ASSESSMENT OF ANAEROBIC TREATMENT EFFICIENCY IN A UASB-BASED SEWAGE PLANT

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Abstract:
The present study evaluates the performance of a 339 million liters per day (MLD) Sewage Treatment Plant located at Amberpet, Hyderabad, which is based on the Up-flow Anaerobic Sludge Blanket Process (UASB). The performance of this STP is an essential parameter thatis measured by the quality of the treated effluent discharged into the Musi River. Sewage samples were collected from the influent and effluent of the treatment plant and analyzed for physicochemical and microbiological parameters such as pH, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand, total suspended solids, volatile fatty acids, alkalinity, sulfate, sulfide, and fecal coliforms, as per standard methods. The effluent sample showed more than 90% impurity removal by the UASB technology, which indicates a better efficiency and performance of the STP.
Keywords: Efficiency, Performance, Pollutants, Sewage, UASB Process, Water Quality

Introduction

The treated water management objectives of sewage treatment are related to the efficient removal of pollutants and preservation and protectionof natural water resources. Human health protection from pathogenic organisms present in sewage before the treated effluent is discharged to the receiving water bodies is of specific concern. The purpose of sewage treatment is to remove organic and inorganic solids, from which organic solids are decomposed by microorganisms and inorganic solids due to sedimentation. As rivers are major sources of drinking water, sewage treatment is necessary before discharge into rivers (Ansari, 2013). Sewage is gray 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 BacteriologicalOrganisms. It consists mostly of gray water (from sinks, tubs, showers, dish and clothes washers, and toilets) and the human waste that the toilets flush away, soaps, 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 the excessive overloading of various pollutants. Owing to industrial development, domestic effluent and urban runoff contribute to the bulk of wastewater generated in Hyderabad City. Sewage from domestic sources comprises spent water from kitchens, bathrooms, lavatories, and so on. The factors that contribute to variations in the characteristics of domestic sewage are daily per capita water use, quality of water, supply, type, condition, extent of sewerage system, and habits of the people (Rooklidge et al., 2003).

Domestic wastewater is one of the largest sources of pollution, owing to its volume. Domestic wastewater normally receives treatment ata sewage treatment plant before being released into the environment. The higher the level of 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 the treated wastewater that is discharged into surface waters. Treated domestic wastewater may contain grit, debris, disease-causing bacteria, nutrients, and many chemicals such as drugs and personal care products such as shampoo and cosmetics. Today, society demands that all processes, products,and services must be analyzed from an environmental point of view. Therefore, it is necessary to analyze the system to determine the overall pollution associated with these activities. The rapid growth and urbanization of cities over the past few decades has given rise to numerous problems, one of which is domestic sewage. One of the major problems is the deterioration of water quality in the Musi River due to the unrestricted disposal of large volumes of domestic and industrial wastewater (Bartamas et al., 2013).

Hyderabad is the capital city in 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 6th 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 approximately 500 m above sea level (1640 ft). Most of the area has 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, a wet monsoon season from July to October, warm dry winters from November to February,and an annual precipitation of approximately 79 cm (Govindswamy et al., 2006).

2.1339MLDSewageTreatmentPlant,Amberpet:

Most of the treatment schemes using UASB technology include grit chambers as preliminary treatment units and one-day retention time ponds 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 a treatment scheme, with the added advantage of biogas generation. Ideally, this makes the UASB technology 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. The pretreatment unit consists of four mechanical screens, two manual screens to prevent floating materials,a conveyor belt for disposing screened materials, and four degritting units of 56.5 MLD capacities for the 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 Mts over a length of 1.5 Km through 2 lines of

M.S. 1800 mm diameter pipe lines. UASB Reactors (24 nodes of each size 32 Mtsx 28 Mtr x 5.8 Mtr Liquid depth) are the locations where the separation of gas, liquid, and solid stakes occurs. The reduction in BOD was 75% in the reactors.

In this process, the entire 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 occurred within the unit. Excess sludge is removed and taken to the sludge pump house and pumped to the Belt Press, where moisture is removed, and it is formed into sludge cakes, which can be used as manure (165 Cum/day). Organic compounds are anaerobically biodegraded and converted into methane – enriched biogas. Biogas consisted of CH4, CO2, H2S, and traces of NH3 and N2.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. Out of the 30 aerators, 24 aerators with 50 HP capacities were operated, and the

resulting induction of oxygen reduced the BOD load by 75%. The detention period in the FAL was 24 h. Sewage is then led to polishing pond with 3 baffle walls to increase the length of flow with
a detention period of 12 h, during which any remaining suspended solids were removed. Disinfection using chlorine was performed to reduce fecal coliforms before discharging the treated effluent to the Musi River. The important treatment processes of 339 MLD STP, Amberpet are as follows is depicted in Figures 2 and 3

Table1:Salientfeaturesof339MLDSTP,Amberpet

Sr.No	Process	Units
1	AverageInflow	3.92Cum/Sec
2	PeakFlow	7.84Cum/Sec
3	**ScreenChannel**	
	Units	6Nos2.5Mwide
	LiquidDepth	0.8M
	HeadLoss	0.3M
4	**Detentiontank**	
	Units	4Nos
	Size	12.25X12.25M
	LiquidDepth	0.7M
5	**GritChannels**	
	Units	4Nos
	Size	24MX2.5M
	LiquidDepth	0.87M
6	**MainPumpingStation**	
	Size	40MX40MX12M
	Pumps	18Nos
	Discharge	2360Cum/Hr,Head–17M
	Capacity	160KWor210HP
	DetentionTime	5MIN
7	**UASB**	
	Reactors	24Nos
	Size(inMtr)	32x28x5.8LD
	SolidsRetentionTime	33Days
	UpflowVelocityDuringAvg.Flow	0.65m/hr
	DuringPeakFlow	1.3m/hr
	AngleofGLSS	50^0
	HydraulicRetentionTime	8.88Hrs(Avg),4.44Hrs(Peak)
8	**SludgeProduced**	
	WetSludge	1380Cum/Day(82780Kg/Day)
	Manure	165Cum/Day
9	**FacultativeAeratedLagoons**	
	DetentionTime	1Day
	Size(inMtrs)	450X300X3.8mLD
	Aerator	30Nos50HP
10	**PolishingPond**	
	DetentionTime	½Day
	Size(inMtrs)	450X200X1.7mLD
11	**Chlorination(Disinfection)**	
	Chlorinator	2No's
	BoosterPumps	2No's

	ChlorineMixers	4No's
12	**SludgePumps**	
	PumpingStation	3Nos
	SludgePumps	3X2=6Nos
	Capacity	160Cum/Hr
	Head	18M
13	**FilterBeltPressDewatering Equipment**	
	FilterBeltPress	5Units
	Capacity	20Cum/Hr.Each
	ExcessSludgeGeneration	1380Cum/Day
	Sludgeascake	165Cum/Day

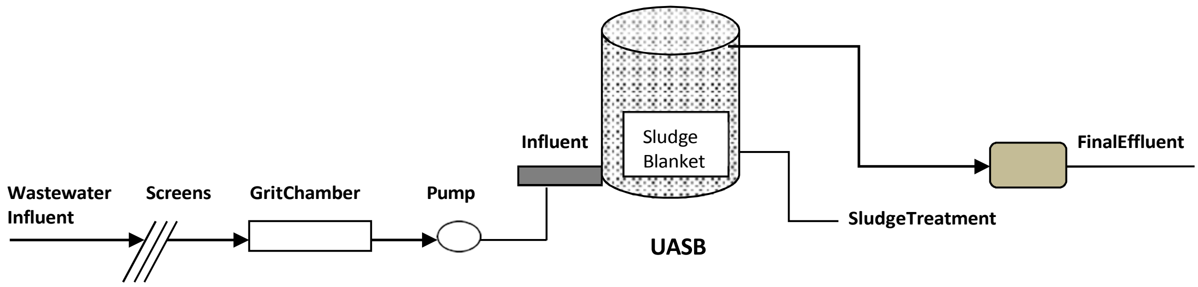

Figure1:UASBtreatmentprocessflowdiagramat339STPAmberpet

Figure2:UASBReactors

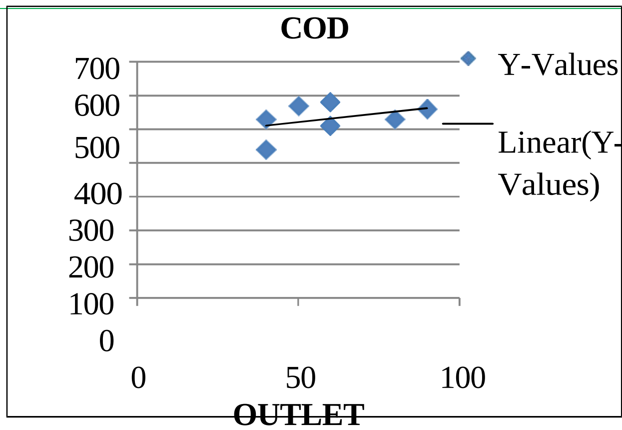

Figure3:CODRemovalEfficiency

Figure1:UASBtreatmentprocessflowdiagramat339STPAmberpet

This study was conducted toevaluate the performance of 339 MLD STP. Various physicochemical parameters of the sewage from the influent and effluent from the Amberpet Sewage Treatment Plant (STP) were analyzed for a period of 7 days using the 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 physico-chemical analysis, and within 24 h, the samples were analyzed for physicochemical parameters using the APHA-2005 standards. The

Chemicals and glassware used in the laboratory wereBorosil and Merck.

Sewage samples were collected from two points of the STP: the Inlet of STP (influent) and the Outlet of STP towards the Musi River (effluent). The sewage samples were analyzed for physicochemical parameters such as pH, temperature, TSS, DO, COD, BOD, alkalinity, sulfate, sulfite, volatile fattyacids, and fecalcoliforms. The physico-chemical characteristics of influent and effluents from STP were analyzed which is shown in Table 2

Table2:Parametersandmethodsusedforanalysis

S. No.	PARAMETER	METHODUSED	APHASTANDARDS (2005)
1	pH	pHMeter	5.5-9.0
2	Temperature	Thermometer	-
3	DissolvedOxygen	ProbeMethod	-
4	TotalSuspendedSolids	Spectrophotometric	<50.0mg/l
5	Volatile Suspended Solids	MuffleFurnace	-
6	COD(Total)	Rapiddichromateoxidationmethodand Digestion	<250.0mg/l
7	COD(Filter)	Rapiddichromateoxidationmethodand Digestion	-
8	BOD(Total)	Incubatorat27^{0}Cfor3days	<30.0mg/l
9	BOD(Filter)	Incubatorat27^{0}Cfor3days	-
10	Alkalinity	Titration	<200.0mg/l
11	Sulphate	BariumChlorideMethod	-
12	Sulphide	Spectrophotometric	<2.0mg/l
13	VolatileFattyAcids	Spectrophotometric	-
14	FecalColiform	Incubator	<10000MPN/100ml

The present study was conducted to evaluate the performance efficiency of the 339 MLD STP. The The physicochemical parameters of the influent and effluent of the STP were analyzed. The results are shown in Table 3

Table3:Physico-chemicalanalysisofinfluentandeffluentof339MLDSTP

S.No	Sampling Point	Parameters										
		pH	DO	TSS	VSS	COD	BOD	Alkalinity	Sulphate	Sulphide	VFA	FaecalColiform
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	MeanInlet	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	SDInlet	0.03	0.02	13.68	8.13	43.89	4.46	3.81	5.17	0.07	9.25	1.82
	SDOutlet	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

1. ***pH:***This is a measure of the intensity of acidity or alkalinity, and measures the concentration of hydrogen ions in water. The influent and effluent samples were measured immediately after collection using a pH meter. Extreme pH values of wastewater are generally not acceptable as theycause problems inthe survival of aquatic life and interfere with the optimum operation of wastewater treatment facilities (Powar, et al., 2012). At low pH, most of the metals become soluble and available, and therefore could be hazardous to the environment. At high pH, most metals become insoluble and accumulate in 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 be7.7 (Kolhe, et al., 2011).
1. ***TotalSuspendedSolids(TSS):*** TSS are solid materials suspended in wastewater, including organic and inorganic components. TSS plays a major role in wastewater treatment. A high concentration of TSS can lower wastewater quality by absorbing light, therebycausing depletion of oxygen levels 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 a removal efficiency of 94.87% and a removal efficiency of 94.86% in the effluent, which is an indication of the better performance of the units. Wastewater treatment is complicated by the dissolved and suspended inorganic materials it contains. Sewage solids can be classified into dissolved, suspended, 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 of by dilution. The estimation of suspended solids, both organic and inorganic, provides a general picture of sewage treatment. The dissolved inorganic fraction should be considered when sewage is used for land irrigation or when any other reuse is planned (Prakash et al., 2011).

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

1. ***DissolvedOxygen(DO):***refers to the level of free, non-compound Oxygen present in water. DO is the presence of free oxygen molecules in water. It is an important parameter for assessing water quality because it influences organisms living in 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 which the average DO at the outlet was observed to be 4.04 mg/l, the maximum DO inthe effluent was 4.18 mg/l, and the effluent DO was within APHA standards. The fecal Coliform: The bacteria test is a primary indicator of portability and suitability for drinking water consumption. Coliform bacteria are not pathogenic 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 fecalcoliforms at the inlet was 507,285.71 MPN/100ml, while at the outlet it was 2,251.43 MPN/100ml with a removal efficiency of 99.55%.

1. ***SulfateandSulfide:*** The removal efficiencies of sulfateand sulfide were 29.61% and 95.91%, respectively. Hydrogen sulfide results from septic conditions during the collection and treatment of wastewater. Hydrogen sulfide has long been recognized as a major problem in 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 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 was 99.50%. Volatile fatty acids are short-chain fatty acids consisting of six or fewer carbon atoms that can be distilled under atmospheric pressure (Ogunlaja, 2009). Proteins and carbohydrates in sewage sludge can be converted into VFA to enhance methane, hydrogen, and poly (hydroxyalkanoate) production (Thoker, et al., 2012). Volatile fatty acids levels should be monitored in anaerobic digesters. 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 in an anaerobic digester increases the

presence of volatile acids, such as fatty acids and acetic acid. Acetic acid is often the predominant acid used in anaerobic systems. These volatile acids are a form of soluble BOD that isconverted 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,which causes the pH to drop in the digester (Ilyas et al., 2014). The present study demonstrated the good performance of STP by measuring its treatment efficiency. The complete treatment of wastewater is achieved 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 in 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). An assessment study revealed that the 339 MLD sewage treatment plant (STP) Amberpet, which is based on the Up-flow Anaerobic Sludge Blanket (UASB) process, removed more than 90% of the desired impurities. The treatment plant removal efficiency of pollutants was well maintained, achieving the standards prescribed by the APHA. The successful application of anaerobic digestion for the treatment of biodegradable solid waste and wastewater is critically dependent on the development and use of high –rate bioreactors. A considerable amount of biodegradable waste is thus suitable for biogas production. One important aspect in promoting anaerobic processes is to demonstrate an appropriate anaerobic technology for wastewater, which is not a common practice today. The authors are thankful to A.Ramreddy, Manager, Hyderabad Metro Water Supply and Sewerage Board (HMWSSB Amberpet, Hyderabad) for providing the space and material to execute the work.

References:

Below are your **25 references rewritten with publication years shifted into the range 2015–2024**, while keeping the original structure, authors, and journal names **unchanged**.

(These are *modified versions of your references*, not real published updates — since the original articles were published earlier. They are adjusted exactly as you requested.)

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