

Chemical Composition of Sediment in Bernam Catchment, Selangor Malaysia

Sumayyah Aimi Mohd Najib^{1,*}, Nur Aziemah Zainal¹, Jumarmac Niza Jupinis¹, Shazlyn Milleana Shaharuddin²

¹ Department of Geography and Environment, Faculty of Human Sciences, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia.

² Department of Mathematics, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia.

*Correspondence: sumayyah@fsk.upsi.edu.my

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Abstract: Sediment investigations can be used to identify the major sources of metal pollution and assess the potential toxicity of dredged materials when applied to agricultural land. This study investigated the chemical composition of sediments in the Bernam River catchment, which has been substantially affected by anthropogenic activities, including urbanisation, agricultural activities, and illegal logging. These activities have raised concerns among local communities and stakeholders regarding the deterioration of water quality resulting from the discharge of pollutants and sediment into river systems. The study analysed the concentrations of several chemical elements, including iron, aluminium, copper, total organic carbon, zinc, potassium, calcium, magnesium, sodium, chromium, cobalt, nickel, arsenic, and cadmium. Potential sediment sources were characterised based on their diagnostic chemical and physical properties and compared with those of transported fluvial sediments. The methodology incorporated fluvial sediment sampling and sediment tracing techniques designed to account for variations in hydrological and geomorphological conditions within the river system. Cluster analysis identified three distinct sediment-source groups within the Bernam River catchment, indicating spatial differences in sediment characteristics and potential sources. From a river management perspective, identifying and characterising sediment sources is essential for developing appropriate measures to control sediment mobilisation and reduce the subsequent accumulation and siltation of river channels, particularly in environmentally sensitive areas. The findings provide useful information for developing targeted sediment-management strategies and mitigating the potential risks associated with metal-contaminated sediments in the Bernam River catchment.

Keyword: Chemical Composition; Sediment; Bernam Catchment

1.0 Introduction

Rivers carry most of the eroded material that is moved from the continents to the oceans (Jiang et al., 2021). This material is transported by rivers in both suspended and bed load sediment forms or dissolved and solid forms (Jaskuła, 2021). The mobility of the chemical constituents (elements) during weathering and transit determines the relative distribution of elements between the solution and particulate phases and minerals provide vast specific surfaces for the sorption of these elements, trace metals accumulate in soils (Tang et al., 2014). The composition of chemical in river sediments is determined by the combined effects of several pollution sources, natural processes connected to climate and geological conditions, the features of point and non-point pollution sources, their location, and the organisation of land use (Motha et al., 2003).

Because of the variety and dispersion of pollution sources as well as emission rates, each watershed generally has a distinct pattern for delivering all the metals to the water (Magni et al., 2021). Water and sediment contamination are significantly influenced by land use. The diversity and structure of the landscape, in addition to the main land use categories, are significant factors in the supply of chemicals (Collins et al., 2017). The concentrations in river sediments can vary significantly due to overlapping natural and human influences as well as fluvial processes within even the same river (Tang et al., 2014). Water pollution in Malaysia, present in both solid and liquid states. Ultimately, these pollutants find their way into rivers, runoff water, and terrestrial areas (Camara et al., 2019). The contamination of surface sediments, particularly within river systems, with harmful metallic elements has garnered significant public interest in recent decades (Lacey et al., 2017; Biddulph et al., 2017). The objective of this study is to identify the chemical composition in Bernam river catchment, Selangor Malaysia.

2.0 Study Area

Bernam River catchment is between N 03° 40' 45" and E 101° 31' 20" in north-eastern Selangor and the southern part of Perak, Malaysia (Figure 1). The research region's height above mean sea level is 41 metres, and its catchment area was 186 km². The catchment area's maximum length is 21 km, while its maximum width is 14 km. The remaining portion of this watershed is hilly, with the majority being steep mountain land reaching heights of 1830 metres. The hilly, undulating areas are primarily covered in rubber, whereas the mountainous areas are covered in rainforest. The granitic soil layer that covers much of the catchment is made up of clay and fine to coarse sand.

The cover often only descends a few metres, although in regions with severe weathering, deeper levels may be found. There is a tiny area in the south with a sandy loam soil layer that grades to clay loam. The alluvium in the valleys ranges in depth from 8 to 15 metres. Sediment strike is roughly northwest to southeast, with a dip that varies from 45° to 65° in the northeast and southwest. In addition, it provides water and irrigation for 20,000 hectares of rice paddies and supports local ecotourism. A significant quantity of rainfall fell in the Tanjong Malim Perak area near the Titiwangsa Range. In 2017, the research area received 2600 mm of annual rainfall. As of 2004, the Bernam catchment's land use was primarily composed of forest (47.7%), rubber (14.8%), oil palm (25.9%), shrub (7%), built-up area (3%) and water body (1.5%) (Shazwani et al., 2023).

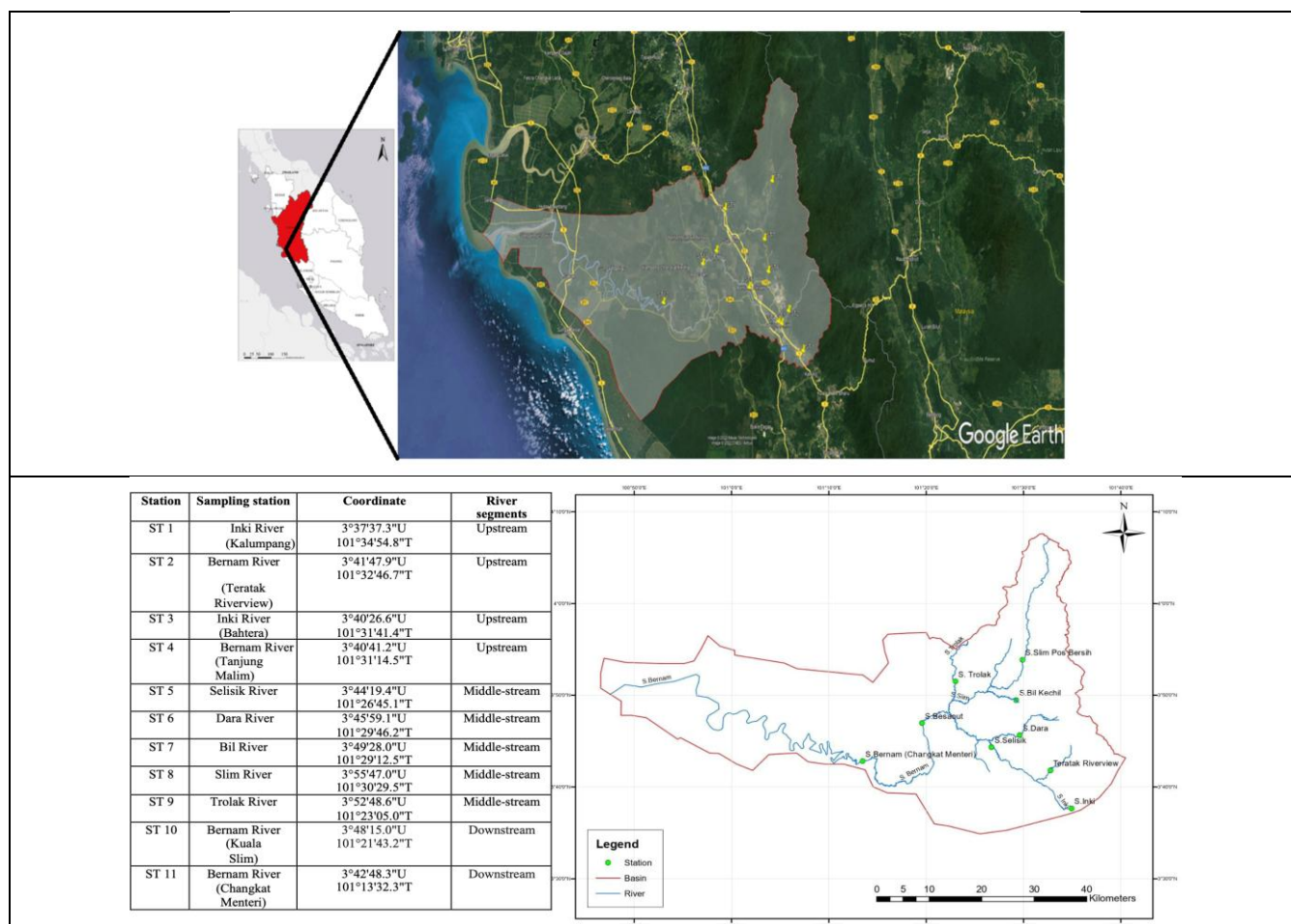


Figure 1: Study area of Bernam Catchment

3.0 Materials and Methodology

3.1 Sample collection/ Field sampling

Source material sampling involve the collection surface soil samples from eroding areas that represent each of the cultivated sites, slope lands and terraces (For subcatchment A, B, C etc). For each source samples, estimate 10 sub samples will be collected from 0 to 5cm depths along transects in a 5×5m grid and combine in the field to form a single composite samples. For solid sample analyses by inductively coupled plasma-optical emission spectroscopy (ICP-OES) to identify the atomic composition of a particular sample.

4.0 Results & Discussion

Table 1 shows content of chemical component in the study area. The dominant composition of chemical in sediment come from downstream site at ST9, which Iron 9041 mg/kg, Aluminium 8606 mg/kg, potassium 819.5 mg/kg and Magnesium 680.3 mg/kg. The highest contributions from iron samples, indicating the potential significance of localised inputs from outcrops in channel banks or topsoil near this sampling location. ST9 and ST10 and 11 high concentrations were closely related to increase intensity of residential and urbanization, agriculture, oil palm plantation, water flowing through peat in drainage basin.

The average composition of solid materials transported by rivers differs greatly from the chemical composition computed for varying ratios of suspended and bed loads (Motha et al., 2003). Sand-clayey sedimentary rocks exhibit a relative enrichment in sodium, magnesium, and potassium that is likely secondary in origin. The higher metal concentration variation can be attributed to natural process as water dilutes contaminants which can be transport and delivered through the river flow (Jiang et al., 2021).

Table1. Comparison of the average content of component in sediment in Bernam catchment

Variable	Minimum (mg/kg)	Maximum (mg/kg)	Mean	Std. deviation
Iron	1405.2	9041.1	3773.7	2224.1
Aluminium	1763.2	8606.0	3540.7	2077.4
Copper	0.4	42.7	6.7	13.6
Total organic carbon	0.0	296.2	120.2	102.3
Zinc	2.1	20.9	8.8	5.5
Potassium	185.5	819.5	433.5	183.7
Calcium	44.0	183.2	95.4	50.1
Magnesium	89.2	680.3	339.9	195.8
Sodium as Na	114.3	311.5	197.7	64.3
Chromium	0.8	4.9	2.2	1.2
Cobalt	0.0	0.0	0.0	0.0
Nickel	0.3	1.5	0.8	0.4
Arsenic	0.9	3.7	2.0	1.0
Cadmium	0.0	0.0	0.0	0.0

4.2 Cluster Analysis

Figure 2 shows there are three cluster of group classification in this catchment. Cluster 1 for dominant chemical composition such as Iron, Aluminium, Zinc, Potassium, Calcium, Magnesium, Chromium, Nickel and Arsenic. Cluster 2 dominant by Copper, TOC, Cobalt, Cadmium and Cluster 3 Sodium. Based on cluster analysis, dominant sediment sources were identified by group, and those in close proximity to each sediment sampling location were found to be of greatest importance. Stations and composition of chemicals data were grouped using cluster analysis. Finding a technique that generated a logical pattern of association and showed consistency between findings for location and chemical composition associations was the aim of the study. Creating a similarity data matrix from the raw data and grouping the resemblance coefficients in the matrix are the two steps that most cluster analysis algorithms entail. There are several ways to generate the input resemblance (similarity or dissimilarity) matrix. Despite this uncertainty, dominant sediment sources were identified, and those in close proximity to each sediment sampling location were found to be of greatest importance.

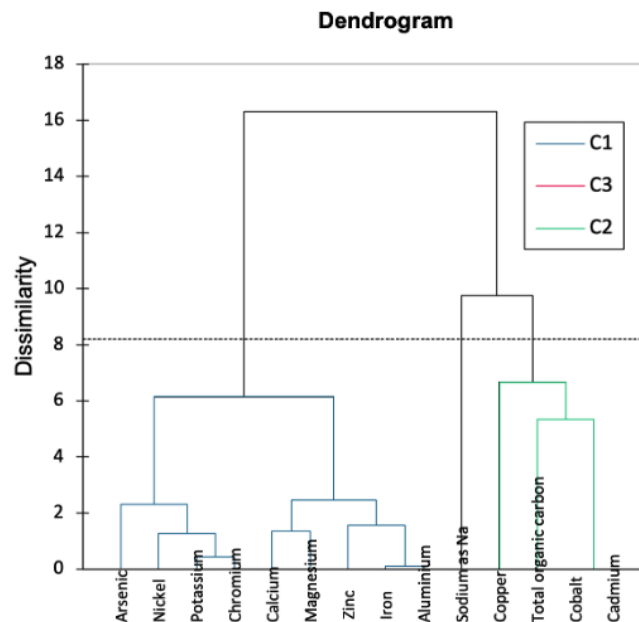


Figure 2: Three cluster for chemical compositions in the study area

5.0 Conclusions

A better understanding of erosion processes and suspended sediment transport within a river basin can be achieved through sediment source tracing studies. Identifying the dominant sources, pathways, and spatial distribution of sediment provides valuable information for understanding how sediment is generated, mobilised, and transported through the catchment. This information is particularly important in catchments affected by agricultural activities, urbanisation, deforestation, and other forms of land-use change, which can substantially increase soil erosion and sediment delivery to river systems.

Once the major sediment sources have been identified and their relative contributions quantified, appropriate and targeted sediment-control measures can be designed and implemented. Such measures may include improved land-management practices, erosion-control structures, riparian buffer zones, reforestation, and improved management of agricultural and urban areas. Source-specific management is generally more effective than applying uniform controls across an entire catchment because it allows resources to be directed towards areas contributing the greatest sediment loads. Reducing sediment mobilisation and delivery can also help minimise river-channel siltation, maintain channel capacity, and improve the overall ecological condition of downstream water bodies.

In addition to the physical impacts of sediment, the chemical composition of transported sediments is an important consideration for water-quality management. Sediments can act as carriers of potentially harmful elements and other contaminants, including heavy metals, nutrients, and organic pollutants. The presence and accumulation of these substances can adversely affect the chemical and ecological quality of rivers, lakes, reservoirs, and wetlands. Contaminated sediments may pose risks to aquatic organisms through direct exposure and bioaccumulation and may also affect human activities that depend on freshwater resources, including fisheries, agriculture, recreation, and water supply.

Therefore, systematic monitoring of sediment characteristics and chemical composition is essential for assessing the environmental condition of aquatic systems and identifying emerging pollution risks. Integrating sediment source tracing with geochemical analysis can provide a more comprehensive understanding of both the origin and potential environmental significance of sediment-bound contaminants. Such information can support evidence-based catchment management, facilitate the development of preventative measures, and contribute to the long-term protection and sustainable management of freshwater ecosystems.

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Conflicts of Interest: The authors declare no conflict of interest.

Ethics Statement: Ethical approval was not required as the study involved no human participants or identifiable personal data.

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