Effect of Land Use on Coastal Water and *Perna viridis* at Johor Straits, Malaysia

Shamila Azman, Benedict Chan Wei Chiang, Razali Ismail, Jafariah Jaafar, Mohd Ismid Mohd Said, and Salmiati

***Abstract*— In this study, land use effect on river water quality and its subsequent impact on Johor Strait coastal water and green mussel, *Perna viridis* cultivated at the strait near the fast growing city of Johor Bahru, is investigated. Over the years, changes in land use and increased discharge of domestic, agricultural and industrial waste into the coastal water has severely impaired the water condition and threatened the profitable green mussel aquaculture activity. Cu and Zn concentrations in water were found to be higher at sampling points closer to Johor Bahru city while Sungai Pendas and Sungai Melayu which are less develop yielded lower pollutants concentration. The heavy metal concentrations (in mg/L) are between 0.18 to 0.38 for Zn and 3.24 to 3.44 for Cu. Coastal water recorded Zn concentration (in mg/L) of 0.03 to 0.05 and Cu concentration of 0.25 to 0.33 while green mussels recorded (in µg/g) 18.24 to 40.01 of Zn and 24.29 to 92.52 of Cu.**

***Index Terms*—Johor strait, land use, perna viridis.**

I. Introduction

One way for economic development is through urbanization. Urbanization increases the economic activities and also human population. However, runoff from urban areas is one of the main sources of contaminant such as causing the increase in toxic content, temperature and changing of water chemical composition. Industrialization and urbanization promote development of socio-economy but they also add to environmental problems, causing large amount of heavy metals to enter soil, water and air yearly through various pathways [1]. Urbanization and industrialization increase water pollution and environmental deterioration prompted needs to study on this matter [2, 3].

Johor Straits is located along the west coast of peninsular Malaysia. Currently, there are rapid land use activities for development near the coastal area of Johor Strait [4]. The effects of changing land use on marine communities are of concern as coastal populations increase at tremendous rates [5]. Land use areas generate both nonpoint and point sources of pollutants. Metals, industrial organic chemicals, nutrients, and pesticides are the main pollutants in the Johor Strait owing to the anthropogenic activities of the agricultural and chemical industries [6]. As areas of natural vegetation are increasingly being used as agricultural and urban land, it is important to evaluate the effect of these transformations on water quality. Pollution of natural environment by toxic chemicals is could give bad impact to human and wildlife via bioaccumulations.

Over the years, the coastal water of Johor Strait which acts as a border between Singapore and Malaysia is being contaminated by pollutants from tributaries like Sungai Perepat, Sungai Bahan, Sungai Melayu, Sungai Skudai and etc. Changes in land use are inevitable because Johor Bahru city centre is undergoing intensive urban development and redevelopment since the early 1980's. Such intense growth transformed Johor Bahru from pre-war type of shop houses to highrise commercial buildings. Large scale clearing of land for residential, commercial, and industrial development has also taken place.

One of the main aqua cultural activities at Johor Straits is the farming of green mussel, Perna *viridis*. Green mussels occur widely in shallow waters along the west coast of Peninsular Malaysia. They have become a food resource especially in Malaysia, which, at one time, exported them [4]. Green mussels are harvested commercially in the Indo-Pacific region as a human food resource owing to their dense and fast growth. Moreover, the harvesting of green mussels can have economic, ecological, and human health impacts. Green mussels are used as a biomonitoring agent for heavy metals because they are commercially important seafood species worldwide [7, 8]

Mussel cultivation is an important source of income as it generates millions of ringgit per year. It is extensively cultivated in Johor Straits and has been aqua-cultured for a few decades [9]. However, degradation of water quality may affect farmers who make their living through aquaculture of green mussels. Besides, there are also cultivations of other seafood such as fishes that provides income for aquaculture farmers. Therefore, both economic and social impact may occur if the water at Johor Straits is polluted. The aim of this study is to investigate the effect of land use along the Johor Strait which is highly urbanized near Johor Bahru and less urbanized towards the west side. Therefore, the objectives of this study are to determine the effect of different land use on the water quality at tributaries; to correlate Zn and Cu concentration at tributaries and receiving coastal water and to compare the coastal water Zn and Cu concentration with Zn and Cu in green mussels.

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II. Methods

A. Study Area

The sampling locations for this study involves six stations located at Johor Straits, between the Second Link and the Causeway Link. These sampling stations were selected based on the criteria as main area for fisheries and aquaculture activities. Water samples were collected along Pendas-Danga coastal area and are accessible by land (Fig. 1.) Sungai Pendas and Sungai Melayu are surrounded by less development whereas Sungai Danga and Sungai Skudai are surrounded by urban areas. All of the water samples were collected in polycarbonate bottles and directly transferred to an ice box maintained at 4^{o}C and stored until further analysis at the laboratory. The coordinates of the sampling locations is shown in Table 1.

Fig. 1. Sampling locations for river and coastal area.

TABLE I: Sampling Stations and Coordinates

Sampling Stations	Coordinate
Sungai Pendas	1°22.752'N 103°38.950'E
Sungai Melayu	1°27.816'N 103°41.200'E
Sungai Danga	1°28.340'N 103°42.539'E
Sungai Skudai	1°28.449'N 103°42.546'E
Nusajaya (S7)	1°27.574N 103°41.308E
Tanjung Kupang (S10)	1°24.544'N 103°39.440'E

B. Sample Preparations

Water samples for analysis were collected in three bottles. The first bottle contained only the water samples, the second bottle contained the water samples and 1 ml L−1 of sulfuric acid (for analyzing nutrients), and the third bottle contained the water samples and 1 ml L−1 of nitric acid (for analyzing metals). Green mussel samples were collected and grouped according to size. Before the mussels were shucked, the external shell surface was thoroughly cleaned with a brush and water to remove all the sand and dirt adhering to the shell to prevent the contamination of composite samples. The mussels were then thawed and shucked, and the flesh was collected in a clean dish and homogenized by mixing. The green mussels (2 g) were weighed and digested on a wet basis, using a modified reflux system by digesting the samples overnight with a hot plate. The digested samples were filtered and diluted using double distilled deionized water to ensure that the acid in the samples was <5%. The digestion method used was adopted from the American Public Health Association (APHA) 3030E, which is a nitric acid digestion method. In this study, only the heavy metal content of adult mussels (7–9 cm) was analyzed on a dry weight basis.

C. Water Quality and Heavy Metal Analysis

YSI Proplus water quality checker was used to measure temperature, dissolved oxygen and pH. Analysis for ammoniacal nitrogen was carried out using HACH DR4000 Spectrophotometer. Cu and Zn concentration was determined using Perkin Elmer AAnalyst 400 Flame Spectrophotometer.

III. Result and Discussion

A. River Water Quality

The temperature at four sampling stations i.e. Sungai Pedas, Sungai Melayu, Sungai Danga and Sungai Skudai are in the range of 28.2^{o}C to 30.9^{o}C. Fig. 2. shows that Sungai Pendas has the higher concentration of DO while Sungai Danga and Sungai Skudai generally recorded lower concentration.

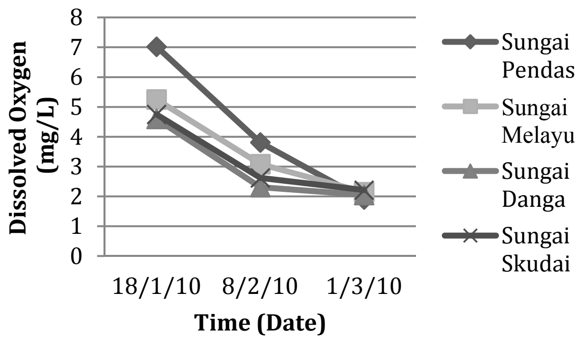

Fig. 2. DO concentration

pH values for all four sampling stations throughout the duration of study was quite constant. The largest gap in pH values occurs at Sungai Pendas where the lowest pH was 6.33 and the highest 7.67. Results for NH_3-N shown in Fig. 3 indicate an upward trend in NH_3-N concentration from Sungai Pendas to Sungai Skudai sampling station. The pattern shows that a more densely populated area such as in Sungai Skudai resulted in higher NH_3-N concentration.

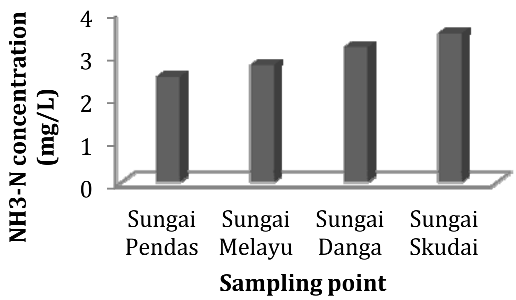

Fig. 3. NH3-N at four sampling stations

Zn concentration in the rivers are similar i.e. in the range of 3.24 to 3.44 mg/L (Fig 4). As for copper concentration in the river, Sungai Melayu has the lowest concentration at 0.18 mg/L whereas the concentration at other rivers are similar in the range of 0.30 to 0.38 mg/L. The relation between development and heavy metal enrichment is justified by [10] where highly urbanized areas are affected by diffuse anthropogenic release of hydrocarbons, combustion products, and waste water to the environment which caused changes in heavy metal concentrations in river and sediments.

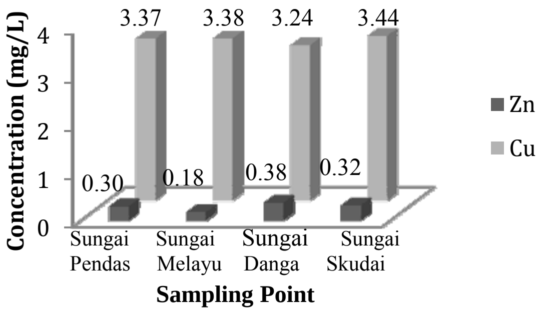

Fig. 4. Zn and Cu in river water

B. Zn and Cu Concentration in Coastal Water and Green Mussel

Urban and industrial developments along coastal areas, rivers and estuary are the major source of anthropogenic metals found in the sea. Station S7 which is adjacent to urbanized areas has higher Cu and Zn concentration while S10 has lower values for both metals. This trend conforms to results from the tributaries. Cu and Zn concentration for coastal water shows that Cu was higher at 0.25 to 0.3 mg/L whereas Zn recorded only 0.03 to 0.05 mg/L. Such amounts correlate well with tributaries metal loading where earlier results indicated that Cu concentration is higher than Zn concentration in all the tributaries studied (Fig. 5)

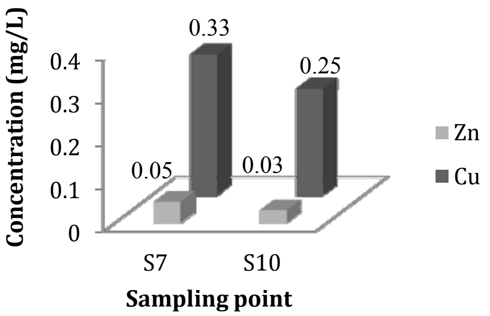

Fig. 5. Zn and Cu in coastal water samples at sampling station S7 and S10

Similarly for Zn and Cu concentration in green mussels, the concentration is higher for mussel samples from S7 as compared to S10. These results are the same for both HNO_3 and $HNO_3 + H_2SO_4$ digestions techniques. In term amount found in mussels, Cu concentration is relatively higher where $HNO_3 + H_2SO_4$ digestion at S7 yielded 92.54 µg/g while Zn concentration at the same location was 40.01 µg/g only based on wet basis. This point out that water with higher metal concentration will result in higher concentration of metals in green mussels. There is a proportional relationship where metal content in green mussels is affected by metal concentration in the water. This result also shows that the Cu concentration exceeds permissible limits set by Malaysian Food Regulations (1985), where the limit is 30 µg/g. Meanwhile, Zn concentration is lower than specified limit of 100 µg/g.

IV. Conclusion

Analysis on tributaries water, coastal water and mussel samples on different sites enable determination of characteristics of water and also pollutants content in water and mussels. Distinctive land use resulted in different water quality in tributaries adjacent to that particular area where tributaries surrounded by more developed areas were found to be more polluted than tributaries bounded by less development. Since metal concentrations in coastal water were found to be corresponding to contributing tributaries, the correlation between tributaries metal content and coastal metal content is established. The observation made from Zn and Cu parameters indicates that concentration of metal in mussels is affected by metal concentration in water body. Hence, changes in land use do have effect on the pollutants concentration at rivers, coastal, and eventually in green mussel.

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