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Analysis of Ammonia and Copper Concentrations on Surface Runoff: A Study of Spatial Distribution at KM 14 – KM 15, Jalan Kluang

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Abstract: This study aimed to analyse ammonia (NH3) and copper (Cu) concentrations on surface runoff of spatial distribution at KM 14 – KM 15, Jalan Kluang. The purpose of this study was to investigate the water quality of the surface runoff at KM 14 – KM 15, Jalan Kluang and to develop the spatial distribution of ammonia and copper concentrations along the surface runoff at KM 14 – KM 15, Jalan Kluang. The focused parameter in this research study is copper (Cu) and ammonia (NH3). Other parameters such as pH, dissolved oxygen and temperature can also be measured runoff characterisitcs. The grab sampling technique was used in this study. Six sampling points were located, and 4-four consecutive weeks were conducted to run this study. This research study used an analytical method to process the data collection. Overall results indicate that the parameters of this study, such as temperature, dissolved oxygen, pH, ammonia (NH3) and copper (Cu), could affect the water quality. Based on the research study conducted, KM 14 – KM 15, Jalan Kluang runoff could be concluded that the water quality of parameters such as ammonia, copper, dissolved oxygen, pH and temperature are ranging between 0.03 – 17.05 mg/L, 0.09 – 0.44 mg/L, 3.31 – 5.92 mg/L, 5.12 – 7.34 mg/L, and 24.8 – 26.9 °C, respectively. All the data analyses were compared to the discharge effluent conditions of Standards B Environmental Quality Act (1974). The software for spatial distribution was determined by using Surfer 16 software. Spatial distribution mapping of copper (Cu) and ammonia (NH_3) has been developed to determine the most polluted area along the runoff at KM 14 – KM 15, Jalan Kluang. The spatial distribution contributes with high technique to determine the polluted area by inputting the longitude, latitude and the data value of each parameter each week. This research study enables the localisation of road runoff facilities and the determination of the highest and lowest concentrations of ammonia and copper pollutants across six different sampling locations, utilising data collection and producing contour mapping software.

Keywords: Ammonia, Analytical Method, Copper, Grab Sampling Technique, Road Runoff, Spatial Distribution Mapping

1. Introduction

Runoff is the interception and removal of water from, over, and under an area. Hence, highway runoff removes excess water from the road surface and subgrade. Historically, urban drainage systems have been viewed from various perspectives (Burian & Edwards, 2002). The main objective of a drainage system is to collect and remove waste matter systematically to maintain healthy conditions in a building. Analysis of ammonia and copper concentrations on surface runoff is used to investigate the spatial distribution of ammonia and copper concentrations along the surface runoff. This study was selected at several points to determine and improve the water quality level. Data collection requires measurement and oversight in the study field and investigating the laboratory parameters. This research analyses ammonia and copper concentrations on surface runoff: A study of spatial distribution at KM 14 to KM 15, Jalan Kluang.

The runoff along the road may contain insufficient water quality treatment because of toxicity from the untreated crucial parameters such as ammonia, copper, pH, dissolved oxygen and temperature. The parameters, mixed with other obstacles, solid waste or liquid, can contaminate the water quality along the road runoff. The road being focused in this research study is affected by various mixtures of water from the roadside and water from the organic agricultural field. The parameter for the road-side is copper, and the organic plantation field is ammonia. The soil activity brings bad water quality to the road and will affect other water quality when mixed in the road runoff.

Meanwhile, the road-side brings bad water quality from spilt unused liquid, dead plants, and road side damage (wrong chemical parameters). Thus, it is important to know the water quality treatment on the road of KM 14 to KM 15, Jalan Kluang, which is exposed to many living things like humans, plants and animals. The surface runoff at KM 14 to KM 15,

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resulting from agricultural and vehicular activities, has exhibited an alarming increase in ammonia and copper concentrations. This concerning trend poses a significant threat to local ecosystems and public health.

Ammonia is crucial in sustaining life and the global chemical economy with, an annual production exceeding 200 million tons (Andersen et al., 2019). In order to manage rainwater runoff, avoid flooding, and preserve the structural integrity of road infrastructure, road drainage systems are essential. However, pollutants in road drainage water can potentially negatively impact the ecosystem and the general public's health. Reported sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources (Tchounwou et al., 2012).

Ammonia and copper are two contaminants of particular concern because of their potential toxicity and frequent prevalence in metropolitan areas. The quality of road runoff water can be influenced by various factors, such as the chemical composition of the runoff, the sensitivity of the receiving ecosystem, and the presence of pollutants from sources like tire wear, dust suppressants, de-icing salts, and metals (Gillis et al., 2022). Heavy metals such as zinc, copper and iron are commonly released from vehicle wear and tear and accumulate in roadside soils (McKenzie et al., 2009). When a road, driveway or other paved surface is inside or close to an agricultural field, the runoff water that flows from those surfaces may contain copper. This is known as copper in road runoff in agricultural areas. Agriculture is not only a source of emerging pollutants; it also contributes to spreading and reintroducing such pollutants into aquatic. environments through wastewater reuse for irrigation and applying municipal biosolids to land as fertilizers (Sagasta et al., 2018).

This study is carried out to investigate the water quality of the surface runoff at KM 14 to KM 15, Jalan Kluang and to develop the spatial distribution of ammonia and copper concentration along the surface runoff at KM 14 to KM 15, Jalan Kluang. Furthermore, examining the distribution points of copper and ammonia at KM 14 – KM 15, Jalan Kluang, is important. This can be illustrated using a distribution map generated by the Surfer 16 software. Therefore, this data could be useful as reference information that a researcher applies to propose alternatives for the problem.

2. Materials and Method

2.1 Study area

KM 14 – KM 15, Jalan Kluang, located at Sri Gading, Batu Pahat, was selected for this research assessment. The connection area between KM 14 – and KM 15, Jalan Kluang is Batu Pahat and Ayer Hitam, which has led to heavy traffic. Point sources of the site area came from the agricultural farmland and road runoff that contributes to ammonia (NH3) and copper (Cu) pollution in KM 14 – KM 15, Jalan Kluang runoff before discharging to the next area. As indicated in Fig 1, six sites along the KM 14 – KM 15, Jalan Kluang runoff will have water samples taken from the site area. The description of the six sampling locations is shown in Table 1.

Table 1 – The sampling area with geographical coordinates along KM 14 – KM 15, Jalan Kluang road runoff

Stations	Latitude (In⁰)	Longitude (In⁰)
S1	1.5112822	103.156210
S2	1.5111802	103.202090
S3	1.5111052	103.207170
S4	1.5110230	103.213650
S5	1.5109318	103.219720
S6	1.5108082	103.228040

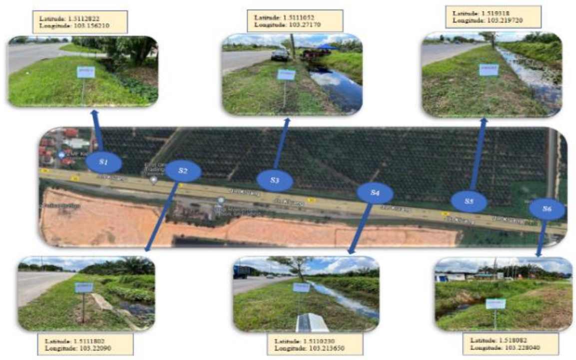


Fig. 1 – Sampling points location along road runoff at KM 14 – KM 15, Jalan Kluang

2.2 Grab Sampling Technique

Grab sampling collects a single fluid sample from a pipeline, runoff, drainage or system for laboratory analysis. The specific objectives of the research, as well as the relevant variables, may have an impact on the water and sediment sample collection techniques. Grab sampling is the most used sampling approach. With this technique, a single sample of sediment or water is directly collected at a specific location and time. Grab sampling is a simple and efficient method for obtaining a high-quality water or sediment composition representative.

With this grab sampling technique, the type of bottle used is a PE bottle with 500ml. The sample will be conducted once a week. The total week is 4-four weeks consecutive in conducting this experiment. Thus, four sampling techniques were used in this project. The total PE bottle used in this project is 6 per week for ammonia and copper concentration levels. This is because six sampling point that needed to be conducted. There are six stations (S1 – S6) with 12 sampling data (2 sampling each station for ammonia and copper concentrations) for one week. The total week for this research study is four weeks.

2.3 Analytical Method

Standard procedures were followed when conducting the methods for each parameter. The American Public Health Association recommended procedures for testing of water and wastewater were followed in all analyses of water quality samples (APHA, 2012). The pollutant removal efficiency was assessed by examining various influent and effluent water quality parameters: pH, dissolved oxygen, temperature, copper (Cu), and ammonia (NH_3). The average reading would be taken, and duplicate experiments would be carried out. Table 2 shows the equipment and method used in the laboratory to assess the level of contamination of the parameters.

Table 2 – The methods and instruments for analytical method

Parameter	Method	Instrument
pH	Method 4500-H-B	HQ430D Multi-parameter meter
DO	Method 4500	HQ430D Multi-parameter meter
Temp (ºC)	Method 2550	HQ430D Multi-parameter meter
Ammonia	Nessler Method	HACH DR6000
Copper	Bicinchoninate Method	HACH DR6000

2.4 Statistical Analysis for Spatial Distribution Mapping

To develop spatial distribution mapping at KM 14 to KM 15, Jalan Kluang, Surfer 16 software will be conducted. Using this software, the result of spatial distribution analysis can be obtained. The result shows a hotspot area concentration of ammonia (NH3) and copper (Cu). Using the Kriging method, the data was well presented in tables, maps, and figures after analysing using Surfer 16 software. The software will be able to present the pattern of copper (Cu) and ammonia (NH3) along the surface runoff. For each sampling data, the coordinate of the locations and the data obtained from the laboratory were used to produce contour mapping. Spatial distribution is chosen for contour mapping on surface runoff concentrations because it is possible to visualise the distribution of the phenomenon across a surface. Contour maps provide insightful information, and are suitable for interpreting the spatial pattern of mapping using Surfer 16 software.

3. Result and Discussion

3.1 Characteristics of Runoff along KM 14 – KM 15, Jalan Kluang

The water quality of road runoff, including temperature, pH, dissolved oxygen, ammonia and copper, was examined and compared with the discharge effluent conditions of Standards B Environmental Quality Act (1974). In order to achieve the objectives of this study, all samples were tested, and the results were analysed. Table 3 shows the average value of water quality on surface runoff of the parameter involved. All the samples comply with the recommended discharge effluent conditions of Standards B, as shown in Table 4.

Table 3 – Water quality of parameter involved along the surface runoff KM 14 – KM 15, Jalan Kluang

Parameter	S1	S2	S3	S4	S5	S6
pH	5.13 – 7.34	5.13 – 7.33	5.12 – 7.32	5.12 – 7.3	5.12 – 7.3	5.15 – 7.3
DO (mg/L)	4.28 – 5.67	3.59 – 5.38	3.31 – 5.76	3.78 – 4.79	4.54 – 5.43	3.51– 5.92
Temp (ºC)	24.8 – 26.5	25.2 – 26.6	25.6 – 26.6	24.9 – 26.7	25.5 – 26.6	25.5– 26.9
Ammonia (mg/L)	8.98 – 17.05	0.6 – 3.06	0.12 – 2.88	0.03 – 0.68	0.1 – 0.62	0.04– 0.64
Copper (mg/L)	0.09 – 0.21	0.17 – 0.2	0.26 – 0.44	0.23 – 0.3	0.22 – 0.29	0.21– 0.28

Table 4 – Comparison To The Discharge Effluent Conditions Of Standards B Environmental Quality Act (1974)

Parameter	Min	Max	Ave	Standard B Effluent
pH	5.12	7.34	6.23	5.5 – 9
DO (mg/L)	3.31	5.92	4.62	N/A
Temp (ºC)	24.8	26.9	25.85	40
Ammonia (mg/L)	0.03	17.05	8.54	5
Copper (mg/L)	0.09	0.44	0.27	1.0

3.2 Relationship Between Concentrations of Water Quality Parameters and Weeks Sampling

The pH value for each week's sampling is displayed at six different sampling locations. The histogram indicates that all pH values are is in range of Standards B Environmental Quality Act (1974). The highest recorded pH across all weeks and stations is 7.34 at station 6 in week 3, and the lowest recorded pH is 5.12 at station 1 in week 4. The pH values vary noticeably over the weeks, with certain stations routinely recording pH levels that are higher or lower than others. The standard pH scale, which ranges from 0 to 14, with 7 representing neutrality, determines how basic or acidic a chemical is. A pH of less than 7 indicates acidity, and baseness is indicated by a pH greater than 7. Certain stations frequently have higher or lower pH levels than others. The fluctuations may be a sign of various variables that affect the acidity of the water at different times and places.

The DO concentrations for 4-four consecutive weeks are above 3 mg/L. The highest recorded DO concentration across all weeks and stations was 5.92 mg/L at station 6 in week 2, and the lowest recorded DO concentration was 3.31 mg/L at station 3 in week 1. Some studies have indicated that road runoff, especially in urban areas, can lead to low dissolved oxygen levels due to high heavy metals and other pollutants (Bozorg-Haddad, 2021).

The findings indicate that the concentration of copper in this study was less then effluent conditions of Standards B. At station 3 in week 1, the highest concentration of copper ever measured over all weeks and stations was 0.44 mg/L. In week 3, station 1 reported the lowest copper content of 0.09 mg/L. Variations in copper concentrations between weeks and stations indicate that copper levels are not constant. High copper concentrations can affect marine organisms' metabolic processes (Leal et al., 2018).

The highest recorded ammonia concentration across all weeks and stations was 17.05 mg/L at station 1 in week 3, and the lowest recorded ammonia concentration was 0.03 mg/L at station 4 in week 1. Ammonia levels fluctuate, as seen by the large variety in ammonia concentrations between the weeks and stations. In short, ammonia contents vary greatly between stations and weeks, with station 1 continuously recording higher values. Ammonia concentrations should be closely monitored since they can negatively affect the environment, especially aquatic ecosystems. If the ammonia value is high in the road runoff, it can harm aquatic life. The concentration of ammonia in road runoff can be influenced by rainfall intensity, with higher intensities leading to higher levels of ammonia (Ni et al., 2019).

The highest recorded temperature across all weeks and stations is 26.9°C at Station 6 in Week 4, and the lowest recorded temperature is 24.8°C at Station 1 in Week 2. The water temperatures vary across stations and weeks, with the highest and lowest temperatures changing throughout the four weeks. Increased air and water temperatures are also likely to affect the survival of waterborne pathogens (Coffey et al., 2019). One element that affects how different plant species in drainage systems absorb pollutants is temperature. When the water is excessively hot, the temperature may impact fish immunity. Fig 2 shows the distribution of values for the parameters mentioned above along the surface runoff.

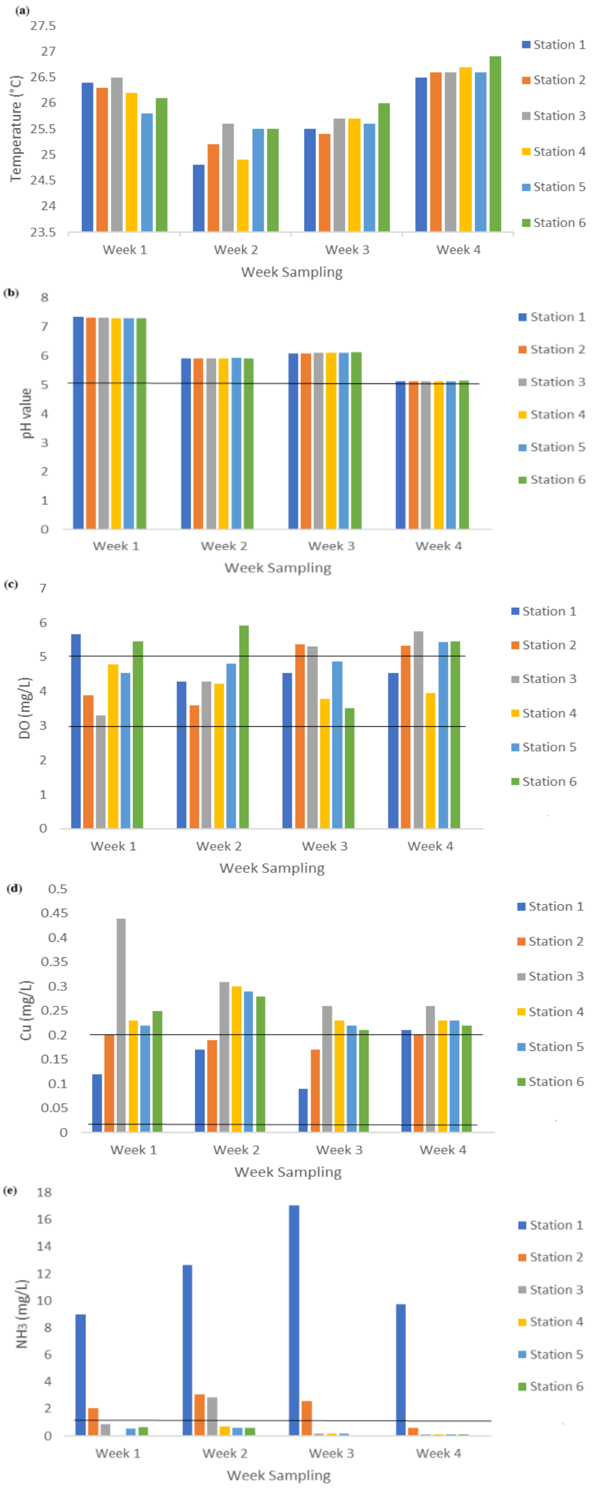


Fig. 2 – Distribution of values for (a) temperature; (b) pH; (c) dissolved oxygen (d) copper and (e) ammonia on surface runoff from 6 sampling points in 4 weeks consecutive

3.3 Spatial Distribution Mapping of Ammonia and Copper

Based on the contour diagram of copper concentration, the pattern of the contour map from week 1 to week 4 has changed significantly. Station 1 for weeks 1 and 2 looks similar to week 4 station 1. The blue colour in the contour mapping represents the highest concentration of copper; meanwhile, the light green colour in the contour mapping represents the lowest copper concentration. Various factors, such as mining activities, geological factors, and pollution, can influence the spatial distribution mapping of copper concentrations. Different techniques, such as Kriging interpolation maps, were used to examine the copper concentrations contour mapping. Kriging interpolation maps were employed in a study on the spatial distribution characteristics of copper in a typical mining location to reflect the considerable spatial distribution of copper, which was influenced by geological and pollution variables (Hua et al., 2013). The concentrations of copper present in road runoff might differ based on various circumstances, including the materials used for the road, the presence of copper roofs, and the land usage surrounding it. Fig 3 shows the concentration maps of copper on surface runoff.

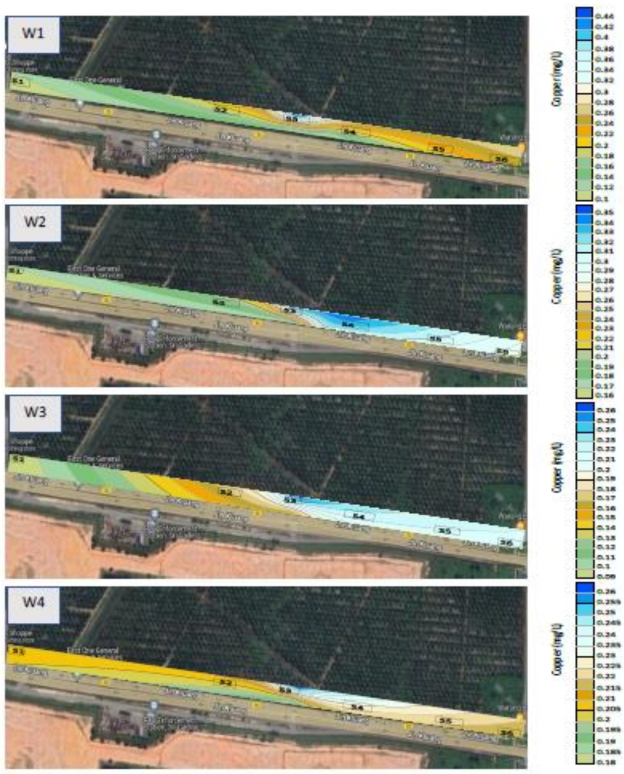
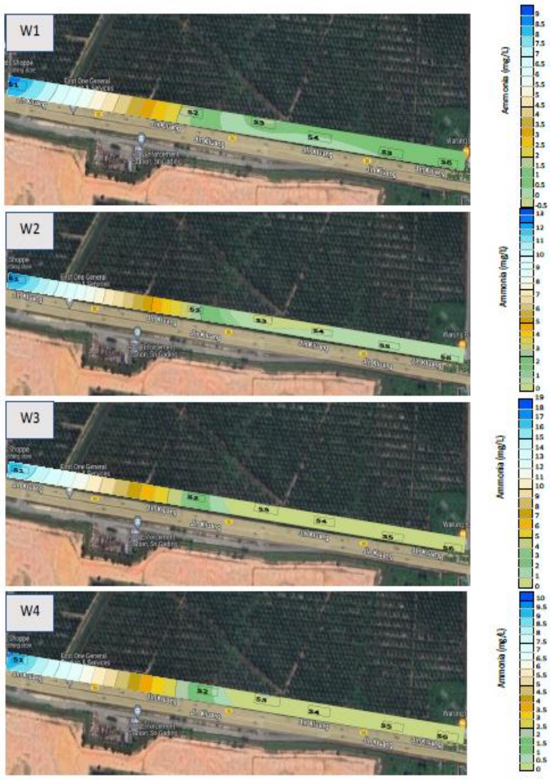


Fig 3 - The copper concentration spatial distribution mappping

Based on the contour diagram of ammonia concentration in Fig.4, the pattern of the contour map from week 1 to week 4 changed slightly from these various colours. Blue in the contour mapping represents the highest peak of ammonia concentration; meanwhile, the light green colour in the contour mapping represents the lowest value in ammonia concentrations. The ammonia concentrations were released from agricultural farmland areas. The sources of ammonia can be determined using fertilisers in nearby areas and vehicle emissions. A mathematical model of ammonia nitrogen transport from soil to runoff on irregular slopes was developed to understand the transport processes in such environments better (Xing et al., 2023). High ammonia concentrations can affect aquatic life and pose risks to human health, especially if drinking water are affected by the runoff. Emission inventories and chemical transport models have been used to study agricultural emissions, contributing to ammonia pollution (Ge et al., 2020).



In conclusion, the spatial distribution mapping of ammonia concentrations in road runoff gives important insights into the trends and causes of ammonia pollution. This helps guide methods for environmental management and pollution control. Fig 4 shows the contour diagram of the spatial distribution maps for ammonia concentration along the surface runoff at KM 14 – KM 15, Jalan Kluang.

4. Conclusion

The first objective was to investigate the water quality of the surface runoff at KM 14 – KM 15, Jalan Kluang. Overall results indicate that the parameters of this study, such as temperature, dissolved oxygen, pH, ammonia and copper could affect the water quality. Based on the research study conducted, KM 14 – KM 15, Jalan Kluang runoff could be concluded that the water quality of this runoff for parameter ammonia, copper, dissolved oxygen, pH and temperature ranges between 0.03 – 17.05 mg/L, 0.09 – 0.44 mg/L, 3.31 – 5.92 mg/L, 5.12 – 7.34 mg/L, and 24.8 – 26.9 °C respectively. The focused parameters in this research are copper and ammonia. The concentration of copper in this finding, is above the Class II limit in the National Water Quality Standards for Malaysia, NWQS. The concentration of ammonia in this finding, for four consecutive weeks, station 1 and station 2 exceeded the limit of the discharge effluent conditions of Standards B Environmental Quality Act (1974), with high-level concentrations to be compared with station 3, station 4, station 5, and station 6. In order to determine which section of the runoff area had the highest concentration of ammonia and copper on the surface runoff, a spatial distribution mapping was generated using the Surfer 16 software. In conclusion, using the Surfer 16 software to map the water quality of road runoff at KM 14–KM 15, Jalan Kluang area, is helps understand the concentration levels of various parameters.

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