Determination of Water Quality and Selected Heavy Metal in Mud Clams (*Polymesoda expansa*) as Bioindicator at Benting Lintang, Besut, Terengganu

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ABSTRACT

Anthropogenic activities are the main cause of water quality deterioration which causes severe impacts on aquatic animals and human health. Mud clams (*Polymesoda expansa*) mostly eaten by people in Southeast Asia especially Terengganu can be exposed to the heavy metal contamination because of their filter feeder behaviour. This study aims to determine the water quality index (WQI) and investigate the selected heavy metal (Cr, Ni, Cu, Zn, Pb) contamination using Lokan (*Polymesoda expansa*) as a bioindicator at Benting Lintang, Besut, Terengganu. Analysis of water quality parameters was conducted In-situ and Ex-situ which involves 3 stations along the Benting Lintang water body. The heavy metal analysis was determined by using the acid digestion method and ICP-OES. The statistical analysis ANOVA shows the p-value is less than 0.05 proved there are significant different of heavy metal in mud clams between wet and dry season. The water quality at all stations during wet and dry season categorized at class II except station 2 during dry season falls on class III. The class II water quality shows that recreational activities can be done at the study location while extensive treatment is required at the station 2 during dry season. Heavy metal accumulated in mud clams for Cr, Ni and Cu in both seasons still in permissible limit according to FDA (2007), FAO (1983) except Pb and Zn exceeded the limit by Malaysia Food Regulation 1985 (2011). As a conclusion, mud clams are a good bioindicator for heavy metal determination in their surroundings. Frequent water quality monitoring and heavy metals analysis in mud clams should be conducted to ensure food safety and human health in future.

Keywords: water quality, heavy metal, anthropogenic activities, mud clams, bioindicator

INTRODUCTION

Water is a crucial source in human’s daily life including uses for irrigation, domestic, industrial, recreational, food source and transportation purposes (Ejigu, 2021; Wu et al., 2021). Besides, it also plays important role in balancing the ecosystem for various flora and fauna by providing habitat and food source for them. Mud clams are known as ‘Lokan’ by local people that are popularly collected from nature (Idris et al., 2017) as a food source.
This type of bivalvia is commonly found at brackish and freshwater areas (Rohalin et al., 2019) which influenced by tidal occurrence by burrowing (Idris et al., 2017) their body into the mud.

Monitoring of water quality is important (Sutadian et al., 2016) because it involves determining of water condition that may affect human health if the water quality is poor (Jennings et al., 2016) and could disrupt the ecosystem chain since it is the most dependable source (Ejigu, 2021) for human and other organisms.

The water bodies can be contaminated due to pollution caused by humans such as the discharge of industrial wastewater and improper garbage management (Sow et al., 2019; Fu et al., 2012) into the environment especially water bodies. Heavy metal is the dangerous contaminant that occurs from human activities which leads their concentration to increase from their natural level that already exists in the environment (Lias, 2013; Hossen et al., 2015). It can accumulate in clams through respiration and diet since they are filter feeders by accumulating the metal in their tissues (Sow et al., 2019). Mud clams are the most collected species along the Mengabang Benting Lintang as a food source and are known as a good bioindicator (Fang et al., 2003; Sow et al., 2019) to measure the level of heavy metal accumulation in them (Elvira et al., 2021) since they can filter between 20 to 100 litre of water per day (Harsono et al., 2017).

**MATERIALS AND METHODS**

**Study area**

The chosen location is Mengabang Benting Lintang (Table 1) located at Kampung Benting Lintang where the water is connected and parallel to the beach that only separated by the sandbar (Pejabat Daerah Besut, pers. Comm., 2022; Sathiamurthy et al., 2021).

<table>
<thead>
<tr>
<th>Station</th>
<th>Coordinate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>5°44'20.3&quot;N 102°39'30.4&quot;E</td>
<td>Last location of water flow, far anthropogenic activities present from location.</td>
</tr>
<tr>
<td>S2</td>
<td>5°43'54.5&quot;N 102°39'53.9&quot;E</td>
<td>Located at the middle of the S1 and S3. Have major anthropogenic activities near the location such as fishing and boating, food stalls and fish processing stalls.</td>
</tr>
<tr>
<td>S3</td>
<td>5°43'43.2&quot;N 102°39'58.8&quot;E</td>
<td>First location of seawater starts to flow from the estuary at Pulau Hujung Uma and Pulau Sutung, Permaisuri, Terengganu located about 19 km from station 3. Have less anthropogenic activities present.</td>
</tr>
</tbody>
</table>

Mengabang Benting Lintang connected to the sea about 19 km by estuary located at Pulau Hujung Uma and Pulau Sutung, Permaisuri, Terengganu. During high tide, the seawater flow from location 3 to location 1 and vice versa occurs during the low tide. There are many human activities along the study location such as fishing, food and fish processing stalls that operate almost every day. The sampling conducted during the wet season in December 2021 and dry season in April 2022 to compare the data obtained between both seasons.
Water quality index

The water quality for in-situ parameters (temperature, pH, dissolved oxygen (DO) and ammonia nitrogen (AN)) were determined by using Multiparameter YSI Professional Plus while for ex-situ, the water samples are collected by using sampling bottles except sample for biochemical oxygen demand (BOD) that is collected in amber bottle wrapped with the aluminium foil to avoid from photosynthesis to occur. The samples collected except BOD sample is preserved with nitric acid and placed into the icebox to keep them fresh while transferring to the chiller by setting up the temperature below 4°C before undergo further analysis (APHA, 2017). The analysis used for biochemical oxygen demand (BOD) by using BOD5 method (APHA, 2005), chemical oxygen demand (COD) by APHA, 2005) and total suspended solids (TSS) by using the filtration (Bala B, 2018; APHA, 2005; APHA, 2017).

**Determination of Water Quality Index (WQI)**

The data of 6 water quality parameters (DO, BOD, COD, AN, pH and TSS) were used to determine the WQI based on National Water Quality Standard for Malaysia (Department of Environment, 2014). The formula is as below:

\[
WQI = (0.22 * S_{DO}) + (0.19 * S_{BOD}) + (0.16 * S_{COD}) + (0.15 * S_{AN}) + (0.16 * S_{SS}) + (0.12 * S_{pH})
\]

Where (Rahim et al., 2021; Naubi et al., 2016):

- \( S_{DO} \) = Sub-Index DO (% saturation)
- \( S_{BOD} \) = Sub-Index BOD (mg/L)
- \( S_{COD} \) = Sub-Index COD (mg/L)
- \( S_{AN} \) = Sub-Index AN (mg/L)
- \( S_{SS} \) = Sub-Index SS (mg/L)
- \( S_{pH} \) = Sub-Index pH

**Heavy metal bioaccumulation**

The mud clams (known as Lokan) samples are randomly collected from the Mengabang Benting Lintang by using suitable tools such as a small rake for scratching the clams in mud and a basket with a holder to collect the clams that already founded. The clam’s shells are cleaned before placing into the icebox to keep them fresh before transferred to the cool room to freeze.

**Mud clam’s dissection**

Frozen mud clams were thawed at room temperature and size are measured before dissection. Then, they were cleaned 3 times by using ultrapure water (deionized water) to ensure any foreign particles on clam’s shells are removed. The wet tissue is removed from the shell by using a knife and stainless-steel scalpel. Next, every weight of clam’s tissues is recorded before we dried overnight on petri dish at temperature 80°C in the oven. Then, the constant weight of dried tissues were weighed and recorded (Rohalin et al., 2019; Kamaruzzam et al., 2011).

**Mud clam’s tissues digestion**

Acid digestion is used to digest the clam tissues (AOAC, 2016). All samples were placed in a test tube that already filled with 10 ml of 69% of nitric acid. Then, the samples were left at room temperature for overnight in fumehood. The other day, the samples were transferred into the digestion tube and residue in the test tube wall was rinsed with 5 ml of 69% of nitric acid. Then, the samples were digested in microwave digestion about an hour and a half. After that, 2 ml of 30% hydrogen peroxide is added to each sample before it was cooled for 30 minutes in fumehood. The solution then undergone filtration by using 0.5 mm filter paper that already placed into 25 ml of volumetric flask. Next, deionized water is added until the 50 ml of flask’s volume is reached. The
heavy metal content in mud clams is determined by analysing the samples solution using Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES).

*Heavy metal calculation*

The metal concentration is calculated by using the formula below (APHA, 2005):

\[ C = \frac{A \times B}{M} \]

- \( C \) = Actual concentration (mg/kg)
- \( A \) = Digested concentration in ICP (mg/L)
- \( B \) = Volume digested (L)
- \( M \) = Weight of dried sample digested (kg)

*Data analysis*

Heavy metal concentration in each sample were analysed using analysis of variance (ANOVA) in Microsoft Excel to investigate the relationship of selected heavy metal concentrations (Pb, Zn, Cu, Ni and Cr) during wet and dry season.

**RESULTS AND DISCUSSION**

*Water quality index (WQI)*

Based on Table 2 below, the temperature is considered as low temperature where it recorded the lowest average at station 1 and 2 with 25.97±0.15 °C and 25.97±0.06 °C while the temperature is a little higher at station 3 with 26.2±0 °C due to the wide water body compare to station 1 and 2. Wide water body causes large water surface exposed to the sunlight that influenced the increasing of temperature. While the temperature is considered as high temperature during dry season where it recorded the lowest average at station 1 with 30.3±0.17°C this due to the surrounding area is shaded and many trees present. Then, the temperature highest at station 3 with 34.5±0.26°C where the location is exposed to the sunlight that influence the temperature to be higher than other locations.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Wet Season</th>
<th>Dry Season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Station 1</td>
<td>Station 2</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>6.63±1.21</td>
<td>6.41±0.04</td>
</tr>
<tr>
<td>pH</td>
<td>6.60±0.03</td>
<td>6.41±0.04</td>
</tr>
<tr>
<td>NH₃N (mg/L)</td>
<td>0.31±0.02</td>
<td>0.18±0.02</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>0.28±0.14</td>
<td>1.64±0.55</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>100.00±23.07</td>
<td>108.00±101.01</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>41.00±11.2</td>
<td>28.67±12.50</td>
</tr>
</tbody>
</table>
The salinity during wet season at all stations (station 1: 0.12±0.01 ppt, station 2: 0.39±0 ppt, station 3: 0.28±0.02 ppt) recorded below 0.5 ppt (class I) where it categorized as freshwater by referring to the National Water Quality Standard (NWQS) (Department of Environment, 2014). Salinity is a measure the amount or concentration of salts that dissolved in water (Mcaffrey, 1997; Pratt-Zavadil, 2021) where different water bodies have different salt concentration. While, the salinity during dry season at station 1 is 1.15±0.08 ppt still categorized as freshwater since it below 2 ppt (class IV) stated by the National Water Quality Standard (NWQS) (Department of Environment, 2014). While salinity at station 2 and 3 is above the standard value stated by Department of Environment (2014) where it little higher with value 2.91±0 ppt and 4.31±0.01 ppt make the water is lightly saline but not categorized as seawater. This is due to the flow of seawater during high tide which affects the amount of dissolved salts in the water to increase (Gasim et al., 2015) since station 3 is the first station received the flow of water from estuary followed by station 2 and station 1 where it is the last receiver of water from the estuary with a distance about 19 km. Salinity supposed to decrease because of the estuary is far away from the study locations. The study from Gasim et al. (2015) recorded the salinity at Paka River, Terengganu which supposed to be freshwater during low and high tide is ranging from 0.01 ppt to 3.48 ppt while the seawater salinity is ranging from 33.7 ppt to 36.77 ppt (Idrus et al., 2017) and other study recorded 30 to 35 ppt of salinity (Suliman, 2018). The salinity during the wet season is low because of the heavy rainfall is the factor of salt dilution in water which influenced the salt concentration. The salinity during dry season is high compared to wet season (Markou et al., 2007) due to some factor that influenced salinity concentration such as dissolution of ion occurs when the ground water moving in the form of geologic formation (Suchan & Azam, 2021).

The dissolve oxygen (DO) during the wet season (6.63 mg/L, 8.1 mg/L, 10.25 mg/L) is higher at all stations compared to dry season (6.1 mg/L, 7.79 mg/L, 6.75 mg/L). This is because the water flow during wet season is fast due to the high-water level influenced by the rainfall compared to the dry season where the increasing of temperature influenced the decreased of oxygen solubility in water (PHILMINAQ, 2010). DO stands for amount or level of oxygen dissolved in water from atmosphere or aquatic plants that undergo photosynthesis process. Photosynthesis is the process of plant to exchange the carbon dioxide produced by the organisms or living thing to oxygen with the aid of sunlight. Dissolved oxygen is crucial for organisms and aquatic animals since it is the most needed source (Mcaffrey, 1997; Industrial Water Treatment, 2020) for them to keep survive. During wet season, station 3 recorded highest DO (10.25 mg/L) due to the low temperature and fast flowing water caused by the boating activity since it’s the one of hotspot area for aquatic food source collecting by local people. Both seasons for dissolved oxygen parameters falls under class I and class II by referring to the Department of Environment (2014).

The pH recorded during dry season at all station is higher than wet season where it measures the alkalinity and acidity of the water. This because the salinity influence pH value where the study from Gasim et al., (2015) recorded high value during high tide which is when seawater enter the estuary and the salinity is increased due to the mix with freshwater.

The ammonia nitrogen (NH₃N) during wet season (0.31 mg/L, 0.18 mg/L, 0.24 mg/L) is high compared to dry season (0 mg/L at all stations) because the rainfall flashed away and dilute the waste produced from the anthropogenic activities at the study area. Higher concentration of ammonia nitrogen during wet season also recorded at Kelantan River Basin recorded by Maulud et al. (2021). Ammonia nitrogen is a parameter used to detect the source of pollution that occurs near the study area that is potentially caused by anthropogenic activities (Maulud et al., 2021). Based on the observation and research at Mengabang Benting Lintang, there are some constructions still run as a type of land use (Wu et al., 2021) which potential cause of water quality changes. Land use also refers to any human use that involves human long-term interaction with the environment such as

<table>
<thead>
<tr>
<th>Salinity (ppt)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12±0.01</td>
<td>25.97±0.15</td>
</tr>
<tr>
<td>0.39±0</td>
<td>25.97±0.06</td>
</tr>
<tr>
<td>0.28±0.02</td>
<td>26.2±0</td>
</tr>
<tr>
<td>1.15±0.08</td>
<td>30.3±0.17</td>
</tr>
<tr>
<td>2.91±0</td>
<td>32.1±0</td>
</tr>
<tr>
<td>4.31±0.01</td>
<td>34.5±0.26</td>
</tr>
</tbody>
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recreational places, residential and economic purposes (Camara et al., 2019). Based on Denchak (2018), the wastewater will flow back to pollute the environment water bodies from 80% of waste dumped. Based on Nathanson (2021), domestic sewage discharge contained high ammonia nitrogen such as waste from food stalls and fish processing stalls is the main source of pathogens that can induce disease caused by microorganisms.

Next, biochemical oxygen demand (BOD) is an indicator for the amount of oxygen used or consumed by the bacteria and other microorganisms. This important to help them decompose the organic matter contained in water in a state of oxygen presence at a certain temperature (Tuser, 2020). The biochemical oxygen demand shows higher during the wet season (0.28 mg/L, 1.64 mg/L, 3.49 mg/L) compared to dry season (0.19 mg/L, 0.66 mg/L, 0.12 mg/L) due to the anthropogenic activities could influence it fluctuation. The high concentration of BOD level in water will affect the decreases of dissolved oxygen in water body (Susilowati et al., 2018). The increasing of this parameter also affected by the natural decaying process by the plant and other human activities caused by discharging of commercial building and industrial wastewater (Al-Badaii et al., 2013) especially from the food stall's kitchen (Madison, 2022) along the Mengabang Benting Lintang. This cause the higher consumption of oxygen needed by the bacteria to break down the organic matter contained in wastewater (Susilowati et al., 2018). Highest level of BOD at station 3 (class II) during wet season due to the waste from the land at study location is flow with rainfall and enter the water body. The waste flow from the major anthropogenic activity areas (station 2) to station 3 before it goes to the estuary located at Pulau Hujung Uma and Pulau Sutung, Permaisuri, Terengganu.

Besides, total suspended solids is the measure of particulate suspended solid in the water (Maulud et al., 2021) that can be determined by the particles retained after filtration process (PHILMINAQ, 2010). The total suspended solids during monsoon season (100 mg/L, 108 mg/L, 76 mg/L) at all station is higher than dry season (26.7 mg/L, 42 mg/L, 12 mg/L) similar with study conducted by Maulud et al. (2021) and Al-Badaii et al. (2013). The increasing of the TSS during wet season because of the fast flowing of the water cause the sediment (Maulud et al., 2021) at the bottom of the water body is spread to the water surface. The TSS results during monsoon season fall under class II while the TSS during dry season categorized as class I by referring to the Department of Environment (2014).

Chemical oxygen demand (COD) during dry season (30.67 mg/L, 48.7 mg/L, 514.67 mg/L) is higher compared to wet season (41 mg/L, 28.67 mg/L, 16.67 mg/L) except for station 1 same result obtained by the both Maulud et al. (2021) and Al-Badaii et al. (2013). The COD parameter is important to determine the pollution level in the study area because the low level indicate the less tendency of water pollution to occurs (Al-Badaii et al., 2013). This showed, station 1 is the lowest of COD level which means less waste enter the water body since the human activities are far from the study location. The COD results for all station during wet season including station 1 during dry season fall under class II (Department of Environment, 2014). COD results for station 2 and 3 during dry season is high which falls under class V caused by the effluent of wastewater (Rahim et al., 2021) from the near food stalls, fish processing stalls and other human activities.

The WQI consists of 6 classes which are (I, IIA, IIB, III, IV and V) with different level of use (Department of Environment, 2014) where class I represent better water quality and class V is the worst (Naubi et al., 2016). Based on the table 3, the water quality during wet (station 1: 78.22, station 2: 80.57, station 3: 83.39) and dry season (station 1: 88.92, station 3: 79.08) at all stations categorized as class II except station 2 during the dry season (73.27) that falls under class III. Class II required the conventional treatment and the recreational

<table>
<thead>
<tr>
<th>Wet Season</th>
<th>Dry season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station 1</td>
<td>Station 2</td>
</tr>
<tr>
<td>WQI</td>
<td>78.22</td>
</tr>
<tr>
<td>Class</td>
<td>II</td>
</tr>
</tbody>
</table>

Table 3. Table of water quality index (WQI) at each station during wet and dry season
activities still can be conducted at the study area during the wet season. While class III required extensive treatment which still can be used for common and economic value species also suitable for livestock drinking (Department of Environment, 2014). Station 2 located near the major anthropogenic activities where the wastewater from the land enters the water body which influenced the water quality during the dry season since lower water level caused the higher concentration of water quality parameters.

Table 4. Comparison of WQI with previous study and present study

<table>
<thead>
<tr>
<th>Location</th>
<th>Water quality index (WQI)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mengabang Benting Lintang (Wet Season)</td>
<td>Class II</td>
<td>Present study</td>
</tr>
<tr>
<td>Mengabang Benting Lintang (Dry Season)</td>
<td>Class II &amp; III</td>
<td></td>
</tr>
<tr>
<td>Terengganu River Basin</td>
<td>Class I</td>
<td>(Suratman et al., 2015)</td>
</tr>
<tr>
<td>Kelantan River Basin (Wet &amp; Dry Season)</td>
<td>Class III</td>
<td>(Maulud et al., 2021)</td>
</tr>
<tr>
<td>Skudai River, Johor</td>
<td>Class III</td>
<td>(Naubi et al., 2016)</td>
</tr>
</tbody>
</table>

Table 4 shows the comparison of water quality index (WQI) recorded by other previous study in Malaysia. The WQI recorded by present study falls under class II during wet season while categorized as class II and III during dry season. The present study showed the under control results and good quality since its falls at the middle of the other previous study where Terengganu River Basin is the good water quality at class I (Suratman et al., 2015) and both Kelantan River Basin and Skudai River, Johor recorded class III (Maulud et al., 2021; Naubi et al., 2016).

Heavy metal bioaccumulation

Some heavy metals are useful but in a certain amount and they can affect human’s health by consuming higher limit in affected food such as mud clams (*Polymesoda expansa*). Different heavy metal required different amount that hazardous and toxic to organisms. Moreover, the statistic of mud clam’s consumption by people who lived near clam’s habitat is higher than people who lived far from brackish water areas (Hamdan et al., 2019). In this study, heavy metal determination in mud clams were undergone by using the range size of samples during wet season is 6.77±0.48 cm (length) and 6.28±0.53 cm (height). While the range size during dry season for length is 6.93±0.41 cm (length) and height 6.53±0.47 cm (height).

Table 5. Comparison of heavy metal in present study with standard and previous study

<table>
<thead>
<tr>
<th>Heavy Metal Concentration (ppm)</th>
<th>Cr</th>
<th>Pb</th>
<th>Ni</th>
<th>Cu</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet season (present study)</td>
<td>8.52</td>
<td>2.26</td>
<td>-0.59</td>
<td>4.79</td>
<td>59.80</td>
</tr>
<tr>
<td>Dry season (present study)</td>
<td>6.23</td>
<td>1.87</td>
<td>-3.50</td>
<td>5.74</td>
<td>132.26</td>
</tr>
<tr>
<td>International Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDA (2007)</td>
<td>13.00</td>
<td>1.70</td>
<td>80.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FAO (1983)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>30.00</td>
<td>40.00</td>
</tr>
<tr>
<td>MFR 1985 (2011)</td>
<td>-</td>
<td>1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Previous Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pahang water body (Chuan &amp; Ibrahim, 2017)</td>
<td>-</td>
<td>1.94</td>
<td>-</td>
<td>15.50</td>
<td>296.00</td>
</tr>
<tr>
<td>Marudu Bay, Sabah (Harsono et al., 2017)</td>
<td>6.55</td>
<td>2.90</td>
<td>5.38</td>
<td>27.73</td>
<td>332.45</td>
</tr>
</tbody>
</table>
Based on the present study, the negative value for nickel shows the value is too small detected below the minimum value from the blank sample (without mud clam’s samples). The average data of zinc shows the highest concentration with 59.80 ppm and the lowest is Nickel with -0.59 ppm. It showed the most metals accumulated by the clam’s sample collected during wet season are is Zn, Cr, Cu, Pb and Ni. Heavy metals accumulated in mud clams by entering their muscle or body part because of their filter feeder behaviour and remain in their body which called bioaccumulation. The average of zinc still the highest concentration during dry season with 132.26 ppm and the lowest is nickel with -3.50 ppm. It determined that the most metals accumulated by the clams during dry season are is Zn, Cu, Cr, Pb and Ni. It is because they are filter feeder species that filter everything in their water environment include accumulating the heavy metals (Dabwan & Taufiq, 2016).

Both season shows higher in zinc because the mud clams itself contained zinc in their body since they rich in minerals (zinc, magnesium, iron and vitamin B12) (Streit, 2019). Furthermore, zinc is a typical mineral which good for the human body but it can be toxic if largely consumed. Based on observation and research at study location, zinc might be contaminated through the use of batteries, other electricals, pigment and paints that are not properly disposed at the study area. Besides, it is also used as galvanized metal to avoid steel from rusting since major activity at Mengabang Benting Lintang are fishing where some of equipment used for fish catching made by the steel are left along the study location are the reason of the introduce of Zn in water body.

The study indicates that Cr and Pb are highly accumulated during wet season while Ni, Cu and Zn are highly accumulated during dry season. The bioaccumulation of heavy metal by mud clams are influenced by some factor such as temperature, salinity fluctuation, rainfall, and pH (Rohalin et al., 2019). The concentration of Cr, Pb, Ni, Cu and Zn are low compared to the previous study recorded by Harsono et al. (2017) except Cr in mud clams located at Marudu Bay while the study by Chuan & Ibrahim (2017) recorded low in Pb concentrations compared to this study.

The heavy metals accumulated in mud clams for Cr, Ni and Cu in both season is still in permissible limit stated by the Food Drug and Administration (FDA, 2007) and Food and Agriculture Organization (FAO, 1983) except the Lead (Pb) concentration that exceed the limit stated by the Malaysia Food Regulations 1985 (MFR, 2011). Hence, the mud clams at Mengabang Benting Lintang already contaminated by the heavy metals cause by the anthropogenic activities near the study location. Heavy metal contamination at Mengabang Benting Lintang comes from anthropogenic activities since that place near to the beach is one of the popular places in Besut state. The non-point source caused an oil spill which occurs when there’s a leak of oil from visitor’s vehicles and fisherman boats at many places along the study locations. Based on Rohalin et al. (2019) and Nathanson (2021), the oil spills from the vehicle on the road can infiltrate into the soil and runoff to the water bodies which can harm aquatic life. Petroleum oil used as vehicle fuel also known as crude oil contain chemical and heavy metal elements such as nickel (Ni), vanadium (V), copper (Cu), aluminium (Al), iron (Fe), cadmium (Cd) and lead (Pb) (Hodgson, 1954; O, 2016). It causes both short (Kadarsah et al., 2020) and long-term (Goldstein, 2019) severe effects on human health such as damaging the internal organ especially in children and pregnant women (Oghenetega et al., 2020).

Paints used in constructing colourful food stall contained heavy metals such as lead (WHO, 2021), copper, cadmium and chromium (Grant, 2016). Lead contained in paint (Ogilo et al., 2017) can cause adverse impacts on human health if exposed such as kidney damage and high blood pressure. High levels of this heavy metal can cause problems in children’s health such as coma and death (WHO, 2021). In addition, the used of cement
for stalls construction cause contamination of chromium (Cr) which is a dangerous heavy metal that enters the water bodies by the surface flow especially during wet season.

Copper usually contaminated to the environment through sewage sludge, cooking utensils, fertilizers, fungicides, algicides and antifouling paint (WHO, 2011) that are usually used to prevent attaching of marine organisms to a boat’s hull (Burden, 2020). Even though it is essential in human development and growth (WHO, 2011), the toxicity of its through consumption of contaminant food and water can cause headaches, diarrhea and kidney failure in humans (Ekse, 2020). Based on the heavy metal that was selected cause contamination in Mengabang Benting Lintang, their toxicity can acutely or chronically affect the aquatic life at the contaminated area (FAO, 1994) and also affect human health (FDA, 2007).

| Table 6. ANOVA single factor for significant of heavy metal during wet and dry season |
|-----------------|-----------------|-----------------|
| Season          | P-value         | Significant     |
| Wet             | 0.0087          | Have significant difference |
| Dry             | 0.0003          |                 |

Based on the table 6, statistical analysis of variance (ANOVA) recorded the p-value for both wet and dry season is 0.0087 and 0.0003 are less than 0.05 prove that there are significant differences between heavy metals and both dry and wet season.

CONCLUSION

In a conclusion, the water quality index (WQI) at all stations during wet and dry season categorized as class II that is suitable for recreational activities except station 2 during dry season which falls on class III due to the major anthropogenic activities. Many anthropogenic activities (human activities) located near the station 2 such as fishing, boating activities, food stalls and fish processing stalls. This proved the water quality at station 2 is poor than station 1 and 3 because of the developing anthropogenic activities. Class III water quality index (WQI) required extensive treatment but still suitable for uses of common culture species and livestock drinking.

Next, heavy metal accumulated in mud clams for Chromium (Cr), Nickel (Ni) and Copper (Cu) in both seasons still in permissible except Lead (Pb) and Zinc (Zn). Hence, the mud clams at Mengabang Benting Lintang is not advisable for large consumption due to its contamination. This to avoid the local and non-local people exposed to the short and long-term health problems in future.

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