Journal of Experimental Biology and Agricultural Sciences, August - 2022; Volume – 10(4) page 870 – 878

Journal of Experimental Biology and Agricultural Sciences

http://www.jebas.org

ISSN No. 2320 – 8694

Assessment of trace element accumulation in surface sediment of Sepang Besar river, Malaysia

Kumar Krishnan[1*], Nadia AS[1], Chong MY[2], Prakash Balu[3]

[1]Faculty of Health & Life Sciences, INTI International University, Negeri Sembilan, Malaysia
[2]Matrix Global School, Negeri Sembilan, Malaysia
[3]Department of Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS) Tamil Nadu, India

Received – April 20, 2022; Revision – July 03, 2022; Accepted – July 23, 2022
Available Online – August 30, 2022

DOI: http://dx.doi.org/10.18006/2022.10(4).870.878

KEYWORDS

Trace element

Pollution

Enrichment factor

Geo-accumulation

ICP-MS

ABSTRACT

Due to non-scientific industrial activity and urbanization, trace elements contamination has posed a threat to Malaysia's biodiversity-rich coastal wetlands, streams, estuaries, and mangroves. Commercialization has taken a toll on mangroves in backwater canals and along the banks of the Sepang River. As a result, a thorough examination of sediment quality from the Sepang River mangrove habitats is done with a focus on trace element pollution and pollution issues, taking into account the enormous ecological services that are offered to coastal communities and offering guidance for upcoming restoration efforts. The concentration of trace elements (Cr, As, Pb, Ni, Mo, Co, Cd, and Hg) in the sediment samples was measured using an induced plasma mass spectrometric (ICP-MS). Results of the study revealed that Arsenic (As) levels exceeded the Canadian range of low effects, indicating the possibility of deleterious biological consequences on mangrove plants and animals. In all sampling locations, the enrichment factor (EF) analysis revealed extraordinarily high enrichment of As (9.89–23.65) and Mo (4.74–12.03). The geo-accumulation index of As (1.83 – 3.04), Mo (1.40 – 2.74), and Cd (0.652 – 3.03) revealed that mangrove locations in the Sepang River have almost extreme pollution effects. Pearson's correlation, which deduced the anthropogenic influence of As, Cd, and Mo in mangroves, backed up this claim. Results of the study recommended that continue monitoring of pollutants released from anthropogenic sources is highly required and there is a strong need to take more stringent measures to protect the environment.

* Corresponding author
E-mail: kumar.krishnan@newinti.edu.my (Kumar Krishnan)

Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

1 Introduction

The term "trace elements" is also known as "common contaminants," which refers to a chemical element found in tiny amounts in a sample (soil, water, or air) or environment (Mishra et al. 2020). Metallic elements with a high atomic number (weight) > 100 grams or a relative density of more than five that are lower on the periodic table are known as trace elements (Malhi et al. 2004; Bhunia 2017). Living organisms only require trace elements in small amounts to grow normally. Some trace metals have a deleterious nutritional effect on plants, animals, and people, whereas others have a beneficial nutritional effect. Natural and man-made (human activity) sources of trace metals are usually found in the environment (Pandey et al. 2019; Islam 2021). The incorporation of heavy metals into agricultural and seafood products are a form of pollution (Ali and Khan 2019; Krishnan et al., 2022). Lead, cadmium, chromium, nickel, silver, and zinc are among the biologically active trace metals that are ground in soil (Zhang et al. 2019). Micronutrient levels are influenced by the amount of sewage sludge, industrial waste, and fertilizer pollutants that enters into the soil (Alloway 2013; Ozkara et al. 2016). Although plants and animals require less than 20 trace elements for optimum growth, high quantities of these elements can be phytotoxic and harm animal health (Garbisu et al. 2020; Zine et al. 2020). Data on trace elements in soils have been collected from a variety of worldwide habitats, including industrialized towns, highways, rural areas in former mining districts, roadsides, and agricultural land utilized for crops or grazing (Yuan et al. 2004; Burges et al. 2018).

Anthropogenic activities including aquaculture, mining, tourism, agriculture, and the industrial usage of metals have increased the concentrations of heavy metals in sediments in Malaysia, further degrading the ecosystem in the mangrove zone (Sericano et al. 1995; Pande and Nayak 2013). A deposit is a detritus-eating marine living organism, which can absorb metals from polluted ground and water. It then becomes a critical channel for toxins to reach its predators (including humans who consume the affected marine organisms) Due to huge economic expansion and activities, as well as the concentration of human population and farming in coastal areas, a series of multi-element studies have been conducted along the west coast of Peninsular Malaysia (Kamarudin et al. 2015). Surface sediments are the final resting place for all sorts of pollution generated by human activities, resulting in a wide range of environmental issues. Furthermore, surface sediment interacts regularly with suspended elements, affecting metal release into overlying water (Zvinowanda et al. 2009). This research focuses on sediments collected from the Sepang River on Peninsular Malaysia's west coast. The current degree of contamination, which is continually changing, is indicated by the top several inches of sediments. As a result, there is a need to examine the pollution level of elements using sediment samples since sediments can provide useful information on marine pollution. The degree of pollution in the sediment of the Sepang River was evaluated using the geoaccumulation index and enrichment factor.

2 Materials and Methods

2.1 Study sites and samples collection

The research area of this study is focused on the sediments collected from the Sepang Besar River (Sungai Besar Sepang) in 2019, which falls along the Straits of Malacca in the Sepang District, Selangor, West Malaysia. Figure 1 shows the GPS coordinate: 02◦ 36’7. 41’’ N and 101◦ 44’ 8.62’ E and the

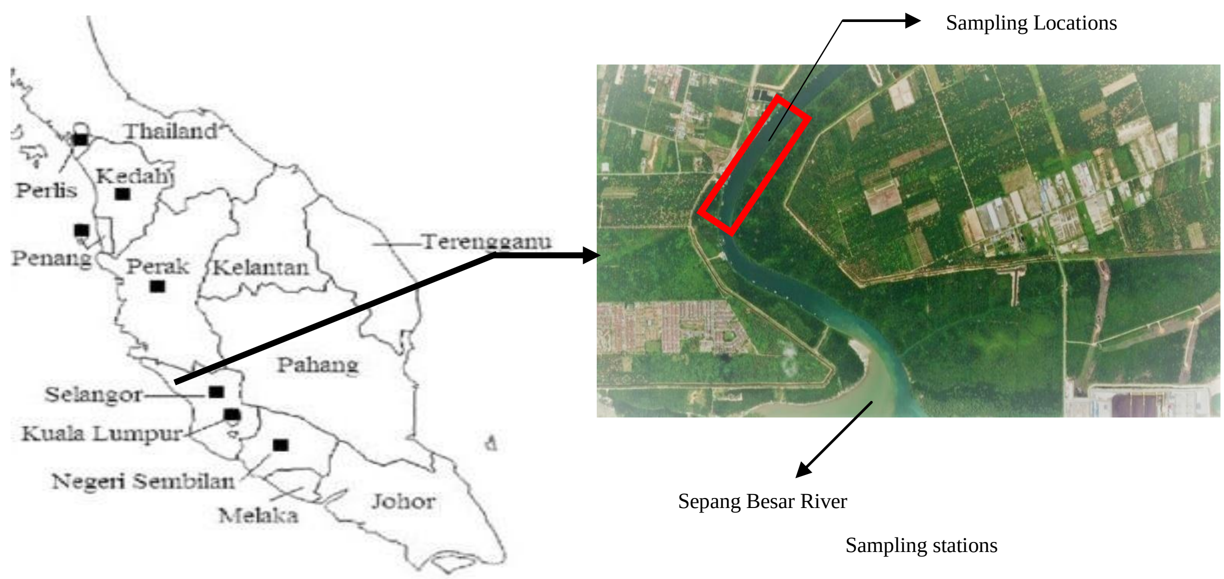

Figure 1 Map of the mangrove region sampling site along Sepang Besar River in Selangor, Malaysia.

Table 1 The description of the sampling site

Location ID	Nearby activity/Location	GPS Coordinate
Station 1	Shrimp pond, Bukit Pelanduk	02° 39'35.8'' N 101° 44'8.62' E
Station 2	Pig Farm, Bukit Pelanduk	2° 39'18.6' N 101° 44'7.85' E
Station 3	Sepang Fish Farm	2° 36'7.41' N 101° 42'39.4' E

nearby activities from the sampling station as also stated in Table 1. The study area's environment has year-round tropical conditions with temperatures ranging from 27°C to 34°C and a moderately humid atmosphere. The cloud cover is modest and November is the wettest month though rain rarely occurs. The Sepang district experienced rapid and significant growth from 1995 to 2015 because of its proximity to the administrative capital of Malaysia- Putrajaya. This expansion of urban growth has affected Sungai Sepang Besar's ecosystems. The forests and mangroves of the Sepang district cover about 546.7 hectares of reserved land corridors along with the Sungai Sepang Kecil and Sungai Sepang Besar rivers. As part of the Sepang 2025 Local Plan, mangrove forests are designated as Level 1 Environmentally Sensitive Areas (SEAs) (Yasin et al., 2019; Muhammad et al., 2020).

2.2 ICP-MS measurements

A plastic spoon was used to scrape the top layer of the mangrove sediments, which weighed roughly 600 grams and were then put into a labeled, clean plastic bag. The sediments were collected at random from a depth of 3.0-5.0 cm. In the laboratory, the sediments were dried for at least 72 hours at 80°C in a kiln until a dry weight was obtained. Using a glass mortar, each sediment sample is ground into a fine powder form. Then the powder was filtered through an opening made of stainless steel of 63 µm. Samples were stored in plastic pill boxes after being stirred vigorously and until ready for further analysis (Kumar et al. 2014).

From the collected sample, 200 mg of homogenized Sepang Besar River sediment samples were digested in a solution of 5 mL concentrated nitric acid (49 percent HF - analytical grade) and 2 mL concentrated hydrofluoric acid (67 percent HNO3 - Trace Metal Fisher brand) using a microwave. Each digestion batch contained duplicate samples, SRM (IAEA soil 7), and at least two blank acid reagents. The default settings of the microwave are 1200 watts, 200 °C, ramped for 20 minutes and maintained for 15 minutes at a constant pressure of 0.6 MPa. The sediment samples were digested for 15 minutes. The samples were withdrawn from the microwave oven after cooling for at least 30 minutes while maintained at a microwave temperature below 50°C. The digestion process was repeated with the addition of 1 mL HNO_3 if there were any residues in the solutions to produce cleaning solutions. Following the transfer to a Teflon beaker, the solution was rinsed with 3mL of Milli-Q water. The digested sample was then put in a Teflon beaker, which was heated at 60 to 70 degrees Celsius until dry and then rinsed with 20 milliliters of Milli-Q water. After being filtered into a polythene container with filter paper, the mixture was diluted with Milli-Q water to a level of 50 mL for ICP-MS analysis (Whatman brand, diameter 125mm) (Marque et al. 2000, Suhaimi et al. 2018).

2.3 Statistical analysis

The data were analyzed by the calculation of average and standard deviation via Microsoft Office Excel 2010. Pearson correlation analysis was performed with SPSS 26.0 for Windows software. The two-tailed test was used to analyze the statistical significance of the correlation coefficient between trace elements in the sediment.

2.4 Tools to measure quality assurance and pollution level

In the analytical method analysis, the SRM (IAEASoil-7) was employed as a tool to measure quality control and quality assurance. The procedures to measure the SRM was similar to the procedures employed in sample analyses. Equation 1 shows how the recovery (percentage) is calculated (Alfian et al. 2020).

$$\% \text{ recovery} = \frac{C_{\text{measured}} - C_{\text{certified}}}{C_{\text{certified}}} \text{ x } 100\% \rightarrow \quad (1)$$

The z-score was also used to evaluate the precision and accuracy of the analytical techniques used. By calculating the standardized difference z while taking into account the uncertainties of both the certified value and the measured results of the SRM, the accuracy of the analysis method is determined. Equation 2 is used to calculate the z-score.

$$z = \frac{c_{measured} - c_{certified}}{\sqrt{\sigma_{measured}{}^2 + \sigma_{certified}{}^2}} \rightarrow \quad (2)$$

If the Z-score falls between -3 and 3, it means that the certified value should lie within the 99 percent confidence interval of the SRM analysis results.

The pollution or contamination status of sediment can be obtained by evaluating the geo-accumulation index (Igeo) and the enrichment factor (EF). The enrichment factor (EF) was developed to evaluate possible anthropogenic sources of hazardous elements as shown in Equation 3 (Kumar et al., 2014):

$$EF = [(X/Y)_{sample}]/[(X/Y)_{shale}] \rightarrow \quad (3)$$

Where X_{sample} is used to refer to the element concentration in the experimental sample, Y_{sample} is used to refer to the Fe concentration in the sample, X_{shale} is used to refer to the element concentration in the average shale, and Y_{shale} is used to refer to the element concentration in the average sale. According to Sutherland's (2000) version of the EF values, EF = 1 denotes no enrichment, minor enrichment if EF = 3-5, EF = 5–10 indicates moderately severe enrichment, severe enrichment if EF = 10–25, EF = 25–50 extremely severe enrichment, and if EF > 50 it indicating the sediment extremely severe enrichment.

The Geo-Accumulation Index (I_{geo}), developed by Muller (1969), is one of the most accurate tools for determining the contaminated state of a sample. It can be determined by equation (4):

$$I_{geo} = \log_2(X_n/1.5Y_n) \rightarrow \quad (4)$$

Whereas X_n denotes the amount of an element in the experiment sample, Y_n denotes the average quantity of an abundant and common element, and X_n denotes the amount of an element in the experiment sample (Turekian and Wedepohl 1961).

To reduce the variation caused by lithogenic influences, a background matrix correction factor of 1.5 is used. Muller (1969) divided the Igeo value into seven categories: virtually unpolluted if I_{geo}=0; 0-1, unpolluted to moderately polluted if I_{geo}=0-1, moderately polluted if I_{geo}=1-2, heavily polluted if I_{geo}=3-4, heavily to severely polluted if I_{geo}=4-5; and, extremely polluted if I_{geo} greater than 5.

3 Results and Discussion

Results presented in Table 2 show the certified and measured value, the percentage recovered, and the coefficient of variation (z-score). The SRM recovery and coefficient of variation percentages varied from 76 to 112 % and - 0.91 to 0.81, respectively. The recoveries between the measured and certified value in the ICP-MS method are within the acceptable range i.e. 100 ± 20% (Alfian et al. 2020). As shown in table 2, the calculated z-score for each element using the ICP-MS technique is acceptable and lies between -3 and +3 (Kumar et al. 2014).

Table 3 shows the concentration of trace elements in sediments collected at the three sampling locations. The average

Table 2 The recoveries and z-score between measured and certified values of Soil–7

Elements	Measured value Soil-7 (mg/kg)	Reference value Soil-7 (mg/kg)	Recoveries (%)	z-score
As	12.3 ± 0.9	13.4 ± 0.8	109	- 0.91
Cd	1.4 ± 0.4	1.3 ± 0.7	93	0.12
Co	9.2 ± 0.6	8.9 ± 1.2	97	0.22
Cr	66 ± 8	60 ± 14	91	0.37
Hg	0.038 ± 0.018	0.04 ± 0.03	105	- 0.06
Mo	3.3 ± 0.9	2.5 ± 1.6	76	0.70
Ni	23.2 ± 4.3	26 ± 5	112	- 0.42
Pb	72.1 ± 10.2	60 ± 11	83	0.81

Table 3 The concentrations of trace elements (mg/kg) at the three sampling location

Heavy metals	Station 1	Station 2	Station 3
As	16.77 ± 1.09	16.76 ± 1.16	7.258 ± 0.294
Cd	0.116 ± 0.006	0.092 ± 0.005	0.022 ± 0.006
Co	3.295 ± 0.142	3.174 ± 0.225	2.791 ± 0.117
Cr	17.32 ± 12.67	23.03 ± 0.68	10.85 ± 0.34
Hg	0.014 ± 0.002	0.018 ± 0.007	0.005 ± 0.001
Mo	5.688 ± 0.956	6.065 ± 0.652	2.391 ± 0.746
Ni	9.778 ± 1.14	10.72 ± 1.96	4.967 ± 0.136
Pb	16.44 ± 1.38	16.38 ± 1.23	10.60 ± 0.20

concentration of As, Cd, Co, Cr, Hg, Mo, Ni, and Pb (in mg/kg) from all stations are13.59, 0.077, 3.087, 17.07, 0.012, 4.715, 8.489 and 14.47, respectively. In general, trace element accumulation in sediments at Station 1, Station 2 and Station 3 were found in the order of Cr >As>Pb> Ni > Mo > Co > Cd > Hg, Cr > As >Pb> Ni > Mo > Co> Cd > Hg, and Cr >Pb> As > Ni > Co > Mo > Cd > Hg. The concentration of Cr was highest and Hg was lowest at all sampling locations. The mean concentrations of all trace elements were found highest at stations 1 and 2 than at station 3. Sediment particles are made up of biogenic and non-biogenic (lithogenic) components and are considered to be the final sinks for trace elements transferred to the mangrove environment. Water has a lower capacity for accumulating persistent hazardous chemicals than sediments (Rodriguez-Barroso et al. 2008; Yuan et al. 2011).

Results presented in table 4 revealed the comparisons between the hazard trace elements reported in this study with the MacDonald Canadian Freshwater Sediment Quality Guidelines (2000) and other studies on rivers in Malaysia and elsewhere. The deposits were considered clean to slightly contaminated if the trace element content in the sediment is less than the threshold effect levels TEL). No effect on the majority of sediment species is expected if the trace element concentration is lower than the TEL value. Sediments are classified as heavily polluted if the trace element concentrations are higher than the probable effect levels (PEL). If the concentration of trace elements exceeds the Freshwater Sediment Quality Guidelines (FSQGs – PEL) level, the consequences are negative impacts will be on the majority of sediment-dwelling species. The concentrations of Cd, Co, Cr, Ni, and Pb in the present study were lower than other studies of Malaysia river sediments except for As which in the present study is slightly higher than previous studies conducted in the Juru river for example (Krishnan et al. 2022). Furthermore, the concentration of Cd, Co, Cr, Ni, and Pb were found to be lower than the Canadian FSQGs, except for As, which were higher than the Canadian FSQGs' TEL values. The concentration of Asin Sepang River sediments was found to be 2.3 times higher than that of the Canadian -FSQGs – TEL value (MacDonald et al. 2000). These results show that the Sepang River sediments were contaminated with As, and could have a negative impact on the majority of sediment-dwelling species. Anthropogenic activities like dredging, the discharge of industrial and municipal garbage, etc. may be to blame for this. This research's findings are in line with earlier findings (Zulkifli et al. 2014, Yasin et al. 2019).

The enrichment factor (EF) is presented in Table 5. The EF analysis demonstrated an anthropogenic source of metal buildup in the Sepang River mangrove sediments. The EF of As, Cd, Co, Cr, Hg, Mo, Ni, and Pb exhibited enrichment from numerous sources, which might be attributable to industrial discharges, mangrove exploitation, aquaculture operations, agricultural inputs, or fertilizers (Nath et al. 2021). In all sampling locations, the EFs of As (EF values 9.89–23.65) and Mo (EF values 4.74–12.03) exhibit severe to excessive enrichment. On the other hand, Cd and Pb

Table 4 Comparison of trace elements in this study with other studies and Canadian - FSQGs in (mg/kg)

Various sites	As	Cd	Co	Cr	Hg	Mo	Ni	Pb	Ref
Sepang River Present study	6.93 -17.9 (13.6)	0.028 -0.122 (0.077)	2.66 – 3.41 (3.09)	2.77 - 25.9 (17.1)	0 – 0.713 (0.0123)	1.58 – 6.79 (4.71)	4.81 - 12.98 (8.49)	10.4 - 17.94 (14.5)	
Sepang River, Malaysia	na	1.15±0.04	na	na	na	na	26.05±0.08	86.89±0.13	Zulkifli et al. 2014
Juru River	9.15 – 11.47 (10.5)	0.572 – 0.696 (0.639)	7.70 – 8.89 (8.23)	78.85 – 89.04 (82.21)	na	na	na	27.64 – 45.25 (34.52)	Krishnan et al. 2022
Linggi River	3.6 – 65.9 (36.0)	0.09 – 1.10 (0.29)	na	1.8 – 105 (33.2)	na	na	1.8 – 29.7 (10.3)	8.2 – 52.3 (30.0)	Khan 1990
Langat River, Selangor	12.4 – 27.3 (17)	3.0 – 37.9 (12.1)	na	11 – 73 (29)	na	na	na	na	Sarmani 1989
Klang River, Selangor	na	0.57 – 2.19 (1.54)	na	na	na	na	5.9 – 24.5 (16.3)	24.2 – 64.1 (47.9)	Naji and Ismail 2016
Kerteh River, Terengganu	na	4.0 – 5.0 (4.3)	na	13 – 67 (33.7)	na	na	7 – 24 (11.2)	11 – 25 (15.5)	Rozaini et al. 2010
Han River, Korea	na	0.05- 1.02	na	na	na	na	9.16- 45.0	14.2- 96.6	Kim et al. (2011)
Hainan Island, China	na	0.11-0.13	na	na	na	na		15.0-19.0	Qiu et al. (2011)
Canadian - FSQGs TEL	5.9	0.60	na	37.3	0.17	na	18	35.0	MacDonald et al. 2000
Canadian - FSQGs PEL	17.0	3.50	na	90.0	0.49	na	36	91.3	MacDonald et al. 2000

Table 5 Enrichment factor for trace element in sediments of Sepang Besar River

Heavy Metal	Station 1	Station 2	Station 3
As	22.164 ± 1.44	22.154 ±1.53	9.595 ±0.37
Cd	1.843 ± 0.09	1.452 ± 0.07	0.354 ± 0.09
Co	0.314 ± 0.01	0.302 ± 0.02	0.266 ± 0.01
Cr	0.404 ± 0.27	0.537 ± 0.02	0.253 ± 0.01
Hg	0.401 ± 0.05	0.491± 0.18	0.073 ±0.07
Mo	11.280 ± 1.73	12.028 ±1.29	4.742 ±1.46
Ni	0.277 ± 0.03	0.304 ± 0.05	0.141 ± 0.01
Pb	2.794 ± 0.23	2.783 ± 0.21	1.801 ± 0.03

Table 6 Geo-accumulation index for trace elements in sediments of Sepang Besar River

Heavy Metal	Station 1	Station 2	Station 3
As	3.037 ± 0.09	3.037 ± 0.10	1.829 ± 0.06
Cd	3.034 ± 0.07	2.690 ± 0.07	0.652 ± 0.39
Co	-6.902 ± 0.06	-6.956 ± 0.10	-7.141 ± 0.06
Cr	-8.565 ± 1.72	-8.153 ± 0.04	-9.240 ± 0.04
Hg	1.654 ± 0.19	1.946 ± 0.50	-0.043 ± 0.53
Mo	2.648 ± 0.21	2.740 ± 0.16	1.397 ± 0.48
Ni	-8.829 ± 0.17	-8.696 ± 0.23	-9.806 ± 0.04
Pb	-2.910 ± 0.12	-2.915 ± 0.11	-3.543 ± 0.03

enrichment ranged from low to severe. Other trace elements including Cr, Co, Hg, and Ni did not exhibit any enrichment at any of the sampling sites. The EF of metals and heavy metals can be useful as an indirect indicator for assessing sediment pollution or toxicity. However, relying solely on the enrichment factor to assess sediment toxicity at a given location is insufficient. To determine the sediment's toxicity at a particular location, the degree of contamination in the sediment should be considered and compared to sediment guidelines. Examples of anthropogenic sources of trace elements, such as waste disposal, industry, and urbanization are the factors that contribute to the highest enrichment factor (EF) (Gao et al. 2010; Krishnan et al. 2022).

Based on the data presented in Table 6, the geo-accumulation index (Igeo) of Co, Cr, Pb, and Ni are below zero, which indicates that the examined mangrove sediment in the Sepang mangrove forest is unpolluted. Meanwhile, at station 3, the positive value of the Cd geoaccumulation index (Igeo) was recorded between 0 and 1, indicating that the mangrove area is significantly polluted. However, in Stations 1 and 2, the Igeo index was recorded between 3 and 4 suggests that the analyzed mangrove sediment in the Sepang mangrove forest is heavily contaminated with As and Cd. The geo-accumulation index of Mo and Hg at stations 1 and 2 falls in the class range between 2 and 3 indicating that the mangrove area is moderate to strongly polluted. Based on Igeo value, it can be concluded that the studied area enriched with As, Cd, Mo, and Hg. The presence of various metals in sediment may result from the interaction of elevated particulate matter with relatively unpolluted sediments (Singh et al. 2020).

The pollution of As, Cd, Mo, and Pb was assumed to have occurred as a result of anthropogenic activities nearby the sampling location as mentioned in Table 1. The use of phosphate fertilizers, lead-arsenate pesticides, and pesticides in agricultural activities is also a possible source of the elements As and Pb (Chen et al. 2004). At Sungai Besar Sepang, a noticeable alteration in mangrove vegetation was detected, indicating a transition from primary mangroves to mixed mangroves and second-rate mangroves. Another noteworthy shift was also observed at the river mouth of the Sungai Sepang Besar, where mangroves were reduced and degraded. The change in land use and land cover in the Sepang District has influenced river features, resulting in a dramatic shift in mangroves (Yasin et al. 2019).

Table 7 Pearson correlation coefficients (r) between trace elements (N = 12) concentrations in sediment samples

	As	Cd	Co	Cr	Hg	Mo	Ni	Pb
As	1							
Cd	.962**	1						
Co	.872**	.908**	1					
Cr	.549	.473	.395	1				
Hg	.864**	.805**	.648*	.579*	1			
Mo	.217	.405	.478	.264	.228	1		
Ni	.908**	.849**	.719**	.520	.778**	.062	1	
Pb	.992**	.946**	.874**	.463	.834**	.158	.881**	1

*: p<0.05; **: p<0.01

In this study, the relationships between element concentrations in surface sediments were investigated using a Pearson's correlation analysis. Table 7 shows the result of correlation coefficients between element concentrations in surface sediments. The relationship between As and Cd, As and Co, As and Hg, As and Ni, As and Pb, Cd and Co and Cd and Hg, Cd and Ni, Cd and Pb, Co and Pb, Hg and Pb, Ni and Pb, and Ni and Pb reveal high correlations between elements with r values of 0.962, 0.872, 0.864, 0.908, 0.982, 0.908, 0.805, 0.849 respectively. Based on the results of correlations analysis, the above trace elements are likely to have come from common sources (Landajo et al. 2004; Kumar et al. 2014). A tepidly positive correlation exists between As and Cr, Cd and Cr, Co and Mo, Cr and Hg, Cr and Ni, Hg and Ni with corresponding r values of 0.549, 0.473, 0.478, 0.579, 0.520, 0.778 respectively.

Conclusion

This study attempted to assess the status of several trace elements (Cr, As, Pb, Ni, Mo, Co, Cd, and Hg) in the surface sediments of the Sepang Besar River. The study showed that the total heavy metals concentrations in the sediment samples in the streams followed the order of Cr > As > Pb > Ni > Mo > Co > Cd > Hg. The values of EF and Igeo show that the sediments surrounding the Sepang River is contaminated with trace metals, especially As, Cd, Mo, and Pb. Pearson's correlation makes it clear that there is an anthropogenic influence of As, Cd, and Mo in the mangroves of the Sepang Besar River. Data collected from the sediments of this study indicate that there is a significant discharge of trace elements to the estuary from anthropogenic activities, though more research is needed to determine the true ecological impact of this pollution on the immediate environment to preserve its biodiversity and resources for human communities.

Acknowledgments

The authors would like to thank INTI International University, Nilai, Malaysia, for their financial assistance through the Research Grant Scheme (Seed Grant no: INTI-FIT-15-02-2021).

References

Alfian, Yusuf, S., & Sutisna. (2020). Elemental analysis of SRM 1547 peach leaves, 1573a tomato leaves, and 1570a spinach leaves. *Journal of Physics*: *Conference Series*, *1436*, 012044.

Ali, H., & Khan, E. (2019). Bioaccumulation of Cr, Ni, Cd and Pb in the economically important freshwater fish *Schizothorax plagiostomus* from three rivers of Malakand Division, Pakistan: risk assessment for human health. *Bulletin of Environmental Contamination and Toxicology*, *102*, 77–83. https://doi.org/10.1007/s00128-018-2500-8.

Alloway, B. J. (2013). Sources of Heavy Metals and Metalloids in Soils. *Heavy Metals in Soils 22*, 11-50.https://doi.org/10.1007/978-94-007-4470-7

Bhunia, P. (2017). Environmental Toxicants and Hazardous Contaminants: Recent Advances in technologies for Sustainable Development. *Journal of Hazardous, Toxic, and Radioactive Waste*, *21*, 02017001.

Burges, A., Alkorta, I., Epelde, L., & Garbisu, C. (2018). From phytoremediation of soilcontaminants tophytomanagement of ecosystem services in metal contaminated sites. *International Journal of Phytoremediation*, *20*, 384–397.

Chen, Y.X., Lin, Q., He, Y.F., & Tian, G.M. (2004). Behavior of Cu and Zn under combined pollution of 2,4-dichlorophenol in the planted soil. *Plant and Soil*, *61*, 127–134.

Gao, X., Arthur Chen, C.T., Wang, G., Xue, Q., Tang, C., & Chen, S. (2010) Environmental status of Daya Bay surface sediments inferred from a sequential extraction technique. *Estuarine, Coastal and Shelf Science, 86*(3), 369–378.

Garbisu, C., Alkorta, I., Kidd, P., Epelde, L., & Mench, M. (2020). Keep and promote biodiversityat polluted sites under phytomanagement. *Environmental Science and Pollution Research, 27*, 44820–44834.

Islam, M. S. (2021). Preliminary assessment of trace elements in surface and deep waters of anurbanriver (Korotoa) in Bangladesh and associated health risk. *Environmental Science and Pollution Research, 28*(23), 29287-29303, Doi:10.1007/ s11356-021-12541-5.

Kamarudin, M. K. A., Toriman, M. E., Rosli, M. H., Juahir, H., et al. (2015). Analysis of meander evolution studies on effect from land use and climate change at the upstream reach of the Pahang River, Malaysia. *Mitigation and Adaptation Strategies for Global Change*, *20*, 1319-1334.

Khan, I.S.A.N. (1990). The mineralogy and trace element constituents of suspended streamsediments ofthe Linggi River Basin, Malaysia. *Earth*, *4*, 133–139.

Kim, K.T., Ra, K., Kim, E.S., Yim, U.H., & Kim, J.K. (2011). Distribution of Heavy Metals in the Surface Sediments of the Han River and its Estuary, Korea, SI 64. *Proceedings of the 11th International Coastal Symposium*, pp. 903 – 907. Szczecin, Poland, ISSN 0749-0208.

Krishnan, K., Saion, E. B., CK, Y., Chong, M. Y., & Nadia, A. S. (2022). Determination of Trace Elements in Sediments Samples by Using Neutron Activation Analysis. *Journal of Experimental Biology and Agricultural Sciences, 10*(1), 21–31. https://doi.org/10.18006/2022.10(1).21.31

Kumar, K., Saion, E., Halimah, M., Yap, C., & Hamzah, M.S. (2014). Rare earth element (REE) in surface mangrove sediment by instrumental neutron activation analysis. *Journal of Radioanalytical and Nuclear Chemistry*, *301*, 667–676.

Landajo, A., Arana, G., de Diego, A., Etxebarria, N., Zuloaga, O., & Amouroux, D. (2004). Analysis of heavy metal distribution in superficial estuarine sediments (estuary of Bilbao, Basque Country) by open-focused microwave-assisted extraction and ICP-OES. *Chemosphere*, *56*,1033–1041.

MacDonald, D.D., Ingersoll, C.G., & Berger, T.A. (2000). Development and evaluation of consensus-basedsediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology*, *39*, 20-31 Doi:http://dx.doi.org/ 10.1007/s002440010075.

Malhi, Y., Baker, T.R., Phillips, O.L., Almeida, S., et al. (2004). The above-ground coarse wood productivity of 104 neotropical forest plots. *Global Change Biology*, *10*, 563–591.

Marques, M.J., Salvador, A., & Morales-Rubio, A.E.M. (2000). Trace element determinationin sediments: a comparative study between neutron activation analysis (NAA) and inductively coupled plasma-mass spectrometry (ICP-MS), *Microchemical Journal*, *65*, 177–187.

Mishra, A.K., Santos, R., & Hall-Spencer, J.M. (2020). Elevated trace elements in sediments andseagrasses at CO_2 seeps. *Environmental Research, 153,* 104810, https://doi.org/10.1016/ j.marenvres.2019.104810

Muhammad, Y.Y., Nisfariza, M.N., Mariney, M.Y., Jamalunlaili, A., & Norzailawati, M.N. (2020). SPOT Imagery Observation on Mangrove Changes Using NDVI Density Analysis: The Case of Sepang Besar River, Malaysia. *The Arab World Geographer / Le Géographe du monde arabe*, *23*(2-3),217-228. https://doi.org/ 10.5555/1480-6800.23.2.217.

Muller, G. (1969). Index of geoaccumulation in sediments of the Rhine River. *Geojournal, 2*(3), 108-118.

Naji, A., & Ismail, A. (2016). Assessment of Metals Contamination in Klang River Surface Sediments by using Different Indexes. *Environmental Asia, 4,* 30–38, *DOI:10.14456/ea.2011.5*.

Nath, A., Samanta, S., Banerjee, S., et al. (2021).Threat of arsenic contamination, salinity and waterpollution in agricultural practices of Sundarban Delta, India, and mitigation strategies. *SN Applied Sciences General*, *3*, 560. https://doi.org/10.1007/s42452-021-04544-1

Özkara, A., Akyıl, D., & Konuk, M. (2016). Pesticides, environmental pollution, and health. In M.L. Larramendy & S. Soloneski (Eds.) *Environmental Health Risk-Hazardous Factors to Living Species*; IntechOpen: london, UK. DOI: 10.5772/63094

Pande, N., & Nayak, G.N. (2013). Understanding distribution and abundance of metals with space andtime in estuarine mudflat sedimentary environment. *Environmental Earth Sciences*, *70*, 2561–2575. https://doi.org/10.1007/s12665-013-2298-y.

Pandey, L. K., Park, J., Son, D. H., Kim, W., et al. (2019). Assessment of metal contamination in water and sediments from major rivers in South Korea from 2008 to 2015. *Science of The Total Environment*, *51*, 323–33. doi:10.1016/j.scitotenv.2018.09.057.

Qiu, Y.W., Yu, K.F., Zhang, G. & Wang, W. X. (2011). Accumulation and portioning of seven trace metals in mangroves and sediment cores from three estuaries wetlands of Hainan Island, *China Journal of Materials*, *190*, 631-638.

Rodríguez-Barroso, M. R., Ramírez-del Solar, M., Blanco, E., Quiroga, J. M., & García-Morales, J. L. (2008). Qualitative estimation of heavy metals in marine sediment using thermal analysis. *Soil and Sediment Contamination*, *17*, 107–120.

Rozaini, M.Z.H., Ramli, A.N., & Jaafar, M. (2010). The determination of heavy metal concentration in sediment from Kerteh River, Terengganu. *Journal of Sustainability Science and Management*, *5*, 1–11.

Sarmani, S.B. (1989). The determination of heavy metals in water, suspended materials and sediments from Langat River, Malaysia. *Hydrobiologia, 176,* 233–238, doi:http://dx.doi.org/10.1007/ BF00026558.

Sericano, J.L, Wade, T.L, & Jackson, T.J. (1995). Trace organic contamination in the Americas: An overview of the US national status and trends and the international mussel watch progammes. *Marine Pollution Bulletin*, *31*, 214-225.

Singh, J.K., Kumar, P., & Kumar, R. (2020). Ecological risk assessment of heavy metal contamination in mangrove forest sediment of Gulf of Khambhat region, West Coast of India. *SN Applied Sciences*, *2*, 2027. https://doi.org/10.1007/s42452-020-03890-w.

Suhaimi Elias, M., Shariff, I., Kamarudin, S., Shamsiah, A.R., & Yii, M.W. (2018). Assessment of toxic elements in sediments of Linggi River using NAA and ICP-MS techniques. *Methods X*, *5*, 454–465.

Sutherland, R. A. (2000). Bed sediment-associated trace metals in an urban stream, Oahu, Hawaii. *Environmental Geology*, *39*, 611–627.

Turekian, K.K., & Wedepohl, K.H. (1961). Distribution of the elements in some major units of the earth’s crust. *Bulletin of Geological Society of America*, *72,* 175–92.

Yasin, M. Y., Yusoff, M. M., & Noor, N. M. (2019). Urban sprawl assessment using time seriesLULC and NDVI variation: a case study of Sepang Malaysia. *Applied Ecology and Environmental Research*, *17*(3). 5583-5602. DOI: 10.15666/aeer/1703_55835602.

Yuan, C.G., Shi, J.B., He, B., Liu, J.F., Liang, L.N., & Jiang, G.B. (2004). Speciation of heavy metals in marine sediments from the East China Sea by ICP-MS with sequential extraction. *Environment International*, *30*, 769—783. DOI: http://dx.doi.org/ 10.1016/j.envint.2004.01.001.

Yuan, X., Huang, H., Zeng, G., Li, H., et al. (2011). Totalconcentrations and chemical speciation of heavy metals in liquefaction residues of sewage sludge. *Bioresource Technology*, *102,* 4104–4110.

Zhang, X., Yan, L., Liu, J., Zhang, Z., & Tan, C. (2019). Removal of different kinds of heavy metalsbynovel PPG-nZVI beads and their application in simulated stormwater infiltration facility. *Applied Sciences*, *9*, 4213.

Zine, H., Midhat, L., Hakkou, R., El Adnani, M., & Ouhammou, A. (2020). Guidelines for a phytomanagement plan by the phytostabilization of mining wastes. *Scientific African*, *10,* 2468–2476.

Zulkifli, S. Z., Siti, A. R., Ferdaus, M. Y., & Ahmad, I. (2014). Geochemical Fractionations of HeavyMetals in Sediments of Sepang Besar River, Malaysia. *Acta Biologica Malaysiana, 3*(1): 1-9. DOI: http://dx.doi.org/10.7593/abm/3.1.1.

Zvinowanda, C. M., Okonkwo, J. O., Agyei, N. M., Sekhula, M. M., & Sadiku, R. (2009). Application of maize tassel for the removal of Pb, Se, Sr, U and V from borehole water contaminated with mine wastewater in the presence of alkaline metals. *Journal of Hazardous Materials, 164* (2-3), 884-891.