also interferes with the optimum operation of wastewater treatment facilities (Powar, et al., 2012). At low pH most of the metals become soluble and become available and therefore could be hazardous in the environment. At high pH most of the metals become insoluble and accumulate in the sludge and sediments. The physico-chemical analysis reveals that the average pH at inlet is 7.14 after the treatment average pH at outlet was observed to be 7.7 (Kolhe, et al., 2011).

3.2 Total Suspended Solids (TSS): TSS are solid materials, including organic and inorganic, that are suspended in its wastewater. The TSS plays a major role in wastewater treatment. High concentration of TSS can lower wastewater quality by absorbing light, hence causes depletion of oxygen level in wastewater (Chaitanya, et al., 2011).The physico-chemical analysis reveals that the average concentration of TSS at inlet was observed to be 381.96 mg/l, while the concentration at outlet was 19.57 mg/l with removal efficiency of 94.87% and the removal efficiency VSS 94.86% in effluent which is an indication of better performance of the units. Wastewater treatment is complicated by the dissolved and suspended inorganic material it contains. The sewage solids may be classified into dissolved solids, suspended solids and volatile suspended solids. Knowledge of the volatile or organic fraction of solids, which decomposes, becomes necessary, as this constitutes the load on biological treatment of oxygen resources of a stream when sewage is disposed off by dilution. The estimation of suspended solids, both organic and inorganic, gives a general picture system during sewage treatment. Dissolved inorganic fraction is to be considered when sewage is used for land irrigation or any other reuse is planned (Jai Prakash, et al., 2011).

3.3 Chemical Oxygen Demand (COD): COD is used as a measure of oxygen requirement that is susceptible to oxidation by strong chemical oxidant (Sundara, 2010). The COD is a test which is used to measure pollution of domestic and industrial waste. The average COD at inlet was observed to 531.43 mg/l, while at outlet it was observed to be 60 mg/l with the removal efficiency of 88.70% which is shown in Figure 3.The COD does not differentiate between biological oxidizable and non-oxidizable material. However, the ratio of the COD to BOD does not change significantly for particular waste and hence this test could be used conveniently for interpreting performance efficiencies of the treatment units (Nobuyuki, et al., 2007).Biological Oxygen Demand (BOD): BOD was determined immediately after collection of influent and effluent samples. The average BOD at inlet was observed to be 269.43%, while at outlet it was observed to be 10.29 mg/l with the removal efficiency of 96.18%. The BOD of the sewage is the amount of oxygen required for the biochemical decomposition of biodegradable organic matter under aerobic conditions. The oxygen consumed in the process is related to the amount of decomposable organic matter (Patil, et al., 2012).

***3.4 Dissolved Oxygen (DO)*:** refer to level of free, non-compound oxygen present in water. DO is presence of free oxygen molecules within water. It is an important parameter in assessing water quality because it influences on the organisms living in the water (Singh, et al., 2012).The physico-chemical analysis reveals that the average DO at inlet is 0.29 mg/l with maximum of 0.32 mg/l and minimum of 0.26 mg/l respectively, after the treatment, average DO at outlet was observed to be 4.04 mg/l, maximum DO at effluent is 4.18 mg/l, the effluent DO is within the APHA standards. Fecal Coliform: The fecal coliform bacteria test is a primary indicator of portability, suitability for consumption of drinking water. Coliform bacteria are not pathogenic organisms, and are only mildly infectious (Sushil, et al., 2008). If large number of coliforms is found in water, there is a high probability that other pathogenic bacteria or organisms such as Giardia and Cryptosporidium may be present (AlZboon, et al., 2008).The average count of Fecal Coliform at inlet was observed to be 507,285.71 MPN/100ml, while at outlet it was observed to be 2,251.43 MPN/100ml with the removal efficiency of 99.55%.

3.5 Sulfate and Sulfide: The removal efficiency of sulphate is 29.61% whereas sulphide is 95.91%. Hydrogen sulphide results from septic conditions during the collection and treatment of wastewater. Hydrogen sulfide has long been recognized as a major problem for municipal wastewater systems (Duangporn, et al., 2009). This colorless gas, known for its rotten egg smell, is produced by the biological reduction of sulfates and the decomposition of organic material. It forms at virtually every point in a system from interceptors, force mains, and lift stations, to holding tanks, mechanical dewatering equipment and drying beds (Ravi, et al., 2010). Alkalinity and VFA: The results revealed that the VFA removal efficiency is 99.50%. Volatile fatty acids are short chained fatty acids consisting of six or fewer carbon atoms which can be distilled at atmospheric pressure (Ogunlaja, 2009). Proteins and carbohydrates in sewage sludge can be converted into VFA to enhance methane, hydrogen and poly-hydroxyalkanoate (Thoker, et al., 2012). Volatile fatty acids levels should be monitored in an anaerobic digester. Volatile acid/alkalinity ratio is a common anaerobic digester test with a ratio of 0.1-0.5 is recommended (Yahaya, et al., 2008). The solubilization of grease and other solids into an anaerobic digester increase the presence of the volatile acids, like fatty acids and acetic acid. Acetic acid is often the most pre-dominate acid in anaerobic systems. These volatile acids are a form of soluble BOD where further these acids convert into methane gas. In plants with high incoming BOD and high levels of grease it is common for the production of volatile acids to precede faster than the production of methane and this causes the pH to drop in the digester (Ilyas, et al., 2014).

The present study showed good performance of the STP by measuring its treatment efficiency. The complete treatment of wastewater is brought by a sequential combination of various physical unit operations, and chemical and biological unit processes. The general yardstick of evaluating the performance of sewage treatment plant is the degree of reduction of such harmful parameters which constitute organic pollution. The performance efficiency of treatment plants depends not only on proper design and construction but also on good operation and maintenance (Tara, et al., 2007).

4.0 Conclusion:

Assessment study reveals that, the 339 MLD sewage treatment plant (STP) Amberpet which is based on Up-flow Anaerobic Sludge Blanket (UASB) process has removed the desired impurities above 90%. The treatment plant removal efficiency of pollutants is well maintained achieving the standards prescribed by the APHA. The successful application of anaerobic digestion to the treatment of biodegradable solid waste and wastewater is critically dependent on the development and use of high –rate bioreactors. There is a considerable amount of biodegradable waste that is suitable for biogas production. One important aspect in promoting anaerobic processes is to demonstrate the appropriate anaerobic technology for wastewater, where it is not the common practice today.

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