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Assessing the Performance of a Sewage Treatment Plant in Habbak, Srinagar: A Physicochemical Analysis

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ABSTRACT

A study was carried out to assess the physicochemical profile of one of the sewage treatment plants in the Habbak region of Srinagar city. The water samples from the inlet and outlet of the plant were analyzed for various limnological parameters like temperature, dissolved oxygen, free carbon dioxide, alkalinity, calcium and magnesium hardness, orthophosphate etc. The average water temperature recorded at the outlet and inlet ranged between 16.56 to 18.03°C, free carbon dioxide between 50.06 to 78.03 mg/l, alkalinity between 328 to 389 mg/l, calcium hardness between 83.41 to 85.12 mg/l, magnesium hardness between 614.58 to 783.53 mg/l, orthophosphate between 503.56 to 650μg/l respectively. The dissolved oxygen content at the inlet was found to be zero during all times in the study while the average value at the outlet was found to be 5.2 mg/l. All the parameters were found to be non-significant except for water temperature, dissolved oxygen, and total hardness.

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INTRODUCTION

Surface water is an important source of water; it becomes useless when pollutants of wastewater get mixed with it. In villages and towns sewage is discharged into rivers, canals etc. and hence water quality is affected (Rainaand *et al*., 2014). The main sources of water pollution can be attributed to the discharge of untreated sanitary and industrial wastes (Sastry *et al*., 2013). It has been seen by various agencies that wastewater comprises of high levels of organic, inorganic, and microbial contaminants (Bohdziewicz *et al*., 2006).

The largest union territory of India, Jammu and Kashmir has always had abundant water resources. According to the comptroller and auditor general of India, irrigation canals across J&K were allowed by the government to turn into sewage drains (CAG, 2011). According to Srinagar city development plan (SCDP), only 30% area is covered by sufficient sewage systems. While only 12% of households have access to sewage connections (JKERA 2007). Against the total sewage generation of 195 MLD, Srinagar has four sewage treatment plants with a total capacity of 32.2 MLD (Farhat, 2006).

Studies have shown that sewage treatment processes might also affect the Physicochemical 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). In addition, purification processes remove pathogenic microorganisms (Reasoner, 1982; Wang *et al.*, 1966). 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

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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).

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). Fluidized aerobic bioreactor (FAB) technology for wastewater treatment is a better alternative to conventional wastewater treatment plants. 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 biofilm that develops on the media, moves along the effluent in 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 air used for fluidization. (Nageswara and Shruthi, 1990). Globally, unclean water poses significant risks of diarrhea, opportunistic infections, and malnutrition, accounting for 1.7 million deaths annually, of which over 90 per cent are in developing countries and almost half are children.

MATERIAL AND METHODS

Present study was carried out on Sewage Treatment Plant Habak in Srinagar city of Union Territory of J&K, India. It is one among the four wastewater treatment plants situated around the periphery of Dal Lake, Srinagar. Located at 4RWV+94P, Foreshore Rd, Habak, Nasim Bagh, it was constructed in 2006 at a latitude of 34.1460 ^{0}N and longitude of 74.8428 ^{0}E. The STP has a capacity of 3.2 MLD, with the average flow rate at the inlet being 133.33m^3/h. During the study period, two sites were selected to carry out the Physicochemical analysis of samples before treatment and after treatment. Water samples were collected from selected sites in the month of May 2022 in 1-liter polyethene bottles. Separate samples were collected for dissolved oxygen in well-stopper bottles of 250 ml capacity. Initial fixation was done on the field and chemical analysis of water samples was carried out in the laboratory within 24hrs. Some other parameters like water temperature, pH, conductivity, free carbon dioxide, chloride, total alkalinity, total hardness, Ca hardness, Mg hardness, and orthophosphate, were carried out following standard procedures of A.P.H.A (2017).

Figure 1. Location of the sewage treatment plant.

RESULTS

The results obtained during the study are presented in Table 1 and 2.

Temperature (^{0}C)

At site 1 a minimum value of water temperature was found to be 16.4 ^{0}C in 1^{st} week of the study while a maximum value of 19.6 ^{0}C was observed in 3^{rd} week with an average value of 18.03 ^{0}C. At site 2 during the study period, the water temperature recorded a minimum value of 15.0 ^{0}C during 1^{st} week and a maximum value of 17.9 ^{0}C in 3^{rd} week with an average value of 16.56 ^{0}C.

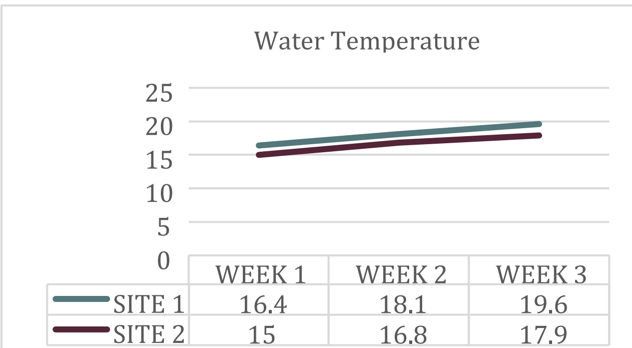

Figure 2. Graph representing water temperature variation at sites.

pH

At site 1 during the study period, the pH recorded a minimum value of 6.95 on the 3^{rd} week and a maximum value of 7.6 on the 2^{nd} week with an average value of 7.17. At site 2 during the study period, the pH recorded a minimum value of 7.15 on 1^{st} week and a maximum value of 7.19 in 2^{nd} week with an average value of 7.16.

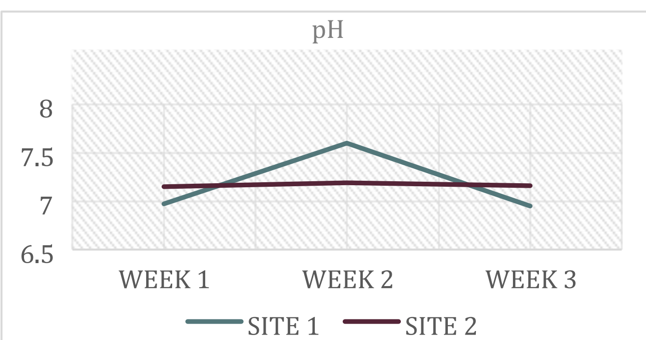

Figure 3. Graph representing pH variation at sites.

Conductivity (µS/cm)

At site 1 during the study period, the conductivity recorded a minimum value of 690.2 µS/cm in 2^{nd} week while a maximum value of 989 µS/cm in 1^{st} week with an average value of 801.93µS/cm. At site 2 during the study period, the conductivity recorded a minimum value of 620.0 µS/cm in 2^{nd} week and a maximum value of 970.0 µS/cm in 1^{st} week with an average value of 766.67µS/cm.

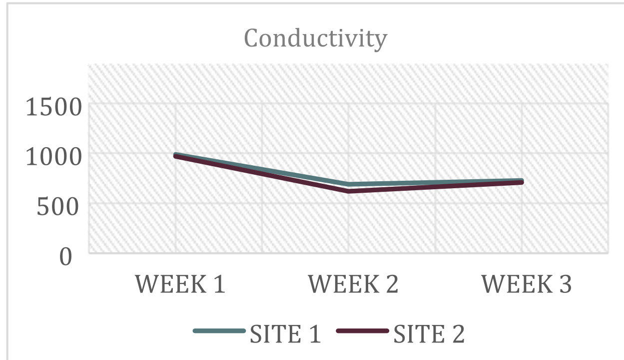

Figure 4. Graph representing Conductivity variation at sites.

Free CO_2 (mg/l)

At site 1 during the study period, the free CO_2 recorded a minimum value of 73.9 mg/l on 3^{rd} week while a maximum value of 81.6 mg/l in 1^{st} week with an average value of 78.23mg/l.

At site 2 during the study period, the free CO_2 recorded a minimum value of 36.9mg/l on 1^{st} week and a maximum value of 58.8 mg/lon2^{nd} week with an average value of 50.06 mg/l.

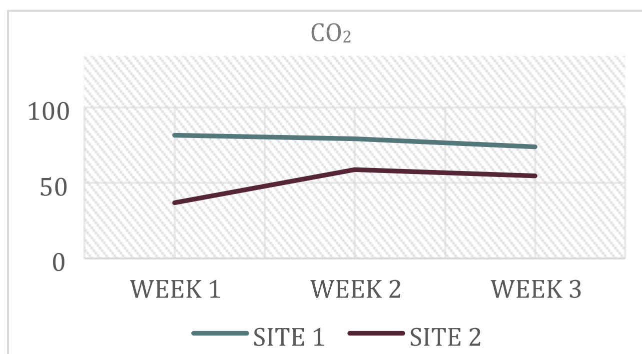

Figure 5. Graph representing Free carbon dioxide variation at sites.

Chloride (mg/l)

At site 1 during the study period, the chloride recorded a minimum value of 26.9 mg/l in 3^{rd} week and a maximum value of 39.9 mg/l in 1^{st} week with an average value of 33.56mg/l. At site 2 during the study period, the chloride recorded a minimum value of 23.9 mg/l in 2^{nd} week and a maximum value of 36.9 mg/l in 3rd week with an average value of 28.56mg/l.

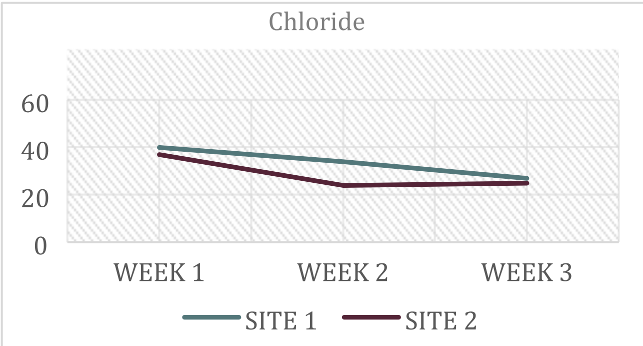

Figure 6/ Graph representing Chloride variation at sites.

Dissolved Oxygen (mg/l):

At site 1 during the study period the DO recorded was zero. At site 2 during the study period, the DO recorded a minimum value of 3.6 mg/l on 1st week and a maximum value of 6.4 mg/l on 2nd week with an average value of 5.2mg/l.

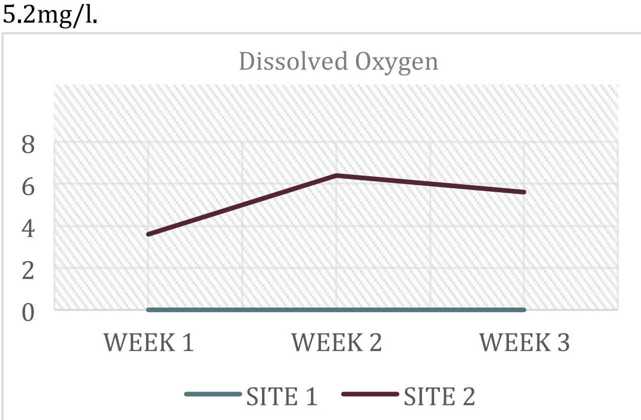

Figure 7. Graph representing Chloride variation at sites.

Total Alkalinity (mg/l)

At site 1 during the study period, the total alkalinity recorded a minimum value of 346 mg/l on 3rdweek while a maximum value of 412mg/l on 1st week with an average value of 380mg/l. At site 2 during the study period the total alkalinity recorded a minimum value of 318mg/l on 2nd week while a maximum value of 336mg/l on 1st week with an average value of 328mg/l.

Total Hardness (mg/l)

At site 1 during the study period, the Total hardness recorded a minimum value of 486 mg/l on 1st week and a maximum value of 1100 mg/l on 3rd week with an average value of 868.6mg/l. At site 2 during the study period, the Total hardness recorded a minimum value of 276 mg/l on 1st week while a maximum value of 920 mg/l on 2nd week with an average value of 698mg/l.

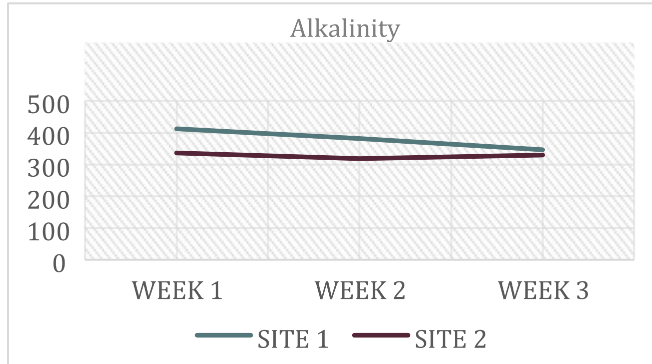

Figure 8. Graph representing Total alkalinity variation at sites.

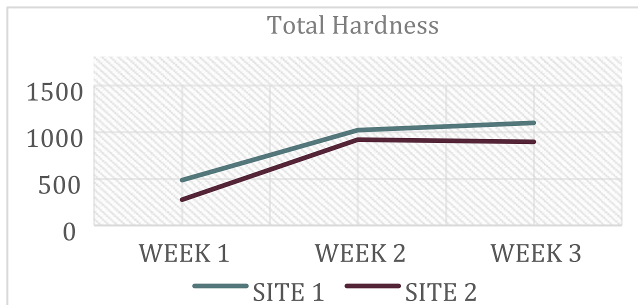

Figure 9. Graph representing Total hardness variation at sites.

Calcium Hardness (mg/l)

At site 1 during the study period, the minimum value for calcium hardness was recorded as 83.16mg/l in 3rd week while a maximum value of 88.2 mg/l was observed in 1st week with an average value of 85.12mg/l. At site 2 during the study period, the calcium hardness recorded a minimum value of 73.08mg/l on 2nd week and a maximum value of 89.8 mg/l on 1st week with an average value of 83.41mg/l.

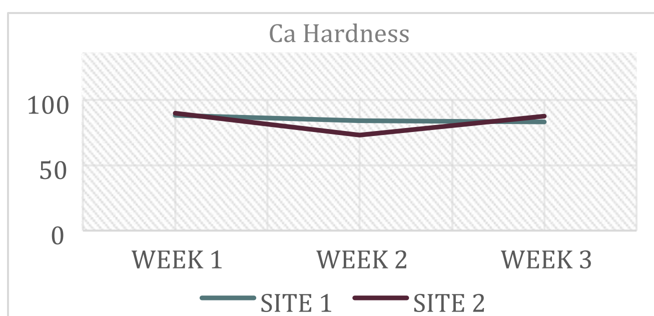

Fig10. Graph representing Calcium hardness variation at sites.

Magnesium Hardness (mg/l)

At site 1 during the study period, the magnesium hardness recorded a minimum value of 397.8mg/l on 1st week and a maximum value of 1016.8 mg/l on 3rd week with an average value of 783.53mg/l. At site 2 during the study period the magnesium hardness recorded a minimum value of 186.2 mg/l on 1st week and a maximum value of 846.9 mg/l on 2nd week with an average value of 614.58mg/l.

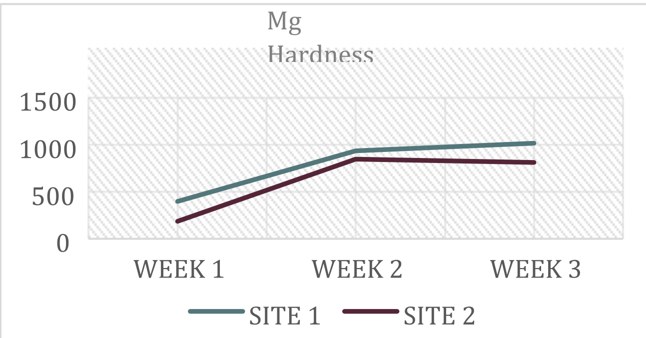

Figure 11. Graph representing Magnesium hardness variation at sites.

Orthophosphate (µg/l):

At site 1 during the study period, the orthophosphate recorded a minimum value of 409.3 µg/l on 3rd week while a maximum value of 889.7 µg/l on 1st week with an average value of 650µg/l. At site 2 during the study period the orthophosphate recorded a minimum value of 377.0 µg/l on 3rd week and a maximum value of 631.3 µg/l on 1st week with an average value of 503.56µg/l.

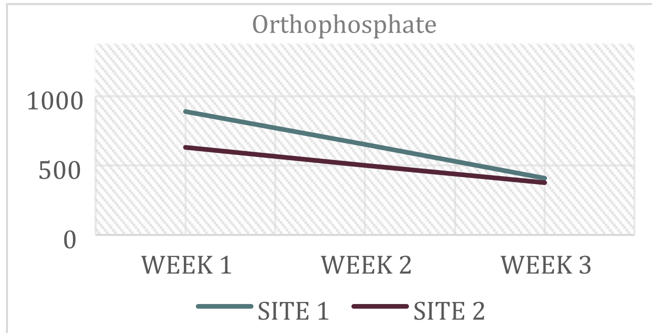

Figure 12. Graph representing Orthophosphate variation at sites.

Table 1. Summary statics of Physicochemical parameters of water of STP at Inlet.

Sr No	Parameters	Week 1	Week 2	Week 3	Average Value	Min. Value	Max. Value
1	Temperature (^{0}C)	16.4	18.1	19.6	18.03	16.4	19.6
2	pH	6.97	7.6	6.95	7.17	6.95	7.6
3	Conductivity(µS/cm)	989	690.2	726.6	801.93	690.2	989
4	Free CO_2 (mg/l)	81.6	79.2	73.9	78.23	73.9	81.6
5	Chloride(mg/l)	39.9	33.9	26.9	33.56	26.9	39.9
6	DO (mg/l)	0	0	0	0	0	0
7	Alkalinity(mg/l)	412	382	346	380	346	412
8	Total Hardness(mg/l)	486	1020	1100	868.6	486	1100
10	Ca Hardness(mg/l)	88.2	84	83.16	85.12	83.16	88.2
11	Mg Hardness(mg/l)	397.8	936	1016.8	783.53	397.8	1016.8
12	Orthophosphate (µg/l)	889.7	651	409.3	650	409.3	889.7

Table 2. Summary statics of Physicochemical parameters of water of STP at Outlet.

S.No	Parameters	Week 1	Week 2	Week 3	Average Value	Min. Value	Max. Value
1	Temperature (^{0}C)	15.0	16.8	17.9	16.56	15.0	17.9
2	pH	7.15	7.19	7.16	7.16	7.19	7.19
3	Conductivity(µS/cm)	970	620	710.01	766.67	620.0	970
4	Free CO_2(mg/l)	36.9	58.8	54.5	50.06	36.9	58.8
5	Chloride (mg/l)	36.9	23.9	24.9	28.56	23.9	36.9
6	DO (mg/l)	3.6	6.4	5.6	5.2	3.6	6.4
7	Alkalinity (mg/l)	336	318	330	328	318	336
8	Total Hardness(mg/l)	276	920	898	698	276	920
10	Ca Hardness(mg/l)	89.8	73.08	87.36	83.41	73.08	89.8
11	Mg Hardness(mg/l)	186.2	846.9	810.64	614.58	186.2	846.9
12	Orthophosphate (µg/l)	631.3	502.4	377	503.56	377.0	631.3

DISCUSSION

The observed pH values were within the allowed range between 6.95 and 7.19. The values obtained are in the range permissible by CPCB for potable water i.e. (5.5-9.0). It is depicted 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 the addition of polyalanine chloride (Dilafroza *et al*., 2013).

Conductivity is a general indicator of water quality, especially a function of the amount of dissolved salt, and can be used to monitor processes in wastewater treatment that causes changes in total salt concentration and thus changes the conductivity. During the study, there is a decrease in conductivity from the mean value of 801.93 to 766.67. The decrease in conducting may be due to the biological nitrogen removal (Erik, 2007).

It was found that the value of the dissolved oxygen obtained in all the untreated samples was zero and after the treatment, it increased to 6.4 mg/l. If DO levels are less than 4 mg/l, water is hypoxic and becomes very harmful, possibly fatal to plants and animals. If there is a serious lack of DO, less than about 0.5 mg/l, the water is anoxic. No plant or animal can survive in anoxic conditions. Irrigation water in many greenhouses has surprisingly low levels, often in the dangerous hypoxic range (Shashanks, 2019). Absence of DO concentration in sewage was recorded due to heavy organic loading and septic condition (Kumar *et al*., 2010). Increase in the effluent DO content due to the treatment processes which may reduce the number of impurities present in sewage through oxidation of organic matter (Prescott *et al*., 2002). The increase in DO is due to the aeration process taking place in the bioreactors resulting in the stabilization of organics (Umara *et al*., 2021).

Carbon dioxide is gaining acceptance for pH control in water treatment plants. It reduces high pH levels quickly. It is non-corrosive to pipes and equipment. It requires less equipment and monitoring costs. It requires no handling cost. During the study, there is a decrease in carbon dioxide from 81.6 to 58.8mg/l, this reduction in carbon dioxide may be attributed to the conversion of carbon dioxide into carbonic acid. Activated sludge is commonly used for the removal of carbon. (Ramnath *et al*., 2014).

Chloride is categorized as a pollutant for many reasons. Chloride is necessary for water habitats to thrive, yet high levels of chloride can have negative effects on an ecosystem. Chloride may impact freshwater organisms and plants by altering reproduction rates, increasing species mortality, and changing the characteristics of the entire local ecosystem. In addition, as chloride filters down to the Water table, it can stress plant respiration and change the quality of our drinking water. An insignificant reduction was observed in chloride while passing from Intel to outlet this is because of the design of fab technology, which is based on the principle that will take care of oxidation stabilization of the organics and also the removal of phosphorus and nitrogen (Umara *et al*., 2021).

Total alkalinity (TA) constitutes an important factor in determining the buffering capacity of a water body. It is the measure of the water's ability to neutralize acidity. In the present study, the average alkalinity value in all untreated wastewater samples was 380mg/l which decreased to 328 mg/l after treatment which is above the desirable alkalinity limit for potable water (20-200mg/l). Total alkalinity remains almost unaffected after treatment, because of the fab technology which is based on the principle that will take care of oxidation stabilization of the organics and also the removal of phosphorus and nitrogen.

Hardness does not indicate much about the degree of pollution of samples of sewage water. The mean value as obtained at the inlet is 868.6 ppm and after treatment, it falls down to 698 ppm. Hardness is a measure of the amount of calcium and magnesium salt that is present in water. The effluents from wastewater treatment plant may be characterized by high concentrations of both calcium and magnesium salts which contribute to the hardness of this particular water. The hardness of wastewater is not a normative indicator. However, it is an important research aspect in the field of water recovery. During the study, there was a decrease in Total hardness and it may be attributed to membrane filtration, including nanofiltration and reverse osmosis (Dudziak and Kudlek, 2019)

Wastewater temperatures normally range between 10 and 20 ^{0}C. Depending on the geographic location, the mean annual temperature of wastewater varies. The temperature of the water is a very important parameter because of its effect on chemical reactions and reaction rates, aquatic life, and the suitability of the water for beneficial uses. Increased temperature, for example, can cause a change in the species of fish that can exist in the receiving water body. In addition; oxygen is less soluble in warm water than in cold water. During the present study, we observed that there is a decrease in temperature from 18.03 to 16.56 ^{0}C.

Phosphorus is an essential nutrient for plants, animals, and humans and under natural conditions typically scarce in water. However, human activities have resulted in excessive loading of phosphorus into many surface glasses of water, which can cause water pollution by promoting excessive algae growth, particularly in lakes and rivers (Mainstone and Parr, 2002; Trépanier *et al*., 2002; Lemley and Adams, 2018). During the present study, there was a decrease in orthophosphoric concentration from 650 to 503.56µg/l. Phosphorus removal mechanism in the treatment facilities is attributed to both biological and chemical treatment like assimilation, adsorption, and precipitation (Lamichhane *et al*., 2011).

CONCLUSION

Although the study was conducted for a short period of one month; it was observed that the effluent concentration for dissolved oxygen, total hardness, magnesium hardness was found significant while as other parameters were not found significant. It was observed that the effluent concentration for orthophosphate, free CO_2, chloride was not up to discharge standards. A regular monitoring and management to limit the effluent discharge into the ecosystem should be taken up for better health of our aquatic ecosystem.

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