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Annual Assessment of Physico Chemical Parameters of The Untreated and Treated Sewage Water Fed Ponds of CHRIST (Deemed to Be University) Campuses, Bengaluru, Karnataka, India

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Abstract

Annual assessment and comparative investigation on six sewage water bodies, among six of the study areas, three were of untreated sewage water bodies and the rest three were of treated sewage water bodies namely MU (Main campus Untreated sewage water), MT(main campus Treated water), BU (Bannerghatta campus untreated sewage water), BT(Bannerghatta campus Treated Sewage water), KU(Kengeri campus untreated sewage water) and KT(Kengeri campus Treated sewage water) were conducted to assess the water characteristics and the effect of water treatment process. Water characteristics were presented in terms of physico-chemical parameters.Twenty physico-chemical parameters of sewage water, were examined on a monthly basis for the time period of November 2019-November 2020. During the analysis, waters of treated sewage samples showed a larger difference and more suitable for daily usage when compared to untreated sewage water samples which were heavily loaded with pollution. As per Two Way ANOVA there was highly significant variation in physico-chemical parameters between the untreated and treated sewage water samples(P<0.01).

Keywords: *Untreated, Treated Sewage Water, Physico-Chemical Parameters, ANOVA.*

1. Introduction

Water is an essential component on the earth as it is the inseparable part of life. All living creatures require water for all the purposes like physical and metabolic activities (Aniyikaiye et al., 2019). Quality of water is the most emerging concern as only 3% is fresh water and 1/3rd of it is available for the use in agricultural purpose and for domestic usage (Salgot and Folch 2018). The rest of the water is frozen in the form of glaciers or hidden in the deep layers of the earth. Presently the surviving population is almost 7.8 billion people on earth solely dependent on these aquifers, the underground stores of water(Kleijn and De Kleijn 2001). The anthropogenic activities like industrialization and urbanization result into the deterioration of water quality as well as depletion of water level. If the world is moving forward at this pace the reserves ensured by the fresh water like basic water. Food and energy security is expected to drop by 40 within a few years(Uitto 2020). Due to the activities of humans, global warming causes the increase of average global temperature which in turn also threatens the ecosystem and environment that are responsible for the protection of the vital water resources(Berger et al. 2006)(Ortiz, Raluy, and Serra 2007). This in turn limits the access to fresh water and in such an alarming situation water sustainability comes into play(Ortiz, Raluy, and Serra 2007; Asano and Levine 1996). The quality of water is identified in terms of its physical, chemical and biological parameters. Polluted surface waters cannot achieve a balanced ecosystem. Water quality obviously plays a critical role in this relationship and it is key to the maintenance of a balanced ecosystem. Changes in ecosystem physical-chemical parameters have a significant impact on the species that live in them. The aspects of distribution, periodicity and quantitative and qualitative composition of biota, are regulated by the seasonal changes of the ecosystem parameters. Understanding the water quality in various effluents (Meybeck 2002)(Meybeck 2002; Hanrahan et al. 2003)(Astel et al. 2008)(Astel et al. 2008; Simeonov et al. 2003)(Dawe 2015) (Sayantan and

Shardendu 2017) has shown that anthropogenic activities have an important negative impact on water quality in major rivers and ponds. Water quality decay, characterized by important modifications of chemical oxygen demand (COD), total suspended solids (TSSs), total nitrogen (TN),total phosphorus (TP) and so forth are the result of wastewater discharge in rivers and ponds. Treatment of wastewater and its reuse are the ecofriendly approach to reduce both the burden on ground water as well as the aquifers. Considering this, the present study has been performed for the comparative assessment of physico-chemical properties of the untreated and treated wastewaters of the three campuses of Christ University, namely Main Campus, Banerghatta campus and Kengeri Campus.

2. Materials And Methods

The six sites of water sample collection were represented as MU, MT, BU, BT, KU, KT i.e Main campus Untreated sewage water (MU), Main campus Treated Sewage water(MT), Bannerghatta campus Untreated sewage water(BU), Bannerghatta campus Treated sewage water(BT),Kengeri campus Untreated sewage water (KU)and Kengeri campus Treated sewage water(KT). The locations of the ponds have been presented in the Table 1, and the photographs of the same have been presented in the Figure 2.

Table1: Latitudes and longitudes of study stations in CHRIST(Deemed to be University) Campuses, Bangalore, Karnataka, India

Stations	Site	Latitudes (North)	Longitudes (East)E
Main campus Untreated sewage water	MU	12°56'39.5" N	77°36'13.4" E
Main campus Treated sewage water	MT	12°55'59.9" N	77°36'14.7" E
Bannerghatta campus Untreated sewage water	BU	12°52'39.3" N	77°35'44.3" E
Bannerghatta campus Treated sewage water	BT	12°52'39.5" N	77°35'45.4" E
Kengeri campus Untreated sewage water	KU	12°51'40.2" N	77°26'19.9" E
Kengeri campus Treated sewage water	KT	12°51'40.5" N	77°26'18.4" E

Sewage treatment plants present in all the three campuses of CHRIST (Deemed to be University) located at the heart of the city of Bangalore belonging to the state of Karnataka, India, receive waste water released mainly from toilets, housekeeping works, laboratories, Laundries, restaurants, washrooms, Hostels and construction works that are present in these huge campuses which provides space for more than 35 thousand of students to study and to live in. Wastewater is collected through sewage systems (underground sewage pipes) to one or more centralized Sewage Treatment Plants (STPs). The main Idea of the sewage treatment is the re-use of waste water generated from the institute into a usable form and can be used for various purposes such as irrigation of plants, toilet flushes, animal husbandry, culturing of fishes and vehicle washing etc.

MU: Main campus Untreated sewage water

BU: Bannerghatta campus Untreated sewage water

KU: Kengeri campus untreated sewage water

MT: Main campus Treated sewage water pond

BT: Bannerghatta campus treated sewage water pond

KT: Kengeri campus Treated Sewage water pond

Figure 1: Images of study sites and Ariel images (source. Google map) of untreated and treated sewage water collection ponds

Collection and Storage of Water For Physico-Chemical Analysis

To study the physico-chemical analysis water, raw and treated sewage water samples were separately collected in Polypropylene plastic water cans of capacity 5 L, which were prior washed with acidified distilled water followed by deionized water for three times. The water samples were brought to the laboratory and kept in the refrigerator at 9˚ C for further analysis (Aniyikaiye et al., 2019). Samples were collected in triplicates between 8 and 9 AM on a monthly basis during the period Nov-2019 to Nov-2020.

Determination of Physico-chemical Parameters

Physico-chemical parameters of such as Water temperature, pH, conductivity, Turbidity, Dissolved oxygen(DO), Biological oxygen demand(BOD), Chemical oxygen demand(COD), Total Solids(TS),Total Dissolved Solids(TDS),Total suspended solids(TSS),Chlorides, Sulphates, phosphates, fluoride, Total Chlorine, Ammonia, Total hardness, Mg hardness, Ca hardness were determined using standard methods as per APHA 2003.

Statistical Analysis

All the values of physico-chemical parameters as well as heavy metal analysis have been represented as means (n=3) with standard deviations. Two Way ANOVA was performed viz across the sites(n=2) treated sewage water samples and untreated sewage water samples and across the month(n=12) to test the significance of variations of the values obtained.

3. Results and Discussion

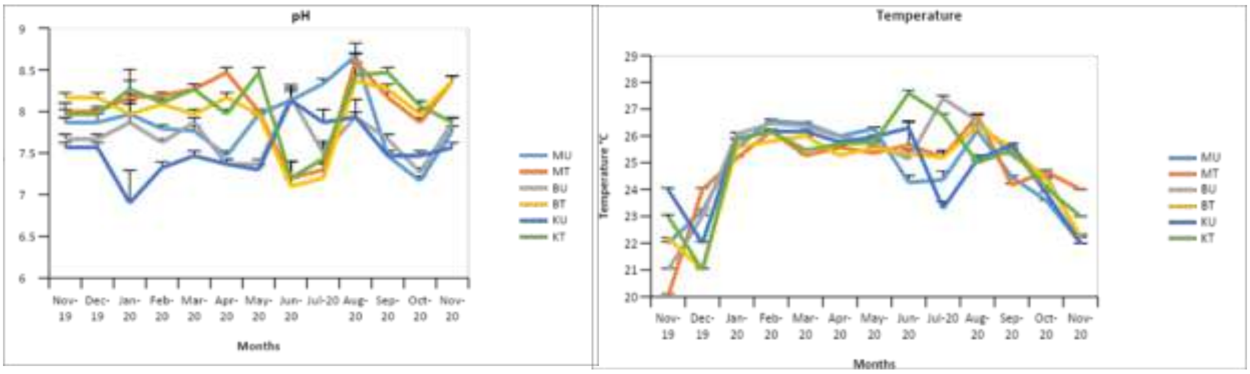

Figure 2: (a) pH and (b) Temperature(°C) of Untreated and Treated Sewage water samples

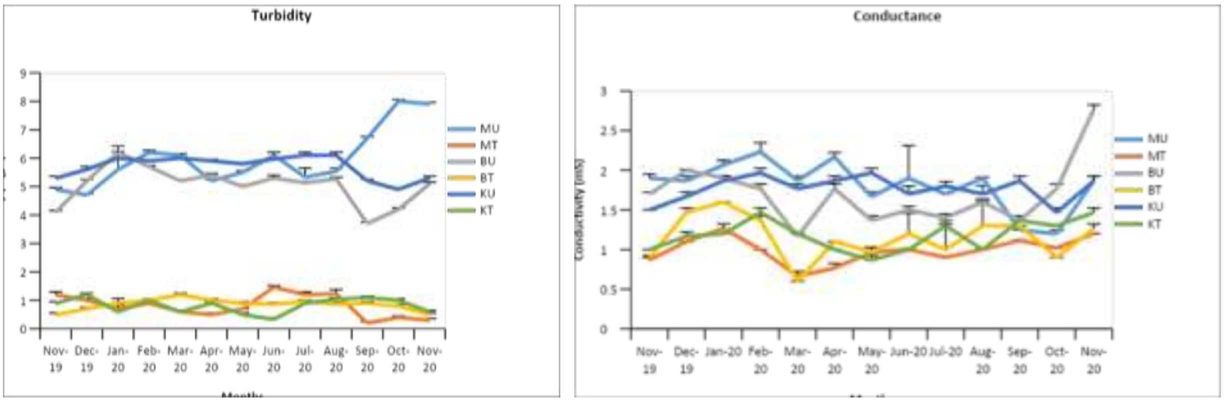

Figure 3: (a) Turbidity(mg/L) and (b) Electrical Conductivity(mS) of Untreated and Treated Sewage water samples

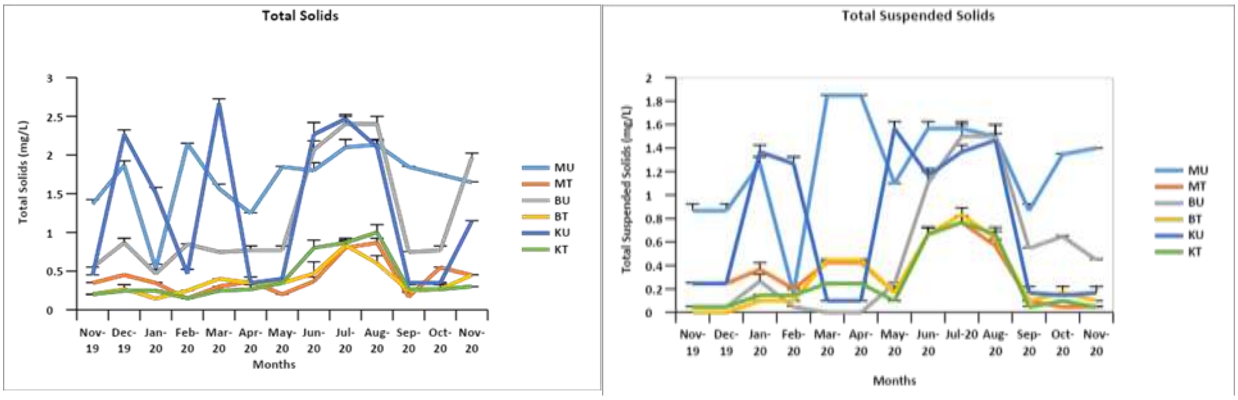

Figure 4: (a) Total Solids and (b) Total Suspended Solids(mg/L) of Untreated and Treated Sewage water samples

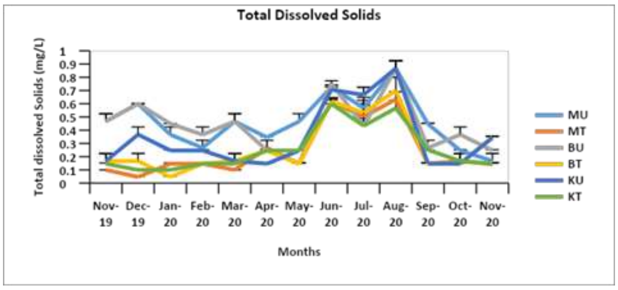

Figure 5: Total Dissolved Solids (mg/L)of Untreated and Treated Sewage water samples

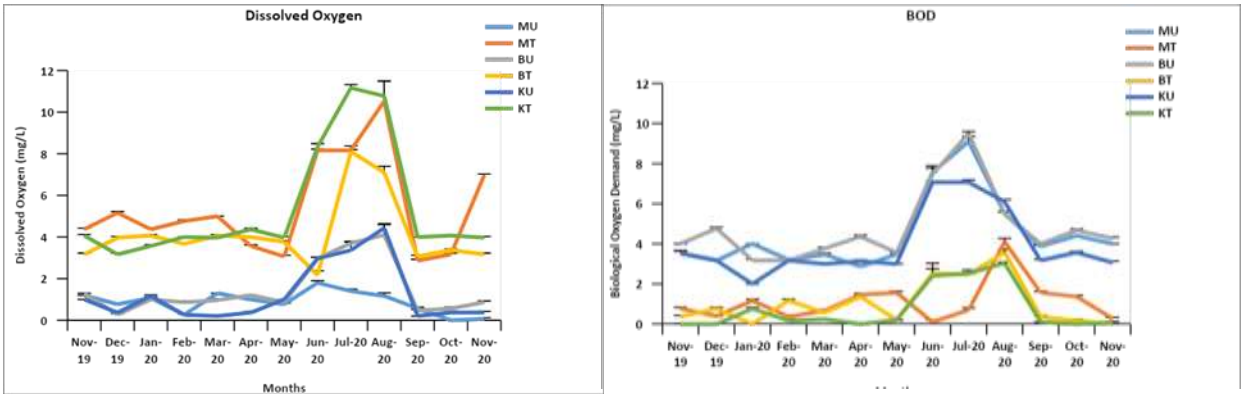

Figure 6: (a) DO and (b) BOD(mg/L) of Untreated and Treated Sewage water samples

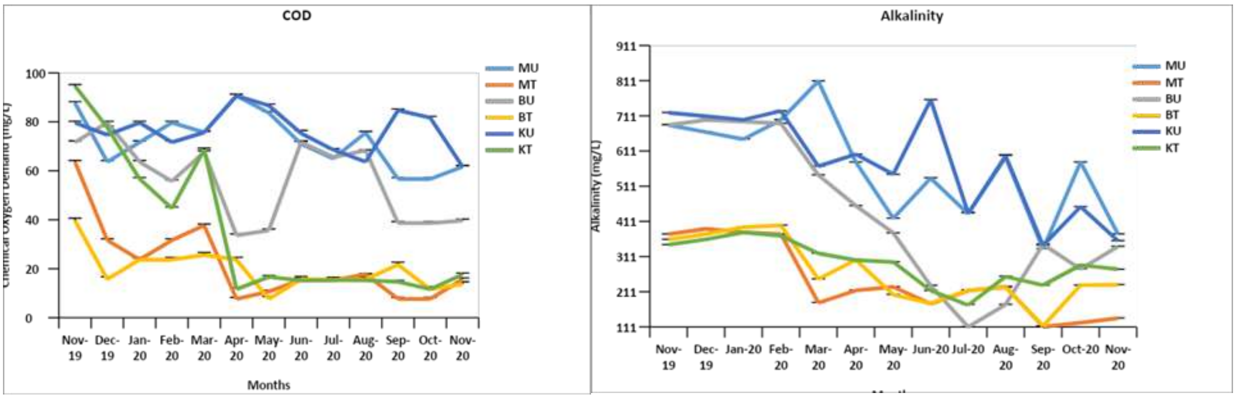

Figure 7: (a) COD and (b) Alkalinity (mg/L)of Untreated and Treated Sewage water samples

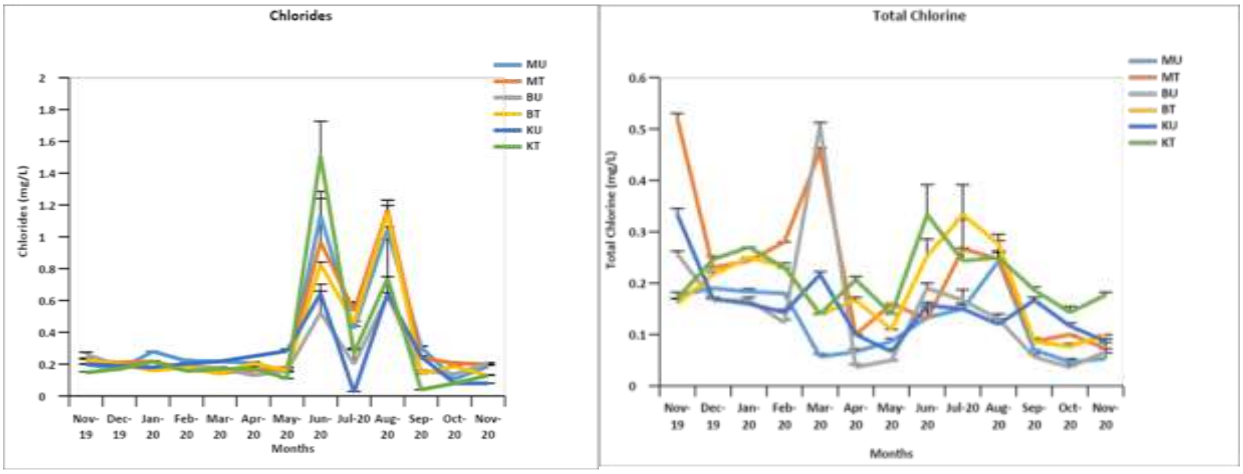

Figure 8: (a) Chlorides and (b) Total Chlorine(mg/L) of Untreated and Treated Sewage water samples

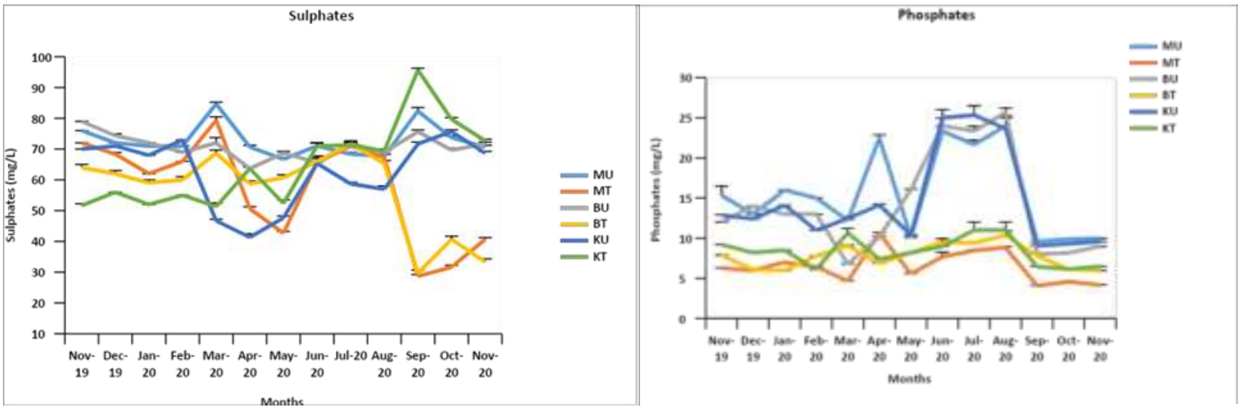

Figure 9: (a) Sulphates and (b) Phosphates(mg/L) of Untreated and Treated Sewage water samples

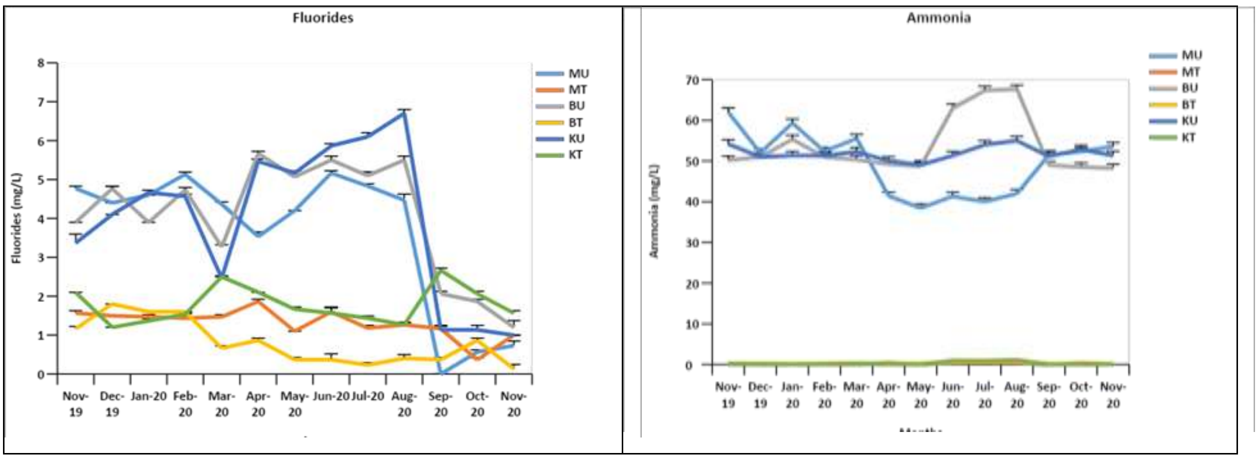

Figure 10: (a) Fluorides and (b) Ammonium(mg/L) of Untreated and Treated Sewage water samples

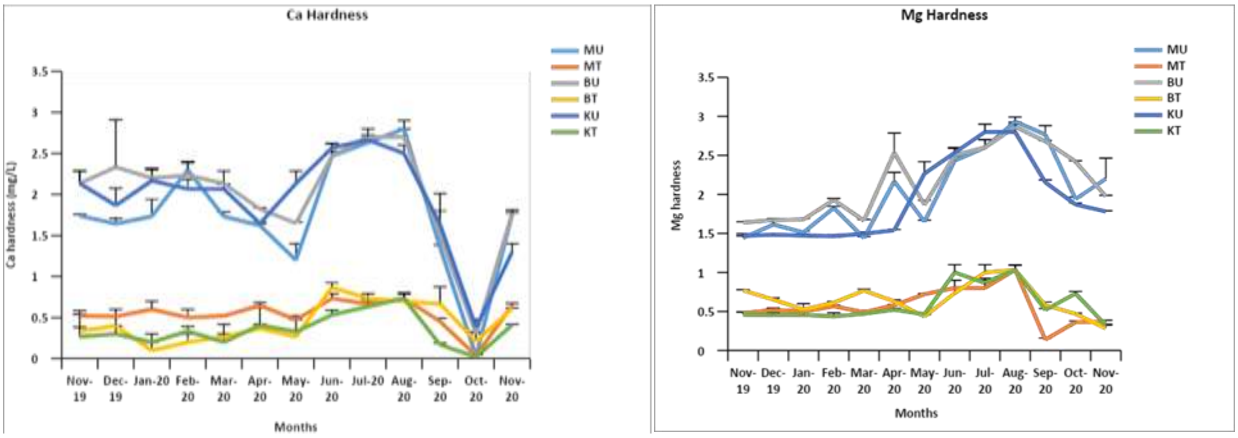

Figure 11: (a) Ca hardness and (b) Mg hardness(mg/L) of Untreated and Treated Sewage water samples

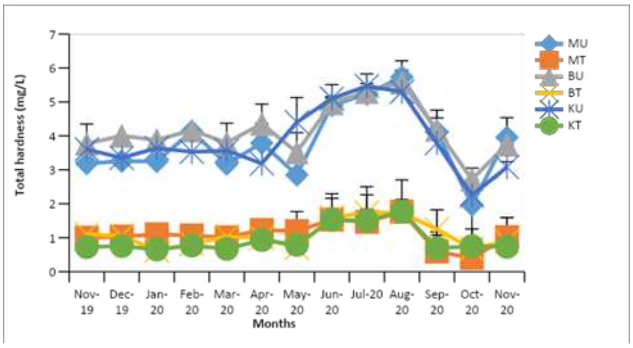

Figure 12: Total Hardness of Untreated and Treated Sewage water samples

Variation of physico-chemical parameters of treated and untreated water samples of the three campuses of Christ University, Bangalore

The mean monthly variations of the physicochemical parameters of the treated and untreated sewage water across the three campuses have been depicted in Figs. 1-12. pH is a basic characteristic that is incredibly essential since it controls the majority of chemical reactions in the aquatic environment. pH variations are sensitive to aquatic organisms, therefore biological therapy necessitates pH control or monitoring. The lowest value of pH was 6.9 observed in KU during the month of January and highest of 8.6 was observed for the month of August at MU (Fig 2a) which was slightly above the acceptable range (6.5-8.5) given by BIS Bureau of Indian standards. Substantial quantities of bicarbonate are produced during the biodegradation of organic matter, which together raises the pH of the sewage water (Gupta and Bux 2020)**.** As per the ANOVA, there was no statistical significance of variation between the pH values of treated and untreated sewage waters of the Main campus (Table 1), whereas there was the Banerghatta and Kengeri campuses showed a significant variation at 0.05 level (Tables 2 and 3). This may be due to the difference in the tertiary treatment of sewage water of the three campuses.

Water temperature is one of the major drivers of aquatic life. The steadily increasing temperature of water was responsible for the increasing chemical and biological reaction of the body of water. Water temperature of the undertaken study sites (Fig 2b) falls under the range of 20-27.6 ℃ with the lower-range values were observed in all spring and winter months and the higher-range values appeared in summer months due to the variation in the atmospheric temperature. Similar findings were reported by (Joseph, Reddy, and Sayantan 2019; Goswami, S. Doifode S. Rewatkar S. Goswami S. Doifode S. Rewatkar S. Goswami, and ijrbat 2014)**.** ANOVA results further supported the findings in terms of significance in variation (at 0.001 level) across months, whereas no variations among the treated and untreated sewage of all the three campuses (since the geographical locations of treated and untreated sewages were the same at each of the three campuses of the University).

Electrical conductivity of the given study area was 0.17-2.76 mS which was above the permissible levels given by BIS:0.05 mS. When compared conductivity was slightly higher in untreated sewage water samples than treated sewage waters. Minimum conductivity values were observed at MU during the months of rainy seasons and maximum values were seen at BU for the months of winter. The discharge of leachates carrying dissolved salts of sodium and magnesium may be the reason for the dump sites' high electrical conductivity. Similar observations were seen by (Magadum, Patel, and

Gavali 2017)**.** ANOVA further indicates the significance of variation at 0.01 level across months (Table .1,2 and 3) and across the site the p value is 0.001.The variation may be in relation with the temperature of the water sample of both the treated and untreated sewage water.

The values of Turbidity (Fig.3) in the treated and untreated sewage ponds were between the range of 0.2 (NTU)-8(NTU). Highest turbidity values were observed in MU and KU during the months of June to August and September to November 2020. Such observation was mainly due to highest inflow of waste water to these ponds through rainfall and runoff received by the ponds and lowest values were observed in the winter months. Some values of turbidity were above the maximum levels by Bureau of Indian Standards (5 NTU). Our results were justified with the reported by other workers (Goswami, S. Doifode S. Rewatkar S. Goswami S. Doifode S. Rewatkar S. Goswami, and Ijrbat 2014; Sonawane 2020)**.** For turbidity the significance of variation of across the sites was at 0.001 level and no significance of variation was seen across the months for all the study areas (Table.1,2and 3). This may the fact that the similar process of sewage treatment followed for all the three study areas viz. the Main, Banerghatta and Kengeri campuses of the University.

One of the most important parameters in water quality analysis is DO. DO levels in water are influenced by chemical, physical, and biological activity in the environment. The range of Dissolved Oxygen level was between: 0 and 11 ppm. The present study showed higher values during the rainy and winter months, which may attributed to the splashing action on the surface due to the falling of rain water, leading to dissolution of air and high photosynthetic activity by lower phytoplankton organisms(Shahzad, Amjad, and Hamid 2014)(Magadum, Patel, and Gavali 2017). However, low DO values were observed at all the untreated sewage waters. This is mainly due to the increased bacterial activity. During the summer months, the DO was comparatively less, which was mainly due to the stratification and increase in temperature. As per the work done by other scientists, temperature shares a negative correlation with the dissolved oxygen (reference required). ANOVA statistics further revealed high level of significance in variation of DO in sewage waters with respect to the treatment process ($p<0.01$) as well as seasons ($p<0.001$) (Tables 2 and 3). This supports the efficiency of the sewage treatment process with respect to aeration during the secondary and tertiary treatment stages.

The amount of dissolved oxygen required for the biochemical decomposition of organic compounds by microorganisms and the oxidation of certain inorganic materials is referred to as the biochemical oxygen demand (BOD). BOD of the sewage treated and untreated ponds values fell in range of : 0-9.5 ppm, BOD values were at an increased level at MU during the month of July and MT has the lowest BOD value in the month of January. The maximum BOD limit to a water body set by BIS is 30(ppm). Results of ANOVA depicted significant variations of BOD for treated and untreated water as well as across the months at all the three campuses of the University (Tables 1-3). From the results obtained for the TDS, it was noted that the values are directly proportional to the EC. In essence, a high EC in wastewater indicates a high concentration of total dissolved solids.TDS values were between 0.0467 to 0.867(ppm). TDS values were highest during the months of rainy season at three untreated sewage water ponds i.e MU,BU and KU. This is due to the continuous mixing of water columns of the pond with incoming rain water stirs up the settled particles in the bottom of the ponds as a result increase of TDS values in the pond. But during the summer months most of the particles settle to the bottom surface of the pond. The above interpretations were supported by ANOVA statistics (Tables 1-3), that showed significant variation (from 0.05 – 0.001 levels) of TDS across the months as well as sites (untreated and treated sewage waters) at all the three campuses.

The total suspended solids (TSS) is a measurement of particulate matter suspended in water. It's a term for the amount of contamination in wastewater. In addition, TSS is a reliable indication of water turbidity. TSS can be made up of a wide range of elements, such as silt, decomposing plant and animal debris, industrial wastes, and sewage (T. Aniyikaiye et al. 2019). Suspended particles in high concentrations can wreak havoc on stream health and aquatic life. Total Suspended Solids of the study sites (Fig.4) were in the range of 0-1.8 ppm. TSS values were within the acceptable levels given by BIS:10 ppm. Lowest TSS values were seen at BU during the march month and high TSS values reported at MU during August. ANOVA results further supported the findings in terms of significance in variation (at 0.001 level) across treated and untreated sewage water samples of Main and Kengeri campuses (Table.1), whereas the seasonal variation was significant for the Banerghatta campus. The reason behind the seasonal variation of TSS would be the monsoon runoff discharge and summer evaporation. TSS and TDS are added together to form total solids. Total Solids of these sewage water fed ponds (Fig.4) were in range of 0.14-2.6ppm and values were within the acceptable range of BIS: 5 ppm. Two way ANOVA further showed the significant variations at 0.001 level for BC, 0.01 for BK (Table.1,3) and not much significant values for BC (Table.1) across the months for treated and untreated sewage water samples of the undertaken study area. The significance of variation among the treated and untreated is due to the efficient primary treatment of waste water whereas the surface runoff during the rainy period of the undertaken study area was the reason for the seasonal variation in the values of TS.

The chemical oxygen demand (COD) is an indicator of the amount of oxygen that can be consumed by chemical reaction, thus serving as an important indicator of water pollution. COD determines the amount of oxidizable contaminants in surface water (such as lakes and rivers) or wastewater. The range of COD (Fig.7) across all the sites was found to be 6 - 94.6 ppm. COD values were at an increased level in the untreated sewage water samples than treated sewage water ponds owing to the efficiency of the treatment process. Minimum COD values were 7.67ppm seen at MT for the months of September-October. Levels of COD were between the acceptable range of values given by BIS: 250 ppm. The seasonal variation of COD values were supported by related works (T. E. Aniyikaiye et al. 2019)(Goswami, S. Doifode S. Rewatkar S. Goswami S. Doifode S. Rewatkar S. Goswami, and ijrbat 2014; Sonawane 2020). For BC, BB and KC (Table.1,2,3) the ANOVA showed significant variation (0.001) in between treated and untreated sewage water samples but no significant variation was noted across the seasons for three sample collection sites of the study area. High levels of COD at untreated water is caused by high levels of organic debris resulted from decaying debris of animal, plant and aquatic organism waste. This got reduced after the treatment, supporting the ANOVA results. The alkalinity (Fig.7) of the treated and untreated sewage wathers across all the three campuses were in the range 110-700 ppm, being above the range defined by BIS (250 ppm). During the rainy season the alkalinity was minimum due to dilution caused by rainwater but increased in the summer. This may be mainly due to the microbial activities as well as increased evaporation of wastewater (Sihabudeen and Mohamed Sihabudeen 2017)(Sihabudeen and Mohamed Sihabudeen 2017). Alkalinity to water is contributed by anions such as carbonate ($CO3-$), bicarbonate ($HCO3-$), hydroxyl, phosphate ($PO4-3-$) and silicate ($SiO4-$). Organisms may change the percentage of carbonate and bicarbonate in water by absorbing or releasing carbon dioxide. ANOVA further supported the above interpretation, showing significant variation across the treated and untreated sewage water as well as across the seasons.

Values of chloride (Fig.8) content the the treated and untreated sewage were 0.02-1.51(ppm). Chloride in wastewater should not exceed 250 mg/L for safety reasons, according to BIS and WHO Standard. Elevated chloride levels in water bodies can affect the long-term viability of ecological food sources, putting species survival, growth, and reproduction at risk . Significant variations of ANOVA at 0.01 level were seen for treated and untreated sewage water samples at BC and KC (table.1,2,3) but across the months the variation was not significant. The non-significance of variation in the total chlorine content in the water may be due to the fact that the level of tertiary treatment in terms of chlorination of the treated sewage water remains the same throughout the year. Sulphate is a vital ingredient for plant and animal tissue growth. Sulphates are an important link in the global sulphur cycle because of their potential to transport sulphur via chemical and microbiological processes.(Magadum, Patel, and Gavali 2017). The sulphate content in the treated and untreated sewage waters ranged between 28.6-95.6(ppm) (Fig.9). It was further found that the level of sulphur was reduced when the sewage water was treated. This was further supported by ANOVA statistics, as the significance of variation of sulphates in treated and untreated sewage waters ranged between 0.001-0.01 levels for all the study areas (Table.1,2 and 3).

The higher values of phosphates were observed during the monsoon months in both the treated and untreated sewage water samples (Fig.9). The levels of phosphate were higher in treated sewage water samples when compared with untreated sewage waters, due to the receival of high concentration of debris through rain water runoff. In general, fertilizers, insecticides, industrial activities, and cleaning materials are the major sources of phosphorus. Alternative causes comprise soluble phosphate-enriched stones and liquid or solid wastes (reference needed). In the conducted study, the main cause of elevation of phosphorus levels may be due to the surface runoffs. ANOVA results further confirmed the significance of variation in the phosphorus levels for the treated and untreated sewage water samples of BC, BB, KC (Table.1) The values of total chlorine (Fig.8) ranged from 0.03 to 0.52 ppm in treated water samples of MT,KT and BT. The presence of chlorine may be due to the use of Chlorine as disinfectant during the tertiary treatment of sewage (Sonawane 2020). ANOVA values of Total Chlorine for treated and untreated values were at 0.05 levels for (Table.2 and 3) and no significant variation was seen across months (Table.1,2,3). This may be due to the fact that the chlorination takes place uniform throughout the year.

Untreated water samples of at the three sites showed higher levels of ammonia than the treated sewage water. The most potent reason for the presence of ammonia in untreated sewage water is due to the discharge of waste from the laboratories involved in using ammonia for reactions. The values (Fig.10) fall in the range of 0-67.6 ppm. As per the ANOVA, ammonia content of treated and untreated sewage waters varied significantly (0.001) at all the study sites (Tables 1-3), whereas there was no significance of variation across the months for the same. Water samples of MU,KU and BU noted maximum values of Fluorides (Fig.10) during the season of rain:0-6.7(ppm). Fluoride, in general, is derived from sodium fluoride, sodium fluorosilicate, or fluorosilicic acid. Cryolite and sulfuryl fluoride are two examples of fluoride-based insecticides. Another "by-product" of phosphate fertilizer is fluoride. However, the fluoride content in the untreated sewage of the three study sites may be attributed to receipt of laboratory sewages that involved fluroride in the research activities. The statistical analysis further supported the variation of fluoride in the sewage of treated and untreated waters (Tables 1-3). The hardness of water is a significant criterion for detecting pollution in water bodies. The hardness of water is expressed in terms of calcium and magnesium hardness (Figs. 11 & 12). In the rainy season and winter months, the hardness levels showed to fluctuate more due to gathering of nutrients and salts in the sewage ponds along with the surface run off and maximum migration of hardness components like calcium and magnesium from the subsurface groundwater (T. E. Aniyikaiye et al. 2019). As per the ANOVA, there was a significant (at 0.001 level) variation between the hardness values of treated and untreated sewage waters of all the study areas (Tables 1-3), depicting the efficiency of sewage treatment process, whereas there was no significance of variation across the months for the same.

4. Conclusion

Our study of wastewater treatment subjected to a basic distillation, secondary and tertiary treatment procedure shows that not all recognized physicochemical parameters are reliable indicators of effluent quality. After considering all soil characteristics, including water physical-chemical properties (electrical conductivity, water pH, total soluble solutes, turbidity, temperature, DO, BOD,COD), phosphates, ammonium, chlorine, sulphates, total hardness, total chlorides, and alkalinity, as well as water nutrients (calcium, magnesium, and potassium), exhibited a statistically significant reduction between raw water and effluent, thus supporting the significance of these parameters for the control of treatment.

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