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Assessment and Mapping of Sulphate Concentration in the Drainage Along Taman Melewar, Parit Raja, Batu Pahat

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Abstract: Rapid industrialization and overpopulation have stimulated an increase in domestic and industrial wastewater, which increases the amount of sulphate discharge into the drainage systems and then affects the environment. The study was to identify the characteristic of drainage water along Taman Melewar. The laboratory testing was carried out based on selected parameters: pH, DO, TSS, turbidity, and sulphate. The application of spatial mapping using Surfer 16 software to identify the sulphate concentration. Water samples were collected from the drains during dry and after a rainy day at various points. The results for each parameter such as pH ranged 2.79 – 2.91; dissolved oxygen ranged 2.3 mg/L – 7.34 mg/L, turbidity ranged 4.31–6.5 NTU, total suspended solid ranged 5 mg/L – 30 mg/L and sulphate ranged 110 mg/L – 138 mg/L. The mapping of sulphate concentration for dry and wet conditions showed a different distribution pattern of sulphate along the water body. The location to be threatened by pollution was Station 4. An improvising recommendation of water quality is determined to execute the improvisation on the water quality management.

Keywords: Sulphate Mapping, Water Quality, Drainage Water

1. Introduction

Sulphate is one of the substances that contribute to water pollution as it can impact water quality. Nowadays, the uses of sulphate are varied in industrial production, such as liquid soap, detergent, and other commercial commodities used by humans for daily activities. Furthermore, sulphate is also commonly produced by various industries sectors such as petrochemical plants, tanneries, manufacturing of viscose radios, coal gasification for electricity or anaerobic treatment of wastewater as a waste product [1]. Sulphates are naturally occurring minerals where they usually discharged into water and commonly used commercially as additives for various industrial. Sulphate in wastewater is not a new or unusual thing to happen in any country. This sulphate substance has been found in almost every commercial product that humans use in their daily lives. The presence of sulphate is almost in all the substances in the atmosphere including air, food, soil and water [2]. Other than that, companies that make things like viscose radios or coal gasification for electricity and those that clean up sulphate waste

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make waste streams that contain sulphate [1]. According to Christian, sulphate production is influenced by rain water as it is produced by the chemical and condensation processes [3].

The flood seriously damaged Malaysia in 1971 across the country, and the necessity of efficient urban drainage was acknowledged [4]. Due to this situation, the Malaysia Department of Irrigation and Drainage is proactively implementing the new Storm Water Manual for Malaysia, known as the Storm Water Management Manual (MSMA). The importance of drainage is to prevent flood or excessive surface runoff even though it can control and minimize environmental pollution. Since sulphate is a primary dissolved ion, its mobility in the aquifer system is high. The manufacture of fertilizers, fungicides, algae control and insecticides, as well as glass to soap and detergent, the paper and wood pulp, medicine, hide-skin processing and water treatment, are widely employed for various sulphur-containing compounds [5] where this may lead to the production of sulphate once it is released into the water body as waste material or wastewater. This research study aims to identify the characteristic of drainage water according to the parameter that had been selected and develop the mapping of sulphate concentration distribution along the drainage using Surfer software.

2. Materials and Method

2.1 Selection of Study Area

The location of study area was at Taman Melewar in Parit Raja, Batu Pahat with coordinate 1°51’13” North and 103°06’01” East. A kilometer length of drains at Taman Melewar was selected for the present study and samples were collected along the drainage as shown in Figure 1.

Figure 1: The location of sampling stations

2.2 Sampling Procedure

The study was carried out from October to February. The samples were taken from the drain once a week within three weeks during this period. Thus, three times of experiments had done for each parameter had been selected. The first sample was taken on Thursday, 10/11/2021, in dry weather conditions, while the second was taken on Thursday, 17/11/2021 in the morning after a rainy day. Then the third sample was taken on Thursday, 24/11/2021, in dry weather. As a result, five drainage water samples have been collected at each station along the drainages. There were five stations located along the drainage. The samples were taken 10 cm deep from the surface using a 500 ml polyethylene bottle with labelling according to standard sampling procedures to ensure the integrity of the collected samples and validity of test results. The samples were then stored closely in a box and carried to the laboratory for analysis immediately after the sampling. After collection, all samples were transferred carefully to the Environmental Laboratory of Faculty Civil Engineering and Built Environment (FKAAB) of UTHM for further analysis.

2.3 Selection of Parameter

Each sample of the wastewater was tested for various parameters, as shown in Table 1. Some of these parameters like pH, turbidity, DO, TSS and sulphate were analyzed to test the water quality of these drains for irrigation. The results were compared with National Environmental Quality Standards (NEQS) for irrigation to establish a baseline condition of pollution levels in the drainage. Table 1 shows the apparatus used to analyze parameters in the water samples.

Table 1: Equipment used for the laboratory testing of drain water samples.

No	Parameter	Equipment
1	Acidic and Alkaline (pH)	pH meter
2	Turbidity	DR/4000 1 Inch Cell Adapter
3	Dissolved Oxygen (DO)	DO meter
4	Total Suspended Solids (TSS)	Filtration apparatus
5	Sulphate	DR6000 spectrophotometer

2.4 Sulphate Concentration Distribution Mapping

A spatial distribution map is an arrangement of phenomena across the Earth's surface. It can be used to summarize or highlight environmental data. In this study, spatial distribution mapping was applied for mapping the concentration of sulphate in the drain water along the drainage that has been selected. Surfer software version 16 was used for this study. From the result, decision-making in several areas, including engineering and environmental fields, has been done.

3. Results and Discussion

The result obtained from all the samples taken throughout the testing made and mapping of sulphate concentration in the drainage along Taman Melewar, Parit Raja was developed. All the results are based on selected parameters: temperature, turbidity, pH, total suspended solid (TSS), dissolved oxygen (DO), and sulphate. Each result from the water samples was analyzed, discussed and compared to the standard to achieve the objectives of this study.

3.1. Analysis of pH value of water sample

From all the sample results, the pH value for the water sample was ranged from 2.79 to 3.47. Based on Figure 2, the most acidic sample was sample 1, ranging from 2.79 to 2.91. Generally, each sample got the same value of pH for each station. This shows the pH value for water in this location is continuous. The pH of the drainage water shows the acidity influenced by the rainwater and others substances that come from the stormwater runoff. The rainwater that falls through the air would be neutral, which is the pH value is 7.0. However, as rain falls through the air, it dissolves carbon dioxide, causing acidic surface water runoff [6].

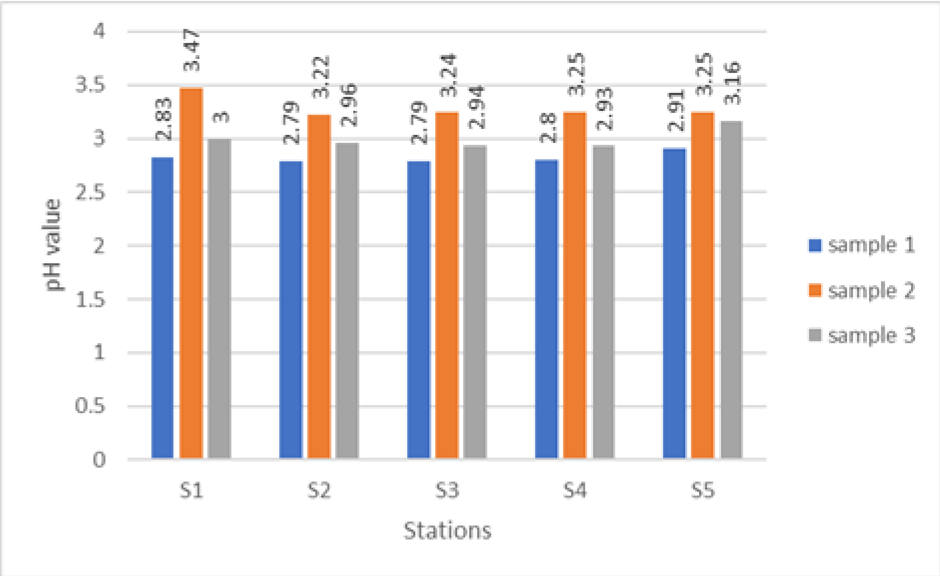

Figure 2: pH value chart for three sample at each station

3.2. Analysis of turbidity value of water sample

Based on Figure 3, the higher level of turbidity was in sample 2 at station 5 with a value of 43.21 NTU, while sample 3 at station 1 is the lower level of turbidity with a value of 6.5 NTU. Therefore, all the samples were categorized as untreated water as the turbidity value is higher than 5 NTU and lower than 1000 NTU. This means this type of water is acceptable in turbidity according to the recommended raw water quality standard [7].

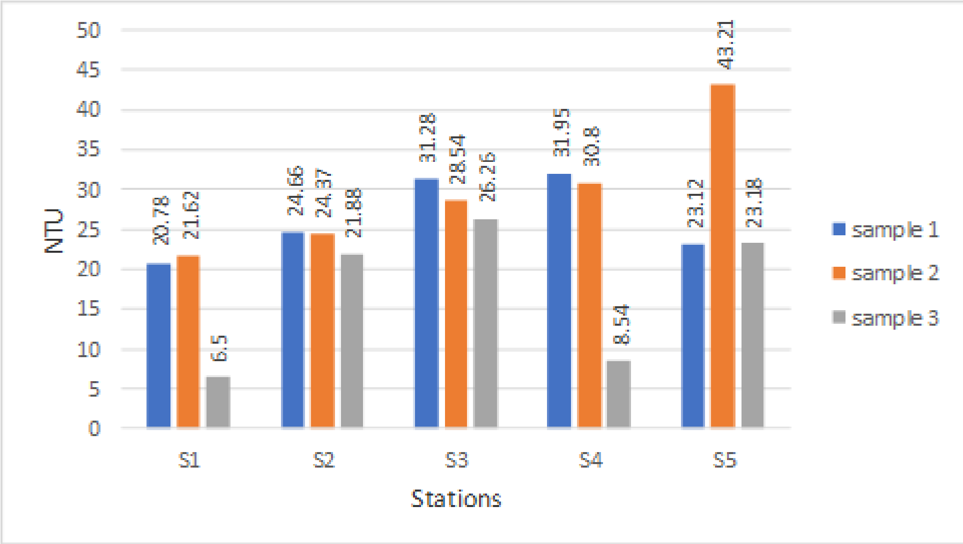

Figure 3: Turbidity value chart for three sample at each station

3.3. Analysis of DO value of water sample

Based on Figure 4, three samples of water were collected in three different weeks indicated as sample 1, sample 2 and sample 3. The water sample from station number 4 has the highest dissolved oxygen concentration value, which is 7.34 mg/L. At the same time, the lowest value of dissolved oxygen was in the water sample in station 1 for the third sample. This can be related to the higher temperature of the water, where reduced DO levels in stream water, maybe because the water is too warm. Because of organisms' respiration, plants' photosynthesis, atmospheric losses and gains, pressure and temperature variations, and groundwater influx, DO concentrations vary regionally and temporally [8]. However, fertiliser runoff from farms and lawns may be to blame for the low DO level. Using the same fertiliser that works for land plants now works for fish and other plants in the water. In addition, during a long period of cloud cover, respiring plants use up more DO than they use for photosynthesis, which leads to aquatic plants dying and an increase in the number of bacteria that use DO [9].

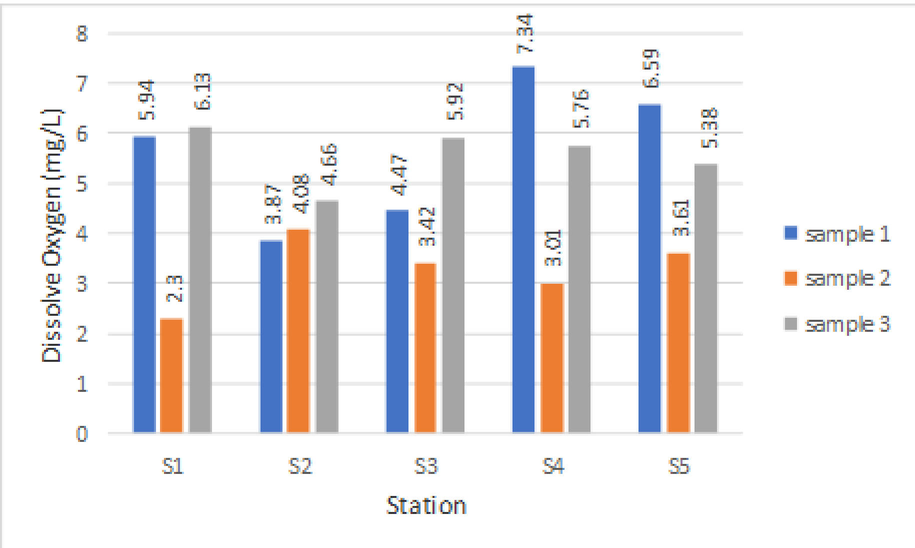

Figure 4: Turbidity value chart for three sample at each station

3.4 Analysis of TSS value of water sample

The TSS value for the drainage water samples are between 5 mg/L and 30 mg/L and it was exceeding the standard limit which is 150 mg/L for class III water [10]. Therefore, the water could be considered as "Fresh Water" because the value for TSS is less than 1000 mg/L [11]. Based on Figure 5. above, the TSS value is different from each sample: sample 1, sample 2 and sample 3. Sample 3 has a huge TSS value difference from other samples at every station except in station 1, where the value is constant. This might be affected by climate change. For example, before the sample was collected was a rainy day, and it caused the suspended material from the surrounding area to flow by surface water runoff into the drainage. The highest value for TSS value is from sample 2 at station 2 and sample 3 at station 5 with 30 mg/L, and the lowest value of TSS is from water samples 2 and 3 at station 5 and station 4, respectively.

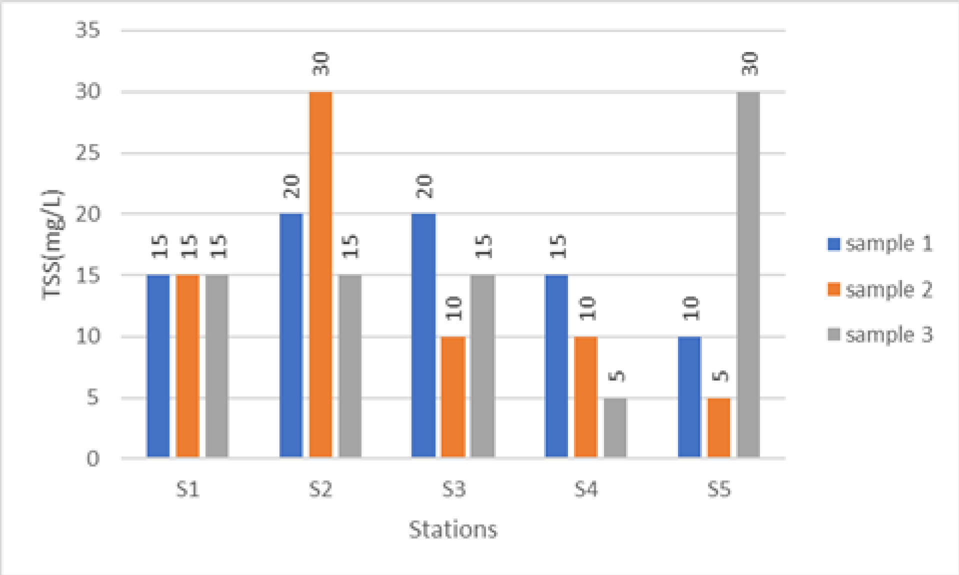

Figure 5: TSS value chart for three sample at each station

3.5 Mapping of Sulphate Concentration

However, based on the result obtained, there is no specific trend such as the increase or decrease trend and should have a difference in mapping since the sampling was done once a week within three weeks. The land use at the sampling station was divided into two zones. Station 1 and 2 were in agriculture and palm oil plantation zones, while the other stations were residential.

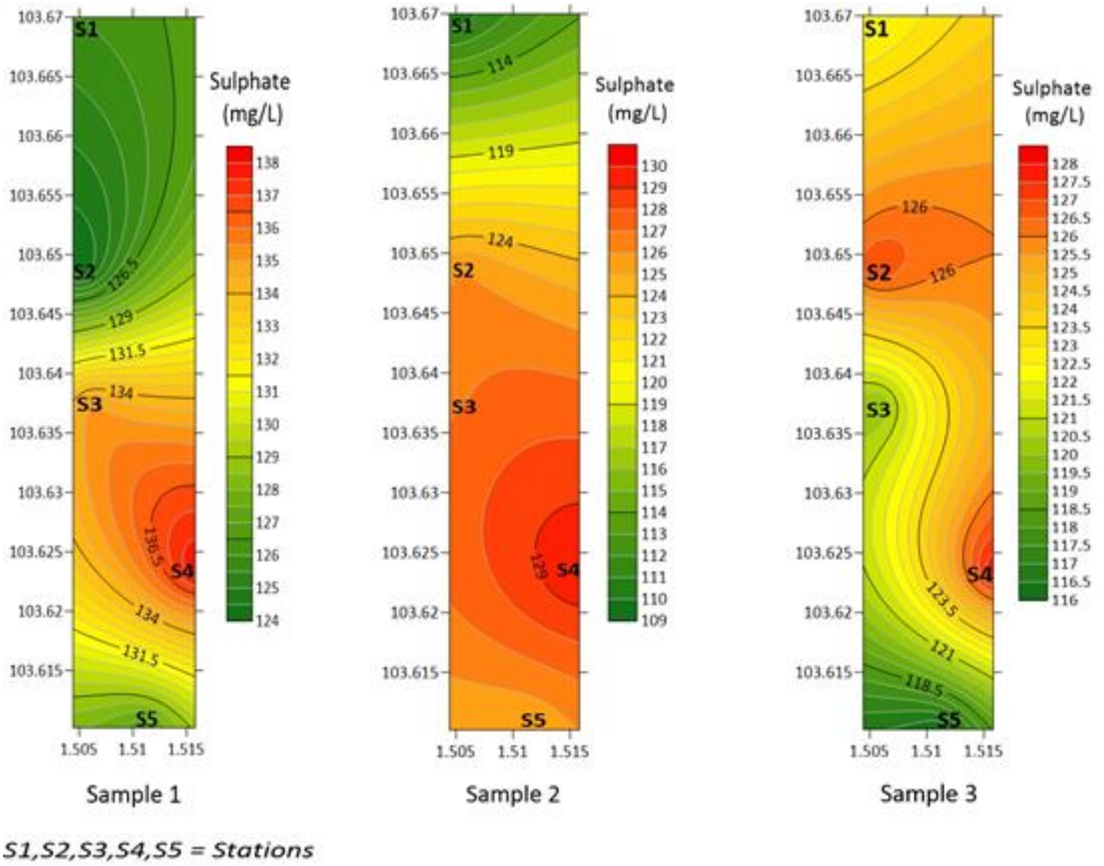

Figure 6: Contour mapping of sulphate concentration distribution along Taman Melewar Drainage

Figure 6 presents the contour illustration map of the sulphate concentration distribution maps for the selected drainage along Taman Melewar drainage. The result of the contour mapping shows that the residential area is more likely than the agricultural area to have sulphate-containing pollutants channeled into the drainage system. So for sample 1, the higher level of sulphate concentration was at station 4 with a value of 138 mg/L, located in the residential zone. In comparison, station 2 was the lower level of sulphate concentration with a value of 124 mg/L located in the agriculture zone. So for sample 2, the higher sulfate concentration level goes to the water sample at station 4, same as sample 1.

Meanwhile, station number 1 has the lower sulfate concentration value, which is 110 mg/L. The level of sulphate concentrations in water from the station in residential areas shows higher levels than farm areas because the use of sulphate in residential areas increases. For example, daily uses products or materials such as liquid soap, dishwashing soap, and detergent contain sulphate, which is in the form of a synthetic sulphate-based chemical such as sodium lauryl sulfate (SLS) and sodium laureth sulfate (SLES) [12].

For sample 3, the higher sulphate concentration was in station 4 and station 2, showing that palm oil plantation and residential areas have a high sulphate concentration. In these cases, stormwater runoff from agricultural lands was also a significant source of dispersed contamination. This is because the water level in the drainage increases during a rainy day, and most of the time, water from the surface flows into the drainage through the surface runoff. This situation causes the contaminants to drain from the land into the drainage. In addition, fertilizers may impact heavy metal accumulation in soil and plant systems, then fertilizers are absorbed by plants through the soil and can enter the food chain. As a result, fertiliser pollutes the water, soil, and air [13].

From the mapping of sulphate concentration that has been developing, there is a difference in the pattern of mapping between dry and wet days, indicating the distribution of sulphate in drainage. In dry conditions, the sulphate concentration does not distribute too much from its source, while in wet conditions, the sulphate distribution is widely distributed surrounding the primary source. This situation might be influenced by the movement of the water, in which the velocity of water during rainy days is higher than on a dry day.

4. Conclusion

In general, the results of experiments involving parameters such as pH, dissolve oxygen, turbidity, total suspended solid and sulphate indicate that these parameters have an effect on changes in water quality. The rate at which a feature on water changes occurs as a result of several factors, including the surrounding area, water movement, point and non-point sources of pollution. The rate of change of feature on water is affected by the surrounding area where the point source of the high concentration of sulphate roughly located at station 4 and 3 which these stations represent residential area. Based on the objective of this study, the characteristics of drainage water have been identified by the selected parameter but the result of the parameter not fully comply to the National Water Quality Standard of Malaysia as the total suspended solid level for drainage water exceed the allowance value. Besides, the mapping of sulphate concentration was very important in presenting very clear information through contour mapping to identify the value of sulphate concentration along the drainage.

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