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Assessment of Water Quality Parameters and Heavy Metals Analysis at Universiti Sultan Zainal Abidin Besut Campus Lake

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ABSTRACT

Water is the most crucial element for living organisms as a component for survival. Even water has become the habitat for some organisms. Therefore, assessment of water quality is vital to keep water in good condition. This study aimed to determine the water quality of Besut Campus Lake by assessing the physicochemical parameters. Water Quality Index (WQI) is related to the process of determining the status class of water according to beneficial use, with a higher index value indicate good water quality. National Lake Water Quality Standard (NLWQS) was also applied in determining the category of enclosed water systems like ponds and lakes. Water samples were taken from sampling stations at Besut Campus Lake and undergo *in – situ* and *ex–situ* analyses involving nine physicochemical parameters. In addition, heavy metal analyses were conducted in the laboratory according to American Public Health Association (APHA) methods. Based on the research conducted, Besut Campus Lake was classified as Class II with an index value of 78.23 from the Malaysia Water Quality Index (MWQI), which means recreational activities can be conducted within the lake area involving body contact. Meanwhile, according to National Lake Water Quality Standard (NLWQS), the water category of Besut Campus Lake can be categorised as Category B, which means recreational activities with secondary body contact. Further in-depth analyses involving other microbiological parameters should be carried out before the water can be recommended for primary contact recreation such as swimming.

Keywords: Water quality assessment, physicochemical parameters, Besut Campus Lake, Water Quality Index, water category.

INTRODUCTION

Water is one of the most essential elements for the human to survive. Although water distribution is 70% of the earth, the freshwater for daily usage consists only less than 2% of total water in this world. The scarcity of clean and safe water has become an issue since pollutants have contaminated most surface freshwater, either naturally or chemically (Li *et al.*, 2020). Therefore, water quality assessment needs to ensure safety either for human consumption or any other usage. Water quality assessment is a method to determine the classification of water: potable water, palatable water, contaminated water, or infected water (Amić & Tadić, 2018; Li *et al.*, 2020; Omer, 2019). It has several types of parameters that are needed to measure, which are physical parameters, chemical parameters, and biological parameters. The water quality assessments can determine the status of water according to specific standards to identify acceptable water quality, depending on respective countries. For instance, Malaysia must follow and abide by the Malaysia Water Quality Index (MWQI) and Malaysia Water Quality Standards (MWQS) in determining the status and class of water in the region. But in this study, we will refer to National Lakes Water Quality Standards (NLWQS) as the leading indicator to determine the category of the lake on the Besut campus. National Lakes Water Quality Criteria and Standards (NLWQS) is a newly developed standard that can be used as guidance for researchers, stakeholders, and the public as main references for enclosed water bodies such as lakes, ponds, and water reservoirs (National Hydraulic Research Institute of Malaysia, 2015).

Rain is one of the major contributors to water quality changes (Fazli *et al.*, 2018). About 69% of water runoff is from rainfall that flows into water bodies which contributed to pollution (Razali *et al.*, 2018). Rain brings all debris such as plastic, nutrient, soil, and organic matters in their path into water bodies, contributing to the deterioration of water quality by the increasing amount of trace elements and degradation of pH and DO level, causing an unconducive environment for aquatic life and affecting the raw water supplies (Amić & Tadić, 2018). This condition will have harmful effects on water bodies, such as high nutrient contents, leading to other problems such as algal blooms and decompose processes by detritivores, affecting the quality status of water bodies from those processes (Haldar *et al.*, 2020). This condition will worsen if the excessive effluent of rainwater runoff gets into water bodies and causing deterioration of water quality, directly affecting our country and leading to high costs for maintenance works to protect the sources of raw water (Wong, Shimizu, & He, 2020). This study's objectives were to assess and determine selected water quality parameters and water classes of Besut campus lake, identify selected trace elements, and determine water category according to NLWQS.

MATERIALS AND METHODS

Study Area

Besut campus lake was chosen as a study area due to its location that consists of many different types of potential pollutants. Besides, lack of study conducted were one of the reason we chose Besut Campus Lake. The Besut campus lake has a Latitude of 5°45'18.5" N and a Longitude of 102°37'34.7" E. It acts as a reservoir that functions to reduce the risks of floods during the monsoon season. The lake received effluent from the whole campus. It therefore may contaminate the lake with a variety of elements and jeopardise the lake's potential as a recreation site such as kayaking or for anthropogenic activities such as small-scale aquaculture for academic purposes. Another source of water may come from rainwater that may be contributed to non – point pollution. In this study, two sampling stations were selected. Sampling sites were named Station 1 (S1) and Station 2 (S2). S1 was located in the inlet area with Latitude 5°45'21.2" N and Longitude 102°37'38.8" E. Besut campus lake consisted of several water inlets. The inlet chosen received effluent from a channel nearby connected to faculty and agriculture land at the backside of the faculty building. Meanwhile for S2, it is located at the outlet area with a Latitude of 5°45'16.1" N and a Longitude 102°37'30.6" E. Water from all over the lake will flow out through it. Besut campus lake has unique characteristics where during monsoon season, water from the lake will flow out to nearby streams but in the dry season, water from those streams will flow back into the lake. A tank was set as a control in the laboratory, known as Tank 1 (T1) to imitate the condition of a close water system in this study.

Fig. 1. The study area which obtained from Google Earth map in satellite image view.


Fig. 2. Station 1 (Inlet Area)


Fig. 3. Station 2 (Outlet Area)

***In – situ* test**

For *In – Situ* test, four water quality parameters were tested directly on the respective study sites. The parameters measured were pH, temperature, dissolved oxygen (DO), and total dissolved solids (TDS) by using YSI Profesional Plus Handheld Multiparameter (APHA *et al.*, 2017; YSI Inc., 2009). The apparatus was calibrated before being used for field sampling and washed thoroughly between sampling sites to avoid reading recorded effects by any elements from other study sites. Water samples were also taken using polyethene bottles that have been overnight acid washed to prevent contamination (USEPA, 2011). Three replications were made at a random sampling point in each site and were analysed separately. On average, sampling times were conducted at 9.00 am to avoid interference of water temperature by sunlight (Kitan & Nang, 2020).

***Ex – situ* test**

The remaining water quality parameters were measured in the laboratory since they involved longer processes and various equipment. The parameters measured and equipment used were total suspended solids (TSS), which used HACH DR900 to analysed the reading. HACH DR900 also have been used to determine the value of ammonia - nitrogen (AN) through Ammonia – Nitrogen Salicylate Method using Powder Pillows (HACH Company, 2017; USEPA, 2011). For biochemical oxygen demand (BOD), YSI MultiLab 4010-1W was used to measure the amount of DO after five days and came out with the value of BOD (APHA *et al.*, 2017; YSI Inc., 2018). Three replications were made in different sampling points to obtain a more accurate reading of each parameter selected in this study.

Water Quality Index (WQI)

Water Quality Index (WQI) is a method used to calculate the class of water body (Ling at al., 2017). The calculation involved six parameters as indicators to determine the class of water, which were DO (%), BOD, COD, AN, TSS and pH. The formula used is:

$$WQI = (0.22*Sl_{DO}) + (0.19*SI_{BOD}) + (0.16*SI_{COD}) + (0.15*SI_{AN}) + (0.16 * SI_{SS}) + (0.12*SI_{pH})$$

where SI_{DO} refers to Sublndex DO (% saturation), SI_{BOD} refers to Sublndex BOD (mg/L), SI_{COD} refers to Sublndex COD (mg/L), SI_{AN} refers to Sublndex AN (mg/L), SI_{SS} refers to Sublndex SS (mg/L) and SI_{pH} refers to Sublndex pH. The range of WQI is from 0 to 100, with values obtained from the calculation that will determine the class of water (Jabatan Alam Sekitar Malaysia, 2018).

Heavy Metals Analysis

In this study, we will only analyse two types of heavy metals: Cadmium (Cd) and Lead (Pb) compared to the original plans, which supposedly have five heavy metals involved. Another reason for the reduction in the number of heavy metals choose was due to equipment that was available only Flame Atomic Absorption Spectroscopy (FAAS) and the number of bulbs available for the analysis was not many; therefore, we have to reduce the elements. Water samples were collected every week between February and March, and preserved using 10 drops of nitric acid to kills the microorganisms that might consume the elements in water samples (AOAC, 2003). As for sediment, samples were taken at each site during the experiment's initial and during the last day of sampling. Those samples then were dried in the oven for 2 days at 80℃. After that, sediment samples were digested with 65% nitric acid in a microwave digestion machine, and samples get filtered so we will obtain the real concentration of heavy metals in samples (AOAC, 2010). Water and sediment samples were then analysed using FAAS to detect the reading of metals concentration in samples.

RESULTS AND DISCUSSION

Water Quality Index (WQI)

Table 1 shows the calculation of the water quality index (WQI) according to the formula obtained from Jabatan Alam Sekitar Malaysia (2018). Six essential parameters were observed to classify the water body so that further planning can be done with the water bodies involved according to their criteria class of water.

Table 1 Water Quality Index (WQI)

Water Quality Parameters	Mean of Data
DO (%)	60.50±27.14
COD (mg/L)	32.87±8.20
BOD (mg/L)	2.12±0.15
AN (mg/L)	0.24±0.29
SS (mg/L)	9.27±8.58
pH	8.02±0.47
WQI	78.23
Class	II

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Solanki *et al.*, (2012) and Omer (2019) described dissolved oxygen (DO) as the amount of oxygen diluted in water that becomes the primary and most important parameter in determining the water quality status. Hakim *et al.* (2017) also defined DO as the most important parameter of water quality as it involved biological processes in the water, including aquatic organisms and bacteria. As for S1, the average DO concentration recorded was 3.28±1.29 mg/L, with data ranges between 1.62 to 7.9. The mean DO concentration for S1 can be categorised as class III according to MWQS. Meanwhile, for S2, the average DO concentration recorded was 6.05±1.84 mg/L, with data range between 4.07 to 12.74 mg/L. The mean DO concentration for S2 can be categorised as class II according to MWQS. The mean DO concentration in S1 recorded the lowest among the other sites. This is due to the water condition in S1 in stagnant condition most of the days during the experimental period compared to S2, which has flowing water all the time, resulting in a high concentration of DO available in the outlet area. The S1 inlet area also has an enclosed water system with marshes and grass grow to form a peninsular-like structure in S1. This has caused limited water changes in the area, continuously receiving effluents from nearby channels that might consist of pollutants such as chemical compounds, either organic or inorganic, which may lead to contaminants in the enclosed water system. Ngabirano *et al.* (2016) in their study at Kabale, Uganda found that introduction of contaminants will deteriorate water quality parameters including dissolved oxygen (DO), water hardness and alkalinity. This statement can be supported by another study from Elias *et al.* (2020). He stated that the introduction of contaminants, especially toxicants, to the aquatic ecosystem will deplete DO concentration in water and affect aquatic organisms' survivability. Besides, high suspended solids also may affect the DO concentration in the water system with the involvement of decomposed bacteria. As we know, S1 has slow to no flow of water compared to S2 where the flow of water and water changes occurrence was consistent. Therefore, the possibility for solid to suspend in S1 is higher and can cause low DO concentration. Ling *et al.* (2017) stated that suspended solids would likely affect DO concentration due to bacterial activities that consumed O_2 for the processes. Suspended solids also blocked sunlight penetration, thus affecting organisms such as aquatic plants and phytoplankton for photosynthesis occurrence, resulting in low DO concentration in water, especially non – flowing water systems.

Omer (2019) has defined chemical oxygen demand (COD) as a method for measurement involving organics materials whether it is biodegradable or not. It is contradicted with DO, which means when the amount of COD is high, the amount of DO will be low. As for S1, the mean COD recorded was 38.67±5.51 mg/L, with data ranging from 31.33 to 44.33 mg/L. The mean COD for S1 can be categorised as class II according to MWQS. Meanwhile, for S2, the mean COD recorded were 27.07±10.27 mg/L, with a range of data between 9.67 to 34.67 mg/L. The sampling for COD was assessed by temporal assessment, with observation done by week since it involved longer evaluation processes. Mean COD recorded for S1 shows the highest among other sampling sites. It is contrary to data for DO where S1 recorded the lowest mean compared to other stations. Ami (2018) in his study, has proved that COD and BOD have an exponential relationship with DO, where the reading of DO was most likely affected due to the chemical process involved. Those processes included the decomposed process of organic materials. The consumption of minerals in the water will likely involve a high amount of DO.

Meanwhile, Maria *et al.* (2001) stated that high reading of COD was likely due to water runoff mixed with pollutants that will enhance microbial activities in the water. In this case, S1 received effluents directly from a channel that came from agricultural lands. Therefore, there are possibilities that water discharged from the inlet contained lots of pollutants that might come from pesticides, fertilisers, and fuel from machinery used for agriculture. Other factors that can be potentially caused by high COD at S1 are rainfall that reduced the concentration of DO in water, causing competition for oxygen supply among aquatic organisms (Ling *et al.*, 2017). A significant amount of rainfall will cause an increment in the number of ionising charges in water, therefore will cause the release of DO into free oxygen in water, causing depletion amount of DO and increase in the concentration of COD since chemical reaction occurs to rainfall. Meanwhile, T1 recorded an uneven pattern of COD which is believed due to high AN that will lead to more chemical processes in water that will consume much more O_2.

Omer (2019) described the Biochemical oxygen demand (BOD) as the need for O_2 in microbiological processes in water for metabolising reaction involved organic substances and energy production for growth and reproduction of species. As for S1, the recorded mean for BOD was 2.01±2.20 mg/L, with data ranging between 0.68 to 5.92 mg/L. Mean BOD for S1 can be categorised as class II according to MWQS. Meanwhile, for S2, the mean BOD value recorded was 2.23±0.8 mg/L, with data ranged between 0.87 to 2.89 mg/L. The mean BOD value for S2 can be categorised as class II according to MWQS. The mean BOD of all sampling sites was varied between stations. This may be due to the amount of DO concentration in water affected by effluents discharged from the inlet. Water effluents may consist of minerals or any elements that can trigger the growth of the population and increase bacterial activities in the water. These results to non – constant BOD values recorded. Another factor is rainfall distribution during the experimental period that may cause fluctuation of BOD values in sampling sites. S1 recorded low BOD value starting with week two till week four may be due to rain before sampling that washed away all potential contributors in elevation of BOD level. Besides on S2, BOD values recorded throughout the experimental period shows slightly different between weeks. This may be due to the constant flow of water, which causes DO concentration in the outlet area to remain stable and thus, low BOD value. T1, on the other hand, has a high value of mean BOD, which may be due to biological processes in water which shows that T1 has a high amount of bacteria and other microorganisms that consumed DO for biological activities, resulting in low DO concentration in the water.

Ammonia-Nitrogen is one of four elements of nitrogen besides organic nitrogen, nitrite nitrogen, and nitrate nitrogen. It can pose threats to aquatic wildlife when it exceeds a certain level (APHA *et al.*, 2017). However, it can be beneficial to aquatic plants since it can become the primary sources of nutrients for the plants to grow by absorption of ammonia-nitrogen (Omer, 2019). As for S1, the mean value of AN recorded was 0.44±0.1 mg/L, with ranges between 0.27 to 0.50 mg/L. The mean of AN for S1 can be categorised as class II according to MWQS. Meanwhile for S2, the mean average of AN recorded were 0.04±0.06 mg/L, ranging between 0 to 0.14 mg/L. The mean value of AN for S2 can be categorised as class I according to MWQS. Mean values in S1 recorded were higher compared to S1. These were due to the condition of water in S1, the inlet area, where the water remains stagnant most of the time. Even if water flow occurred during the experiment period, it flows at a slow pace due, added with the geography of the inlet area where it is likely enclosed by marshes and, therefore, least water flow in S1 compared to S2. This explained the high level of AN recorded at S1 as enclosed water system may cause accumulation of ammonia that came through effluents from nearby agriculture lands located behind faculty (Mustafa *et al.*, 2020). This could be worsened by applying chemical elements in agriculture such as pesticides, herbicides, and inorganic fertilisers, which may cause a high concentration of ammonia to be introduced to water bodies (Elias *et al.*, 2020). It may come in different forms of a compound but within a certain amount of dosage, each one of the nitrogen elements may pose health threats to aquatic organisms or even humans (Omer, 2019).

Total suspended solids (TSS) can be described as large removable particles through a filtration process mostly made up of organic materials (APHA *et al.*, 2017). A previous study has proven that TSS has higher saturation at a lower temperature. Ngabirano *et al.* (2016), in their study in Uganda found that during the wet season, reading of TSS recorded higher compared to the dry season. As for S1, the mean average TSS recorded was 15.33±2.20 mg/L, ranging between 11.67 to 17.33 mg/L. TSS for S1 can be categorised as class I from MWQS. Meanwhile, for S2, the average TSS recorded was 3.20±1.71 mg/L, with a range of data between 1.33 to 5.33 mg/L. TSS for S2 can be categorised as class I from MWQS. S1 recorded a higher amount of TSS during the experimental period compared to S2. This is due to different water conditions for both stations where S1 has slow-moving water. Sometimes, the water in the inlet area keeps stagnant during a sunny day, added with effluent from agricultural lands that may consist of dried leaves resulting in accumulation of suspended solids. Meanwhile, in the outlet area where sampling station S2 is located, the water condition was flowing out from the lake at a higher pace than the inlet area. Therefore, not much suspended solid was recorded since the flowing water will bring all the solids to receiving water bodies. This statement can be supported by previous studies conducted where Ling *et al.* (2017) stated that anthropogenic activities such as residential agriculture areas directly impact water quality parameters such as COD, total AN, turbidity and TSS when effluent is released into water bodies without prior treatment. Rainwater runoff also will likely be caused a higher amount of suspended solids in water bodies since the rainwater will indirectly bring contaminants, either organic or inorganic and causing non – point sources of pollution (Hafizza *et al.*, 2018). Therefore, in this case, rainfall most likely contributed higher TSS recorded in S1, added with the inlet area that enclosed with marshes, causing almost closed water ecosystem and stagnant water (Razali *et al.*, 2018). However, TSS levels for all sampling sites were still in class I according to MWQS, and the water Category was still categorised as Category A according to NLWQS. For T1, the mean TSS recorded were reasonable and still within acceptable ranges. Filtration systems were set to remove excessive solids such as feed and fish wastes to maintain good water quality for control.

Potential Hydrogen or pH is a method used to determine the level of acidity of alkalinity involving oxidation-reduction processes (APHA *et al.*, 2017; Omer, 2019). pH has big influences on water quality status, where certain pH values will create an unfavourable condition for living organisms and influence processes in the water, including biological and chemical (Amić & Tadić, 2018). As for S1, the mean value of pH recorded was 7.69±0.34, with ranges of data between 7.21 to 8.74. The mean of pH value for S1 can be categorised as class I according to MWQS. Meanwhile, for S2, the mean pH value recorded was 8.36±0.62, with data ranging from 6.98 to 9.73. The mean value of pH for S2 can be categorised as class I according to MWQS. The mean pH value recorded in S2 was significantly higher compared to S1. This is believed due to lots of potential factors such as ions exchange involving heavy metals or rainfall that contributed to pH alteration. Miswan, Maya, & Radin (2019), in their study, stated that pH value exceeds seven usually due to the presence of ammonium hydroxide. Ions exchange might also occur in S2 since the outlet area received effluents from different inlets and, therefore, might contain contaminants from the hostel and agricultural land. Free active ions will react with other active compounds such as Hydrogen, and therefore, water will eventually turn to basic. Besides, rainfall may also contribute to a high reading of pH value in S2 as excess water will turn the pH reading slightly basic (Kitan & Nang, 2020). Rainwater runoff will carry many potential contaminants that will most likely affect the pH through chemical processes. Temperature also can be a factor in why the pH value in S2 slightly higher than S1. S2 received direct sunlight exposure and caused an increase in temperature, causing more active ions reaction in water (Haldar *et al.*, 2020; Wotany *et al.*, 2013). However, the mean value of pH recorded in both sites on the field is still within the acceptable value according to MWQS. As for T1, the mean pH value was adequate since it was under controlled conditions compared to field sampling sites since it was not exposed to direct sunlight and other potential causes. Water changes were done also ensure the pH remained control.

NLWQS Water Category

NLWQS is a new standard developed back in 2015, with the purpose of distinguishing other freshwater quality standards from enclosed water systems such as lakes and ponds (NAHRIM, 2015). All the parameters and categories listed in the standard have been referred to reliable standards for lake water quality that has been set by local and international water management agencies such as USEPA, MOH, DOE and Health Canada. However, in this study, we only studied selected parameters due to constraints faced such as equipment availability and MCO enforcement that caused limitation of sampling time, manpower and therefore experimental period was revised to ensure this project can still be operated with significant data be collected.

Table 2 NLWQS Water Categories

Water Quality Parameter	Mean Value	Category A	Category B	Category C	Category D
Temperature (°C)	28.12±1.34	28±3	28±3	28±3	28±3
AN (mg/L)	0.24±0.29	0.1	0.3	1	2.7
TDS (mg/L)	112.83±9.64	1000	1000	1000	1000
TSS (mg/L)	9.27±8.58	<100	100 – 200	200	>200
pH	8.02±0.47	6.5 – 8.5	6.5 – 8.5	6.0 – 9.0	5.5 – 9.0
DO (mg/L)	4.67±1.57	6.3 – 7.8	5.5 – 8.7	4.5 – 10.3	3.3 – 10.3
DO (%)	60.50±27.14	80 – 100	70 – 100	55 – 130	40 – 130
COD (mg/L)	32.87±8.20	10	25	25	50
BOD (mg/L)	2.12±0.15	3	6	6	8
Cd (ppm)	0.008±0.004	0.02	0.02	0.01	0.01
Pb (ppm)	0.495±0.088	0.05	0.05	0.05	0.05

The selected parameters listed were compared to the NLWQS Category of lakes, as shown in Table 2. Seven of the parameters were recorded within the category A limits, which involved temperature, AN, TDS, TSS, pH, BOD and Cadmium. The detailed parameters have values that fit with the criteria of Category A. As for Category B, two parameters were listed: AN and Pb level, since the values recorded for both parameters fit in the category. DO concentration differs from both prior category since DO concentration and percentage saturation were both listed in Category C since the DO readings fit with the level for the parameters. The mean COD level was high and within Category D. To determine the categories, 90% of parameters should be listed in a category that seems fit. If the parameters do not reach the requirement of 90%, the targeted category cannot be chosen and re-evaluation needs to be made with the suitable category of lake uses. In this case, since the parameters listed for Category A do not reach 90%; therefore the requirement was revised to categorise the suitability category of lake uses. After revising the criteria and requirements needed, the category that fits with the value of selected parameters is Category B, which allows the lake to be used for recreational purposes that involved secondary body contacts such as boating and cruising. However, these results were due to limited parameters tested resulting from limitations faced whilst completing this project. Further scientific data analysis of other water quality parameters will give better accuracy on the categorisation of Besut Campus Lake.

Heavy Metals Analysis

Cadmium (Cd)

Cadmium is an inorganic metallic compound that is a toxic substance found in water in trace amounts (Omer, 2019). It may threaten aquatic organisms, even in minimal amounts, and even human health. In their study, Elias et al. (2020) found that exposure of Cadmium to catfish results in a smaller liver size with low reserved energy stored in the liver. Cadmium threat to health is chronic; therefore, long term exposure will degrade the health of organisms.

The mean of Cd recorded in water samples for S1 was 0.0117±0.005 ppm, with data ranging between 0.006 to 0.019 ppm. The mean for S1 can be categorised as class II according to MWQS and Category A according to NLWQS. Meanwhile, for S2, mean Cd recorded were 0.0026±0.002 ppm, with data ranging between 0 to 0.004 ppm. The mean for S2 can be categorised as class I according to MWQS, which indicates the level of Cd found is natural level. As for NLWQS, Cd concentration in water can be classified as Category A. The mean recorded level for S1 is higher than S2 since S1 has stagnant water conditions that allow the accumulation of pollutants in the long term. The trend for S1 from week 0 until week 2 shows declination or dropped in the amount of Cd concentration. Inversely, the trend for S2 shows significant inclination in terms of Cadmium concentration; this is believed due to rainfall occurs that washed away the pollutant from S1 since S1 is an inlet area that has a direct channel of effluents from agriculture lands behind faculty buildings, and pollutant from S2 show increment due to possibilities of accumulation of pollutant from different part of lake since S2 is an outlet area. For trend weeks 3 and 4, both show a slight inclination of Cd. This is possibly due to the reduced amount of rainfall and, therefore, not much water runoff to wash away the pollutant, thus allowing accumulation to occur.

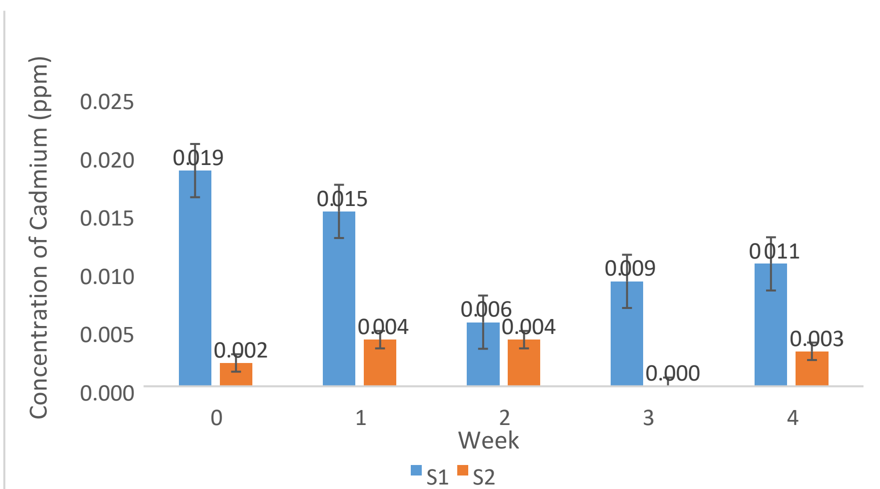

Fig. 4 Mean concentration of Cadmium in water (ppm)

The mean concentration was recorded in sediment in sampling sites of Besut campus lake. Sediment samples were collected at the beginning of the experiment and the end of the experiment period. The mean recorded value for S1 was 0.039167±0.0068 ppm, with the initial mean concentration was 0.440 ppm, and the final mean concentration recorded was 0.343 ppm. As for S2, the mean concentration recorded was 0.037167±0.0101 ppm, with an initial and final mean concentration of Cd were 0.443 ppm and 0.300 ppm, respectively. The mean concentration of Cd in sediment was recorded in both sampling sites. Data shows that the mean Cd concentration for both S1 and S2 shows no differences at the beginning. However, the final mean concentration for both sites shows there was a slight depletion of Cd concentration, which is believed due to rainfall throughout the experimental period.

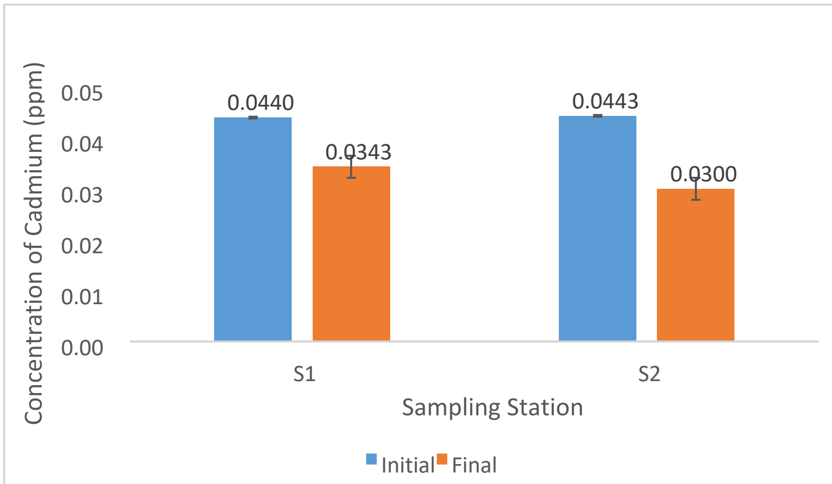

Fig. 5 Mean concentration of Cadmium in sediment (ppm)

Lead (Pb)

Lead (Pb) are metallic compounds that may post health effects to human and aquatic organisms in chronic terms (Omer, 2019). Pb availability in the surrounding is not something that we can avoid since Lead also available in essential needs in this modern era, such as fuels. Machinery application in agriculture activities with power generated by fuels can cause direct and indirect contamination to the environment (Kadarsah *et al.*, 2020). Usage in anthropogenic activities such as fertiliser, pesticides and animal feed is shared, thus causing metal accumulation in water and soil from effluents released to water bodies (Amić & Tadić, 2018). Faculty also not missed from using machinery and chemical compounds in agriculture for academic purposes. Therefore, contamination of Pb to Besut campus lake most likely will occur through a channel that directly flows to the inlet area (S1). Non – point source pollution also might happen due to weather conditions such as rain that will contaminate water runoff that flows to the lake.

The mean concentration of Pb in water was recorded. S1 has a mean concentration of 0.4661±0.087 ppm, with data ranges between 0.350 to 0.593 ppm. Mean for S1 can be categorised as class II according to MWQS and Category B according to NLWQS. Meanwhile, for S2, the mean concentration of Pb in water was 0.5229±0.090 ppm, with data ranges from 0.373 to 0.591 ppm. Mean for S2 can be categorised as class III according to MWQS and Category B according to NLWQS. Mean concentration of Pb in water for both S1 and S2. From the results, S2 shows a significant increase in Pb concentration in water. This is believed due to effluents received from different places such as agricultural lands and hostels, and rainwater runoff that may cause non – point pollution that led to this phenomenon. Meanwhile, for S1, there has been depletion of Pb concentration occurs in week 2, which is believed due to rainfall that washed the metals away from the inlet area. Other than that, the concentration recorded shows an increasing pattern. Pb may come from nearby agricultural lands located around the site of the lake. It also might come from the usage of machinery powered by fuels that contained Pb elements such as a generator for the water pump and vehicle for transportation.

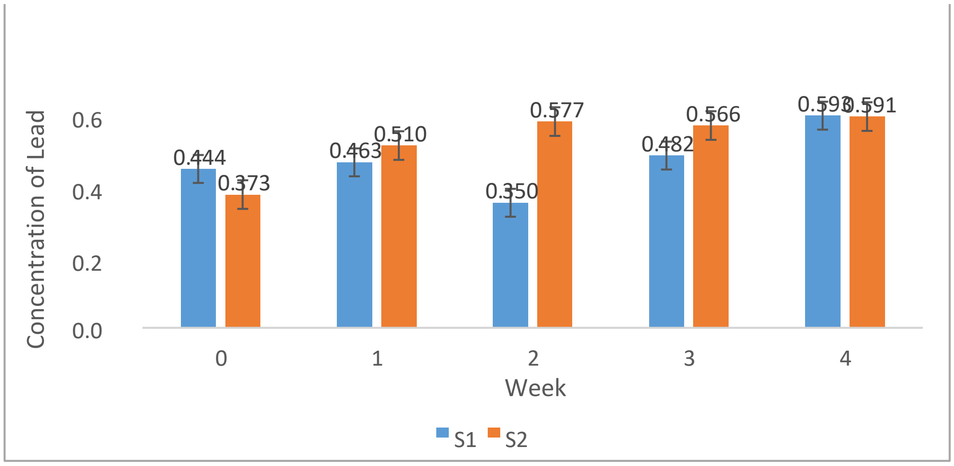

Fig. 6 Mean concentration of Lead in water (ppm)

Figure 7 shows the mean of Pb concentration in sediment for S1 and S2 at Besut campus lake. For S1, there is a slight increase of Pb concentration in sediment. This is believed due to the ecosystem of the inlet area, which is almost the same as an enclosed ecosystem of water with grow of marshes and weeds in the area. Besides, water conditions in S1 are also mostly stagnant, which can be related to a slight increase in Pb concentration since the accumulation might occur due to stagnant water conditions (Kitan & Nang, 2020). As for S2, there were almost no changes of concentration between the initial and final experimental periods. Therefore, very small declination in the mean of Pb concentration in sediment recorded was due to water flow occurrence. Thus, accumulation occurrence most likely will not happen. The slight reduction occurred possibly due to constant water flowing (Amic & Tadic, 2018) in the outlet area (S2) that brings contaminants such as Pb in sediment flow to another site.

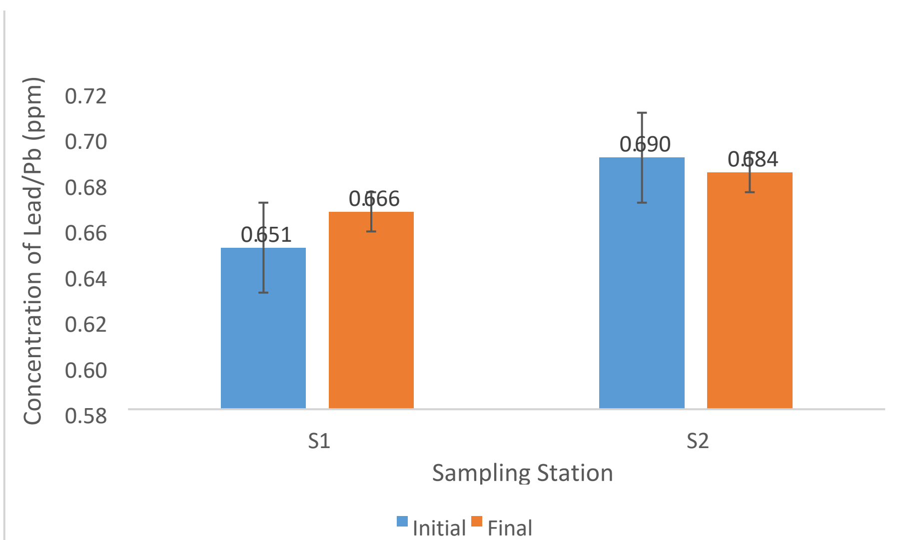

Fig. 7 Mean concentration of Lead in sediment (ppm)

This study is limited by equipment availability and MCO enforcement that caused limitation of sampling time, human resources and therefore experimental period was revised to ensure this project can still be operated with significant data be collected. To enhance the water quality assessment, future studies should be conducted involving more sampling stations at different depths of water and a longer period to gain more precise and unbiased data. Other parameters for water quality assessment can also be included: Chlorophyll-a, Colour, Conductivity, total phosphorus, and Total Coliform. More sampling stations with different depths of water for sampling also can be considered in the future study, so the data gained would be more precise and not bias.

CONCLUSION

Overall, lake water quality assessment and management are crucial to ensure water security for future use. The physicochemical parameters for water quality at Besut Campus Lake have been assessed, including several trace elements that have been chosen for three different purposes. The water Quality Index obtained for Besut Campus Lake was 78.23, which is classified as Class II. For water supply usage, conventional water treatment needs to be made first to avoid any health risks. For fishery, sensitive species can be cultured according to criteria, and for recreational purposes, body contact can be allowed according to Malaysia Water Quality Index (MWQI). Based on the analysis of the selected parameters, Besut Campus Lake can be categorised as Category B from National Lake Water Quality Standard, which allows secondary body contact activities to be done within the lake area and primary contact such as swimming are not recommended as not enough essential information about microbiological and water – borne diseases aspect. As for heavy metals content, Cadmium concentration in Besut Campus Lake is still under range, which can be considered as safe. However, Lead concentration recorded in this study was high, and therefore, treatment needs to be done to allow any recreational activities such as kayaking or boating. Prolong exposure may cause health degradation. From the study conducted, several recommendations can be taken for future research. The experiment should be performed with more sampling stations and at different water depths, so the data gained would be more precise and not bias. Other parameters for water quality assessment can also be included: Chlorophyll-a, Colour, Conductivity, total phosphorus, and Total Coliform.

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