ASM Sc. J., 14, Special Issue 1, 2021 for ICSTSS2018, 108-111

The Preliminary Heavy Metals Assessment in Pahang River, Malaysia

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An investigation was done to measure the heavy metals traces in Pahang River and to classify the river water according to the Interim National Water Quality Standards (INWQS). Surface water samplings were taken from five different locations along Pahang River including three of its river creeks namely Jelai River, Tembeling River and Semantan River. The dissolved oxygen (DO), total dissolved solids (TDS), salinity, conductivity and alkalinity or acidity index (pH) were measured in-situ by means of Hydrolab YSI ProPlus. The concentrations of copper, aluminium, iron, manganese, nickel and lead were determined and analyzed using the Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The mean values for aluminium are found the highest ranging from 1.03 to 5.88 mgL^{-1} followed by iron which ranges between 0.76 to 2.46 mgL^{-1}. Copper, manganese, nickel and lead showed low readings of not more than 0.04 mgL^{-1}. The water constituents of Pahang River from the sampling stations namely Jelai River, Semantan River and Tembeling River were suggested to fall under Class IIA according to the INQWS, which means that conventional treatment must be done prior to consumption.

Keywords: heavy metals; mining effluent; pollutant; riverside agriculture; soil erosion; water quality index

I. INTRODUCTION

Pahang River flows through the state of Pahang, Malaysia with 459 km in length and 29,300 km^2 basin size. It is the third longest river in Malaysia which consists of two main tributaries which are the Jelai River and the Tembeling River before joining the mainstream Pahang River at Kuala Tembeling. The Jelai River originates from the mountainous of Pahang-Perak state border in the Raub district. On the other hand, there is the Semantan River which begins in the Bentong district and ends at Kuala Semantan. Here, all the rivers merge with the mainstream Pahang River before draining into the South China Sea.

Pahang is one of the biggest states in Malaysia that has the biggest land use in the plantation of oil palms and rubber trees. The major use of the riverside lands along the Pahang River are rubber plantations, oil palm estates and agronomic farms. In order to enhance the quality of soil and to increase productivity, huge amounts of fertilizers have been used. The state of Pahang, which is also rich in rainforest timber, has also experienced deforestation activities that are susceptible to the degradation and soil wearing away into the waterway. Likewise, waste from industrial plants such as from the paper industry in the Bentong district and the possible removal of metal ores from the mining activities in the Raub district have brought about considerable change in the water quality.

Heavy metals are dangerous metallic elements that can damage human body and other living organisms in the long term due to their bioaccumulation ability. Even in low concentrations and minute amounts (parts per billion range), heavy metals are still very harmful and poisonous. In this region, they might be introduced into the aquatic systems due to the weathering of soils and rocks from mining activities, accidental spillage of chemical waste from industries, agriculture drainage and domestic waste that

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contain metal pollutants (Lakherwal, 2014). Common heavy metal pollutants such as lead (Pb), mercury (Hg), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu) and nickel (Ni) are non-degradable, thus they impose an eco-toxicological impact to the plants, aqua organisms as well as human beings if they dissipate into our bodies via the food chain.

Water quality measurement is a vital part of the environment monitoring system. It monitors crucial parameters such as the dissolving oxygen ability, the acidity or alkalinity (pH), the total dissolved solid, the temperature and the salinity as well as the conductivity to describe the condition of water (Diersing, 2009). Poor water quality leads to non-healthy environment to the aquatic organisms which in consequence will affect the consumer in the food chain related to the ecosystem. Pahang River is a major water resource to domestic and industries in this state as well as the plantation sector. Moreover, due to the demand from the food industries, this river has been the main raising place for freshwater fish like silver catfish and tilapia. These aquatic organisms are vulnerable to heavy metals accumulation (Amirah *et al.*, 2003).

The Interim National Water Quality Standards (INWQS) is a set of standards derived based on beneficial uses of water. The INWQS defined six classes (I, IIA, IIB, III, IV and V) referring to classification of rivers or river segments based on the descending or order of water quality (Zaki, 2010). In terms of water used for domestic supply, fisheries and aquatic propagation, livestock drinking, recreation and agricultural, Class I is considered the best while that of Class V is the lowest. Thus, the objective of this study is to measure the concentration of heavy metals in water samples taken from the constituents of the Pahang River to serve as a preliminary screening that will help classify the water according to the INQWS. Hence, further research to set more effective policies and strategies for well management and governance of water resources in this state could be stimulated.

II. MATERIALS AND METHOD

Samples of river water were taken at about one-foot depth of moving water. Each sample was collected in a 5 litre sanitized bottle container. The container was lowered into the water facing upstream and gradually filled to allow air bubbles to float out. To minimize contamination, the lid was opened only after the container was totally immersed in the water and was capped while it was still submerged.

Table 1 lists five sampling stations selected along the Pahang River and Figure 1 illustrates the pathway of the Pahang River.

Table 1. Locations of river water sampling along the Pahang River

Station	Main river	GPS
Kg Jeram Landak (S1)	Jelai	4.1079°, 102.2394°
Kg Megat Segama (S2)	Semantan	3.4790°, 102.3948°
Kg Pangsenam (S3)	Pahang	3.4220°, 102.4263°
Kg Lada (S4)	Pahang	3.9629°, 102.4038°
Kg Labu (S5)	Tembeling	4.3512°, 102.3940°

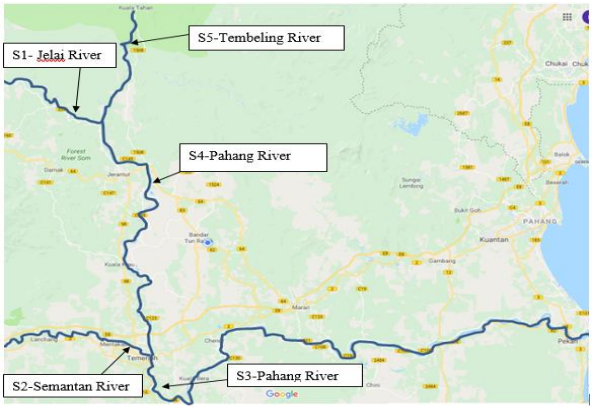

Figure 1. The route of the Pahang River and the sampling locations

Next, the samples underwent water acidification process whereby three drops of concentrated nitric acid, HNO_3 were added into the water. This process is important to prevent metal loss and inhibit microorganism growth (Olowu *et al.*, 2010). The physical parameters namely the temperature (θ), the dissolved oxygen (DO), the conductivity (σ), the salinity (S), the pH and the total dissolved solids (TDS) were measured in-situ by means of the Hydrolab YSI ProPlus. The heavy metals content in the water samples were then analyzed by using the Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). In order to assure that the results were reliable and conformed to quality control and assurance, the time and the water temperature during which the sampling took place were controlled and recorded.

III. RESULTS AND DISCUSSION

The in-situ physical parameters that represent the profile of the Pahang River water is shown in Table 2. Dissolved oxygen (DO) determines the livability of a stream for fish and many other aquatic organisms. Dissolved oxygen level that drop below 5.0 ppm causes stress to aquatic life (Murphy, 2007). The DO for all the sampling stations ranging between 5.79 and 6.09 ppm represented a good environment for freshwater fish farming.

Table 2. In-situ parameters of river water at sampling stations

Parameter	S1	S2	S3	S4	S5
θ (°C)	27.70	26.1	27.6	28.5	29.3
DO (ppm)	5.79	5.28	5.36	5.51	6.09
TDS (ppm)	20.1	20.2	26.0	35.2	21.4
Salinity (ppt)	0.01	0.02	0.02	0.02	0.01
σ (μScm^{-1})	48.5	31.2	41.9	54.0	36.4
pH	8.59	8.55	8.61	8.36	8.37

The dissolved oxygen may probably originated from direct absorption from the atmosphere and further contributed by the rapid stream movement and product of plant photosynthesis. Moreover, the water temperature which was slightly above room temperature keeps dissolved oxygen sustained.

The conductivity of the samples was a direct indication of the existence of saline in the river water. Excessive amounts of dissolved salt in water may have an effect towards agricultural productivity, the drinking water quality and the health of the ecosystem. Salts are highly soluble in surface and groundwater and can be transported with water movement. Additional salt is transported to the soil surface or waterways due to altered land use such vegetation clearance, poor land management, irrigation and industrial practices (Nielsen *et al.*, 2003). The results showed tolerable amount of salt in the Pahang River which was on an average of 0.01 ppt. The pH of the river water was alkaline.

Total dissolved solid (TDS) is a measure of the relative weight of dissolved materials in a sample of water. The average value worldwide for freshwater is approximately 100 ppm and the maximum TDS concentration of drinking water allowed by the EPA is 500 ppm (EPA, 2012). The greatest value of TDS for S4 station was suggested due to the downstream accumulation of chemical and metallic compounds from the gold and iron mining activities near the Jelai River which drained into the Pahang River. It might also be contributed by the mineral drainage from the mountainous area where the stream begins. As far as the water index was concerned, Pahang river showed a TDS reading that was far below the hazard line. According to the INQWS, the river water at all the stations fall under Class IIA which means that conventional treatment on the water must be done prior to consumption.

Table 3 shows the mean results of heavy metal concentration in ppm from the water sampling at selected locations. Note that, since this study is a preliminary screening of the water, no statistical analysis was done to find the significant difference of metal concentrations between all the sampling stations.

Table 3. Mean metal concentrations at sampling stations

Element	S1 mgL^{-1}	S2 mgL^{-1}	S3 mgL^{-1}	S4 mgL^{-1}	S5 mgL^{-1}
Al	5.88	6.01	6.11	4.67	1.03
Cu	0.00	0.01	0.00	0.01	0.00
Fe	2.46	2.68	2.66	2.07	0.76
Mn	0.01	0.08	0.04	0.01	0.02
Ni	0.00	0.01	0.00	0.00	0.01
Pb	0.00	0.14	0.00	0.00	0.03
*K	2.88	4.90	3.30	2.73	1.45

*non heavy metal

Aluminium showed the highest concentration among all the metals in the sampling stations. This might be attributed to the possible existence of bauxite at the riverside of the Pahang River. Bauxite is a rock composed mainly of aluminium-bearing minerals. Pahang is a state in Malaysia that is rich in metallic ores such as bauxite, gold and iron. To date, these minerals are actively excavated as part of the economic activity. Likewise, mining activities of iron ores may also have contributed to the iron trace effluent into the Pahang River. The low amounts of nickel, lead, and copper does not necessarily represent the non-

existence of these elements in the Pahang River. Future investigation is recommended to ascertain their amount by finding their accumulation in fish anatomy, which is a more reliable indicator. The apparent presence of potassium, though not heavy metal, might be attributed to the effluent of fertilizer by-product into the Pahang River through soil erosion and underground leakage (Wantzen & Mol, 2013). Fertilizer are introduced in large amounts to promote growth since plantation and farming activities have been the major economic benefactor in this state. Among all the stations, the result for the Tembeling River (S5) showed the least readings of heavy metals. This was expected as this river flows from Kuala Tahan, the gateway to the National Park, Malaysia's preserved rainforest, far off from man-made activities.

IV. CONCLUSION

The constituent of the Pahang River water namely the Jelai River, the Semantan River and the Tembeling River may fall under Class IIA according to the INQWS. This means that treatment of water is compulsory prior to consumption. The existence of heavy metals, even though in low amounts, has provided a pollutant indicator that the environment authority must be made aware of. Further investigation in determining the accumulation of heavy metals in aquatic organisms is recommended.

V. ACKNOWLEDGEMENT

The authors would like to thank the Institute of Science, Universiti Teknologi MARA for allowing us to use their facilities to complete this study.

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