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Efficiency Study of Fluidized Aerobic Bioreactor Technology in Sewage Treatment Plant of Industrial Complex at Barbil, India

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Efficiency of sewage treatment plant employing fluidized aerobic bioreactor technology in an industrial complex at Barbil, Odisha, India was studied. Parameters like pH, TSS, BOD, COD, oil and grease were monitored. There is a considerable reduction of parameters in outlet samples with respect to inlet samples (81.5 % TSS, 94.65 % BOD, 85.51 % COD, 91.66 % oil and grease). pH changes from neutral to slightly alkaline. One way ANOVA test shows the significance reduction of different parameters ($F = 14.13$ for pH, $F = 831.3$ for TSS, $F = 7759.8$ for BOD, $F = 9276.72$ for COD and $F = 78.62$ for O & G at $p = 0.01$). Percentage increase/decrease of each parameter with respect to the previous treatment unit shows that the individual units are also performing well and their removal efficiencies are satisfactory. All the parameters studied are well within the prescribed standard for discharge of waste water to outside.

Keywords: Fluidized aerobic bioreactor, Sewage treatment plant, Biochemical oxygen demand, Chemical oxygen demand.

INTRODUCTION

Sewage is a complex matrix, with many distinctive chemical characteristics which include high concentrations of BOD, COD, high conductivity (due to the presence of high dissolved solids), with pH typically ranging between 7 and 8. The waste water varies in characteristics from the industries and domestic waste. The composition of waste water from the same industry also varies widely from day to day [1]. The organic fraction is composed of proteins, carbohydrates and fats, which reflects the diet of the community served by the treatment system [2]. Due to the characteristics of raw sewage and the requirements for disposal or reuse, the waste water usually requires some type of preparation or treatment before it is rendered fit for disposal or reuse [3].

Biological treatment of waste water [4-10] is an important and integral part of any treatment process that treats the wastewater having soluble impurities. Activated sludge process treatment technology is one such option for treating domestic wastewater [11]. Increasing pressure to meet more stringent discharge standards for waste water has led to the implementation of a variety of biological treatment processes in recent years. Special attention is necessary to assess the environmental impacts of existing waste water treatment facilities [12].

The degree of treatment provided to the waste water is largely being based on the effluent standards prescribed by the regulatory agencies to be discharged into a watercourse or land. The complete treatment of wastewater is brought by a sequential combination of various physical, chemical and biological unit operations. The performance efficiency of treatment plant not only depends on proper design and construction but also on good operation and maintenance. Performance evaluation of existing treatment plant is required [13] to assess the existing effluent quality and/or to meet higher treatment requirements and Environmental Protection Agency [14] to know about the treatment plant whether it is possible to handle higher hydraulic and organic loadings. Poor conditions of sewerage system, improper design of the plant and organizational problems are important factors that cause treatment plant not to meet the effluent standards [15]. If the system is hydraulically under loaded [16] or overloaded due to increase in population and water use, discharge of trade effluents are some of the reasons of recent times for the poor performance of waste water treatment plants [17].

Fluidized aerobic bioreactor (FAB) technology for waste water treatment is a better alternative to the conventional waste water treatment plants. Due to the scarcity of open space geographical network of piping, high power and land cost has made the conventional waste water treatment system obsolete.

Fluidized aerobic bioreactor technology serves as an efficient option for the purpose because of significant reduction in space requirement due to high surface area and loading rate of fluidized aerobic bioreactor media, reduced power and operating costs and no sludge recycle is required, hence no sludge recycle pumps. Fluidized aerobic bioreactor consists of a tank filled with specially developed media which are made of special material of suitable density that can be fluidized using an aeration device through diffusers. The bio-film that develops on the media, move along the effluent in the reactor. The movement within the reactor is generated by providing aeration with the help of diffusers placed at the bottom of the reactor. This thin film on the media enables the bacteria to act upon the biodegradable matter in the effluent and reduce BOD/COD content in presence of oxygen from the air used for fluidization [18].

EXPERIMENTAL

The study area is situated at Deojhar, Barbil of Odisha, India. It is a pelletization unit of capacity 10 MTPA which was commissioned during the year 2008. The industry is having a dedicated township with a population of 700 numbers which is also provided with a staff canteen. The domestic waste water is generated from all the house hold activities and also from canteen provided for staff.

The objective of the present study is to monitor the physico-chemical parameters like pH, total suspended solid, BOD, COD and oil and grease of the raw inlet sewage and outlet treated water of the sewage treatment plant employing fluidized aerobic bioreactor technology and to study the efficiency of the treatment system. The present treatment system comprises of inlet chamber, inlet to fluidized aerobic bioreactor, outlet of fluidized aerobic bioreactor (tube settler outlet) and outlet (filtration unit).

For the present study, waste water samples were collected from the inlet and outlet point of sewage treatment plant and analyzed for the various physico-chemical parameters. Standard methods were followed for collection and analysis of different parameters [19]. Performance appraisal has been carried out comparing the concentrations of pollutants at the inlet and outlet of the treatment units.

RESULTS AND DISCUSSION

pH: The results of the pH from various sections of the sewage treatment plant of the industrial township during the sampling period are shown in Fig. 1. It was observed that the pH in inlet chamber varies between 6.9-7.2 with an average pH value of 7.0. Further in outlet it varies between 7.9 to 8.2 with an average pH value of 8.0.It shows that the inlet pH is neutral and outlet pH is slightly alkaline in nature. So necessary pH adjustment of the waste water is of least concern. The above result shows that the pH of the waste water samples both in inlet and outlet are maintained as per the required norm (5.5-9.0). One way ANOVA shows a significant difference in change in pH (F = 14.13 at p = 0.01). Usually, sewage is acidic to a degree, but it depends on the specific effluents being conveyed by the sewer [20]. Further, Jan & Rafiq [21] and Mehdi & Rafiq [22] also conducted a similar type of experiment and

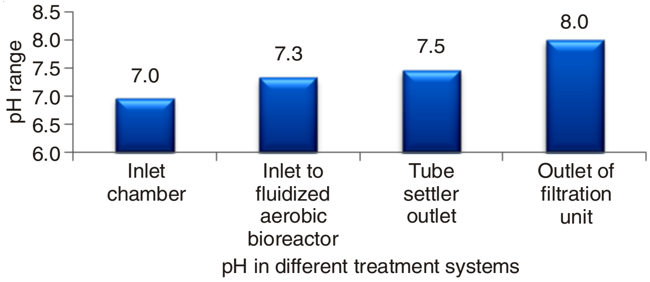

Fig. 1. Variation of pH in different sections

found that the mean pH increases from neutral to slightly alkaline with respect to influent to effluent.

Total suspended solid: The TSS concentration in the wastewater samples collected from various sections of the sewage treatment plant of industrial township during the sampling period are shown in Fig. 2. It was observed that during the study period, the mean TSS was found to be little high in inlet (146 mg/L) whereas it drastically decreases in the outlet sample (27 mg/L). The TSS value in the inlet varied between 126-183 mg/L and in outlet it varied between 16-39 mg/L. The outlet TSS was well below prescribed discharge standard (100 mg/L). This means the filters of the sewage treatment plant are functioning efficiently with 81.5 % reduction of TSS content of waste water. One way ANOVA shows a significant reduction in TSS (F = 831.3 at p = 0.01). A similar type of experiment [23] observed that there is a reduction of 93.72 % of TSS in treated effluent in comparison to untreated effluent. TSS reduction [24] of 94.51-99 % while studying the efficiency of a sewage treatment plant. Further, Jan & Rafiq [21], Mehdi & Rafiq [22] and Powar *et al.* [25] also observed similar type of trends in while studying the efficiency of different sewage treatment plant and ETPs.

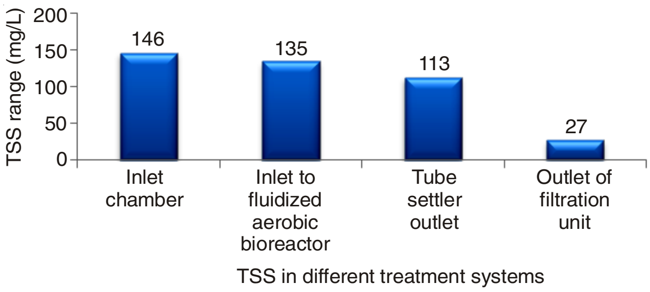

Fig. 2. Variation of total suspended solid (TSS) (mg/L) in different sections

Biochemical oxygen demand: The BOD of the wastewater samples collected at various sections of the sewage treatment plant at industrial township during the sampling period are shown in Fig. 3. During the sampling time the BOD was found to be high in inlet which varies between 217-265 mg/L with an average value of 243 mg/L. Whereas the value was declined in the outlet sample which varies between 10-16 mg/L with an average value of 13 mg/L, which is much below the prescribed standard (30 mg/L). This reveals that the secondary treatment through fluidized aerobic bioreactor technology is efficient for biological treatment process with 94.65 % reduction of BOD content of waste water. One way ANOVA shows a significant reduction in BOD (F = 7759.8 at p = 0.01). Further, Powar *et al.* [25] in their study found a BOD reduction of 258 to 30

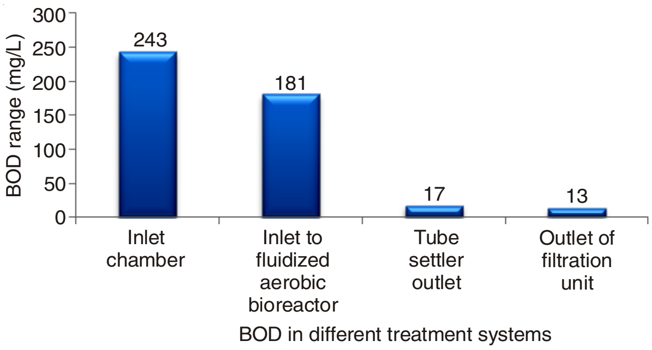

Fig. 3. Variation of BOD (mg/L) in different sections

mg/L, Kumar *et al*. [23] found a reduction of about 94 % of BOD, Ravi Kumar *et al*. [24] found a BOD reduction of 47.16 and 64.24 % in two different treatment systems, Jan and Rafiq [21] found a BOD reduction from 350.1 to 149.2 mg/L and Mehdi and Rafiq [22] found a BOD reduction of 261 to 59.43 mg/L in effluent in comparison to influent in their respective studies.

Chemical oxygen demand: The COD of the wastewater samples collected at various sections of the sewage treatment plant at industrial township during the sampling period are shown in Fig. 4. During the sampling time the COD was found to be high in inlet which varies between 419-562 mg/L with an average value of 497 mg/L. Whereas the value was declined in the outlet sample which varies between 51-96 mg/L with an average value of 72 mg/L, which is much below the prescribed standard (250 mg/L). This reveals that the secondary treatment through fluidized aerobic bioreactor technology is efficient. There was a reduction of 85.51 % in COD content of wastewater was noticed. One way ANOVA shows a significant reduction in COD value ($F = 9276.72$ at $p = 0.01$).There was a reduction of COD by 59.7 % [21], 76.26 and 91.60 % [24], 546 to 142 mg/L [22] and 500 to 170 mg/L [25] as studied by different authors.

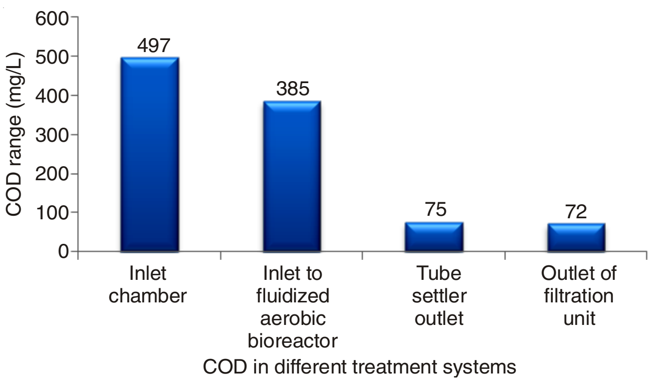

Fig. 4. Variation of COD (mg/L) in different sections

Oil and grease: The oil and grease of the waste water samples collected at various sections of the sewage treatment plant at industrial township during the sampling period are shown in Fig. 5. During the sampling time the oil and grease was found to be high in inlet which varies between 9-15 mg/L with an average value of 12 mg/L. Whereas the value was declined in the outlet sample which varies between 1-2 mg/L

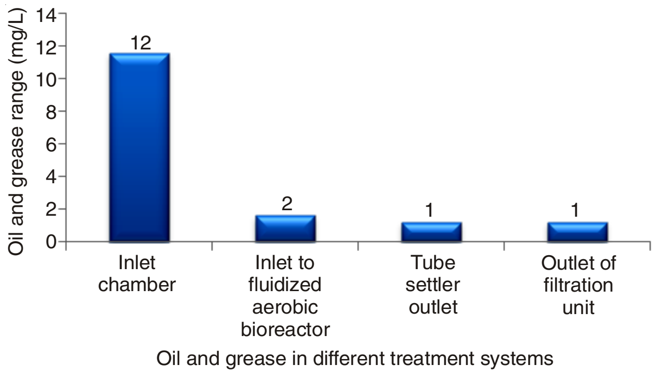

Fig. 5. Variation of oil and grease (mg/L) in different sections

with an average value of 1 mg/L, which is much below the prescribed standard (10 mg/L). This reveals that the secondary treatment through fluidized aerobic bioreactor technology is efficient. 91.66 % reduction in oil and grease content of wastewater. One way ANOVA shows a significant reduction in O & G ($F = 78.62$ at $p = 0.01$). A study on a common effluent plant, Powar *et al.* [25] have also found out that there is a reduction of oil and grease from 15-8 mg/L in the outlet with respect to inlet.

From the above study it was observed that, there is a reduction of all the parameters except pH, in the outlet with respect to the inlet. However in the outlet sample all the parameters are much below the limit as prescribed by the statutory bodies. Fig. 6 shows a comparison of inlet and outlet parameters.

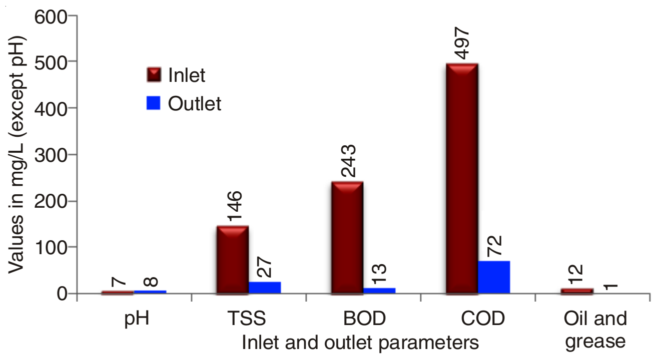

Fig. 6. Comparison of inlet and outlet parameters

Table-1 shows the percentage increase/decrease of each parameter in outlet with respect to inlet chamber. Further the mean percentage increase/decrease of each parameter with respect to the previous treatment unit is shown in Table-2.

TABLE-1
PERCENTAGE INCREASE/DECREASE OF EACH PARAMETER IN OUTLET WITH RESPECT TO INLET CHAMBER

Parameter	Inlet chamber	Outlet (filtration unit)	Percentage increase/ decrease
pH	7.0	8.0	14.28
TSS	146	27	81.5
BOD	243	13	94.65
COD	497	72	85.51
Oil & Grease	12	1	91.66

TABLE-2
PERCENTAGE INCREASE/DECREASE OF PARAMETERS WITH RESPECT TO THE PREVIOUS TREATMENT UNIT

Parameter	Inlet to fluidized aerobic bioreactor	Outlet of fluidized aerobic bioreactor (Tube settler outlet)	Outlet (filtration unit)
pH	4.28	2.73	6.66
TSS	7.53	16.29	76.1
BOD	25.51	90.6	23.52
COD	22.53	80.51	4.0
Oil & Grease	83.33	50.0	0.0

Conclusion

The performance study of the fluidized aerobic bioreactor technology in sewage treatment plant in the industrial complex indicated a positive efficiency of the system. The individual units are also performing well and their removal efficiencies are satisfactory. There is a considerable reduction of different parameters in the outlet sample with respect to the inlet samples. All the outlet parameters are well below the prescribed standard of the statutory bodies. Fluidized aerobic bioreactor technology can serve as an efficient option for the purpose. Therefore, fluidized aerobic bioreactor technology for waste water treatment is a better alternative to the conventional waste water treatment plants.

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