SEPKA 2016 - TECHNICAL NOTE

COPPER AND ZINC ACCUMULATION IN SEDIMENT AT STRAITS OF JOHOR

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Abstract: A study was carried out to investigate heavy metal level in aquatic environment and its effect due to land use. The main objective of this study is to evaluate the concentration of copper (Cu) and zinc (Zn) in sediment at Straits of Johor. Four sampling stations in *Kampung* Pasir Puteh were chosen for sediment sampling. Heavy metal analysis was carried out for zinc (Zn) and copper (Cu) using Atomic Absorption Spectrophotometer (AAS). The in-situ results showed dissolved oxygen concentration in the range of 0.31 to 5.90mg/L while pH was recorded at 7.35 to 8.29. Heavy metals analysis in sediment for copper depicts copper accumulation in sediments exceeded the allowable limit at Station 5 whereby the highest readings recorded was 146 µg/g. Zinc accumulation at Station 3, Station 4 and Station 5 exceeded the allowable limit which was 271 µg/g. Enforcement should be taken to reduce the accumulation of pollutants thus can prevent the aquatic environment from polluted.

Keywords: *Sediment, heavy metal, Johor straits*

1.0 Introduction

Anthropogenic activities have been increase dramatically due to human population which grows rapidly. The result of these anthropogenic activities can lead to heavy metal accumulation in marine environment. Although it may occur naturally in the environment, but the side effect of anthropogenic activities has adding up more heavy metals that are hazardous for marine ecosystems. Located at the eastern part of Straits of Johor, Kampung Pasir Puteh was selected as the study area for this study. A lot of human activities such as shipping and transport, oil and petrochemical industry, fishing as well as residential and commercial wastewater render Kampung Pasir Puteh as a

suitable location to study on the heavy metal accumulation in sediment. According to Eugene Ng *et al.*, (2013), Johor Straits is an important area which is crucial for fishing and aquaculture activities along the narrow straits separating Peninsular Malaysia and Singapore. In addition, Zulkifli *et al.* (2010) stated that the existence of mangrove, sea grass, coral and mudflat ecosystem also makes it an important straits which can provide habitat for many flora and fauna. Oil pollution has been identified as a major contributor to the pollution of water in the Straits of Johor (Department of Environment, 1994; Moradi, 2001; Shahbazi *et al*., 2010; Eugene Ng *et al.*, 2013).

The main objective of this study is to evaluate the concentration of Cu and Zn in sediment at Straits of Johor. Point and non-point sources pollution has been identified to contribute to heavy metal accumulation in sediment. In a study conducted by Abdullah *et al*. (1996), sources of pollutant to the straits have been identified through the shipping activities which involve tankers and other vessels as well as industrialisation and urbanization sources. Kampung Pasir Puteh has been reported as a highly polluted site, where there are on-going large shipyard repair and construction facilities and shipping dock activities (Eugene Ng *et al*., 2013). Due to its strategic location and ecological importance, the Straits of Johor has become a hotspot for pollution studies (Wood *et al*., 1997; Shazili *et al*., 2006; Department of Environment, 2007; Eugene Ng et al., 2013).

Heavy metal could bring high risk for the aquatic environment. This is because it may affect the water quality although it exists in low levels. Usually, water, sediments and biota can be used to monitor the heavy metal concentration in aquatic environment which generally exist in lower levels in water and attain considerable concentration in sediments and biota (Ebrahimpour and Mushrifah, 2008). Since all living things on earth need water, monitoring is crucial to ensure that the water is clean and safe. Moreover, clean water is needed to use in daily life and activities such as drinking, agriculture, swimming and others work activities. Water is very important for every aspect in our lives.

Water monitoring can prevent and protect the aquatic environments from pollution. Each water body contains different levels of pollution. Water quality issues influence the environmental health and human in many ways, so the more we monitor our water, the better we will be able to prevent the contamination problems. Most rivers in the world flowing through the populated areas are highly exposed to heavy metal pollution due to urbanization and industrialization. Anthropogenic impact and geologic process also become progressively worse on sediment and water quality. Therefore studies on the determination of degree of anthropogenic impact on sediment have been especially relevant over the last decade (Barakat *et al*., 2012).

Urbanization and industrialization have been identified as the main sources which lad to heavy metal pollution at Kampung Pasir Puteh. Expansion of human population and rapid coastal development has induced severe threats to marine and aquatic habitats which caused to an increase in anthropogenic pollutant loads. Heavy metal effluent from industries and shipping activities has been identified to contribute to the heavy metal accumulation in sediment. A lot of waste materials have been released or thrown into Sungai Laloh. Oil pollution which originated from water transportation such as ferry and ship also increased the heavy metal concentration in sediment. Therefore, it is crucial to have a study on Cu and Zn accumulation in sediment at Straits of Johor.

2.0 Materials and Methods

2.1 In-Situ Analysis

Six sampling stations were selected to conduct *in-situ* analysis at Sungai Kampung Pasir Puteh. YSI Proplus was used to carry out in-situ measurement such as dissolved oxygen, conductivity, pH, salinity and temperature. Sediment samples were collected using eckmen dredge at four stations which are Station 2, Station 3, Station 4 and Station 5 where the anthropogenic sources can be identified. The coordinates of sampling points are shown in Table 1 and Figure 1.

Table 1: Coordinates of sampling location

Station	Description	Coordinates
1	Sungai Kampung Pasir Puteh (Mangrove area)	01°25'56.2 N , 103°56'49.2 E
2	Green Mussels Culture Area	01°25'48.6 N , 103°56'34.1 E
3	Near villagers house and restaurants	01°25'59.4 N , 103°55'50.9 E
4	Green Mussels Culture Area	01°26'13.2 N , 103°55'27.3 E
5	Sungai Laloh (effluent from factory)	01°26'06.3 N , 103°55'15.9 E
6	Near Johor Port Terminal (JPT)	01°26'00.4 N , 103°55'34.5 E

Figure 1: Sampling Stations Location along Sungai Kampung Pasir Puteh, Pasir Gudang

2.2 Digestion & Analysis

Sediment sample was oven dried and 1 g of sample was digested according to US EPA Method 3050a and 3050b. Sediment sample was oven dried at 30-40˚C for 24 hours. For each digestion 1 g of sample was transferred to a beaker, 10 mL of 1:1 HNO_3 was added into the beaker and covered with a watch glass. The sample was then heated to 95˚C and reflux for 10 to 15 minutes. After that, the sample was allowed to cool and 5 ml of concentrated HNO_3 was added and sample was relux for 30 minutes. Then, the solution was allowed to evaporate to 5 mL without boiling. The sampled was then cooled; 2 mL of water and 3 mL of H_2O_2 was added. The beaker was covered with a watch glass and returned to the hot plate for warming and to start the peroxide reaction. Samples were heated until effervescence subsides and cool in the beaker. Then H_2O_2 was added in 1 mL aliquots with warming until the effervescence is minimal or until the sample appearance is unchanged. Then, 5 mL concentrated HCL and 10 mL of water was then added and the covered beaker was returned to the hot plate, and reflux for an additional 15 minutes without boiling. After cooled, sample was then diluted to a 100 ml volume with water into a volumetric flask and filtered. Standard solution for Cu and Zn were prepared first before tested using Atomic Absorption Spectrophotometer (AAS) for sediment sample. Metal analysis was then carried out using Perkin Elmer Atomic Absorption Spectrophotometer Model PinAAcle 900T (Edgell, 1989).

3.0 Results and Discussion

3.1 Concentrations of Heavy Metals in Sediments

Figure 2 depicts dissolved oxygen (DO) data obtained at the coastal area of *Kampung* Pasir Puteh. The DO concentration was in the range of 0.31 to 5.90 mg/L. DO concentration on 27th March 2016 was slightly higher compared to other sampling days. This was due to heavy rainfall. The amount of oxygen that can dissolve in water is strongly limited by the temperature of the water where cold water can dissolve more oxygen. pH was recorded in the range of 7.35 to 8.29. Salinity was 27.39 to 31.88 ppt which is related to tide table and rain since the study area is an estuary. Temperature in the range of 28.9 to 31.2°C.

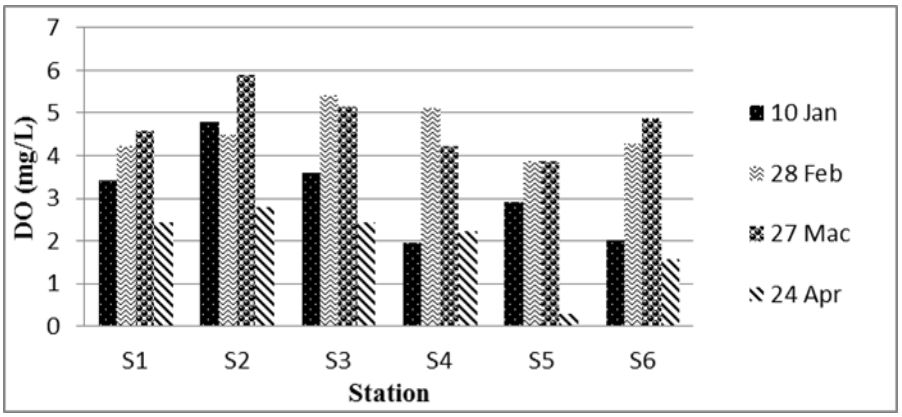

Figure 2: DO (mg/L) measured at Kampung Pasir Putih

Figure 3 shows the pH graph result from in-situ analysis at Sungai Kampung Pasir Puteh. According to the graph, it shows that the lowest pH reading was 7.35 on 28th February 2016 at Station 1 while the highest pH reading was 8.29 on 27th March 2016 at Station 3. By looking into relationship between the surrounding area at Station 3 and pH reading recorded, it can be concluded that the nearby restaurants and villagers house effluent contributed to the alkaline condition of water during in-situ analysis. Instead of it, Station 1 recorded a reading of 7.35 which was almost neutral. This is because the surrounding area at Station 1 was surrounded by mangrove area which helps in preserving the water quality and far away from pollution sources.

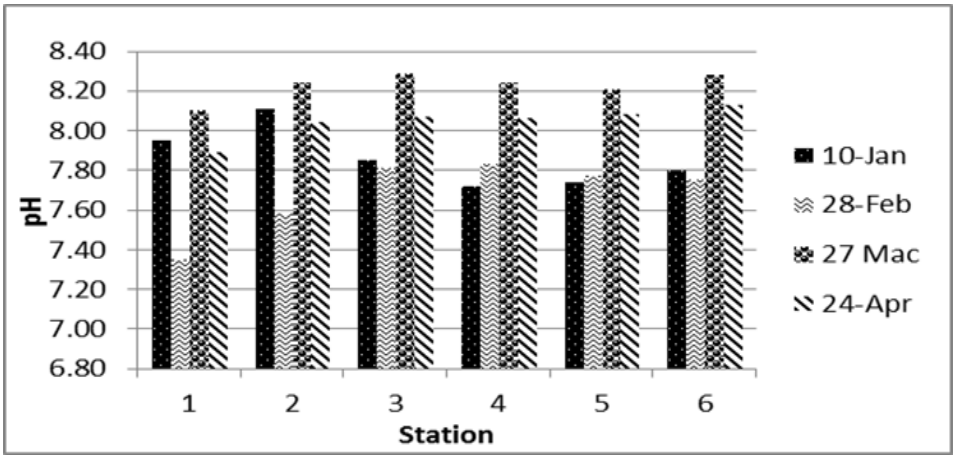

Figure 3: pH measured at Kampung Pasir Putih

Figure 4 shows the accumulation of copper in sediment. Only four sampling stations were selected for sediment analyses which were Station 2, Station 3, Station 4 and Station 5. The highest reading was recorded on 27th March 2016 which was 146.5 µg/g at Station 4. The reason behind this was because Station 5 was located at Sungai Laloh where the effluent from the factories are released. The graph also shows that Station 5 has the most constant copper concentration for all sampling occasions compared to other stations. Station 2 recorded the lowest reading of copper accumulation in sediment which was 19.5 µg/g on 27th March 2016. According to Canadian Sediment Quality Guidelines (CSQG), the allowable limit for copper in sediment was 108µg/g.

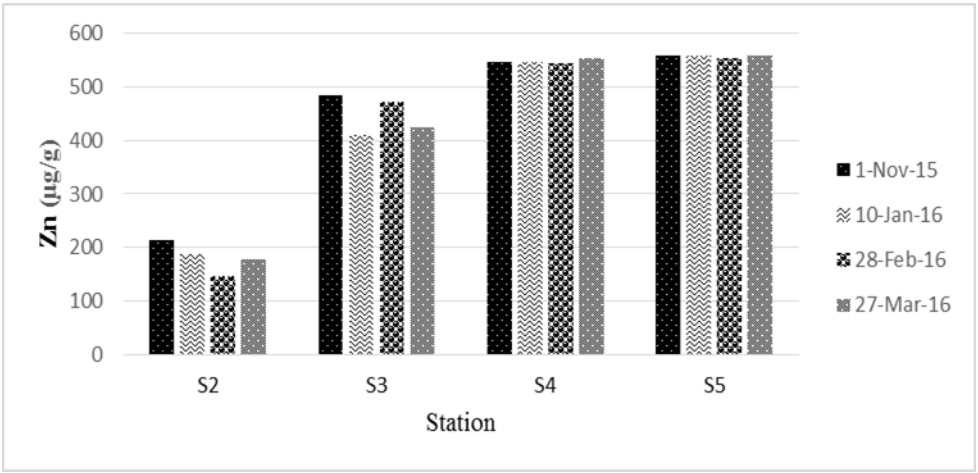

Figure 4: Copper accumulation in sediment at Kampung Pasir Puteh

Figure 5 depicts zinc accumulation in sediment in the range of 147.0 to 560.2µg/g. Based on CSQG, the allowable accumulation for zinc in sediment was 271µg/g. The data shows that the highest zinc accumulation recorded was 560.2µg/g on 27th March 2016 at Station 5 while the lowest reading recorded at Station 2 which was 147µg/g on 28th February 2016. Station 4 which green mussel culture area and Station 5 which surrounded by effluent from factories recorded almost similar value compared to the other two stations. Since Station 2 was located far away from the sources of pollution, it shows a lower value which was below the allowable limit for zinc accumulation in sediment.

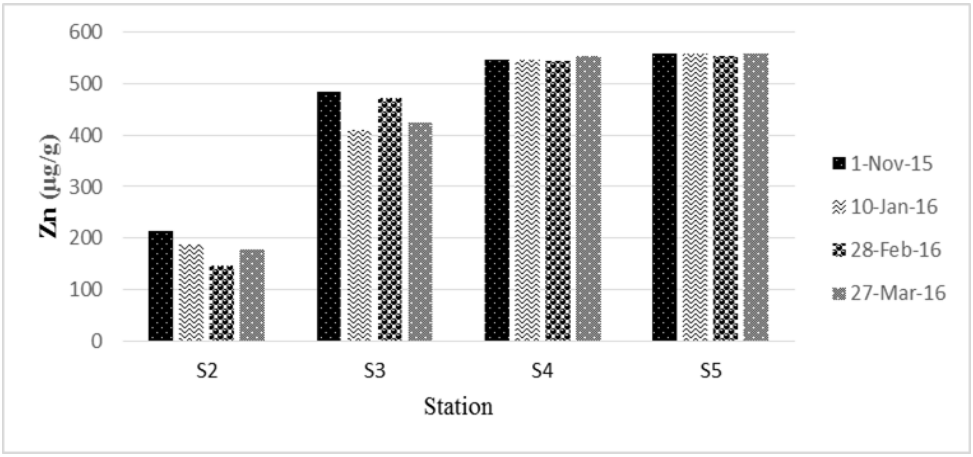

Figure 5: **:** Zinc accumulation in sediment at Kampung Pasir Puteh

3.2 Sources of Pollution at Kampung Pasir Puteh

A lot of point and non-point sources of pollution have been identified and contributed to the heavy metal accumulation in sediment which indirectly threatened the aquatic life at Sungai Kampung Pasir Puteh. Point sources pollution such as effluent from factories contained chemicals which can cause death to the aquatic life. Besides that, effluent from nearby villager house and restaurants would also induce heavy metal accumulation in sediment. Non-point sources pollution such as oil pollution from shipping activities and coastal development as well as soil erosion also would affect the water quality along Straits of Johor.

4.0 Conclusions

Copper concentration in sediment was 19.5 to 146.5 µg/g while zinc concentration was in the range of 147.0 to 560.2 µg/g. Almost all sampling stations for both copper and zinc concentration exceeded the allowable limit stated by CSQG. Rapid land use activities such as urbanization and industrialization affect the water quality and metal accumulation in sediments. Sullage from restaurants and sewage flowing into the area also increases the level of water pollution. The uncontrollable development and human activities along Straits of Johor have caused disturbance and increased the heavy metal content in sediments. Indirectly, this will create a toxic environment for the aquatic life, thus can lead to death of many aquatic life such as fish, crab and green mussel. Since the area is also known for mussel aquaculture and fishing activities, enforcement should be taken to reduce accumulation of pollutants.

5.0 Acknowledgements

The authors wish to thank the fishermen from Kampung Pasir Puteh for their participation and collaboration to complete the research and UTM Research University Grant Vot 11H97 for financial assistance.

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