Performance Evaluation of 15MLD Sewage Treatment Plant (STP) at Gorakhpur

Nidhi[1] Dr. Govind Pandey[2]
[1]P.G. Student [2]Associate Professor
[1,2]Department of Civil & Environmental Engineering
[1,2]Madan Mohan Malviya University of Technology, Gorakhpur 273010

Abstract— In Gorakhpur city there are two sewage treatment plants of total capacity 45MLD (30MLD+15MLD). This paper deals with the performance evaluation of 15 MLD Sewage Treatment Plant (STP) located at Maherva Ki Bari, Near Lifting Canal Pumping Station Jharkhandi of Gorakhpur which works on Sequential Batch Reactor (SBR) technology. Performance of this plant is an essential parameter to be monitored as the treated effluent is discharged into Ramgarh Lake. 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 Inlet and Outlet of the Treatment Plant and analyzed for the major waste-water quality parameters, such as Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and Total Kjehldal Nitrogen (TKN). Actual efficiency of the 15 MLD STP will be evaluated by collecting samples (24 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 CPCB. DO is a very essential parameter to test because treated effluent discharged into Ramgarh Lake which is huge containment for aquatic life.

Key words: Efficiency, Evaluation, Performance, Sequential Batch Reactor, Total Kjehldal Nitrogen

I. INTRODUCTION

The main function of wastewater treatment plants is to give patronage to human health and defend the environment from excessive overloading of various contaminants. Due to industrial development in GIDA (Gorakhpur Industrial Development Authority), domestic effluent and urban run-off bring about the bulk of wastewater generated in Gorakhpur city. Domestic wastewater usually contains grey water (sullage), which is generated by washrooms, bathrooms, laundries, kitchens etc. It also contains black water made up of urine, excreta and flush water generated from toilets. Mechanical and biological processes are applied to remove screenings, debris, inorganic particles and biological contaminants. The chief objective of this wastewater treatment plant is to produce a waste stream (or treated effluent) and a biological solid waste or sludge also suitable for discharge or reuse back into the environment. In Gorakhpur, the common treatment technologies adopted for domestic sewage treatment are sequential batch reactors. The efficiency of sewage treatment plants can be given by measuring the pollutant levels of the influent and the effluent at the treatment plant discharging into the environment.

The treatment plant at Gorakhpur is designed to treat 15MLD sewage. There has not been any research conducted on the plant to ascertain the impact of the final effluent being discharged into Ramgarh lake.

A. *Present Scenario*

India is the country which faces the poor sanitation and maintenance system. Treatment capacity is much lower than the sewage generation capacity. Wastewater generation over the wastewater treatment ratios are *15644(MLD): 8040 (MLD), 35558(MLD): 11553(MLD), 2696(MLD): 233.7 (MLD)* in Metropolitan Cities, Class *I* Cities and Class *II* Towns respectively. This is due to the lack of sewage treatment plants at many places within the country the undesirable water is consume by the human beings as well as by animal which causes health hazards and sometime death. Irrigation system may also use that unwanted water which can adversely affect the agricultural activities.

Due to urbanization, largest sources of pollution are Municipal waste water and hence it requires intense 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”. In spite of treatment, some pollutants remain in effluent discharged into the water body. Treated wastewater sometimes may pathogens causing nuisances to human/ animal and also water containment. At present time, all process, product or services must also be analyzed. Therefore it is necessary to analyze the system to determine the overall pollution associated to these activities. Decadal population growth and migration of rural people to city has given rise to innumerable problems. Greater problem associated is the deterioration of Ramgarh Lake water quality index due to more or less unrestricted disposal of huge amount of wastewater.

II. SEWAGE TREATMENT PLANT AT GORAKHPUR

The sewage treatment plant at Maherva Ki Bari is designed to treat 15 MLD incoming flow on average basis but peak flow factor is 2.25 so it can handle up to 33.75 MLD of waste water which is just double for which it is designed. At present, the plant receives the waste water mainly from Kuda Ghat Nalla (Nalla No.1) and Gordhaiya Nalla (Nalla No.2). The outcome of these two Nallas ultimately meets at SPS 1(sewage pumping station situated at RKBK Mohaddipur), from where it pumped to STP by means of gravity pipes and conduits. The STP includes mainly 4 individual operating units that are Screens, Grit Chamber, SBR and Chlorine Contact Tank. Organic matters such as plastic, rags, large objects etc are removed by screens. Grit chambers are designed to deposit heavy inorganic solids by sufficiently reducing the velocity so these channels are long in construction but organic material remain in suspension.

For the removal of soluble organic matter and possibly also nitrogen from the wastewater, biological treatment, the second step is employed and followed by disinfection unit (Chlorine contact tank).

Fig. 1: Google Earth Image of the Treatment Plant

Wastewater treatment plants are constructed to give patronage to the environment from excessive overloading from various kinds of hazardous contaminants. These treatment plants must meet the appropriate effluent discharging standards. The present study is based on sequential batch reactor system because they are among the most widely-used systems.

A. *Sequencing Batch Reactors for Wastewater Treatment*

Water containment that receives the discharge of domestic waste water can be hazardous from environmental point of view. Therefore, it is necessary to treat waste water by some kind of application and technology to produce effluent with good quality standards. In this regard selecting an effective treatment system is important.

A treatment process that undergoes through repetitive cycles of sequenced aeration, settling, decant phase to treat slots of waste water. Sequencing batch reactors (SBR_s) based on a fill-and-draw activated sludge treatment process. SBRs are a variation of the activated-sludge process. Unlike, activated-sludge plants SBR_s combine all of the treatment steps and processes into a single basin, or tank, whereas conventional processes rely on multiple basins. Although the processes implied in SBR are similar to the conventional activated sludge process. SBR is time oriented and compact system, and all the steps are carried out sequentially in the same basin. SBR's presents a cost-effective way to produce lower effluent limits. Advancements in aeration devices and controls approved the SBRs to successfully rival over 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."

B. *SBR Operating Principles*

There are number of tanks/ basins implied by conventional activated sludge systems 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, treatment functions such as equalization, aeration and sedimentation occur sequentially within the identical tank in a time rather in a space sequence. Hence, SBR system requires less civil construction, inter-connected gates to regulate flow, and process equipment and the consequent savings in capital and operating costs. Operating function of SBR system based on extended aeration activated sludge principle to reduce carbonaceous BOD, nitrification, denitrification, prevent nitrogen gas disruption in the settle phase as well as total phosphorus removal using energy-efficient, fine bubble diffused aeration system with automatic control of air supply based on oxygen uptake rate. The Aerobic floating decanter follows the liquid level and maximizes the gap between the effluent withdrawal and sludge blanket. This facilitates withdrawal of supernatant under laminar flow condition to ensure the settle solids or floating debris does not interfere with treated sewage.

C. *Phases of Operation*

The sequencing batch reactor system makes use of the variable treatment in combination with a biological selector and operated in a batch- fed reactor mode. Equalization and clarification takes place within a reactor itself. The complete biological operation is divided into various cyclic modes. Each basic cycle comprises of:

- Fill Aeration (F/A)
- Settling (S)
- Decanting (D)

1) *Fill Aeration (F/A)*

During the period of fill- aeration, the liquid volume inside the reactor increases from a set operating low water level up to the high water level. Mixed liquor from the aeration zone is also recycled into the selector during the fill- aeration sequence.

2) *Settling (S)*

Aeration ends at a predetermined period of the cycle to allow the biomass to flocculate and settle under quiescent conditions.

3) *Decanting (D)*

After a predetermined period of settling, the treated supernatant is decanted using a moving weir electromechanical decanter. After decanting, the liquid level in the reactor is returned to the bottom water level after which the cycle is repeated.

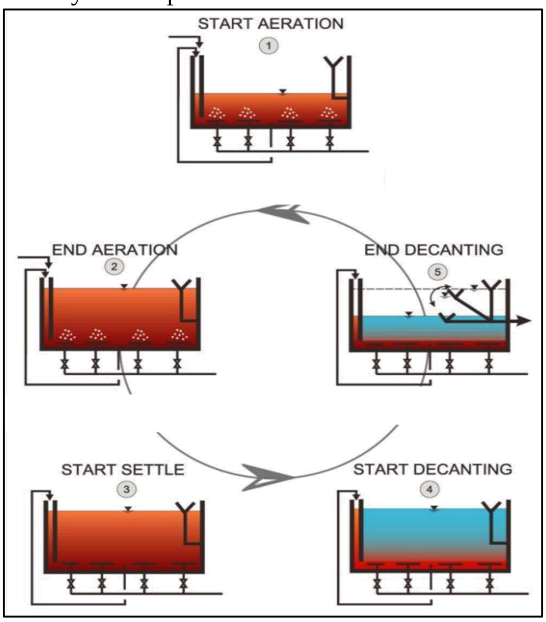

Fig. 2: Cyclic Phases of Sequential Batch Reactor

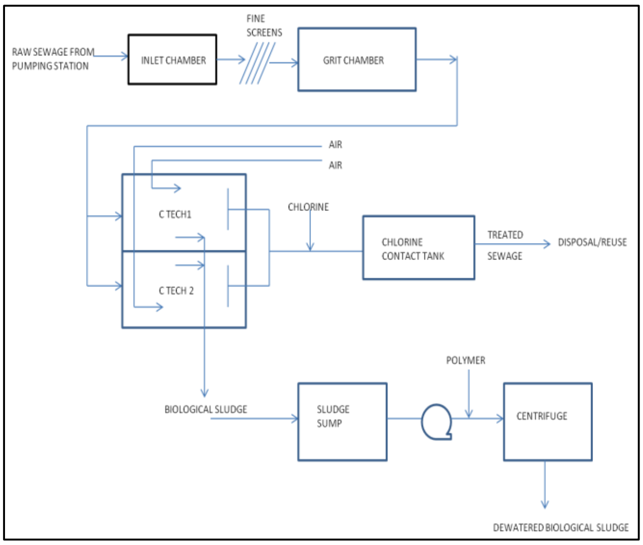

Fig. 3: Process Flow Sheet of Sewage Treatment Plant

III. METHODOLOGY

The Sewage treatment plant at Maherva Ki Bari, Near Lifting Canal Pumping Station Jharkhandi is being designed to treat 15 MLD of sewage from area of Gorakhpur city. The flow chart is as shown in Figure 2.

A. *Specifications of Plant*

1) *Capacity of plant: 15 MLD*
2) *Raw Sewage Quality Parameters:*
   - BOD_5@ 20°C = 200 mg/l
   - COD = 450 mg/l
   - TSS = 300 mg/l
   - TKN = 25 mg/l
   - Fecal Coli Forms = 1×10^7 MPN/100 ml
3) *Screens*
   - Type: Mechanically and Manual fine bar screen
   - Total number of screens = 3 Nos.
   - Total number of Mechanical screens(Automatic Raking Mechanism) = 2 Nos. of 6m×0.65m×0.50 (L×B×SWD) having angle of inclination as 45° with channel bottom and clear opening between bars is 6mm each.
   - Total number of Manual screens (Standby arrangement) = 1 Nos. of 6m×0.65m×0.50 (L×B×SWD) having angle of inclination as 45° with channel bottom and clear opening between bars is 10mm.
4) *No. of reactors: 2 no.s*
5) *Size of reactor: 42 m x 21 m x 5 m*
6) *C Tech Operating Sequence Comprises:*

	Time, Hrs →											
	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
Basin 1	F/A	F/A	F/A	F/A	F/A	F/A	S	S	D	D	D	D
Basin 2	S	S	D	D	D	D	F/A	F/A	F/A	F/A	F/A	F/A

Table 1: Operating Sequence Comprises

7) *The total cycle time for completing the process is 3 to 5 hours (3.0 hrs as per design basis) at 15 MLD Maherva Ki Bari STP.*
   - Fill Aeration (F/A)
   - Settling (S)
   - Decanting (D)
8) *The STP consists of 2 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).*
10) *The 15 MLD Maherva Ki Bari plant having "Sequential batch reactor technology" produce an effluent as per CPCB:*
   - BOD5@ 20°C ≤ 10 mg/l
   - TSS ≤ 30 mg/l
   - TKN ≤ 2 mg/l
   - COD ≤ 100 mg/l
   - Fecal Coli Forms ≤ 1000 MPN/100 ml

B. *Sampling Locations*

Samples were collected at Inlet/ Stilling Chamber (inlet), and chlorine contact tank (outlet).

C. *Sampling Period*

24 samples (12 sets of 2 samples) were collected for period of December to February.

D. *Laboratory Analysis*

Collected samples will be tested by standard methods in the laboratory for the parameters:
- Inlet sample: BOD, COD, Total suspended solids, Total Kjehldal Nitrogen and DO.
- Outlet sample: BOD, COD, Total suspended solids, Total Kjehldal Nitrogen and DO.

IV. OBSERVATION AND RESULTS

Parameter	DO(mg/l)		
Date	Inlet	Outlet	η%
05-12-16	1.3	4.2	69.04762
12-12-16	1.9	4.9	61.22449
19-12-16	1.2	4.1	70.73171
26-12-16	1.1	4.2	73.80952
02-01-16	1.2	4.6	73.91304
09-01-16	1.2	4.9	75.5102
16-01-16	1.2	4.2	71.42857
23-01-16	1.1	3.6	69.44444
06-02-16	1.2	4.1	70.73171
13-02-16	1.2	4.6	73.91304
20-02-16	1.1	4.8	77.08333
27-02-16	0.5	4.5	88.88889

Table 1: Test Observations for DO and incremental efficiency

Parameter	BOD(mg/l)		
Date	Inlet	Outlet	η%
05-12-16	57	10	82.45614
12-12-16	44	10	77.27273
19-12-16	45	11	75.55556
26-12-16	54	11	79.62963
02-01-16	55	8	85.45455

09-01-16	42	8	80.95238
16-01-16	52	9	82.69231
23-01-16	44	8	81.81818
06-02-16	42	8	80.95238
13-02-16	45	10	77.77778
20-02-16	52	8	84.61538
27-02-16	48	10	79.16667

Table 2: Test Observations for BOD and removal efficiency

Parameter	COD(mg/l)		
Date	Inlet	Outlet	η%
05-12-16	55	28	49.09091
12-12-16	52	20	61.53846
19-12-16	68	30	55.88235
26-12-16	72	24	66.66667
02-01-16	60	24	60
09-01-16	72	25	65.27778
16-01-16	80	24	70
23-01-16	72	30	58.33333
06-02-16	80	26	67.5
13-02-16	76	22	71.05263
20-02-16	68	22	67.64706
27-02-16	76	24	68.42105

Table 3: Test Observations for COD and removal efficiency

Parameter	TKN(mg/l)		
Date	Inlet	Outlet	η%
05-12-16	27.1	1.7	93.72694
12-12-16	24.2	1.8	92.56198
19-12-16	25.3	1.8	92.88538
26-12-16	24.8	1.7	93.14516
02-01-16	13.81	1.4	89.86242
09-01-16	15.36	1.8	88.28125
16-01-16	14.97	1.9	87.30795
23-01-16	12.89	1.7	86.81148
06-02-16	12.4	1.5	87.90323
13-02-16	14.81	1.7	88.52127
20-02-16	12.71	1.4	88.98505
27-02-16	13.51	1.9	85.93634

Table 4: Test Observations for TKN and removal efficiency

Parameter	TSS(mg/l)		
Date	Inlet	Outlet	η%
05-12-16	62	19	69.35484
12-12-16	52	20	61.53846
19-12-16	60	22	63.33333
26-12-16	58	19	67.24138
02-01-16	58	18	68.96552
09-01-16	52	17	67.30769
16-01-16	58	20	65.51724
23-01-16	54	17	68.51852
06-02-16	56	18	67.85714
13-02-16	66	20	69.69697
20-02-16	54	16	70.37037
27-02-16	74	18	75.67568

Table 5: Test Observations for TSS and removal efficiency

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 48.33 mg/l which is much lower than design consideration. Effluent BOD is within standard limits of discharging in the lake.
2) The overall BOD removal efficiency is 75%.
3) The concentration of total suspended solids at inlet was observed to be 58.67 mg/l with the removal efficiency of 62.60%.
4) Average COD at inlet is 67.58 mg/l with removal efficiency 63.44 %.
5) The removal efficiency of total kjehldal nitrogen was accounted as 89.65%.
6) Average DO at inlet is 1.09 mg/l and that of at outlet is 4.3 mg/l which meets the permissible limit of DO required by water body for survival of aquatic life.

Following observations were made during the onsite survey:

1) The major attempt in this treatment is removal of BOD, COD, TSS and Nitrates. It is found that the BOD removal efficiency as 75%. The higher efficiency is due to the proper maintenance of aeration equipment's (blowers and diffused aerators).
2) At 15 MLD STP, the major problem associated with influent is dilution.
3) Influent dilution causes the foaming because diluted influent does not contain sludge as much required for treatment phenomenon.
4) The flow is under estimated.
5) Fecal coli form test for outlet sample conducted once or twice during a month.

ACKNOWLEDGMENT

I would like to express my sincere thanks to the Head of Department, Dr. S.M. Ali Jawed and with deep sense of gratitude to my supervisor Dr. Govind Pandey, who, made things easy and possible. I thankfully acknowledge the use of facilities and data available at UP Jal Nigam and 15 MLD STP and their officials for receiving the valuable cooperation from time to time during the project.

REFERENCES

[1] Metcalf and Eddy, Wastewater Engineering, treatment and reuse, New Delhi: Tata McGraw-Hill Publishing Company Limited, 2003.
[2] Wastewater technology factsheet - Sequencing batch reactor," EPA, 1999.
[3] A. Gallego, A. Hospido, M. T. Moreira and G. Feijoo, "Environmental Performance of Wastewater Treatment Plant," Resources, Conservation and Recycling, vol. 52, pp. 931-940, 2008.

[4] D. Nolasco, D. Irvine, M. Manoharan and E. Giroux, “Evaluation and Optimization of Design/ Operation of Sequencing batch Reactors for Wastewater treatment”.
[5] A. H. Mahvi, “Sequencing Batch Reactor- A Promising Technology in Wastewater Treatment,” Iran Journal of Environmental Health Sciences and Engineering, vol. 5, no. 2, pp. 79-90, 2008.
[6] EPA, “Manual on Procedures for evaluating performance of wastewater treatment plants”.
[7] C.P.H.E.E. Organization, “Manual on Sewerage and Sewage Treatment,” Ministry of Urban Development, New Delhi.
[8] N. E. I. W. P. Control, “Sequencing Batch Reactor Design and Operational Consideration,” Sept, 2005.
[9] Colmenarejo et al. “Evaluation of municipal wastewater treatment plants with different technologies at Las-Rozas, Madrid (Spain)”. J. Environmental management, vol. 81 (4), pp. 339–404, 2006.
[10] Vigneswaran, S., Sundaravadivel, M., Chaudhary, D.S., “sequencing batch reactors: principles, design/operation and case studies”, water and wastewater treatment technologies, unesco-eolss sample chapter.