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ASSESSMENT OF THE CURRENT SPATIAL-TEMPORAL VARIATIONS OF PH ON THE SURFACE WATERS OF KUALA PERLIS, PERLIS

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Abstract:

This research aims to assess the spatial-temporal pH variations on the surface water of Kuala Perlis, Perlis. The sampling points were determined and recorded using the Global Positioning Systems (GPS) in December 2021. A total of five sampling points for each morning, afternoon, and evening period were established, and the pH meter readings were recorded. The analysis of variance (ANOVA) was set at 0.05 to determine the significant difference in the spatial-temporal mean pH readings using the Statistical Package for the Social Sciences (SPSS) version 26. The research found that the pH readings were 6.98 – 7.24, 6.76 -7.41, and 6.58 – 7.54 for the morning, afternoon, and evening periods. The research also found no significant difference in the mean pH readings with respect to temporal variations (> .05). However, the research found a significant difference in pH readings (p< .05) concerning spatial variations. The local government and non-government bodies can utilize the output of this research to monitor river acidification processes and the social-economic development of this area.

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Keywords:

Kuala Perlis, pH, River Acidification, Spatial, Temporal

Introduction

Body river is a vital functioning ecosystem or natural landscape that provides tremendous significance to aquatic inhabitants and humankind. The importance of the river in freshwater fisheries to offer protein sources for low-income households was elaborately discussed (Dugan, Dey, & Sugunan, 2006). For agricultural production, basic needs, livelihoods, and ethnic backgrounds, the Mekong River's locals solely rely on the Mekong River and its tributaries' diverse and rich resources (Morton & Olson, 2018). Therefore, river essentiality should be highly acknowledged as it has been neglected for decades compared to prolonged exploitation.

Prolonged exploitation of the water bodies has negatively impacted the quality of the water bodies, resulting from pollution and possible anthropological activities that might be responsible for this worsening situation (Kamaruddin et al., 2020). According to Al-Badaii et al. (2013), anthropological activities may have altered the natural physicochemical properties of the river, derived from anthropological pollutants, industrial effluent, soil runoff, agriculture, and urban discharge from the land area. Domestic sewage and animal manure have been significant sources of organic contamination in aquatic environments for the past two decades. In addition, increased abundance and variety of toxic and hazardous wastes due to fast industrial expansion and urbanization (Abdullah, 1995). In short, the high-functioning aquatic system has been dictated by the impurities that cause it to be polluted, and water quality monitoring should be done.

Furthermore, water quality monitoring is a practical approach to monitoring river physicochemical properties over the years. In Malaysia, the Department of Environment (DOE) has provided National Water Quality Standard (NWQS) to be used as a primary reference to categorize the river status to the public (Ministry of Natural Resources and Environment Malaysia, 2014). Factors such as altitude, parent rocks, vegetation, and anthropogenic activities influence soil and water physicochemical properties like pH, organic matter, cation exchange capacity (CEC), soil properties, and water chemistry (Norbert et al., 2018). Water quality indicators include biological oxygen demand (BOD), temperature, electrical conductivity, nitrate, phosphorus, potassium, dissolved oxygen, hazardous heavy metals, and algal bloom (Bhateria & Jain, 2016). Therefore, water quality monitoring should be done to study the current physicochemical properties of the Kuala Perlis.

The previous study depicts Kuala Perlis River has become the main pathway for transportation, fisheries, and irrigation for Perlis's residents, and its current condition keeps changing through the years. Perlis River is located on Malaysia's northern peninsula, at latitude 6.40° and longitude 100.13°. The Perlis River has over ten tributaries and a 350-square-kilometer river basin. The river runs 9.6 kilometers from Kangar City to Kuala Perlis (Amneera et al., 2013). In water quality index studies conducted by Amneera et al. (2013), throughout three stations set up along Kuala Perlis River, the water quality index was found to be at 58.30, 61.87, and 41.64, respectively. That finding shows decline trends in WQI values that point to an increasing level of water pollution in the Kuala Perlis River. Kuala Perlis River shows the potential risk

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of being highly polluted in the future. If no effort is made, a harmful impact on the river may occur, such as river acidification.

River acidification is an occurrence where the pH of the river shifts to be more acidic as carbon dioxide is absorbed into the river from the polluted atmosphere. Changes in pH in coastal ecosystems are caused by various factors, including watershed processes, nutrient inputs, and changes in ecosystem structure and metabolism (Duarte et al., 2013). The chemical composition and discharge magnitude are rapidly changing due to climate change and land-use practices (Salisbury et al., 2008). The pH range of freshwater is wider than the ocean, as freshwater alkalinity is lower than the ocean due to the absence of the salt buffer. Thus, to detect the river acidification at its earliest before it threatens the water bodies and their habitat, there is a need for spatial-temporal variation of pH assessment.

Spatial-temporal variation of pH assessment should be conducted regularly to understand changes in river bodies. Water quality varied spatially and temporally; the most spatial variability occurred during the no-flow phase, with flow driving temporal changes (Sheldon & Fellows, 2010). For example, the monsoon season, tidal activity, and the timing of sampling processes all temporarily influence pH levels (Kamaruddin et al., 2021a). The pH reading measures hydrogen ions in the water sample and is considered the most functional parameter to indicate the water quality, especially in aquaculture. For different sorts of samples, measuring the pH value of water is crucial. Too High and too low pH levels of aquatic species are harmed, either directly or indirectly. Changes in pH substantially impact phytoplankton and zooplankton biodiversity at the water bodies' surface (Kamaruddin et al., 2021a). In determining the corrosive qualities of an aquatic environment, the pH value is the most useful parameter (The British Standards Institution, 2012). Contamination and acidification are indicated by pH, and toxic elements and compounds become mobile when the pH is low. The higher the hydrogen ion (H+) activity and the more acidic the water, the lower the pH (Amneera et al., 2013). In short, pH monitoring is vital to understand the condition of the water bodies, in this case, the Kuala Perlis River.

Literature Review

Several highlights should be focused on in the literature review section. First and foremost, the activity of hydrogen ions in solution is measured by pH, which is the logarithm to the base 10 of the ratio of molar hydrogen-ion activity multiplied by 1. The pH value is determined by measuring the potential difference of an electrochemical cell with an appropriate pH meter (The British Standards Institution, 2012). Next, acidification can disrupt many marine biogeochemical and biological processes. The pH of the ocean has already decreased and will continue to fall as more carbon dioxide (CO2) is emitted (Turley et al., 2006). Because there is growing concerned about global warming, it is critical to investigate the pH distribution in coastal and mangrove ecosystems, particularly in areas with high species richness (McNicholl et al., 2020). For a sustainable approach to healthy coastal and estuarine ecosystems, surface water pH can be forecasted using various instruments or modelling techniques (Kamaruddin et al., 2021b).

The primary sources of river pollution include growing urbanization, which results from the construction of residential, commercial, and industrial sites and infrastructure, and other utilities (Amneera et al., 2013). The Kuala Perlis River is designated as a Class III river. It is undergoing severe erosion along its riverbanks and has become extremely shallow. Kuala Perlis

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has a landfill, which directly impacts the river's water quality. Squatters near the river reserve area are also causing pollution. Shrimp livestock ponds, Kangar Wet Market, Sungai Perlis Esplanade, food vendors, and the Kuala Perlis Fisherman Jetty are further polluting sources (Samsudin et al., 2011). The lack of prior research in the study area provided another problem for research because there was no baseline data for water pH (Kamaruddin et al., 2021a). Therefore, this study proposes to obtain a current spatiotemporal variation of pH on the surface water of the river, thus providing preliminary for future endeavours, especially in monitoring the Kuala Perlis River quality.

Methodology

This section briefly explained the sampling method, selection of sampling sites, and sampling location positioning (latitude and longitude). The observation made during sampling activities was also recorded, and the sampling location was also mapped to view possible anthropogenic activities using satellite images comprehensively

Sampling Method

Sampling was conducted in early December 2021, and five locations were determined, starting from the first location (L1), Jetty Tok Kuning, until it reached the river's mouth, the fifth location (L5). Each sampling location was carefully marked and recorded using Global Positioning System (GPS). Sampling was conducted three times, which were in the morning, afternoon, and evening. Water samples were collected around one meter below the surface. The observations at each sampling site focused on the natural landscape and possible anthropological contributors that might affect the water quality and pH distribution. 1.5-liter plastic bottles were used to collect the water samples, carefully labeled according to sampling sites, and brought to the laboratory for further analysis. The pH reading was immediately taken after the sample collection using a pH meter. The reading was taken in triplicate, and the average reading was calculated.

Sampling Sites

Sampling sites were conducted at three different periods, which were morning (AM), afternoon (AF), and evening (PM). Each sampling point during surface water sampling will be labeled (L1-L5), and the latitude and longitude will be recorded each time using GPS System. Observation for possible anthropogenic activities was also conducted during the sampling activities, and Table 1 shows the sampling location and possible anthropogenic activities observed.

Table 1: Sampling Location and Possible Anthropogenic Activities

Sampling	Location	Latitude	Longitude	Possible Anthropogenic Activities
AM	L1	6˚25'04.853"N	100˚09'01.853"E	Jetty Tok Kuning, Agriculture
	L2	6˚25'19.128"N	100˚08'32.333"E	Agriculture, Aquaculture/ Fishing Pond
	L3	6˚25'03.461"N	100˚08'22.434"E	Solar Power Plant
	L4	6˚24'37.799"N	100˚08'23.903"E	Solar Power Plant, Roadside, Residential Area
	L5	6˚24'28.511"N	100˚08'23.364"E	Restaurant, Floating Village
	L1	6˚25'04.992"N	100˚09'00.774"E	Jetty Tok Kuning, Agriculture

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AF	**L2**	6˚25'17.364"N	100˚08'46.409"E	Agriculture, Aquaculture, Fishing Pond
	L3	6˚25'20.808"N	100˚08'31.746"E	Fishpond, Solar Power Plant, Roadside
	L4	6˚24'57.449"N	100˚08'18.917"E	Roadside, Restaurant
	L5	6˚24'27.263"N	100˚08'20.742"E	Floating Village
PM	**L1**	6˚25'04.787"N	100˚09'01.290"E	Jetty Tok Kuning, Agriculture
	L2	6˚25'22.188"N	100˚08'44.322"E	Agriculture, Aquaculture, Fishing Pond
	L3	6˚25'00.653"N	100˚08'19.679"E	Aquaculture, Solar Power Plant
	L4	6˚24'34.355"N	100˚08'29.033"E	Solar Power Plant, Roadside, Residential Area
	L5	6˚24'27.479"N	100˚08'23.364"E	Restaurant, Floating Village

In addition, sampling locations were mapped based on the latitude and longitude of each sampling activity. The sampling point positioning can be accurately defined from the map, and possible anthropogenic activities can be studied appropriately. Figure 1, Google, 2021b, showed the sampling location for morning (AM) sampling; Figure 2, Google, 2021a, showed the sampling location for the afternoon (AF) sampling, and Figure 3, Google, 2021c, showed the sampling location for the evening (PM) sampling.

Figure 1: AM Sampling Location

Source: (Google, 2021b)

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Figure 2: AF Sampling Location

Source: (Google, 2021a)

Figure 3: PM Sampling Location

Sources: (Google, 2021c)

Results and Discussion

The results obtained from the spatiotemporal finding for Kuala Perlis's pH variation were discussed distinctly for the temporal and spatial pH variation at the Kuala Perlis river. The data were tabulated and illustrated in tables and figures, respectively. The data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 26. The current pH spatiotemporal variation and possible factors affecting the pH spatiotemporal variation were further discussed.

Temporal Variation of pH at Kuala Perlis River

The pH distribution for five sampling locations for three sampling times was recorded in Table 2. The finding found three different average pH ranges measurement, which was 6.98 – 7.24,

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6.76 -7.41, and 6.58 – 7.54, respectively, for the morning (AM), afternoon (AF), and evening (PM) sampling time.

Table 2: Data Collection of pH Reading Distribution at Kuala Perlis River

Sampling	Location	pH (Mean ±SD)
AM	L1	6.98 ±0.01
	L2	7.24 ±0.01
	L3	7.11 ±0.02
	L4	7.00 ±0.01
	L5	7.16 ±0.00
AF	L1	6.76 ±0.03
	L2	7.01 ±0.01
	L3	7.00 ±0.01
	L4	7.10 ±0.01
	L5	7.41 ±0.01
PM	L1	6.57 ±0.00
	L2	7.24 ±0.01
	L3	7.25 ±0.01
	L4	7.24 ±0.00
	L5	7.54 ±0.02

During the morning sampling, the pH distribution was recorded at 6.98, 7.24, 7.11, 7.00, and 7.16, respectively, at L1 till L5. The average pH range of the morning sampling was 7.1 ± 0.11. While the pH distribution during afternoon collection was 6.76, 7.01, 7.00, 7.05, and 7.41 throughout L1, L2, L3, L4, and L5. The mean pH distribution was calculated at 7.12 ± 0.28, slightly higher than the average obtained during the morning sampling. Lastly, during the evening sampling time (PM), the pH distribution was at the highest average of 7.17 ± 0.35. In contrast, the pH was recorded at 6.58, 7.24, 7.25, 7.25, and 7.54 at the respective location 1 till location 5 along the Kuala Perlis river. Figure 4 illustrates the pH distributions within different sampling times throughout areas.

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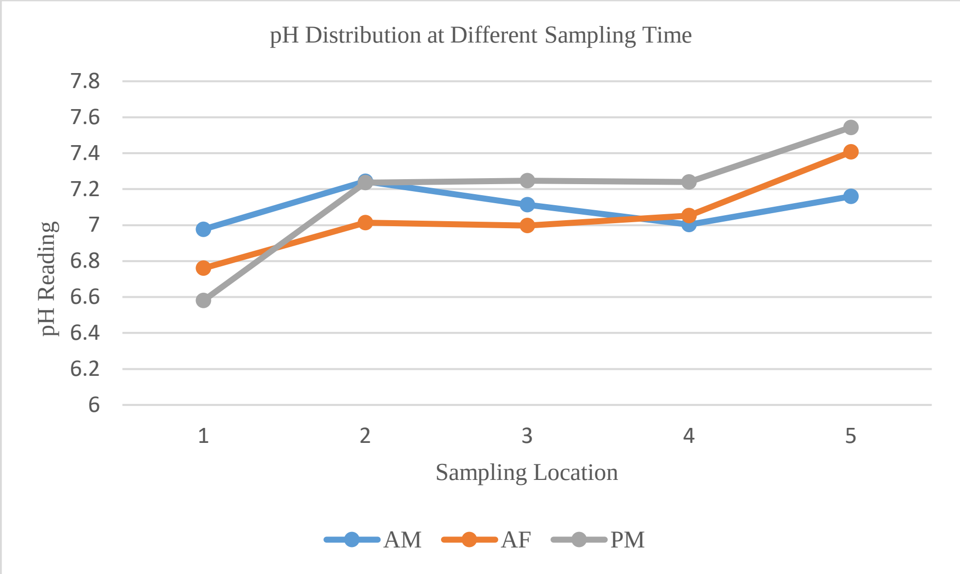

Figure 4: pH Distribution Within Different Sampling Times

The average pH distribution shows inclining trends throughout the morning sampling (AM), afternoon sampling (AF), and evening sampling (PM). The standard deviation also shows slight expansion among the range of pH values from the mean calculated on each sampling time throughout locations, which was 6.98 – 7.24, 6.76 -7.41, 6.58 – 7.54, respectively, for the morning (AM), afternoon (AF), and evening (PM) sampling time. Even though there is an average difference between the values, there was no significant difference between the pH distribution and the sampling time. Figure 5 shows the average pH between three different sampling times.

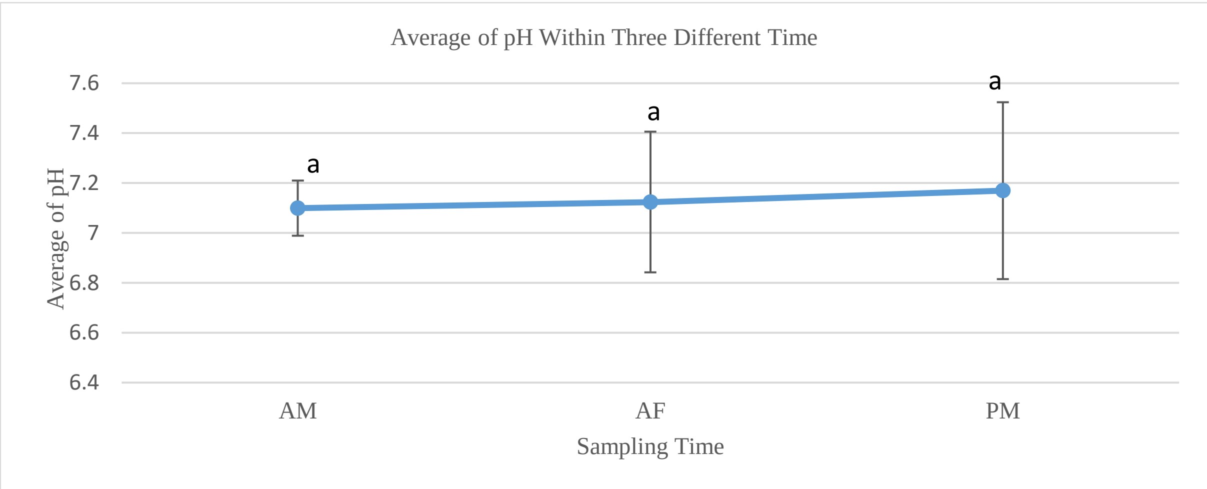

Figure 5: Average of pH Within Three Different Times,
*Same letters indicate values with non-significant differences (P > .05).

A one-way between-subject ANOVA was conducted to study the effect of the sampling time on surface water pH value in the morning, afternoon, and evening. There was not a significant effect of the sampling time on surface water pH value at the $p< .05$ level for the three conditions [$F(2,12) = 0.303$, $p = 0.744$], as can be seen in Table 3. Therefore, these results suggest that

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sampling time does not affect water surface pH value. Generally, there was no temporal variation of pH assessment in the study area, Kuala Perlis River. Post hoc Tukey HSD was not conducted further as there was no significant difference in the temporal variation of surface water pH assessment.

Table 3: One Way ANOVA for Temporal Variation of pH

Temporal Variation of pH			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		.039	2	.019	.303	.744
	Linear Term	Contrast	.013	1	.013	.203	.660
		Deviation	.026	1	.026	.404	.537
Within Groups			.767	12	.064		
Total			.805	14			

* There was not a significant effect of the sampling time on surface water pH value at the $p< .05$ level for the three conditions [$F(2,12) = 0.303$, $p = 0.744$].

Spatial Variation of pH at Kuala Perlis River

Moreover, the data obtained from the research and pH distribution at the different sampling locations can also be found. An increasing pattern was recorded, and the pH became more essential as the sea approached. Location 1 shows the lowest pH values for each sampling time, 6.98, 6.76, and 6.58, respectively, for the morning, afternoon, and evening sampling. The highest pH was recorded at locations 5, pH 7.54 during the PM sampling. Location 1 is the furthest from the sea opening than location 5, which is nearest the sea. There is a significant difference in the pH distribution between location 1 and location 5, as shown in Figure 6. Location 1 is significantly different from location 5, as $P = 0.007$, thus $P\leq 0.05$, which means there was a significant difference, computed using ANOVA SPSS and Post-Hoc (Tukey Test)

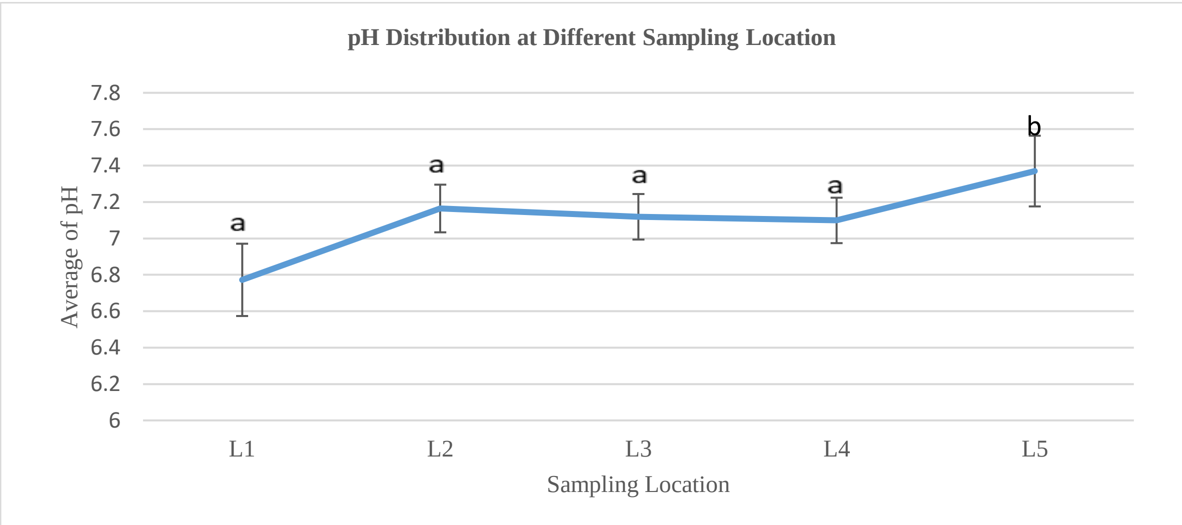

Figure 6: pH Distribution at Different Sampling Locations

*L1-L5: Location 1 till Location 5

*Different letters indicate values with significant differences ($P > .05$).

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A one-way between subject's ANOVA was conducted to compare the effect of different sampling locations on water surface pH value in five locations of the sampling point. There was significant effect of sampling location on water surface pH value at the $p < .05$ level for the five locations [$F (4,10) = 5.439$, $P = 0.014$]. Table 4 shows the one-way ANOVA of spatial variation in pH value.

Table 4: One Way ANOVA of Spatial Variation in pH

Spatial Variation of pH			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		.552	4	.138	5.439	*.014
	Linear Term	Contrast	.381	1	.381	15.016	.003
		Deviation	.171	3	.057	2.247	.145
Within Groups			.254	10	.025		
Total			.805	14			

*There was significant effect of sampling location on water surface pH value at the $p < .05$ level for the five locations [$F (4,10) = 5.439$, $P = 0.014$].

The Post hoc comparisons using the Tukey HSD test indicated that the mean score for location 1 (M = 6.77, SD = 0.20) was significantly different than location 5 (M = 7.37, SD = 0.13). However, other location which were location 2 (M = 7.16, SD = 0.13), location 3 (M = 7.12, SD = 0.13) and location 4 (M = 7.10, SD = 0.13) is not significantly different from location 1 and location 5. To recapitulate, these results suggest the spatial variation of pH assessment between location 1 and location 5. However, location 2, location 3, location 4 do not have a spatial variation of surface water pH value. Table 5 shows the comparison of the P-value (Tukey Test) of the pH reading on each sampling location

Table 5: Comparison of The P-value (Tukey Test) of The pH Reading on Each Sampling Location

Comparison Between Sampling Location		P-value
Location 1	Location 2	.078
	Location 3	.130
	Location 4	.170
	Location 5	***.007**
Location 2	Location 1	.078
	Location 3	.997
	Location 4	.984
	Location 5	.535
Location 3	Location 1	.130
	Location 2	.997
	Location 4	1.000
	Location 5	.366
Location 4	Location 1	.170
	Location 2	.984

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	Location 3	1.000
	Location 5	.290
Location 5	Location 1	***.007**
	Location 2	.535
	Location 3	.366
	Location 4	.290

*The mean is significantly different at 0.05 level (p<0.005) by Post-Hoc Tukey.
*There were significant differences between pH readings between Locations 1 and 5.

Possible Factors Affecting Spatiotemporal Variation of pH Assessment in Kuala Perlis River

Several possible factors might affect the pH distributions spatially: the presence of soil producing acid area, colloidal particle binding with seawater, possible sea intrusion, rainfall distribution, and possible anthropogenic activities. Location 1 for each sampling, near the river bench, thus soil acidity will significantly affect the pH reading on these water bodies compared to location 5. The acidity of upland freshwaters, metal concentrations, dissolved organic carbon (DOC) and color, and the concentration of suspended particles are all affected by blanket peat degradation (Martin-Ortega et al., 2014). According to Reuss, Cosby, and Wright (1987), the pH of surface water is affected by the accumulation of acid deposition over natural acidifying reactions in soils.

Next, possible sea intrusion can also be a factor that affects the difference in pH distribution as seawater contains a salt buffer that increases the river's alkalinity. Lower salinity ranges exhibited significant pH increases, but higher salinity ranges showed delayed increases (Mosley, Husheer, & Hunter, 2004). The pH distribution can also be influenced by rainfall distribution, and rainfall intensity impacts water quality. According to the findings, the deeper the water level, the lower the pH value of the soil and water (Tuan Besar, Sofik, & Mat Daud, 2019).

Finally, anthropogenic factors might also affect the river pH, such as the agriculture runoff from paddy fields along the river. Agricultural runoff is the primary cause of pollution in low-pollution areas (Tengku Ibrahim et al., 2021). Discriminant analysis of river water quality conducted by Samsudin et al. (2011) shows possible nutrient runoff from paddy fields due to strong positive loading of biological oxygen demand (BOD) and chemical oxygen demand (COD), which represent anthropogenic pollution sources, thus able in reducing the pH spatially. From the observation, locations 1 and 2 are near the paddy field and fishpond; therefore, the pH reading is slightly lower than the others. The study suggested the applicability of spatial interpolation method to map and estimate pollutant concentration in future research (Kamaruddin et al., 2018). Spatial interpolation has become a popular method for evaluating and mapping water pollutants concentration (Kamaruddin et al., 2019).

Conclusions

Based on the finding obtained, preliminary data on the current spatiotemporal variation in pH assessment on the surface water of Kuala Perlis River was successfully obtained and studied. The research found no temporal variation of pH assessment on different surface water locations in Kuala Perlis. In contrast, the finding showed the spatial variation of pH assessment of surface water at Kuala Perlis between Location 1 and Location 5. The preliminary data on pH variation can be used as a future endeavor for the researcher, government, and non-government to

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monitor the river acidification and plan for social-economic development along the Kuala Perlis area. The data also can be used to preserve the Kuala Perlis river ecosystem and promote sustainable river management.

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