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Lake UniSZA Water Quality Monitoring: Pollution Effects to The Aquatic Environment

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Abstract. Lake is one of the complete ecosystems and source of freshwater itself. Lake serves as a habitat for aquatic plants and animals, including the microorganisms. Lake can either be formed naturally or manmade. Most formed lakes are from volcanic eruptions, or cave ruins and lakes are formed from the rainwater. Man-made lakes usually formed after mining activities, and many can be found all over the world. Water pollution, including lake pollution, is common worldwide. It can be from point-source or non-point source. Natural environmental factors can also contribute to the lake pollution. In this study, aquatic life has been found dead and the samples of both water and aquatic life were taken for analysis. Two types of analysis were conducted; in-situ sampling analysis with YSI handheld parameter and an ICP-OES analysis were conducted. The analysis shown that early low concentration of dissolved oxygen (DO) (3.5~4.5 mg/L) and highest concentration of ammoniacal nitrogen (NH_4-N) (20.69 mg/L) as well as high concentration of sulphur (S) 3.506 mg/L) were found in both water sample and the tissue samples of the organisms. This concludes that the death of the aquatic life was due to the toxicity of sulphur found in the tissue samples.

1 Introduction

Lake is one of the freshwater habitats that exist around the world and has its own ecosystem for its inhabitants. A normal lake ecosystem provides essential resources for both terrestrial and aquatic organisms [1]. Lake also serves a catchment area for that specific area of land. Natural lake is usually protected from water pollution due to its location, which is always away from human activities and development. Man-made lakes are more prone to pollution due to human activities and development. It is highly likely to get contaminated with pollutants that come from various human activities such as urbanisation, housing developments, agriculture, and industrial activities [2]. Water pollution, such as pollution,

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can be measured through its water quality index (WQI). Water quality is an important parameter to be observed, for water pollution, especially in a confined area/environment such as ponds and lakes. For a balanced and healthy ecosystem, the environment needs to be freed from any abnormalities to ensure the well-being of its ecosystem. In a lake, which has an aquatic life ecosystem, many factors can contribute to the healthy and balanced ecosystem. pH, dissolved oxygen (DO), ammoniacal nitrogen (NH_4-N), temperature are among the principal elements that play important roles in the ecosystem. Disruptive changes in these parameters can cause terrible effects to the ecosystem.

Water quality can be measured by calculating the water quality index (WQI). The water quality is characterised by the water quality parameters (physical, chemical, and microbiological) [3]. The water quality indices are calculated water quality parameters values and from the values obtained, the water quality is grouped into the five classes by the Department of Environment (DOE). In a classification by the Department of Environment (DOE), water quality index classifies water quality into five classes (I, II, III, IV and V). Class I refers to the environment that is very natural and conserved and practically requires no treatment and it is suitable for very sensitive aquatic species. Class II can be divided into two; Class IIA and Class IIB, where Class IIA does need water treatment, however only conventional treatment processes and its environment is suitable for sensitive aquatic species. Class IIB is suitable for recreational use of body contact, meaning it is safe for humans. Class III water requires an extensive treatment process while it is also suitable for common and economic value and tolerant of fish species, as well as suitable for livestock drinking. The fourth class is for irrigation purposes and the last class, which is Class V where the water has no classification as listed previously.

In this case study of the death of aquatic life (fish, snails, and prawns) from the lake, the factors that contribute to the deaths are studied. The objective of this report is to analyse the factors that caused the deaths of aquatic life of the lake and to report the findings and to provide the recommendations for further improvements by the authorities. UniSZA Lake serves as a water catchment body from the nearby area, especially wastewater from the surrounding housing areas, as well as from the university itself. There was a similar incident that happened in 2017, where tilapia fish were found floating on the surface of the lake. Thus, the water quality check of the lake was conducted.

Fig. 1. Dead fish found in the lake.

2 Methodology

UniSZa lake is situated in the campus and functions as the main catchment area from the neighbouring housing areas and the university itself. The possible point sources of pollution identified are from the nearby domestic and industrial wastewater. It is highly possible for the lake to be contaminated with pollutants due to the few entry points located at the lake itself, thus can be a source for the death of the aquatic life due to the high concentration of pollutants in the lake water.

2.1 *In-situ* sampling

For in-situ sampling, a professional handheld portable water quality parameter (YSI) was used. It can detect temperature (T, °C), pH, dissolved oxygen (DO, mg/L), total dissolved solids (TDS, mg/L), salinity (SAL), ammoniacal nitrogen (NH_4-N, mg/L) which serve as sampling data on this study.

2.2 ICP-OES (Inductively coupled plasma – optical emission spectrometry)

ICP-OES (Inductively coupled plasma – optical emission spectrometry) is a technique which is usually used for determination of elements in most water-dissolved samples using a plasma and spectrometer. ICP-OES ICAP 7000 (Thermo Fisher Scientific) was used in this elements' determination. In this study, samples of aquatic life also analyse with ICP-OES (fish, snail, small prawn, and aquatic plant). By principle, ICP-OES converts samples into aerosol, which is lead to argon plasma, leading to atomization and ionizations of the samples take place. electrons reach the "excited state" due to the absorbed thermic energy and are liberated as light (photons) when the electrons' energy drops to the ground level. Thus, this light (photons), will be measured with a spectrometer since each element has its own characteristic emission spectrum. The light intensity on the wavelength is measured.

Fig. 2-4 shows the sampling of the lake water samples using the *in-situ* handheld parameter as well as the collection of water samples. Water quality parameters measured were dissolved oxygen (DO), mg/L), ammoniacal nitrogen (NH_4-N, mg/L), pH, temperature (^{0}C), total dissolved solids (TDS, mg/L) and salinity. Sampling was done for nine-days daily in the morning for uniformity. Water samples and animal and plant tissue samples were collected on the first day of sampling and were sent to the laboratory for ICP-OES analysis. For the in-situ water sampling, the water quality parameters were observed at three (3) sampling points. First point is located at the entrance of the point-source, the second point is where the aquatic life was found dead, and the third point is the location near the water output source.

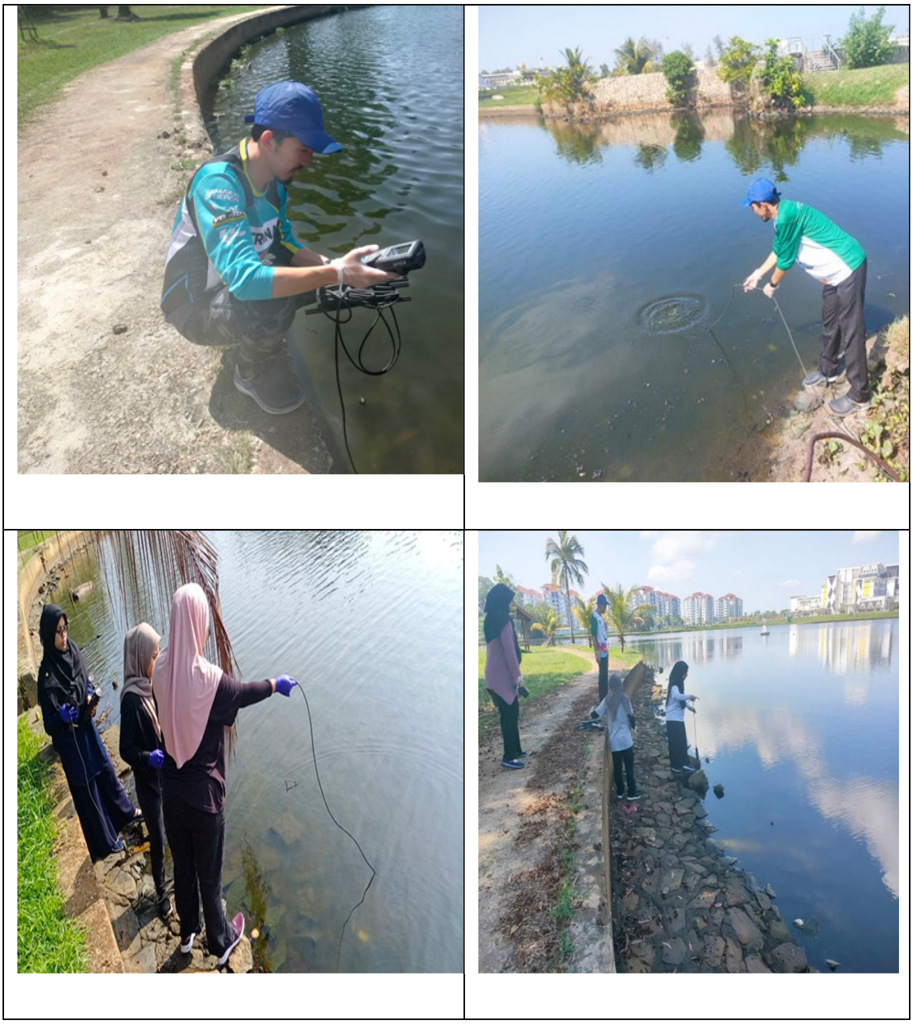

Fig. 2. In-situ measurement of dissolved oxygen and ammoniacal nitrogen (mg/L)

Fig. 3. Water sample collection from the lake

Fig. 4. YSI *in-situ* handheld parameter for the sampling

3 Results and Discussion

There are many environmental factors that need to be put into consideration when a calamity happens in a lake. Although the occasion is rare, the possibility for the event to happen cannot be ignored. The fatality of aquatic life in this lake especially fish, snails and prawns has raised questions especially among the people. Nonetheless, the occurrence of this event needs to be understood that various factors contributed to this, especially if there is water pollution that has occurred in the lake. The pollution of the lake water can be either from point-source or nonpoint-source. Point-source pollution, as straightforward as it is referring to the single source of pollution source. For example, discharge pipes from local housing complexes. As for non-point sources of pollution, it can be harder to identify as it comes from various sources of pollutants. An example of non-point source is runoff, as water is projected to the streams or rivers after accumulating pollutants from various sources.

Table 1. Dissolved oxygen (DO), pH and ammoniacal nitrogen (NH_4-N) in-situ readings for nine-days sampling

Day	Temperature, ^{0}C	pH	Dissolved oxygen, DO (mg/L)	Ammoniacal Nitrogen, NH_4-N (mg/L)
1	33.5	8.31	6.09	20.61
2	32.1	7.06	4.23	9.42
3	31.4	7.15	4.54	12.78
4	31.2	8.27	3.35	13.49
5	30.9	7.76	3.26	12.89
6	30.2	7.86	3.15	15.36
7	27.7	7.03	2.67	12.10
8	30.8	7.12	2.80	10.78
9	29.8	7.58	2.35	11.69

From Table 1, it was observed that concentration of dissolved oxygen gradually decreased from the first day of sampling to the ninth day and the highest concentration of ammoniacal nitrogen was recorded also on the first day (20.61 mg/L). The initial in-situ sampling and analysis observed these crucial parameters that had a big impact on aquatic lives. pH plays an important role in the water, especially in a catchment area. Balanced pH in water is vital to aquatic life as well as to the environment. In this case where aquatic life such as fish, snails, prawn were found floating and dead in the lake, there are many contributing factors that should be considered. Few common factors include low oxygen levels, pollution, diseases and parasites, algal blooms, chemical spills, changes in water temperature, habitat destruction, overfishing and natural disasters. Low oxygen levels in the water can cause oxygen depletion among aquatic life especially fish, prawns, and snails. There are few factors that can contribute to this oxygen depletion phase such as algal blooms, excessive plant growth, pollution, or changes in water temperature. All these factors are closely related to each other. [4] in his study concludes that Lake Kabo's dissolved oxygen (mg/L), changes in water temperature and pH fluctuation are the cause of the sudden death of fish in the lake. Tilapia fish requires > 5 mg/L of dissolved oxygen however can tolerate 3~4 mg/L of DO level in the water. Decreased levels of DO can cause distress to the fishes and may result in death.

Ammoniacal nitrogen (NH_4-N, mg/L) is another important water quality parameter that should be taken care of. It is present naturally in natural water and can significantly affect aquatic life and the ecosystem itself [5]. When the concentration of ammonia in water increases, it stimulates the primary production of plankton communities, leading to the rapid growth of algae and eutrophication. High concentration of ammoniacal nitrogen in water can cause the water to be anoxic, resulting in the increase of marine fish and invertebrates' sensitivities to impart the ammonia toxicity.

Another significant factor to be considered is pollution of the lake. Pollution can happen when foreign substances that have potential harmful effects to the environment are introduced to the environment. In this situation, potential pollutants could come from domestic and industrial discharge, agricultural runoff, or improper waste disposal to the lake. UniSZA Lake is situated inside the university's compound and the lake functions as a major catchment area. The inlet source of wastewater can be from domestic and industrial wastewater nearby, as well as the wastewater from the university itself. The possibility of pollution source and pollutants to enter the catchment is high and it can be the source of the death of the aquatic life due to its extreme concentrations in the water.

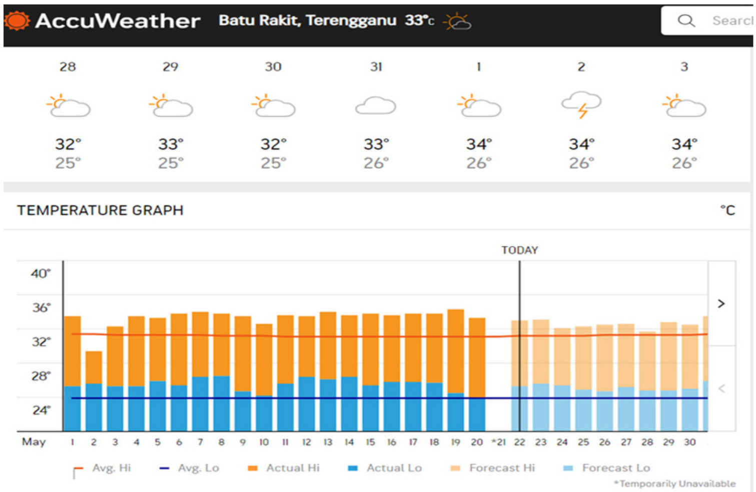

Fig. 5. Temperature of May 2023 in Batu Rakit Terengganu (www.accuweather.com)

Figure 5 above displays the temperature of May 2023 in Batu Rakit Terengganu, where temperature can be a contributing factor for the stability of the water ecosystem. It can be observed that the temperature on the day ranges from 28 ~ 35 ℃ whilst temperature at night ranges from 25 ~ 27 ℃. Increased temperature in water bodies could affect aquatic life due to the stress and shock which is introduced to the water. Increased temperature of water can stimulate the sludge decomposition, leading to the formation of sludge gas and multiplication of saprophytic bacteria and fungi, resulting in the consumption of oxygen by decomposition processes, affecting the aesthetic value of water [6].

Table 2. ICP-OES heavy metals analysis for initial water sample

Samples	Mg	Mn	Fe	Cd	Pb	S	Zn	As	Al
W1	0.778	0	0.055	0	0	3.235	0	0.018	0.134
W2	0.800	0	0.066	0	0	3.210	0.200	0.021	0.131
W3	0.771	0	0.067	0	0	3.506	0.02	0.031	0.165

Table 2 refers to ICP-OES analysis for water samples taken on 13/5/2023. Water samples from three points of sampling were analysed and nine heavy metals components were analysed using ICP-OES. It was observed that among the nine heavy metals, three of them which are manganese (Mn), lead (Pb) and cadmium (Cd) were not present in the samples, while magnesium (Mg), iron (Fe), Sulphur (S), zinc (Zn), arsenic (As) and aluminium (Al) all are present in the sample. The highest concentration detected by ICP-OES is from sulphur which gives 3.235 ppm, 3.210 ppm and 3.506 ppm. All samples were measured in ppm (part per millions) which is equal to mg/L. As compared to other heavy metals content that only has <1 ppm, the concentration of sulphur is relatively high. Nitrogen (N), potassium (K), phosphorus (P), calcium (CA), magnesium (Mg)< sulphur (S) and Si (silicon) are the most common nutrients that present in the water that are vital to the aquatic life while there are no traces of cadmium (Cd) and lead (Pb) recorded in the initial water samples collected. In reference to Table 2, it is observed that concentration of sulphur is relatively high as compared to other elements.

Table 3. Heavy metals / nutrients' traces found in the tissue of aquatic life.

Samples	Mg	Mn	Fe	Cd	Pb	S	Zn	As	Al
Blank 1	0	0	0	0	0	0.018	0	0.008	0.132
Plant	0.0445	0.0017	0.0104	0	0.0001	0.3453	0.0097	0.0003	0.0608
Fish	0	0.0446	0.4282	0	0.0004	0.7112	0.0153	0.0004	0.1043
Prawn	0.313	0.0249	0.058	0.0005	0.0131	0.5131	0.0349	0.0006	0.0394

Table 3 shows the heavy metals / nutrients' traces in the tissue samples of the dead aquatic life as retrieved from the lake. Since in the first batch of water sample analysis, sulphur is relatively high in concentration as compared to others, tissue sample analysis was done to validate the previous results. It can be observed that concentration of sulphur is still the highest as compared to other elements, and it is relatively high in both tissue samples of fish and prawn. Sulphur is also naturally present in the aquatic environment and the presence of sulphate can be divided into two categories: natural sources and manmade sources. Natural sources include the release of sulphate from mineral components, oxidation of metal sulphides, acid rains and many more. However manmade sources come from industries such as mining, metallurgy, food, medicine, steel manufacturing, kraft pulp and paper mills [7]. Higher concentration of sulphate in the water can be a cause for fish toxicity, leading to the death of the fish and prawn.

In Table 4, there are two additional samples analysed: tissue sample of snail and soil sample. In the tissue sample of snail, concentrations of heavy metal iron (Fe) were the highest with 7.6071 ppm followed by aluminium (5.3424 ppm) and the lowest concentration of heavy metal recorded was cadmium (Cd, 0.0000 ppm). Nevertheless, concentration of sulphur is still highest compared to other elements in the snail' tissue sample (0.0853 ppm). However, in the soil sample collected, sulphur with the concentration of 2.7189 ppm is the highest and still, Cd is the lowest in concentration with 0.0001 ppm. Iron is naturally high in snails as well as protein and becomes a food not only to other aquatic organisms but also to humans for its high protein content. In Turkiye, snails become an exported agricultural product as well as a popular type of food consumed in European countries [8]. Aluminium is widely available in the environment, and its solubility is greatly influenced by environmental factors, especially pH. Under acidic conditions, Al will appear as white soluble compound, while at neutral pH, it will become an insoluble compound of Al (OH_3) [9 -12]. Both elements are relatively high, but aluminium is considered a toxic substance to the organisms if it's in high concentrations. Furthermore, aluminium is insoluble in neutral pH and soluble in acidic conditions, thus indicating that it is dangerous to the environment. It can cause organ pro-inflammatory effects such as organ inflammation, enzymatic stimulation, or inhibition as well as oxidative stress [13].

Table 4. Water, snail, and soil samples for ICP-OES analysis

Samples	Mg	Mn	Fe	Cd	Pb	S	Zn	As	Al
Snail	0.0245	0.0179	7.6071	0	0.0033	0.0853	0.0138	0.006	5.3424
Soil sample	0.6478	0.3617	1.2916	0.0001	0.0013	2.7189	0.2389	0.0047	0.3031

WS 1	0.853	0.010	0.177	0.002	0	3.062	0.012	0.002	0.131
WS 2	0.914	0.004	0.148	0.001	0	3.317	0.019	0.025	0.042
WS 3	0.808	0.011	0.128	0	0	3.176	0.012	0.017	0.090
WS 4	0.817	0.011	0.166	0	0.018	3.390	0.015	0.005	0.090
WS 5	0.793	0.017	0.184	0	0	3.362	0.008	0.027	0.116
WS 6	0.836	0.014	0.139	0	0	3.972	0	0.002	0.082
WS 7	0.991	0.012	0.381	0	0	3.610	0.037	0.029	0.161

4 Conclusion and Recommendation

From the findings and analysis, the death of aquatic life (tilapia fish, prawn, and snails) can be caused by a few factors. Heavy metals mainly contributed to the death of aquatic life especially the tilapia fish, snails, prawns, and the aquatic plant. High concentrations of sulphur (S) are identified as the major cause of the death of the said living organisms. Other heavy metals / nutrients composition is found to be in low concentrations as compared to sulphur. Besides, the eutrophication as well as high temperature of lake water factor are eliminated since it was not significant in the study. Further monitoring and analyses are being conducted to the UniSZA lake to enhance its water quality as well as future water treatment to produce cleaner and safer water following the guidelines and requirements of the Department of Environment (DOE).

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