

# Determination of Heavy Metals in Water and Sediment from Pahang River, Pahang, Malaysia

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## Abstract

A study was conducted in order to determine heavy metal concentration in water and sediment at selected sites of Sg. Pahang, Pekan, Pahang (Pahang River). A total of three monitoring stations were established along Sg. Pahang. Three selected sampling points are located near Kampung Batu Sawar, Kampung Padang Rambia and Taman Merdeka, Pahang. Samplings were conducted seven times over a period of seven months from March 2010 to September 2010. Concentrations of heavy metals such as Zinc (Zn), Plumbum (Pb), Copper (Cu) and Cadmium (Cd) were determined. The results were then compared with the Interim National Water Quality Standards for Malaysia (INWQS). In determination of heavy metals, water and sediment samples were analysed using Inductive Coupled Plasma- Mass Spectrometer (ICP-MS) and Atomic Absorption Spectrophotometer (AAS). Results of this study indicated that Sg. Pahang is classified into class I –class II based on (INWQS). The trend of heavy metals in water and sediments of Sg. Pahang is Zn > Pb > Cu > Cd. All heavy metals were detected at low concentration in water and sediment samples. The concentrations of heavy metals in the river water ranged between Zn, (15.22 – 52.91) µg/ L.; Pb, (2.75 – 12.38) µg/ L.; Cu, (2.79 – 9.92) µg/ L.; Cd, (0.16 – 0.37) µg/ L and the concentrations of heavy metals in sediment ranged between Zn, (20.92 – 189.34) µg/ g.; Pb, (8.91 – 38.52) µg/ g.; Cu, (3.83 – 26.54) µg/ g. It was found that the concentration for metals increased as the river water flow from Kampung Batu Sawar to Taman Merdeka. This may be due to agricultural activities, sand mining, fishing activities, sea dumping and industrial development near Pekan. Generally, the concentrations of heavy metals were relatively low and it can be concluded that the river status is clean.

Keywords: Heavy metals, sediment, Sg. Pahang, water.

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**1. INTRODUCTION**

Pahang River basin is located in the eastern part of Peninsular Malaysia. The river is about 440 km in length and drains an area of 29,300 km<sup>2</sup> [1]. Pahang River plays major roles because it provides water to small scale paddy irrigation schemes. It was found that total amount of water extracted from Pahang River is about 8.3 cumecs for irrigating the paddy fields. In many years, water from Pahang River also supports the needs of rubber and oil palm plantations and other agricultural activities such as corn plantations and vegetables plantations. Pahang River also, delivers more than 120 mld of water, via the Public Works Department to meet the demand of domestic and industrial sectors.

However, there is an increasing of activities that may pollute the river water. This is due by the discharges of municipal and industrial wastes [2]. The rapid development is one of the factors that increase the contamination in river system. Therefore, the water pollution has become a question of considerable public and scientist in order to get the evidence of the toxicity to human health.

In recent years, studies were conducted by other researcher in order to determine the concentration of heavy metals. This is because, there is an increasing of pollutants such as heavy metals, that have been introduced into rivers through land surface runoff, rainfall precipitation and factory waste outlet point discharge [3].

Therefore, it is important that a study is conducted in order to determine the contaminants in river water by heavy metals. Poor monitoring and enforcement leads to a wide range of health impact. So it is clearly necessary to understand and control the hazard levels of contamination based on the Water Quality Index (WQI) and Interim National Water Quality Standards for Malaysia (INWQS). The objectives of this study are to determine the concentration of heavy metals in Pahang River with particular reference to water and sediments and secondly, to classify Pahang River with INWQS level. This study also was conducted to provide useful inputs for decision making on preventing or reducing adverse impacts on the environmental contamination cause by river pollution.

**2. MATERIALS AND METHODS**

*SAMPLING SITE AND SAMPLES COLLECTION*

The study was carried out at Pahang River where three different sampling points is located near Kampung Batu Sawar, followed by Kampung Padang Rambia and last sampling point is located near Taman Merdeka, Pahang as stated in Table 1 and Figure 1.

Table 1: Location of Sampling Points

Station	Location	Observation Period	Observation Items
Kampung Batu Sawar	N 3°29'17.17" E 103°06'07.32"	(March 2010 - September 2010)	Pb, Cd, Zn, Cu
Kampung Padang Rambia	N 3°31'41.17" E 103°11'52.55"	(March 2010 - September 2010)	Pb, Cd, Zn, Cu
Taman Merdeka	N 3°29'31.94" E 103°23'53.25"	(March 2010 - September 2010)	Pb, Cd, Zn, Cu



Fig 1: Location map of sampling sites, Kg. Batu Sawar, Kg. Padang Rambia and Taman Merdeka, Pekan, Pahang.

Sampling was carried out for 7 months started on March 2010 to September 2010. The water and sediment samples were taken from 3 different locations. Concentrations of heavy metals (Pb, Cd, Zn and Cu) were measured in water and sediments. While physical water quality such as pH, dissolved oxygen, conductivity and temperature was measured during sampling using probe YSI.

### Water samples

Water samples were collected to depths of 10 m using flexible plastic pipe with internal diameter 2.5 cm [4]. The samples were then put into pre-rinsed 1 L plastic container and preserved in polyethylene bottle. Reference [4] shows that each sample bottle was added with 1 mL of concentrated nitric. The concentrated sample will be diluted and heavy metals were analyzed using ICP-MS according to standard method (APHA).

### Sediment samples

Sediment samples were collected using a stainless Van-ven grab, where the PVC tube is dropped at the bottom and penetrates to take samples. These samples will bring to the surface and were collected into a plastic bag. In laboratory the samples were oven dried at 105° C to constant weights [4]. Then, 5 g of cleaned and dried sediment were taken into 150 mL conical flasks. 50 mL of 0.1 M HCl was added and filtered into 50 mL volumetric flask.

For the preparation of sediment, digestions of samples were carried out. The digestion method involved the addition of 5 mL of HNO<sub>3</sub> to 25 mL round bottom flask containing 0.200 g of sediment sample and 5 mL deionised water. Then the solution was refluxed at a temperature of 120° C [5]. Finally, the samples were diluted and ready for analysis. An Inductively-Couple Plasma Mass Spectrometer (ICP-MS) was used for the determination of heavy metals [6].

### Statistical Analysis

Statistics analysis (ANOVA) was used in order to differentiate the concentration of heavy metals at different location site. Statistics were performed using a two factor analysis of variance. Factor 1 was based on the sampling location while factor 2 was based on concentrations of heavy metals in water and sediments. An ANOVA paired tests were used for two-sample comparisons, where  $P \leq 0.05$  was considered statistically significant [7].

## 3. RESULTS AND DISCUSSION

The measured results of the concentrations of heavy metals (Pb, Cd, Zn and Cu) in water and sediment samples taken from the three sampling sites are showed in Table 3 and Table 4. A total of 84 samples were analyzed using ICP-MS.

While for water quality data for river at Kampung Batu Sawar to Taman Merdeka (Pahang River) is tabulated in Table 2. It was found that, the pH value in this study area varies between 5.5 and 8.0. Reference [6] shows that the pH value of water is an important indication of river water quality. This is because acid-

base reactions may influence on pH and ion Chemistry. For turbidity of Pahang River, it was high. This may be due to the boating activities, sand mining and construction of roads along that river. Other physical parameters were detected at low concentrations. Generally, it shows that Pahang River is characterized by clean river.

Table 2: Overall average water quality results of Pahang River (from Kampung Batu Sawar to Taman Merdeka).

Sampling location	Temperature (° C)	pH	Turbidity (FTU)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)
River at Kampung Batu Sawar	28.9	5.82	41.2	6.4	364
River at Kampung Padang Rambia	32.3	6.33	53.4	5.6	237
River at Taman Merdeka	32.7	6.81	73.8	5.3	163

### Water analysis

The concentration of heavy metals in river water such as Pb, Cd, Zn and Cu are detected by the used of analytical techniques. Most of the concentration of heavy metals for Pb, Cd, Zn and Cu were detected at low concentrations especially Cadmium. The concentration was in the order of Zn > Pb > Cu > Cd. The concentrations of heavy metals (Table 3) in the water ranged between Zn, (15.22 – 52.91) µg/ L.; Pb, (2.75 – 12.38) ; µg/ L. Cu, (2.79 – 9.92) µg/ L.; Cd, (0.16 – 0.37) µg/ L. From Figure 2, 3 and 4, compared with these four heavy metals, zinc gives the highest concentration in river water [8]. The highest level of zinc was obtained at Taman Merdeka and the lowest at Kampung Batu Sawar.

Reference [9] shows that the average zinc concentration found in Sg. Skudai river system is 40.54 µg/ L while reference [10] reported that there was an increase of zinc in Sg. Skudai which is 0.016 mg/L of zinc in year 2000 and 0.0346 mg/ L of zinc in year 1999. However in this study, it was found that the concentration of zinc in Pahang River does not exceed Malaysian Interim National Water Quality Standard (INWQS) level which is 0.35 mg/ L.

While for cadmium, it shows that the highest level of cadmium in water was obtained at Taman Merdeka and the lowest at Kampung Batu Sawar. The average cadmium concentration found in waters of Pahang River system is 0.28 µg/ L.

Table 3: The concentration of heavy metals in water from the Pahang River, Pekan, Pahang (ppb)

Month (2010)/ Location	Pb			Cd			Zn			Cu		
	K.B.S	K.P.R	T.M	K.B.S	K.P.R	T.M	K.B.S	K.P.R	T.M	K.B.S	K.P.R	T.M
March	4.21±0.04	4.33±0.06	4.89±0.12	0.16±0.06	0.18±0.03	0.29±0.04	22.56±0.12	23.42±0.42	44.27±0.28	3.02±0.18	2.99±0.03	6.73±0.02
April	4.19±0.12	6.25±0.08	9.24±0.05	0.18±0.04	0.19±0.11	0.23±0.07	27.34±0.23	26.82±0.13	42.39±0.28	2.79±0.05	2.88±0.08	7.03±0.06
May	3.98±0.07	4.76±0.12	6.01±0.03	0.25±0.05	0.27±0.04	0.37±0.12	19.47±0.18	31.75±0.26	52.91±0.65	2.88±0.08	3.33±0.04	6.48±0.05
June	2.75±0.09	12.38±0.06	5.67±0.0	0.15±0.07	0.18±0.08	0.25±0.12	23.92±0.13	23.51±0.18	45.29±0.71	3.08±0.05	5.21±0.12	9.92±0.09
July	2.93±0.13	4.89±0.07	7.31±0.04	0.39±0.12	0.21±0.03	0.33±0.04	21.32±0.24	33.24±0.67	47.33±0.24	4.43±0.04	8.77±0.09	7.27±0.07
August	3.33±0.04	3.76±0.13	4.96±0.04	0.18±0.08	0.20±0.04	0.31±0.18	15.22±0.63	42.82±0.54	64.83±0.78	3.71±0.24	3.58±0.04	6.44±0.04
September	3.5±0.08	4.98±0.05	5.47±0.04	0.16±0.06	0.18±0.05	0.24±0.11	23.73±0.44	24.81±0.63	42.98±0.23	2.93±0.25	5.29±0.07	6.38±0.03

Table 4: The concentration of heavy metals in sediments from the Pahang River, Pekan, Pahang (ppb)

Month (2010)/ Location	Pb			Zn			Cu		
	K.B.S	K.P.R	T.M	K.B.S	K.P.R	T.M	K.B.S	K.P.R	T.M
March	17.72±0.20	19.73±0.26	21.41±1.72	30.95±2.82	43.44±2.42	128.64±3.47	7.89±0.33	6.98±0.22	23.81±0.45
April	22.77±0.21	24.31±0.31	38.52±0.21	23.44±1.75	32.27±1.89	118.30±1.76	5.24±0.26	3.83±0.16	15.89±0.63
May	15.81±0.10	29.89±0.74	36.49±1.34	29.72±0.71	28.91±1.56	189.34±4.97	8.87±0.16	5.23±0.77	14.20±0.59
June	8.91±0.22	18.22±1.72	25.03±0.12	35.82±1.76	34.58±0.93	166.92±9.73	6.33±0.22	7.94±0.46	17.86±0.25
July	9.03±0.12	36.78±0.31	40.32±0.21	20.92±1.89	27.46±1.18	183.44±6.43	12.39±0.56	6.85±0.18	26.54±0.63
August	16.72±0.34	22.32±0.91	24.36±1.27	28.30±1.64	48.76±0.89	133.44±4.55	6.72±0.52	12.90±0.21	24.20±0.23
September	18.38±0.28	17.91±1.38	32.48±0.31	42.18±1.13	38.49±2.13	121.73±5.32	4.88±0.84	6.32±0.45	15.76±0.18

\*K.B.S: Kampung Batu Sawar

\*K.P.R: Kampung Padang Rambia

\*T.M: Taman Merdeka

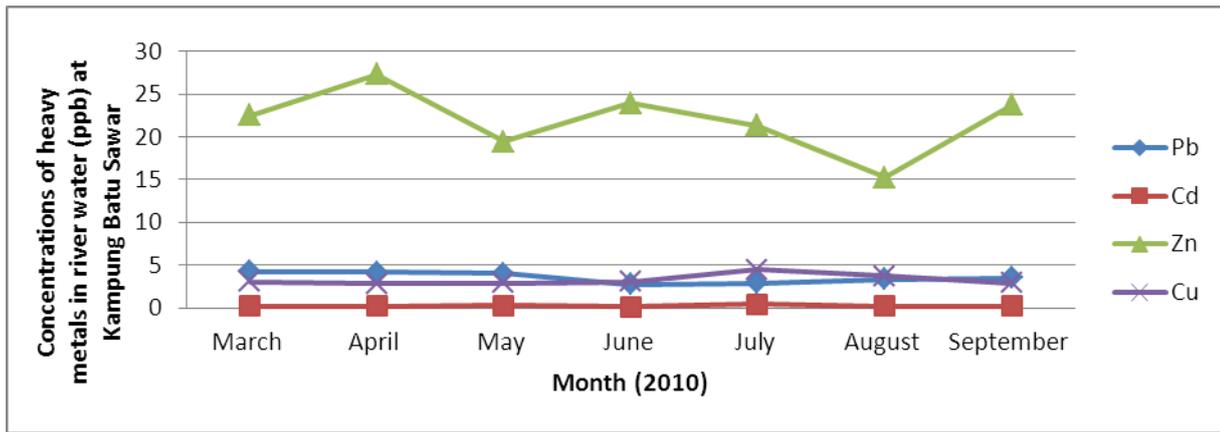


Fig 2: The concentrations of heavy metals Pb, Cd, Zn and Cu in water samples from Kampung Batu Sawar (K.B.S).

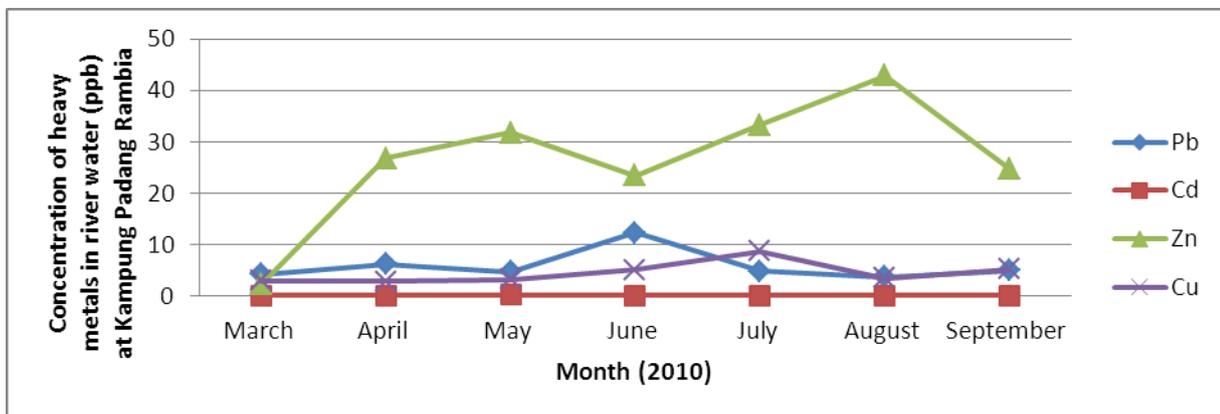


Fig 3: The concentrations of heavy metals Pb, Cd, Zn and Cu in water samples from Kampung Padang Rambia (K.P.R).

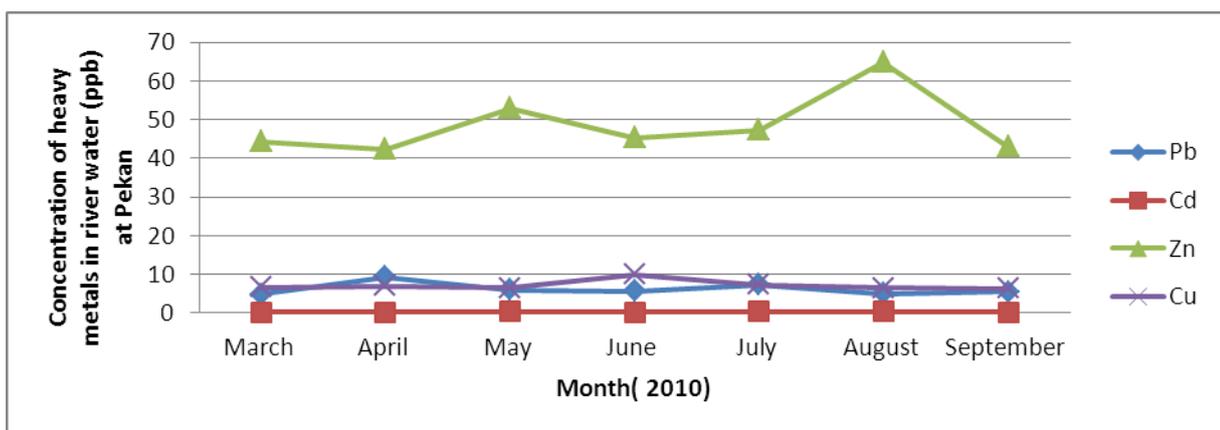


Fig 4: The concentrations of heavy metals Pb, Cd, Zn and Cu in water samples from Taman Merdeka (T.M), Pekan.

A study of cadmium levels in Sg. Semenyih showed an average concentration of 0.18 µg/ L [11] and 0.37 µg/ L at Sg. Skudai [12]. Reference [9] shows that cadmium concentration of 0.0004 mg/ L in Sg. Prai, 0.002 mg/ L in Sg. Kelang and 0.002 mg/ L in Sg. Melaka.

Based on INWQS, the study shows that the concentration of cadmium is low compared with the level of cadmium for Malaysian rivers, 10 µg/ L. Reference [12] shows that, cadmium concentration in non-polluted natural waters usually are lower than 1 µg/ L. This shows that cadmium concentration found in Pahang River is below the polluted level set by INWQS.

By referring to heavy metals trend zinc has the highest level concentration and the lowest is concentration of cadmium in Pahang River. Reference [14] reported that a study in Sg. Sepang Kecil, Selangor showed the trend of heavy metals concentration in water is Pb> Zn> Cr> Cu> Cd while Vynavi (2000) stated that the trend of heavy metals in Sg. Skudai is Zn> Ni> Cu> Cr> As> Pb> Hg> Cd.

However for this study, heavy metals concentrations showed that all elements do not exceeded the INWQS level as shown as in Table 5.

Table 5: Malaysian Interim National Water Quality Standard (INWQS)

Parameters	Classes					
	I	IIA	IIB	III	IV	V
DO (mg/ L)	7	5-7	5-7	3-5	3	1
pH	5-7	5-7	3-5	3	1	
Conductivity (umhos/ cm)	1000	1000	1000	-	6000	-
Temperature	Normal	Normal	Normal	-	-	-
Turbidity (NTU)	5	50	-	-	-	-
Cadmium (mg/ L)	-	-	-	0.011	0.011	-
Copper (mg/ L)	-	-	-	0.012	0.2	-
Plumbum (mg/ L)	Natural level	0.05	-	-	5	-
Zinc (mg/ L)	Natural level	-	-	-	0.35	-

Source: INWQS (Tong & Goh, 1997)

#### Sediment analysis

The heavy metal concentrations in the sediments are presented in Table 4. A comparison of results shows that the concentration of Pb, Cd, Zn and Cu at Taman Merdeka are considerably higher than those obtained at Kampung Batu Sawar and Kampung Padang Rambia. The concentrations of heavy metals in sediment ranged between Zn, (20.92 – 189.34) µg/ g.; Pb, (8.91 – 38.52) µg/ g.; Cu, (3.83 – 26.54) µg/ g while Cd has to small concentration and is not detected. Relatively higher concentration of Zn, Pb and Cu concentration in river at Taman Merdeka to Kampung Padang Rambia were due to seabed topography, anthropogenic activities such as sand mining, road construction and boating activities [13]. While higher concentration at Kampung Padang Rambia compared to Kampung Batu Sawar

were caused by agriculture activities such as herbicide and pesticide and domestic waste [2].

Analysis of variance (ANOVA) shows that, there is significant difference between the sampling locations and the concentration of heavy metal ( $P$  value < 0.05). It shows that  $P$  value for water analysis is  $1.07 \times 10^{-36}$  while  $P$  value for sediment analysis is  $1.13 \times 10^{-19}$  which are less than 0.05. Therefore,  $H_0$  is rejected thus there is an interaction or significant different between sampling locations and the concentration of heavy metal.

In general, the heavy metal concentrations in the water samples taken from river at Taman Merdeka were higher than in river at Kampung Batu Sawar. Same as heavy metal concentrations in sediments, it suggests that this is due to the higher flow disturbance in the mainstream that leads to

resuspension and downstream movement of pollutants [15].

#### 4. CONCLUSION

Consequently, it can be concluded that the concentrations of heavy metals in water and sediments are low and under the limit of detection when compared with (INWQS). As compared with the overall heavy metals, Zn has the highest concentration in water and sediments followed by Pb, Cu and Cd. While sampling point at Taman Merdeka show the highest metals contained in river water, followed by Kampung Padang Rambia and Kampung Batu Sawar. The results of this study supplied valuable information on the metals level in Pahang River. It shows that, Pahang River near Pekan is characterized by good water quality, where the metals concentrations classify all sampling stations between class I and II. In addition, the levels of detected metals in sediment are low. However a potential dangerous may occur based on the agricultural and fishing activities, dumping of sediment and industrial development in the future.

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