RESEARCH ARTICLE

Nitrate Analysis of Sungai Ulung in Cameron Highlands, Malaysia

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Abstract:

Excessive fertiliser application in agricultural activities, can be washed into the streams and decline the water quality. Nitrate from fertiliser may increase the oxidising activity especially chemical oxygen demand (COD) and also affect the quality of the river. This research aims to determine the relationship between nitrate concentration with COD, Ammoniacal Nitrogen (AN), temperature, Dissolved Oxygen (DO) and pH of a stream flows within the vegetable farm area. This study used a cross-sectional study design and water samples were collected at seven sampling points of Sungai Ulung in Cameron Highland, Malaysia. The concentration for nitrate, AN and COD at downstream was higher than those in the upstream. The results indicated a positive correlation, where an increase in nitrate concentration corresponded with an increase in COD ($r = 0.865^*$, $p = 0.012$), AN ($r = 0.753$, $p = 0.051$), and temperature ($r = 0.847^*$, $p = 0.016$), which can be attributed to the oxygen-dependent decomposition process. Conversely, there were negative correlations, as an increase in nitrate concentration was inversely related to DO ($r = -0.775$, $p = 0.041$) and pH value ($r = -0.126$, $p = 0.788$), likely due to the reduction of oxygen in water during nitrate decomposition. The degradation river quality of Sungai Ulung was probably due to the agricultural activity near the river. Farmers can practice Best Management Practices (BMPs) for their crop to reduce the chance of nutrient losses to the impaired water bodies.

Keywords: COD, Nitrate, relationship, vegetable farm, water quality.

1. INTRODUCTION

Streams are freshwater bodies that keeps the natural and human systems alive. As a small stream flows downhill, it will feed into a larger stream or river and merge to form many tributaries, which will then end up in the ocean. The upper streams usually are clean and safe compared to the lowland. However, pollutants from anthropogenic activities near tributaries is often creating pollution of the mainstream since the tributaries from upstream to downstream carry all the runoff and pollution.

Agriculutural activity accounts for 70% of total water usage worldwide and has become the single-largest cause of non-point-source pollution to surface water and groundwater (Sagasta et al., 2017). This diffuse pollution pose a major problem to sustainability of rivers since it contains various pollutants and the control measures also is hard and costly (USEPA, 2015). Review research on land use's impact on water quality in Malaysia conducted by Camara, Jamil and Abdullah (2019) found that agricultural and forest-related activities show a significant positive relationship to become the main factor that causes physical and chemical changes in the river water quality.

There are three essential plant nutrients in fertilizer include nitrogen (N), phosphorus (P), and potassium (K). Among these nutrients, N is an essential nutrient needed for the production of amino acids that could help the development of plants. Nitrogen applied in fertilizer cannot be taken up directly by the plants. It needs to undergo the process of nitrification by bacteria, which converts nitrogen into nitrate (Dave, 2013 ; Xu et al., 2022). This nitrogen ion is highly leachable and easily wash away into stream water through runoff.

Study found that there are not more than 50% of the nitrogen from fertilisers is used by crops, while others are lost and washed out of the soil and end up in waterways (Bijay-Singh & Craswell, 2021). The excessive use of organo-fertilizers in agricultural activities possible to caused nutrient enrichment in freshwater ecosystems, mainly due to the discharge of nitrogen and phosphorus effluent from the crop (UNEP, 2016). High nutrients in the stream can lead to the water being unable for drinking water purposes and lead to the occurrence of eutrophication (USGS, 2019).

In conjuction with that, recent study done in Cameron Highland found that higher concentrations of nutrients parameter, including total nitrogen (TN), nitrogen-nitrate

(NO_3-N), total phosphorous (TP), and phosphate phosphorous (PO_4-P) in the downstream river catchment within the agricultural area were generally affected by the agricultural runoff. This phenomenon of nutrients runoff from agriculture into surface water may increase the organic loading and affect the river quality (Camara, Jamil & Abdullah, 2019).

Chemical oxygen demand (COD) is an important indicator in assessing water quality as it represents the level of biodegradability. Higher level of COD indicates greater oxidizable organic materials or organic pollutants in the water sample (Ashitha, Rakhimol & Mathew, 2021). In addition, this condition also indicates lower dissolve oxygen (DO) concentration present in the water as many oxygens are used to oxidize the pollutant and organic material.

Nutrient runoff into water bodies may stimulate alga growth, produce excess organic matter, and reduce the concentration of dissolved oxygen (DO) that leads to hypoxia in water bodies (Prambudy, Supriyatin & Setiawan, 2019). Organic matter uses dissolved oxygen in the water as it degrades, which in turn increases the COD values. Thus, the aim of this study is to assess the present status of nitrate in Sungai Ulung as well as its association with water quality parameters.

2. MATERIALS AND METHODS

Study design and data collection

Cameron Highlands is considered a highland area, located in the western part of Pahang state. This district's dynamic topography is crucial for Malaysia's economic development since it supports agriculture activities (i.e., tea plantation and vegetable cultivation) and eco-tourism (Wato & Amare., 2020). Cameron Highlands is divided into three main subdistricts: Hulu Telom, Ringlet and Tanah Rata. This study was carried out in Habu, Ringlet because of its engagement in farming, especially the production of tea and vegetables. Vegetables that have been mostly planted in this agricultural area such as watercress, cabbage, tomatoes, spring onion, carrots, corn, green beans and some areas grown for flowers.

In the agricultural area, there is a stream identified as Sungai Ulung that flows from the tea plantation area upstream to the vegetable farm parts before it reaches the Sungai Bertam stream downstream. It will subsequently flow into the Ringlet reservoir of the Sultan Abu Bakar Dam, which is used only for hydropower and controlling flooding (Razali et al., 2018). According to Jabatan Pengairan dan Saliran Cameron Highlands and Sidek & Luis (2014), the length of the Sungai Ulung is 4.5 km and has about 5.0 m for the width.

A total of 14 grab water samples were collected from the seven (7) different sampling points along Sungai Ulung as shown in Figure 1. The coordinates for each sampling points were described in Table 1. Surface water temperature, dissolved oxygen (DO) and pH were measured using portable HI 9146 Dissolved Oxygen & Temperature Meter and WinLab pH-meter. For chemical oxygen demand (COD), ammoniacal nitrogen and nitrate analysis, 1000 mL of surface water samples were collected in pre-cleaned amber glass bottles. In the laboratory, the samples were filtered using Whatman filter paper No. 42 and analyzed using the standard methods (APHA, 2012).

Figure 1. Location of water sampling points

Table 1. Coordinates for each sampling points

Sampling Points	Latitude	Longitude
SP 1 (upstream)	4°27'06.1"N	101°24'32.3"E
SP 2 (upstream)	4°27'11.3"N	101°24'19.7"E
SP 3 (middle stream)	4°27'08.2"N	101°24'08.6"E
SP 4 (middle stream)	4°27'02.7"N	101°23'55.7"E
SP 5 (middle stream)	4°27'00.6"N	101°23'50.2"E
SP 6 (downstream)	4°27'04.5"N	101°23'33.9"E
SP 7 (downstream)	4°27'03.1"N	101°23'29.5"E

Data obtained from the analysis were analyzed using IBM Statistical Package (SPSS) version 28.0. The correlation between nitrate concentration and selected water quality parameters concentration in water samples was tested using Spearman correlations. The level of significance was established at $p<0.05$. Regression analysis was applied to establish the interrelationship between nitrate concentration and COD level.

3. RESULTS AND DISCUSSION

The concentration values for physical and chemical variables at the sampling points of Sungai Ulung are presented in Table 2. There were significant increases in the concentration values of nitrate and COD upstream of the river compared to downstream. The mean concentration of nitrate upstream was 1.5 mg/L, 1.73 mg/L for the middle stream, and 2.0 mg/L downstream. At the same time, the mean concentration of COD upstream was 11.5 mg/L, 13.6 mg/L in the middle stream and 14.0 mg/L downstream. The highest nitrate and COD concentrations in Sungai Ulung were 2.1 and 14, respectively.

Table 2. Concentration value of physical and chemical analysis at the sampling points of Sungai Ulung

Sampling Points / Parameter	Upstream		Middle stream			Downstream		Mean, SD
	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	
Ammoniacal Nitrogen NH_3^-N, mg/L	0.16	0.16	0.16	0.18	0.17	0.17	0.18	0.17 (0.009)
Chemical Oxygen Demand (COD), mg/L	12	11	13	14	14	14	14	13 (1.21)
Dissolved Oxygen (DO), mg/L	8.59	8.21	8.56	7.96	8.51	6.23	7.75	7.97 (0.83)
Nitrate, mg/L	1.6	1.5	1.7	1.8	1.7	2.1	1.9	1.8 (0.12)
pH	6.27	6.91	6.34	6.11	6.22	6.87	6.29	6.43 (0.32)
Temperature, °C	22.5	22.0	22.4	22.9	22.2	23.2	23.4	22.7 (0.52)
Chemical Oxygen Demand (COD), mg/L (Mean, SD)	11.5 (0.7)		13.6 (0.58)			14.0 (0)		-
Nitrate, mg/L (Mean, SD)	1.5 (0.07)		1.73 (0.58)			2.0 (0.14)		-

The river upstream is usually cool and rich in oxygen compared to the downstream. From the study, the DO level also shows a decline after the river flows pass through the agricultural crop, with the higher level being 8.59ppm upstream and decreasing to the lowest level of 6.23ppm downstream of the river. Besides, the temperature has also increased a few degrees in the downstream compared to the upstream and middle streams. The analysis showed that Sungai Ulung was slightly acidic to neutral, where the range of pH value was 6.11 to 6.91. Apart from that, there was also a determination of ammoniacal nitrogen in the river, with a higher concentration of 0.18mg/L.

The deterioration of river quality may due to the anthropogenic activity particularly from agricultural activities at the river bank. As stated by the United States Environment Protection Agency (2015), the agriculture sector significantly impacts water quality, usually due to the runoff of sediment, nutrients, pesticides, and herbicides into the surface water (USEPA, 2015). These circumstances constitute the primary stressors to water quality and contribute to the values increase for important water quality parameters downstream. A study conducted by Masthurah, Juahir and Zanuri (2020) found that applying nitrogen fertilizer to the vegetable crop has caused nitrates pollution on surface water that flows within the vegetable farm areas.

On the other hand, the high concentration of ammoniacal nitrogen, nitrate and COD level detected in the river of this study were possible consequences of the nutrient load in the river during the rainy season. The water sample in this study was collected in October, which has high of rainfall. Razali et al. (2018) also stated in their study that Cameron Highlands has maximum rainfall (wet season) from October to November and April to May, while minimum rainfall (dry season) is from January to March and June to August. High water flow occurs during the wet season led to the runoff that bring the pollutant from the crop especially nutrients from fertilizer which could impact the water quality (Razali et al, 2018; Mellander et al., 2018).

High concentration of COD parameters is responsible for the depletion of oxygen levels in the river. This could be best explained by the fact that oxygen is required to oxidize organic matter in water which in turn causes the decrease of oxygen level. This was in line with a study conducted by Susilowati et al. (2018) where they reported that high organic pollutants such as nitrate and phosphate released from fertilizer may seep into the stream and result in high COD values and lower DO values.

Generally, it was briefly hypothesized in this study that there was probably a relationship between the nitrate level and COD in stream flows within the vegetable farm area. To test the relationship, the Spearman correlation coefficient was tabulated as shown in Table 3.

Table 3. Correlation between Nitrate level and COD level

			Nitrate
Spearman's rho, ρ	COD	Correlation Coefficient	0.865*
		Sig. (2-tailed)	0.012
	AN	Correlation Coefficient	0.753
		Sig. (2-tailed)	0.051
	Temperature	Correlation Coefficient	0.847*
		Sig. (2-tailed)	0.016
	DO	Correlation Coefficient	-0.775*
		Sig. (2-tailed)	0.041
	pH	Correlation Coefficient	-0.126
		Sig. (2-tailed)	0.788

* Correlation is significant at the 0.05 level (2-tailed)

From the analysis that carried out, these two variables shown a strong and significant positive relationship with 0.865* ($p = 0.012$), indicated that if nitrate level increase, the level COD in streams also increase. This study also revealed that there is a positive correlation, where an increase in nitrate concentration corresponded with an increase in AN ($r = 0.753$, $p = 0.051$) and temperature ($r = 0.847$*, $p = 0.016$). Conversely, there were negative correlations, as an increase in nitrate concentration was inversely related to DO ($r = -0.775$, $p = 0.041$) and pH value ($r = -0.126$, $p = 0.788$). Further analysis was performed using simple linear regression test for nitrate and COD level. From Table 4 and Figure 2, the regression analysis here shows high correlation with R-Square at 0.62 and to be functioned to the regression equations, y= 4.82x* + 4.67.

Table 4. Model Summary and Parameter Estimates Dependent Variable: COD

	Model Summary					Parameter Estimates	
Equation	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.622	8.222	1	5	.035	4.675	4.819

*Independent variable: Nitrate

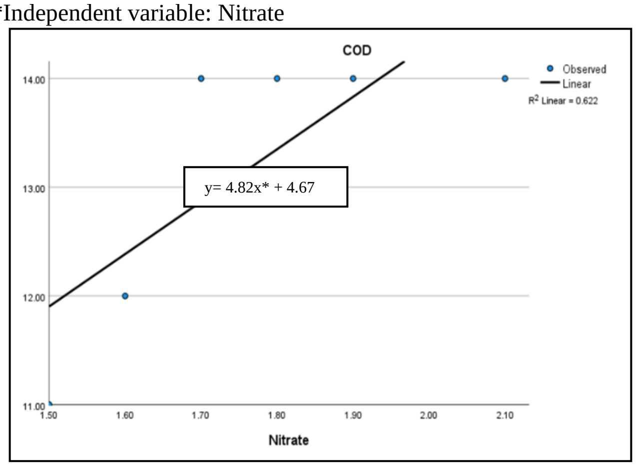

Figure 2. Simple linear regression between Nitrate and COD level

Nutrients such as nitrate is an organic matter from the fertilizer that applied to the crop. Nitrates are nitrogen ions that have high migration in the soil and are loosely bound to the soil (Maghanga et al., 2012). Consequently, it is easily washed into surface water and increases the organic contents. The high organic content in the river may increase oxidation activity, resulting in increased COD levels.

4. CONCLUSION

In this study, there have been nutrients loading in Sungai Ulung possibly due to the excessive application of fertilizer from agricultural activity near the river basin and high runoff of the pollutants during rainy seasons. It marked by the increased of nitrate, ammoniacal nitrogen and COD levels from upstream to downstream of the river. The high concentrations of parameter detected in the river of this study were possible consequences of the high runoff of agricultural pollutants into the streams since the river monitoring were done during the rainy season. Nitrate is considered as organic pollutants from agricultural activities. The increases of nitrate loading will also increase the river's COD level. Therefore, Farmers can practice Best Management Practices (BMPs) for their crop to reduce the chance of nutrient losses to the impaired water bodies.

ACKNOWLEDGEMENTS

The authors wish to thank and gratitude to every person that involve directly or indirectly and giving extraordinary support in this research process. Thank also to the Department of Irrigation and Drainage, Cameron Highlands for their contribution for providing data related to the study area.

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