E-J.Chem
http://www.e-journals.net

ISSN: 0973-4945; CODEN ECJHAO
E-Journal of Chemistry
2010, **7(S1)**, S245-S254

Water Quality Characterization of Varsity Lake, University of Malaya, Kuala Lumpur, Malaysia

M. AQEEL ASHRAF, M. JAMIL MAAH and ISMAIL YUSOFF

Department of Chemistry, University of Malaya
50603, Kuala Lumpur Malaysia.
chemaqeel@perdana.um.edu.my

Received 16 April 2010; Accepted 10 June 2010

Abstract: Lakes and reservoirs are important sources of water supply, generate electricity and to irrigate fields. Since, lakes act as catchment basins for close to 40% of the landscape so serve as recreational, sporting and fishing activities. Varsity Lake University of Malaya (UM) is beautiful landscape at the front of the UM main entrance. It is used mainly for recreational and sporting (canoeing) activities. Study has been carried out in order to analyze water quality, nutrients and metals load starting from water inlets into the lake basin. It was found that there is high concentration of oil and grease particles in water due to water flow from cafeteria of college 2, engineering and built environment faculties which cause BOD and TSS value to be higher then normal in the lake. It was one of the main factors that caused the death of fish in the lake in recent months. Mercury and nitrate concentration is also high in the lake. A body contact is involved due to sporting and recreational activities so parameters are compared with Malaysian Interim water quality standards and it was concluded that lake water quality is not fulfilling the recreational spot criteria and is hazardous to human and fish life in the lake. Recommendations are proposed for immediate action. Best management practices is also discussed for prevention of oil and grease particles from entry into lake water to protect this valuable water resource from being polluted.

Introduction

Lakes and reservoirs are a vital component of our environment as these are a source of fresh water, habitat of plants and animals, for aquatic life, essential component of water cycle, air conditioning, renewable energy and for recreational activities. However in past few decades most lakes and reservoirs have become polluted. Over one third part of our nations streams, lakes and estuaries are impaired by some form of water pollution[1].

The main cause of water pollution is human activities. Humans produce bodily wastes that enter lakes and reservoirs[2]. Industries discharge variety of pollutants in the waste water including heavy metals, organic toxins, oils nutrients and solids. Many of the substances are toxic or even carcinogenic. Pathogens can obviously produce water born diseases in either human or animal hosts. These wastes also increase the concentration of suspended solids (turbidity), bacteria and virus growth leading to potential health impacts. Increase in nutrient load may lead to eutrophication; organic wastes increase the oxygen demand in water leading to oxygen reduction in water with potentially severe impacts on whole ecosystems[3].

There are two sources of water pollution, point sources and non point sources. Point sources discharge pollutants at specific locations (land fills, industrial wastes) through inlets into surface water while nonpoint sources (acid rain, agriculture, construction, home pollutants) cannot be traced into single discharge. The effects of non point pollutant sources on water resources may vary and cannot be fully accessed. However these pollutants have harmful effects on drinking water supplies, recreation, fisheries, and wildlife. Human beings are the main cause of nonpoint sources. Each of us is contributing to this problem without realizing it. Damage to streams, lakes and estuaries from non-point sources pollution was estimated to be about $7 to $9 billion a year in the mid-1980s[4].

From past three decades strong attention has been given to water pollution. Environment legislations have been introduced to control point sources of water pollution and had shown to be effective.On the other hand non point sources are very difficult to analyze, monitor and control. The only way to control this type is the Best Management Practices (BMPs).

Objective and significance

The objective of this study is to determine the water quality, nutrients and metals load in the lake and also to investigate whether the varsity lake has some bad impact on the aquatic life and students of the University Malaya who use the lake for recreational activities (canoeing). On 15 October 2009 most of the fish in the lake suddenly died and management authorities of University Malaya were surprised so the authors took the opportunity to study the lake and report the findings.

University of Malaya, the first university of Malaysia, is situated on 750-acre (309-hectare) main campus in the southwest of Kuala Lumpur, the capital city of Malaysia[5]. Varsity Lake is situated (3^0 25' 27.52" N, 101^0 25' 53.89" E, Max. Elev. 558 m) in front of the main gate of University Malaya, making a sight seeing landscape. Varsity Lake has a length of 250.6 meters, width of 85.3 meters and an average depth of 6 meters with a trapezium shaped geometric structure typically located in the central part of drainage basin. The deepest part of the lake is near the outlet channel.

Varsity Lake is basically a man made reservoir to meet the recreational and sporting needs of University of Malaya. There are three main inlets to supply water to the lake one from faculty of engineering and built environment. Second from Residential College 2 (RC 2) (Kollege Tuanku Bahiyah) and third inlet is underground water pump that is normally used when the water in the lake reach the dead level.

There is water filter basin at the main inlet into lake that stops excessive suspended particles in water. There is another portable water disposal pump near the outlet drain1 that pumps water from main drain channel to lake in condition of dead level. There are two drain outlets to main drain channel to drain water in case of high level in lake.

Experimental

Field tests and samples were taken during morning, evening and night times and also during rainy and sunny days in order to check any variations in results, probably due to active time for organisms and nutrients depending on the temperature of water and emissions of the sunlight.

After careful field survey ten locations were selected for sampling based on impact of that point to the inlet and outlet that could affect the actual results. Samples were collected from ten selected locations. All water samples collected and stored in a pre cleaned 1 liter HDPE plastic bottles, washed & rinsed several times with acid and water. Samples bottles were labelled properly.2-10 mL / liter nitric acid is used as preservative for metals analysis. 1 mL / 100 mL 1 M Boric acid is used as preservative for nitrate analysis. Samples were sealed and cooled upon collection below 4 ^{0}C in ice cooling box before analysis[6].

Sample analysis

Water quality parameters temperature, pH, turbidity, dissolved oxygen (DO) and total dissolved solids (TDS) were analysed in situ by hydrolab MS-5 while oil and grease particles (O & G)[7], total suspended solids (TSS)[8] and biological oxygen demand (BOD)[9] were measured in laboratory by standard methods. Nutrients that include nitrate[10] and phosphate[11] were also analyzed by standard methods while heavy metals barium, manganese, mercury and Iron were analyzed by inductively coupled plasma mass spectrometry (Perkin Elmer 6100 ICP-MS).

Results and Discussion

In order to develop clear understanding, results of water quality study of Varsity Lake were separated into three sections. First section includes physical water quality parameters temperature, pH, turbidity, DO, TDS, O & G, TSS and BOD. Second section includes nutrient parameters nitrate and phosphate. Third section includes metal parameters barium, manganese, mercury and iron. The results of data from field and laboratory were analyzed and discussed through mean value by graphical presentation in order to sum up all the data results to reach the findings. Table 1 shows samples were taken during morning, evening and night times and also during rainy and sunny days in order to check any variations in results, probably due to active time for organisms and nutrients depending on the temperature of water and emissions of the sunlight.

Table 1. Sampling plan.

Sampling Station	Sampling Location	15 October 2009 Thursday 2:00 P.M	28 December 2009 Monday 10:00 A.M	16 February 2010 Tuesday 5:00 P.M
	Water Level	Low Level	High Level	High Level
S1	Engineering Faculty Inlet	Sunny	Sunny	After Rain
S2	College 2 Inlet	Sunny	Sunny	After Rain
S3	Water Filter Basin	Sunny	Sunny	After Rain
S4	Lake Jetty	Sunny	Sunny	After Rain
S5	Underground Water Pump	Sunny	Sunny	After Rain
S6	Outlet to Drain 1	Sunny	Sunny	After Rain
S7	Boat House	Sunny	Sunny	After Rain
S8	Outlet Darin 2	Sunny	Sunny	After Rain
S9	Centre Stream	Sunny	Sunny	After Rain
S10	Main Road Corner	Sunny	Sunny	After Rain

Temperature and pH are important parameters in water. Thermal pollution occurs as a discharge of municipal or industrial effluents. Most of the aquatic life is cold blooded so they cannot regulate their body temperature according to condition so temperature has a great influence on aquatic life[12]. pH is a measure of acidity or alkalinity of water which is expressed in terms of hydrogen ion concentration[12]. Small variations in pH do not have any effect on aquatic life. However water generally becomes more corrosive with decreasing or increasing in pH value[13]. The pH of water also has a great influence on the biochemical processes occurring in surface waters and on the processes of water purification and wastewater treatment[14]. Figure 1, 2 show temperature and pH variations at different stations, as pH and temperature are mutually related to each other thus similar kinds of variations in pH and temperature are observed at each station. From Figure also show that average value of pH at every sampling station is below while temperature value exceeds INWQS standardization that is 7.5 and 20 ^{0}C respectively. This could be contributed by water from engineering faculty as lowest pH was recorded at this station.

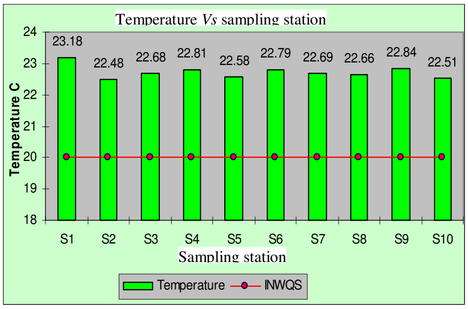

Figure 1. Temperature *vs.* Sampling Station.

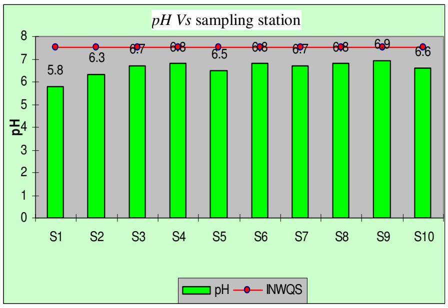

Figure 2. pH *vs.* Sampling Station.

Turbidity is a good indicator for water clarity. Water turbidity has a special significance in deep reservoirs because the depth to which sunlight penetrates depends on the turbidity[12]. The extent of illumination influences many processes occurring in the water such as photosynthesis, which is why the transparency of water is often measured as a quality parameter[15]. Figure 3 indicates the turbidity of water in the lake. The average values for turbidity at every sampling point meet the limitations for INWQS that is 50 NTU.

Dissolved oxygen is an important physical parameter. Adequate dissolved oxygen is needed and necessary for good water quality. Fish and other aquatic life needs oxygen to survive in water. DO level in water decreases as the concentration of oxygen demanding organic matter and anaerobic bacteria increases in water[12]. Figure 4 shows the amount of dissolved oxygen in water and it was found that level of DO at all sampling stations are within the permissible limits set by INWQS.

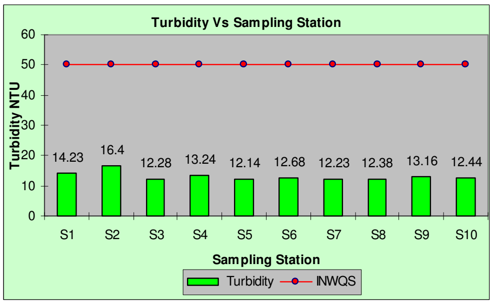

Figure 3. Turbidity *vs.* Sampling Station.

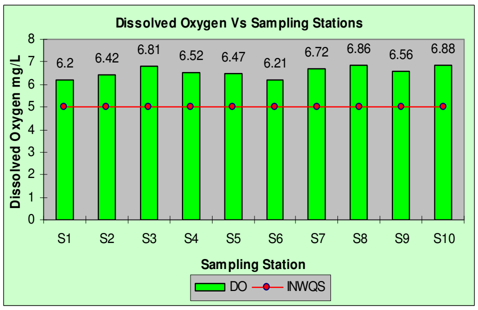

Figure 4. Dissolved Oxygen *vs.* Sampling Station.

Total dissolved solids is a measure of the amount of solids dissolved in water whether natural or anthropogenic (human made) which mainly composed of inorganic with minor organic constituents as well. There is no serious effect of high TDS on aquatic life. However TDS cause toxicity through increase in salinity, changes in ionic composition of water that become a cause of shift in biotic communities, limit biodiversity and cause acute or chronic effect at specific life stages[16]. Certain components of TDS such as chlorides, sulphates, effect corrosion or encrustation in water pipes[17]. High TDS levels results in excessive staining of water pipes, water heaters, water boilers and household appliances[18] such scaling can shorten the service life of these appliances[19]. Figure 5 clearly shows the high concentration of TDS at all stations particularly S1 (engineering faculty inlet), S2 (college 2 inlet) and S7 (Boat House). The possible cause of high TDS at S7 is a disturbed sedimentation due to canoeing activities point.

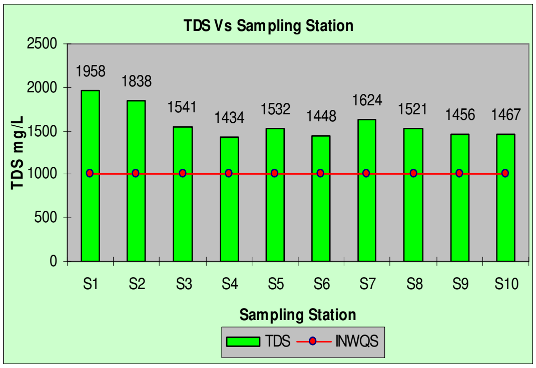

Figure 5. Total Dissolved Solids *vs.* Sampling Station.

Figure 6 shows the contribution of oil & grease particles in water. It was observed that there is very high concentration of oil and grease particles in water at all sampling locations. Fats, oil and grease particles (FOG) cause sewage spills, property damage, manhole overflows, health hazards and environmental problems. When fats, oil and grease particles are washed through kitchens, restaurants or cafeteria sinks or floor drains, they sticks inside the pipe and start building up and eventually blocks the whole pipe causing sewage spills and manhole overflows[20]. Brown grease is floatable fat, oil, grease and settled solids recovered from grease control devices.

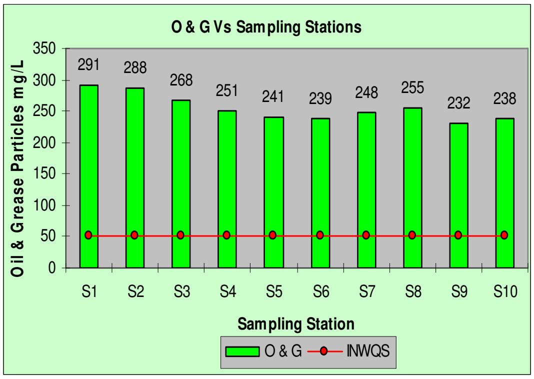

Figure 6. Oil & Grease Particles *vs.* Sampling Station.

Typically, brown grease is not reusable and is generally disposed off through wastewater treatment facilities. Yellow grease is fat, oil and grease that are not contaminated. Yellow grease is also referred to as recyclable FOG[21]. Detergents, that claim to dissolve grease, simply move pass grease down the pipe and create a larger problem downstream. The main cause of high level of oil & grease particles in lake water is the contribution of cafeteria of residential college 2, engineering and faculty of built environment. When oil & grease particles reaches water resource it forms a thick layer on water surface causing the temperature of water to increase, decrease dissolved oxygen in water and high BOD present in grease thus enhances the bacterial growth in water.. Figure 7, 8 clearly shows very high concentration of TSS and BOD in water than permissible limits of INWQS standardization. High concentration of oil and grease particles decreases oxygen concentration by the increase of bacterial growth in water.

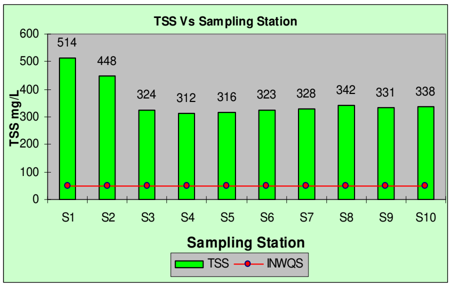

Figure 7. Total Suspended Solids *vs.* Sampling Station.

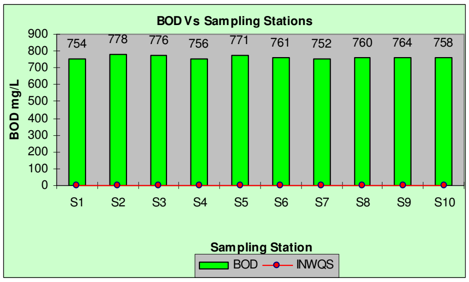

Figure 8. Biological Oxygen Demand *vs.* Sampling Station Nutrient Parameters.

Nitrate and nitrite are naturally occurring chemicals that are parts of nitrogen cycle. Nitrate is less toxic than the other forms of nitrogen in the aquatic environment, such as nitrite and ammonia. Nitrate can have a harmful impact on the development of early life stages in aquatic organisms, by reducing the oxygen-carrying capacity of the blood, or by disrupting an ability to maintain proper balance of salts. Increased levels of nitrogen in the water, combined with phosphorus, can cause excessive plant and algal growth that depletes oxygen levels, possibly to lethal levels. Some algal blooms also produce toxins that can affect aquatic life or humans that consume them[22]. Figure 9 & 10 show nutrients (nitrate and phosphorus) concentration in water. Concentration of nitrate and phosphate are exceeding the safe limits of INWQS at all sampling stations with maximum concentration of nitrate and phosphate at S1 engineering faculty outlet. The water at this outlet comes from the biomedical and chemical engineering departments.

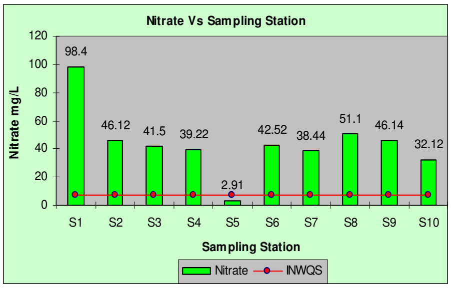

Figure 9. Nitrate *vs.* Sampling Station.

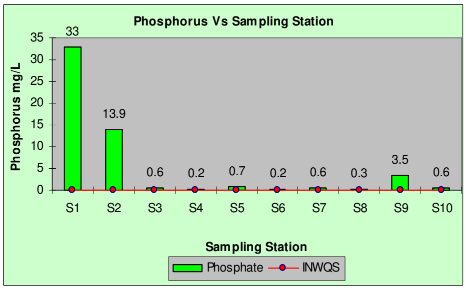

Figure 10. Phosphorus *vs.* Sampling Station Metal Parameters.

Heavy metals are important constituents of the ecosystem. Human activities can cause their modification or distribution. Heavy metal pollution is the major problem to our oceans, rivers and lakes and also the biggest threat to human health, animals and plants. The main source is the current rapid industrialization. Figure 11,12,13,14 describes metals (barium, manganese, mercury and iron) in water analyzed by ICP-MS.

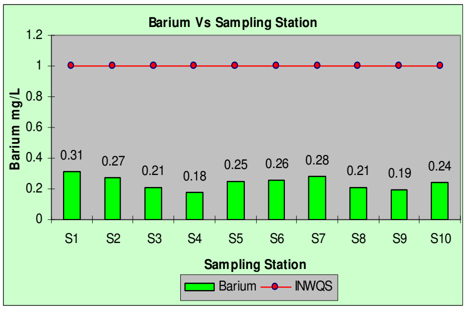

Figure 11. Barium *vs.* Sampling Station.

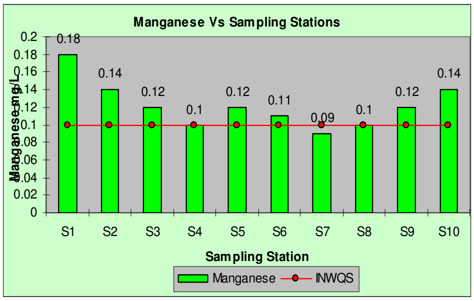

Figure 12. Manganese *vs.* Sampling Station.

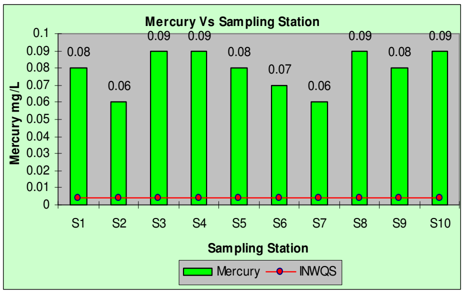

Figure 13. Mercury *vs.* Sampling Station.

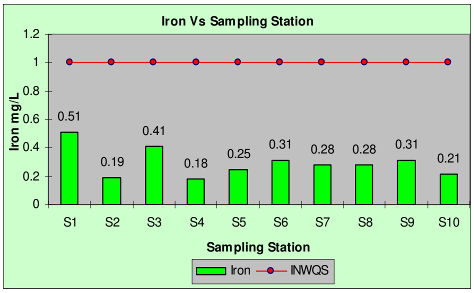

Figure 14. Iron *vs.* Sampling Station.

Barium and iron concentrations are within the safe permissible limits set by INWQS but mercury and manganese exceeded the limits. Mercury concentration is very high in water. In order to justify the classification of studied parameters were compared with class IIB INWQS standards as Figure 15, 16 shows overall picture of physical, nutrient and metals parameters in water with respect to INWQS standards.

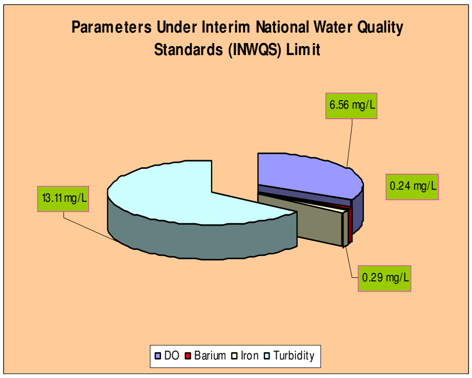

Figure 15. Parameters under Safe Water Quality Limits.

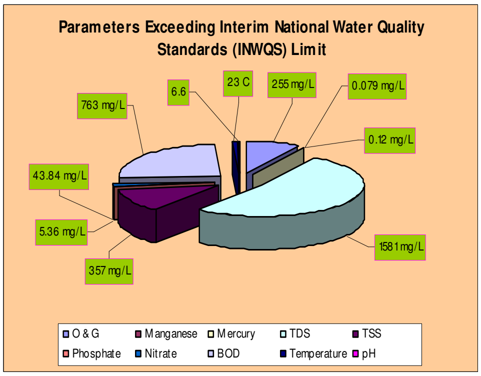

Figure 16. Parameters Exceeding Safe Water Quality limits Color Plates.

According to Figure 15 turbidity, DO, barium and iron concentrations are under the safe limits of INWQS standardization for class IIB which is specific for recreational use with body contact while Figure 16 shows that temperature, pH, TDS, O & G, TSS, BOD, nitrate, phosphate, manganese and mercury exceeding the safe limits of class IIB INWQS standardization. Mercury should be limited in water body as it can cause death and illness[16]. According to United States Clean water Act (passed in 1990), mercury has been placed on top of the list for toxic pollutants that need to be controlled to the greatest possible extent. It shows that most of the parameters that fail to act in accordance with INWQS standardization are those which give much more significant effect to water body. Lake is being used as a recreational point and body contact is involved, therefore mercury is the main concerning parameter in the lake water. Phosphorus contamination should also be focussed as it can leads to eutrophication phenomenon in the lake.

Best Management Practices (BMPs) for prevention of fats, oil & grease (FOG)

Fats, Oil and grease (FOG) is a major problem nowadays in cities and towns due to rapid increase in restaurants, hotels, cafeteria and also household kitchens. The main reason for originating this problem is the downplaying about the discharges of oil and grease particles from restaurants and cafeteria into water resources. Attention has only been given to industrial waste discharges so it has become an environmental problem. BMPs is an effective tool in controlling the FOG at its stem of origin rather then using chemical or biological methods to treat water after problem arisen. Some of the BMPs are discussed here in order to protect our water resources and sewage pipes from this environmental hazard.

1. Trash should be used for pouring dry wiped FOG and scraped cooked food from pans, pots and dishware.
2. Paper towels should be used to wipe out excess FOG from pans, pots and dishware.
3. Grease trap should be used under every sink in restaurants and cafeteria and should be clean properly when a certain percentage of traps become full.
4. Conventional in-ground grease traps should be installed to handle kitchen flows at restaurants, nursing homes, schools, hospitals and other facilities from which quantities of grease expected to be discharged.
5. Grease trap should be checked and maintained properly in order to ensure its proper working.
6. Oil recycle container should be used in order to prevent the oil being drained into the drain channel.
7. Discontinue the use of garbage grinder (food disposals). Should use trash.
8. Regular training of the restaurants and cafeteria employees should be held in order to make them trained for the implementation of GMPs.
9. Law enforcement agencies should make sure the proper implementation of GMPs at all restaurants and cafeteria.
10. Recycled FOG should check for pesticides and other contaminants, heat in vacuum to volatize impurities and sold out to companies to be used as animal feed additives, soap production, oil, cosmetics and skin care products.

Conclusion

This study has been carried out to test the compatibility of water quality, nutrients and metals load in the lake water in comparison with Interim National Water Quality Standards INWQS and also to determine the impact of water quality on aquatic life and the health of students using lake for sporting. From above results and discussion it can be concluded that lake water failed to fulfill the criteria as a recreational point due to high nutrients load and concentration of metals especially mercury and is hazardous for the students using lake for canoeing. Overall water quality of lake is moderately doubtful if we talk in terms of INWQS.

The second main finding is the high concentration of oil & grease particles which is one of the main factor for increase in temperature, BOD, TSS and decrease of DO in lake water. Based on these findings, on 15 October 2009 the death of fish in lake water can be attributed to high concentration of oil & grease particles as well as nitrate concentration. The other major cause of high pollution is the use of waste water from university main drain channel at the time of dead water level in the lake. The waste water of faculty of science, faulty of social science and perdanasiswa complex flows through main drain channel. Therefore the possibility of waste water being polluted is very high.

Recommendations

Based on findings, the following recommendations were given:

1- Preventive measures should be taken to control the flow of FOG into the lake.
2- Use of engineering faculty drain into the lake should be ceased.
3- BMPs should be strictly followed to drain water into the lake.
4- Use of waste water from main drain channel to increase the dead water level of the lake should be strictly prohibited.
5- Water pump used for the suction of waste water from main drain channel into the lake should be immediately removed.
6- It is advisable that university management authorities should properly take care of the lake as a true recreational point.
7- Fishing in the lake should strictly prohibited as the level of mercury is high in water.
8- This study brought many questions for further study so it is recommended that further study should examine from other viewpoints.

References

1. U.S.E.P.A.National Water Quality Inventory, 1996 Report to Congress. U.S. Environmental Protection Agency Office of Water. E.P.A. Publication, 841-R-97-008. Washington, D.C. 1998, 521.
2. U.S.E.P.A.,Water Pollution Prevention and Conservation, Pollution Prevention (P2) Education Tool Box. E.P.A Publication, EPA-905-F-97-011. Washington D.C. 1997, 1.
3. www.water-pollution.org.uk/environment.html
4. Ribaudo M O, Regional Estimates of Off-Site Damages from Soil Erosion. Pages 29-46. In: Waddell, T.E. (Editor). The Off-Site Costs of Soil Erosion. Proceedings of a symposium held May 1985. Conservation Foundation, Washington, D.C. 284 pages. Soil & Water Conservation, 1986, 40, 9-13.
5. www.topuniversities.com/university/384/university-malaya-um
6. Maria Csuros, Csaba Csuros, Environmental Sampling and Analysis for Metals. CRC Press, Lewis Publishers, 2002, pp. 203-225.
7. American Society for Testing and Materials, ASTM D3921-96, Standard Test Method for Oil and Grease and Petroleum Hydrocarbons in Water, 2003.
8. U S Environmental Protection Agency, EPA. Methods for the Chemical Analysis of Water and Waster, 600/4-79-020, 1979, p.160.2,
9. Winkler L W, *Berlin. Deut Chem Ges.*, 1888, **21**, 2843.
10. American Society for Testing and Materials, ASTM D3867-09 Standard Test Methods for Nitrite-Nitrate in Water.

11. American Society for Testing and Materials, ASTM WK4052 - New Test Method for Determination of Total Phosphorus in Water, Waste Water by Suppressed Ion Chromatography.
12. Michaud J P, A citizen's guide to understanding and monitoring lakes and streams. Publ. #94-149. Washington State Dept. of Ecology, Publications Office, Olympia, WA, USA, 1991.
13. U.S.E.P.A. National Water Quality Inventory, 1996 Report to Congress. U.S. Environmental Protection Agency Office of Water, E.P.A. Publication 841-R-97-008. Washington D C, 1998, p.521.
14. Alabaster J S and Lloyd R, Water Quality Criteria for Freshwater Fish. Butterworth, London, 1980.
15. Jan R Dojlido, Gerard A Best, Chemistry of Water and Water Pollution. Ellis Horwood Limited, Great Britain, 1993
16. Phyllis K Weber-Scannell and Lawrence K, *Am J Environ Sci*., 2007, **3(1)**, 1-6.
17. Sawyer C N and McCarty P L, Chemistry for sanitary engineers, 2nd Edition, New York McGraw Hill. (McGraw-Hill Series in Sanitary Science and Water Resource Engineering) 1967.
18. Tihansky D P, *Water Resour Res.,* 1974, **10(2),** 145.
19. Mc Quillan R G and Spenst P G, *J Am Water Works Assoc*., 1976, **68,** 415.
20. http://www.barnstablecountyhealth.org/AlternativeWebpage/Grease/Grease.htm
21. George R Alther, *Water Engineering & Management*, 2001, **148,** 7.
22. Balogh J, Fausey N, Harmel R, Hughes K and King K, *J Soil Water Conservation*, 2006, **61(1)**, 31-41.