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Research article

Maximum Consumption Limits of Fish Catches Tainted by Lead (Pb) in 3 Fish Auction Markets (FAM) in Cilacap, Indonesia

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Abstract

Heavy metals produced by the industrial sector in Cilacap will contaminate the waters and impact the organisms in them, which will affect the condition of humans as consumers. The purpose of the importance of this research activity is to compare the type of fish and the value of heavy metal Pb with the quality standards of the Ministry of Environment No.51 of 2004, BPOM Regulation 2009 and SNI 7387 of 2009, as well as knowing the maximum consumption limit of consumption fish catches to control the pattern eat fish indicated heavy metals. The method used is a comparative description with survey techniques in 3 locations where fish auctions (FAM) and Pb level analysis using the AAS method. The types of fish with the highest level of consumption in Cilacap are kembung, tuna and tongkol. The Pb level of kembung, tuna and tongkol passes the threshold> 0.4 ppm from SNI 7387-2009 and BPOM 2009, namely 0.7 ppm, 2.9 ppm, and 2.3 ppm, respectively so it is essential to have a consumption limit per week through Tolerable Maximum Intake (MTI) with categories for adults and children for the consumption of each type of fish consumption. Research shows that the maximum consumption limit for adults in kembung, tuna and tongkol is 16.9 kg, 2.8 kg, and 9.2 kg, respectively. Meanwhile, the maximum limit of consumption of kembung, tuna and tongkol for children is 6.4 kg, 1 kg, and 2.9 kg, respectively.

Keywords: *Lead (Pb), maximum consumption limit, MTI*

1. Introduction

Cilacap Regency has high potential in the capture fisheries sector because it is located on the southern coast of Java Island, where there is the most extensive fishing base (Widyaningrum, 2013). Fish Auction Place (FAM) is one of the main functions in fishery activities and is one factor that drives and improves fishermen's business and welfare (Setiarso, 2010). Apart from that, Cilacap also has an ideal ocean port because of its strategic geographical location on the sea's edge. It faces the Indian Ocean on Turtle Bay and is bordered by Nusakambangan Island, extending west-east. The seaport located in Cilacap waters functions as an export-import port, shipping lanes or ship traffic on the southern coast of Java Island and there are piers owned by an Indonesian oil and gas company, namely Pertamina Oil Management Unit IV, which causes activities at Cilacap Port to continue to increase, such as traffic. Cross tanker ships carrying various types of oil (Widhayanti, 2015).

Industrial potential with national scale activities also dominates the Cilacap area, such as Pertamina company, which has an oil refinery with a production capacity of up to 400,000 barrels per day which supplies 30 percent of the national oil demand and a PLTU that is connected to the Java-Bali electricity system (Pemkab Cilacap, 2020). Another industry in Cilacap, namely SBI company, asphalt processing, lubricating plants, LPJ filling and others. Industrial, domestic and other activities will harm

water resources in the form of a decrease in water quality (Sasongko, 2014). The case of decreasing water quality due to industrial, household and other activities has occurred in Indonesia, including in Cilacap Regency. One of the types of pollutants suspected to be contained in the waste from these activities is lead (Pb) (Hidayati. N.V. et al., 2014).

Heavy metal Pb becomes dangerous due to the bioaccumulation process. Bioaccumulation is the increasing concentration of chemical elements in the body of living things according to the food pyramid. Heavy metals cause adverse effects on living things, such as disrupting chemical reactions, inhibiting the absorption of essential nutrients (Hananingtyas, 2017). Heavy metal Pb can cause adverse effects on health depending on where the heavy metal accumulates in the body. The impact on health from heavy metal accumulation is that it causes allergies and is carcinogenic. The results of Hananingtyas (2017) show that tuna in the North Coast of Central Java is contaminated with heavy metals, most of which have exceeded the quality standard threshold of Indonesian Government Regulation No.28 of 2004, BPOM Regulations 2009 and SNI 7387 in 2009. From 10 The research sample found that 40% of the samples exceeded the maximum limit of Pb contamination, namely with levels of 0.420-0.610 mg/kg and 60% containing heavy metal Cd. The compound lead (Pb) in water can be found in tetravalent ions with high toxicity compared to divalent ions. So waters that have been contaminated with Lead compounds and exceed the quality standard limit can result in death for aquatic biota and endanger food safety.

Thus, this research activity's importance is to know the maximum limit of fish catches' consumption in Cilacap waters contaminated with heavy metals by conducting survey techniques, namely questionnaire interviews with fishers, sellers and buyers at FAMs spread across Cilacap, namely FAM Kemiren, FAM Tegalkatilayu and FAM. PPC to obtain data on the types of fish that are most consumed as well as analysis of the maximum limit of consumption through the Pb value data obtained from the Atomic Absorption Spectrophotometer (AAS) analysis in Jenderal Soedirman Purwokerto's laboratory so that it can be compared with the quality standard in the 2009 BPOM Regulation, Indonesian National Standard 7387 -2009 and Ministry of Environment No.51 of 2004.

2. Methodology

2.1 Materials

This study aims to analyze the fish catch that contains heavy metal Pb with a maximum limit of consumption. The method used in this research is a comparative descriptive method, where there are different variables in 9 samples at the 3 FAM research locations to present precise data in the formulation of the maximum limit level of fish consumption. This research begins with a survey technique, namely analysis by collecting data in the form of pictures or words without generalizing the results of research conducted at the Fish Auction Place (FAM). The sampling technique is based on specific considerations or purposive sampling using questionnaire interviews with fishers, sellers and buyers at 3 FAM locations. While analyzing lead (Pb) levels in tongkol, tuna and kembung is using Atomic Absorption Spectrophotometry (AAS) instruments at the Laboratory of the University of Jendral Soedirman..

The AAS instrument analysis was carried out with several stages in the test, namely calculating the standard solution concentration, which was included in the linear range by diluting the leading solution using a specific volume. After the standard solution's concentration is taken into account, the sample is prepared by homogenizing the test sample by diluting it with a solvent where the minimum sample volume is 0.5 mL and free of disturbing matrices. The choice of resonance line is determined because an element has a level of energy used in the absorption of light. In the analysis with AAS, optimization of the condition of the tool was also carried out. The following test analysis is carried out by reading from the absorbance of the standard solution and the absorbance of the sample solution, which is finally in the interpolation stage of the sample's absorbance on a linear curve to obtain data on the Pb value of fish and water.

2.2 Location and Research Schedule

There were three research locations in this study, namely FAM Kemiren, FAM Tegalkatilayu and FAM PPC Cilacap, Central Java. The research was carried out in July - October 2020.

2.3 Analysis Method

The maximum limit for the concentration of food contaminated with heavy metals per week (Maximum Weekly Intake) uses the threshold figures published by the international food agency World Health Organization (WHO) and the Joint FAO / WHO Expert Committee on Food Additive (JEFCA). Maximum Weekly Intake calculation using the formula:

$$MWI(g) = Weight^{a)} x\ PTWT^{b}$$

Where :

a) body weight The average body weight of adults and children are seen from the questionnaire data
b) PTWI (*Provisional Tolerable Weekly Intake*) or the maximum tolerance limit per week issued by the Food Institution related to heavy metal Pb, namely 25 μg.kg^{-1}.

Then the maximum tolerable weight limit for fish meat for consumption in one week (Maximum Tolerable Intake / MTI) is calculated by the formula:

$$MTI = MWI/Ct$$

Where:

MWI: Maximum Weekly Intake (mg for body weight for adults and children from the mean per week questionnaire data)
Ct : Heavy metal concentration found in fish meat (mg.kg^{-1})

3. Result And Discussion

3.1 Consumable Fish

Types of fish that were often consumed or in high demand were analyzed as follows:

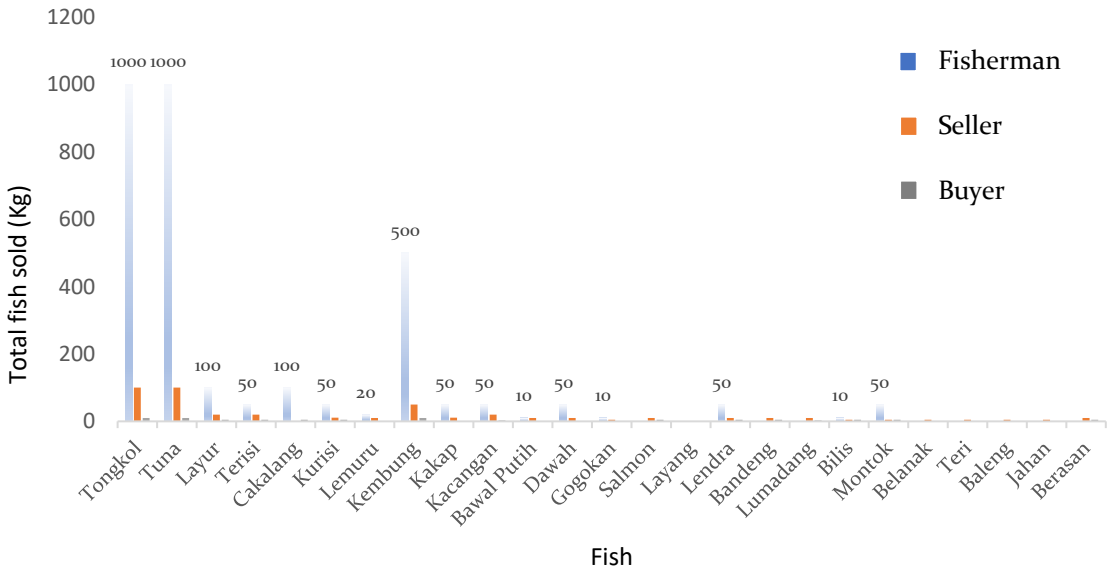

Figure 1. Consumable fish

The variety of fish species in Cilacap waters is very diverse. The fishing catches taken by the fishermen's sailing distance between 3-12 miles. The data in Figure 1 is secondary data; the picture shows the types of fish that are mainly obtained, sold and consumed by the community. Fish types with the highest catch and demand are tongkol and tuna, with a catch of up to 1 ton and kembung up to 500 kg in the one-time sailing phase. The types of fish with minor catch and are of interest are fish such as Beleng, Jahan and Rice. Based on the survey, the community had fewer fish because the meat texture was not as thick as tongkol, tuna and kembung. In one day, the tongkol, tuna and kembung seller can sell as much as 10-50 kg per day.

3.2 Pb Concentration

3 types of fish were obtained from the data, namely tongkol, tuna and kembung, with nine samples of each type of fish in 3 FAM. The three types of fish must be analyzed for heavy metal Pb with the Atomic Absorption Spectrophotometry (AAS) method, which is a quantitative elemental analysis method based on light absorption and wavelengths by metal atoms in the free state. Samples will experience deatomization and then react with radiation energy. The atoms in the ground state require a large amount of energy to obtain it; the atom then absorbs energy from the Atomic light source absorption Spectrophotometry (AAS) tool, then analyzed using the Lambert-Beer Law. Pb testing on tongkol, tuna and kembung was carried out at the Laboratory of Jendral Soedirman University. Pb analysis is needed to determine the Pb level in Cilacap waters because the waters of Cilacap have been exposed to industrial activities around Cilacap.

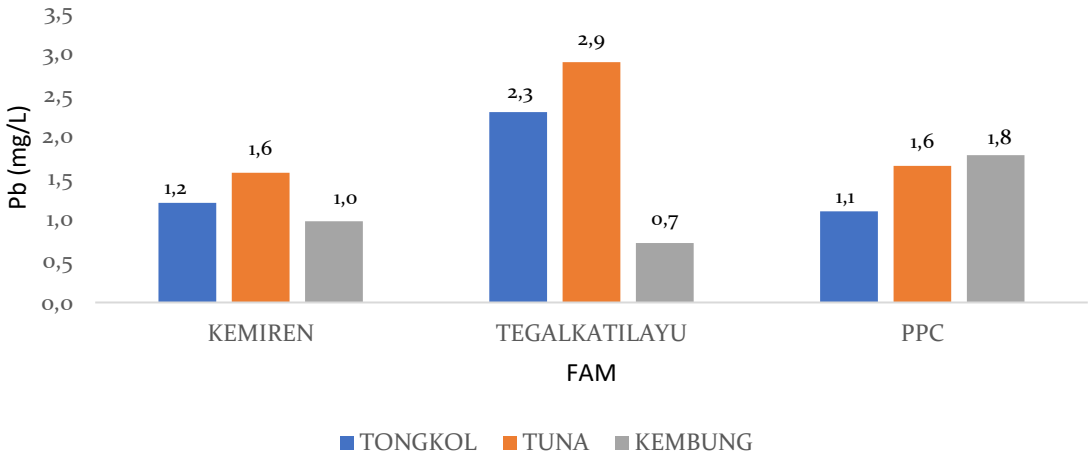

Figure 2. Pb Concentration in fish

The figure shows that the FAM with the highest Pb value is Tegalkatilayu FAM. The data obtained from the average value of Pb in tuna is 2.3 ppm, tuna is 2.9 ppm and kembung is 0.7 ppm. Meanwhile, FAM, which has the second-highest Pb value for fish species, is PPC FAM with Pb value in tongkol, tuna and kembung, respectively 1.1 ppm, 1.6 ppm and 1.8 ppm. Meanwhile, the FAM with the lowest Pb value for fish species was Kemiren FAM with a Pb value on tuna of 1.1 ppm, tuna of 1.6 ppm and kembung of 1.0 ppm. The results also showed that the most considerable Pb value in Cilacap waters was tuna and the so-called kembung.

The high content of heavy metals in the lead (Pb) in tuna is caused by the large size of the tuna and the largest between tongkol and kembung. Fish is easy to bioaccumulate in their bodies, where the bioaccumulation of heavy metal Pb is greater than the content of heavy metals dissolved in seawater. According to Lubis (2015), heavy metal Pb enters the environment in two ways: natural and anthropogenic. Heavy metals naturally contaminate the environment due to the influence of weather, erosion and volcanic activity. Meanwhile, heavy metals that contaminate the environment anthropogenically are caused by human activities, including metal plating, mining, pesticides, and others.

After the heavy metals enter the water body, they will be biologically accumulated by the fish through the food network system so that heavy metals will increase their levels in the fish's body. If humans consume fish, it will indirectly cause biomagnification in the human body.

Table 1. Deviation value

No.	Types of Fish	Deviation Value Per FAM		
		Kemiren	Tegalkatilayu	PPC
1.	Tongkol	0,6	1,9	0,7
2.	Tuna	0,7	2,0	1,0
3.	Kembung	0,7	0,5	1,5

According to SNI 7387-2009 and BPOM 2009, the quality standard of Pb value in predatory fish such as tuna, tongkol and kembung is 0.4 mg/kg. Compared with the research data, the Pb value in Cilacap waters has passed the indicated threshold so that it is not safe if consumed by humans continuously shortly. The average pH value of Cilacap waters in the results of the study was 7.6. According to Kemenlh No. 51 of 2004 concerning the quality standard of seawater pH, which is 6.5 - 8.5. This means that the pH in Cilacap waters is still within the required quality standards. However, the Pb value of Cilacap waters according to the research is 0.2 ppm. Where this value has passed the threshold set by the Ministry of Environment No.51 of 2004, namely, the maximum Pb value of seawater is 0.05 ppm.

3.3 Maximum Consumption Limit

The calculation begins with determining the Maximum Weekly Intake (MWI) value, which is multiplying the average body weight from the questionnaire data with the PTWT. The MWI data will be obtained to calculate the Tolerable Maximum Intake according to the MTI formula with MWI data input and get the Ct data from the concentration of the Pb value of the research results. Then the Maximum Tolerable Intake data can be obtained by entering the MTI calculation, which produces the following data:

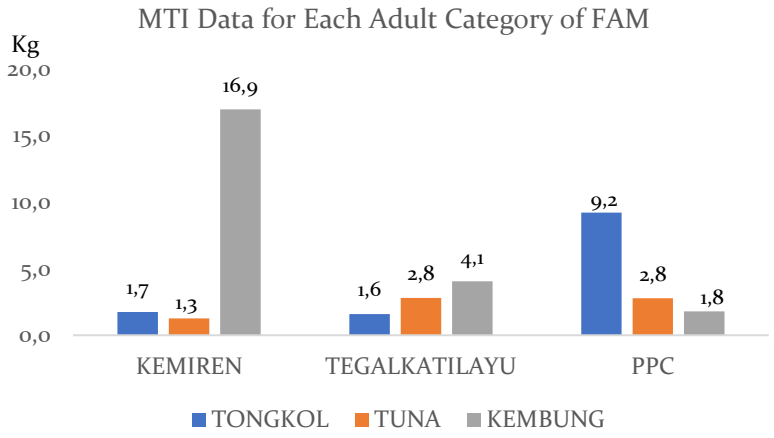

Figure 3. MTI Data for Each Adult Category of FAM

The Tolerable Maximum Intake or MTI value is the maximum weight limit of fish meat that can be tolerated for consumption within one week. The standard MTI value can be determined from the standard MWI calculation divided by the standard Pb value concentration so that the standard MTI data is 3.125 kg per week for the adult category. According to the research results in Figure 3, the largest MTI data is obtained, namely tongkol fish in the Kemiren FAM of between 1.8 kg - 16.9 kg per week. This means that the maximum limit of consumption of tongkol for adults can be consumed a maximum of 16.9 kg per week. Meanwhile, for tuna, the highest MTI value was in FAM Tegalkatilayu of 1.3 kg - 2.8 kg

per week. As well as the highest MTI value for tuna, namely 1.6 kg - 9.2 kg per week. When compared with the standard MTI value, the consumption limit for tuna must be considered. So it is recommended that the consumption of 3 types of fish does not exceed the maximum consumption limit because it can harm the accumulation of heavy metal Pb.

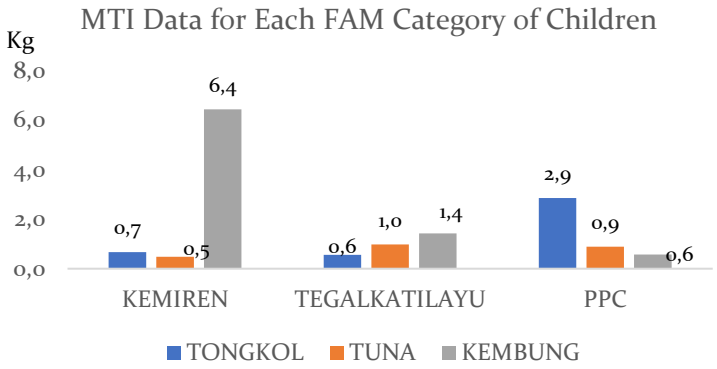

Figure 4. MTI Data for Each FAM Category of Children

The standard MTI value intended for the category of children is 0.9 kg per week. Based on the data in Figure 4, the maximum limit for fish consumption is kembung in the Kemiren FAM with a limit of 0.6 kg - 6.4 kg per week. Meanwhile, tuna has a maximum consumption limit of 0.5 kg - 1.0 kg per week. As well as for tuna, it has a maximum consumption limit of 0.6 kg - 2.9 kg per week. Compared with the standard MTI value for children, it is essential to pay attention to tuna consumption where the fish has the minor maximum limit. As for all types of fish, it is recommended to consume according to the maximum consumption limit to reduce the harmful effects of heavy Pb accumulation in the body.

4. Conclusion

Through the analysis of questionnaire data from fishers, sellers, and buyers, it can be concluded that the types of high-consumer fish are tongkol, tuna and kembung with an average sale of 500-1000 kg per day. The results showed that the Pb values in tongkol, tuna and kembung were 1.5 ppm, 2.0 ppm and 1.1 ppm, respectively. The data is compared with the threshold required by SNI 7387 in 2009 and BPOM in 2009, the Pb value in the research data shows that the Pb level has exceeded the recommended quality standard threshold. The permissible threshold is less than 0.4 ppm. To minimize the accumulation of heavy metals in the human body, a maximum limit of consumption is required by calculating the maximum limit for the categories of adults and children for each type of fish. The maximum limit for adults' tongkol consumption is 1.6 kg - 9.198 kg per week and for children 0.6 kg - 2.9 kg per week. The maximum limit for consumption of tuna for adults is 1.3 kg - 2.8 kg per week and for children 0.5 kg - 1.0 kg per week. The maximum limit of kembung consumption for adults is 1.8 kg - 16.9 kg per week and for children 0.6 - 6.4 kg per week. The existence of a maximum limit for fish consumption can control the consumption pattern of fish caught in Cilacap waters, especially 3 populations that are indicated to contain heavy metal Pb, namely tongkol, tuna and kembung.

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