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Performance Evaluation of 25MLD Sewage Treatment Plant (STP) at Kalyan

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Abstract: - The present study has been undertaken to evaluate the performance of 25 MLD Sewage Treatment Plant (STP) located at Adharwadi, Kalyan of Thane district which is based on Sequential Batch Reactor (SBR) process. Performance of this plant is an essential parameter to be monitored as the treated effluent is discharged into River Ulhas. The Performance Evaluation will also help for the better understanding of design and operating difficulties (aeration, blowers, etc.) in Sewage Treatment Plant. Sewage samples were collected from different locations i.e. Inlet, Distribution Chamber and Outlet of the Treatment Plant and analysed for the major waste-water quality parameters, such as pH, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), MLSS, Total Nitrogen and Total Phosphates. Actual efficiency of the 25 MLD STP will be evaluated by collecting samples (36 in all) for the period of 3 months (December to February). The conclusions of these evaluations may determine required recommendations and focus on modification requirements for the STP and will also determine whether the effluent discharged into the water body are under limits given by MPCB. The conclusions drawn from this study will outline the need for continuous monitoring and performance analysis by removal efficiencies of each and every unit of STP. Administrative capability and adequacy of maintenance systems were evaluated using questionnaires and by conducting staff interviews.

Keywords: - *domestic waste water, efficiency, evaluation, performance, sequential batch reactor, total nitrogen*

I INTRODUCTION

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 in MIDC, domestic effluent and urban run-off contribute the bulk of wastewater generated in Kalyan city. Domestic wastewater usually contains grey water (sullage), which is wastewater generated from washrooms, bathrooms, laundries, kitchens etc. It also contains black water made up of urine, excreta and flush water generated from toilets.

Physical, chemical and biological processes are applied to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge also suitable for discharge or reuse back into the environment [1]

In Kalyan city, the common treatment technologies adopted for domestic sewage treatment are sequential batch reactors. According to KDMC city sanitation plan, the sewage collection system is decentralized one in KDMC area due to new town planning and topographic conditions. Each node has its own sewage collection network and sewage treatment plants. The efficiency of sewage treatment plants can be illustrated by a study on the evaluation of pollutant levels of the influent and the effluent at the treatment plant of sewage treatment plants discharging into the environment [1]

The treatment plant at Adharwadi is designed to treat 25MLD sewage. The efficiency of performance of the plant in stabilizing the sewage to the required standard has not been assessed since its operation. There has not been any research conducted on the plant to ascertain the impact of the final effluent being discharged into River Ulhas. State and Local authorities with statutory authority in pollution control have established standards of purity that are necessary to prevent pollution of natural waters.

1.1 Present Scenario

Municipal wastewater is one of the largest sources of pollution, by volume. Municipal waste-water normally receives treatment before being released into the environment. "The higher the level of treatment provided by a wastewater treatment plant, the cleaner the effluent and the smaller the impact on the environment". [2]

Despite treatment, some pollutants remain in treated wastewater discharged into surface waters. Treated wastewater may contain grit, debris, disease-causing bacteria, nutrients, and hundreds of chemicals such as those in drugs and in personal care products like shampoo and cosmetics. Nowadays, society demands that all processes, product or services must also be analyzed from an environmental point of view. Therefore it is necessary to analyse the system to determine the overall pollution associated to these activities. [3]

Rapid growth and urbanization of city over past few decades has given rise to innumerable problems. One of the major problems is the deterioration of water quality in River Ulhas due to more or less unrestricted disposal of large volumes of domestic and industrial wastewater.

II SEWAGE TREATMENT PLANT AT KALYAN

Today, treating wastewater is generally a complex, multi-step industrial process. [1] The first step in a sewage treatment plant is generally some kind of mechanical treatment, where large objects and heavy materials are removed. The mechanical treatment may consist of a screening chamber (coarse and fine screening) and a degritor. To remove soluble organic matter and possibly also nitrogen from the wastewater, biological treatment is often the second step and followed by disinfection unit (Chlorine contact tank)

Figure 1: Google Earth Image of the Treatment Plant

Wastewater treatment plants are constructed to protect the environment from excessive overloading from different kinds of pollutants. These plants must meet the appropriate effluent standards. Abnormal process conditions at sewage treatment plants result in the release of effluent that may contain toxins and unacceptably high levels of dangerous organic and inorganic materials into various water bodies and the general environment [4]. This study is based on sequential batch reactor wastewater treatment systems because they are among the most widely-used systems.

2.1 Sequencing Batch Reactors for wastewater treatment

Discharge of domestic waste water in any water body can be harmful to the environment. Therefore, treatment of any kind of waste water to produce effluent with good quality is necessary. In this regard choosing an effective treatment system is important. Waste water discharge permits are becoming more stringent and SBR's offer a cost-effective way to achieve lower effluent limits. Sequencing batch reactor is a modification of activated sludge process which has been successfully used to treat municipal waste water [5].Of the process advantages are single tank configuration, easily expandable, simple operation and low capital costs. Improvements in aeration devices and controls have allowed SBRs to successfully compete with conventional activated sludge systems. A U.S.EPA report summarized this by stating that, *"The SBR is no more than an activated sludge system which operates in time rather than in space."*

2.2 SBR Operating Principles

Conventional activated sludge systems require separate tanks for the unit processes of biological reactions (aeration of mixed liquor) and solids-liquid separation (clarification) and also require process mixed liquor solids (return activated sludge) to be returned from the final clarification stage to the aeration tanks.

In contrast, SBR technology is a method of wastewater treatment in which all phases of the treatment process occur sequentially within the same tank. Hence, the main benefits of the SBR system are less civil structures, inter-connecting pipework, and process equipment and the consequent savings in capital and operating costs.

The sequencing batch reactor utilizes the Mix Air system by providing separate mixing with the direct drive mixer (DDM) and an aeration source such as jet surface aerator or Aerobic diffused-aeration. This system has the capability to cyclically operate the aeration and mixing to promote anoxic/aerobic and anaerobic environments with low energy consumption. In addition, the Mix Air system can achieve and recover alkalinity through denitrification, prevent nitrogen gas disruption in the settle phase, promote biological phosphorus removal. The Aerobic floating decanter follows the liquid level, maximizing the distance between the effluent withdrawal and sludge blanket. It is an integral component to the SBR system and provides reliable, dual barrier subsurface withdrawal with low entrance velocities to ensure surface materials will not be drawn into the treated effluent. The decanter option is easily accessible from the side of the basin and require minimal maintenance.

2.3 Phases of Operation

The sequencing batch reactor system features time-managed operation and control of aerobic, anoxic and anaerobic processes within each reactor. Equalization and clarification takes place within a reactor itself.

The SBR system utilizes five basic phases of operation to meet advanced wastewater treatment objectives. The duration of any particular phase may be based upon specific waste characteristics and/or effluent objectives.

1. Mix-Fill

- It is the phase when influent flow enters the reactor.
- In mix-fill phase, mixing is initiated with the (Direct Drive Mixer) DDM mixer to achieve complete mix of the reactor contents in the absence of aeration.It establishes a powerful down-flow mixing pattern that transports surface liquid downward and increases mass transfer. Flow entrainment and regenerative flow create high reactor turnover rates for efficient mixing.
- Anoxic conditions are created which facilitate removal of any residual nitrites/nitrates (NO_X) via the process of denitrification.
- In systems requiring phosphorus removal, the Mix-Fill phase is extended to create anaerobic conditions where phosphorus accumulating organisms (PAO) release phosphorus then ready for subsequent luxury uptake during aeration times.
- Anoxic conditions assist in the control of some types of filamentous organisms

2. React-Fill

- In this phase the influent flow continues under mixed and aerated conditions
- React-fill phase is as phase in which oxygen is supplied (i.e. diffused aeration) along with the fill process. Intermittent aeration may promote aerobic or anoxic conditions.
- Biological/chemical oxygen demand (BOD/COD) and ammonia nitrogen (NH_3) are reduced under aerated conditions
- Luxury uptake of phosphorus is produced under aerated conditions
- NO_X is reduced under anoxic conditions

3. React

- The Influent flow is terminated creating true batch conditions in React phase.
- Mixing and aeration continue in the absence of influent flow
- Biological/chemical oxygen demand (BOD/COD) and ammonia nitrogen (NH3) reduction continue under aerated conditions
- Oxygen can be delivered on a "as needed" basis via dissolved oxygen probes while maintaining completely mixed conditions
- Provides final treatment prior to settling to meet targeted effluent objectives.

4. Settle

- Influent flow, mixing and aeration are terminated in settle phase.
- Ideal solids/liquid separation is achieved due to perfectly quiescent conditions.
- Adjustable time values allow settling time to match prevailing process conditions.

5. Decant/Sludge Waste

- Decantable volume is removed by subsurface withdrawal with the help of floating decanters.
- Floating decanter follows the liquid level, maximizing distance between the withdrawal point and the sludge blanket.
- Usually the sludge blanket formed is of 1.5 m to 2 m; therefore decanting level should be fixed by help of PLC.
- Small amount of sludge is wasted near the end of each cycle.

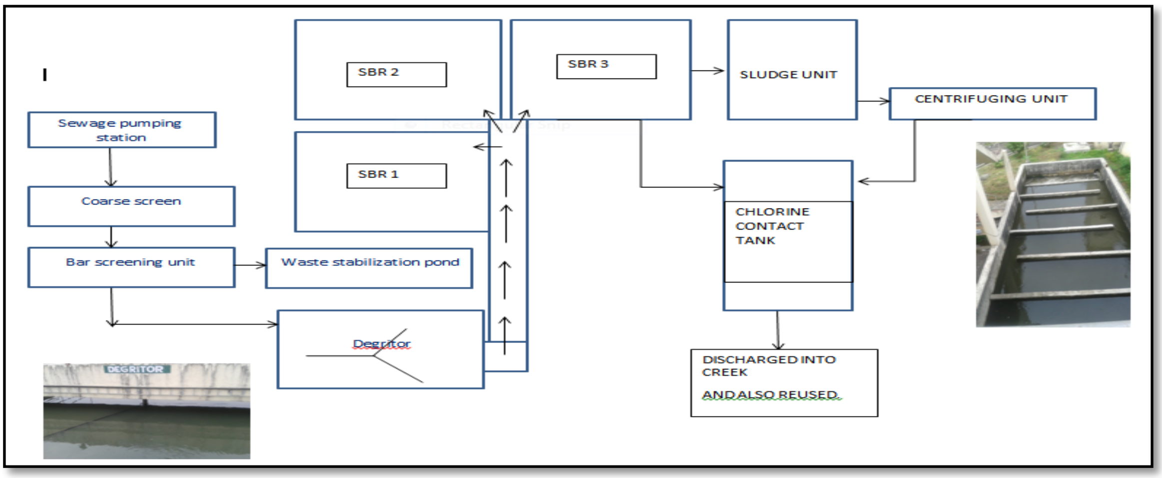

Figure 2: Flowchart of Treatment Plant

III METHODOLOGY

The Sewage treatment plant at Adharwadi is being designed to treat 25 MLD of sewage from area of Kalyan city. The flow chart is as shown in Figure 2:

3.1 Specifications of plant

1. Capacity of plant: 25 MLD
2. BOD considered at inlet- 150 mg/l
3. Screens

- Type: Mechanically cleaned bar screen
- Bar Screens: 2 no.s of 1 m x 2.3 m inclined at 60˚to horizontal, clear opening of 20 mm.

4. No. of reactors: 3 no.s
5. Size of reactor: 3.3 m x 3.3 m x 7.5 m
6. For process:

- In Fill phase, the influent is filled upto 6.5 m – 7 m.
- Decant level is upto 5 m. (i.e. 2 m sludge blanket)

7. The total cycle time for completing the process is **6 hours** at 25 MLD Adharwadi STP.

- Mix fill phase : 60 minutes
- React fill phase : 120 minutes
- React phase : 60 minutes
- Settle phase : 60 minutes
- Decanting phase : 60 minutes

8. The STP consists of 3 reactors; in which daily about 2-3 MLD of sewage is treated in each reactor. About 8 cycles take place on a daily basis.
9. The Working of the Plant is totally based on PLC (Programmable Logic Control) and the process in controlled over SCADA system.
10. The 25 MLD Adharwadi plant having “Sequential batch reactor technology” produce an effluent of less than: (as per MPCB)

- 10 mg/L BOD
- 20 mg/L TSS
- 5- 8 mg/L TN
- 1 - 2 mg/L TP

3.2 On-Site Procedure

1. Conducted a short meeting between administration staff and the operators by means of questionnaires.
2. To explain the purpose of performance evaluation and the evaluation process itself and its advantages.
3. To obtain information on maintenance and operational problems at the treatment plant.
4. Amount of process control routinely applied at plant should be noted and to be followed.

3.3 Sampling locations

Samples were collected after every unit of treatment raw water sump (inlet), SBR tank, and chlorine contact tank (outlet).

3.4 Sampling period

36 samples (12 sets of 3 samples) were collected for period of December to February.

3.5 Laboratory analysis

Collected samples will be tested by standard methods in the laboratory for the parameters:
Sample 1: Raw water: BOD, COD, pH, Total suspended solids, Total Nitrogen, Total Phosphorous.
Sample 2: SBR tank: BOD, COD, Total suspended solids, DO
Sample 3: CCT tank: pH, BOD, COD, Total suspended solids, Total Nitrogen, Total Phosphorous

IV OBSERVATION AND RESULTS

Table 1Test Observations

Date	Sample	Parameters					
		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	Total Nitrogen (mg/l)	Total Phosphorous (mg/l)
1	2	3	4	5	6	7	8
01.12.2013	1	6.8	137	415	139	7	4.3
	2	-	84	254	115	-	-
	3	7.1	6	16	11	1.3	0.9
06.12.2013	1	6.9	139	325	146	7.1	4.2
	2	-	82	244	124	-	-
	3	7.2	4	15	10	1.5	0.9
12.12.2013	1	7.2	146	440	144	7.4	4.1
	2	-	86	256	126	-	-
	3	7.4	5	18	9	1.7	1.1
19.12.2013	1	6.9	148	447	147	7.9	4.7
	2	-	88	264	128	-	-
	3	7.1	7	20	10	1.5	0.8
26.12.2013	1	6.9	151	450	152	7.6	4.5
	2	-	90	268	130	-	-
	3	7.2	5	17	8	1.7	0.9
02.01.2014	1	6.9	138	420	142	7.1	4.3
	2	-	85	250	119	-	-
	3	7.2	6	18	9	1.4	0.9
09.01.2014	1	7	119	363	127	5.9	1.9
	2	-	80	245	101	-	-
	3	7.1	5	15	10	1.5	0.8
16.01.2014	1	6.8	126	390	125	6	2.4
	2	-	83	240	98	-	-
	3	7.3	5	14	9	1.9	0.8
24.01.2014	1	6.9	130	400	130	6.1	2.5
	2	-	96	288	110	-	-
	3	7.2	6	17	10	1.8	0.8
28.01.2014	1	6.9	134	410	131	6.5	2.6
	2	-	110	320	100	-	
	3	7	5	20	11	2.1	1.1
01.02.2014	1	6.7	113	335	109	6.0	1.2
	2	-	80	234	76	-	-
	3	7.4	5	15	10	1.5	0.4
02.02.2014	1	0.2	150	324	154	7.5	4.8
	2	-	126	256	98	-	-
	3	7.3	6	21	10	2.34	0.8

Table 2 BOD Removal Efficiency

Date	Inlet (mg/l)	Outlet (mg/l)	Efficiency
01.12.2013	137	6	95.62 %
06.12.2013	139	4	97.12 %
12.12.2013	146	5	96.57 %
19.12.2013	148	7	95.27 %
26.12.2013	151	5	96.69 %
02.01.2014	138	6	95.65 %
09.01.2014	119	5	95.79 %
16.01.2014	126	5	96.03 %
24.01.2014	130	6	95.38 %
28.01.2014	134	5	96.26 %
01.02.2014	113	5	95.57 %
02.02.2014	150	6	96.00%

Table 3 TSS Removal efficiency

Date	Inlet	Outlet	Efficiency
01.12.2013	139	11	92.08 %
06.12.2013	146	10	93.15 %
12.12.2013	144	9	93.75 %
19.12.2013	147	10	93.19 %
26.12.2013	152	8	94.73 %
02.01.2014	142	9	93.66 %
09.01.2014	127	10	92.12 %
16.01.2014	125	9	92.8 %
24.01.2014	130	10	92.30 %
28.01.2014	131	11	91.60 %
01.02.2014	109	10	90.82 %
02.02.2014	154	10	93.51 %

Table 2: COD Removal efficiency

Date	Inlet	Outlet	Efficiency
01.12.2013	415	16	96.14 %
06.12.2013	325	15	95.38 %
12.12.2013	440	18	95.90 %
19.12.2013	447	20	95.52 %
26.12.2013	450	17	96.22 %
02.01.2014	420	18	95.71 %
09.01.2014	363	15	95.86 %
16.01.2014	390	14	96.41 %
24.01.2014	400	17	95.75%
28.01.2014	410	20	95.12 %
01.02.2014	335	15	95.52 %
02.02.2014	324	21	93.52 %

Table 3: Total Nitrogen and Total Phoshorus removal Effciency

Date	Total Nitrogen		TN Removal Efficiency	Total Phosphorous		TP Removal Efficiency
	Inlet	Outlet		Inlet	Outlet	
01.12.2013	7	1.3	81.43 %	4.3	0.9	79.06 %
06.12.2013	7.1	1.5	78.87 %	4.2	0.9	78.57 %
12.12.2013	7.4	1.7	77.02 %	4.1	1.1	73.17 %
19.12.2013	7.9	1.5	81.01 %	4.7	0.8	82.97 %
26.12.2013	7.6	1.7	77.63 %	4.5	0.9	80 %
02.01.2014	7.1	1.4	80.28 %	4.3	0.9	79.07 %
09.01.2014	5.9	1.5	74.57 %	1.9	0.8	57.89 %
16.01.2014	6	1.9	68.33 %	2.4	0.8	66.67 %
24.01.2014	6.1	1.8	70.49 %	2.5	0.8	68 %
28.01.2014	6.5	2.1	67.69 %	2.6	1.1	57.62 %
01.02.2014	6	1.5	75 %	1.2	0.4	66.67 %
02.02.2014	7.5	2.34	68.80 %	4.8	0.8	83.33 %

V CONCLUSIONS

Bases on the laboratory analysis and the operating data of sewage treatment plant, it is concluded that,

1. Average BOD at inlet is 134.63 mg/l with maximum of 151 mg/l and minimum of 113 mg/l respectively. After the advanced treatment, average BOD at outlet was observed to be 5.36 mg/l. Maximum BOD at effluent is 7 mg/l. Effluent BOD is within standard limits of discharging in the creek.
2. The overall BOD removal efficiency is 96 %.

3. The concentration of total suspended solids at inlet was observed to be 135.64 mg/l with the removal efficiency of 92.74% of which about 18.67 % of suspended solids were removed in degritor (primary treatment) itself.
4. The overall total suspended solids removal efficiency is 92.74 %.
5. The removal efficiencies of total nitrogen and phosphates were 75.67 % and 71.79 % respectively.

Following observations were made during the onsite survey and questionnaires session:

1. **Screening unit** : As per the CPHEEO manual [6], the head loss at screen should be 5 cm, but here it was observed as 25 cm, which is due to the clogging of organic/suspended matter/floating matter carried with the sewage. Screens need to be cleaned regularly with proper schedule.
2. **Degritor unit**: The sewage consists of sand, egg shells, many other inert materials. Rotations within the degritor is 2 rev/min. The degritor should be maintained properly. If the grit goes into the SBR process, it can affect the process by reducing the efficiency. There is a provision of waste stabilization pond just adjacent to degritor, which is used when the maintenance work of degritor is in process. The detention period is 15 days.
3. **SBR Tank**: The major criteria in this treatment is removal of BOD, removal of nitrates and phosphates. We have observed the BOD removal efficiency as 96 %. The higher efficiency is due to the proper maintenance of aeration equipment's (blowers and diffused aerators).

After discussion of the survey, proper scheduling was planned and was followed till present.

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