

POLLUTION STATUS OF SEDIMENTS OF TANGGUK RIVER OF GEBENG, PAHANG, MALAYSIA

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Keywords: Sediments, Tangguk river, Heavy metals

Abstract

The Gebeng industrial estate is a vital industrial zone of Pahang, Malaysia. A study was conducted to investigate the effects of industrial activities on physicochemical properties as well as heavy metal concentrations in the different points of river Tangguk. It has been found that the studied sediments were extremely polluted, especially by Hg, Co and As. Moreover, the Pb, Zn, Cu, Cr, Cd, Ni, Ba were detected above the recommended limits. This is an endeavor to explore the sediment pollution status of the riverbed. This research would help in getting pragmatic treatment phenomena of industrial wastewater and promote sustainable industrial and river management approaches.

Introduction

At the beginning of civilization, human interferences induced changes in nature and environment. The human footprints are touching the continents, oceans and even outer space. The industrial revolution and its negative impact expedite the global environmental degradation. Large scale environmental changes are found in recent years. These alterations on temperature, water, soil, sediment, air and plants are enormous, creating adverse effects on ecosystem (Karim *et al.* 2013). The increasing trend of anthropogenic activities like industrialization especially rapid industrialization is a great threat in this millennium and that could destroy the green planet. At present, industrialization and its impact on environment are causing versatile problems around the world. Anthropogenic activities like industrial activities are the prime causes of sediment pollution. The main problem behind sediment pollution is the entry of pollutants in food chain and ultimately causes the threat for lives (Karim and Happy 2014, Oo *et al.* 2023, Saraswathy *et al.* 2026). The aim of the study is to investigate the actual plight of industrial effects, by analyzing the sediments of Tangguk river which could explore the long-term deposition scenario.

Materials and Methods

Gebeng industrial estate is the main industrial area at Kuantan, the capital city of Pahang, Malaysia. It is located near Kuantan Port. Since types of industries, topography and discharge points, a total of 12 stations were selected on the Tunggak riverbed for sampling (Fig. 1). Among them 5 from up-stream (US), 4 from down-stream (DS) and 3 from non- disturbed points (NS). Sediment sampling was made twice, once in dry season and another in wet season following standard procedure by Van Veen grab sampler. Three replications of each sample were taken from each sampling sites. About 800 gm of sediment was collected from 0 to 15 cm depth. The collected samples were put into polythene bags. All samples were cleaned, air dried, ground and sieved in the laboratory before analysis. Air dried and sieved samples (2.00 mm sieves) were used for analysis. pH and EC were measured by soil survey standard test method (Mosley *et al.* 2024) using seven easy pH meter (Mettler Toledo) as well as organic matter was determined by weight loss-on-ignition method (Combs and Nathan 2011) utilizing Muffle furnace- Carbolite ELF 11/23, drying oven. Small Pycnometer method was used to determine the particle density (BSI 2022). In addition, to interpret the results, sediment quality guidelines (Simpson *et al.* 2013, MacDonald *et al.* 2000) were used.

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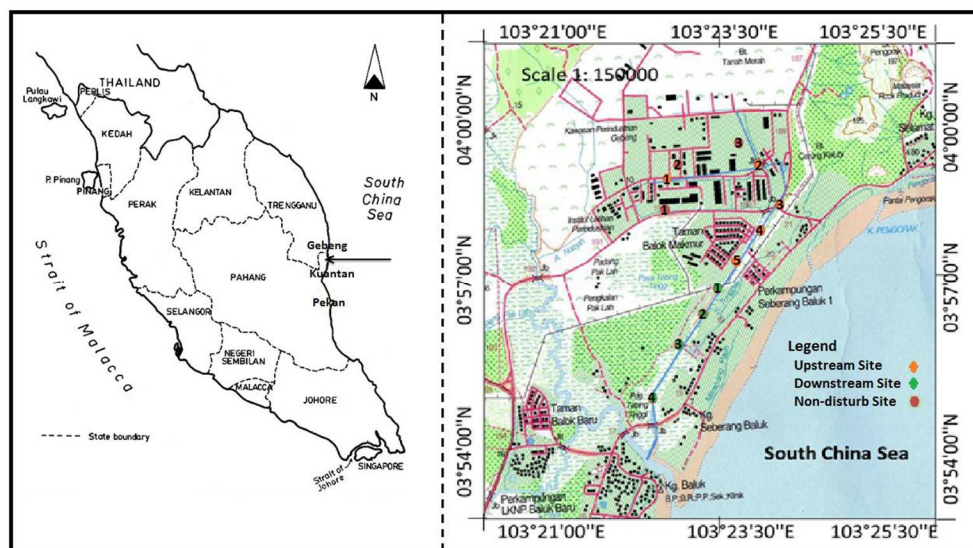


Fig. 1. Map of the study area presenting sediment sampling stations.

Results and Discussion

The physicochemical properties of the studied sediments were determined from 12 monitoring sites in dry and wet seasons (Table 1 and 2). Particle densities of the studied sediment varied from 1.61 to 2.65 and 2.16 to 2.71 g/cm³ in dry and wet season, respectively (Table 1 and 2). The highest particle density was found at site NS2, while the lowest at site US1. It has been observed higher particle density in wet season than dry season. Rahman *et al.* (2025) reported the similar results in Ganges–Brahmaputra–Meghna riverine and coastal system in Bangladesh. Additionally, particle density was higher in wet season than dry season (Nabayi *et al.* 2021, Pandion *et al.* 2023). The pH of studied sediments was found to be varied from 4.81 to 8.83. The highest average pH value (7.90) was determined in river downwards sediments whereas the lowest value (4.81) was measured in upstream sediments. The lowest value resulted because of the availability of organic wastes and its decomposition. Zhang *et al.* (2024) launched a study on the sediments of Yangtze River, China and observed lower pH values in upstream stations caused by the organic waste's accumulation and humic acid formation. The results revealed that the overall EC value in studied sediments ranged 0.09–9.60 mS/cm. The heaviest EC was detected at station DS4 in both the seasons. In wet season, comparatively low EC was measured owing to dilution effect (Table 2). The high EC content was found in downward river sediment due to vicinity of the South China Sea and the influence of saline water. Moreover, Islam *et al.* (2023) launched a study on coastal river sediments of Bangladesh and observed similar findings. The overall organic matter content varied from 1.27 to 8.11 %. It ranges from 2.14 to 8.11 % and 1.27 to 4.74 % in dry and wet season, respectively. The high average organic matter was found to be at station US1 and the least at station NS3 in both the seasons. The highest organic matter was detected in upstream sediments (Table 1), however, the lowest organic matter was illustrated at non-disturbed stations (Table 1 and 2). The less organic matter was exhibited at wet season due to the high rainfall which washed away the wastes. The findings agree with Islam *et al.* (2024) who worked on the river sediments of Buriganga river and Turag river in Bangladesh and showed higher organic matter enrichments in upstream stations and industrially discharged stations due to effluent throwing and solid waste discharging. Furthermore, the higher organic matter content in upstream stations and the stations

close to industries indicated that there were industrial wastes dumping. The sand content ranged from 49.31 to 90.88, 53.46 to 73.71 and 50.89 to 68.17 % for upstream, downstream and non-disturbed stations, respectively at dry season. Moreover, 5.20 to 43.43, 19.57 to 34.17 and 25.63 to 34.40 % for silt in upstream, downstream and non-disturbed stations, respectively at dry season. Furthermore, 2.13 to 7.64, 6.42 to 15.17 and 6.20 to 14.71 % for clay in upstream, downstream and non-disturbed stations, respectively at dry season. In addition, the sand content ranged from 55.98 to 96.33, 72.54 to 87.36 and 64.48 to 85.99 % for upstream, downstream and non-disturbed stations, respectively at wet season. Additionally, 2.71 to 38.55, 9.17 to 19.09 and 10.12 to 24.98 % for silt in upstream, downstream and non-disturbed stations respectively at wet season. The clay content ranged from 0.96 to 6.51, 3.47 to 7.92 and 3.89 to 10.54 % for upstream, downstream and non-disturbed stations, respectively at wet season. However, the highest average sand and silt percentage were recorded at station US5 and the lowest at US1 in both the seasons. Higher percentage of clay was found at station US1 in both the seasons whereas the lowest clay percentage was found to be at US5 in wet and US4 in dry season. From the study, 44.38 % silt content has found that is very high in percentage suggesting the industrial dumping. The similar result was found in the sediments of Tigris and Euphrates rivers (Al-Shihmani *et al.* 2025). Different heavy metals such as As, Ba, Cd, Co, Cr, Cu, Hg, Ni, Pb and Zn were found at 12 sampling sites during both the dry and wet season (Table 3) that was compared with the values of freshwater sediments (MacDonald *et al.* 2000, Simpson *et al.* 2013). The average As of studied sediments was 11.52, 12.53, and 3.46 mg/l at up-stream, down-stream and non-disturbed sites, respectively at dry season (Table 3). In accordance with the sediment quality guidelines of MacDonald *et al.* (2000), the average As concentrations of both upstream and downstream sites were recorded higher than TEC in both dry and wet seasons. Moreover, Ali *et al.* (2022) found high As content in the bank of Buriganga river, Dhaka of Hazaribagh area. The Ba of the sediment was 85.93, 32.85 and 16.37 mg/l at up-stream, down-stream and non-disturbed sites, respectively at dry season and it was 79.99, 27.70 and 11.07 mg/l, respectively at wet season (Table 3).

Table 1. General parameters of sediment at dry season in the study area.

Sites	Particle	pH	EC (mS/cm)	OM (%)	Particle size (%)		
					Sand	Silt	Clay
US1	1.62 ± 0.01	4.81 ± 0.05	4.31 ± 0.05	7.82 ± 0.38	49.31 ± 0.40	43.43 ± 0.83	7.26 ± 0.20
US2	2.55 ± 0.02	4.84 ± 0.06	4.75 ± 0.18	4.29 ± 0.08	81.97 ± 3.19	17.29 ± 1.38	6.74 ± 0.49
US3	2.01 ± 0.01	6.27 ± 0.06	2.36 ± 0.03	2.43 ± 0.03	87.16 ± 0.01	5.20 ± 0.16	7.64 ± 0.36
US4	2.62 ± 0.01	7.07 ± 0.08	2.19 ± 0.03	2.92 ± 0.16	89.96 ± 0.33	5.07 ± 0.14	4.97 ± 0.24
US5	2.48 ± 0.01	5.84 ± 0.05	2.21 ± 0.04	2.33 ± 0.17	90.88 ± 0.26	6.99 ± 0.28	2.13 ± 0.33
DS1	2.56 ± 0.01	5.89 ± 0.21	1.73 ± 0.22	4.78 ± 0.25	73.71 ± 0.38	19.57 ± 1.23	15.17 ± 0.48
DS2	2.61 ± 0.01	5.79 ± 0.03	2.60 ± 0.07	6.60 ± 0.09	61.24 ± 1.11	23.59 ± 0.19	15.17 ± 0.48
DS3	2.55 ± 0.01	6.34 ± 0.06	6.86 ± 0.29	5.96 ± 0.26	67.11 ± 1.15	26.47 ± 0.01	6.42 ± 0.91
DS4	2.50 ± 0.01	6.89 ± 0.13	9.41 ± 0.18	4.52 ± 0.10	53.46 ± 1.56	34.17 ± 0.05	12.37 ± 0.74
NS1	2.61 ± 0.01	6.88 ± 0.16	0.16 ± 0.01	4.38 ± 0.34	50.89 ± 0.39	34.40 ± 0.68	14.71 ± 0.58
NS2	2.64 ± 0.01	6.11 ± 0.11	0.17 ± 0.01	4.79 ± 0.36	59.16 ± 1.28	33.94 ± 0.57	6.90 ± 0.22
NS3	2.63 ± 0.01	6.78 ± 0.15	0.15 ± 0.01	2.49 ± 0.35	68.17 ± 0.89	25.63 ± 0.53	6.20 ± 0.72

The industrial discharge and wastes of the steel, petrochemicals and plastic industries having Ba and induced Ba pollution in sediment of Tangguk river. Haque *et al.* (2021) launched research in Konabari-Kashimpur industrial area at upstream zone of the Turag river and found higher Ba concentrations in sediments. The average Cd was 0.20, 0.17 and 0.02 mg/l at up-stream, down-stream and non-disturbed sites, respectively at dry season and it was 0.17, 0.11 and 0.03 mg/l,

respectively at wet season (Table 3). Cd pollution in the research sites was observed due to steel production industries, iron, metal electroplating, phosphate fertilizer industries and coal combustion. Islam *et al.* (2021) observed higher Cd contents in the sediment of Savar tannery industrial area. Furthermore, Singh *et al.* (2022) reported the high Cd in the sediment of the Hindon river of Muzaffarnagar industrial area at Uttar Pradesh, India due to fertilizer use, coal burning and metallurgical industries. The Co was 1085.58, 991.58 and 0.26 mg/l at up-stream, down-stream and non-disturbed sites respectively at dry season that was 1002.98, 974.17 and 0.22 mg/l at wet season (Table 3). Rahman *et al.* (2021) reported higher Co in the sediments of Karnaphuli river, Chattogram and Buriganga-Turag river, Dhaka at dry season. Khan *et al.* (2022) found higher Co in the sediments of Bangladesh, Pakistan, and India and parts of East Asia and observed higher cobalt contamination are due to industrial effluents from alloy manufacturing hubs and catalyst-based chemical industries especially from rapidly developed industrial estate.

Table 2. General parameters of sediment at wet season in the study area.

Sites	Particle	pH	EC (mS/cm)	OM (%)	Particle size (%)		
					Sand	Silt	Clay
US1	2.16 ± 0.01	5.63 ± 0.27	2.91 ± 0.20	4.59 ± 0.20	55.98 ± 0.70	38.55 ± 0.52	5.47 ± 0.48
US2	2.65 ± 0.01	5.69 ± 0.04	3.33 ± 0.35	1.76 ± 0.07	91.80 ± 0.07	6.21 ± 0.24	1.99 ± 0.12
US3	2.04 ± 0.01	6.73 ± 0.17	1.71 ± 0.03	1.46 ± 0.08	89.14 ± 0.92	4.35 ± 0.04	6.51 ± 0.25
US4	2.63 ± 0.01	8.35 ± 0.48	1.71 ± 0.34	1.41 ± 0.16	92.40 ± 1.86	4.59 ± 0.05	3.01 ± 0.41
US5	2.52 ± 0.01	7.75 ± 0.05	1.60 ± 0.28	1.88 ± 0.22	96.33 ± 0.63	2.71 ± 0.02	0.96 ± 0.05
DS1	2.58 ± 0.01	6.72 ± 0.03	1.24 ± 0.09	1.76 ± 0.17	87.36 ± 1.14	9.17 ± 0.04	3.47 ± 0.42
DS2	2.65 ± 0.01	7.10 ± 0.04	1.22 ± 0.20	3.53 ± 0.05	72.54 ± 0.99	18.58 ± 1.11	8.88 ± 0.45
DS3	2.63 ± 0.01	7.88 ± 0.02	4.34 ± 0.18	2.52 ± 0.14	83.05 ± 0.19	12.60 ± 0.37	4.35 ± 0.23
DS4	2.62 ± 0.01	7.83 ± 0.10	7.19 ± 0.22	3.49 ± 0.22	72.99 ± 0.61	19.09 ± 0.32	7.92 ± 0.32
NS1	2.71 ± 0.01	6.97 ± 0.06	0.11 ± 0.01	2.26 ± 0.20	64.48 ± 0.62	24.98 ± 0.74	10.54 ± 0.47
NS2	2.68 ± 0.01	7.12 ± 0.05	0.12 ± 0.01	2.44 ± 0.92	79.43 ± 1.08	14.79 ± 0.49	5.78 ± 0.55
NS3	2.65 ± 0.01	7.36 ± 0.07	0.10 ± 0.01	1.43 ± 0.18	85.99 ± 0.48	10.12 ± 0.56	3.89 ± 0.51

The Cr was 16.28, 16.78 and 2.17 mg/l, respectively at dry season and it was 10.52, 14.09 and 2.02 mg/l, respectively at wet season (Table 3). Hossain *et al.* (2021) observed significant Cr enrichments in sediments of Buriganga, Turag, and Shitalakkhya rivers and the Karnaphuli river, Chattogram and near tannery industries, textile dyeing units, metal-processing workshops, and shipbreaking yards, Chattogram. Wu *et al.* (2020) found substantial Cr content in the sediments Pearl River Delta (Guangdong Province) and parts of the Yangtze River basin, China, from the discharge of stainless-steel manufacturing, metallurgical processing plants, electroplating industries and leather tanning. The Cu was 20.98, 15.39 and 1.47 mg/l at dry season and 7.25, 9.00 and 1.38 mg/l at wet season, respectively (Table 3). The river sediments of Buriganga, Turag, Shitalakkhya and Karnaphuli shown higher Cu and Ni contents (Rahman *et al.* 2021). The Hg was 2.29, 0.56 and 0.02 mg/l at dry season and 2.93, 0.85 and 0.03 mg/l at wet season, respectively (Table 3). According to Simpson *et al.* (2013) the average Hg concentrations at upstream stations in both dry and wet season were recorded above HGV, whereas the Hg contents in both dry and wet season were observed below the HGV but above the LGV. The Hg pollution was higher than the Threshold Effect Concentration at up and down stream sites and it is 16.28 and 12.72 times more than permissible limits at wet season and dry seasons, respectively, while the Hg was found 4.7 and 3.1 times higher than in wet and dry seasons at downstream stations, respectively (MacDonald *et al.* 2000). Wang *et al.* (2020) launched a study in the sediments of the Hubei, Jiangsu, and Shanghai of Yangtze River basin in China and illustrated higher Hg contamination

probably due to chlor-alkali industries, gold mining activities, coal-fired power plants, cement production units and e-waste recycling industries. Zhang *et al.* (2022) showed Hg pollution in sediments adjacent to the rapidly developed industrial areas of China, India, and Bangladesh owing to industrial emissions from coal combustion, waste incineration, chemical manufacturing metal smelting, and cement production. The same high concentration of Ni, Pb and Zn was found during dry and wet seasons (Table 3).

Table 3. Concentrations of heavy metals from different stations in different seasons.

Parameters	Up-stream river stations (Mean $\pm$ SD)	Down-stream river stations (Mean $\pm$ SD)	Non-disturbed stations (Mean $\pm$ SD)
Dry Season			
As (mg/l)	11.52 $\pm$ 0.21	12.53 $\pm$ 0.21	3.46 $\pm$ 0.06
Ba (mg/l)	85.76 $\pm$ 2.62	32.85 $\pm$ 1.98	16.37 $\pm$ 1.48
Cd (mg/l)	0.20 $\pm$ 0.03	0.17 $\pm$ 0.03	0.02 $\pm$ 0.01
Co (mg/l)	1085.58 $\pm$ 17.29	991.58 $\pm$ 6.79	0.26 $\pm$ 0.04
Cr (mg/l)	16.28 $\pm$ 1.52	16.78 $\pm$ 1.42	2.17 $\pm$ 0.06
Cu (mg/l)	20.98 $\pm$ 2.44	15.39 $\pm$ 1.56	1.47 $\pm$ 0.07
Hg (mg/l)	2.29 $\pm$ 0.05	0.56 $\pm$ 0.02	0.02 $\pm$ 0.01
Ni (mg/l)	9.17 $\pm$ 1.79	7.10 $\pm$ 0.73	2.08 $\pm$ 0.07
Pb (mg/l)	18.19 $\pm$ 1.72	50.60 $\pm$ 2.90	1.39 $\pm$ 0.08
Zn (mg/l)	54.25 $\pm$ 4.16	39.71 $\pm$ 3.16	3.48 $\pm$ 0.09
Wet Season			
As (mg/l)	10.54 $\pm$ 0.19	14.44 $\pm$ 0.16	3.57 $\pm$ 0.05
Ba (mg/l)	79.99 $\pm$ 1.56	27.70 $\pm$ 1.22	11.07 $\pm$ 1.33
Cd (mg/l)	0.17 $\pm$ 0.02	0.11 $\pm$ 0.02	0.03 $\pm$ 0.01
Co (mg/l)	1002.98 $\pm$ 12.61	974.17 $\pm$ 5.64	0.22 $\pm$ 0.03
Cr (mg/l)	10.52 $\pm$ 1.54	14.09 $\pm$ 1.41	2.02 $\pm$ 0.04
Cu (mg/l)	7.25 $\pm$ 2.19	9.00 $\pm$ 1.18	1.38 $\pm$ 0.06
Hg (mg/l)	2.93 $\pm$ 0.04	0.85 $\pm$ 0.03	0.03 $\pm$ 0.01
Ni (mg/l)	3.05 $\pm$ 1.48	5.67 $\pm$ 0.66	1.74 $\pm$ 0.05
Pb (mg/l)	31.59 $\pm$ 1.57	91.44 $\pm$ 2.13	1.45 $\pm$ 0.04
Zn (mg/l)	26.02 $\pm$ 3.13	38.73 $\pm$ 2.11	3.28 $\pm$ 0.06
As (mg/l)	10.54 $\pm$ 0.19	14.44 $\pm$ 0.16	3.57 $\pm$ 0.05

Note: Values are presented as Mean $\pm$ SD.

The Zn was 54.25, 39.71 and 3.48 mg/l, respectively at dry season and it 26.02, 38.73 and 3.28 mg/l, respectively at wet season at wet season (Table 3). The average Zn concentration at up and down stream stations were found to be higher than Low Alert Level (LAL) while the values were detected lesser than LAL at non-disturbed stations. Zinc could be incorporated from the effluents of petroleum, metal productions and steel processing industries. The similar findings were observed by Wang *et al.* (2020) in the sediments of Yangtze River Delta and the Pearl River Delta of China due to the discharge of Zn rich effluents and wastewater from steel manufacturing plants, electroplating industries, metallurgical industries, galvanization units and petrochemical processing facilities. Wang *et al.* (2020) reported significant Zn enrichment in river sediments in China, particularly in heavily industrialized regions such as the Yangtze River Delta and the Pearl River Delta probably from the metallurgical industries, steel manufacturing plants, galvanization units, electroplating industries, and petrochemical processing facilities, which discharge zinc-rich effluents into surrounding river systems. Moreover, Rahman *et al.* (2021) investigated on the

rivers of the Buriganga River, Turag River, Shitalakkhya River, and the Karnaphuli River in Bangladesh and observed similar findings.

Gebeng is a small town but because of many industrial clusters the area has become very important both economically and ecology. The study was conducted in Gebeng industrial estate, to investigate the effect of industrialization on sediments in the river tributaries. The studied results compared with the standard threshold of established sediment quality guidelines. From the study, it was found that the organic matter content in most of the up and down stream stations was measured higher while in non-disturbed stations it was determined lower. The As concentrations were recorded higher than toxic effect level while the sediments were not polluted by Ba. Moreover, Cd, Cr, Ni, Pb and Zn were found higher than LAL. Co and Cu higher than High alert level (HAL) while Hg higher than Threshold Effect Level (TEL). The data pointed out that the studied sediments are contaminated by organic wastes and heavy metals like Co, Hg, As, Pb, Cu, Cd and Zn. Moreover, up-stream river sediments were badly affected by wastes and effluents were directly thrown and deposited at those stations. So, from the study, it is clear that the studied sediment contaminations are in very risk condition which is a great threat for aquatic ecology and total environment.

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(Manuscript received on 15 May, 2026; revised on 13 September, 2026)