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Research Article

Ecological Risks of Contaminated Lead and the Potential Health Risks among School Children in Makassar Coastal Area, Indonesia

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Abstract

Background and Objective: Distribution of lead for certainty of their suitability for consumption and other domestic uses from the sea water, bottom sediment, biota for *Anadara trapezia* sp. and crab were widely polluted the coastal area of Makassar. This research aimed to investigate the lead (Pb) accumulation both in aquatic and terrestrial habitats and assess the potential ecological risks and the potential health risks among school children in Makassar coastal area. **Materials and Methods:** Water column, sediment, shellfish (*Anadara trapezia* sp. and crab) soil and snack food samples were collected in one time collection. Then, in terrestrial surface soil and snack food sold was collected in the school children. Those samples were analyzed using varian AA240FS atomic absorption spectrophotometer. In addition, the ecological risks assessment was determined using ecological hazard quotient from EPA formulation. Data was also analyzed by one-way analysis of variance ANOVA ($p<0.05$) using SPSS. **Results:** Results revealed that the lead distribution concentration in aquatic in water column, sediment, shells and crab were ranged from 0.12-0.21 mg L^{-1}, 6.03-8.00 mg kg^{-1} dry weight (d.w) and 1.22-2.90 mg kg^{-1} wet weight (w.w), 1.02-2.91 mg kg^{-1} w.w, respectively whereas in the terrestrial of surface soil and school snack were ranged from 5.00-37.40 mg kg^{-1} dw and 0.01-0.90 mg kg^{-1}, respectively. The magnitude values of ecological risks for water column, sediment and surface soil were in the range of 3.0-4.4, 0.16-0.22 and from 0.6-1.1, respectively. **Conclusion:** Most values have been exceeded the limit standard or ecological risks >1 for potential ecological risk which is hazardous and potentially not safe for consumption for the long period of Pb contamination seafood.

Key words: Water column, sediment, shells, surface soils, snack food, ecological risks quotient

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Direct disposal waste into the aquatic contributed a major pollutant level which may generate a threat both to environment and human health surround the niece. Lead is one of the neurotoxin and accumulative substance in the environment and human body. In young children lead can generate a decrease in the inability of the brain to grown maximum, whereas in adults may cause interference of high blood pressure and other tissue toxicity. Any increase in the levels of lead in the blood of 10 μg dL^{-1} may led to a decrease in IQ of 2.5 points or 0.975 IQ scores.[1] Any exposure to air polluted by lead 1 μg m^{-3} likely to contribute 2.5-5.3 mg dL^{-1} in the blood of the person that is in place. Lead is taken into the body is normally 0.3 mg/100cc/day, if the intake of lead 2.5 mg/day then it took 3-4 years to get the toxic effects. If the intake of lead 3.5 mg/day, it takes only a few years to be intoxicated. Research conducted by Construction Week Online[2] at Taibah, Saudi Arabia for 167 students showed 85% of respondents have a lead concentration >10 mg dL^{-1} in the blood and 16.8% of respondents had <10 mg dL^{-1} and the results showed no correlation with levels in the blood Pb decline in IQ and work performance.

Leads are the major chemical waste components of the industrial wastes and vehicle emission along with other products from industrial operations are discharged into the aquatic environment. Direct disposal waste into the aquatic contributed a major pollutant level which may generate a threat to people surround[3], this Pb substances disposal is toxic to aquatic life and harm to human being[4,5]. The tendency of lead accumulate in various organs of the aquatic organisms, especially in the shells, fish and other, which in turn may enter into the human metabolism through consumption and leading to a serious problem to health[6]. Lead bioaccumulation adversely affect liver, muscle, kidney and other tissues of fish, disturb metabolism and hamper development and growth of fish[7]. Coastal areas and estuaries are particularly sensitive to metal contamination from anthropogenic sources and in the last few decades the study of space-time distribution and variation of metals has been extensively researched[8].

Demographic factors such as location of house, house conditions, a distance trip to the school and the type of vehicles to the school has a critical influence on blood lead levels. Research conducted by Sakkir *et al.*[9] on street children and kindergarten children in Makassar 90% of which contain concentrations of lead in their blood above the 10% threshold and the other had a lead concentration 10 mg dL^{-1} in the blood. The average content of lead in children's blood were examined is 23.96 μg dL^{-1}. Research conducted in the city of Ambon by Mulyadi[10] on the transport driver city there are 47% of respondents that the concentration of lead in the blood exceeds the normal limit of >40 g/100 mL and the concentration of hemoglobin below normal is <13 g/100 mL. Results of research conducted by Sari[11] showed the difference in average air lead concentrations in densely populated areas of vehicles of 2.05 μg m^{-3} were slightly past the environmental quality standards and the area is not densely vehicle average lead concentration is still below the air quality standard environment that is 0.10 μg m^{-3}. The average difference in Pb blood concentration on traders in overcrowded vehicles by 37.25 mg/100 mL and the area is not congested vehicles by 33.43 mg/100 mL. The average difference in blood hemoglobin concentration in a congested area merchants vehicles 11.32 g/100 mL and the area is not densely vehicles by 13.71 mg/100 mL.

The results of research from various countries indicated that Indonesia, especially the city of Makassar are not safe from the lead hazard. This substance may cause symptoms of poisoning both to environment and human, as well as the source of food contamination, even low doses of lead also have permanent effects on children[12]. Lead can be taken in by eating food, drinking water or breathing air by children and to lesser extent, adults can also be exposed by ingesting soil. Present day lead pollution is an environmental hazard of global proportions. A correct determination of natural lead levels is very important in order to evaluate anthropogenic lead contributions. The metals from anthropogenic sources mainly occur in the labile fraction and may be taken up by organisms as the environmental parameters change[13]. Recent industrialization and community development have exerted considerable stress on the marine environments and provoked habitat degradation. This case also may occur anywhere else at the similar circumstances like in coastal area of Makassar city. There was no any research have been done before associate to the lead health risks assessment in the study area of concern, this study will be beneficially give a valid data relate the potential health effect of Pb contamination in the site and assist the local and province decision maker to set and monitor the trend of the accumulation of pollutants and hazards produced. Thus, research relate to this is highly required to investigate and assess the target hazard of lead contamination and the risks among school children in the Makassar coastal area.

This research aimed to investigate the lead (Pb) accumulation both in aquatic and terrestrial habitats and assess the potential ecological risks and the potential health risks among school children in Makassar coastal area.

MATERIALS AND METHODS

Study area: This study was conducted during the period of 4 months, from March, 2017 until July, 2017. This research was located in the coastal area of Makassar which is located in the four districts of South Sulawesi Indonesia. Coastal area of Makassar is an important drinking water sources and main food protein source such as various fishes, bivalve, shells and other aquatic seafood which are become daily consumption by local people along the coastal area of Makassar. Some bivalve, shells, fishes even are sold out to the next district around coastal area of Makassar. In this coastal area, some interesting daily activities seen at the Losari Beach the like weekend fishing and boating among dwelling along the beach.

Sample collection for water column, sediment and shellfish: Samples were collected from the study aquatic tract such as, water column, sediment, shells and crab. Water samples were collected at eight varied stations at a depth of 30 cm below the water surface in high density glass bottles. Then, sediment at the top 10 cm of the bottom samples were collected at the same stations where water sample collected using the Eickman bottom sampler device, those samples were kept in polypropylene containers (20g) for Pb analysis and in glass bottles (at least 150 g) for texture analysis. After the analysis, we calculate the quotient of the potential target hazard to estimate the health risks. In addition, shellfish was collected at the aquatic track stations where water and sediment samples collected. Approximately 10-15 shellfish with the size in the range of 5-8 cm in length for *Anadara trapezia* were collected. The tissues were immediately cut off and placed into polyethylene sample bags and kept in an ice box with the temperature of 4°C before being transported to laboratory and put into a freezer (-20°C). Soft tissue of bivalve were removed and cut in section of small pieces at the end the homogenized representing samples were frozen prior being analyzed[14,15].

Sample collection for surface soil: In the study used the soil taken from five elementary schools divided into five three stations. Soil sampling at each elementary taken three different locations and at each location were taken three points, then at any point in doing the repetitions. Soil samples were taken to a depth of 10-20 cm. The soil were cleared from rubbish, gravel, grasses and also roots. Equipment used to take soil samples comprising: A small shovel, navy (screwdriver), spoons, filters soil (sieve), measuring the depth of the soil (the crossbar), buckets of places to sift the soil, containers for storing soil samples were filtered and some plastic bags to store, samples collected immediately taken to the Health Laboratory of Makassar city[15].

Sample collection for school snack foods: Snacks food samples taken at three stations at four school children with 3 repetitions in each district adjacent to the air and soil sampling.

Laboratory quality control: All collected samples were analyzed at certified Makassar Health Laboratory in South Sulawesi Province, Indonesia. Standard reference material (SRM 1643e) for water was used to have an accuracy in procedures of analyses. Here calibrations were done using 3 replicate samples for water from the U.S. Department of Commerce, National Institute of Standard and Technology (NIST), with three samples of blank. All analyses of parameters were done by 3 replicates. Their certified values for both of measured values of water (SRM 1643e) lead parameter with recovery percentage were above of 91%.

Ecological risks: In order to determine the potential environmental risks hazard, a quantitative screening the hazard quotient (HQ) approach was applied. Here the estimates of ecotoxicity (Dose) to exposure respond was compared to estimate the potential environmental risks. The HQ concentration in the background which are about 15 km upstream and downstream from the area of concern is determined and the formulation of HQ = Dose/NOAEL were used for calculations. If the HQ value is >1 then it indicates the state of risks to the environment.

$$HQ = \frac{Dose}{NOAEL} \text{ or } HQ = \frac{EEC}{NOAEL}$$

Where:

HQ = Hazard quotient

Dose = Estimated contaminant intake at site (e.g., mg contaminant kg^{-1} b.wt./day)

EEC = Estimated environmental concentration at the site (e.g., mg contaminant L^{-1} water, mg contaminant kg^{-1} soil, mg contaminant kg^{-1} food)

NOAEL = No observed adverse effects level (in unit that match the dose or EEC)

The contaminant concentration is categorized become four levels standard as follow:

If	HQ <0.1	No hazard exist
	HQ 0.1-1.0	Hazard is low
	HQ 1.1-10	Hazard is moderate
	HQ >10	Hazard is high

Statistical analysis: At the first time collected data were transformed to improve its normality and homogeneity of variance. Then, one way analysis of variance ANOVA ($p<0.05$) was performed to examine the statistical significance of heavy metal concentrations among the different sampling sites Use SPSS, IBM software (version 22). Concentration-response curves from toxicity tests were analyzed with STATA software (version 8.2)[15]. The criteria for significance in the procedures was set at $p<0.05$ (significant) and $p<0.01$ (highly significant).

RESULTS AND DISCUSSION

Lead concentration in water column, sediment, shells and crab: Various level of lead concentration in the water column is mostly affected by the purpose of the area use with its pollutant point sources. The maximum mean Pb level concentration in water column, sediment, shellfish and crab, surface soil and school snack were ranged from 0.14-0.22 mg L^{-1}, 6.03-8.0 mg kg^{-1} dry weight and 1.22-3.05 mg kg^{-1} wet weight, 2.56-3.11 mg kg^{-1} wet weight, 5.00-37.40 mg kg^{-1} dry weight and 0.01-0.90 mg kg^{-1}, respectively (Table 1). This may be attributed to the large amounts of sewage, vehicles and home industrial wastewater discharged into the coastal. The high levels of Pb in water can be attributed to vehicles, industrial, urban and agricultural discharge[14,16]. The monthly concentrations of lead in water samples remained below the WHO standard of 50 µg $L^{-1}$and the total mean concentration of Pb 0.04 µg L^{-1} was considerably lower during the study. Study in Keenjhar[15] revealed the monthly variation of lead in water samples from Keenjhar Lake during 2003 shown a maximum level of lead concentration was about 0.235 µg L^{-1}. In addition, the monthly variation during 2004, with a maximum lead concentration of 0.225 µg L^{-1}.

Pb concentrations in shellfish and fishes organs are closely associated with Pb content of water in Makassar coastal area. This obviously may be generated to the abundance of Pb into water by the similar pattern. A remarkable relationship between Pb concentrations in aquatic organisms and water as well as sediment were observed by Ibrahim and El-Naggar[17] in Damietta Branch of the River Nile. The lead concentration magnitude sequences in aquatic habitat from Makassar coastal was sediment>shell>crab, with the maximum values were (8.0>3.0.>2.9) mg kg^{-1} w.w), respectively. Phillips also reported a higher amount of lead and cadmium in mollusks higher than those in water. None of the species analyzed in this study were found to contain level of lead concentration above the proposed permitted concentration.

However, it is different with the study in Newark bay, concentrations of lead measured in all reaches of the estuary were found to exceed sediment quality criteria (250 mg kg^{-1}) and predicted toxic effects values (110 mg kg^{-1}). The highest lead concentrations in the estuary were located adjacent to petroleum refineries, paint and pigment formulating plants and other industrial areas. These results indicate that lead contamination of superficial sediments in Newark Bay may pose a significant threat to aquatic biota[18].

Analysis of the data can be explained that in the city of Makassar there was considerable industrial watersheds and Tallo, especially the food industry and clothes, bamboo, wood.

The average lead (Pb) in the water column has different variations, it appears that the average value is highest at the station 8 with 0.22 mg L^{-1}, while the lowest in the station 1 at Tamalate district with 0.12 mg L^{-1} (Table 1). Then, based on the analysis of spatial distribution of metals in the sediment lead concentration shows that the distribution pattern of high St 3 around the station of Mariso then coastal waters Tallo and lowest districts in waters Tamalate district, while the analysis

Table 1: Distribution of lead concentration in water column, sediment, shell, crab and surface soil and school snack in four districts of Coastal area in Makassar City, 2017

	Stations							
Variables	St 1 Tmlt	St 2 Tmlt	St 3 mriso	St 4 mriso	St 5 UT	St 6 UT	St 7 Tlo	St 8 Tlo
Surface water (mg mL^{-1})	0.15	0.20	0.17	0.14	0.16	0.18	0.18	0.22
Sediment (mg kg^{-1} dw)	6.03	6.68	8.00	7.97	7.45	7.13	7.77	7.67
Shellfish (mg kg^{-1} ww)	1.22	1.12	3.02	3.05	1.95	1.58	2.92	2.73
Crabs (mg kg^{-1} ww)	3.03	3.21	2.90	3.11	2.88	2.56	2.76	2.50
Surface soil (mg kg^{-1} dw)	16.24	15.17	8.70	15.81	7.12	5.00	37.40	9.04
School snack (mg kg^{-1})	0.01	0.02	0.02	0.03	0.21	0.22	0.90	0.69

St: Station, Tmlt: Tamalatea, Mriso: Mariso, UT: Ujung Tallo, Tlo: Tallo

Table 2: Ecological risks quotient for water column, sediment and surface soil from Makassar coastal area, Sulawesi Selatan, Indonesia 2017

		Ecological risks quotient		
Station	Location	Water column	Sediment	Surface soil
St 1	Far upstream at Tamalate sub district	3.0	0.16	1.1
St 2	Upstream at Tamalate near dwelling	4.0	0.18	1.0
St 3	At Mariso near the bridge	3.4	0.22	0.6
St 4	At the border in the West of Mks city	2.8	0.22	1.0
St5	At the Ujung Tanah	3.2	0.21	0.5
St 6	Near shopping and entertainment center	3.6	0.21	3.0
St 7	Close to the river mouth in the North	3.6	0.22	2.5
St 8	Close to river mouth to the North	4.4	0.22	0.6

of the spatial distribution of metals in mussels with Pb method is seen that the distribution pattern of high Pb in St 4 around the station of Mariso then coastal waters Tallo and lowest districts in waters Tamalate district can be 5.00-7.20 mg g^{-1}.

Based on the analysis of spatial distribution of lead on surface soil shown that the highest was the station 7 in the Tallo district with 37.40 value, followed by Tamalate districts with 16.24 mg g^{-1} and the lowest in Ujung Tanah districts with 5.00 mg g^{-1}.

Some relevant studies presented data on cadmium and lead content in the studied fish species provide no proof of the general pollution of the Adriatic. Obtained data were tested in relation to fish length. Metal concentrations in liver decreased with the increase in fish size, whereas no significant correlation was found between trace metal levels in the muscle tissue and the length of both species[17]. Hence study in Nigeria indicated contamination of these fish foods by lead with mean values varying from 8.0 ± 0.8 to 12.5 ± 1.6 mg kg^{-1}. The food processing technique accounted for up to seven times increase in fish lead levels, Abeokuta, Nigeria[19].

Then, forty-seven samples collected from the villages of São Bento, Muribeca and Pati Island were analyzed for their trace metal levels using electrothermal atomic absorption spectrometry (ETAAS). Cadmium and lead contents detected in the samples were found to range from 0.01-1.04 mg kg^{-1} and from 0.10-5.40 mg kg^{-1}, respectively. In this study, most of the Pb pollutant released from vehicles, urban waste which is containing some small industrial waste mixed with the home industry and open market waste. This situation is similar with the research on Oise river that revealed the finding signature is called “urban” rather than “industrial” because it was clearly distinct from the Pb that was found in areas contaminated by urban waste and heavy industry[7,20].

Presented data of lead content in the collected shell, shrimp and school snack provide proof of the general pollution of the coastal area of Makassar city. Obtained data were measured in relation to shell and crab size. Metal concentrations in liver decreased with the increase in fish size, whereas no significant correlation was found between trace metal levels in the muscle tissue and the length of both species. Other results indicate contamination of these fish foods by lead with mean values varying from 8.0 ± 0.8 to 12.5 ± 1.6 mg kg^{-1}. The food processing technique accounted for up to seven times increase in fish lead levels, Abeokuta, Nigeria[18]. Study from Yangtze river, China, associate to the health risk analysis of individual heavy metals in fish tissue indicated safe levels for the general population and for fisherman but in combination, there was a possible risk in terms of total target hazard quotients[13].

Ecological risks quotients: The objective of this formulation earmarked for the estimation of environmental risks to the potential receptors that were performed in both aquatic and terrestrial habitats. The potential environmental risks evaluations were calculated by HQ equation for the estimation of environmental risks to potential receptors in all environmental compartments. In this study, the screening benchmark was based on the Standard of the Ministry of the Republic of Indonesia and other relevant standards.

Table 2 shows, the value of ecological risks assessment for water column, sediment and surface soil were ranged from 3.0-4.4, 0.16-0.22 and from 0.6-1.1, respectively. The highest value observed in St.5 and St.6 where open market and community dwelling are located. In general, although this study did not calculate, the consumption of shell and crab is an important source of exposure to lead for humans. Communities are suggested to consume those contaminated aquatic habitat not regularly and in small amount[21-23].

The magnitude of lead release to environment is primarily emitted by the big number of vehicle both from the land and from the sea as well as from the domestic waste along the coastal areas. These, communities around the site are suggested to limit the aquatic habitat consumption and school children suggested to reduce to play on the ground due to the lead dust pollution.

CONCLUSION

The concentration of lead in water column, sediment, bivalve and shells from coastal area of Makassar are varied. Those considerable variation in lead levels among the different species, highlights the important role of environment and human behavior being. From the ecological risks point of view, Pb values are (>1). This estimated values seem to indicate that consumption of shells, shrimps does potentially implicate an appreciable human health risk. Nevertheless, it must be remembered either that the limit value set by WHO or estimated intake does not exceed the allowable standard, however the lead may accumulate in such biota and in human body. Consequently, intake might be underestimated and might be of concern, above all in the cases where the exposure is closer to the tolerable weekly intake. As a final conclusion, we suggest that more specific recommendations regarding human consumption (kind of species and frequency and size of meals) are done according to the data concerning levels of environmental pollutants in the most consumed fish and seafood species.

SIGNIFICANCE STATEMENTS

This study discovers the potential effect of lead pollution risks among school children and community, who are living in the Makassar coastal areas. This study help the researchers, fisheries, school children and communities to understand and manage the lead pollution in initially reducing the lead hazard before generate seriously health and environment problem. Thus, a new design of target hazard assessment and a good design of closed technology need to be applied as the alarm and basic instrument for decision makers to set good lead elimination program.

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