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Study On Toxic Chemicals In Kuantan River During Pre And Post Monsoon Season

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Abstract: A study on water quality based on toxic heavy metals was carried out between October, 2010 and January, 2011 at Kuantan River, Pahang. Three stations expected to be polluted were chosen to be studied in this study. The stations were firstly, the area near to the fish landing jetty, secondly the area adjacent to Hospital Tengku Ampuan Afzan, Kuantan and thirdly at the Kuantan River estuary. *In-situ* measurements were conducted and samples were also collected during low tides for laboratory analysis. The results of this study showed that the metalloid such as arsenic ranged from 5.05 to 32.09 µg/L during pre-monsoon and from 5.71 to 22.81 µg/L during post-monsoon. The two highest quantity of heavy metals found were copper ranging from 2.66 to 26.27 µg/L and zinc from 6.02 to 38.61 µg/L for pre-monsoon season. During the post-monsoon season, copper ranged from 18.03 to 90.79 µg/L and zinc from 3.42 to 11.34 µg/L. The values for other heavy metals were low compared to these two. Results of this study shows that the Kuantan River can be classified under Class 2 based on the Interim National Water Quality Standards (INQWS) classification which indicates that it is not heavily polluted. The study revealed that seasonal changes and human activities had affected the quality of water in the river.

Key words: River estuary, heavy metal, metalloid, heavily polluted

INTRODUCTION

A river is characterized by unidirectional flow of water; much more than water flowing into the ocean. It is a necessity for animals, a habitat for fish, and a source of recreation and income for many people. Protecting a river is more important than maintaining a subtle balance of plants, animals, nutrients, and microorganisms. Unfortunately, rivers nowadays have been contaminated by many pollutants including toxic chemicals. (Chan *et al*., 2003) mentioned the major contribution of river pollutions come from drainage systems from urban, commercial, industrial and pharmaceutical sites. Most pollutants that entered the rivers are chemicals, both organic and inorganic waste such as drugs, explosives and heavy metals. A toxic chemical is any chemical which can cause death, temporary incapacitation, or permanent harm to living beings through its chemical action on life processes (Toxic Chemical, 2005).

The composition and concentration of the components of pollutant, both suspended and in solution, determine the quality of water. The impression about water quality in most people is based on physical rather than on chemical or biological characteristics. Usually people expect water to be clear, odorless and colorless as a good water quality but it is not a simple thing to say that “this water is good” or “this water is bad”. Other than that water quality can be defined as the measurement of a particular water system on its suitability for use by humans and its suitability for providing and sustaining a viable and pollution-free environment (Diersing and Nancy, 2009). Thus, drinking water must not have excessive concentrations of mineral, it must be free from toxins as well as pathogenic microorganisms.

There are many factors that can control water quality. The vulnerability of surface water to degradation depends on a combination of natural landscape features, such as geology, topography, and soils; climate and atmospheric contributions; and human activities related to different land uses and land-management practices. The other factor that control water quality is rain water. The rain water contains gases and traces of mineral and organic matter originating from gases, dust and other substances in atmosphere. When rain falls, the flowing water can dislodge soil particles that become suspended soil particles in water (Malia, 2005). In addition, biological activity can give effects to the pH and concentration of dissolved gases, nutrients as well as organic matter.

According to Jasim *et al*. the occurrence and fate of pharmaceuticals and personal care products (PPCPs) in surface water originating from urban sources is a leading and emerging issues in environmental chemistry (Jasim *et al*., 2006). The genetic of personal care products are the active ingredients or preservative in cosmetics, toiletries or fragrances. At least 80 PPCPs (for e.g. analgesics, antibiotic and antidepressants) have been identified in outflows from sewage treatment plants and surface water worldwide. However, many PPCPs remain unidentified.

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There are many rivers that are categorised as highly polluted where water can no longer be used or treated. In Malaysia, the number of polluted river is increasing and the condition is worsening rapidly. In year 2008, 17 rivers of Malaysia's 186 river systems have become so toxic and the water was unsafe for human to touch (Tengku, 2008). Water quality management in Malaysia has been regulated by Environmental Quality Act (1974) on pollution using concentration based Interim National Water Quality Standards (INWQS). All pollutants discharged from industries are controlled by the EQA Regulation under INWQS. Under this regulation, wastewater treatment and industrial discharge must comply with the limits set under the regulation.

Kuantan River estuary is located adjacent to the Tanjung Lumpur mangrove forest reserve near the town of Kuantan in the state of Pahang. It runs from Sungai Lembing through Kuantan Town before flowing out into the South China Sea. Kuantan River has a diverse ecosystem and also rich with natural resources like prawn, shell fish and some mangrove species. However, this river is now threatened with several kinds of pollution as this river is situated near the fishing villages and the development of this area is currently in rapid progress.

MATERIALS AND METHODS

Study Area:

Kuantan River located at 03˚50.9˚N latitude and 103˚29.2˚ E longitude, within the capital state of Pahang. Kuantan River was chosen as the sampling site because it is believed that this river has been polluted with several kinds of pollution. In addition, the location was near the fishing villages and there is rapid development in this area.

Location of Sampling Site:

Three different stations along the Kuantan River were chosen (Figure 1). The first station (St-1) was at 3˚47.556˚N and 103˚18.437˚E that is located near to the fish landing jetty and industrial area. The second station (St-2) was at 03˚47.945˚N and 103˚19.395˚E which is located in front of Hospital Tengku Ampuan Afzan (HTAA) Kuantan . The last station (St-3) was at 03˚48.543˚N and 103˚20.042˚E which was near to Kuantan estuary. All of the stations were about 4 to 6 meters from drains that discharged water from the expected polluted area. The samples were taken from the surface level, middle level and bottom level. The analyses were conducted twice where first analysis was done in October, 2010 and the second one was done in January, 2011 where pre-monsoon and post-monsoon were predicted occur. Both samplings were done in the morning from 9 am to 11 am. The main reason to analyze twice is to determine the changes of toxic chemical content between pre-monsoon and post-monsoon.

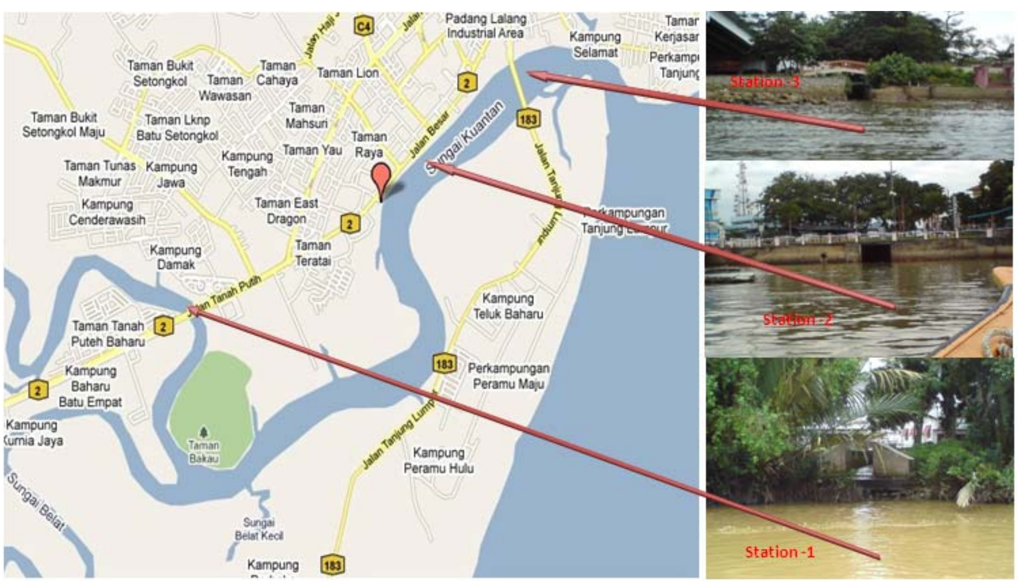


Fig. 1: Sampling Locations along the Kuantan River

In Situ Measurements: Physico-chemical Parameters:

Physicochemical parameters especially temperature, pH, dissolved oxygen, salinity and turbidity were determined. The water quality was analyzed *in-situ* by using Hanna Multiparameter Water Quality Parameter model HI 9828. The meter was calibrated before it was used and the probe was allowed to equilibrate with water at least 60 seconds. In order to take the readings, the probes were placed inside in the water at a required depth and waited until a stable reading was obtained. *In situ* measurements were made since some water samples tend to change their original condition during transportation and storage process.

Laboratory Analysis:

All samples were collected by using Van Dorn water sampler and stored in 500ml Polyethylene bottles. Then the samples were filtered into 250 ml Polyethylene bottles for heavy metals analysis and 250ml sterile Schott bottles for nutrients compound analysis. The samples were filtered with Whatman filter paper in order to separate the particles and debris from water samples.

Toxic Metalloid and Heavy Metals Analysis:

After filtration, the samples were preserved by adding concentrated nitric acid (HNO_3) to achieve pH less than 2 to prevent precipitation of metal hydroxide or adsorption of metal ions on the walls of the bottles. Water samples were cooled down to 4ºC to reduce microbial activity. Then, the samples were measured using ICP-MS.

Metalloid and Heavy Metal Detection using ICP-MS:

The samples were analyzed using Inductively Coupled Plasma Mass Spectrometer (ICP-MS). ICP-MS was used for quick and precise determination of elements. However, ICP-MS can only detect the metalloid and heavy metals in ppb value. Before the detection process, dilution was prepared for each diluted sample, SRM and blank. Double distilled water was used in this dilution process. The standard preparation for ICP-MS of metalloid and heavy metals was done as 0 ppb, 5 ppb, 10 ppb, 20 ppb and 50 ppb. The standard preparation for mercury was done as 0 ppb, 0.5 ppb, 1 ppb, 2 ppb and 5 ppb. Then the standards were introduced to ICP-MS. After obtaining the standard correlation coefficient curve in range of 0.996 – 0.999, the samples then were analyzed by ICP-MS. The ICP-MS used 1 ml for each sample to be tested.

RESULTS AND DISCUSSIONS

Toxic Metalloid and Heavy Metal:

Arsenic:

The values of arsenic (As) in Kuantan River during the post-monsoon were higher at St-1 and St-2 but lesser at St-3 when compared to those during the pre monsoon. During pre-monsoon, the highest value of As was at middle point of St-3 (32.09 µg/L) and the lowest value was at surface point at St-1 (5.05 µg/L). During post monsoon season the highest value for As was at middle point of St-3 (22.81 µg/L) and the lowest value was at surface point of St-1 (5.72 µg/L). Figure 2 shows that the concentration of As was increased during post-monsoon at St-1 and St-2. In contrast, the concentration of As at St-3 was decreased slightly during post-monsoon. During both pre and post monsoon season, at the middle point at St-3 the concentration of As (32.09 µg/L and 22.81 µg/L) was found to be highest. The reason could be due to the activities of the local industries as reported by Branislav (Branislay *et al*., 2007).

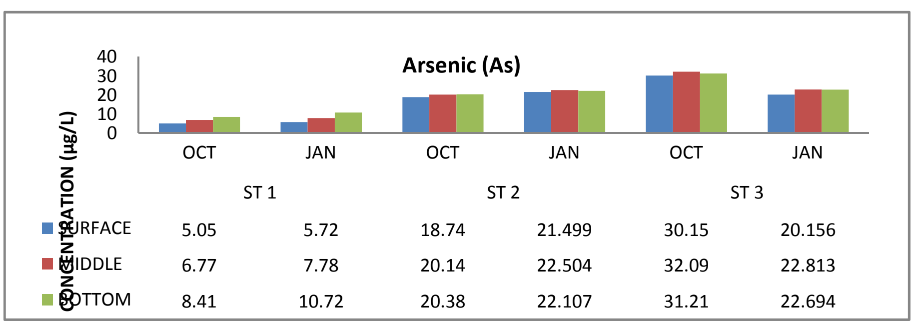


Fig. 2: Arsenic in Kuantan River for three stations between October and January.

Cadmium:

In Figure 3, it is shown that during pre-monsoon season, the concentration of cadmium (Cd) was not detectable. However during post-monsoon there was presence of cadmium (Cd) where the highest concentration was at middle of St-3 (0.18 µg/L). The cadmium (Cd) levels in samples showed that there was no detectable concentration during pre-monsoon which means the concentration of Cd could either be absent or ignorable concentration. These statements are in agreement with the findings of Kamarudin (Kamarudin, 2008). According to WHO (WHO, 2004) contamination of water may occur as a result of the presence of cadmium as an impurity in the zinc of galvanized pipes or cadmium-containing solders in fittings.

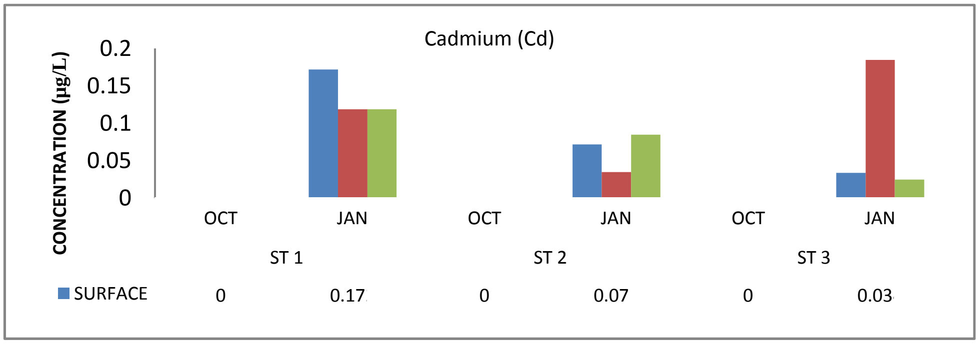


Fig. 3: Cadmium in Kuantan River for three stations between October and January.

Cobalt:

Figure 4 shows the concentration of cobalt (Co) increased in both pre and post-monsoon. The highest concentration of Co was detected at the bottom of St-3 (0.66µg/L) and the lowest was at the middle and bottom of St-1 (0.28µg/L) during pre-monsoon. During post-monsoon, the highest value was detected at the middle of St-3 (1.33 µg/L) and the lowest was at the surface of St-1 (0.17 µg/L). From the result in Figure 4, Co concentration was found to be increased during post-monsoon which ranged from 0.66 to 1.33 µg/L. During pre-monsoon the bottom of St-3 was the highest in concentration of Co while the middle of St-3 was found to be the highest in concentration of Co during post-monsoon. These could be due to the activity of the industries such as combustion of fossil fuels, mining, and phosphate fertilizers on soil and smelting and refining of metals (WHO, 2006).

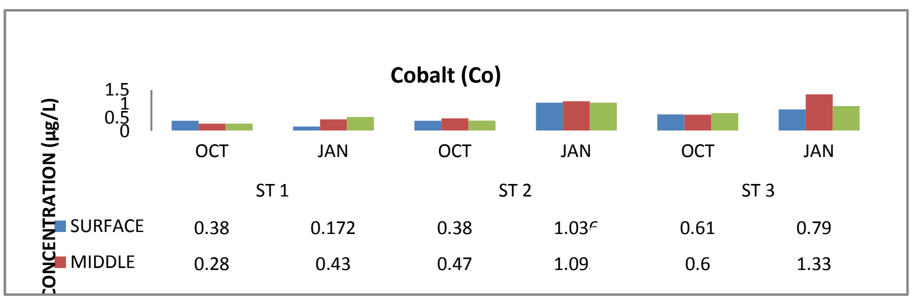


Fig. 4: Cobalt in Kuantan River for three stations between October and January.

Chromium:

In Figure 5 it could be found that the concentration of chromium (Cr) decreased during post-monsoon compared to pre-monsoon season. The highest value for Cr during pre-monsoon was found at the bottom of St-2 (15.53µg/L) and the lowest value was observed at bottom of St-1 (2.67). Similarly, during post-monsoon, the highest value was detected at the bottom of St-2 (1.92 µg/L) and the lowest concentration was observed at the surface of St 2 (0.81 µg/L). The Cr level of Kuantan River decreased in January for all stations which ranged from 15.53 to 0.81 µg/L. This was due to the heavy rainfall that diluted the water to become less concentrated. During both seasons, the bottom of St-2 has the highest level of Cr concentration. The pathway leading to Cr deposition in the water is the same with the other metals; through precipitation when released from the drain. According to WHO (WHO, 1996) the Cr could come from steel and textile industry as well as cigarette butts and from the disposal of metal products.

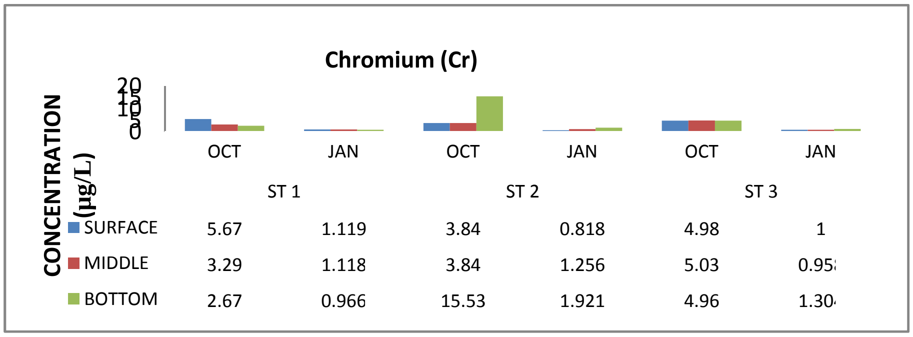


Fig. 5: Chromium in Kuantan River for three stations between October and January.

Copper:

Figure 6 shows the concentration of Cu in Kuantan River that increased from pre to post-monsoon season. The highest value of Cu during pre-monsoon was at the surface of St 1 (26.27µg/L) and the lowest was at the surface of St 1 (2.66µg/L). The highest value of Cu during post-monsoon was at the middle of St 3 (90.79 µg/L) and the lowest was found at middle of St 1 (18.03µg/L). Concentration of Cu increased considerably during post-monsoon season where St 3 has the highest concentration (26.27 µg/L) of Cu for both seasons at the surface of St-3 and 90.79 µ/L, and at the middle of St 3. Cu rapidly increased during post-monsoon. This could be due to its widespread in the environment from natural sources: settle and bind to water sediment, soil particles and minerals, and as well as from human sources. During rainfall, Cu enters into river water through release of fossil fuels into water and also from corroded pipe. It settles from air during rainfall then enters in the river system that pollutes the river water. According to WHO (WHO, 2004) the absorption of Cu is essential to human as human can handle relatively large concentration of Cu intake and Cu is used as food preservatives.

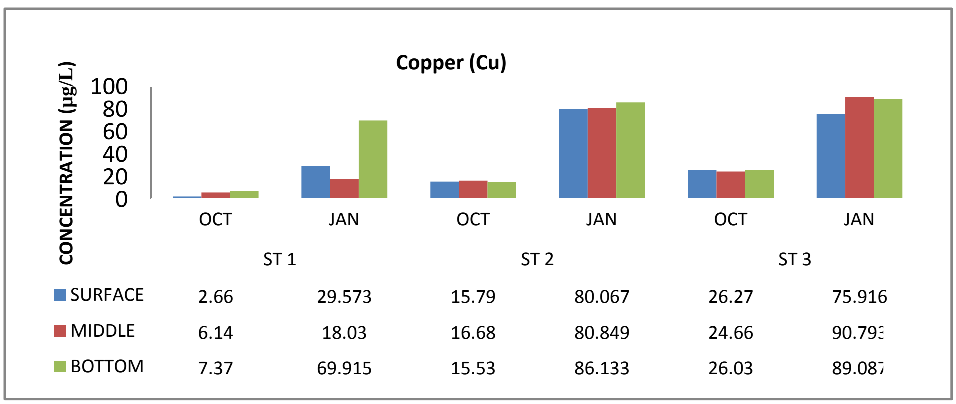
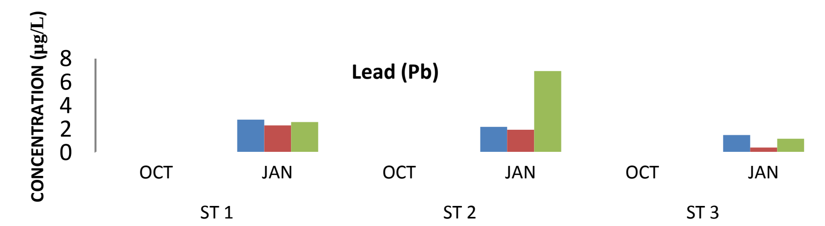


Fig. 6: Copper in Kuantan River for three stations between October and January.

Lead:

Figure 7 shows the concentration obtained for lead (Pb). During pre-monsoon season, the lead (Pb) was not detectable due to its low level of concentration. However during post-monsoon there was presence of Pb where the highest concentration could be found at the bottom of St-2 (6.95µg/L) and the lowest was at the middle of St-3 (0.43 µg/L). The concentration of Pb was observed to be detectable only in the post-monsoon season at the bottom of St-2 (6.95 µg/L) and the value was found to be the highest. High concentration of Pb during post-monsoon resulted from heavy rainfall that could make run of the Pb from the batteries and discharge of the city into the river. High concentration at St-2 was due to sources in the direct vicinity of the station that is the residential areas and surrounded by combustion of certain grades of gasoline fuel, usage of building materials, metal products, lead piping and pesticides. David *et al*. also reported similar observation that was in line with our findings (David *et al*., 2008)



	ST 1 OCT	ST 1 JAN	ST 2 OCT	ST 2 JAN	ST 3 OCT	ST 3 JAN
SURFACE	0	2.808	0	2.201	0	1.496
MIDDLE	0	2.32	0	1.949	0	0.436
BOTTOM	0	2.608	0	6.95	0	1.194

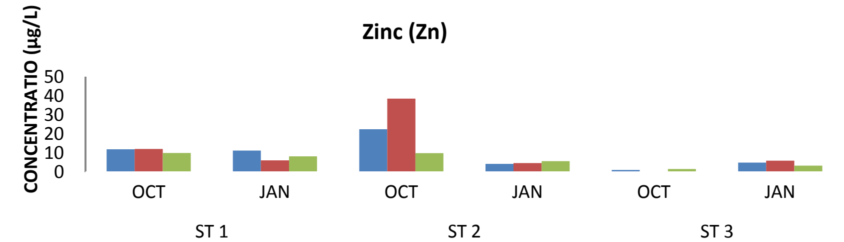
Fig. 7: Lead in Kuantan River for three stations between October and January.

Selenium:

There was no identified selenium (Se) for both seasons in all research stations. Major contributor of selenium (Se) releases to the environment that has been primarily from copper smelting industries, (WQA, 2005). So far there are no such industries in the adjacent area to the Kuantan River. Thus, it could be concluded that the Se was not detectable in Kuantan River.

Zinc:

In the Figure 8, the values of zinc (Zn) concentration decreased through pre to post-monsoon season. The highest value of Zn during pre-monsoon was found at the middle of St-2 (38.61 µg/L) and the lowest was at the middle of St-3 (0 µg/L) which means there was no detectable concentration of Zn. During post monsoon, the value of Zn was the highest at the surface of the St-1 (11.34 µg/L) and was found to be the lowest at the surface of St-2 (4.33 µg/L).The highest concentration of Zn was at the middle of St-2 (38.61 µg/L) in pre-monsoon season and the lowest was at the middle of the St-3 (0 µg/L). During post-monsoon the highest concentration of Zn was found at the surface of the St-1 (11.34 µg/L) whereas the lowest concentration was observed at the surface of St-2 during pre-monsoon. Pistelok and Galas reported that zinc can be found due to the presence of large quantities of zinc in the waste water from industrial plant because this waste water was not purified satisfactory (Pistelok and Galas 1998).



	ST 1 OCT	ST 1 JAN	ST 2 OCT	ST 2 JAN	ST 3 OCT	ST 3 JAN
SURFACE	12.063	11.34	22.55	4.333	1.213	5.029
MIDDLE	12.174	6.227	38.61	4.756	0	6.02
BOTTOM	10.081	8.329	9.99	5.753	1.679	3.42

Fig. 8: Zinc ~~of~~ in Kuantan River for three stations between October and January.

Mercury:

The concentration of the total mercury (Hg) is shown in Figure 8. The values of the total mercury (Hg) decreased from pre-monsoon to post-monsoon. The highest value during pre-monsoon was found at the surface of the St-1 (0.14 µg/L) and the lowest was at the bottom of St 3 (0.05 µg/L). During post-monsoon Hg was only detected at surface at St-1 (0.03 µg/L). The concentration of Hg decreased during post-monsoon season where only the surface at St-1 (0.03 µg/L) has detected the concentration of Hg. The Hg concentration was not detected during post-monsoon due to heavy rainfall that increased levels of water during this time diluting and lowering the concentration of Hg. During pre-monsoon, surface at St-1 (0.14 µg/L) was the highest concentration of Hg. However, the bottom point at St-3 (0.05 µg/L) was the lowest concentration of Hg during pre-monsoon. This was due to industrial and residential activities as mercury has been used in electrical appliances such as lamp and arc rectifiers (WHO, 2005). Improperly disposed household products, such as mercury containing outdoor paints, can move through the soil and reach private well water supplies then enter the river water.

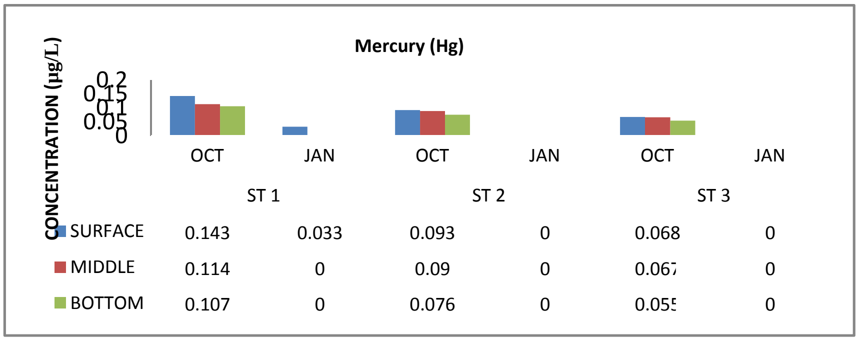


Fig. 8: Mercury in Kuantan River for three stations between October and January.

The result from analysis of metalloid and heavy metals was compared with Interim National Water Quality Standard (INQWS) for Rivers in Malaysia. From the total average reading of heavy metals as compared to standard, it has been discovered that the Kuantan River fall under Class 2 of INQWS which is within the permissible level.

Conclusion:

The concentration of Cu was the highest (90.973µm/L) among all the heavy metals especially at St-3. Whereas the concentration of Se was the lowest (N.D) heavy metal at all the stations. The Kuantan River is one of the busiest rivers with fishing boats. The pollutants in the river can arise from a number of sources, including municipal and industrial discharges, urban and agricultural runoff, atmospheric deposition and waste water from the hospital (HTAA). These waste materials ultimately affect the quality of water in Kuantan River. Based on INQWS classification, Kuantan River, Pahang could be classified into Class 2. Nevertheless, continuous long term monitoring is needed to assess the toxic heavy metals in this river as it could ultimately have effects on food for the fishes which are consumed by anglers and communities around the Kuantan River.

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