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Mapping Spatial Distribution of Ammonia Nitrogen and Biochemical Oxygen Demand Along a New Road Construction Area

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Abstract: It is a fact that construction activities cause water quality problems. The word most commonly applies to oceans, rivers, and streams, but contains smaller bodies of water, such as ponds, wetlands, or more rarely, puddles. The secondary data were used in this study to analyse the water quality index and develop spatial distribution mapping of NH_3-N and BOD on new road construction areas by using software (Surfer 8.0). A total of seven sampling stations including WQ1 upstream and downstream stations were taken from previous project data in Sri Gading. The water quality in the stormwater varied spatially and focused parameters were NH_3-N and BOD. The results revealed that the highest concentration of NH_3-N was 2.2 mg/L at the WQ1 downstream station and while the lowest concentration was 0.1 mg/L was recorded at WQ2, WQ3 and WQ5 station. The highest concentration of BOD was 24.0 mg/L at WQ6 station, while the lowest concentrations were 2.0 mg/L at WQ2, WQ3 and WQ6 station. These concentrations exceeded the permissible limits of class II of the National Quality Water Standard. The pattern of the spatial distribution of NH_3-N and BOD concentration show higher density color at the upper and lower part of the stormwater because the location was near to the plantation and residential area. The findings also revealed the importance of assessment of mapping spatial distribution water quality for better insight on surface water.

Keywords: Spatial Distribution, Biochemical Oxygen Demand, Stormwater

1. Introduction

A water body is any substantial concentration of water, usually on the surface of the earth. The word most commonly applies to oceans, rivers, and streams, but contains smaller bodies of water, such as ponds, wetlands, or more rarely, puddles. The main source of water used for human use, cultural agriculture, and agricultural uses are the rivers. Efficient maintenance of these water supplies needs knowledge on the condition and variability of river water [1]. When contamination exceeds the

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threshold level, human activities pose an important threat to the water quality of rivers. In particular, urban activities are highlighted as one of the main sources of pollution in Asian countries by surface water bodies [2].

There are two sources, point, and non-point sources, of water contamination. Point sources inject contaminants at a certain site by inlets into surface water (landfills, hazardous waste), whereas nonpoint sources (acid rain, forestry, construction, and domestic pollutants) cannot be traced to a specific release [3]. Wetlands, ponds, reservoirs, streams, and rivers may cause substantial non-point source contamination from soil runoff from construction sites. Runoff at the construction site can accumulate 1-30 g/l of nitrogen and 0.2-10 g/l of phosphorus at medium flows, compared to 1-10 g/l of nitrogen and 0.2-2.2 g/l of phosphorus from impermeable surfaces from urban stormwater runoff. Therefore, due to unremitting growth, stormwater contamination is increasing [4].

For effective urban construction management, stormwater management systems are critical. Due largely to the interrelationship of the decision factors concerned, identifying the appropriate solution has always been a concern for decision-makers [5]. Stormwater runoff has been a significant cause of pollution from surface water. Based on past research, construction waste has been chosen to extract heavy metals from stormwater runoff as bioretention media. In the removal of pollutants from stormwater runoff, bioretention, a low-impact construction measure in urban stormwater management was effective [6].

The consequences of construction site degradation and stormwater runoff on water reception are sediments that fill waterways and destroy aquatic habitat, increased runoff levels and flooding rates, growth of algae from nutrient discharges, declining water quality, harmful heavy metal and organic pollution, changing water life to more pollutant resistant organisms and swimming [7]. According to Udo (2007), the chemical conditions of soils on which the water is flowing influence the consistency of the water used in the pond. Water quality is adversely impacted by inadequate management of supply pipes and an unsuitable drainage scheme.

The biochemical oxygen demand (BOD) and ammonia nitrogen (NH_3-N) is the most widely used criteria for water quality assessment. This parameter has been described as a significant pollutant that affects harmful environmental consequences, such as eutrophication, acidification, and climate change [8]. It is a significant harmful agent for fish and other marine species. It joins natural water bodies from a variety of causes, including toxic waste, sewage effluent, coal and liquefaction manufacturing facilities, and farm discharges, including feedlot runoff. It is also exposed to the closes associated with elevated pH and, to a smaller degree with low dissolved oxygen (DO) and higher water temperatures [9].

Spatial distribution analysis plays an important role in evaluating the pollution status in an aquatic environment since the contaminated sediments had great ecological impacts on wetlands. Also, the contour mapping of sediments is widely used to represent the abundance and distribution of various chemical substances. Prevention of pollution are needed for the conservation of biodiversity and the potential regeneration of the lake to reduce the volume of heavy metals in sediments generated by traffic pollution and delivered by the river [10].

This study aims to evaluate the water quality index (WQI) of water bodies nearest the new road construction area using secondary data. Also, to develop the spatial distribution mapping of ammonia nitrogen (NH_3-N) and biochemical oxygen demand (BOD) concentration along a new road by using Surfer 8.0 software. Thus, it showed that the reliability of the model findings was characterized by decision-making for future water management and spatial planning policymakers working in related contexts.

2. Materials and Methods

2.1 Location of the study area

The water quality monitoring has been conducted at the new road construction area from Kg. Rahmat crossing Sri Gading Estate, Batu Pahat, located approximately 10 km north of the Batu Pahat town. Land usage in the immediate area of the planned project consists primarily of palm oil and small-scale farmland. There are a recreational area and some residential areas in the vicinity of the proposed project. The environmental monitoring of river water quality was identified at the project site on a monthly or quarterly basis. Figure 1 shows a map of the sampling point. The sampling for environmental monitoring was conducted from January 2019 to December 2019.

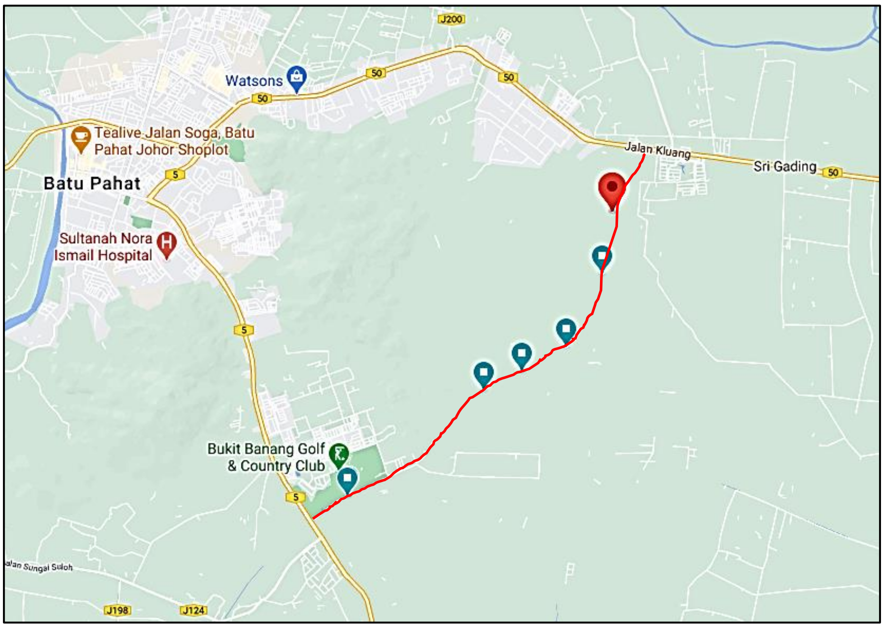

Figure 1: Location of the sampling point

Within the boundary of the project site, seven sampling point was identified that the stormwater from construction area flowing into water bodies. Therefore, water samples from selected sampling points are obtained monthly. Samples were taken at seven stations and the location is listed in Table 1 below.

Table 1: Sampling station and location

Sampling station	Location
WQ 1 Upstream	1°47'56.3"N 102°58'13.7"E
WQ 1 Downstream	1°47'55.6"N 102°58'13.3"E
WQ 2	1°48'57.0"N 102°59'33.1"E
WQ 3	1°49'08.4"N 102°59'55.1"E
WQ 4	1°49'22.7"N 103°00'21.2"E
WQ 5	1°50'05.2"N 103°00'42.2"E
WQ 6	1°50'41.3"N 103°00'48.1"E

2.2 Secondary data

Secondary data is data that is obtained and collected by another. These types of data sources are generally referred to as secondary sources. It refers to the whole process of collecting these types of data sources as secondary data collection [11]. Secondary data include water quality parameter such as pH, BOD, COD, TSS, DO and NH_3-N has been measured following the standard method procedures. The findings from the environmental sampling and observations during the field investigation were analyzed and documented monthly and compared to the guidelines adopted by DOE to assess the environmental quality trend in the area.

2.3 SURFER software

The main objective of this study is to create spatial distribution based on the parameter of NH_3-N and BOD of the work construction area. Surfer 8.0 is a contouring and 3D surface mapping software program that runs under Microsoft Windows. The Surfer software quickly and easily converts your data into outstanding contour, surface, wireframe, vector, image, shaded relief, and post maps.

Figure 2: Surfer 8.0 version

The free downloadable version of the Surfer 8.0 model software was installed to map the BOD and NH_3-N water quality parameters of the stormwater construction area. Kriging option was chosen in the model for scattered data interpolitan. As shown in Figure 3, the procedure used for making the maps is presented in a basic flow chart.

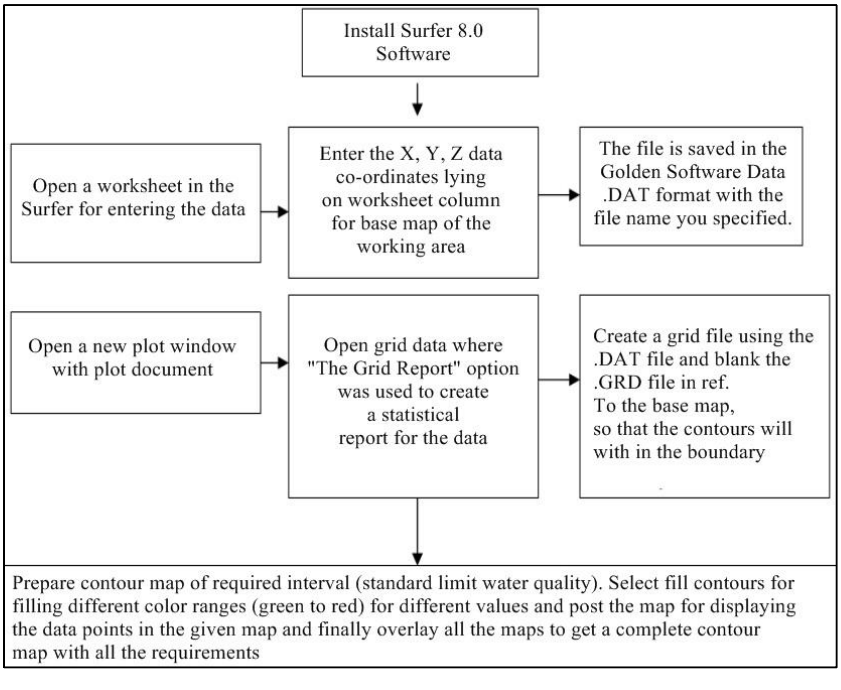

Figure 3: Step by step procedure of using Surfer 8.0 for mapping the water quality parameters

3. Results and Discussion

3.1 Concentration of BOD and NH_3-N

Figures 4 and 5 show the result of the parameters by using secondary data. From the result, the value of the water quality parameter has been tabulated in January, April, July and December in the year of 2019. The reason to choose those selected months of January, April, July and December in 2019 were because of the difference of the value in the early of construction work and during the construction work in the middle of the month. Also, the weather in Malaysia is characterized by two monsoon regimes, namely the southwest monsoon which occurs from May to September and the northeast monsoon which occurs from November to March [12]. The northeast monsoon season is also known as the "wet season". The weather in the southwest monsoon season is relatively drier [13].

BOD is an indicator of the organic water load and is a pollution index primarily for organic effluent water bodies [14]. As shown in Figure 4, the highest BOD value (24 mg/L) was measured in April 2019 at the WQ6 station (dry season) and the lowest (2.0 mg/L) was at WQ2, WQ3 and WQ6 in January (wet season). During the dry season, the metabolic activity of various aerobic and anaerobic micro-organisms increased at high temperatures, resulting in a significant drop in water levels. But the water diluted the organic matter during the wet season, which resulted in a decrease in BOD values [15]. This WQ6 station was located near to the plantation area which possibly contributed to pollution from fertilizers and pesticides. The INQWS threshold level of BOD for Malaysian surface water is 6 mg/L meaning that the BOD values of the study area were observed to be in the acceptable range [15].

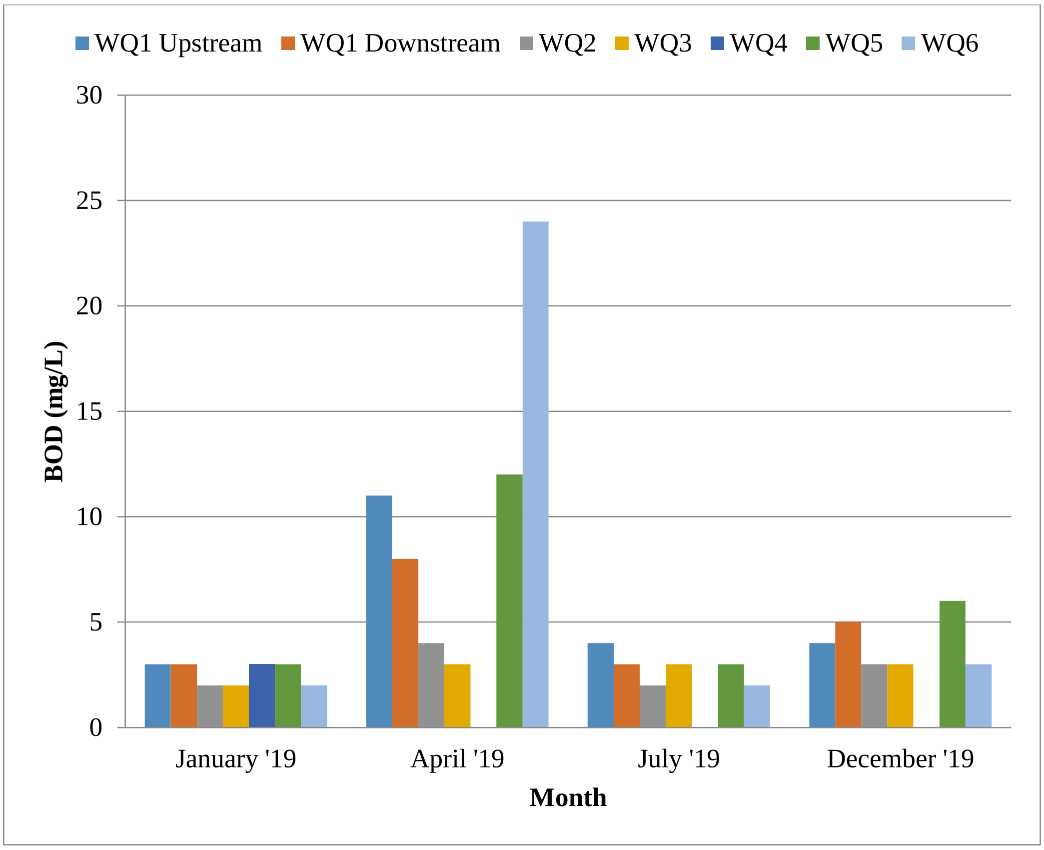

Figure 4: Monitoring data for BOD

As shown in Figure 5, the highest NH_3-N concentration (2.2 mg/L) was recorded at the WQ1 downstream station in July 2019 (dry season), while the lowest value (0.1 mg/L) was recorded in April (dry season) at WQ2, WQ3 and WQ5.

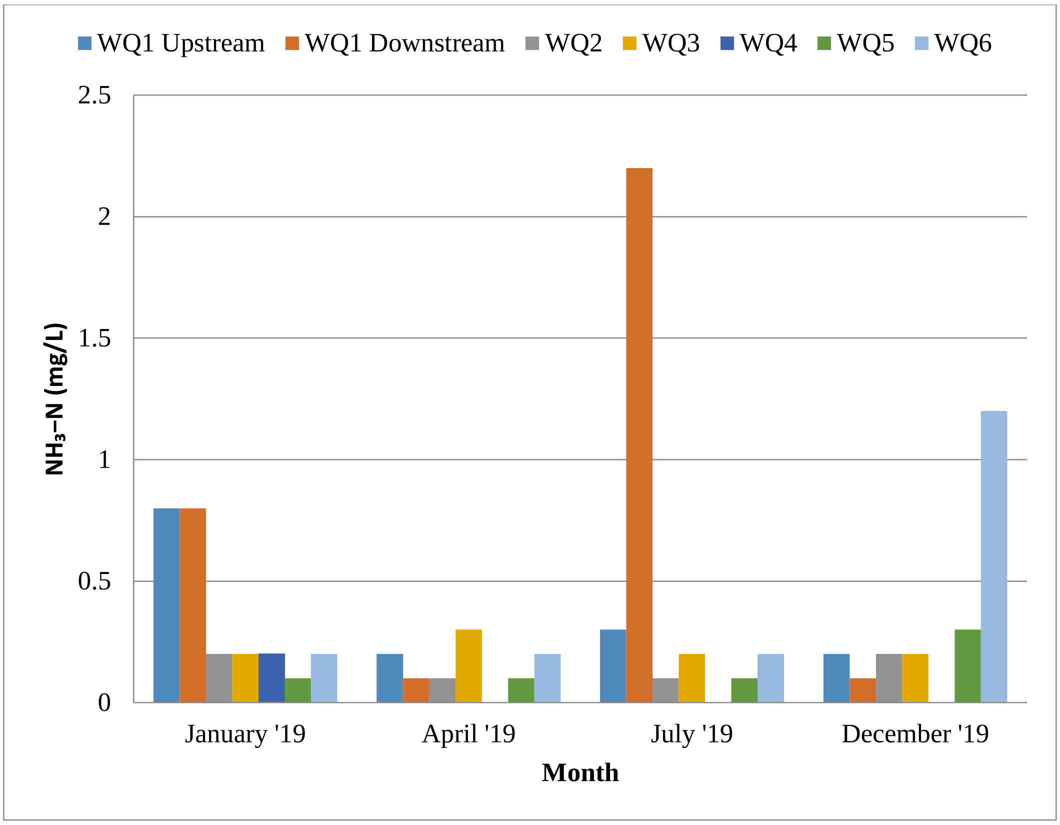

Figure 5: Monitoring data for NH_3-N

The INWQS maximum threshold level for NH_3-N in Malaysian surface water is 0.90 mg/L for it to be able to support aquatic life [15]. In any case, higher NH_3-N values could be harmful to fish, but they may act as nutrients for excessive algae growth at small concentrations.

3.2 Spatial distribution of BOD and NH_3-N

According to the obtained spatial distribution in Figure 6 and 7, the colors in the spatial distribution are the interval of classification of water on INQWS. From green to red color that brings to mean of Class I to Class V. Class I is green color, Class II and III are in yellow-orange, while Class IV and V are in red.

Overall findings as shown in Figure 6(a), spatial distribution BOD on January are in range color green to yellow, which is yellow are in WQ1 (lower part) and WQ6 (upper part) station, meanwhile green in the middle of the stormwater construction area. The pattern then changed to yellow to red in April as shown in Figure 6(b), the upper and lower of the stormwater are obviously in the red range, this WQ6 station was located near to the plantation area which possibly contributed to pollution from fertilizers and pesticides. High BOD is an indication of poor water quality. This was probably because of the direct flow of earth materials to the water body. Soil erosion and sediment load could not be controls during the construction road were happen.

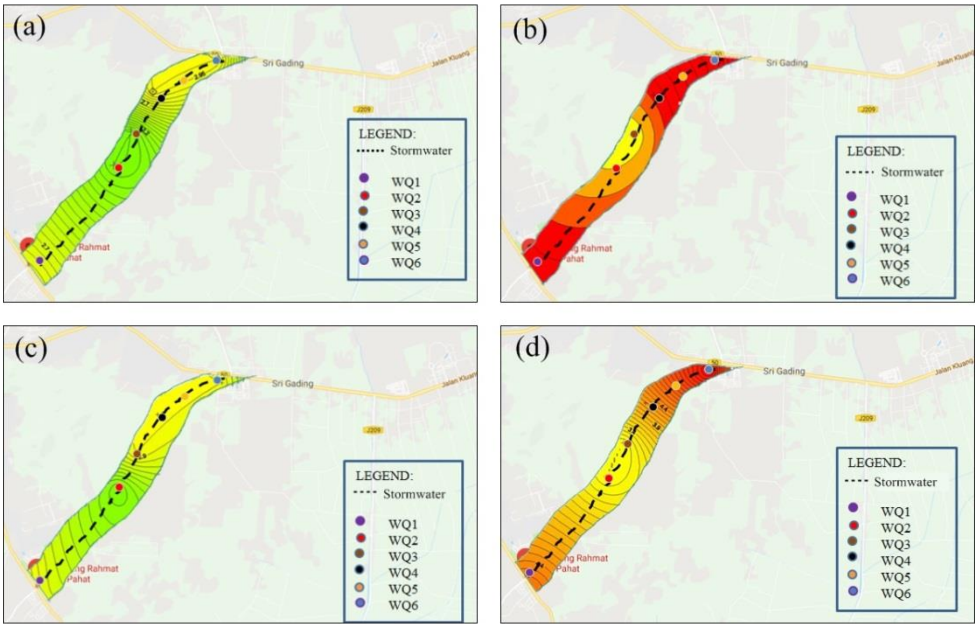

Figure 6: Spatial distribution of BOD (a) in January 2019; (b) in April 2019; (c) in July 2019; and (d) in December 2019

According to the obtained spatial distribution, the colors in the spatial distribution are the interval of classification of water based on INQWS. From green to red color that brings to mean of Class I to Class V. Class I is green color, Class II and III are in yellow-orange, while Class IV and V are in red.

NH_3-N is a nitrogen variable used as a measure for the assessment of water quality pollution. The highest NH_3-N value was 2.2 mg/L at the WQ1 downstream station in July. The INWQS maximum threshold level for NH_3-N in Malaysian surface water is 0.90 mg/L for it to be able to support aquatic life [15]. Overall findings as shown in Figure 7(c), spatial distribution NH_3-N on July are in range color of green to red, which is red are in WQ1 station (lower part) and WQ6 station (upper part) are in green color, meanwhile green-yellow color in the middle of the stormwater construction area.

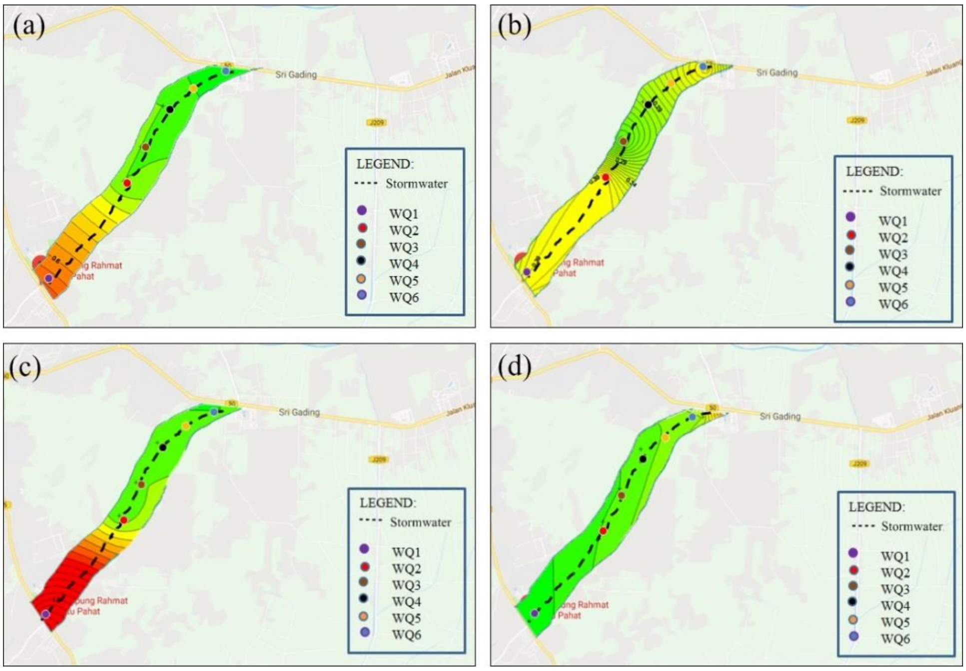

Figure 7: Spatial distibution of NH_3-N (a) January 2019; (b) in April 2019; (c) in July 2019; and (d) in December 2019

The station was located near to the plantation area which possibly contributed to pollution from fertilizers and pesticides. The red is means of higher NH_3-N pollution. It might be due to wastewater discharges from the residential area and golf course runoff. According to the monthly report, foul odor occurred during water sampling due to the presence of bacteria that come from food, soap or other materials from the residential area. The pattern then changed to green color in December.

4. Conclusion

Firstly, from the characteristic of the stormwater of the construction work area, it can be concluded that some of the parameters are still within the limit that has been used as a guideline for the water quality. Overall, the WQI of the stormwater was classified as Class II (slightly polluted) during the construction activities based on the table of Sub Index & Water Quality Index. A mapping of the stormwater of the construction work area was proposed to develop the spatial distribution of water quality (NH_3-N and BOD) concentration along a new road that has been determined by using Surfer software version 8.0. The result shows that the highest value for NH_3-N is 2.2 mg/L and for BOD is 24 mg/L, while the lowest value is 0.1 mg/L for NH_3-N and 2.0 mg/L for BOD. The findings also revealed the importance of assessment of mapping spatial distribution water quality for better insight on surface water quality, which can be provided extra information to environmental managers to make better choices on action plans. Based on the latest obtained information, it is recommended to use other software tools such as ArcGIS for a better comparison of spatial distribution mapping and for future study, biological parameters need to be studied together.

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