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LEAD (Pb) AND ZINC (Zn) CONCENTRATIONS IN MARINE GASTROPOD *STROMBUS CANARIUM* IN JOHOR COASTAL AREAS

(Kepekatan Plumbum (Pb) dan Zink (Zn) di dalam Gastropoda Laut *Strombus canarium* di Kawasan Perairan Johor)

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Abstract

Strombus canarium is a popular food source with high commercial value in southern part of Peninsular Malaysia. As a deposit feeder, *Strombus canarium* can accumulate pollutants especially heavy metals in their system. Study on this species was conducted at Teluk Sengat and Mersing, Johor where samples of seawater and *Strombus canarium* were collected during spring low tides around 0 to 0.2 meters. Lead (Pb) and zinc (Zn) concentrations were investigated to determine pollution status in the area. Samples from Teluk Sengat showed that Zn has higher concentration in both water and *S. canarium* with 0.055 mg/L and 20.257 mg/kg wet weight respectively. However the concentrations were within permissible limit of Malaysia Marine Water Quality Criteria and Standard (MMWQS). In contrast, Pb concentration at Teluk Sengat exceeded the MMWQS and its concentration in soft tissues of *S. canarium* also exceeded the permissible limit recommended by Food and Agriculture Organisation (0.5 mg/kg wet weight) and World Health Organisation (0.2 mg/kg wet weight).

Keywords: Johor coastal areas, lead, zinc, *Strombus canarium*

Abstrak

Strombus canarium adalah sumber makanan yang popular dan mempunyai nilai komersil yang tinggi di bahagian selatan Semenanjung Malaysia. Sebagai pemakan mendapan, *Strombus canarium* dapat mengumpulkan bahan cemar terutama logam berat di dalam sistem mereka. Kajian terhadap spesies ini telah dijalankan di Teluk Sengat dan Mersing, Johor di mana sampel air laut dan *Strombus canarium* diambil ketika air surut sekitar 0 hingga 0.2 meter. Kepekatan plumbum (Pb) and zink (Zn) disiasat untuk penentuan status pencemaran kawasan kajian. Sampel air dan *S. canarium* dari Teluk Sengat mengandungi kepekatan Zn paling tinggi iaitu masing-masing 0.055 mg/L dan 20.257 mg/kg berat basah. Walaubagaimanapun, kepekatan berada di dalam had yang ditetapkan oleh *Malaysia Marine Water Quality Standard and Criteria* (MMWQS). Sebaliknya, kepekatan Pb di Teluk Sengat melebihi MMWQS dan kepekatan di dalam tisu lembut *S. canarium* juga melebihi had yang dibenarkan oleh *Food and Agriculture Organisation* dan *World Health Organisation* (0.5 mg/kg berat basah) dan *World Health Organisation* (0.2 mg/kg berat basah).

Kata kunci: perairan Johor, plumbum, zinc, *Strombus canarium*

Introduction

Metals such as zinc, copper and iron are important element and nutritionally essential to living organisms. Some metals also received more attention for example lead, cadmium and tin which is referred as heavy metals due to their high toxicity and effect on environment. Generally metals enter the environment via natural weathering, erosion and volcanic activity [1]. However, their occurrence and distribution especially in coastal ecosystem are often related to anthropogenic activities. The anthropogenic sources of metals normally come from industrial and municipal waste products, urban and agricultural runoff, sediments eroded from catchments and atmospheric deposition [2]. In fact, these pollutants have capability to accumulate in the food chain and could impose adverse effects in marine organisms [3]. Humans who occupy top level of the food chain and consume metal-contaminated seafood may face greater risk of health problem. Previous studies have shown that progressive and irreversible

accumulation of Pb in human bodies can impair the functions of renal and liver [4]. Long-term intake of Zn (150 – 2000 mg/day) will induce sideroblastic anemia, leukopenia and hypochromic microcytic anemia [5].

The present study focus on marine gastropod, *Strombus canarium* which is widely distributed in the coastal waters of Johor and highly associated with sandy mud bottom at seagrass areas [6]. *Strombus canarium* or locally known as 'siput gonggong' is a popular seafood delicacy and have high demand in the market. However, there is limited information regarding metal concentration of this gastropod at coastal area of Johor. *Strombus canarium* are deposit feeder therefore they can accumulate metals from water and sediment. Currently, their habitats are highly exposed to coastal contamination induced by anthropogenic factors, which can also lead to their depletion [7]. Therefore, metal assessment on *Strombus canarium* is important since it could pose a serious threat to human health risk for individuals who consume them.

This study reports on the concentration of Pb and Zn in soft tissues of *Strombus canarium*, seawater and sediment samples from Teluk Sengat and Pulau Setindan, Mersing. The statistical difference of metals concentration between these sites was also investigated since the areas have different type of human interference. Water quality data were compared to Malaysia Marine Water Quality Criteria and Standard (MMWQCS) and World Health Organisation (WHO), whereas Pb and Zn concentrations in the soft tissues of *Strombus canarium* were compared to Food and Agriculture Organisation (FAO) and WHO. Sediments collected at the study areas were also classified according to sediment criteria proposed by U. S. Environmental Protection Agency (U.S.EPA) and New York Sediment Criteria.

Materials and Methods

Samples of seawater, sediment and *Strombus canarium* were collected in 2011 from two stations located at Johor coastal area. The first sampling station is Teluk Sengat (N 01^{o} 32' 48.3'', E 104^{o} 01' 57.7") located at the estuary of Johor River on the eastern part of Johor Straits. Teluk Sengat is situated approximately 1.30 km to the north of Senai-Desaru Highway. It is a sub-tidal area covered mainly with muddy substrates and dominated by seagrass *Halophila ovalis*. The second station is Pulau Setindan, Mersing (N 02^{o} 30' 11.7", E 103^{o} 50' 26.1") located at the eastern coast of Johor. The main economic activities in Mersing are tourism, agricultural and fishing.

All sampling and experimental apparatus were soaked in 10% nitric acid for 24 hours and double rinsed with Milli-Q (18 MΩ) water. The seawater was sampled using polyethylene bottles (1 L) approximately 10 cm below the water surface. The water samples were filtered using Whatman syringe filter (0.2µm) then preserved with concentrated nitric acid and later kept at 4^{o}C prior to analysis. Twenty *Strombus* specimens were collected from each station which were immediately stored in a cool box and later transported to the laboratory for metal analysis. The average specimen shells used for analysis from Teluk Sengat were from 55 to 66 mm and weight 21 to 39 g whereas samples from Mersing were 50 to 56 mm of shell length and 28 to 35 g of weight.

Soft *Strombus* tissues were dissected by removing the specimen body from its shell using sterilized stainless steel equipment. The digestion procedures were carried out according to U.S EPA method 3050 where soft tissues were oven dried at 105°C for 24 hours. After drying, 1 g of samples were weighed and transferred to SMA model ARM6 block digester sample vessels followed by addition of 20 mL of 98% nitric acid (AnaR grade, Merck). The samples were then digested at 95^{o}C for 2 hours. The digested samples were later diluted with 100 mL of Milli-Q deionised water and filtered into clean bottles using Whatman syringe filter (0.2 µm). Pb and Zn concentration were then measured by inductively coupled plasma mass spectrometry (ICP-MS) using 6100 ELAN instrument (Perkin Elmer). Metal concentrations in seawater is reported in milligram per liter (mg/L), metal in sediment in microgram per gram dry weight (µg/g) and metal in soft tissues of *Strombus* specimen is reported as milligram per kilogram (mg/kg) dry weight.

The dry weight is then converted to wet weight using a conversion factor of 0.3 for comparison purposes with guidelines recommended by FAO [8] and WHO [9]. The conversion factor used is based on assumption that 70% of mollusk's soft tissue weight is water [10]. Student t-Test with 95% confidence limits was also used to determine the statistical significance of metal concentrations between the stations.

Results and Discussion

Metal concentration in seawater

Result of water quality at Teluk Sengat and Mersing is tabulated in Table 1. Water temperature at Teluk Sengat and Mersing were recorded at 29.23 ^{o}C and 29.80 ^{o}C respectively. Salinity concentration at Teluk Sengat (22.24 ppt) was lower than Mersing waters (30.0 ppt). Teluk Sengat waters have lower value of salinity since the samples were taken during rainy period and the station located near an estuary. Variable salinity values of estuary are often influenced by tides, weather and other environmental factors [2]. The DO values (4.41 and 5.52 mg/L) at both sampling stations were above the criteria recommended by MMWQS (4 mg/L), whereas pH (7.72 to 8.12) were within the range recommended by WHO (6.5-8.5).

Table 1: Result of water quality at Teluk Sengat and Mersing

Location	Parameter					
	Temp (^{o}C)	**Salinity (ppt)**	**pH**	**DO (mg/L)**	**Pb (mg/L)**	**Zn (mg/L)**
Teluk Sengat	29.80	22.24	7.72	4.41	0.032	0.055
Mersing	29.23	30.3	8.12	5.52	0.013	0.017
MMWQCS	-	-	-	4	0.0085	0.05
WHO	-	-	6.5 - 8.5	-	0.01	5

MMWQCS – Malaysian Marine Water Quality Criteria Standard

The concentration of Pb and Zn in Teluk Sengat water were found to be significantly higher ($p < 0.05$) than Mersing at 0.032 and 0.055 mg/L respectively. The metals concentration also exceeded MMWQC for Class E where the class is applicable to assess water quality at mangrove and estuarine areas. Based on the findings, seawater at Teluk Sengat is polluted by Pb which can cause adverse effect to living organisms.

Higher metals concentration in samples from Teluk Sengat compared to Mersing is expected since the location of Teluk Sengat is adjacent to industrial, urbanisation and port area. It has been reported that intensive dredging, reclamation and shipping activities at the eastern coast of Johor Straits has led to the enrichment of metals in the aquatic environment [11]. However, the results obtained from the study is lower compared to previous studies reported by [12] and [13] in the water column of Johor Straits and Mersing respectively.

Metal concentration in sediment

Table 2 shows the concentration of metals in marine sediment from each sampling stations. The metals concentration at Teluk Sengat was significantly higher ($p < 0.05$) than metals concentration at Mersing. Both stations recorded high concentration of Zn than Pb, however according to U. S. EPA guidelines; the sediment at Teluk Sengat is classified as slightly polluted with Pb at 45.572 µg/g dry weight. Studies conducted on sediment from Pulau Tekong located approximately 20 km to the south of Teluk Sengat by Cuong et al. [14] shows lower concentration of Pb (29.8 µg/g dry weight) and Zn (49.8 µg/g dry weight) compared with the current study.

Table 2: Mean metal concentration in sediment comparison with EPA sediment quality guidelines and New York Sediment Criteria

Station/EPA Guidelines and New York Sediment Criteria	Pb(µg/g dry weight)	Zn(µg/g dry weight)
Teluk Sengat	45.572	54.491
Mersing	13.624	22.530
EPA Sediment quality proposed		
Non-polluted	< 40	< 90
Slightly polluted	40 - 60	90 – 200
Severely polluted	> 60	> 200
New York sediment criteria		
Lowest effect range	31	120
Severe effect range	250	220

Previous studies reported enrichment of Pb in sediment along Johor Straits were due to combustion of fuel by vehicles and boat [15, 16]. Yap et al. [17] suggested that Zn contamination in Johor Straits is contributed by mussel processing factory at Kampung Sungai Melayu. Zn was released to the coastal water by direct discharge of water used in the boiling process. The boiling method was used to facilitate the removing of soft tissue from the shell for packaging and freezing purposes. Ong and Kamaruzzaman [18] reported that the present of Pb concentration in sediment at eastern coast of Johor was resulted of natural erosion of earth's surface.

Metal concentration in soft tissue of *Strombus canarium*

Mean concentration of Pb and Zn in soft tissues of *Strombus canarium* is shown in Table 3. *Strombus canarium* from both sampling stations have higher accumulation of Zn compared to Pb since Zn is one of the essential element required by aquatic organism [19]. McManus and Newton [20] also reported that seafood contained high level of Zn than other food.

Pb and Zn concentrations were lower compared to the permissible limits recommended by FAO and WHO except for Pb in samples from Teluk Sengat. Pb concentration (2.701 µg/g wet weight) exceeded the limit of FAO (1.5 µg/g wet weight) and WHO (0.2 µg/g wet weight). Therefore, consumption of *Strombus canarium* should be controlled since 25% of total Pb intake will remain in human blood and could cause neurotoxic effects [21].

Table 3: Metal concentration in *Strombus canarium*'s soft tissues and guidelines recommended by FAO and WHO

Station/Food Guidelines	Metal (µg/g wet weight)	
	Pb	Zn
Teluk Sengat	2.701	20.257
Mersing	0.095	12.253
Food and Agriculture Organization (FAO)	0.5	150
World Health Organization (WHO)	0.2	500

The results obtained in the present study are comparable to previous studies by [10, 22, 23]. Rizo et al. [22] reported that Pb and Zn concentration in soft tissues of *Strombus gigas* in Cuba were in the range of 0.2 to 2.3 µg/g wet weight and 20.4 to 31.1 µg/g wet weight respectively. The study suggested high value of Pb in *Strombus gigas* was caused by contaminated effluent from sewage, industrial and agricultural. [10] found high values of Pb (2.778 µg/g wet weight) and Zn (30 µg/g wet weight) in *S. canarium* sampled from Pulau Bangka, Indonesia compared to the present study.

Conclusion

The present study showed that seawater and sediment at Teluk Sengat contain high concentration of Zn and Pb compared with samples from Mersing. Generally, Zn concentrations were higher in seawater, sediment and soft tissues of *Strombus canarium* at both sampling areas. However, Pb concentrations at Teluk Sengat exceeded the permissible limit by Malaysia Marine Water Quality Criteria and Standard and can be classified as slightly polluted based on U. S. EPA sediment criteria. Moreover, the concentration of Pb in soft tissues of *Strombus canarium* from Teluk Sengat could pose toxicological risk to human health since the concentration exceeded the maximum limit recommended by FAO and WHO.

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