Malaysian Journal of Chemistry, 2024, Vol. 26(5), 165-174
(Special Issue: *3rd Virtual International Symposium on Sciences 2023*)

Application of Heavy Metal Pollution Index (HPI) of Water Quality Assessment in Tengi River

Nurul Syazwa Tasnim Saipul Bahri[1], Nadasofa Mohd Saidi[2], Nik Azlin Nik Ariffin[1] and Sabarina Md Yunus[3]*
[1]Faculty of Applied Sciences, Universiti Teknologi MARA, 40000, Shah Alam Selangor, Malaysia
[2]Lembaga Urus Air Selangor, 40000, Shah Alam, Selangor, Malaysia
[3]Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Pahang, 26400 Bandar Tun Abdul Razak, Pahang, Malaysia
***Corresponding author (e-mail: sabarina2020@uitm.edu.my)

A study was carried out on water quality and heavy metal concentration in the Tengi River near Tanjong Karang, Selangor. Tanjong Karang is known for its fishing industry, agriculture and economic activities. Therefore, due to the human activities in this area, monitoring the water quality and heavy metal concentration is crucial. The samples were collected using water sampler, which was then acidified until pH 2 and filtered using cellulose acetate 0.45 µm. The concentration of heavy metals was determined using inductively coupled plasma optical emission spectroscopy (ICP-OES). The water quality parameters mean values for DO (5.8 mg/L), pH (8.4), TDS (287.4 mg/L), salinity (32.0 mg/L), and temperature (30.7℃) was obtained. While, the mean values for COD, BOD, TSS, and NH3-N were, 27.09 mg/L, 1.10 mg/L, 61.42 mg/L, and 2.32 mg/L, respectively. According to the results, all sites were categorized as CLASS IV except Site 3 and 14. A lower WQI number indicates that the river is more polluted. All sample locations are classified as contaminated ranges in the range of 0 to 59 by the DOE Water Quality Index Classification. The mean concentrations of Pb, Zn, and As were significantly lower than the Malaysian National Water Standard, with a mean value of 36.07 µg/L, 5, 211.47 µg/L, and 10.87 µg/L, respectively. In general, the concentration of heavy metals in river water was found to decrease in the following order: Zn > Pb > As. All the HPI values in fifteen sampling locations exceed 100. All the HPI values in fifteen sampling cites exceeded 100, indicating that the water HPI was above the critical limit (HPI > 100), hence unfit for drinking. This study may serve as a template for future research in terms of methodology and assist in the identification of the sources, water quality, and effects on the waterways of the Tengi River.

Keywords: Heavy metals; Heavy Metal Pollution Index (HPI); river water quality; water quality

Received: November 2023; Accepted: February 2024

The sustainability of humans and the development of the planet both depend on the availability of water. There are two common ways for pollutants to enter rivers which are through known point sources and diffuse. The availability of water for people, animals, and certain sectors of the economy makes water resources, particularly surface waters like rivers, is very crucial [1]. Heavy metals seriously threaten the sustainability of ecosystems and biological health. Although the risks posed by heavy metals are known, and some nations have taken steps to reduce their emissions, this has not been achievable in the majority of the world [2]. Many areas of the globe currently employ different heavy metals in wholly unregulated ways as a result of industrialization. Through soil, air, and water pollution, this harms ecosystems such as forests and aquatics [3].

Tengi River is situated in the Kuala Selangor and Sabak Bernam districts, and it is well-known for its busy aquaculture and agriculture industries, such as paddy soil. The water from Tengi River was used to irrigate the paddy fields in the Sekinchan, Sungai Besar and Tanjung Karang areas, known as the biggest rice production area in Selangor district. The activities in the study area, can pollute rivers, making it imperative to evaluate the Tengi River's water quality and locate any potential causes of contamination. Along the Tengi River, there are several human activities, such as industries industrial activities, including oil palm plantations, manufacturing facilities, and mining operations. Other than that, Agricultural and domestic activities like sowing, manuring, weeding, and harvesting [4-5]. These activities can sometimes indirectly increase the number of heavy metals discharged by natural processes into the environment [6]. The river is polluted with pesticides due to agricultural activities and the use of pesticides in the area [7]. The water from Tengi River moves from a peat swamp forest, through different agricultural land uses, and finally through an urban area to the Straits of Malacca. Heavy metals affect water quality and

†Paper presented at the 3rd Virtual International Symposium on Sciences (3rd VISoS 2023)

potability, and their presence in aquatic systems promotes the production of reactive oxygen species that can damage physiological processes in fish and other aquatic organisms, thus releasing them into water.

The instrument used to analyse heavy metals in river water samples is inductively coupled plasma optical emission spectroscopy (ICP-OES). ICP-OES is a widely used environmental analysis technique because it can detect a wide range of metals at very low concentrations [5]. It is also a relatively fast and cost-effective method compared to other analytical techniques [1], [8- 9, 10]. The quality of river water has significantly declined due to contaminated discharges and effluents from human activities. A significant number of rivers were contaminated to the point that they could not be restored, making it difficult for the government to provide access to a clean and safe water supply [6]. Heavy metal pollution is a considerably greater issue since heavy metals cannot be naturally broken down, Therefore, they stay in soil and sediment, swiftly released as drains into watercourses [8, 11].

The objectives of this study embarked on the investigation of selected metals in Tengi River are to determine the current status of water quality index (WQI) in Tengi River, to determine the concentration of heavy metals (Pb, As, Zn) in Tengi River by using inductively coupled plasma optical emission spectroscopy (ICP-OES) and to estimate the levels of pollution in the Tengi River by using Heavy Metal Pollution Index (HPI). This study may serve as a template for future research in terms of methodology and in assisting in the identification of the sources, and underlying causes of issues with water quality, such as land use decisions and the effects such decisions have on the waterways of the Tengi River. The data acquired might be used to monitor and evaluate the pollution caused by human activity. There are not enough studies on the topic, Thus, this study will increase the amount of research on heavy metals in water in the Tengi River near Tanjung Karang. Additionally, there is a lack of knowledge and statistics on Tengi River water pollution brought on by heavy metals.

EXPERIMENTAL

Study Area

The Tengi River is situated in the Kuala Selangor and Sabak Bernam districts, which are well- known for their busy aquaculture and agriculture industries. These activities have the potential to pollute rivers, making it imperative to evaluate the current status of water quality and locate any potential causes of contamination. The study's focus on the Tengi River was chosen due to its distinctive features. Before draining into the Straits of Malacca, the river travels through a variety of land uses, including a peat swamp forest, agricultural districts, and an urban area. This feature made it possible to see how the water quality changed as the river moved through this various land use, and pesticides are often used in agricultural activities.

Sampling Points

Table 1 shows the list of 15 sampling locations with the activities. The stations were chosen because of their ideal locations to represent the Tengi River near Tanjung Karang. The distance of each sample that will been taken are around 1 km for each ten sampling areas. To evaluate the heavy metal concentrations in the Tengi River and its tributaries, 15 sample locations were chosen, as shown in Figure 1. The samples were taken using a water sampler from 10 cm below the water's surface and kept in a 10-litre high-density polyethylene container that will be cleaned first [10]. Each sample will be taken at around 1 km for each of the ten sampling areas. The samples were collected at fifteen sampling points. All the sample containers will be labelled before site collection.

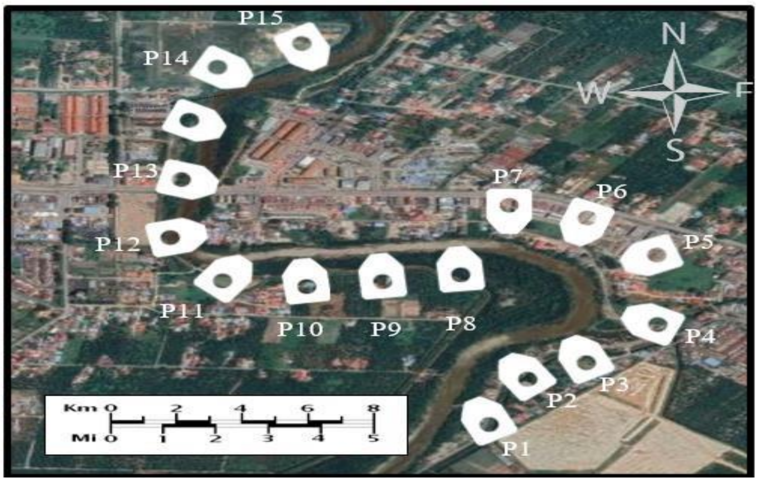

Figure 1. Sampling location along Tengi River, Selangor.

Table 1. Location of sampling points.

Sampling Points	Major Activity
P1	Ocean Fishing Boat Services
P2	Palm oil mills
P3	Temple
P4	Marine supply Store
P5	Residential Area
P6	SEGI Fresh
P7	7-Eleven
P8	Eco-Shop
P9	Residential Area
P10	Amway Tanjung karang
P11	Tanah perkuburan Islam
P12	Organic shop
P13	Ani Beauty Collection
P14	Restaurant PAMA
P15	Pasar Awam

Sample Preparation

The samples were stored in the laboratory following sample collection. After following the USEPA-2007 protocol, the sample preparation was completed. Before adding 0.4 mL of nitric acid (1 + 1) to each sample, 20 mL was poured into a 50 mL centrifuge tube. This step helped to slow down biological activity and ensured all chemicals were present in the water column. The centrifuge tubes were then heated to 85 °C in a water bath for two hours [5]. Afterward, the centrifuge tubes were removed from the water bath to allow the solution to cool until it reached room temperature. Subsequently, the water samples were filtered using a 0.45 µm cellulose acetate membrane filter with a syringe filtering equipment [8]. This was done to collect dissolved metals without obstructing the spectrometry device during analysis. Any dissolved metals that could potentially clog the spectrometer during analysis were removed through filtration.

In-Situ Analysis

Acidity (pH), temperature, salinity, total dissolved solids (TDS) and DO were the basic parameters used to determine the quality of the Tengi River. YSI Model Multi probe system was used to provide in-situ temperature measurements, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), and pH. It was calibrated and cleaned before being used in the sampling. At each sampling location, three copies of each in-situ parameter were obtained. Each water sample was labelled with the date and the sampling locations. The laboratory received additional samples, including water samples treated with nitric acid to make them acidic (pH = 2). The use of acid helped prevent the precipitation of metal hydroxides and metal ion adsorption on the container walls [8]. The results of the samples' analysis were recorded. When moving the samples, care was taken to ensure that the device did not come into contact with the sample containers, and preservation measures were implemented on-site immediately after sample collection.

Ex-Situ Analysis

Laboratory measurements were made of the concentrations of BOD, COD, TSS, NH3-N, and heavy metals. The water samples were put in a temporary ice box container for transit and then analysed for BOD, COD, heavy metals, and NH3-N parameters. Following the steps outlined in Standard Method APHA 5210-B, the biochemical oxygen demand (BOD) was determined [1]. The reactor and spectrophotometer were utilized to analyze the chemical oxygen demand (COD), with the addition of digestion reagent as a reagent. A spectrophotometer was used to measure the number of suspended solids (SS), ammoniacal nitrogen (AN), and Nessler ammonia reagent, utilizing Mineral Stabilizer, Polyvinyl Alcohol Dispersing Agent, and Nessler Reagent. The pH meter was used to determine the pH. Each parameter was examined, and the river's water quality rating was determined based on Malaysia's National Water Quality Standards.

Water Quality Index (WQI) Calculation

The WQI, primarily used in Malaysia, was developed by an expert board advising factor selection and parameter weighting. The six parameters utilised for the WQI are pH, ammonia, total suspended solid

(TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solid (TSS). A river may be classified into a variety of groups based on the computed WQI, each of which illustrates the beneficial uses the river may be put to [2]. The categorization is based on the permitted limits for the specified pollutant criteria. The parameters dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), ammoniacal nitrogen ($NH3 - N$), and pH will be used in accordance with the DOE's WQI equation to ascertain the parameters' values and the Tengi River's overall water quality classification. After the sub-indices are computed, as shown in Table 2, WQI is then will be determined by this equation:

$$WQI = (0.22 * SIDO) + (0.16 * SICOD) + (0.19 * SIBOD) + (0.16 * SISS) + (0.12 * SIPH) + (0.15 * SIAN)$$

Where,

SIDO = Sub-index for DO; SIBOD = Sub-index for BOD; SICOD = Sub-index for COD; SIAN = Sub-index for AN; SISS = Sub-index for SS; and SIpH = Sub-index for pH.

Sample Measurement

Inductively coupled plasma optical emission spectroscopy (ICPOES) was used to analyze the produced samples for the presence of heavy metal concentrations in the Tengi River. The samples taken during the day of sampling were analyzed for heavy metals shortly after their collection. This was done to ensure a high level of accuracy in the outcomes of heavy metal detection. The concentrations of total dissolved elements and major ions, including Lead (Pb), and Zinc (Zn). Sample water was analyzed to evaluate water quality. The ICP multi-element standard solution was used as the usual solution. A standard combination of heavy metals was created and measured to provide calibration curves for each element. To achieve a high degree of accuracy in the results of the detection, the samples obtained throughout the sampling day were immediately examined for the presence of heavy metals. Measurements of heavy metals were kept as precise as possible because of ICP-OES. The results of this evaluation were expressed as micrograms per liter (μg/L) for seawater [8].

Table 2. Calculation of WQI.

Sub-indices DO (% saturation)	
$x < 8$ $x \geq 92$ $8 < x < 92$	SIDO = 0 SIDO = 100 SIDO = $-0.395 + 0.030^{x2} - 0.00020^{x3}$
Sub-indices BOD (mg/L)	
BOD ≤ 5 BOD > 5	SIBOD = 100.4 – 4.23BOD SIBOD = 108e-0.055BOD – 0.1BOD
Sub-indices COD (mg/L)	
COD < 5 COD > 5	SICOD = $-1.33x + 99.1$ SICOD = $103e^{-0.0157x} - 0.04x$
Sub-indices ammonia, AN (mg/L N)	
$x \leq 0.3$ $0.3 < x < 4$ $x \geq 4$	SIAN = $100.5 - 105x$ SIAN = $94^{e-0.573x} - 5\|x - 2\|$ SIAN = 0
Sub-indices TSS (mg/L)	
$x \leq 100$ $100 < x < 1000$ $x \geq 1000$	SITSS = $97.5e^{-0.00676x} + 0.05x$ SITSS = $71e^{-0.0016x} - 0.015x$ SITSS = 0
Sub-indices pH	
$x < 5.5$ $5.5 \leq x < 7$ $7 \leq x < 8.75$ $x \geq 8.75$	SIpH = $17.2 - 17.2pH + 5.02x^2$ SIpH = $-242 + 95.5pH - 6.67x^2$ SIpH = $-181 + 82.4pH - 6.05x^2$ SIpH = $536 - 77.0x + 2.76x^2$

Note: x is the concentration in mg/L for all parameters except pH
Source: Department of Environment, Ministry of Natural Resources and Environment Malaysia (NRE).

Data Analysis

Heavy Metals

The heavy metal pollution index combines many criteria to arrive at an accurate number that may be related to the significant quantity to quantify the amount of pollution capacity, making it a helpful tool for detecting surface water contamination. The formula for determining the concentration of an element in a sample is commonly presented as by the real concentration of heavy metals in the ICP-OES analysis equation:

$$\text{Concentration (mg/L)} = C \times DF$$

Where:

C is the concentration obtained from the instrument (µg/L)

DF is the dilution factor (final volume / initial volume)

Heavy Metals Pollution Index (HPI)

The HPI is a method of assessment that shows the compound influence of individual heavy metals on the total quality of water. HPI is sophisticated in two steps. The first step establishes a rating scale for each selected parameter giving weightage, whereas the second step selects the pollution parameter on which the index is to be based. The evaluation is based on a comparison between the measured values and reference values from the National Water Quality Standards for Malaysia (NWQSM) for drinking water [12]. HPI is calculated by the following equation 1:

$$\text{HPI} = \sum \text{QiWi}$$

where Wi is the score weight for each parameter preferred for heavy metal assessment and is directly related to the suggested standard, the highest allowable amount for heavy metals' drinking water (Si). The rating is a value between zero and one. Qi, is the Subindex of the ith parameter and was calculated using (2)

$$Q_i = \frac{(Mi - Ii) \times 100}{(Si - Ii)}$$

where Mi is the measured value of the ith parameter; Ii is the desired maximum value (ideal) of the ith parameter; and Si is the suggested ith parameter standard. The crucial index of pollution is 100. The Si and Ii values have been taken from the Malaysian national water quality standard for the current study. After the completion of the results, the concentration of any pollutant was converted into HPI, and the critical HPI value was 100 for drinking water.

RESULTS AND DISCUSSION

In-Situ Analysis

Table 3 shows the values of in situ of basic water quality parameters measured using multi probes meter from fifteen sampling locations. The range of dissolved oxygen (DO) in this study was 5.0 to 7.4 mg/L. The DO measurement was lowest at sample location 7 and highest at sampling location 12. In Tengi River, DO is typically 6.0 mg/L. However, the variation in water DO cause by temperature change is not very great. Changes in value of DO usually depend on organic materials and organisms, such as bacteria in the water Salinity and temperature have an impact on DO levels. The results showed that the Tengi River's surface water had a temperature range of 30.0 to 30.9 °C, with a mean of 30.4 °C. Sampling location 2 recorded the greatest value, while sampling location 14 recorded the lowest value. River water temperatures may rise due to hot water discharges from industrial activities or warm water from industry. The Tengi River of total dissolved solids (TDS) content ranged from 131.1 to 431.1 mg/L. Extreme human activities and runoff with significant suspended matter are to blame for the high TDS content in the rivers. The Tengi River's salinity ranges from 0.4 mg/L to 1.9 mg/L. Due to the distance from the coastline, all sample locations have low salinities. Salinity levels in rivers are frequently highest near the mouth, where salt water from the ocean first interacts with freshwater from the river, and lowest farther upstream. The pH of most natural waterways ranges from 6.0 to 8.5, with eutrophic fluids, groundwater brines, and salt lakes having higher pH values than diluted waters rich in organic content [5, 10 - 12].

Table 3. The in-situ data collected at Tengi River.

LOC.	DO (mg/L)	pH	TDS (mg/L)	SALINITY (mg/L)	TEMP. (°C)
S1	5.3	8.1	1013.5	1.2	30.8
S2	5.0	8.3	2031.1	1.1	30.9
S3	6.0	8.1	345.9	1.0	30.5
S4	5.5	8.1	1231.9	1.0	30.7
S5	6.1	8.1	805.9	1.0	30.5
S6	6.0	8.2	1012.8	1.1	30.5
S7	5.0	8.1	631.4	1.9	30.1
S8	5.9	8.2	915.9	1.2	30.2
S9	5.8	8.2	1010.2	1.0	30.6
S10	6.1	8.1	731.4	0.9	30.2
S11	5.5	8.2	1001.4	1.1	30.8
S12	7.4	8.0	331.1	0.4	30.1
S13	6.8	8.1	1101.5	0.9	30.4
S14	7.1	8.2	1101.9	0.9	30.0
S15	5.9	8.2	1022.0	1.2	30.2
RANGE	5.0-7.4	8.0-8.3	345.9-2031.1	0.9-1.9	30.1-30.9

Ex-Situ Analysis

Table 4 shows the results of in-situ analysis. The BOD level in the Tengi River ranged from 0.50 to 2.81 mg/L. Due to its proximity to the Tanjung Karang oil factory, sample location 2 was discovered to contain a significant amount of industrial waste, particularly oil. Tengi River's COD concentration was 5.10 to 59.10 mg/L, in the range. The chemical oxygen demand (COD) at sample point 1 was significantly higher than it was at the other locations due to the huge quantity of oxygen used during the breakdown of organic materials in the water. Because of this, there would not have been nearly enough oxygen available to support the survival of other aquatic species. At Tengi River, the ammonia nitrogen concentration ranged from 1.10 to 2.97 mg/L. The greatest value of NH_3-N was reported at sample point 11 as it is next to a cemetery. Organic material found in buried remains eventually decomposes. Ammonia and other chemicals containing nitrogen are emitted during the breakdown process. The TSS concentrations in the Selangor River varied from 21.10 to 61.41 mg/L. Numerous pollutants, including silt, dead plant and animal species, industrial waste, and sewage entering the river from nearby sources, might result in high TSS levels.

Water Quality Index (WQI)

The Tengi River's water quality index (WQI) was computed as shown in Figure 2. The water quality of this river was in Classes III and IV, according to the DOE Water Quality Classification, which uses WQI values in the index range of 39.1 to 53.9. Additionally, WQI scores between 0 to 59 show the level of pollution in river water. The findings of the analysis indicate that sample locations 3 and 12 fall into the Class III category, while other places are classified as Class IV.

It was discovered via observation that non-point sources are to blame for river water contamination. This was due to the fact that the study's class IV areas were close to industries, hardware stores, workshops, cemeteries, restaurants, and housing estates. Wastewater discharges, industrial dischargers, drainage, spills, and other factors may all contribute to pollution. This discharges waste that is contaminated physically, chemically, and biologically into the adjoining river. It was discovered pipelines and drains drain chemical and physical effluent from commercial, social, and developmental activities straight into the river without sufficient treatment, which further emphasises the fact that there is spot pollution. Based on Figure 2, the value at Location 2 was the lowest (more polluted), compared to other locations. However, the results from all 15 sample sites showed that the water contamination level ranged from Class III to IV [13].

Table 4. The in-situ data collected at Tengi River.

SAMPLING LOCATION	BOD, (mg/L)	COD, (mg/L)	TSS (mg/L)	NH_3-N, (mg/L)
S1	1.25	**59.10**	91.80	**2.90**
S2	**2.81**	54.20	**141.90**	**2.90**
S3	1.07	9.00	41.60	2.30
S4	1.05	45.50	97.10	2.80
S5	0.63	16.80	30.40	2.30
S6	1.00	7.40	55.70	2.50
S7	0.50	5.20	59.80	1.70
S8	0.54	5.10	48.80	1.10
S9	1.02	21.40	50.20	2.40
S10	1.05	22.10	63.40	2.10
S11	1.94	39.90	91.70	2.97
S12	0.70	38.50	21.10	2.30
S13	0.90	7.01	30.90	2.10
S14	1.01	37.80	43.80	2.30
S15	1.09	37.40	53.10	2.10
RANGE	0.50-2.81	7.01-59.10	21.10-141.90	1.10-2.90

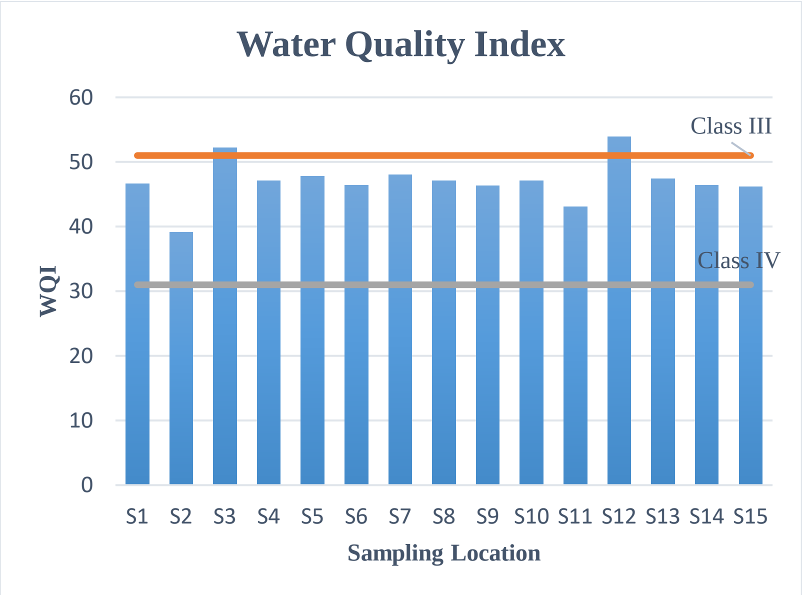

Figure 2. The water quality index results for Tengi River.

Heavy Metals

Heavy metals were measured during sampling at 15 sampling locations along Tengi River, which are Lead (Pb), Zinc (Zn), and Arsenic (As). In this study, the ICP-OES method was used to quantify the presence of heavy metals directly. The total amount of heavy metals detected in river water drawn from the Tengi

River close to Tanjung Karang is displayed in Table 5. The measurements for heavy metals are given in micrograms per litre (µg/L) units.

The concentration of lead in all fifteen locations of the collected water samples ranged between 31.00 to 47.00 µg/L which is below the limit set by the Ministry of Health of Malaysia. The highest value was recorded at sampling location 1 while the lowest was at sampling location 14. The existence of lead (Pb) in the environment is deemed pollution as compared to anthropogenic activities. Pb pollution through the river can be caused by anthropogenic soil activity enrichment. The highest lead concentrations were recorded at sampling locations 1 and 2, which are situated near industrial and agricultural activities, including paddy plantations in Sekinchan and Tanjong Karang [14].

The zinc concentrations in water samples from the Tengi River ranged from 133 µg/L to 522 µg/L, with the highest value observed at sampling location 1 and the lowest at sampling location 13. This suggests that the primary sources of zinc are the numerous buildings and houses in the area, often equipped with metallic roofing containing zinc. Acid rain and pollution can easily wash zinc from these roofs into the water supply. The arsenic (As) concentrations analyzed at the fifteen locations ranged from 6 to 27 µg/L, with the highest value recorded at sampling location 5 and the lowest at sampling locations 12 and 14. Arsenic levels in the Tengi River are sufficiently low to permit its use for home water supply, industry, agriculture, and the preservation of aquatic life. In general, the heavy metals concentration of river water was found to decrease in the following order Zn > Pb > As.

Table 5. The total concentration of heavy metals in Tengi River.

Loc.	**Heavy metals (µg/L)**		
	Pb	**Zn**	**As**
S1	47.00 ± 0.30	522.00 ± 2.20	11.00 ± 3.10
S2	45.00 ± 1.90	228.00 ± 0.70	11.00 ± 2.70
S3	39.00 ± 0.50	180.00 ± 1.80	11.00 ± 1.60
S4	39.00 ± 0.90	395.00 ± 0.60	12.00 ± 1.70
S5	36.00 ± 1.60	277.00 ± 0.20	27.00 ± 2.00
S6	38.00 ± 1.80	212.00 ± 0.70	10.00 ± 2.40
S7	39.00 ± 1.80	187.00 ± 0.40	9.00 ± 1.40
S8	34.00 ± 1.50	159.00 ± 0.50	8.00 ± 1.70
S9	35.00 ± 1.40	142.00 ± 1.20	12.00 ± 1.20
S10	34.00 ± 0.80	165.00 ± 0.60	10.00 ± 1.10
S11	33.00 ± 0.50	138.00 ± 0.40	11.00 ± 1.30
S12	31.00 ± 0.80	149.00 ± 0.80	6.00 ± 0.60
S13	31.00 ± 1.60	133.00 ± 1.00	11.00 ± 3.00
S14	28.00 ± 0.60	148.00 ± 0.50	6.00 ± 1.60
S15	32.00 ± 0.80	137.00 ± 0.50	8.00 ± 2.80
MOH (µg/L)	10.00	3,000.00	10.00
NWQS (µg/L)	50.00	5,000.00	50.00

MOH: Ministry of Health, NWQS: National Water Quality Standard

Table 6. Heavy metal pollution index (HPI) in Tengi River water.

Loc.	Overall HPI values
S1	330.81
S2	317.98
S3	276.99
S4	276.99
S5	261.45
S6	269.54
S7	278.25
S8	242.22
S9	256.38
S10	241.36
S11	234.68
S12	221.25
S13	220.52
S14	200.35
S15	227.82

Heavy Metal Pollution Index (HPI) in Water

In order to calculate the HPI of the water, the mean concentration value of the selected metals which are Pb, Zn and As have been taken into the calculations of HPI with unit weightage (Wi) and standard permissible value (Si) as obtained as shown in Table 6. All sampling locations in Tengi River shows HPI values greater than 100, indicating that these areas were most likely to have high pollution from heavy metals. The HPI was found to be the highest at sampling point 1, reaching 330.81, surpassing the critical threshold value of 100. Notably, all HPI values across the fifteen sampling locations exceeded 100. The lowest HPI value was found at sampling location 14, which was 200.35, but it still exceeded the acceptable HPI value. Temperature, oxygen content, and pH are additional physicochemical parameters that can influence heavy metal speciation.

The primary factor contributing to high HPI values could be the presence of elevated concentrations of lead in the water. Pb pollution through the river can be caused by anthropogenic soil activity enrichment. Lead goes through natural weathering processes, and rocks and soils that contain lead can erode over time and release it into rivers. The Tengi River's location near the urban areas with extensive infrastructure, such as roads, buildings, and roofs, can contribute to lead pollution in rivers, which explains why sampling location 3 has the second highest HPI value (317.98).

CONCLUSION

As a result, it is obvious that it is crucial to comprehend the water quality parameters and the levels of heavy metals in river water. The hazard that such operations provide to aquatic creatures and public health makes water quality monitoring crucial. In this study, the mean values for the water quality parameters of the Tengi River were calculated. According to the results, all sampling sites are categorized in CLASS IV, except sampling sites 3 and 14 are categorized in CLASS III. A lower WQI number indicates that the river is more polluted. All sampling locations in Tengi River show HPI values greater than 100, indicating that these areas were most likely to have high pollution from heavy metals. There has to be further study done in order to improve the research results that may be obtained in the future. To accurately reflect Tengi as a whole, more sampling locations must be selected. The distances of the sample from the discharge site, the accessibility of the sampling location, and the duration of the monitoring must also be considered in order to establish an adequate water quality index. In the upcoming monitoring studies, sediment and biota samples must also be taken in order to obtain the linkages of pollutants between water, sediment and biota. These methods will give a more accurate picture of the data currently available on the availability of metals in the many matrices that make up the coastal environment.

ACKNOWLEDGEMENTS

The authors would like to thank Faculty of Applied Sciences, Universiti Teknologi MARA Shah Alam for the facilities provided and Lembaga Urus Air Selangor members for their assistance, collaboration, and support in our study project. We also thank everyone who has contributed in some way to this effort.

REFERENCES

1. Hanafiah, M. M., Hasan, R. M., Nizam., N. U. M., Aziz, N. H. A. (2021) Water quality of the klang river, Selangor, Malaysia and heavy metal removal using phytoremediation. *Appl. Ecol. Environ. Res.*, **19**, 3655–3677.

2. Nadzirah, S. W. H., Bellona, J., Mathressa, M., Shirley, S. A. K. (2019) Water Quality Assessment of Rivers and Heavy Metal Analysis of Small-Scale Black Pepper Farm in Singai Area, Bau. *Journal of Engineering and Applied Sciences*, **14**, 10018–10022.

3. Fadzillah, N. A. S., Kasmin, H. (2022) Journal of Advancement in Environmental Solution and Resource Recovery Study on the Water Quality Index (WQI) of Parit Besar River in Batu Pahat. *Journal of Advancement in Environmental Solution and Resource Recovery*, **2**, 8–14.

4. Camara, M., Jamil, N. R. B., Abdullah, F. B. (2020) Variations of water quality in the monitoring network of a tropical river. *Global Journal of Environmental Science and Management*, **6**, 85–96.

5. Othman, F., Chowdhury, M. S. U., Jaafar, W. Z. W., Faresh, M. E. M., Shirazi, S. M. (2018) Assessing risk and sources of heavy metals in a tropical river basin: A case study of the Selangor River, Malaysia. *Pol. J. Environ. Stud.*, **27**, 1659–1672.

6. Zamora-Ledezmaa, C., Negrete-Bolagayb, D., Figueroab, F., Zamora-Ledezmac, E., Ni, M., Alexisb, F., Guerreroe, V. H. (2021) Heavy metal water pollution: A fresh look about hazards, novel and conventional remediation methods. *Environmental Technology and Innovation*, **22**, 10154.

7. Baharudin, F., Kassim, J., Imran, S. N. M., Wahab, M. A. (2021) Water Quality Index (WQI) classification of rivers in agriculture and aquaculture catchments in *IOP Conference Series: Earth and Environmental Science*, **646.**

8. Hee, Y. Y., Suratman, S., Aziz, A. A. (2019) Water Quality and Heavy Metals Distribution in Surface Water of the Kelantan River Basin (Malaysia). *Oriental Journal of Chemistry*, **35**, 1254–1264.

9. Yunus, S. M., Hamzah, Z., Wood, A. K., Ahmad, S. (2015) Assessment of heavy metals in seawater and fish tissues at Pulau Indah, Selangor, Malaysia. In *AIP Conference Proceedings*, **1659**, 050007.

10. Ibrahim, T. N. B. T., Othman, F., Mahmood, N. Z. (2020) Baseline Study of Heavy Metal Pollution in a Tropical River in a Developing Country. *Sains Malays*, **49**, 729–742.

11. Razak, M. R., Aris, A. Z., Zakaria, N. A. C. S. Wee, Y., Ismail, N. A. H. (2021) Accumulation and risk assessment of heavy metals employing species sensitivity distributions in Linggi River, Negeri Sembilan, Malaysia. *Ecotoxicol. Environ. Saf.*, **211**, 111905.

12 Arshad, N., Rahman, A. T. A., Osman, R., Jafar, S. M., Aziz, N. W. A. A. (2022) Assessment of Water Quality in the Temenggor Forest Reserve Based on Physicochemical Data and Elemental Content. *Malaysian Journal of Chemistry*, **24(2)**, 1–11.

13. Maharjan, A. K., Wong, D. R. E., Rubiyatno, R. (2021) Level and distribution of heavy metals in Miri River, Malaysia. *Tropical Aquatic and Soil Pollution*, **1 (2)**, 74–86.

14. Shanbehzadeh, S., Vahid Dastjerdi, M., Hassanzadeh, A., Kiyanizadeh, T. (2014) Heavy metals in water and sediment: A case study of Tembi River. *J. Environ. Public Health*, **2014**, 858720.