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Water quality assessment of UPM Lake and the impact of geographic information system

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Abstract: A study of the water quality changes of engineering lake was conducted for 3 months in March, August and September. A total of 8 water quality parameters were measured and their average monthly observations were recorded with consideration of both point source and non-point source (NPS) pollutants. The parameters measured were Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Ammonia-Nitrogen (NH_3-N),pH, Total Suspended Solids (TSS) and water temperature.This was done according to the guidelines of department of environment (DOE) Malaysiaon water quality assessment with respect to Interim National Water Quality standards (INWQS). Based on INWQS and WQI Malaysia the lake was classified as polluted against class IIb. This shows the lake is not suitable for recreational activitiessuch as fishing, canoeing. The level of pollution based on spatial resolution of two water quality parameters, BOD and water temperature was made possible using geographical information system (GIS). ARCMAP 10.1 softwarewas used for this application to determine the concentration of the parameters at every position in the lake.

Keywords: Water Quality Index, NON-Point Source, GIS, ARCMAP 10.1

1. Introduction

Water quality assessment is a major concern since it has effect on human's health and quality of life. Thequality of surface water has become a global concern since it is envisaged that fresh water will be a scarce resource in the future. Almost one-quarter of the population in Ghana experiences shortage of adequate water supplies (Lean *et al.,*1990). Despite Malaysia having abundance of surface water with little attention given to ground water supplies, there is still issues relating to water rationing. Forthis reason water quality monitoring programme is very important for the preservation of fresh water resources (Fulazzaky, 2010). To ensure that water quality is effectively monitored, pollution identification from point source and non-point source (NPS) is necessary and investigated. Pollution investigation and control may pose difficulty for water quality managers because they are difficult to control. To achieve effective water quality management, assessment of water quality of lakes can be done in several ways such as the use of Water Quality Index (WQI) (Horton, 1965), the use of local standards for example, the Interim National Water Quality Standards (INWQS) Malaysia. (DOE, 2006),the use of ecological models for water quality prediction (Kianirad *et al*., 2006). Geographic Information System (GIS) has emerged as a powerful technology for research (Openshaw, 1991). This concept and advancement in space technology has resulted in great efficiency in land and water management (Gogu *et al*., 2001). Remote sensing with its spatial and temporal features and also availability of data over large area within short time has become a very effective tool to explore, evaluate and manage water resources (Madan K *et al*., 2007). GIS has become a very effective tool for processing spatial data and enhance decision making in engineering and geology (Gossel e*t al*., 2004).

Pollution of water in lakes are primarily caused by deposition of waste water substances, this is usually done with little or no treatment plan before they are deposited. This is a common trend in most developing countries including Malaysia. In UniversityPutra Malaysia (UPM),

there are lots of lakes which are designed for recreational purposes. The major problem facing the lakes has to do with non-point source pollution as a result of runoff from agricultural fields, domestic waste disposal and deposition of soil and organic particles due to erosion, this in a way has affected the surface water quality of the lakes. Hence the aesthetic value is reduced and consequently the desire for recreational activitiesis reduced. To improve the water quality of the lakes, the type of pollution from different sources entering into the lakes must be identified and investigated to ensure adequate measures to control the pollutants from the sources without economic implication. Research effort has been made on investigating the water quality of some lakes in Malaysia. For example Chini Lake which is considered as one of the most important lakes in peninsular Malaysia reported the investigation of 14 water quality parameters within 12 months of sampling (Mushrifah and Ahmad, 2005), these parameters were Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO),Total Suspended Solids (TSS), Ammonia- Nitrogen, pH, TotalDissolved Solids (TDS), turbidity, nitrate, chlorophyII conductivity, phosphate, dissolved oxygen and sulphate. The results were compared with INWQS which classified the lake under class 1, DO, pH, turbidity, BOD, COD and ammonia-nitrogen were classified under class 11. The extent at which these parameters were violated was not investigated. The physico-chemical properties of Selangor river in 2000 investigated the BOD, NH_4, Fe and SS with a view of appraisal of their reliability for recreational activities. However, the concentration of each parameter at every point is very difficult, therefore effective documentation of the status of the lake becomes incomprehensive. GIS can achieve this desired goal by acquiring rasta data set at dispersed sample locations and the prediction can be achieved for all other locations. This is possible by assigninginput points features and data from sample measurement for all locations in an output raster data set. The objective of this work is to determine the spatial variations of water quality parameters of the engineering lake in UPM and their effect on the condition of the lake.

2. Materials and Methodology

2.1. Site Description

The engineering lake is chosen for this work because of its importance in the university. The lake is located around the academic buildings which is strategic and good location for recreational activities such as fishingfor varsity staff and students. The lake covers an area of 24,140m^2. The source water is principally from precipitation events and runoff.

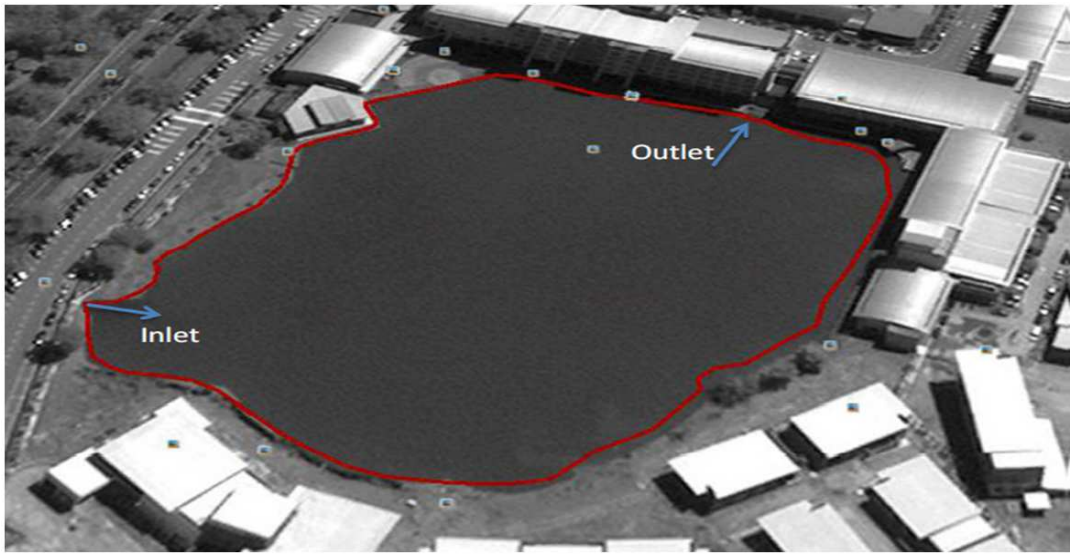


Fig. 1. *Location of varsity lake engineering*

2.2. Method of Sample Collection

Samplings were made with a sterilized plastic container at the point of influent, effluent and center of the lake in March, August and September 2013. A total monthly precipitations were recorded as 212, 93 and 409mm respectively (JPS Ampang, 2013). The measurement of surface water temperature and pH on- site using pH meter/ thermometer (UNEP/WHO, 1996). The remaining sample taken were stored under icepack and transported to the laboratory. The other parameters measured were (BOD), (COD), turbidity, ammonia- nitrogen, DO and suspended Solids. All sampling procedures, storage conditions and methods for the laboratory examination comply with the INWQS (DOE, 2006).

Arc GIS 10.1 was used to interpolate a raster surface for the lake from sampling points using an inverse distance weighted (IDW) techniques (Lam, 1983).

3. Results and Discussion

Table 1. *The average monthly result of the physico-chemical analysis of the water samples*

Month	BOD(mg/L)	DO(mg/L)	pH	Tur (NTU)	NH_3-N(mg/L)	COD(mg/L)	SS	Temp° C
March	342.9	0.21	6.7	13.6	0.42	359	80	28.6
August	162.1	0.94	7.3	12.3	0.36	192	52.5	29.51
September	179.4	1.37	7.24	14.0	0.40	275	42.5	28.20

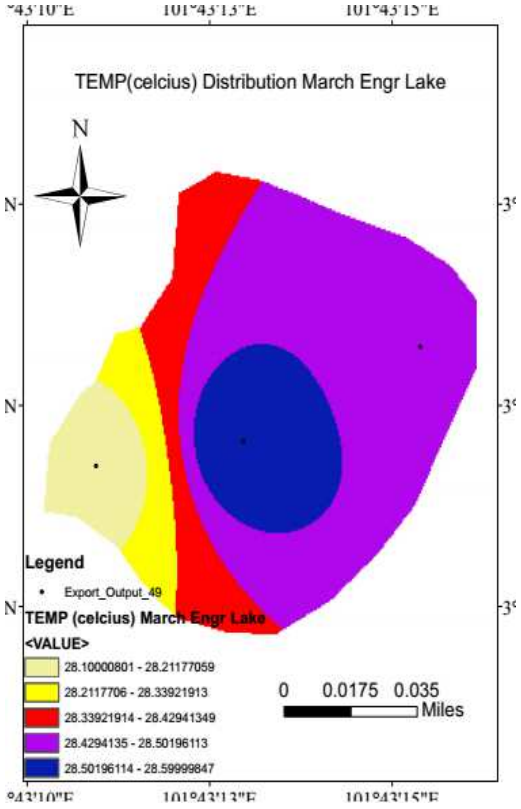
BOD- Biochemical Oxygen demand, DO- Dissolved Oxygen, SS- Suspended Solid, TUR- Turbidity, COD- Chemical Oxygen Demand NH_3-N-Ammonia-Nitrogen

3.1. Pollution Source Investigation

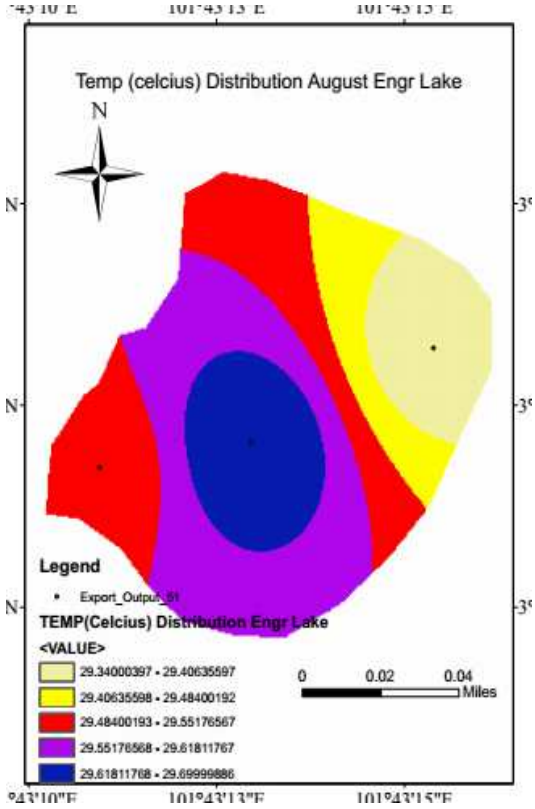
The result of the preliminary investigation of the engineering lake show pollutants were from domestic waste water and NPS from agricultural areas. Water Quality can be analyzed using WQI (Fulazakky, 2010). The statistical analysis of the selected pollution parameters by WQI which has its root from INWQS Malaysia (DOE, 2006) classified the polluted against class IIb. The WQI cannot effectively analyze the condition of the lake since the indexes has less information than the observed data they summarize.

3.2. GIS Analysis

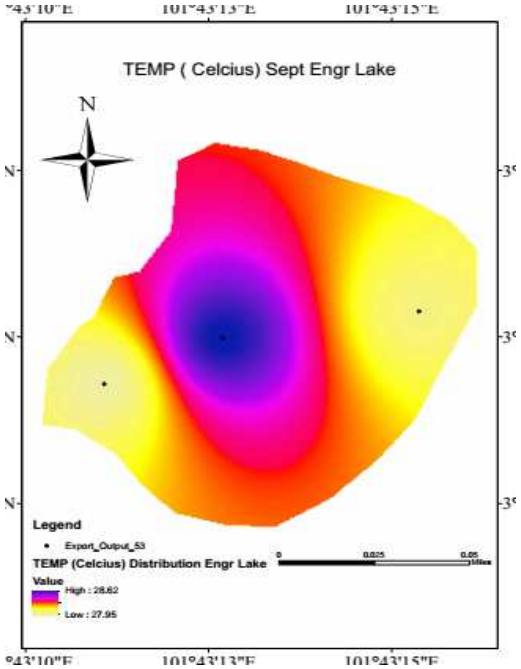
Spatial analyses were aimed at establishing relationship between water quality parameters by creating a prediction from the sample point values. These spatially referenced data were used to determine the contribution of each water quality parameter across the lake through GIS spatial distribution map. These maps for two selected parameters are illustrated in fig 2.The result of the preliminary investigation and spatial analysis shows temperature for the lake is high throughout the period of the study across the lake. BOD and other parameters are also very high as they do not agree with the INWQS standards except for turbidity. High level of BOD concentration in the lake does not support aquatic habitation probably explains the reduction of aquatic population in the lake. A low BOD value is an indicator of good water quality and a high BOD indicates pollution (Shelton, 1991).



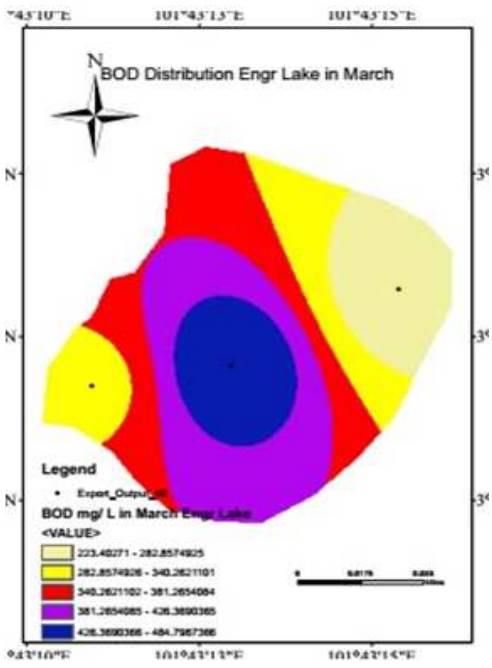
(a) Temp℃March



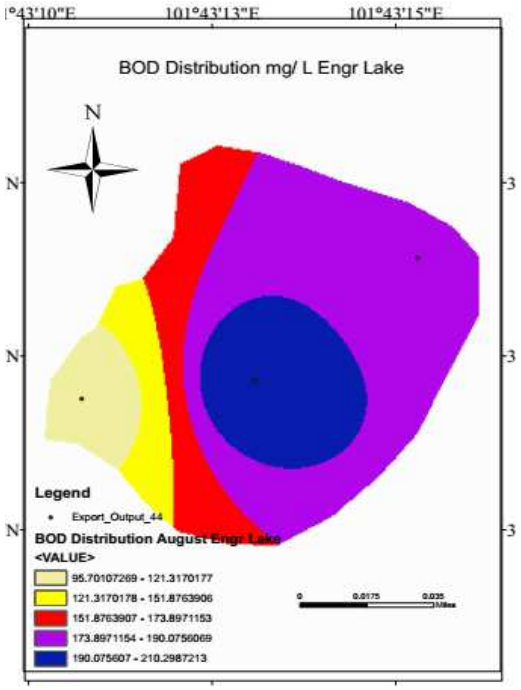
(b)Temp ℃August



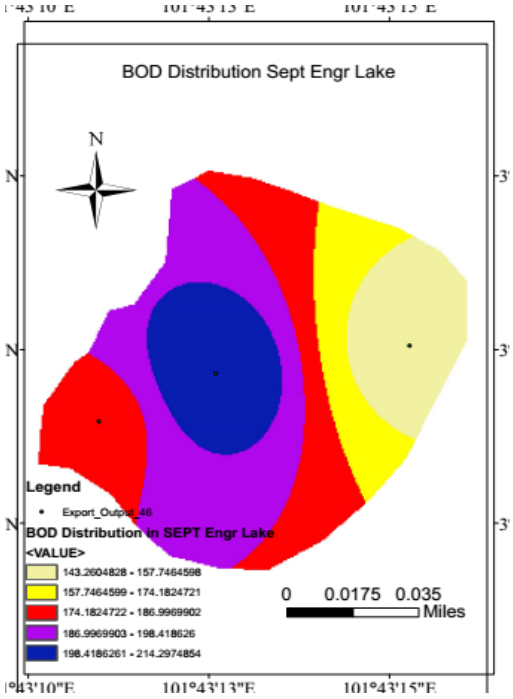
(C) Temp ℃ Sept



(D) BOD mg/L March



(E) BOD mg/L August



(F) BOD mg/L Sept

Fig. 2. *Spatial analysis*

4. Conclusions

The importance of this study is to ensure that the condition of the engineering lake supports body contact activities such as fishing and canoeing can be achieved by putting in best management practices such as planting of trees around the lake to reduce sunlight penetration, conservation efforts such as removal of organic materials on the surface of the lake periodically is very necessary. Application of GIS has shown to be very effective in water quality management since if the level of pollution is known for each water quality parameter across the lake, planning effort through processing observed data, analyzing and interpreting the levels of pollution will be made easier. The use of remote sensing technique has proven to be cost effective in water quality assessment because it reduces the amount of field data collection. GIS does not eliminate the

effort of data collection since it will help in the verification of remote sensing data and their interpretations.

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