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Performance Evaluation of Prevailing Biological Wastewater Treatment Systems in West Bengal, India

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Abstract The present study has been undertaken to evaluate the performance of wastewater treatment systems (WWTS) in three different districts (Kolkata, Howra and Hugli) in West Bengal, India. Performance of these wastewater treatment plants are essential parameter to be monitored as the treated effluent is discharged into River Ganga which is the National River of India. The performance evaluation will also help for the better understanding of design and operating difficulties in wastewater treatment plants. The performance evaluation was done on the basis of removal efficiency of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Coliform (TC) and Fecal Coliform (FC). The performance of prevailing oxidation pond and activated sludge process type was good in terms of BOD, COD and TSS removal. Even though the removal efficiency of total and fecal coliform was high (85-98%), none of the plants meet the coliform discharge standards because of the high incoming TC and FC.

Keywords: *Activated sludge process, Oxidation pond, Coliform, wastewater treatment*

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1. Introduction

Water is the prime natural resource useful for the existence development of all living things in the world. Domestic wastewater usually contains greywater, which is wastewater generated from washrooms, bathrooms, laundries, kitchens etc. It also contains blackwater made up of urine, excreta and flush water generated from toilets [1]. The surface water bodies have been polluted to such an extent that they have been converted to natural effluent channels. In order to protect and preserve the limited water bodies, the formulation of appropriate pollution abatement strategies is essential. One of the steps in this direction is, to develop, a methodology finding integrated efficiency of wastewater treatment plant.

According to Vandeweerd et al. [2], about 90% of sewerage is discharged without treatment into lakes, rivers, and coastal waters bodies from developing world. The treatment methods were developed to answer the health issues of community and for the poor situations caused due to the wastewater discharge off in environment [3]. The correct wastewater treatment produce the effluent meeting to the desired guidelines in microbiological and chemical quality with minimum cost in operation and maintenance [4].

The main wastewater treatment technologies prevailing in India are Activated Sludge Process (ASP) and Oxidation Pond (OP). During mid-seventies, urban per capita solid waste generation in India was 250–350 gm/day1, whereas it has increased to 320–530 gm/day in late eighties; total sewage generated in India was about 30 billion litres/day in 1997 and recent figures indicated additional 50-70 % increase [5]. In the activated sludge process, the dispersed-growth reactor is an aeration tank or basin containing a suspension of the wastewater and microorganisms, the mixed liquor. The contents of the aeration tank are mixed vigorously by aeration devices which also supply oxygen to the biological suspension. Hydraulic retention time in the aeration tanks usually ranges from 3 to 8 hours but can be higher with high Biochemical Oxygen Demand (BOD) wastewaters. Following the aeration step, the microorganisms are separated from the liquid by sedimentation and the clarified liquid is secondary effluent. A portion of the biological sludge is recycled to the aeration basin to maintain a high mixed-liquor suspended solids (MLSS) level. The remainder is removed from the process and sent to sludge processing to maintain a relatively constant concentration of microorganisms in the system [6].

One of the oldest means of treating wastewater is the oxidation pond or stabilization pond. A stabilization pond is a lagoon that receives primary effluent and acts only as a secondary treatment process. All of these oxidation pond systems utilize bacteriological waste stabilization and long detention times to decompose the organic wastes that make up the BOD loading on the process. The long detention times also result in faecal coliform reduction. Ponds and lagoons can be mechanically aerated, but most are not aerated and rely on the natural oxygen transfer from wind and the symbiotic relationship between the

bacteria and the algae in pond. Algae provide much of the dissolved oxygen needed to maintain aerobic conditions and avoid odors caused by anaerobic or septic conditions [7].

West Bengal is facing a number of challenges affecting availability, acceptability and sustainability of water resource. Demand of water has been increasing rapidly during the last few decades resulting in acute scarcity to meet the very basic needs. In developing countries only a small proportion of the wastewater produced by sewered communities is treated. Developing country governments and their regulatory agencies, as well as local authorities, need to understand that domestic and other wastewaters require treatment before discharge or, preferably, re-use in agriculture and/or aquaculture [8].

The current practice is to evaluate the performance of the wastewater treatment systems (WWTS) by the removal of various parameters during the treatment. This reflects the individual parametric removal efficiency. However it is worth noting that all the parameters together will have a degrading effect on the surface water environment [9]. 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 [10]. Colmenarejo et al. [11] determined the general efficiency indicator to compare overall performances of the different plants in terms of average Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), BOD and ammonia removal efficiencies. The pH directly affects the performance of a secondary treatment process [10] because the existence of most biological life is dependent upon narrow and critical range of pH. Since, the solids removal is an important measure for the success of a primary treatment unit [12] and the dissolved solids content of the wastewater is of concern as it affects the reuse of wastewater for agricultural purposes [13]. Also, BOD removal is indicative of the efficiency of biological treatment processes [14].

The main objective of the study is to evaluate the performance of waste water treatment units existing in Howrah, Hugli and Kolkata districts of West Bengal. The treated waste water is discharged into the national River of India, Ganga which is polluted day by day by anthropogenic activities.

2. Methodology

2.1. Study Area

The study area lies between 23°22'28.84"N, 88° 8'57.71"E and 22°28'43.95"N 88°13'28.96"E in the state of West Bengal in India.

2.2. Sample Collection and Analysis

The WWTS were operated 24 hours a day and domestic sewage are channelled by drains leading to River Ganga. Composite sampling was done. Samples were collected in different containers at each point to add necessary preservatives as per standard procedure. The samples were preserved in icebox and transported to laboratory within 3 hours from the time of collection and analyses. The samples were analysed as per standard methods for the examination of water and wastewater [15] and triplicates of the samples were used.

2.3. Microbiological Analyses

For microbiological analyses, 100 ml water samples were collected from Sewage treatment plants in separate sterilized glass bottles. The samples were subjected to serial dilution in nutrient water containing potassium dihydrogen phosphate and magnesium chloride and inoculated in multiple tubes as per the maximum probable number method. The tubes contained 10 ml of lauryl tryptose broth for the detection of total coliform and faecal coliform were incubated at 35 ± 0.5°C for three hour in A1 broth. For faecal coliform, the tubes were inoculated serially and were incubated for three hour at 35 ± 0.5°C for three hours and transferred to a water bath at 44.5 ± 0.2°C and incubated for an additional 21 ± 2 hour. Production of an acidic reaction or gas production in any A-1 broth culture within 24 hours or less is a positive reaction indicating the presence of faecal coliform [15].

2.4. Statistical Analysis

The data obtained on the physicochemical and microbiological parameters of the ground water were subjected to correlation analysis. The correlation was carried on statistical software SPSS version 18.

3. Results

The inlet BOD of the wastewater ranged from 13 mg/l to 126 mg/l in ASP and the BOD to COD ratio ranged from 0.25 to 0.51. The BOD load by the WWTS to the environment ranged from 93 Kg BOD/day to 530 Kg BOD/day in ASP type of treatment plants. In oxidation ponds (OP), BOD varied from 13 mg/l to 88 mg/l and the BOD to COD ratio ranged from 0.18 to 0.38. The BOD load by the oxidation ponds to the environment ranged from 8 Kg BOD/day to 261 Kg BOD/day in ASP type of treatment plants. The BOD removal efficiency of Activated Sludge Process was ranged from 39% to 86% with an average of 61% (Table 1). The BOD removal efficiency of oxidation pond was ranged from 39% to 91% with an average of 69% (Table 2).

Table 1. The Removal efficiency of ASPs for different parameters

	Percentage Removal				
	BOD	COD	TSS	TC	FC
ASP 1	39	39	71	94	91
ASP 2	48	58	79	90	84
ASP 3	47	40	91	90	80
ASP 4	85	69	79	98	86
ASP 5	84	70	85	96	86
Average	61	55	81	94	85

The Chemical Oxygen Demand (COD) of the wastewater varied from 51 mg/l to 392 mg/l. The percentage removal efficiency of COD is ranged from 39% to 70% in ASP with an average of 55% (Table 1). In oxidation pond, the COD of the wastewater varied from 51 mg/l to 232 mg/l. The percentage removal efficiency of COD is ranged from 26% to 82% with an average of 50%.

The TSS of the wastewater varied from 24 mg/l to 248 mg/l. The percentage removal efficiency of TSS is ranged from 71% to 91% in ASP averaging 81%. In oxidation pond, the TSS of the wastewater varied from 58 mg/l to 888 mg/l. The percentage removal efficiency of TSS is ranged from 71% to 96% (Table 2).

Table 2. The Removal efficiency of OPs for different parameters

	Percentage Removal				
	BOD	COD	TSS	TC	FC
OP1	85	55	93	98	90
OP 2	65	56	96	95	85
OP 3	64	26	71	90	75
OP 4	39	32	91	98	90
OP 5	91	81	54	94	90
Average	69	50	81	95	86

In ASP, the total coliform in the incoming wastewater is as high as $16X10^{10}$ MPN/100 ml. Fecal coliform ranged from $16X\ 10^{7}$ MPN/100ml to $16\ X\ 10^{9}$ MPN/100ml. In OP also total and fecal coliform count is same in wastewater as that of ASP.

4. Discussion

Assessment of the performance of the Sewage treatment plants were based on BOD, COD, total suspended solids (TSS), and microbial removal. The percentage BOD and COD removal were low (61% and 55% respectively) compared to TSS, total coliform and fecal coliform removal in ASP. In oxidation pond also BOD (69%) and COD (50%) removal was lower than TSS, total coliform and fecal coliform removal. The ratio between BOD and COD plays an important role in the efficiency of wastewater treatment plants. In the present study the BOD to COD ratio ranged from 0.25 to 0.51 in ASPs and 0.18 to 0.38 in OPs. The biodegradability of the influent wastewater is low as they may be combined with industrial wastewater. This may cause the reduction of the efficiency of sewage treatment plants. There is no official value for BOD to COD biodegradability index for different types of wastewater [16]. However, reported values for biodegradability index vary from 0.4 to 0.8, for municipal raw wastewater [17].

In Oxidation ponds, aerobic bacteria oxidize organic matter and about 30% of the influent biochemical oxygen demand (BOD) escapes in the form of methane gas. Also, duration of retention, high temperature, pH (> 9) and light intensity together with high dissolved oxygen concentration is some of the principal mechanism that remove faecal bacteria in oxidation ponds [18]. In most of the Sewage Ops in the study area aquaculture is practised. For oxidation pond to be utilized for fisheries it has to meet acceptable standards. Svobodova et al. [19] listed the toxic concentrations of some parameters for fish in culture. Moreover, the oxidation pond environment was badly maintained hence macrophytes took over the pond. Macrophytes affect insolation by their shading effect; reduce wind overturn and increase evapo-transpiration in the pond thereby causing the sludge to build up. These agree with the works of [20,21]. The total suspended solids removal of both ASP and OP type of treatment systems found same. But the BOD removal was high in oxidation pond than the ASP (Figure 1).

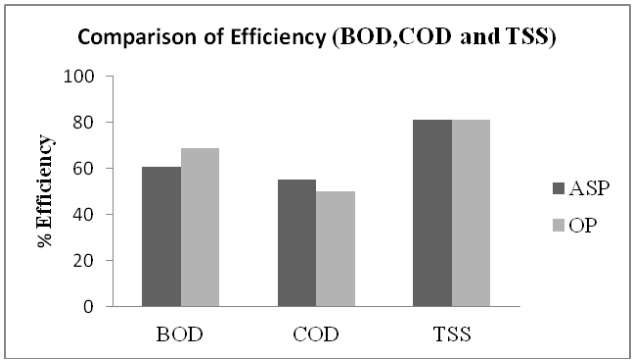

Figure 1. Efficiency of ASP and OP for BOD, COD and TSS removal

The average totalcoliform (TC) removal efficiency of ASP is 95% and that of fecal coliform (FC) is only 85%. But in the case of oxidation pond, the average efficiency in removing the total coliform is same as ASP (Figure 2). But fecal coliform removal efficiency is much higher in oxidation pond (98%)than ASP (85%). However, none of the WWTS have the coliform discharge standards of WHO [22].

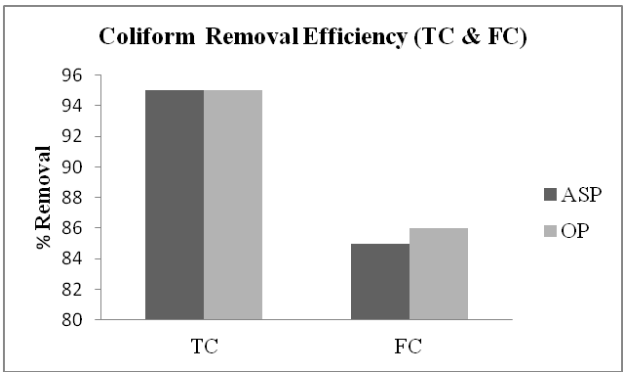

Figure 2. Total and Fecal coliform removal efficiency of ASP and OP

The discharge of untreated sewage and the ensuing bacterial contamination of surface water bodies pose a health risk in its reuse, be it for a variety of domestic purposes including safe drinking water, as well as exposing farmers who often use raw sewage or polluted streams to meet their irrigation needs. Although the oxidation pond is not designed for microbial removal, it could achieve that by algal productivity raising the hydroxyl ion content of the pond [21,23].

Oxidation pond technology is a highly sustainable technology for wastewater treatment [24], designed to function efficiently and effectively in the tropics due to favourable environmental factors. They are natural, have low operating and maintenance costs and can be used for fisheries and irrigation purposes [20]. They use direct solar energy and do not need any electromechanical equipment, saving expenditure on electricity and more skilled operation; hence appropriate for developing countries. The efficiency of OPs will impact on their uses for beneficial purposes. However, they require much more land than conventional electromechanical treatment processes such as activated sludge.

5. Conclusion

The expected removal efficiency of oxidation pond and Activated sludge process of waste water treatment plants in three districts of West Bengal is upto the design parameters and in physicochemical parameters. But the coliform content in the incoming wastewater is so high that even with this high performance, it is very difficult to meet the National or International Standards. Implementation of newer technologies to treat municipal wastewater is the need of the hour in West Bengal. One of the main problems in West Bengal is that the waste water is used for irrigation purpose and wastewater from these types of wastewater treatment plants will have negative impact on agriculture and consequent health hazards. Impact assessments have to be carried out to gauge and link effects on soil, possible groundwater contamination and food quality characteristics.

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