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Database Development for Water Quality Index using Geographical Information System

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ABSTRACT

The present study aimed to identify drainage pollution at Parit Raja, Johor in accordance to the Water Quality Index (WQI) and based on Geographic Information System (GIS) data analysis. A total of 18 sampling stations at six drainage ditches were selected to be sampling points. The parameters investigated included Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solid (SS), Ammonia Nitrogen (AN) and pH. ArcGIS software was selected and the water quality data were gathered and digitized in the GIS as data storage system in order to develop database. The results revealed that 13 stations were categorized as polluted, 5 stations classified as slightly polluted. These findings indicated that GIS have an ability to provide interactive visual and attribute information effectively in order to improve water quality management system. Therefore, GIS can be applied on a big study area and this is useful for wastewater management by authorities.

Keywords: Water pollution; Water Quality Index; Geographical Information System

INTRODUCTION

Water quality is identified based on the physical, chemical and biological characteristic which reflect the suitability as a drinking water. The polluted water is associated with many impact for life such as infections transmission, destruction of aquatic life and disruption of comfort population (Abdul Rahman 2007). The main factors contributing of water pollution are the discharge of domestic sewage wastewater from settlements (Al-Gheethi et al. 2016), agricultural activities (Atsushi et al. 2005), disposal of industrial waste and garbage disposal. The main sources of water pollution can be categorized as point sources and non-point sources. Point sources of pollution are classified as occurring due to contamination from domestic sewage and industrial waste from houses or premises discharged directly into the river without any process wastewater in wastewater treatment plants (Hanum et al. 2019) while the non-point sources of pollution are caused by agricultural runoff and urban runoff. Agriculture is a contributory factor to the pollution of water quality in Malaysia due to the use of organic chemicals, such as fertilizers and biocides (herbicides and pesticides) to encourage the process of plant growth (Ishak et al. 2020).

Therefore, the waste management and involvement of authorities has been taken by the country for water conservation. The water quality should be collected frequently to provide a database for the water security. However, the data stored manually requires large space and is not efficient in handling large amount of data as well as consume a lot of time to retrieve. Geographical Information System (GIS) has created to ease the management of water quality information. GIS is a computer-based system in the processing of geographical data and maps to produce information created digitally [4]. Therefore, by using the GIS, trends and distribution of water quality levels can be known and investigated the sources of pollution occur in the study.

GIS is a computer system that is used to create maps and even an analysis tool that allows us to identify spatial relationships between feature on earth, save the map in the system for a particular geographical area, store geospatial data for specific purposes such as infrastructure construction, planning, development, environmental restoration and natural resource management (Abd Majeed 2010). Spatial data is usually stored as coordinates and topology, and data that can be mapped and frequently accessed, manipulated or analyzed through GIS (Malaysia Geoportal 2013). Space Data can also be classified into two physical state such as discrete data and continuous data (Nayan 2007). From the point of function, GIS is used for collecting, storing, converting or transforming and displaying spatial data (Shamsi 2005).

The objective of the current study is to identify the level of water pollution based on Water Quality Index (WQI) and

to analysis the water quality data by using the Geographical Information System (GIS) database.

MATERIALS AND METHODS

A total of 18 sampling stations at six drainage ditches were selected to be sampling points (Figure 1). The parameters investigated included Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solid (SS), Ammonia Nitrogen (AN) and pH according to APHA (2005). The water quality was evaluated based on Water Quality Index (WQI) as shown in Table 1.

$$WQI = (0.22\,SIDO) + (0.19 \times SIBOD) + (0.16 \times SICOD) + (0.15 \times SIAN) + (0.16 \times SISS) + (0.12 \times SIpH)$$

Where: SIDO is Sub index DO, SIBOD is Sub index BOD, SICOD is Sub index COD, SIAN is Sub index AN, SISS is Sub index SS and SIpH is Sub index pH.

GIS DATABASE

Two types of data included spatial data and attribute data were stored using GIS. The spatial data are these need to be converted from hard copy to soft copy such as map of Parit Raja, while the attribute data are that belong to the water quality. This process is essential to ensure that data is easily to be read by GIS software. The design of database consists of three different phases such as conceptual design, logical design and physical design. The purpose of development database is to demonstrate the uses of GIS software applications. The collected data from water quality test, design and build geographic database, create and manage GIS workspaces, data editing and compilation, design database and map the location for water quality, make query of water quality data and analysis water quality data were performed by using GIS.

In order to analysis the collected data, the geographical information was inserted into ArcMap and followed by the attributes data. The attribute data of DO, pH, BOD, COD, AN, SS, WQI and Status of Pollution were also inserted. The analysis of water quality data was conducted in the form of statistic presentation and attribute query analysis by using the GIS software. The attributes data in ArcMap were displayed in the form of statistic.

The analysis of water quality data was conducted in the form of statistic presentation and attribute query analysis by using the GIS software. The attributes data in ArcMap can be displayed in the form of statistic. First step is right click on the sampling stations layer > Open Attribute Data > right click on the column of DO > select Statistics. Figure 2 shows a result of statistic process. The query analysis was performed by the selection of attributes data. The selection was also known as Structured Query Language (SQL). The

TABLE 1. Water Quality Index (WQI)

Sub-index and Water Quality Index	Index Range		
	Clean	Slightly Polluted	Polluted
Biochemical Oxygen Demand (BOD)	91-100	80-90	0-79
Ammonia Nitrogen (AN)	92-100	71-91	0-70
Suspended Solid (SS)	76-100	70-75	0-69
Water Quality Index	81-100	60-80	0-59

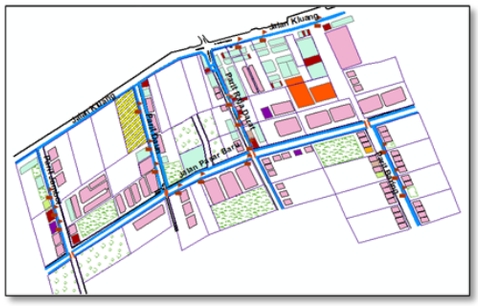

FIGURE 1. Spatial data map of Parit Raja
Source: The Water Quality is determining by the equation (DOE 2005)

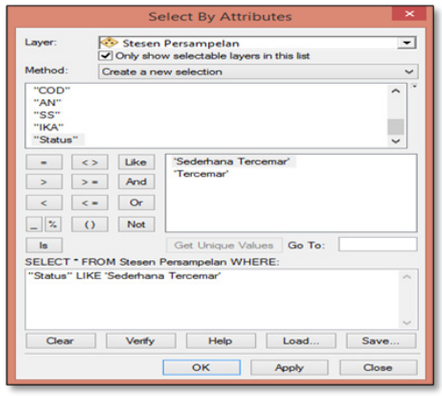

FIGURE 2. Dialog box for Select by Attributes

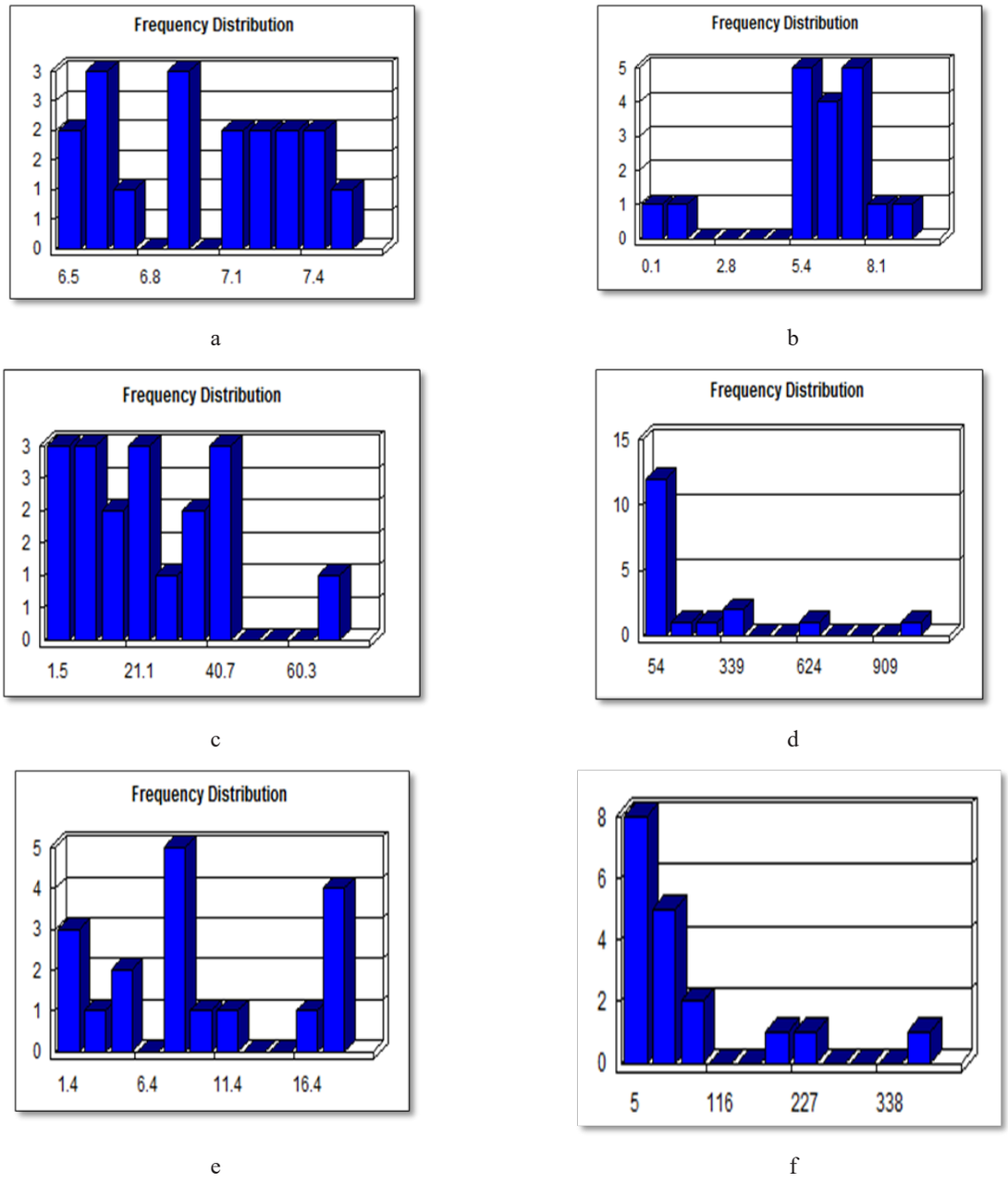

FIGURE 3. Water quality of samples from investigated study area; a) DO; b) pH; c) BOD; d) COD; e) AN; f) SS

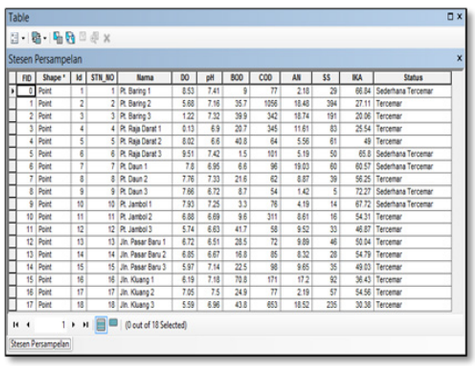

FIGURE 4. Attributes data of water quality

first step is click Selection in the main menu toolbars and click the Select by Attributes. The dialog box was displayed then the sampling stations for layer was selected to show the Status (Figure 2).

RESULTS AND DISCUSSIONS

The frequencies of DO, pH, Cod, BOD and AN as well as SS are presented in Figure 3.

The concentrations of DO ranged from 0.13 to 9.51 mg /L with 6.40 mg / L of the average (Figure 4). DO is inversely proportional to water temperature. The higher the temperature, the lower the concentration of DO. pH was between 6.51 and 7.50, the average was 7.02 which indicated that the water was in good condition and suitable for aquatic life. The minimum value of BOD was 1.5 mg / L, while the maximum value was 70.8 mg / L, the average was 24.8 mg / L. The difference among the values in the samples might be due to the concentrations of oxygen used by microorganisms to decompose the organic matter contained in the drainage. In comparison the COD was between 54 and 1056 mg/L with 211 mg / L of the average. These values indicated for the higher the content of organic in water and the higher the level of pollution.

The minimum content of AN was 1.42 mg / L, while the maximum was 3.19 mg / L, the average content was 9.95 mg / L. The high concentrations of ammonia are associated with low water quality. The highest concentrations of SS were 394 mg / L, while the lowest was 5 mg / L. The average was 81.56 mg/L. The higher content of SS indicates that the disposal of solid waste and domestic waste directly contributed to the suspended solids in drainage. The results in the current work showed that polluted drainage has the value of index range less than 59. Therefore, the analysis shows that the drainage of Parit Baring at station 2 and station 3, Parit Raja Darat at stations 4 and station 5, Parit Daun at 8 stations, Parit Jambul at station 11 and station 12, Jalan Pasar Baru at stations 13, station 14 and station 15 and Jalan Kluang at station 16, station 17 and station 18 are polluted. In comparison, the drainage ditch of Parit Baring at station 1, Parit Raja Darat at station 6, Parit Daun at station 7 and station 9 and Parit Jambol at station 10 are slightly polluted.

CONCLUSIONS

The design and develop a database of water quality around Parit Raja was achieved where the level of pollution on 18 sampling stations at study area shows that 13 stations were categorized as polluted, 5 stations classified as slightly polluted, while no stations are categorized as unpolluted. As conclusion, GIS is suitable and excellent tools that can help to combine information from various sources and to monitor the environmental management more easily and quickly on a big area. It is a really helpful tool for decision making procedure and information can also be delivered to the public with easier and faster.

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DECLARATION OF COMPETING INTEREST

None.

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