academicJournals

Vol. 12(17), pp. 2224-2233, 24 April, 2013
DOI: 10.5897/AJB12.2748
ISSN 1684–5315 © 2013 Academic Journals
http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Efficiency evaluation of three fluidised aerobic bioreactor based sewage treatment plants in Kashmir Valley

Dilafroza Jan*, Ashok K. Pandit and Azra N. Kamili

Centre of Research for Development, University of Kashmir, Srinagar-190006, Jammu and Kashmir, India.

Accepted 5 April, 2013

The present investigation was conducted to monitor the physico-chemical characteristics and microbial load of sewage treatment plants (STPs) around the Dal Lake. The results show highly significant ($P<0.001$) reduction in some physico-chemical features and in microbial load at outlet of each STP. Order of reduction in all the STPs was found to be biochemical oxygen demand (BOD) > chemical oxygen demand (COD) > conductivity and fecal coliform (FC) > total coliform (TCC) > fecal streptococcus (FS) in the case of physico-chemical parameters and microbial characteristics, respectively. The overall performance of the wastewater treatment plant effectively removed TCC, FC and FS as follows, 52, 65 and 45%, respectively. Raw sewage showed insignificant ($p>0.05$) variation in some of the physico-chemical features and microbial load between the three STPs. Similarly, effluent also showed insignificant ($p>0.05$) variation in some of the physico-chemical features and microbial load, except conductivity which showed significant difference between the three STPs. Efficiency rates showed significant ($p<0.05$) differences in COD between the three STPs. The removal efficiency rate was not dependent on the type of STP and the year. It can be concluded from the study that the majority of physico-chemical features and microbial load exceeded the permissible limit as per Indian national standards. Therefore as per the results, it is suggested that the effluent should be pretreated before disposing into the environment. In addition, there is an urgent need to improve their efficiency rate by including advanced tertiary treatment processes such as rapid sand filtration, UV disinfection, chlorination, effluent polishing, construction of artificial wetlands, etc.

Key words: Microbial load, sewage treatment plants, contamination load, efficiency rate.

INTRODUCTION

Urbanization, industrialization, modernization as well as agricultural activities have put tremendous pressure on the limited freshwater resources, causing eutrophication and pollution of freshwater bodies all over the world. In recent times, abrupt increase in production and domestic use of organic chemicals has obliged sewage treatment plants (STPs) to improve their efficiency. Freshwater systems of Kashmir have not remained immune to the anthropogenic pressures and many of these, especially those located close to the human habitations, have deteriorated during the last 50 years. In addition to other anthropogenic activities, sewage discharges from STPs are considered a major contributor of contamination in this urban lake of Kashmir.

Wastewater is a major burden for water bodies and improper disposal of sewage leads to oxygen demand, increased nutrient concentration and promotion of toxic algal blooms leading to a destabilized aquatic ecosystem

*Corresponding author. E-mail: dilafroza.wani@gmail.com.

(Morrison et al., 2001). It has been seen by various agencies that India wastewater is comprised of high levels of organic, inorganic and microbial contaminants (Bohdziewicz and Sroca, 2006). So far, extensive work has been carried out to study the physico-chemical removal efficiencies of STPs, whereas there is less literature regarding the microbial load in wastewater treatment plants and their removal efficiency. Sewage from households is collected via a sewer system and flows to STP for treatment of chemicals and microbial load. The high level of fecal contamination and enteric viruses present in raw sewage is a major concern for public health and the environment; and therefore assessment of sewage is essential to safeguard the public health (Okoh et al., 2005, 2007).

In most cases, STPs consist of two types of treatment systems: a physical and a biological purification steps. In physical purification, removal of the chemical is mostly due to sorption of chemicals to organic carbon. The effectiveness of the removal is directly related to the size and density of the particles. In the biological purification, removal is achieved by bacterial biodegradation, which mainly occurs via oxidation. At the end of the treatment processes, sludge and final effluent are released to the environment. Every chemical that enters the STP that is neither sorbed nor degraded will enter the environment via the effluent or evaporation from the STP. The priority objectives of wastewater treatment are to degrade organic wastes so that they do not cause oxygen demand in the receiving water body, remove nutrients to prevent eutrophication and protection of public health by destroying the pathogenic microorganisms (Gerardi, 2006; Akpor and Muchie, 2011).

Studies have shown that sewage treatment processes might also affect physico-chemical parameters of the final effluent such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity, total hardness, alkalinity, dissolved oxygen, some metals and non-metal ions (Rawat et al., 1998; Adami et al., 2007). Although, various microorganisms in water are considered to be critical factors in contributing to numerous waterborne outbreaks, they play many beneficial roles in wastewater influents (Kris, 2007). In addition, purification processes remove pathogenic microorganisms (Reasoner, 1982 Wang et al., 1966). Furthermore, microbiological indicators have been used for decades to monitor fecal pollution of water (Standard Methods, 1998).

Different studies have evaluated the efficiency of STPs and have compared the concentration of the chemical in the influent and that in the effluent. In most studies, significant reduction has been observed at outlet sites of STPs (Saha et al., 2012; Kumar et al., 2010; Desai and Kore, 2011). However, some studies have shown little or no reduction of pollutant concentration (Igbinosa and Okoh, 2009; Antunes, 2007; Momba et al., 2006; Akpor and Munche, 2011) which is a major concern for water bodies as well as public health. The comparative studies between STPs have shown both significant and insignificant variation (Jamwal et al., 2009; Kumar, 2010) in efficiency rates. In the past, some studies have also shown that STPs deviate from normal permissible limit which have been given by WHO and the United States Environmental Protection Agency (EPA) (Igbinosa, 2009; Antunes, 2007; Momba et al., 2006; Akpor, 2011).

Dal Lake receives effluent from the three STPs namely, Habak STP, Hazratbal STP and Lam STP as well as domestic wastewater from the surrounding settlements. These STPs were constructed by a private firm under the guidelines of Lakes and Waterways Development Authority (LAWDA) in 2004 at the cost of Rs 8.90 crore. In recent past, there has been debate on the working capability of these STPs. Although LAWDA seems to be satisfied with the working condition of these STPs, and claims that Dal lake's health would improve after all the STPs have started working, some analytical reports have raised questions about the working condition of these STPs. The research and monitoring division of LAWDA in August 2006, for example, reported increased nutrient concentration at the outflow stage, thus negating the claims made by LAWDA. So, knowing the above mentioned facts was necessary to perform a current monitoring survey on these STPs in order to know the present status of these STPs.

No past extensive study has been carried out to assess the efficiency and quality of these STPs. Because of the associated dangers of sewage, the present study was carried out to investigate the impact of the wastewater effluent discharged and to estimate the pollutant removal efficiency of STPs around the Dal Lake. We predicted that removal efficiency will depend on the characteristic features (working capability) of the individual STP, extent of aeration, hydraulic retention time, contact time and type of treatment used. In addition, microbial load will be greater in the influent than in the effluent (Figure 1).

MATERIALS AND METHODS

This study was conducted at three sewage treatment plants viz., Habak STP (34008'50"N - 74050'36"E), Hazratbal STP (34°08'06"N - 74°50'29"E) and Lam STP (34°07'42"N - 74°523'36"E) in the vicinity of Dal Lake with the design capacity of 3.2, 7.5 and 4.5 MLD, respectively (Table 1). All these plants receive domestic sewage and are treated using the fluidised aerobic bioreactor (FAB) biological treatment systems; a combined, dispersed and attached bacterial growth on fluidized media that is a modified version used in Germany, Netherlands, Europe and Canada successfully. This technology comprises of components like screening, grit removal, fluidised aerobic bioreactor followed by clarification and addition and precipitation to remove phosphates and chlorination (Figure 2). The final treated effluent is discharged into the lake. The water samples were collected on monthly basis for a period of 24 months between June 2010 and May 2012 for analysis of physico chemical features, in white plastic containers, which were previously sterilized with 70% alcohol and rinsed with distilled water. For microbial analysis, samples were collected seasonally at the three

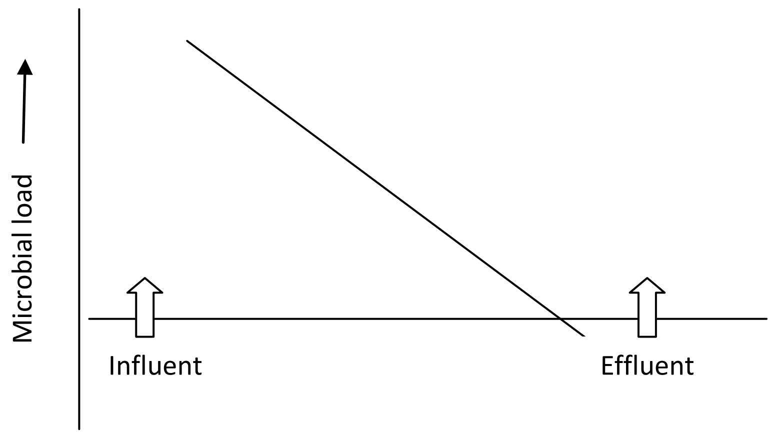

Figure 1. Hypothesis showing that microbial load decreases as the wastewater proceeds through the treatment processes.

STPs. At the sites, the containers were rinsed thrice with the wastewater before being used to collect the samples.

Physico-chemical parameters of water samples

The influent and effluent water samples were collected between 10.00 and 15.00 h from all the sampling stations in 1 L polyethylene bottles. The parameters pH and conductivity were recorded on the spot. For the estimation of dissolved oxygen, separate samples were collected in separate glass bottles and fixed at the sampling sites in accordance with the Winklers method (APHA, 1998). BOD was determined by the 5 day test method, while COD determination was carried out using the open reflux method as per Standard Methods in APHA (1998). For removal efficiency of physicochemical parameters, inlet concentrations were subtracted from outlet concentrations for each parameter.

$$\text{Removal efficiency} = \frac{\text{concentration in influent} - \text{concentration in effluent}}{\text{concentration in influent}} \times 100$$

Microbial examination of water samples

Microbiological examination of samples was conducted promptly as possible (within 24 h) after collection or were stored at 4°C in a refrigerator until use. Serial dilutions were prepared immediately after sample collection. The proper dilutions for various bacterial groups were selected so that number of colonies on plate was between 30 and 300 using spread plate method. A multiple tube fermentation technique or most probable number (MPN) technique was used to determine the bacterial indicators as faecal coliforms (FC) and faecal streptococci (FS) according to standard methods described in APHA (1998). Multiple tube fermentation method used in the present work included measurement of total plate count and MPN of coliform. After incubation for 24 h at 35°C, results were recorded when acid and gas liberated in Durham tubes had changed in color to yellow. The spread-plate method was used for all counts. FC agar and FS agar were used for enumeration of faecal coliform and faecal streptococci. Each test was done in triplicate and the geometric means were recorded. The removal efficiency of bacterial indicators was calculated using the following formula:

$$\text{Removal efficiency} = \frac{\text{log CFU in influent} - \text{log CFU in effluent}}{\text{log CFU in influent}} \times 100$$

Statistical analysis

Students t test was used to assess the significant variation between the raw influent and the effluent in the different STPs. One way ANOVA test was used to analyze the significant differences in influent and effluent between the three STPs. Similarly, efficiency rate between the different STPs was tested by using one way ANOVA test.

All statistics were carried out with the SPSS 11.5 statistical software package with significance levels set at P<0.05.

RESULTS

The data shows highly significant differences (P<0.001) in physico chemical features and microbial data between the inlet and outlet samples (Tables 2 and 3; Figures 3 and 8). Statistically, insignificant differences were observed in raw sewage and effluent between the three STPs (P>0.05) (Tables 4 and 5). Similarly, insignificant differences were observed in the efficiency rate of

Table 1. Details of sewage treatment plant around Dal Lake (LAWDA).

STP name and location	STP at HABAK	STP at Hazratbal	STP at Lam Nishat
Design capacity/day (MLD)	3.2	7.5	4.5
Land required (sqm)	600	1123	850
Average flow rate at inlet	Average flow rate 133.33 (m^3/h)	Average flow rate 312.5 (m^3/h)	Average flow rate 187.5 (m^3/h)
Peak flow rate	333 MLD	781.25 (m^3/h)	468.75 (m^3/h)
Grit chamber specifications	Long channel with Hopper bottom 6.0 x 1.2 m	Long channel with Hopper bottom 9.5 x 1.9 m	Long channel with Hopper bottom 7.5 x 1.5 m
Aeration tank i) Aeration tank volume (m^3) ii) Rated aeration capacity kg/KW hr or kg/hour	Fluidized aerobic bio-reactors 5.0 m diameter, 5.0 m depth + 1 meter free board x 2 NOs 98.19 m^3 x 2 = 196.38 m^3 260 m^3/hour 130 x 2 + 1 Standby	Fluidized aerobic bio-reactors 7.75 m diameter, 5.0 m depth 1 meter free board x 2 NOs 236 m^3 x 2 = 472 m^3 650 m^3/hour 325 x 2 + 1 Standby	Fluidized aerobic bio-reactors 6.0 m diameter, 5.0 m depth + 01 meter free board x 2 NOs 141.39 m^3 x 2 = 282.78 m^3 400 m^3/hour 200 x 2 + 1 Standby

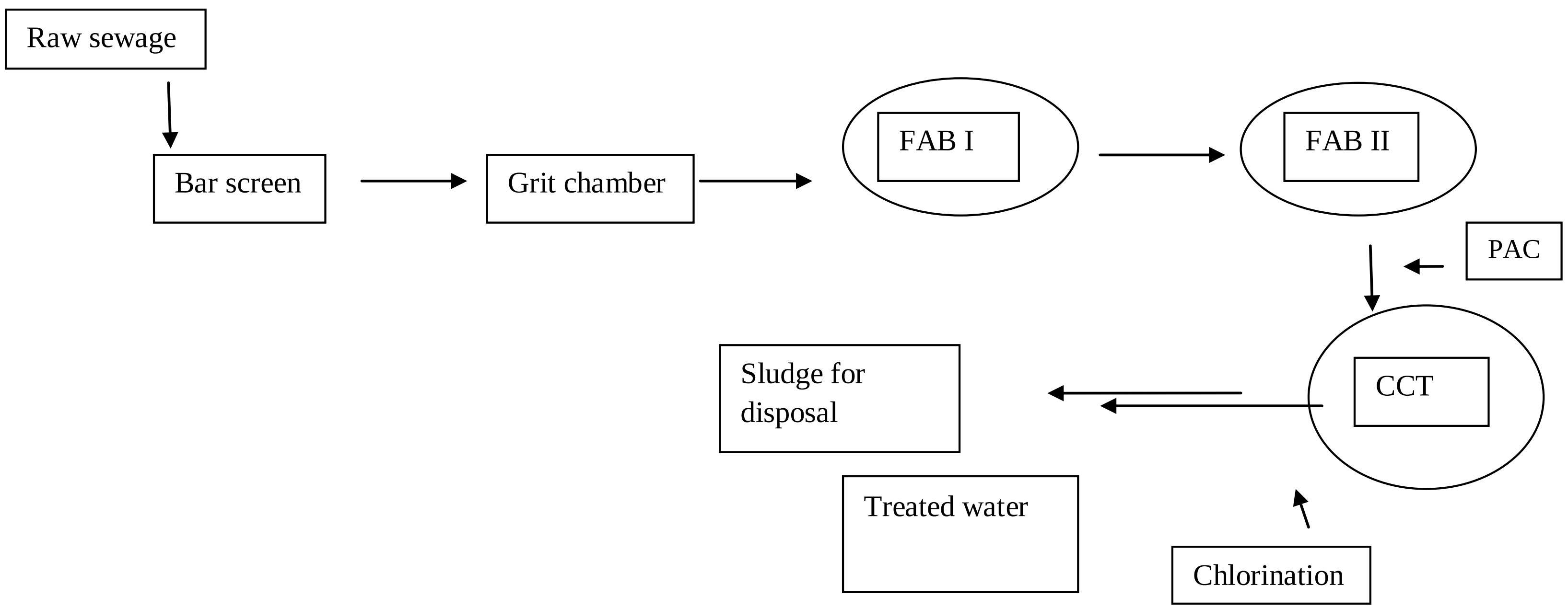

Figure 2. Process flow diagram for FAB based sewage treatment plants. FAB, Fluid aerobic bioreactor; PAC, poly aluminum chloride; CCT, calori tube settler.

Table 2. Physico chemical characteristics of raw sewage and effluent.

STPs	Raw conductivity (μScm^{-1})	Effluent conductivity (μScm^{-1})	*P-value*	Raw DO (mgl^{-1})	Effluent DO (mgl^{-1})	*P-value*	Raw BOD (mgl^{-1})	Effluent BOD (mgl^{-1})	*P-value*	Raw COD (mgl^{-1})	Effluent COD (mgl^{-1})	*P-value*
Habak												
2010-2011	787.81±136.9	533.27±86.86	P<0.001	1.5±.84	3.92±0.58	P<0.001	200.72±35.35	70.63±11.70	P<0.001	496.30±103.15	233.45±42.31	P<0.001
2011-2012	658.0±46.72	443.4±28.5	P<0.001	1.70±0.48	3.94±0.49	P<0.001	185.72±44.32	65±10.49	P<0.001	486.52±152.13	228.9±72.46	P<0.001
Hazratbal												
2010-2011	866.18±94.05	571.27±63.75	P<0.00	1.44±0.88	3.87±0.50	P<0.00	200±42.46	70.45±11.80	P<0.00	471.74±161.77	216.4±68.35	P<0.00
2011-2012	783.09±63.65	520.7±45.6	P<0.001	1.49±0.72	3.94±0.53	P<0.001	205.27±42.68	70±12.09	P<0.001	520.45±110.32	234.3±43.56	P<0.001
Lam												
2010-2011	880.54±59.9	590.90±37.86	P<0.001	1.31±.70	3.50±0.47	P<0.001	206±46.37	69.81±13.71	P<0.001	519.39±78.87	225.43±34.1	P<0.00
2011-2012	791.8±117.2	521.63±76.64	P<0.001	1.65±0.91	4.07±0.45	P<0.001	243±48.78	80.18±15.03	P<0.001	566.32±190.9	252.94±87.43	P<0.00

Table 3. Microbial load in sewage and effluent.

STPs	Raw Log TCC ($\times 10^7$)	Effluent Log TCC ($\times 10^6$)	*P-value*	Raw Log FC ($\times 10^5$)	Effluent Log FC ($\times 10^4$)	*P-value*	Raw Log FS ($\times 10^{74}$)	Effluent Log FS ($\times 10^3$)	*P-value*
Habak									
2010-2011	1.89±0.14	1.96±0.20	P=0.001	1.8±0.04	0.58±0.58	P=0.002	1.0175±1.01	0.55±0.12	P<<0.001
2011-2012	0.87±0.09	0.94±0.12	P<<0.001	1.88±0.04	1.05±0.11	P<<0.001	1.92±1.27	0.7148±0.03	P<<0.001
Hazratbal									
2010-2011	2.07±0.11	2.04±0.19	P<<0.001	1.7±0.05	0.58±0.65	P<<0.001	0.99±1.25	0.66±0.05	P<<0.001
2011-2012	0.99±0.10	0.99±013	P<<0.001	1.91±0.07	1.05±0.11	P<<0.001	1.87±0.12	0.75±0.10	P<<0.001
Lam									
2010-2011	1.99±0.16	2.03±0.18	P=0.001	1.82±0.07	0.58±0.65	P<<0.001	1.02±1.26	0.71±0.12	P<<0.001
2011-2012	0.96±0.10	0.97±0.12	P<<0.001	1.87±0.07	1.05±0.11	P<<0.001	1.92±0.13	0.70±0.1	P<<0.001

different physico chemical features and microbial loads between the three STPs (P>0.05), except COD, which showed significant variation between the three STPs (F = 4.6; P = 0.013) (Table 6).

The results obtained showed the pH on alkaline sideand ranged between 7.48 ± 0.08 and 7.53 ± 0.11 in raw sewage. Conductivity was found to be fluctuating in sewage from 658.0 ± 46.72 to 880.54 ± 59.9 (Figure 3). In the raw sewage, DO, BOD (Figure 4) and COD (Figure 5) were found to vary from 1.31 ± 0.70 to 1.70 ± 0.48 mg/L, 185.72 ± 44.32 to 243 ± 48.78 mg/l and 486.52 ± 152.13

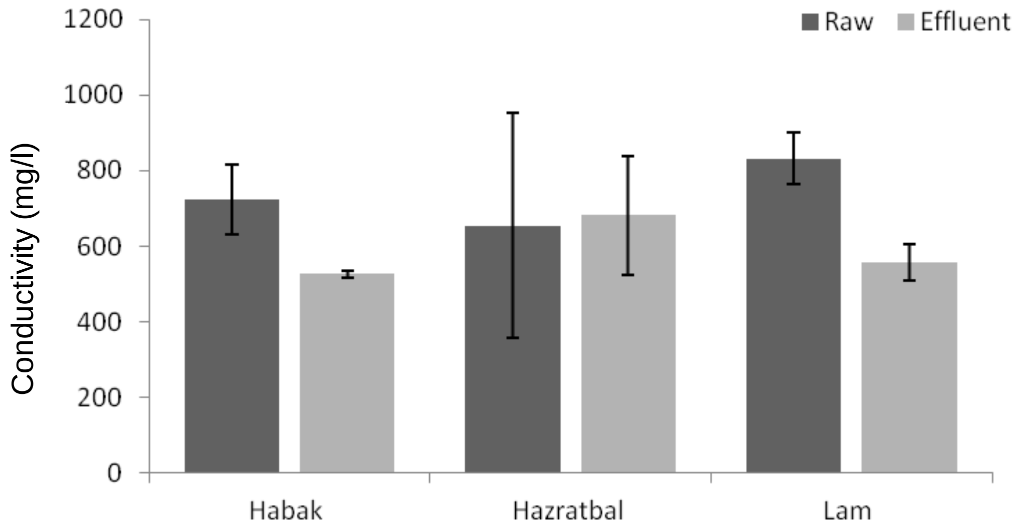

Figure 3. Conductivity of influent and effluent sewage from different STPs.

Table 4. Removal efficiencies (%) of different STPs.

STP location	Conductivity (μScm^{-1})	BOD (mgl^{-1})	COD (mgl^{-1})	TCC (cfu/100 ml)	FC (MPN/100 ml)	FS (MPN/100 ml)
Habak						
2010-2011	32.28±1.4	64.62±1.07	52.62±3.3	53.59±5.38	69.99±6.3	47.49±3.54
2011-2012	32.47±1.58	64.47±3.08	52.64±4.33	50.82±2.3	62.06±1.13	45.35±3.31
Hazratbal						
2010-2011	34.05±1.00	64.32±2.28	53.52±4.08	52.28±2.66	62.98±2.11	47.52±3.55
2011-2012	33.48±1.36	65.54±2.39	54.65±3.5	50.53±3.33	60.70±4.05	44.16±3.28
Lam						
2010-2011	33.03±1.56	65.99±2.82	56.55±1.8	51.67±4.78	60.82±5.32	46.10±3.53
2011-2012	34.01±0.95	66.61±1.79	55.34±4.2	52.30±4.38	62.29±3.8	45.52±2.77

Table 5a. Results of ANOVA test in raw sewage between three STPs.

Test parameter	Conductivity (μScm^{-1})	BOD (mgl^{-1})	COD (mgl^{-1})	TCC (cfu/ ml)	FC (MPN/100 ml)	FS (MPN/100 ml)
F	2.5	1.22	0.95	0.44	0.13	0.09
P-value	0.08ns	0.30ns	0.39ns	0.64ns	0.87ns	0.91ns

*Indicates significant at 0.05; ns indicates not significant.

Table 5b. Results of ANOVA test in effluent between three STPs.

Test parameter	Conductivity (μScm^{-1})	BOD (mgl^{-1})	COD (mgl^{-1})	TCC (cfu/ml)	FC (MPN/100 ml)	FS (MPN/100 ml)
F	6.12	2.29	0.28	0.37	1.01	0.00
P-value	0.004*	0.10ns	0.75ns	0.69ns	0.37ns	1.0ns

*Indicates significant at 0.05; ns indicates not significant.

Table 6. Results of ANOVA test in efficiency rate between three STPs.

Test Parameter	Conductivity (µScm^{-1})	BOD (mgl^{-1})	COD (mgl^{-1})	TCC (cfu/ ml)	FC (MPN/100 ml)	FS (MPN/100 ml)
F	0.13	0.61	4.6	0.47	1.57	0.10
P-value	0.87^{ns}	0.54^{ns}	0.013*	0.63^{ns}	0.22^{ns}	0.90^{ns}

*Indicates significant at 0.05; ns indicates not significant.

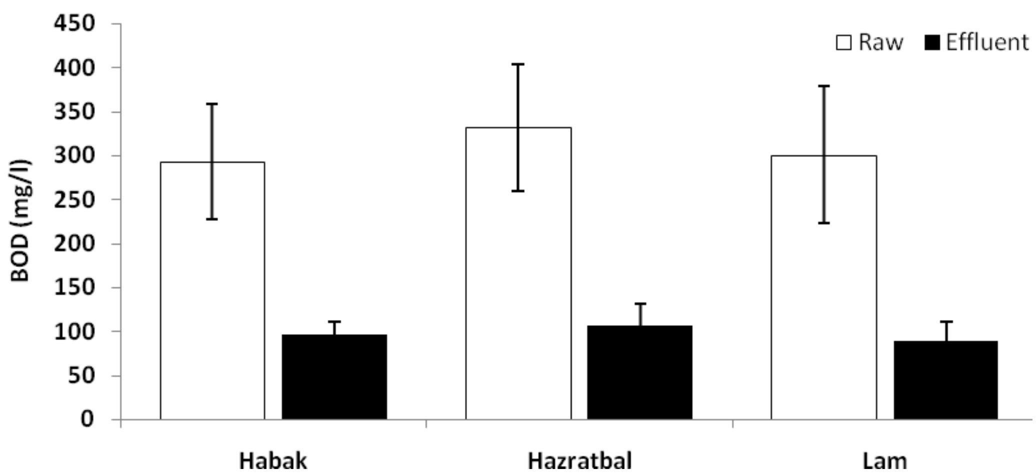

Figure 4. BOD of influent and effluent sewage from different STPs.

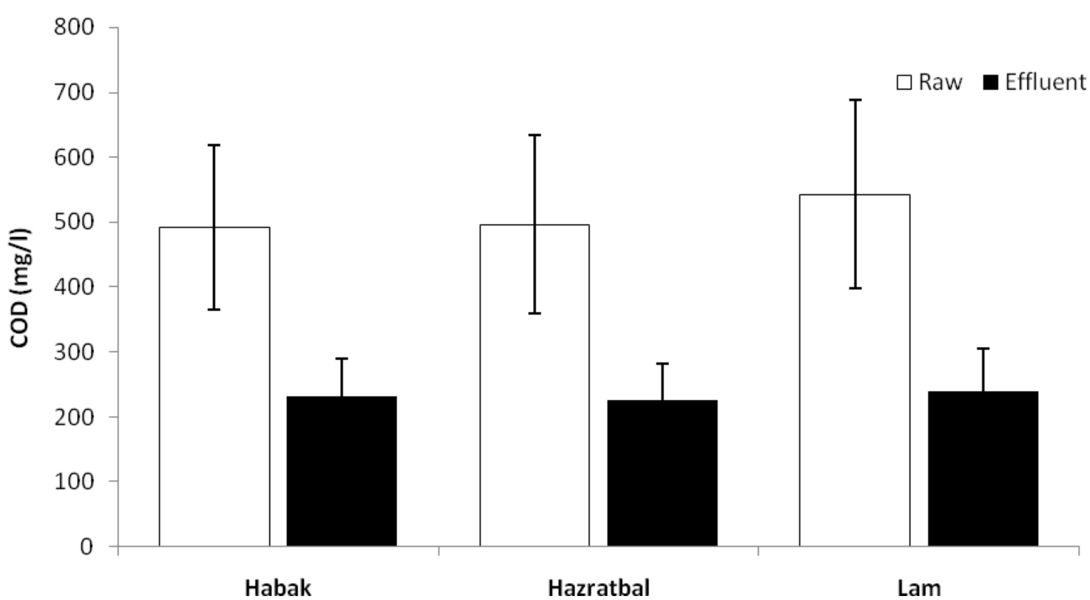

Figure 5. COD of influent and effluent sewage from different STPs.

to 566.32 ± 190.9 mg/L, respectively. The pH in the effluent was found to vary in the range of 7.64 ± 0.12 to 7.73 ± 0.09. The effluent concentrations of conductivity ranged from 443.4 ± 28.5 to 590.90 ± 37.86 µScm^{-1}. The DO, BOD and COD concentration in effluent ranged from 3.50 ± 0.47 to 4.07 ± 0.45 mg/L, 65 ± 10.49 to 80.18 ± 15.03 mg/L and 216.4 ± 68.35 to 234.3 ± 43.56 mg/L, respectively at all the sites. The overall removal efficiency of conductivity, BOD and COD was found to be 32.28 ± 1.4 to 34.05 ± 1.00, 64.32 ± 2.28 to 66.61 ± 1.79 and 52.62 ± 3.3 to 56.55 ± 1.8, respectively.

In the case of microbial indicators, TCC, FC and FS

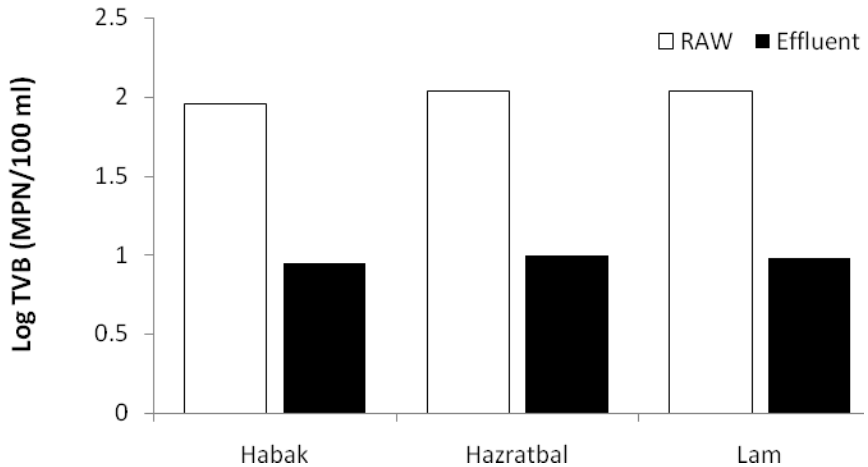

Figure 6. Microbial quality of raw and effluent sewage from different STPs (TCC in 2010-2011).

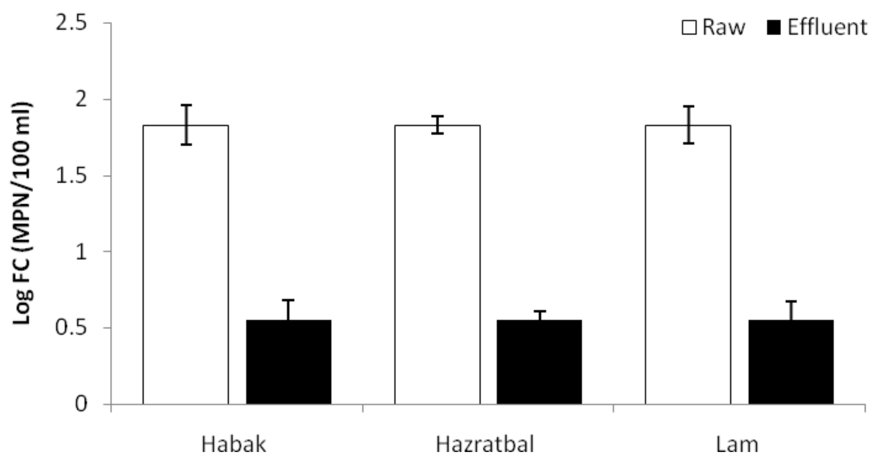

Figure 7. Microbial quality of influent and effluent sewage from different STPs (FC in 2010-2011).

concentrations in the inlet sample were found to fluctuate from 0.94 ± 0.12 to 2.07 ± 0.11 (cfu/ml), 1.7 ± 0.05 to 1.91 ± 0.07 (MPN/100 mL) and 0.99 ± 1.25 to 1.92 ± 0.13 (MPN/100 mL), respectively (Figures 6, 7 and 8). TCC, FC and FS concentrations were found to vary in the outlet water samples from 0.94 ± 0.12 to 2.04 ± 0.19 (cfu/ml), 0.58 ± 0.58 to 1.05 ± 0.11 (MPN/100 mL) and 0.55 ± 0.12 to 0.75 ± 0.10 (MPN /100 mL), respectively. Observations also revealed that the percent removal efficiency of TCC, FC and FS in all the STPs ranged from 50.53 ± 3.33 to 53.59 ± 5.38, 60.70 ± 4.05 to 69.99 ± 6.3 and 44.16 ± 3.28 to 47.52 ± 3.55, respectively.

DISCUSSION

Although data shows significant differences in physico-chemical features and microbial load between the inlet and outlet, nevertheless, these variations do not meet the Indian national standards. As per Indian standards, to discharge effluents into water bodies, BOD, COD and faecal coliform should be less than 30 and 250 mg/L and 2500 MPN/100ml, respectively.

The insignificant differences observed in the efficiency rate between the three STPs may be due to the fact that the same treatment technologies are employed for treatment of sewage at the three plants. Jamwal et al. (2009) while evaluating the efficiency of STPs in Delhi observed that effluents from all STPs exceeded FC standard of 10^3 MPN/100 ml for unrestricted irrigation criteria set by the National River Conservation Directorate (NRCD). However, they investigated STPs which were using different types of technologies including activated sludge process (ASP), extended aeration (EA),

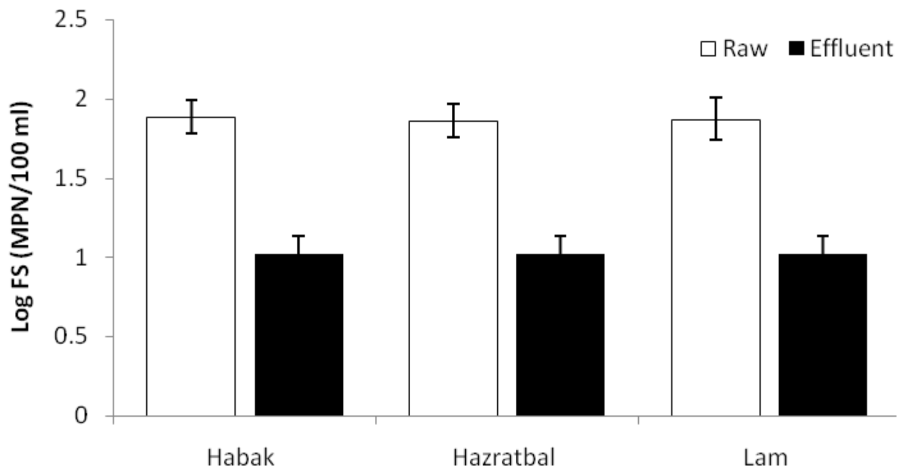

Figure 8. Microbial quality of influent and effluent sewage from different STPs (FS in 2011-2012).

BIOFORE, trickling filter and oxidation pond for the treatment of sewage. In our case, all STPs used the FAB based technology, which is a recent technique for removal of pollutants from municipal sewage. The comparatively low efficiency rate in the three STPs may be due to the fact that primary sedimentation is not carried out in these STPs and as such, the efficiency rate of pollutant removal is affected. Furthermore, the high bacterial load in the effluent may be attributed to the fact that an appropriate dose of chlorine for disinfection is not given to the effluent. The results show that faecal streptococci are more resistant and persistent even after chlorination as compared to faecal coliforms. These results coincide very well with the findings of Cohen and Shuval (1972). The reduction of microbes depends on protozoan predation, settlement of suspended solids, inactivation due to sunlight, activity of filamentous bacteria, turbidity and sedimentation.

It seems from the results that pH increased slightly from raw to final effluent which may be due to the reduction of free CO_2 level in final effluent and addition of polyaluminium chloride. The pH range recorded for all the sampling sites lie within the WHO pH tolerance limit, that is, 6 to 9 for wastewater to be discharged into water body. Our results coincide with the findings of Morrison et al. (2001) who also found increase in pH level during treatment process. Occasional absence of DO concentration in sewage was recorded in some STPs due to heavy organic loading and septic conditions. Kumar et al. (2010) found similar sewage characteristics while working on two STPs in Karnataka. The DO concentrations of the effluents in our study were less than 5 mg/l. Consequently, these water sources would not be suitable for use of aquatic ecosystems (Rao, 2005). However, there was a slight increase in the effluent DO content due to the treatment processes, which may reduce the amount of impurities present in sewage through oxidation of organic matter (Prescott et al., 2002).

The high values of conductivity in raw sewage in the present study indicate increased salt concentration and pollution level of STPs. Reduction in BOD in all STPs during the treatment process may be due to the oxidation of organic matter by microorganisms that are used in FAB treatment as well as coagulation and flocculation brought about in the Claritube settler, which is a clarification cum flocculation chamber. Similar results were observed by Jamwal et al. (2009). The percentage removal of BOD in all the STPs was 67.86 ± 2.6 to 70.00 ± 3.6%, which is below the expected value of 85 to 90%, thus showing that BOD reduction is less than the expected. The same rate of reduction in BOD in all STP's could be due to similar technology which is currently used in all three STPs. COD shows similar trend as BOD. The significant variation in efficiency rate in COD between three STPs could be due to different types of sewage coming from different catchment areas.

Similarly, results show decrease in COD level at outlet during the treatment process due to the above mentioned facts. High COD and BOD concentration observed in the wastewater might be due to the use of chemicals, which are organic or inorganic that are oxygen demanding in nature (Akan et al., 2008). The values for most of the parameters in the discharged effluent were almost higher than the acceptable limits. This shows the inefficiency of the treatment plant in removing the pollutants in the sewage.

Tertiary treatment methods are essential to remove nitrogen, phosphorus, suspended solids, dissolved solids, refractory organics and heavy metals. Tertiary treatment process involves the addition of certain chemicals such as alum and polyelectrolytes which convert the dissolved substances into a solid settle able form. These chemical coagulates, mix up with the sewage water to form an insoluble gelatinous floc of suspended solids which settles down quickly.

In our case, it was observed that tertiary treatment is not capable of removing pollutants to a large extent. The reason may be inflow of sewage beyond designed capacity and improper maintenance and lack of expertise in the field.

The high coliform count in raw sewage obtained in our results may be an indication that the sewage is comprised of faecal matter coming from household latrines (APHA, 1998). The presence of pathogenic bacteria in treated wastewater effluent is a potential public health hazard, as this water source is directly discharged in receiving water bodies and may be used by communities for multiple purposes. At the inlet, physico-chemical parameter values are relatively high which causes microbial biomass development, in particular, increases in faecal coliform and faecal streptococci (Rajib et al., 2011). It is clear from our results that some amount of microbial load is retained even after the purification treatment process. So, it is essential to include a tertiary treatment step in STPs so that the purification process results in bacterial concentrations that are in compliance with discharge (Koivunen et al., 2003).

CONCLUSION AND SUGGESTIONS

All the municipal wastes that may have otherwise gone untreated into the environment are restricted from entering. Thus, these treatment plants play an important role in the control of pollution level. The results show highly significant reduction in some of the physic chemical features and microbial load. However, performance of these STPs do not meet the permit standards set by the Indian standard and WHO. Therefore, it is suggested that authorities should improve their efficiency capability by including tertiary treatment processes such as rapid sand filtration, UV disinfection, artificial lagoons, wetlands, adequate contact time, etc. In addition, there is need of trained and technical staff for proper monitoring and operation of these STPs in a standardized manner. Furthermore, regular monitoring of these STPs by national experts is necessary in order to improve the operational capability of these STPs.

REFERENCES

Adami G, Cabras I, Predonzani S, Barbieri P, Reisenhofer E (2007). Metal pollution assessment of surface sediments along a new gas pipeline in the Niger Delta (Nigeria). Environ. Monit. Assess. 125:291-299.

Akpor OB, Muchie M (2011). Environmental and public health implications of wastewater quality Afr. J. Biotechnol. 10:2379-2387.

American Public Health Association (APHA) (1998). Standard Methods for the examination of water and waste water, 19th edition. American Water works Association Water Pollution Control Federation publication, Washington, D.C.

Antunes S, Dionisio L, Silva MC, Valente MS, Borrego JJ (2007). Proc. of the 3rd IASME/WSEAS Int. Conf. on Energy, Environment, Ecosystems and Sustainable Development, Agios Nikolaos, Greece, pp. 24-26.

Bohdziewicz J, Sroka E (2006). Application of hybrid systems to the treatment of meat industry wastewater. Desalination 198(1-3):33-40.

Cohen J, Shuval HI (1972). Coliforms, faecal coliforms and faecal streptococci as indicators of water pollution. Water Air Soil Pollut. 2:85-95.

Desai PA, Kore VS (2011). Performance evaluation of effluent treatment plant for textile industry in Kolhapur of Maharashtra. Univ. J. Environ. Res. Technol. 1:560-565.

EPA (2003). US Environmental Protection Agency Safe Drinking Water Act. EPA 816-F-03-016.

Igbinosa EO, Okoh AI (2009). Impact of discharge wastewater effluents on the physico-chemical qualities of a receiving watershed in a typical rural community. Int. J. Environ. Sci. Technol. 6(2):175-182.

Jamwal P, Mittal AK, Mouchel JM (2009). Efficiency evaluation of sewage treatment plants with different technologies in Delhi (India). Environ. Monit. Assess. 153:293-305.

Koivunen J, Siitonen A, Heinonen-Tanski H (2003). Elimination of enteric bacteria in biological-chemical wastewater treatment and tertiary filtration units. Water Res. 37:690-698.

Kris M (2007). Wastewater pollution in China. Available from http: www.dbc.uci/wsu stain/suscoasts/krismin.html

Kumar PR, Pinto LB, Somashekar RK (2010). Assessment of the efficiency of sewage treatment plants: a comparative study between nagasandra and mailasandra sewage treatment plants. Kathmandu Univ. J. Sci. Eng. Technol. 6:115-125.

Momba MNB, Osode AN, Sibewu M (2006). The impact of inadequate wastewater treatment on the receiving water bodies – Case study: Buffalo City and Nkokonbe Municipalities of the Eastern Cape Province. Water SA. 32:687-692.

Morrison GO, Fatoki OS, Ekberg A (2001) Assessmetn of the impact of point source pollution from the Keiskammahock sewage treatment plant on the Keiskamma River. Water SA 27:475-480.

Okoh AI, Barkare MK, Okoh OO, Odjadjare E (2005). The cultural microbial and chemical qualities of some waters used for drinking and domestic purpose in a typical rural setting of Southern Nigeria. J. Appl. Sci. 5:1041-1048.

Okoh AI, Odjadjare EE, Igbinosa EO, Osode AN (2007). Wastewater treatment plants as a source of microbial pathogens in the receiving watershed. Afr. J. Biotechnol. 6:2932-2944.

Prescott LM, Harley JP Klein DA (2002). Microbiology, 5th edition. Mc Graw Hill, New York. pp. 651-658.

Rajib AB, Kallali H, Saidi N, Abidi S (2011). Physico-chemcial and microbial characterization performancy in waste water treated under aerobic reactor. Am. J. Environ. Sci. 7(3):254-262.

Rao PV (2005). Textbook of environmental engineering. Eastern Economy Ed., Prentice-Hall of India Private Limited, New Delhi, Chapter 3, p. 280.

Rawat KP, Sharma A, Rao SM (1998). Microbiological and physicochemical analysis of radiation disinfected municipal sewage. Water Res. 32:737-740.

Reasoner DJ (1982). Microbiology: detection of bacterial pathogens and their occurrence. J. WPCF. 54:942.

Saha ML, Alam A, Khan MR, Hoque S (2012). Bacteriological, physical and chemical properties of the Pagla sewage treatment plant's water. J. Biol. Sci. 21:1-7.

Wang WLL, Dunlop SG, Munson PS (1966). Factors influencing the survival of Shigella in wastewater and irrigation water. J. Water Pollut. Control Fed. 38:1775-1781.