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THE INFLUENCE OF PHYSICO-CHEMICAL FACTORS ON BACTERIAL LOADS IN MAGADA LAKE SEDIMENTS.

[1]Ibadin, F. H., [2,3]Akinyugha, A. A. & [*1]Abiala, M. A

[1]*Department of Biological Sciences, Mountain Top University, Prayer City, Ogun State, Nigeria*
[2]*Department of Chemical Sciences, Mountain Top University, Prayer City, Ogun State, Nigeria*
[3]*Ministry of Environment and Natural Resources, Ekiti State Government, Ekiti State, Nigeria*

***Corresponding Author Email:** *maabiala@mtu.edu.ng*

ABSTRACT

Lake sediments are faced with continuous pollution from different allochthonous and autochthonous sources, and this directly poses a threat to ecosystems and public health. Sediments of Magada Lake have not been adequately assessed for their ecological potential. Based on this understanding, this study investigates the effect of physico-chemical factors on bacterial loads in Magada Lake sediments at the Mountain Top University Campus located in Prayer City, Obafemi-Owode, Ogun State, Nigeria. Among the physicochemical factors evaluated, some significantly ($P > 0.05$) varied, while a few exhibited outstanding similarities. Specifically, the total suspended solids, total dissolved solids, and total solids resulted in high levels of turbidity and conductivity from 6 am to 6 pm. This in turn gradually increased the salinity by >14-fold from 6 am to 6 pm. The biochemical oxygen demand sequentially increased from 12 pm to 12 am with resultant effects on bacterial loads from 12 pm to 6 pm in the sediments. In addition to lead and chromium, water temperature, turbidity, hardness, and sulphate remarkably correlated with the increase in the bacterial load of Magada Lake sediments. Hence, further studies are recommended to ascertain other factors that may equally result in related changes in the sediments of Magada Lake.

Keywords: *Water, Microbial load, Pollution, Aquatic, Sediments, Magada Lake*.

INTRODUCTION

Globally, water is one of the necessities of life. The existence of all life forms continues to depend on water. However, dependence on water is attributed to its quality. The quality of water in relation to the aquatic environment is now becoming a matter of worldwide concern (Gosling & Arnell, 2016; Pastorino & Ginebreda, 2021; Caretta *et al*., 2022). Among the aquatic environments, lake environments are unique ecosystems that used to experience a high level of anthropogenic activity (Custodio *et al*., 2022). Reinforcement of water use, overuse of hydrobiological resources, hydrological stress, dumping of agricultural, nutrient inputs, and urban and industrial wastes place high pressure on natural water bodies, thereby resulting in sediment accumulation (Vareda *et al*., 2019; Custodio *et al*., 2022). Unfortunately, quality water from lakes cannot be ascertained without adequate information on their sediment status. Sediments are produced when soil and bedrock erode or when plants and animals decompose. (Zhou *et al*., 2017; Custodio *et al*., 2022). Apart from providing a habitat for many organisms, sediments are crucial because many toxic substances found only in trace amounts in water may accumulate to higher levels in sediments (Shao *et al*., 2023).

An excessive amount of nutrients, especially nitrates and phosphates, can cause algal bloom and the deposition of organic matter, which can change the sediment layer and affect its health, resulting in eutrophication. The mixture of materials, in the form of nutrients, entering the lake can affect the quality and composition of the sediment layer (Custodio *et al*., 2022; Cuevas *et al*., 2024) under favorable physiochemical conditions. The amount of sediment-released P relies mostly on the duration, which is connected with the water level and suspended sediment concentration (Kim *et al*., 2019). Technically, the removal and precipitation of chemical components from surface water and/or their discharge into the water column are significantly aided by sediment, particularly in the pore water, close to the sediment-water interface (Cook *et al*., 2018). This means that in addition to the nutrient concentration gradient between these compartments, additional environmental conditions, bacterial activity, and their content and composition also have an impact on the nutrient fluxes at the water-sediment interface (Zhu *et al*., 2022; Custodio *et al*., 2024). In this sense, as the physiochemical factors of the lakes change, bacterial communities in sediments also change. Changes in the physiochemical conditions of the water can affect the health of the sediment layer, which can in turn influence the bacterial composition in the sediment layer (Zhu *et al*., 2022; Shao *et al*., 2023; Cuevas *et al*., 2024). In addition, the role of the bacterial communities is important to the nutrient structure and energy flow in aquatic systems (Song *et al*., 2011; Dai *et al*., 2016).

Sediments sink pollutants like heavy metals and organic contaminants, which can build up over time and endanger aquatic life and public health, in addition to providing vital habitat for benthic organisms and a source of nutrients for aquatic plants and other organisms (Akinnawo *et al*., 2016; Malau *et al*., 2021; Ugwu & Ofomatah, 2022). Contamination of aquatic systems by heavy metals is a broad challenge due to their toxicity, non-degradability, persistence, and propensity to accumulate in different compartments (Bhardwg *et al*., 2017; Custodio *et al*., 2022). On this note, the validation of Magada Lake sediments as a potential eco-friendly system was prioritized in this study. In addition to the time-dependent ecological variation that has not been ascertained in the sediments of Magada Lake, heterotrophic bacteria are also expected to be an important component with the possibility of influencing the sediments of Magada Lake either positively or negatively. This study therefore raises the hypothesis that: Does the ecological factor at each time point vary? Does the load of bacteria at each time point vary? Irrespective of the time points, which of the physiological factors, nutrient contents, and heavy metals influence the bacterial load? Therefore, this study assessed the effect of time-related ecological factors on bacterial load in the soil sediments of Magada Lake that passes through the Mountain Top University campus to ascertain its ecological and public health implications.

MATERIALS AND METHODS

Description of the study area

Magada Lake is one of the lakes around Kilometer 12 of the Lagos-Ibadan Expressway and flows through the Kuro community. The actual water body of this lake studied was located within the Mountain Top University (MTU) campus, which is bounded by latitudes 6°43'50" N and longitudes 3°24'39''E. The MTU Campus is located in Prayer City, Obafemi-Owode, Ogun State, Nigeria. The water body is typically lentic and thus does not have a defined unidirectional flow pattern, except for limited movement as a result of wind action. The sampling times were selected based on anthropogenic activities around the study area.

Collection of samples and analyses

Sediments were collected from the upper 5 – 10 cm depth of the water body into clean containers in three replicates at time variations of 12 am, 6 am, 12 pm, and 6 pm from MTU Magada Lake. The sediments collected were a mixture of soil and water and were kept in a regulated cold chain temperature before being transported to the laboratory for immediate analysis. pH, temperature, turbidity, conductivity, and salinity were determined in situ, while dissolved oxygen, biochemical oxygen demand, total alkalinity, phosphate, nitrate, sulfate, calcium, magnesium, and heavy metals such as cadmium, iron, lead, and chromium were all analyzed using the standard method as described by APHA/AWWA/WPCF (1985). Briefly, 2 g of air-dried sediment sample was digested using 20 mL of a mixture of HNO_3, HF, and $HCLO_4$ (3:2:1) to near dryness. The digested sediment samples were analyzed for heavy metals using an atomic absorption spectrophotometer (AAS BUCK SCIENTIFIC 210 VGP). SO_4^{2-}, PO_4^{-3}, and NO_3 were analyzed using a colorimeter (DR/890). All chemicals used for analysis and elemental analysis were of analytical grade.

Bacterial loads

Exactly, 9 mL of 1% peptone water was mixed with precisely 1 gram of air-dried soil, serving as the primary enrichment for the samples. Bacteria on nutritional agar were isolated using a serial-dilution pour plate method (Oxoid) and MacConkey agar (Himedia). The plates were inoculated and then incubated at 37 °C for 18–24 hours. The isolation was done in three replicates. Thereafter, apart from the bacterial loads from each sample, isolates with unique and consistent morphological characteristics were purified, and preliminary identification was done using morphological approaches, Gram staining, and biochemical characteristics (Olutiola *et al*., 1991; Harrigan & McCance, 1996).

Statistical analysis

SAS software, version 9.1 (SAS Institute, Cary, NC, USA), was used to compare variance in values. According to the experimental design, three replicated data sets were treated to the one-way analysis of variance (ANOVA) approach for each of the ecological parameters taken into consideration in this study to determine the significance of the variation. The variation in each of the physiochemical characteristics, bacterial load, heavy metals, and nutritional content with regard to the time points was ascertained using ANOVA. To achieve a normal distribution, the bacterial load was log-transformed. The mean comparison was performed using protected LSD ($P = 0.05$; Students-Newman-Keuls Test), with the standard error of differences between the means represented by the error mean square. The bacterial load was correlated with other ecological factors using Spearman rank correlation.

RESULTS AND DISCUSSION

Although aquatic resources, especially lake water, are managed based on the quality of the water, without sediments quality, there would not be quality water because the sediments determine the fate of quality water. However, the quality of sediments can be altered at different time points due to fluctuations in climate change, and this will invariably affect the water quality as well as aquatic organisms. Based on the sediments from our study, the air temperature (AT) and water temperature (WT) were relatively similar in their variation. For WT, it was higher at 6 am, followed by 12 am and 6 pm, while 12 pm was the least (Table 1). This is in agreement with the work of Piccolroaz *et al*. (2024), who found that lake temperature is dynamic and can be influenced by a slight change in environmental conditions that has a major effect on the aquatic ecosystem. This implies that thermal dynamics can influence the lake temperature within a time frame. Ptak *et al*. (2019) revealed that time-related changes in temperature are obvious for lakes, consequently triggering other processes related to eutrophication and the intensification of high temperatures. As against the temperature of the sediments, the pH was higher at 12 am, followed by 12 pm, in comparison to 6 am and 6 pm (Table 1). One crucial measure of the water quality and level of contamination in an aquatic system is its pH (Malau *et al*., 2021). Although the pH of 12 am, 6 am, 12 pm were slightly different from that of 6 pm. This suggests that aquatic life can be significantly impacted by changes in a water body's pH, including that of the sediment, because these organisms have adapted to live in water with a particular pH, and even minor changes can be fatal (Ugwu & Ofomatah, 2022). The high pH at 12 am can be linked to changes in other physiological factors. The salinity was extremely high at 6 am in comparison to 12 am (Table 1).

Salinity is crucial in aquatic environments and also an essential tool for interpreting changes in the hydroclimate on land (Liu *et al*., 2023). The extreme salinity could be linked to the rising temperatures, increased evaporation, and changes in precipitation patterns associated with global warming (Han *et al*., 2022). In addition, anthropogenic activities could be responsible for the high salinity (Ugwu & Ofomatah, 2022; Custodio *et al*., 2024). The turbidity was on the high side at 6 pm (Table 1); this was the exact time that the residents of this study area used to release their domestic wastes into the Magada Lake at the MTU campus as a routine cycle. Magada Lake is slow-moving and mostly undisturbed by erosion, so intentionally released domestic wastes will result in higher turbidity. For

Table 1. Physiochemical properties of sediments in Magada Lake

Time point	AT (°C)	WT (°C)	pH	Salinity (mS)	Turbidity (FNU)	Conductivity (µS/cm)
12am	25.62(±0.01)[c]	27.03(±0.02)[b]	7.63(±0.02)[a]	7.33(±0.01)[d]	17.94(±0.01)[b]	0.66(±0.03)[a]
6am	27.87(±0.02)[a]	27.94(±0.03)[a]	6.98(±0.07)[c]	130.44(±0.02)[a]	7.93(±0.01)[c]	0.27(±0.07)[b]
12pm	26.39(±0.02)[b]	26.84(±0.03)[c]	7.16(±0.01)[b]	113.72(±0.07)[b]	6.58(±0.01)[d]	0.15(±0.01)[c]
6pm	23.61(±0.01)[d]	27.05(±0.01)[b]	0.34(±0.01)[d]	80.64(±0.03)[c]	18.68(±0.01)[a]	0.15(±0.01)[c]

Time point	TDS (mg/L)	TSS (mg/L)	TS (mg/L)	Hardness (mg/L)	Alkalinity
12am	33.57(±0.04)[a]	20.62(±0.42)[a]	53.74(±0.21)[b]	12.83(±0.22)[b]	1.62(±0.36)[a]
6am	16.34(±0.04)[b]	8.63(±0.02)[b]	24.68(±0.02)[c]	14.87(±0.07)[a]	1.07(±0.07)[ab]
12pm	13.84(±0.21)[c]	7.68(±0.42)[c]	21.40(±0.49)[d]	12.63(±0.52)[b]	1.55(±0.04)[a]
6pm	34.36(±0.01)[a]	20.74(±0.05)[a]	55.46(±0.56)[a]	14.98(±0.01)[a]	0.56(±0.01)[b]

AT – air temperature, WT – water temperature, TDS – total dissolved solid, TSS – total suspended solid, TS – total solid. Values followed by different letters within a column indicate significant differences according to the Student-Newman-Keuls multiple-range test ($\alpha = 0.05$).

Conductivity, that of 12 am had the highest conductivity (Table 1). The high level of conductivity indicates that there are anthropogenic processes that are used to disturb the soil sediments and elevate the salinity of the water at 12 am. The hardness of a freshwater body can be defined as the total amount of soluble magnesium (Mg) and calcium (Ca) salts present and is expressed as $CaCO_3$. In most natural water, the predominant ions present are those of bicarbonates, which are associated mainly with Ca, to a lesser degree with Mg, and still to a lesser degree with sodium and potassium. The values ranged from 12.63 mgL^{-1} at 12 pm to 14.984 mgL^{-1} at 6 pm (Table 1). The alkalinity values ranged from 0.56 mgL^{-1} at 6 pm to 1.62 mgL^{-1} at 12 pm (Table 1). Wilson (2010) states that the geology of the region where the surface water is found and the solubility of carbon dioxide from the atmosphere are the main factors influencing the alkalinity and hardness of the water. The values found in this study are consistent with these findings and can be explained by the influx of runoff water that contains a significant amount of dissolved suspended materials. The values for total suspended solids (TSS) and total dissolved solids (TDS) varied from 7.68 mgL^{-1} at 12 pm to 20.74 mgL^{-1} at 6 pm and 13.84 mgL^{-1} at 12 pm to 34.361 mgL^{-1} at 6 pm (Table 1), respectively. The presence of high values could be linked to a high flow of runoff water carrying a lot of dissolved and suspended materials. The water body may become silted up as a result of suspended materials settling to the bottom and suffocating the benthic inhabitants (Matej-Łukowicz *et al*., 2023). This may affect the activities of plants and animals and, therefore, the natural food supply of fish (Bergström *et al*., 2019). The high level of dissolved solids could also be linked to the high influx of rainy-season runoff water. The influx of rain is, however, capable of diluting dissolved solids in water. The dissolved oxygen (DO) was lower (9.68 mgL^{-1}) at 12 am and higher (15.32 mgL^{-1}) at 12 pm (Fig. 1a). The BOD was determined knowing fully well that the photosynthetic activity around the water bodies has the potential to influence the sediments, which may lead to organic pollution. The BOD values ranged from 0.05 mgL^{-1} at 12 am to 0.167 mgL^{-1} at 12 pm (Fig. 1b). The WT, pH, DO, and BOD are important in the survival of an aquatic ecosystem (Malau *et al*., 2021). As a result of the above, the nutritional contents of Magada Lake sediments were looked into.

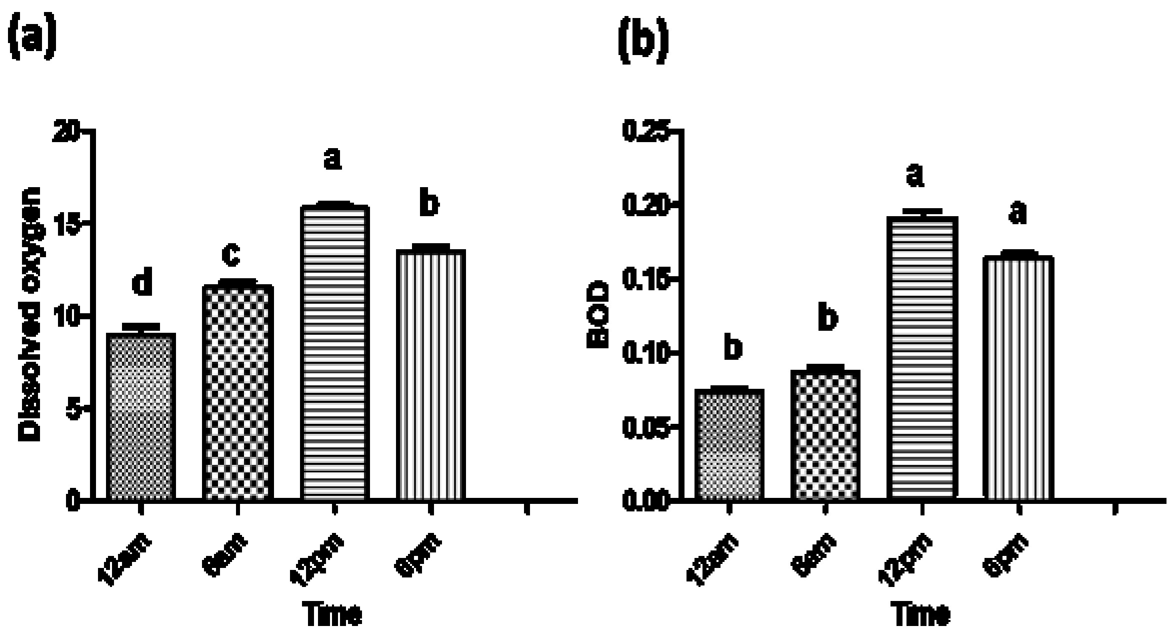

Figure 1: Dissolved oxygen (a) and biochemical oxygen demand (b) in sediments of Magada Lake. BOD – biochemical oxygen demand

In aquatic systems, phosphate, sulphate, nitrate, magnesium (Mg), calcium (Ca), and sulfur dioxide are vital nutrients for plant life. Eutrophication, the term used to describe the unfavorable plant development caused by excessive concentrations of these nutrients, can have an adverse effect on the use of lakes because cyanotoxins, which are produced when blue-green algae proliferate in high amounts, can obstruct access to waterways (Igbinosa & Okoh, 2009). Even when the external loading is reduced, the release of accumulated phosphate in the sediments may contribute significantly more than external sources and keep lakes in a eutrophic state for longer periods (Kowalczewska-Madura *et al*., 2024); unfortunately, that was not the case in our study. Based on this study, phosphate levels ranged from 0.0090 mgL^{-1} at 6 pm to 0.0095 mgL^{-1} at 12 pm (Table 2). These values are extremely against those recorded by Namsaraev *et al*. (2018), who found that the water bodies reach eutrophication levels when the total phosphate is > 0.02 mgL^{-1}. For sulphate, the sulphate levels ranged from 3.49 mgL^{-1} at 12 am to 6.57 mgL^{-1} at 6 pm (Table 2). There was a slightly higher sulfate level at 6 pm, and this could be due to the usage of fertilizers for horticultural practices around the water body during the day. In addition, the burning of fossil fuels for power generation and transportation around the water bodies can catch up in run-off water during rains, which can flow into the waterbody. The nitrate values recorded were between 4.41 mgL^{-1} at 12 am and 8.70 mgL^{-1} at 12 pm. Low nitrate was observed in this study (Table 2). This is an indication that Magada Lake may not have much difficulty with eutrophication since nitrate was very low in Magada Lake sediments. Mg and Ca are the main indicators of water hardness, which can be expressed as the equivalent amount of calcium carbonate that is usually formed from the Ca and Mg in solution. The levels of Mg recorded in this study varied from 1.55 mgL^{-1} at 12 am to 4.59 mgL^{-1} at 12 pm, while the levels of Ca recorded ranged from 14.09 mgL^{-1} at 6 am to 17.69 mgL^{-1} at 12 am (Table 2), meaning that both Mg and Ca significantly ($P > 0.05$) varied across the different time points. There is an indication that both Mg and Ca tend to decline or fluctuate based on the time point, probably from discharges of domestic wastes and ongoing site construction in the study area during the day. Potasznik & Szymozyk (2015) emphasized in their study that both Mg and Ca were retained in the lake sediments; thus, the leaching of high concentrations of Mg and Ca into the water bodies, which eventually settles in the soil sediment, is possible. Additional investigation into this study points to heavy metal leaching as well. In water, heavy metals are carried in dissolved form or as an essential component of suspended sediments. Heavy metals can attach to organic materials, sink to the lake's bottom, and combine with sediments in the right circumstances (Malau *et al*., 2021). The Lead (Pb) levels in the soil sediments ranged from 0.0003 mgL^{-1} at 12 am to 0.0367 mgL^{-1} at 6 pm; Chromium (Cr) ranged from 0.0246 mgL^{-1} at 12 pm to 0.7132 mgL^{-1} at 6 am; iron ranged from 0.3441 mgL^{-1} at 6 pm to 1.0727 mgL^{-1} at 6 am; and cadmium ranged from 0.0034 mgL^{-1} at 12 am to 0.3875 mgL^{-1} at 6 pm (Table 3). Although particles on sediment surfaces can accumulate heavy metals and pollute waters (Malau et al., 2021), the salts typically form metal complexes with anions in water, reducing the availability of potentially toxic metals (Ugwu & Ofomatah, 2022; Custodio *et al*., 2022).

Table 2. Nutritional contents of sediments in Magada Lake

Time point	Phosphate	Sulphate	Nitrate	Magnesium	Calcium
12am	0.0085(±0.0007)^{a}	3.49(±0.0100)^{c}	4.41(±0.5200)^{c}	1.55(±0.0600)^{d}	17.69(±0.0700)^{a}
6am	0.0088(±0.0001)^{a}	4.96(±0.0600)^{b}	7.52(±0.5000)^{b}	2.66(±0.0400)^{b}	14.09(±0.0100)^{d}
12pm	0.0095(±0.0004)^{a}	4.94(±0.0777)^{b}	8.76(±0.1838)^{a}	4.59(±0.0033)^{a}	16.67(±0.4243)^{b}
6pm	0.0091(±0.0007)^{a}	6.57(±0.4525)^{a}	7.56(±0.0374)^{b}	2.30(±0.0007)^{c}	15.77(±0.0388)^{c}

Values followed by different letters within a column indicate significant differences according to the Student-Newman-Keuls multiple-range test ($\alpha = 0.05$).

Table 3. Profile of heavy metals in sediments of Magada Lake

Time point	Cadmium	Iron	Lead	Chromium
12 am	0.0034(±0.0002)[b]	0.7350(±0.0040)[c]	0.0003(±0.0001)[d]	0.0368(±0.0001)[c]
6 am	0.0078(±0.0005)[b]	1.0727(±0.0270)[a]	0.0012(±0.0001)[c]	0.0770(±0.0020)[b]
12 pm	0.3872(±0.0125)[a]	0.8586(±0.0200)[b]	0.0044(±0.0001)[b]	0.0246(±0.0001)[b]
6 pm	0.3875(±0.0115)[a]	0.3441(±0.0040)[d]	0.0367(±0.0003)[a]	0.7132(±0.0030)[a]

Values followed by different letters within a column indicate significant differences according to the Student-Newman-Keuls multiple-range test (α = 0.05).

The correlation established that Pb and Cr have the potential to form complexes and drive bacterial load in aquatic environments; this therefore raised a point of concern. Pb is a cumulative poison widely distributed in the environment. The source of lead in the aquatic environment has been traced to automobile exhaust, the rusting of Pb pipes used in pipe-borne water supply (Mombeshora *et al*. 1983), and the use of Pb in other activities. Ugwu & Ofomatah (2022) reported in their study that lake water has the highest Pb concentration. This implies that the high level of Pb at 6 pm may be a result of exhaust emissions and atmospheric Pb depositions deposited in the water. For Cr, the presence of Cr could be attributed to the fact that it can be carried as runoff water from industrial sites, transported, and deposited in natural debris, which precipitates deep down into the water body (Mosalem *et al*., 2024). Contamination of aquatic environments by Cr threatens public health because of its bioaccumulation, toxicity, persistence, and biomagnification in the aquatic system (Chapman, 1996; Radfard *et al*., 2023). Under favourable physiochemical conditions, Cr has the potential to increase in concentration and cause ecological menace (Tumolo *et al*., 2020; Prasad *et al*., 2021; Chen *et al*., 2024). According to Malau *et al*. (2021), pH may be an important factor that influences metal behavior in the environment. Akinnawo *et al*. (2016) and Custodio *et al*. (2024) unfolded that the solubility of some toxic metals increases with a lower pH, as observed in this study. Low pH values can easily allow toxic elements and heavy metals to form complexes, thus producing conditions that are detrimental to aquatic life (Custodio *et al*., 2021, 2022). The heavy metal concentration in sediments is highly dependent not only on pH but also on temperature (Kussainova *et al*., 2023; Geng *et al*., 2024) because high temperatures increase the toxicity of heavy metals (Xiao *et al*. 2019; Wang *et al*. 2020). Similarly, the kind of sediments, time of contact, salinity, and density of water are also among the ecological factors that can trigger high levels of heavy metals. This is why sediments in contact with heavy metals can be the channel of heavy metals in water because of the diffusion of heavy metals from the bottom sediment layer to the surface through the influx of water in the sediment pore spaces (Malau *et al*., 2021).

The bacterial load varies (Table 4, Figure 2). This was more significant ($P > 0.05$) at 12 am and gradually increased to a higher level at 6 am. This could be attributed to the anthropogenic influence. The bacterial load was high, probably due to point discharges from anthropogenic activities near the lake. It was also observed that the residents used to release organic waste into this water body around 6 pm; bacteria would utilize the organic waste as substrate, and by 12 am to 6 am, the bacteria would have multiplied and increased. The temperature, pH, salinity, turbidity, conductivity, depth, hardness, and alkalinity variably contributed to the bacteria load irrespective of the time point (Table 5). This alteration in the sediment temperature, pH, salinity, turbidity, conductivity, and depth corroborated with the work of Akinnawo *et al*. (2016) on seasonal variation in the physiochemical and bacterial load of lake sediment. Xiong *et al*. (2012) revealed that the pH was the major driver for bacterial diversity in alkaline lake sediments across the Tibetan Plateau. Olalemi & Okunade (2024) reported in their work that pH 5-7 and optimum salinity are very good factors for enhancing the population of bacteria in the lake water. In our study, the depth of the sediments was < 5 cm. Fischer *et al*. (2002) showed that the major activity of bacteria used to take place in the upper 5 cm of the sediments. Similarly, Wang *et al*. (2022) uncover that DO is more profound at 0–7 cm of the depth where sediment bacteria are located. DO concentration might have affected the activity of the bacterial load in the sediments, though this was not part of the objectives of this study and was not investigated. Apart from the DO concentration in lake sediments, nutrients also impact the bacteria load (Shao *et al*., 2011; Wang *et al*., 2022). Lake sediment is one of the major substrates for nutrient transformation and mobilization geared towards overlying the water column; thus, sediments exhibit an effect on the nutrient contents of lakes, with a resultant effect on the bacterial load (Liu *et al*., 2020; Custodio *et al*., 2021). Our results corroborated those of Zhu *et al*. (2022) on sediment nutrients and bacteria load (Table 5). Among the nutrients that enhanced bacterial load based on our correlation strength (Table 5) was sulphate. Bak & Pfenning (1991) revealed that bacteria have the potential to utilize sulphate as their primary source of nutrients, which is possible in lake sediments. In addition to the nutrient reserves and bacterial load in the lake sediments, the effects of heavy metal and bacterial load help find ways to alleviate the change in heavy metal pollution in aquatic ecosystems. This is an indication that in sediments contaminated by heavy metals, the bacterial load can change even at the slightest time point.

Table 4. Bacteria isolates in Magada Lake

Time point	Bacterial isolates
12am	*Bacillus* species, *Staphylococcus* species, *Escherichia coli*, *Enterobacter* species *Pseudomonas* species, *Klebsiella* species, *Enterococcus* species, *Citrobacter* species
6am	*Bacillus* species, *Staphylococcus* species, *Escherichia coli*, *Enterobacter* species *Pseudomonas* species, *Klebsiella* species, *Enterococcus* species
12pm	*Bacillus* species, *Staphylococcus* species, *Escherichia coli*, *Enterobacter* species *Pseudomonas* species, *Klebsiella* species
6pm	*Bacillus* species, *Staphylococcus* species, *Escherichia coli*, *Enterobacter* species *Pseudomonas* species, *Klebsiella* species

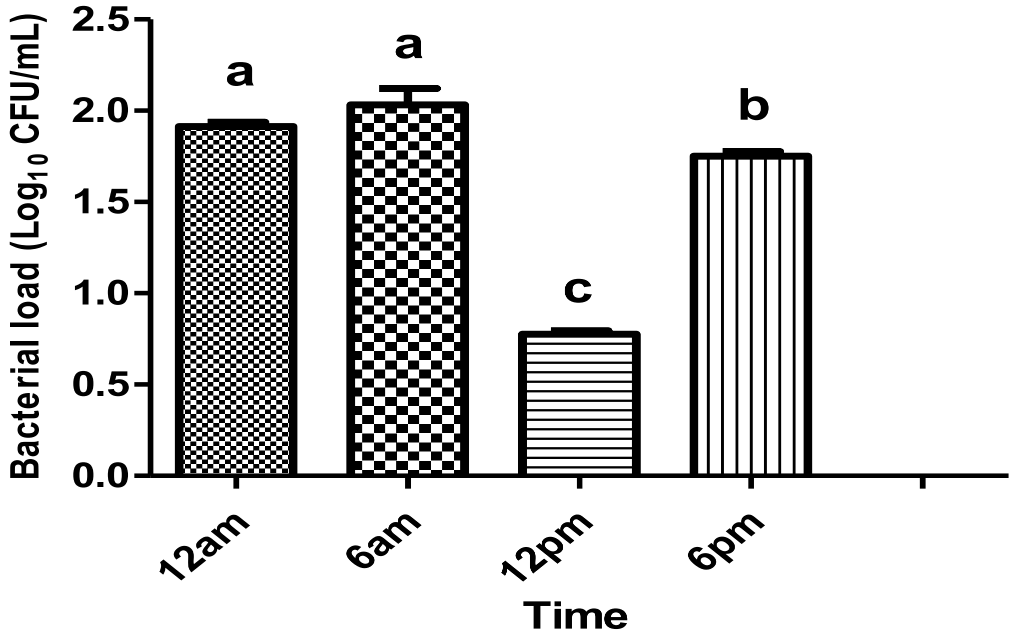

Figure 2: Bacterial population in sediments of Magada Lake

Table 5: Relationship effect of physiochemical factors, nutritional contents, heavy metals and bacterial population

	WT	pH	Sal	Turb	Cond	Har	Alk	Bact	BOD	DO	Phos	Sulp	Nit	Mg	Ca	Cad	Fe	Pb	Cr
WT	1.00	-0.73	0.75	-0.31	-0.52	0.96	-0.39	0.61	-0.74	-0.38	-0.17	0.82	0.47	-0.23	-0.91	-0.89	-0.54	-0.07	0.08
pH		1.00	-0.13	-0.33	-0.04	-0.91	0.95	-0.96	0.91	0.82	0.51	-0.93	0.26	0.71	0.71	-0.98	0.08	-0.54	-0.67
Sal			1.00	-0.91	-0.99	0.30	0.03	-0.14	-0.05	0.45	0.27	0.21	0.91	0.60	-0.78	-0.32	0.97	-0.76	-0.65
Turb				1.00	0.97	0.17	-0.42	0.54	-0.36	-0.78	-0.46	0.19	-0.98	-0.88	0.44	-0.11	-0.97	0.96	0.91
Cond					1.00	-0.08	-0.19	0.31	-0.12	-0.60	-0.35	-0.04	-0.96	-0.73	0.66	0.15	-0.99	0.86	0.77
Hard						1.00	-0.93	0.90	-0.92	-0.74	-0.31	0.92	-0.14	-0.61	-0.76	-0.96	0.05	0.42	0.56
Alk							1.00	-0.95	0.95	0.84	0.24	-0.93	0.41	0.77	0.86	0.21	-0.63	-0.73	-0.95
Bact								1.00	-0.95	-0.93	-0.48	0.90	-0.52	-0.88	-0.30	-0.88	-0.34	0.74	0.84
BOD									1.00	0.81	0.36	-0.96	0.32	0.74	0.65	0.93	0.14	-0.58	-0.69
DO										1.00	0.50	-0.69	0.74	0.98	0.20	0.69	0.61	-0.91	-0.96
Phos											1.00	-0.19	0.34	0.55	0.15	0.43	0.37	-0.54	-0.57
Sulp												1.00	-0.19	-0.60	-0.73	-0.91	0.01	0.42	0.55
Nit													1.00	0.86	-0.48	0.06	0.97	-0.94	-0.88
Mg														1.00	0.03	0.56	0.75	-0.97	-0.99
Ca															1.00	0.84	-0.62	0.19	0.24
Cad																1.00	-0.11	-0.34	-0.51
Fe																	1.00	-0.87	-0.79
Pb																		1.00	0.98
Cr																			1.00

WT – water temperature, Sal – salinity, Turb – turbidity, Cond – conductivity, Hard – hardness, Alk – alkalinity, Bact – bacteria, BOD, biochemical oxygen demand, DO – dissolved oxygen, Phos – phosphate, Sulp – sulphate, Nit – nitrate, Mg – magnesium, Ca – calcium, Cad – cadmium, Fe – iron, Pb – lead, Cr - chromium

CONCLUSION

In Magada Lake of MTU, the physico-chemical factors have a significant effect on bacterial loads of the lake sediments. Although, other factors may be involved. Therefore, further studies into sediment bacterial structures across different time series and seasons may be needed and this will offer opportunities to understand the changes in bacterial loads under the influence of different physico-chemical factors in Magada Lake of MTU.

CONFLICT OF INTERESTS

I declare that there are no competing interests.

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