Assessment of metals contamination in sediment and water of Sungai Gemang, Jeli, Kelantan

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Abstract. You Sediment and water contamination by metals poses a significant environmental risk to aquatic ecosystems worldwide. Concerns about the environmental and health impacts of these metals have grown, emphasizing the need for comprehensive analysis. Sungai Gemang, located near a residential area, serves as a vital source of water and protein. Due to the potential carcinogenic and toxic nature of these contaminants, their impact on both the environment and human health has raised considerable concern. Therefore, this study aims to determine the concentrations of metals (Zn, Pb, Ni, Cu) in the sediment and water samples of Sungai Gemang. Additionally, the correlation between metal concentrations in sediment and water samples was studied. Risk characterization was analyzed using Geoaccumulation Index (Igeo). The results indicate a low distribution of metal concentrations in Sungai Gemang, suggesting an uncontaminated status of the water sources. While the water quality meets acceptance standards, the elevated metal concentrations in sediment compared to water highlight the dynamic interplay between water and sediment. This underscores the importance of sustainable management practices for this crucial aquatic ecosystem.

1 Introduction

Use Rivers serve a variety of human and natural needs, including sediment and water transportation, ecological habitats, irrigation, aquaculture, and ecotourism [1]. Water and sediment are important components of a river. Water bodies have long been identified as crucial natural resources for human services, as well as the primary consumers of several pollutants from a variety of sources [2]. Thus, rivers and sediments may get contaminated with numerous numbers of contaminants [3].

After being released from a source, metals can drastically influence the chemical and physical properties of water and sediment by limiting microbial activity. Metals from sediments can also be released into river water by particle resuspension and microorganism activity at the

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poly-water interface. These soluble metals can be found in aquatic ecosystems such as fish, crabs, and mussels and can be transmitted to human through food chains and consumption. From this, pollutants can interrupt the natural food chain and have both acute and long-term impacts on the human system [4]. Metals in river sediment may also be transferred to groundwater during natural recharge [2]. When these pollutants are discharged into the sediments and water column, variations in environmental parameters such as temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), salinity, and turbidity parameters can impact river water quality [5].

Kelantan, a state in Malaysia, covers an area of about 15,099 km² [6]. The major sources of water in Kelantan are rivers and groundwater, which are used for agriculture, domestic, and industrial activities [7]. However, Kelantan's rivers face great pressure from the increasing population and water usage, which can increase the load of pollutants, especially metals, and reduce the quality of river water [8]. Metal pollution in rivers is a significant concern due to its negative effects [9]. Thus, this study aims to determine the quality of the river by quantifying metal deposition in riverine water and sediment, to control and mitigate water pollution and protect the water bodies from further degradation.

2 Materials and methodology

2.1 Study area

Briefly, Sungai Gemang, Jeli, Kelantan are one of the stream tributaries located along the housing area. The river is roughly 33.4 km long and flows through Jeli before entering the Sungai Lebir (Figure 1). This river is a vital supply for the district's agricultural activities. For sample collection, the samples were collected from three distinct areas; residential area, domestic dumping area and agricultural area (Table 1). This approach aims to identify the primary contributors to water contamination.
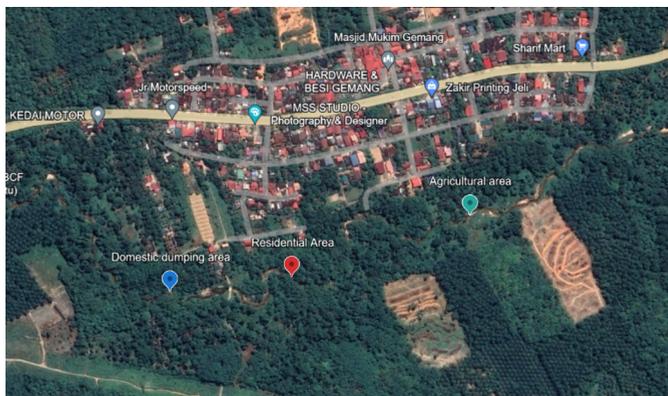

Fig. 1. Map showing sampling sites along the Sungai Gemang, Jeli, Kelantan (Google)

Table 1. Sampling sites

Sampling station	Coordinate
(S1) Agricultural area	05'45'54.29N 101'51'47.65E
(S2) Residential area	05'45'46.25N 101'51'48.28E
(S3) Domestic dumping area	05'45'55.72N 101'51'48.96E

2.2 Sample collection and preparation

The basic chemical and physical water quality parameters include pH, temperature, turbidity, and dissolved oxygen were collected using YSI multiparameter. Water samples were systematically collected during the morning hours to minimize disturbances of natural variations that could impact the analytical outcomes. The samples were collected using 100 mL polyethylene bottles, which were initially rinsed with water from the study site. The sample water was then acidified with 5 mL of 10 % nitric acid. The water samples were kept at 4 °C for subsequent elemental analysis. Prior to analysis, the samples were filtered using Whatman filter paper.

A stainless-steel scoop was used to collect superficial sediments from the bottoms of river reservoirs. Bulk samples were transferred into low-density polyethylene sampling bags, marked, and returned to the laboratory. Then, the samples were stored at -20 °C on the same day. Before drying in an oven at a temperature of 60 °C, all foreign material (e.g., stones and detritus) was removed from the sediment samples [10]. The dried materials were pulverized and filtered using a 50-mesh sieve. The homogenized dried sediment samples were using of HNO^3 and H_2O_2. Sample of water and sediment, were then analysed using Atomic Absorption Spectroscopy (AAS).

2.3 Risk characterization and data analysis

2.3.1 Geoaccumulation index (Igeo)

The geoaccumulation index can quantify the degree of contamination of metals in sediments [11]. This index was calculated by using Equation 1 [12] :.

$$I_{geo} = \log_2 \frac{[sediment]}{1.5 \times reference\ sample} \qquad (1)$$

where, sediment sample was measured in (mg/kg) and reference sample is refer to geochemical background value (Zn : 70 mg/kg, Pb : 13 mg/kg; Ni : 75 mg/kg; Cu : 55 mg/kg).

All calculations and statistical analyses were performed using Microsoft® Excel 2019 and the JMP® version 18 software package. These analyses were conducted to compare the relationships between samples. Pearson matrix analysis was used to determine the strength of correlation between metal levels in water and sediment. The p value of 0.05 shows strong and significant associations.

3 Results and discussion

The evaluations of water quality are listed in Table 2. There were noticeable differences in physicochemical parameters, which were most likely caused by spatial variability between sampling locations and the water management programme. Table 2 shows a temperature variance of around ± 1 °C for all measurements. Water temperature fluctuations are linked to temporal variability during the sample period (8 a.m. to 12 p.m.). Furthermore, the mean value indicated within the acceptable condition outlined by National Water Quality Standard (NWQS). Temperature shows a good positive correlation with pH (r = 0.99).

The concentration of four metals is summarized in Table 3. The mean concentrations in water varied significantly between the studied sites for all metals, with the exception of metal,

which remained below the detection limit. Variations in metal concentrations can be linked to human activities.

Table 2. The physico-chemical quality of water at each sampling site

Sampling station	S1 (Agricultural)	S2 (Residential)	S3 (Domestic dumping)	Legal limit NWQS [13]
pH	7.01 ± 0.10	7.59 ± 0.30	7.28 ± 0.54	5.0 -9.0
Temperature (°C)	27.31 ± 0.02	28.66 ± 0.03	27.92 ± 0.00	Normal (+ 2 °C)
Turbidity (NTU)	15.7 ± 0.62	16.53 ± 0.15	18.76 ± 0.46	< 50
DO (mg/L)	5.80 ± 0.33	5.53 ± 0.00	5.70 ± 0.37	Not indicate

One significant observation is that elevated mean concentrations of Pb and Cu are found only in the water bodies within residential areas. It was indicated that metal pollution discharge from residential activities influenced the water quality. Lead and copper can be found as pollutants in several activities, such as transportation, industrial activities, metal workshops, and coal combustion [14]. Compared to the National Water Quality Standard for Malaysia, the average concentration of all studied elements in all studies areas was below the recommended limits. However, the results of the water quality assessment did not show the real situation because some of the metal inputs could be accumulated in fishes or absorbed into sediment particles [15].

Table 3. Average metal concentration in water sample of Sungai Gemang

Concentration of metal (mg/L)	S1 (Agricultural)	S2 (Residential)	S3 (Domestic dumping)	Legal limit NWQS (Class IIA/IIB [13]
Zn	$3.3 \times 10^{-3} \pm 0.01 \times 10^{-2}$	$6.6 \times 10^{-3} \pm 1.2 \times 10^{-2}$	$2.2 \times 10^{-3} \pm 0.02 \times 10^{-3}$	5.0
Pb	ND	$3.05 \times 10^{-2} \pm 2.3 \times 10^{-2}$	ND	0.05
Ni	ND	$2.1 \times 10^{-2} \pm 0.2 \times 10^{-3}$	$1.1 \times 10^{-2} \pm 2.1 \times 10^{-3}$	0.05
Cu	ND	$3.0 \times 10^{-3} \pm 0.00$	ND	0.02

Mean $\pm$ standard deviation (n=10)
ND : Not detected

Table 4 shows that the average concentrations in sediment samples varied significantly across the sampling sites ($p<0.05$). The metal elements in surface sediments might reflect the quality of the water, because these metals can remobilised and redistributed between water and sediment under particular situations [16]. However, contrasting trend is seen, where elevated levels of Zn was recorded in the sediments of residential area instead of from agricultural area and domestic dumping areas as shown in Table 4. These data suggest that metal

concentrations in sediment fractions are mainly independent of current inputs and presumably represent long-term metal deposition in the aquatic system, with sediment acting as a sink for metal residues [17]. Additionally, elevated metal concentrations in sediments may be linked to prolonged anthropogenic activities along river basins [18].

Table 4 Average metal concentration in sediment layer of Sungai Gemang and Geoaccumulation Index (*Igeo*) (mg/kg)

Concentration of metal (mg/kg)	S1 (Agricultural)	S2 (Residential)	S3 (Domestic dumping)
Zn	9.36 ± 1.00	15.42 ± 1.00	11.63 ± 2.60
Pb	5.51 ± 0.61	8.27 ± 4.10	0.17 ± 0.01
Ni	0.12 ± 0.05	3.12 ± 4.80	ND
Cu	9.94 ± 4.20	3.75 ± 1.00	12.64 ± 7.50
Igeo (mg/kg)			
Zn	-3.49	-2.77	-3.17
Pb	-1.82	-1.32	-1.51
Ni	-10.57	-5.17	0
Cu	-3.05	-4.46	-2.71

Mean ± standard deviation (*n*=10)
ND : Not detected

The geoaccumulation index (*I*geo) fundamentally specifies seven descriptive groups as indicated in Table 5 by examining the effect of geochemical background concentrationson the metal assessment contamination in sediment.

Table 5. Classes of *I*geo [19]

*I*geo value	*I*geo class	Pollution level
≤ 0	0	Unpolluted
0-1	1	Unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	Moderately to strongly polluted
3-4	4	Strongly polluted
4-5	5	Strongly to very strongly polluted
> 5	6	Very strongly polluted

The *I*geo values for Zn, Pb, Ni and Cu for each studied site are shown in Table 4. The results indicated that the sediment sample can be classified as 'unpolluted' with respect to all elements. The *I*geo values below than zero suggesting that a negligible pollution risk existed in the Sungai Gemang. This trend is found consistent with the concentration of metals found in water and sediment sample, where is below the guidelines limit.

4 Conclusion

This study investigated the metal distribution in water and sediment samples from Sungai Gemang, Jeli, Kelantan. The results showed that the average concentrations of Zn, Pb, Ni, and Cu in the sediment samples were higher than those in the water samples. All targeted elements were within the defined limits. The geoaccumulation index (Igeo) indicated that the values of Zn, Pb, Ni, and Cu for all sampling sites were below zero, suggesting a minor pollution risk in Sungai Gemang. Although there is no significant pollution, more attention should be given to sustainable management approaches for this vital aquatic habitat.

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