Journal of Tropical Resources and Sustainable Science

journal homepage: jtrss.org

Determination of Heavy Metals in Water Samples from Sungai Kerteh and Sungai Paka, Terengganu, Malaysia

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Received 12 April 2017
Accepted 9 May 2017
Online 16 November 2017

Keywords:
Flame Atomic Absorption Spectroscopy (ASS), water samples, Sungai Kerteh, Sungai Paka.

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Abstract

Rapid development of industrialization and urbanization along Sungai Kerteh and Sungai Paka was become a problem due to metal pollution. Namely, anthropogenic activities nearby Sungai Kerteh and Sungai Paka were contributed to heavy metals pollution into those rivers. The aims for this study were to determine the selected heavy metals contamination in water samples and compared with National Water Quality Standard for Malaysia (NWQS). A total of 8 water samples were collected from both rivers and heavy metal concentration were analyzed using flame Atomic Absorption Spectroscopy (ASS). Four parameters of physical chemical properties were also analyzed which are pH, temperature, dissolved oxygen and turbidity. The ranges of physical chemical properties are pH (7.84-8.78), temperature (31.20 -38.70 ºC), dissolved oxygen (27.90-107.20%) and turbidity (1.83-10.5 NTU) respectively. The mean of heavy metals concentration was ranged as followed; As (2323.00 ug/L) > Hg (571.93 ug/L) > Pb (402.13 ug/L) > Zn (87.13 ug/L) >Cr (74.63 ug/L) > Cu (48.50 ug/L) > Ni (17.25 ug/L) > Cd (11.38 ug/L). When compared with NWQS, most of metals (Cu, Pb, Ni and Zn) are below the NWQS threshold limit except As, Cd, Cr and Hg. The output data from this study can be used as database for continuous monitoring at both rivers.

1. Introduction

Heavy metals are commonly known as environmental pollutants particularly from anthropogenic and regarded as natural trace components of the aquatic environment (Lim et al., 2012). This pollution is introduced into environment through lithogenic process (natural process) and anthropogenic process (induced by human activities) (Sany et al., 2011).

Existence of heavy metals pollution in river water is a consequence of several activities such as chemical manufacturing, painting and coating, mining, extractive metallurgy, nuclear and other industries. When heavy metals are in contact with aquatic environment, heavy metal pollution is occurred. Heavy metals pollution represents a serious problem wastewater, metals leach into ground water or soil for human health and for life in general. Thus, water quality monitoring has been done based on the collection and laboratory analysis of samples since ages.

The quality of the water itself is vital concern for human being since it is directly related to human welfare (Patil & Pati, 2010). According to Badaii et al. (2014) river systems are a basic part of the water supply in Malaysia and there are more than 150 rivers systems present in Malaysia which 100 of them are located in Peninsular Malaysia.

2. Materials and Methods

The study was carried out at Sungai Paka and Sungai Kerteh which are located at southern part of Terengganu Malaysia as shown in Figure 1. Land use within the catchments of Dungun and Kemaman are predominantly agricultural activities with urban development and petrochemical industries situated at the coastline especially in Kerteh and Kemaman.

Kerteh known as an industrial complex operating oil and gas landing facilities whereas Dungun formerly was known for iron-ore mining activities. The data of Global Positioning System (GPS) and description of sampling location was shown in Table 1. Prior to the sample collection, in-situ reading of physicochemical parameters including pH, temperature, dissolved oxygen and turbidity were taken. The sampling procedure

eISSN Number: 2462-2389

involved the collection of water using polyethylene bottles respectively at 4 stations in each sampling area; Sungai Kerteh and Sungai Paka and a total of 8 water samples were collected in bottle. For sample preparation about 2 ml of HNO_3 & 5ml of HCl was added to beaker containing 100ml of water sample. The beaker then was heated on hot plate at 90 to 95°C until the volume reduces to 15 to 20ml. After cooled, the water sample was filtered using filter paper if there is any silicates water and around 1.5 ml of prepared digested samples were transferred into 15ml of centrifuge tube and 13.5 ml of distilled water was added to the centrifuge containing 1.5 ml prepared digested sample. The digested samples were diluted using dilution factor of 10-1. The digested samples and diluted samples stored in polyethylene tubes of 15 ml then ware stored in 4°C fridge before heavy metal analysis using flame Atomic Absorption Spectroscopy (ASS). The sampling, preservation and analysis procedures were based on APHA (1995).

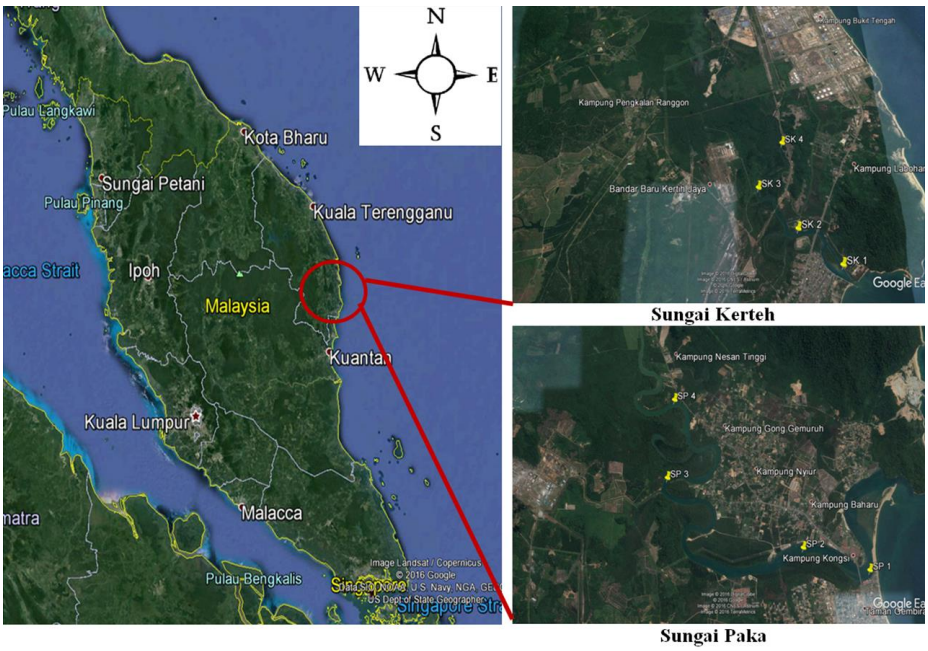

Figure 1: Sampling locations in Terengganu, Malaysia (Source: Google Map)

Table 1: The Global Positioning System (GPS) data and description of sampling locations

Station	Latitude	Longitude	Description
SK 1	N 04º31'01.7"	E 103º27'09.1"	Nearby fisheries area
SK 2	N 04º31'26.9"	E 103º26'37.4"	Discharge from housing areas
SK 3	N 4°31'58.02"	E 103°26'7.42"	Water way discharge from airport
SK 4	N 04º32.589'	E 103º26.485'	Petroleum plantation
SP 1	N 4°38'28.10"	E 103°26'13.41"	Aquaculture activities
SP 2	N 04º38.690'	E 103º25.492'	Residential area and sand mining area
SP 3	N 04º39.383'	E 103º23.992'	Petroleum plantation
SP 4	N 04º40.167'	E 103º24.068'	Aquaculture activities

*SK= Sungai Kerteh ; SP= Sungai Paka

3. Results and Discussion

Table 2 shows the physical chemical properties in all 8 water samples from Sungai Kerteh and Sungai Paka. Four parameters of physical chemical were analyzed in these studies which are pH, temperature, dissolved oxygen and turbidity. The range of pH value (7.84-8.78), temperature (31.20 -38.70ºC), dissolved oxygen (27.90-107.20%) and turbidity (1.83-10.5 NTU). The pH value in all sampling stations still did not exceed than the alkaline pH (7.2-9.8) for water. Meanwhile, station SK 2 shows the highest dissolved oxygen (107.20%) and station SK 1 shows the lowest dissolved oxygen content in water sample (27.90%). For turbidity parameter, station SK 4 shows the highest with 10.5 NTU and station SK1 show the lowest turbidity value (1.83 NTU) due to the anthropogenic activity that happened in that area.

Table 2: Physical chemical properties of water samples from Sungai Kerteh and Sungai Paka

Station	pH	Temperature (ºC)	Dissolved Oxygen (%)	Turbidity (NTU)
SK 1	8.11	32.8	27.9	1.83
SK 2	8.26	31.2	107.2	3.18
SK 3	8.14	31.5	94.0	4.94
SK 4	8.78	31.5	95.3	10.5
SP 1	8.11	36.0	85.3	3.04
SP 2	8.11	38.4	93.5	7.35
SP 3	7.84	38.7	94.7	8.22
SP 4	8.11	32.9	93.5	3.85

*SK= Sungai Kerteh ; SP= Sungai Paka

The metal concentration in water of Sungai Kerteh and Sungai Paka are given in Table 3 and Figure 2. Among the detected heavy metals in water sample from Sungai Kerteh, arsenic had the highest concentration at

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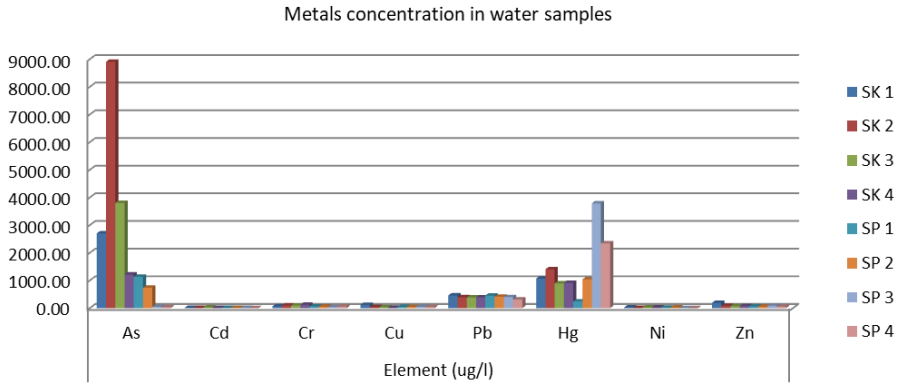
station SK 2 (8,905.00 ug/L) due to the effluent discharge from housing areas and Copper contamination was recorded the lowest concentration in station SK 4 (16.00 ug/L) . Meanwhile in Sungai Paka, mercury values recorded the highest value from station SP 3 (3,787.00 ug/L) due to the anthropogenic activity from petroleum plantation and Nickel shows the lowest values from station SP 4 (2.00 ug/L).

Among all the selected heavy metals, As, Hg, Pb, Zn and Cr have significant contribution on heavy metals contamination in river whereas Cu, Ni and Cd have contributed in low concentration. The mean concentration of heavy metals from both rivers was shows in decreased order as followed; As> Hg> Pb> Zn>Cr>Cu>Ni>Cd. Food and Agriculture Organization (FAO) (1992) had claimed that the occurrence of metal contaminants especially the heavy metals in excess of natural loads has become a problem of increasing concern. The rapid development in contents of population, urbanization, industrial activities, exploration and exploitation of natural resources, extension of irrigation and other modern agricultural practices were risen the result of heavy metals concentration in water (Gebremedhin & Berhanu, 2015).

Table 3: Metal content in water from Sungai Kerteh and Sungai Paka

Station	Element (ug/L)							
	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
SK 1	2702	11	65	120	460	1067	24	191
SK 2	8905	13	98	39	396	1403	10	86
SK 3	3805	24	96	30	388	896	27	75
SK 4	1216	10	122	16	391	912	25	77
SP 1	1132	11	63	48	454	241	22	68
SP 2	739	11	57	45	416	1039	24	60
SP 3	50	8	37	50	400	3787	4	85
SP 4	35	3	59	40	312	2343	2	55

*SK= Sungai Kerteh ; SP= Sungai Paka



*SK= Sungai Kerteh ; SP= Sungai Paka

Figure 2: Metals concentration in water samples from Sungai Kerteh and Sungai Paka

From the Table 4, the range of metal concentration in all sampling stations was recorded as follow: As (2,323.00 ug/L), Cd (11.38 ug/L), Cr (74.63 ug/L), Cu (48.50 ug/L), Pb (402.13 ug/L), Hg (571.93 ug/L), Ni (17.25 ug/L) and Zn (87.13 ug/L). Furthermore, in this study most of metals (Cu, Pb, Ni and Zn) are below the National Water Quality Standard for Malaysia (NWQS) threshold limit except As, Cd, Cr and Hg as shown in Figure 4 and 5. For Arsenic and Cadmium contaminations, all stations were recorded exceed the INWQS threshold limit 100ug/L (As), 10ug/L (Cd) except station SP3 and SP 4.

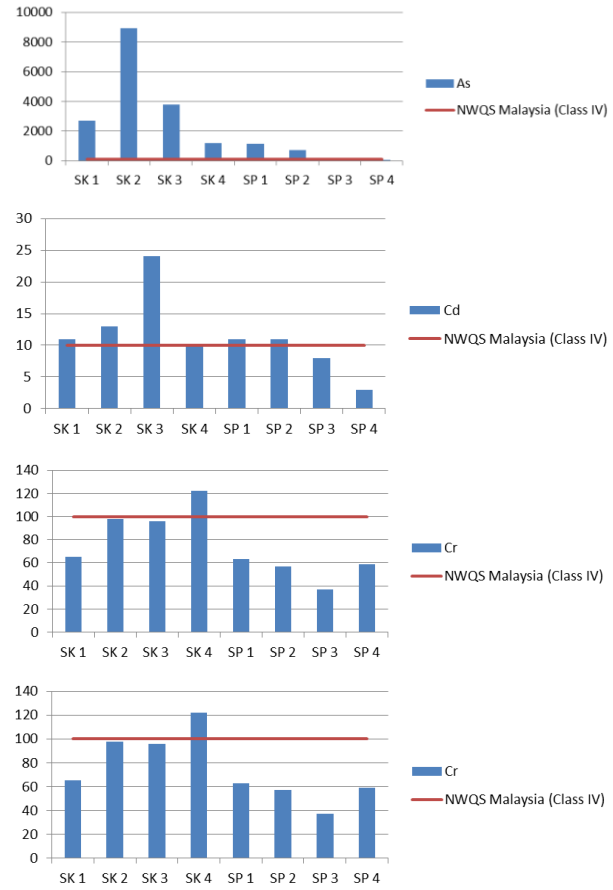
Table 4: Mean concentration of metals in selected rivers and National Water Quality Standard for Malaysia (NWQS)

Metals	Measured value (ug/L)	NWQS Malaysia (Class IV) (ug/L)
As	2,323.00	100
Cd	11.38	10
Cr	74.63	100
Cu	48.50	200
Pb	402.13	5,000
Hg	571.93	2
Ni	17.25	200
Zn	87.13	2000

The potential sources of arsenic and cadmium contaminations may come from fisheries area, residential area and petroleum plantation. Meanwhile, only station SK4 was recorded Chromium contamination exceed NWQS threshold limit 100ug/L. Chromium usually used in metal alloys such as stainless steel, protective coatings on metal which is electroplating, magnetic tapes, and pigments especially for paints, cement, paper, rubber, and composition floor covering. All stations were recorded mercury contamination exceed NWQS threshold limit 2ug/L. The possible sources of mercury contamination may come from point and non-point sources nearby those areas.

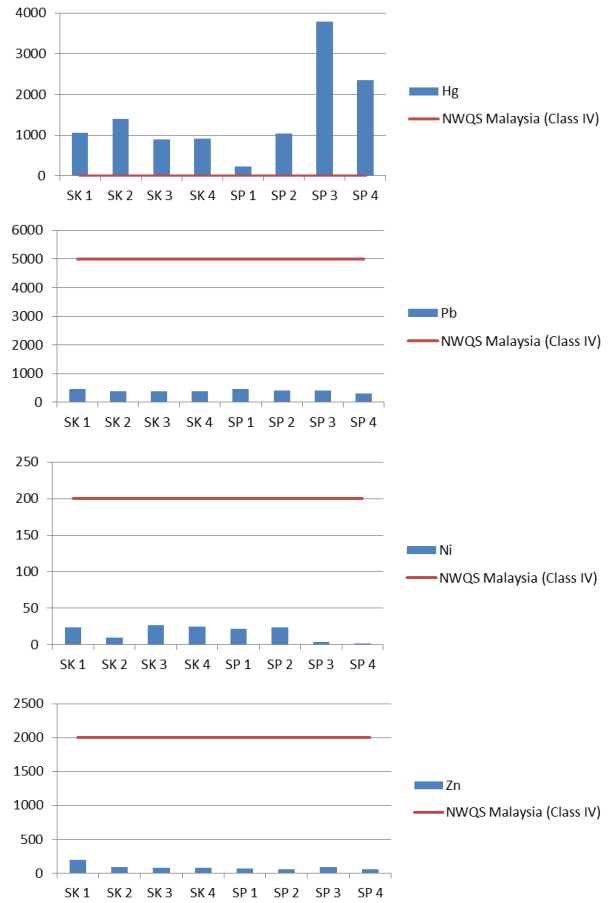
In this study, one-way ANOVA was chosen for statistical analysis. Statistical analysis proved that sampling location strongly influences the distribution of metal concentration. The descriptive analysis of the selected metals concentration in Sungai Kerteh and Sungai Paka was shown in Table 5.

eISSN Number: 2462-2389



*SK= Sungai Kerteh ; SP= Sungai Paka

Figure 4: Arsenic, cadmium, chromium and copper concentration in Sungai Kerteh and Sungai Paka



*SK= Sungai Kerteh ; SP= Sungai Paka

Figure 5: Lead, mercury, nikel and zink concentration in Sungai Kerteh and Sungai Paka

Table 5: Descriptive analysis of the selected metals concentration in Sungai Kerteh and Sungai Paka

Metals	N		Units		Minimum		Maximum		Mean		Std. Deviation	
	Sungai Kerteh	Sungai Paka	Sungai Kerteh	Sungai Paka	Sungai Kerteh	Sungai Paka	Sungai Kerteh	Sungai Paka	Sungai Kerteh	Sungai Paka	Sungai Kerteh	Sungai Paka
As	4	4	ug/l	ug/l	1,216	35	8,905	1,132	4,157.00	489.00	0.001	0.002
Cd	4	4	ug/l	ug/l	10	3	24	11	14.50	8.25	0.001	0.002
Cr	4	4	ug/l	ug/l	65	37	122	63	95.25	54.00	0.001	0.002
Cu	4	4	ug/l	ug/l	16	40	120	50	51.25	45.75	0.001	0.002
Pb	4	4	ug/l	ug/l	388	312	460	454	408.75	395.50	0.001	0.002
Hg	4	4	ug/l	ug/l	896	241	1,403	3,787	1069.50	1852.50	0.001	0.002
Ni	4	4	ug/l	ug/l	10	2	27	24	21.5	13.00	0.001	0.002
Zn	4	4	ug/l	ug/l	75	55	191	85	107.25	67.00	0.001	0.002

4. Conclusion

In this study, the mean concentration of selected metals was range in decreased order as follow As> Hg> Pb> Zn>Cr>Cu>Ni>Cd. All sampling stations recorded below National Water Quality Standard for Malaysia (NWQS) threshold limit except As, Cd, Cr and Hg metals. The potential pollutant sources may come from anthropogenic activities such as from fisheries area, petroleum plantation, agriculture area and residential area.

Acknowledgment

The authors would like to thank to Malaysian Ministry of Higher Education for financial supports under R/RAGS/A08.00/01203A/001/2015/000187 grant and also to Faculty of Earth Sciences (Jeli Campus), Universiti Malaysia Kelantan for providing kindly laboratory and material supports.

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eISSN Number: 2462-2389