ISSN 2250-3153

# Environmental Risks of Mercury Contamination in Losari Coastal Area of Makassar City, Indonesia

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***Abstract-*** Coastal area of Makassar City spread out of ± 35km. This area is susciptible on various polutants resulting from some activities both naturally and mostly antropogenic. The existing of industrial, agricultural, hospital wastes and gold processing enteprise were the main potential source of Mercury (Hg) in form of metal and vapor through waste disposals. This study aimed to investigate the concentration of mercury (Hg) on sea water, mollusk *Marcia Hiantina* and urine of molusk seekers and the potential environmental risk posed in coastal area of Makassar. This obersevational reserach was conducted by delivering laboratory analysis. Sample collection tecnique of sea water and molluscк used a grab sample and for urine sample using purposive sampling method then hazarq qoetiont calculated using available formulation. Sample analysis used Atomic Absorbtion Spectrofotomery (AAS) MVU-1, oceonographyc data measured was temperature ranged of 32-34$^0$C. The results showed that concentration of Mercury (Hg) in sea wáter in three stations during high tide were 0,001mg/L, 0.001mg/L and 0.002mg/L respectively. While at low tide condition ranged from 0.001–0.008mg/L, in small-sized shelfish, Hg concentration ranged from 0.042–0.112 ppm and large-sized shelfish ranged from 0.044–0.077 ppm, whereas Hg in urine ranged 0.811–6.589 µg/L. In conclusion, concentration of mercury (Hg) in sea water during low tide in point I and II with concentration 0.006 mg/L and 0.008mg/L had exceeded the establsihed quality standard of 0.001 mg/L, in small- and large-sized mollusсks,its concentration was still under maximum limit within 0.5ppm and while in urine was found at four samples; 4.489µg/l, 5.493µg/l, 5.836µg/l dan 6.589µg/l respectively which had exceeded normal concentration namely 4µg/l.

***Index Terms***- Mercury (Hg), Sea Water, Marcia Hiantina, Urine

## I. INTRODUCTION

Indonesia as a tropical country, marine waters have a fairly high biodiversity such a variety of fish, coral reefs and mangrove forests. However, behind the above given function potential sea can also multi-dimensional role in development such as fisheries, mining and it is not uncommon to marine tourism activities threatens the survival of marine organisms that exist such as fish and other biota (Supriharyono, 2000). As one of the pollutants in waters due to human activity, mercury (Hg) is classified as the most dangerous pollutants. Effect of Hg as pollutants on marine life can be direct or indirect, for example through a reduction in water quality. The ability to accumulate in the body can be harmful to marine biota as well as other organisms through the food chain or food chain, this condition allows the accumulation of heavy metals in the tissues of organisms (bioaccumulative) at each tropic level (Supriharyono, 2000).

The tragedy of Minamata disease in Japan in 1955-1960 as a result of Hg water pollution or other heavy metals from industrial waste plastics are dumped into the waters. The content of Hg fish around Minamata Bay was 9-24 ppm which is then consumed by people which resulted in 110 deaths (Boediono, 2003). Cases of poisoning by Hg have also been reported in several countries, namely in Iraq in 1961 resulted in 35 deaths, in the 1963 western Pakistan which resulted in 4 deaths, in Guatemala in 1966 which resulted in 20 people dead and Niigata in Japan in 1968 that resulted of 5 people died (Widowati, Sastiono, Rumampuk, 2008).

Acute mercury poisoning can cause damage to the gastrointestinal tract, cardiovascular disorders, acute renal failure and shock (Sudarmaji, Mukono, Corie, 2006), and chronic toxicity in the form of digestive system disorders and nervous system such as tremors , impaired eye lens and mild anemia (Widowati, Sastiono, Rumampuk, 2008).

The existence of gold merchants who process (electroplating) and selling gold has contributed greatly to the increase of Hg in the coastal areas of Makassar (Sultan in Dullah, 2009). In addition to the waste comes from gold merchants also expected because of the sewage flow through Tallo River and Jeneberang River which empties into the coastal city of Makassar. Results of the study found levels of Hg Tallo river water was 0.002 mg/l (Utami, 2009) and Hg Jeneberang sediment was 0.669 mg/kg and in the Harbour Paotere was 0.6636 mg/kg (Nurhidayah, 2008).

One type of marine organism that are easily contaminated by pollutants are shellfish. Marcia Hiantina is one type of shellfish found in coastal areas other than the type of Makassar and shellfish Anadara maculosa are much sought after and sold by fishermen and consumed by the community due to the a high protein content. According Yennie and under Suprapti Martini (2008), potential biota shellfish is contaminated by heavy metals because it is a filter feeder, so these species are often used as test animals in monitoring the rate of accumulation of heavy metals in marine organisms.

Shellfish seekers are potentially exposed to the toxicity of Hg through the consumption of shellfish. The content of Hg in the urine is used as a marker to determine levels of Hg in the body. Someone who consume fish or other food that has been contaminated with Hg 95 % will be absorbed by the body that can attack the central nervous system and the kidneys are then excreted through the urine. Research conducted in the United States in the gold shop workers found that the levels of Hg in urine was 1200 ug /l (Inswiasri, 2008).

## II. MATERIAL AND METHODS

### 2.1. Types of Research

This observational study applied Risk Analysis (Hazard Quotient) approach to conduct a risk assessment to the environmental and laboratory analysis for Hg concentration in the *Marcia hiantina*, potential environmental risks in coastal areas of the city of Makassar.

### 2.2. Time and study area

This study conducted in the year 2010 which include: sampling, treatment, analysis and examination of samples. Then perform the calculation of health risk analysis (HQ) of mercury pollution in the coastal region of Makassar.

Coastal waters of Makassar various every day depend on the human activities. At high tide, fisherman catches fish and in low tide they crowdedly catching shellfish. From the results observation conducted along the coastal areas of Makassar only a few places that still can be found the presence of mussel populations, namely Tanjung Bunga, shipyard area (PT IKI) and the local fishing village. At the point I (fishing village) and II (shipyard) sources of pollution by Hg is derived from Tallo River, Navy Dental Hospital, PT.IKI and gold processing business in Satando Road, while the third point (Cape of Flowers) are thought to originate from the River Jeneberang, RS and gold merchant business in Jalan Somba Opu (Figure 1)

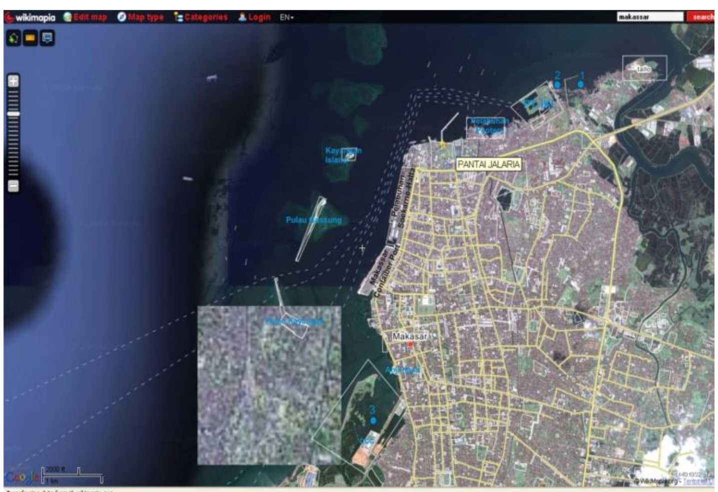


**Figure 1. Map of sampling location**

Temperature is the physical parameters that are important for living organisms in the sea, and is one of the parameters that affect the concentration of heavy metals (Rochyaton in Palar, 2004). Temperature rise above the tolerance range where organisms can increase the rate of metabolism such as growth, reproduction and activity of these organisms (Damandiri, 2006). The increase in sea water temperature will reduce adsorption heavy metal compounds on the particulate. The temperature of the sea water cooler will increase the adsorption so that it will settle, while when the temperature of the sea water rising, a heavy metal compound dissolves in sea water due to a decrease in the rate of adsorption into particulate (Palar, 2004).

### 2.3. Population and Sample

*Population*

The population in this study is the *Marcia hiantina* shellfish, community around the study area, and shellfish seekers as well as their children.

*Sample*

In this study samples of *Marcia hiantina* shellfish that commonly consumed, Community around the study area, fishermen and shellfish seeker children in coastal areas of Makassar using purposive sampling method. The number of shellfish samples were 10-25 samples at any point while the environmental risk analysis carried out in the study area around the Community, fishermen and shellfish seeker children.

### 2.4. Equipment, Materials and Works Process

*Sampling Process for Bivalve*

*Marcia Hiantina* were collected in coastal areas of Makassar in three points each residential area fishing, shipbuilding and Tanjung Bunga. Shellfish samples taken based on their size of the search and a scallop catches at three points. Determination of the size of the shells based on the weight of the clam meat, scallop small samples (< 2.4 g) and large mussels (>3.1 g). Shellfish samples obtained by hand picking and when needed can use tools (rakes and spades). Sampling was carried out during low tide. The number of shellfish were taken of 10-25 at each point, given the number of samples required for laboratory examination is 10 grams dry weight. The mussels were taken and stored in a plastic container that has been labeled and immediately taken to laboratotium for in the analysis.

*Laboratory analysis*

Samples were washed with water until the shells lost all the mud, then separate the meat from the shell. Clam meat is then weighed using an analytical balance. Small shellfish samples is determined based on the weight of scallop meat. For small shellfish samples required approximately 15-20 seed mussel shells while for large samples approximately 10-15 seed shells, and boil for 10 minutes. Then enter into the oven to be dried at a temperature of 30 º C, after dried and then powdered (crushed).
Powdered samples were weighed accurately (by using the analytical balance) less than 10 grams of dry weight and then put in a porcelain cup and destructed, heated at a temperature of 70-80 °C for 3-5 hours. At this stage add the destruction p 5 ml $HNO_3$ solution, add 2.5 ml of $H_2SO_4$ solution p. Destruction until the vapor becomes white and clear solution. If the steam is not yet clear white and add another solution $HNO_3$ solution p as much as 5 ml and then in destruction again. Then the sample was cooled and added to 5 ml $HCl_6$ N, then heated to boiling and all ingredients dissolve. The sample was then filtered using filter paper. Add distilled water to the appropriate volume of 100 ml, then homogenized. Subsequently the samples prepared were analyzed using MVU - IA. The purpose of this is to overhaul the destruction of organic materials.

*Processing and Data Analysis*

Data obtained from the results of field observations and laboratory tests are presented in table form, further described in the form of descriptive then compared with the corresponding sea water quality standard MOE Decree 51 of 2004, according shells Decision No. Directorate General of POM. In 1989 and 3725 according to WHO standard 1990 for Hg in urine.

## III. RESULTS

### 3.1. Hg concentrations in sea water

The difference between high tide and low tide occurs as a result of the influence of gravity. Seawater sampling method using the grab sampling method, where samples are taken only once when the ups and downs at every point. The sampling distance from the shoreline ± 5 meters at a depth of 30 cm from the surface of the water, as shown in Table 1.

**Table 1. Hg Concentrations of sea water in high and low tides at the three stations in Coastal areas of Makassar, year 2010**

| Stations | Time | | Hg Concentration (mg/l) | | Standard |
|---|---|---|---|---|---|
| | High tide | Low tide | High tide | Low tide | |
| **I** | 10.00 | 11.15 | 0.001 | 0.008 | |
| **II** | 09.50 | 11.00 | 0.001 | 0.006 | 0.001 mg/l |
| **III** | 11.20 | 14.10 | 0.001 | 0.001 | |

Table 1 shows that the concentration of Hg in sea water at low tide at the point I and II in the coastal areas of Makassar exceeded the standard with 0.008 and 0.006 mg/l, whereas at high tide concentration reached the maximum limit set by Ministerial Decree environment, no. 51 / 2004 on marine water quality standard that is equal to 0.001 mg/l. and the assessment of potential risks assessment for the environment is calculated as revealed in the Table 2.

**Table 2. Potential environmental risks (HQ) of Hg in sea water at three stations of Coastal areas of Makassar, 2010**

| Stations | Time | | HQ | | Standard |
|---|---|---|---|---|---|
| | High tide | Low tide | High tide | Low tide | |
| **I** | 10.00 | 11.15 | 1 | 8 | >1 at risk |
| **II** | 09.50 | 11.00 | 1 | 6 | |
| **III** | 11.20 | 14.10 | 1 | 1 | |

Table 2 revealed that all those three HQ stations have equal values for environmental risks and exceeded the standard set by the EPA in 2000 (>1). That indicates that risks for the environment in the coastal area of Makassar.

### 3.2. Hg concentrations of *Marcia Hiantina*

*Marcia Hiantina* types were collected at three points made during low tide the water height ± 25 cm, considering Marcia Hiantina live on muddy or sandy substrate. There are differences in the size of the shells between points I and II to point III. From the observation at the point of the first and second shells sizes larger than at point III. Based on information from the shellfish collectors, this difference occurs as a result of reclamation activities at point III (Tanjung Bunga) that covers the bulk of the coastal areas, resulting in more coastal base substrate dominated by mud affecting shellfish breeding including its size, in Table 3.

**Table 3. Hg Concentrations in *Marcia hiantina* at three stations in Coastal areas of Makassar, 2010**

| Stations | *Size of Marcia Hiantina* (gr) | | Hg concentration (ppm) | | Standard |
|---|---|---|---|---|---|
| | Small | Big | Small | Big | |
| I | 0.9 – 2.5 | 4.7 – 10 | 0.11 | 0.06 | 0.5 ppm |
| II | 1.6 – 2.3 | 3.9 – 7.2 | 0.04 | 0.04 | |
| III | 0.5 – 2.4 | 3.1 – 5.6 | 0.08 | 0.08 | |

The results of the analysis of Hg in shellfish samples Marcia Hiantina conducted in Makassar Health Laboratory Center for further reference to the quality standards established by the Director General of the Republic of Indonesia POM. No. 03725/B/SK/VII/1989.

Table shows that the concentration of Hg in *Marcia Hiantina* from coastal city of Makassar at station I, II and III as a whole still meets the standard set by the Director General of POM RI 1989 on the concentration of metals in decent seafood consumed in the amount of 0.5 ppm.

### 3.3 Hg Concentrations in the urine of shellfish seekers

Urine sampling of shellfish seekers from the coastal of Makassar region made at the time they were looking for shellfish. The urine sample is a 24-hour urine was collected in a bottle with a lid Winkler dark despair with a volume of 250 ml. The results of the analysis of urine samples can be seen in the Figure 1.

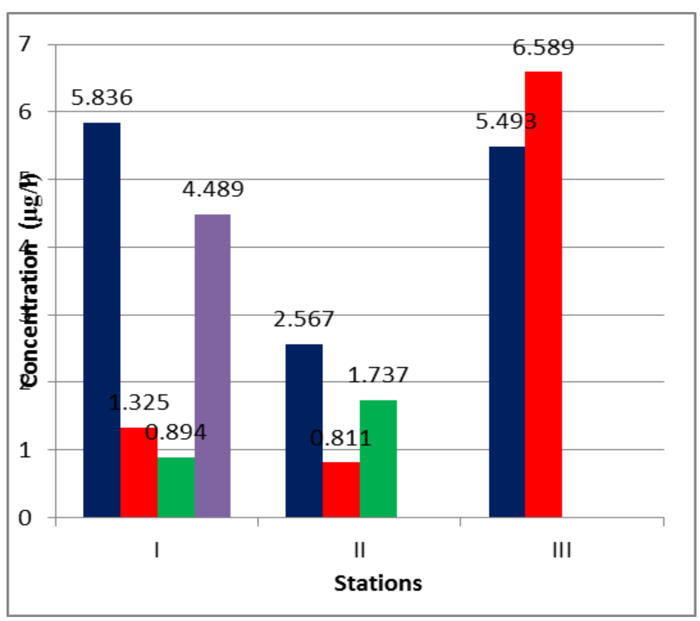


**Figure 1. Hg Concentrations in the Urine of Shellfish seekers from coastal regions of Makassar, 2010**

Figure 1 indicated that Hg concentration in the urine of those nine respondents, that there were four respondents who had concentrations of mercury (Hg) in the urine is exceeded the standard; 4.4885 mg/l, 5.4926 mg/l, 5,8357 mg/l and 6.5899 mg/l, respectively. However, there are five respondents concentrations of Hg in urine were still meet the standard. The number of respondents in the four person fishing village, numbering around three shipyards and in a two-person flower cape. Concentrations of Hg in urine was found in the highest interest of the respondents in the Tanjung Bunga. Then, the association between age of respondents and the Hg concentration in urine is described in the following Table 4.

**Table 4. Distribution of respondents' age and Hg concentration in urine of the shellfish seekers in coastal areas of Makassar, 2010**

| **Age (year)** | **Hg concentration in urine (µg/l)** | | | | | |
|---|---|---|---|---|---|---|
| | Meet standard | | Not meet standard | | **number** | **%** |
| | n | % | n | % | | |
| **22** | 1 | 100 | 0 | 0 | 1 | 100 |
| **30** | 0 | 0 | 1 | 100 | 1 | 100 |
| **31** | 1 | 100 | 0 | 0 | 1 | 100 |
| **40** | 2 | 100 | 0 | 0 | 2 | 100 |
| **42** | 0 | 0 | 1 | 100 | 1 | 100 |
| **46** | 0 | 0 | 1 | 100 | 1 | 100 |
| **64** | 0 | 0 | 1 | 100 | 1 | 100 |
| **65** | 1 | 100 | 0 | 0 | 1 | 100 |
| **Total** | 5 | 56 | 4 | 44 | 9 | 100 |

Table 4 shows that the concentrations of Hg in the urine exceeded the standard was found on respondents aged 30 years, 42 years, 46 years and 64 years. With the highest concentration of respondent aged 46 years. While five respondents with Hg concentrations in urine still meet the guideline defined by WHO ie ≤ 4 mg /l.

## IV. DISCUSSIONS

### 4.1 Hg Concentrations in Sea Water

Hg enters water bodies sourced from a wide range of activities both directly using Hg in its activities and is a byproduct of the industry. The existence of vendors selling and processing of gold ore that occupies Somba Opu Street and Road Satando as well as the industrial and agricultural discharges through the Jeneberang and Tallo rivers are the main factor that can affect the concentration of Hg in the coastal areas of Makassar. From the results of research conducted by Utami (2009) found that the levels of Hg in Tallo river water of 0.002 mg/l and Nurhidayah (2008) found Hg content in sediments Port Paotere of 0.6636 mg/kg and at Jeneberang River at 0.669 mg/kg. Based on the Decree of the Minister of the Environment no.51 /2004 Hg on Sea Water Quality Standard for marine life. Results of laboratory tests on the three stations either tide or low tide in coastal areas of Makassar showed that the concentrations of Hg in sea water has been at the limit the third point is a maximum of 0.001 mg/l, even concentrations have exceeded the quality standard with a concentration of 0.006 mg/l and 0.008 mg/l which is the point I and II at low tide.

Concentrations Hg based on the results of the analysis in the waters of Tanjung Bunga is located on either stable or fixed concentration of Hg at high tide and low tide is equal to 0.001 mg/l, oceanographic data obtained found that the water temperature at the point during the tide or low tide is 33ºC. By contrast, the concentration of Hg in the fishing village and surrounding shipyards when the ups and downs that have differences, where in tide, Hg concentration of 0.001 mg/l with the same temperature is 34ºC, whereas at low temperature measured was 32ºC with Hg concentrations reached 0.006 mg/l around shipbuilding and 0.008 mg/l in the fishing village. This shows that when there is a change in water temperature will be followed by changes in the Hg concentration in seawater, considering the temperature is one of the parameters that affect the concentration of heavy metals in water (Rochyaton in Palar, 2004).

Hence, changes in the pattern of currents and wave motion as a result of reclamation occurred in Tanjung Bunga may lead to the difference concentration, thus indirectly tide and low tide conditions also influence the increase of Hg concentration in seawater. Results of research conducted by WALHI (2006) in Kendari Bay found Hg concentrations in sea water at 1 ppm and allegedly one of the impact of reclamation. According Damandiri (2001), reclamation of coastal region will generate changes to the coastal ecosystems and artificial ecosystems.

Another case, in Buyat area found that the tailings are discharged by NMR Industry that affect the metabolism of aquatic animals also reduce waters fertility. Because of the movement of sea water, waves and tides resulting tailings are difficult to control, given the river at high tide the water will spread out into the sea while at low tide the river water will be carried out to sea (Hadi, 2007). Sea water as a pollutant that fall reception of the atmosphere, which is then entered into the coastal waters and marine ecosystems. Partially soluble in water, mostly sink to the bottom and sediments and partially concentrated to enter the body tissues of marine organisms (Fachruddin, 2008).

Waters are often contaminated by inorganic components include pollution due to heavy metals originating from the place itself as well as from the results of human waste being dumped directly into the water. Presence of heavy metals that fall into a body of water is strongly supported by the solubility of heavy metals in water. According (Romimohtarto,1991 in Palar 2004) after a trip pollutants entering coastal and marine waters will be diluted and dispersed by ocean currents and mixing turbulence and will be dispersed directly by currents and biota.

Hg is discharged into the river, beach or body of water is only temporary so it will still be carried by the flow of water to the mouth and will spread to the coast by the influence of the motion pattern of sea currents and waves, can further contaminate marine life including algae and plants other water is switched on inside. The concentration of Hg in seawater is usually lower than in biota and sediment. In the aquatic environment, sea water Hg concentrations generally ranged between 0.6 to 3.0 mg/l, whereas methyl mercury concentration in sea water is not polluted by 3 to 6% and in fresh water ranged from 26 to 53% of the total mercury concentration.

### 4.2 Hg concentration in *Marcia Hiantina*

Hg is classified into groups and non essential metals are highly toxic, methyl mercury found in the environment in small quantities, but very harmful to humans and animals, since these compounds can only be accumulated by fish and other aquatic organisms (FAO, 1971 in Budiono, 2002). In the animal body, the metal is then absorbed by the blood, binds to blood proteins which are then distributed throughout the body tissues. The highest accumulation in organs usually detocxicated via (liver) and excretion (kidney).

Future growth and development of the embryo mussel to adult phase will be hampered because of the influence of heavy metal toxicity is expressed as a sublethal effect (chronic). Barriers such growth will be much longer in larval shells that would easily fall prey to predators or suffer pain and cause many deaths, which in turn lowers the population in areas contaminated shellfish (Darmono, 2001).The results of the analysis of shellfish samples in Makassar Health Center for Laboratory showed that the Hg concentrations for small clams ranged from 0.079 to 0.112 ppm, while for bigger shellfish between 0.044 to 0.077 ppm. Of the three stations, Hg concentrations were elevated in the fishing village that is for small clams with a concentration of 0.112 ppm, while for large shells in Tanjung Bunga is 0.077 ppm. Results of research conducted by Indrakusuma (2008) on the coast of Surabaya Kenjeran Ria found mercury concentrations in muscle and gill blood clam (*Anadara Granosa*) bigger size > 25.1 mm was 0.032 ppm and 0.1615 ppm, respectively, while the small clams (size 10.0 to 25.0 mm ) was not detected. The big difference in the concentrations occurred partly due to differences in size are used, the type and location of shellfish research.

The difference in concentration of heavy metals mercury (Hg) between small and bigger shellfish can occur considering all species of life in water is affected by the presence of dissolved metals in the water. Especially at concentrations that exceed the normal limits, depending on the condition of the fish / biota phase of the life cycle (egg, larvae and adults) the large size of the organism, sex and nutritional adequacy requirements as a factor that can affect the toxicity of heavy metals in the water of the living creatures in it. Several studies on the toxicity of the metal on the type of shellfish has been done, and it turned out stage larvae are usually more sensitive to the effects of metal pollution on adult life.

Metal heavy metal generally has a deadly poison to organisms in different conditions. This situation will occur when the concentration of the solubility of heavy metals in water bodies is high. Because of the accumulation in the body of organisms that occur in organs of heavy metals will exceed the tolerance which later became the cause of death. Hg Concentrations in shellfish between 0.058 to 32 mg / l is lethal in 96 hours of exposure (Palar, 2004).

Hg enter into the bodies of living organisms primarily through the food line. The number may have experienced a doubling of the initial amount that goes through the process of methylation that occurs in sediments by reducing bacteria. Sediment characteristics will affect the morphology, function, behavior and animal nutrient benthos, which is the lowest level in the tropic level. Because it is easy to bind to organic matter and sediment in the bottom waters, resulting in higher concentrations in sediments than in water (Harahap, 1991 in Damandiri, 2007). It is not advantageous for a living organism on the basis of such small shells (Oyster) as filter feeders, because the sediment particles will enter the digestive system (Williams, 1979 in Damandiri, 2007).

### 4.3 Hg concentrations in Urine of shellfish seekers

Excretion is the process of releasing the rest of the body's metabolism of substances, such as $CO_2$, $H_2O$, $NH_3$, dyes bile and gout. Disposal of mercury compounds in the body is closely related to the urinary system. Mercury that enters the liver would split in two, some will accumulate in the liver and the other part will be sent to the gall. In the gallbladder, mercury compounds will be overhauled to be destroyed and detoxicated. The results are then sent through the overhaul of blood to the kidneys, where some will accumulate in the kidneys and some will be discharged with the urine (Palar, 2004).

Based on the analysis conducted, it was found that all existing nine urine samples containing mercury at various concentrations. The high concentration in the urine was found on the third point with concentration is 5.836 mg/l and 6.589 mg/l and at a point I of 4.489 mg/l and 5.836 mg/l, respectively. However, overall urine in the third point containing heavy metals mercury at various concentrations. The difference in concentration of mercury in the human body is affected by the magnitude of the dose, how it exposure, forms of Hg compounds and biota species. Mercury toxicity and metabolism depend on the form of mercury compounds, pathways of exposure, duration of exposure and the amount of other elements present in the food (Widowati, et al, 2008).

Hg can enter into the human body through food contaminated with mercury is usually in the form of organic mercury compounds (methylmercury), and ± 95 % will be absorbed by the body (Inswiasri, 2008). Biological half-life for mercury is 70-90 days. Levels of Hg in the urine of 150 mg/l not show specific symptoms, while at levels of 300-600 mg/l showed symptoms of tremor (Klaassen et al in Widowati, Sastiono, Rumampak, 2008). Muscle tremor is an early symptom of the Hg toxicity. But the degree of toxicity depends on the diet per day and age. Thus, the more and the longer people consuming food contaminated metal mercury per day, the more severe symptoms of the disease because of the toxicity of the metal mercury (Alfian, 2006) .

## V. CONCLUSION

1. Concentrations of heavy metals Hg in sea water at high tide in the fishing village, shipbuilding and cape flowers are at the maximum limit determined by the concentration of 0.001 mg/l, while the concentration of Hg at low concentrations has been found to exceed the requirements defined by a concentration of 0.008 mg/l in the fisherman township and 0.006 mg/l at the shipyard.

2. Health risk occurs when people consume water from mercury-contaminated water in the fishing village area when taken 2 L/day for 350 days/year within a period of 20 years or 70

years and by people with a weight of 60 kg or less is 0:11 which means dangerous and passing standard.

3. Concentrations of Hg in the shellfish in the fishing village area, shipbuilding and flowers cape were still meet the standard, with a concentration on small shellfish ranged from 0.042 to 0.112 ppm, while the bigger ranged from 0.044 to 0.077 ppm.

4. Concentrations of Hg in the urine shellfish seekers in the fishing village area and cape flowers mostly found exceeded the values set by the WHO.

## ACKNOWLEDGEMENT

Author highly appreciate, would like to thank to the Municipality of Makassar city, Head of Somba Opu District who have given a permission of research commencement and a very kind cooperation during the field study in Coastal Area of Makassar. Hence, thank to the communities and the fisherman in all study areas who have very kind to let us get some necessary information and samples collections. We grateful thanks to laboratory members of chemical laboratory, Makassar for their very good work for sample analysis in accordance to the quality assurance and quality control.

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