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Identification of Community Knowledge on Lead Contamination and Analysis of Lead Level in Fish

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ABSTRACT

Poisoning is an event of human exposure to poisonous substances that are harmful to the body at certain doses. Lead is a heavy metal that can cause toxicity, including neurotoxic effects, hypertension, digestive system disorders, bone and tooth growth disorders, immune system disorders, infertility, and fetal disorders. Fish is a source of nutrients that are often consumed by people, however can also accumulate lead. This study aimed to analyze the lead level in fish and identify the community knowledge level regarding lead contamination in fish. Identification of community knowledge levels regarding lead. Identification of community knowledge levels regarding lead contamination in fish was conducted on three hundred respondents consisting of School of Pharmacy (SF) Institut Teknologi Bandung (ITB) one hundred students, one hundred community, and one hundred housewives. This study also analyzed lead levels in six fish samples using Graphite Furnace Atomic Absorption Spectroscopy (GFAAS). As the result, SF ITB students had the highest level of knowledge in the definition of lead (97%), lead poisoning (98%), fish lead accumulation (75%), the poisoning effects of lead, and sources of lead. However, all of the respondents had a low level of knowledge regarding regulations about lead levels in fish. The lead levels analysis on fish showed that three out of six samples had lead levels that exceeded the limit of lead contamination (>0.2 g/kg). The study indicated that respondents' knowledge regarding lead contamination in fish is still low and lead-contaminated fish is still being sold on the market.

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INTRODUCTION

Poisoning is an event of human exposure to poisonous substances which at certain doses are harmful to the body. Lead is a heavy metal that can cause poisoning. Lead has a molecular weight of 207.2 g/mol, a density of 11.34 g/cm^3, and can accumulate in various media. The effects of lead poisoning include neurotoxic effects, hypertension, digestive system disorders, impaired bone and tooth growth, immune system disorders, infertility, and fetal disorders (Mitra et al., 2017). Moreover, children are more vulnerable to the toxic effects that are caused by lead. In children, the neurotoxic effects of lead and impaired bone growth cannot be cured (Hauptman et al., 2017). Thus, lead can trigger a disturbance in children's behavior, intellectual disability, hearing loss, hyperactivity, and stunting. In 2020, Indonesian people had a blood lead level of 3.2 µg/dL on average and 8,270,000 children had blood lead levels of more than 5 µg/dL that required medical treatment (IHME, 2020). Fish is a source of nutrients that is commonly consumed by Indonesian people. However, fish can accumulate lead in their tissues from the ecosystem (Rajeshkumar & Li, 2018). Lead contaminated fish can produce toxic effects when consumed in large quantities or continually for a long period (Pizzol, 2010). Therefore, it has been regulated in National Agency of Drug and Food Control of Indonesia Regulation (*Peraturan BPOM*) No. 23/2017 concerning Limit of Heavy Metal Contamination in Processed Food, that the limit of lead level in fish is 0.2 mg/kg. Lead poisoning can be prevented by educating the public and identifying the sources of lead to reduce lead exposure.

This study identified the community knowledge level regarding lead contamination in fish for School of Pharmacy, Institut Teknologi Bandung (SF ITB) students, the community in Bandung Raya, and housewives in Bandung Raya. Furthermore, an analysis of lead level was also carried out on 6 samples of fish consisting of 3 random samples and 3 samples of fish most frequently bought by respondents based on types and locations of fish bought using Graphite Furnace Atomic Absorption Spectroscopy (GFAAS).

METHODS

Materials

Fresh fish, nitric acid (HNO_3) 65%, hydrogen peroxide (H_2O_2) 30%, lead standard solution, and ammonium dihydrogen phosphate ($NH_4H_2PO_4$).

Instruments
Questionnaire of community knowledge according to lead contamination in fish, microwave 1200 watts (CEM MARS 5, USA), Graphite Furnace Atomic Absorption Spectrometry (GFAAS) (Perkin Elmer 3110, Germany).

Identification of Community Knowledge Level on Lead Contamination
A descriptive study was conducted to identify the community knowledge of lead contamination in fish among respondents who lived in Bandung Raya and were over 17 years old. Respondents consisted of 100 SF ITB students, 100 housewives in Bandung Raya, and 100 respondents of the community in Bandung Raya. Respondents had various characteristics in terms of age, education, occupation, and economic level. The parameters of community knowledge that being identified were the definition of lead, poisoning that can be caused by lead, the ability of fish to accumulate lead, the toxic effects and sources of lead, the limit of lead level in fish that has been regulated by BPOM, fish processing to minimize lead level, and the importance of adequate nutrition to minimize toxic effects of lead. Identification was conducted using a questionnaire that has been validated using the Pearson test and the reliability has been tested using the Cronbach method. Data collection was carried out from February to March 2021. The data were processed using Microsoft Excel and Statistical Product and Service Solutions (SPSS) version 25.

Lead Analysis in Fish
The lead-level quantitative analysis of fish was carried out using GFAAS. GFAAS was used because the detection limit is small, the spectral interference is low, and it does not require large samples. Analysis was conducted on 6 samples of fish muscle, which is the most consumed part of fish. The sample consisted of 3 random samples and 3 samples of fish that were most frequently bought by respondents based on the type and location of fish bought. Quantitative analysis was conducted at the Indonesian National Nuclear Energy Agency (BATAN), Bandung, West Java.

Fish Sample Collection
Samples were obtained from 6 different locations. Three locations were chosen based on respondents' answers regarding the most visited locations to buy fish, which are Ciroyom Market, Andir Market, and Dimensi Market. The other 3 locations in Bandung Raya were selected using a simple random sampling method. The fish was separated from the bones and scales and then minced using a blender. The fish was placed in the refrigerator before being brought to BATAN to keep it fresh.

Wet Digestion of Fish Samples
SNI 2354.5:2011 method was used in this study. About 3 g of fish muscle was weighed and put into a sample tube. Next, the sample was added with 7 mL of 65% nitric acid and 2 mL of 30% peroxide. The solution was put in the microwave CEM MARS 5 1200 watts for 15 minutes. Then, the solution was transferred into a 25 mL volumetric flask and 40 mg/mL of ammonium dihydrogen phosphate solution was added to the mark.

Measurement of Lead Level in Fish Using GFAAS
Standard solutions were prepared to give 5 concentrations of 0, 10, 20, 30, and 40 µg/L. GFAAS was prepared. Blank, standard, and sample solutions were injected into the GFAAS. Absorbance readings were carried out at a wavelength of 283.3 nm. Concentration can be calculated with the equation where D is the concentration of the reading (µg/L), E is the blank concentration (µg/L), and Fp is the dilution factor.

Furthermore, the concentration (µg/g) can be calculated with the equation where V is the final volume of the solution (L) and W is the weight of the sample (g).

The results of the analysis were observed for conformity to the requirements regulated in *Peraturan BPOM No. 23/2017* concerning the Limit of Heavy Metal Contamination in Processed Food.

RESULTS AND DISCUSSION

Questionnaire Validation and Reliability
The result of the validity test using SPSS showed that the Pearson correlation obtained at a significance of 0.05 was more than 0.355 which indicated that the questionnaire was valid. The reliability of the questionnaire was determined by the value of Cronbach's Alpha test result of 0.751 which indicated that the questionnaire was reliable (Tavakol and Dennick, 2011).

Questionnaire Supporting Data
Supporting data obtained from this study included age, education, frequency of consuming fish in one week, type of fish consumed, and most visited location to buy fish in Bandung Raya. The data obtained in this questionnaire provided an overview of the respondents. This study population criterion included ages ranging from 17 to 78 years, lived in Bandung Raya and had a final education ranging from elementary to master's degree (Table 1).

Frequency of Eating Fish in A Week
Based on the survey, each group of respondents had a different frequency of consuming fish. Housewives were

Table 1. Respondents' characteristic

Characteristic	n (%)
Age group	
17-20	47 (15.67)
21-30	134 (44.67)
31-40	14 (4.67)
41-50	44 (14.67)
Above 50	61 (20.33)
Latest education	
Elementary	1 (0.33)
Middle school	3 (1)
High school	148 (49.33)
Diploma 1	2 (0.67)
Diploma 2	1 (0.33)
Diploma 3	6 (2)
Undergraduate	128 (42.67)
Postgraduate	11 (3.67)

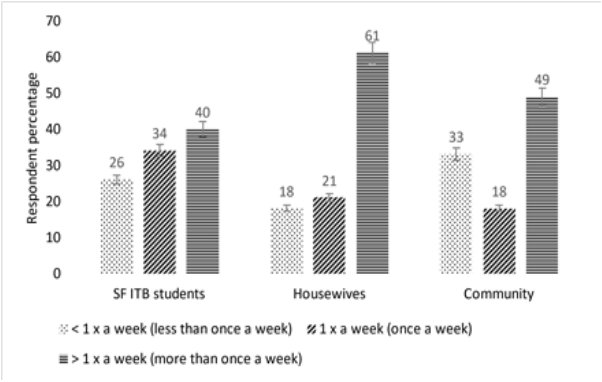

Figure 1. Respondents' frequency of consuming fish in a week

the group that consumed fish the most when compared to the other respondent groups (Figure 1). This can be caused by housewives who tend to provide nutritious food for their families, one of which can be done by providing fish for consumption.

Types of Fish Consumed by Respondents

The most consumed types of fish by the three groups of respondents are tuna (24.3%), tilapia (22%), and catfish (18.67%). The choice of fish for consumption by respondents can be influenced by taste, affordability, easy processing, and availability on the market.

Locations to Buy Fish

A total of 12.3% of respondents bought to fish in locations closest to their respective residences. In addition, the locations frequently visited to buy fish are Ciroyom Market (8.67%), Andir Market (7.33%), and Dimensi Market (6.67%). The choice of destinations to buy fish can be influenced by the distance from the location to where the respondent lived, the quality of the fish, and the price of fish offered at each location.

Community Knowledge of Lead Definition

Regarding the level of community knowledge about the definition of lead, there were 97% of SF ITB students, 75% of housewives, and 85% of the community answered that they knew the definition of lead (Table 2). The knowledge of SF ITB students was the highest among the other respondent groups, followed by the community and housewives. The difference in the level of knowledge regarding the definition of lead can be caused by the education of SF ITB students regarding lead as heavy metal.

Community Knowledge of Lead's Ability to Cause Poisoning

In the parameter of knowledge regarding the ability of lead to cause poisoning in humans, there were differences that can be observed between the three groups of respondents (Table 2). SF ITB students had the most respondents (98%) who knew that lead can cause poisoning. Furthermore, 82% of housewives and 80% of the community also knew that lead can cause poisoning. This was due to the education obtained by SF ITB students regarding the ability of lead to cause poisoning in humans and other organisms.

Community Knowledge of Fish's Ability to Accumulate Lead

Table 2 shows the comparison of respondents' knowledge regarding the ability of fish to accumulate lead. About 75% of SF ITB students, 59% of housewives, and 54% of the community knew that fish can accumulate lead in their bodies. The result showed that SF ITB students had the highest level of knowledge about lead accumulation in fish. This is due to the education of SF ITB students regarding the presence of certain substances that can accumulate in organisms.

Community Knowledge of BPOM Regulation on Lead Level in Fish

In this study, knowledge of the respondent groups was assessed on BPOM regulation regarding the limit of lead contamination in fish which has been regulated in Peraturan BPOM No. 23 Tahun 2017 concerning Limit of Heavy Metal Contamination in Processed Food. Based on the data obtained, the highest level of knowledge can be observed in SF ITB students. There were 39% of SF ITB students, 15% of housewives, and 13% of the community who knew about BPOM regulation regarding the limit of lead level contamination in fish

Table 2. Respondents' knowledge regarding lead contamination in fish

Knowledge Parameter	Respondent Group		
	SF ITB	Housewives	Community
Knowing lead definition, n (%)	97(32.33)	75 (25)	85 (28.33)
Knowing lead's ability to cause poisoning, n (%)	98 (32.67)	82 (27.33)	80 (26.67)
Knowing fish's ability to accumulate lead, n (%)	75 (25)	59 (19.67)	54 (18)
Knowing BPOM regulation on the lead level in fish, n (%)	39 (13)	15 (5)	13 (4.33)
Knowledge of the effect of lead poisoning score, mean ± SD	3.17 ± 1.40	2.26 ± 1.53	2.34 ± 1.40
Knowledge of lead sources score, mean ± SD	3.36 ± 1.12	2.22 ± 1.23	2.12 ± 1.17
Knowing about good fish processing, n (%)	26 (8.67)	22 (7.33)	11 (3.67)
Knowledge about the importance of adequate nutrition, n (%)	70 (23.33)	82 (27.33)	69 (23)
Awareness of the importance of education on lead poisoning, n (%)	98 (32.67)	98 (32.67)	99 (33)

Table 3. Analysis of Lead Level in Fish Samples

Sample	Fish Type	Sample's Number	Concentration (mg/kg)
Respondent sample	Tuna	1	0.204
	Tilapia	2	0.285
	Catfish	3	0.152
Random sample	Pomfret	4	0.166
	Goldfish	5	0.213
	Tuna	6	0.149

(Table 2). Based on the data, it can be observed that most respondents did not know BPOM regulations regarding the limit of lead level contamination in fish. This can be caused by the lack of education regarding the limit of lead contamination in fish and the lack of public awareness to obtain information about food regulations that have been regulated by BPOM.

Community Knowledge of the Effects of Lead Poisoning on Human

In the parameter of knowledge regarding the effects of lead poisoning in humans, a score was made based on the number of known effects. The scoring was conducted using a scale of 0-5, a value of one was intended for respondents who know one effect of lead poisoning. In this study, SF ITB students had the highest average score, followed by the community and housewives (Table 2). The difference in respondents' knowledge about the effects of lead poisoning in humans can be caused by SF ITB students receiving education related to the effects of poisoning caused by heavy metals such as lead.

Community Knowledge of Lead Sources

Knowledge of lead sources was observed in respondents and scored based on the number of known effects. The scoring was conducted using a scale of 0-5, a value of one is intended for respondents who know one effect of lead poisoning and so on. SF ITB students had the highest average score of 3.36, followed by housewives with an average score of 2.22 and the community with the average score of 2.12 (Table 2). The factor that can influence the difference was SF ITB students have received education about various sources of heavy metals such as lead.

Community Knowledge of Fish Processing to Minimize Lead Contamination in Fish

Community knowledge about fish processing to minimize lead levels were observed, the data obtained in Table 2. A total of 26% of SF ITB students, 22% of housewives, and 11% of the community knew how to process fish properly to minimize lead levels in fish. Most respondents did not know how to process fish to minimize lead levels. This was due to the lack of education regarding good fish processing to minimize lead levels.

Community Knowledge About the Importance of Adequate Nutrition to Minimize the Effects of Lead Poisoning

Knowledge of the importance of adequate nutrition to minimize the effects of lead poisoning was observed in respondents. Based on Table 2. It can be obtained that housewives had the highest number of respondents who

knew the importance of adequate nutrition to minimize the effects of lead poisoning, which is 82%. Furthermore, there are 70% of ITB SF students and 69% of the community knew the importance of adequate nutrition to minimize the effects of lead poisoning. The difference in observed data between each group can be caused by education about the importance of adequate nutrition and the benefits of having adequate nutrition are easily accessible and has haven obtained by housewives and most of the other respondents.

Public Awareness About the Importance of Education on Lead Poisoning

Table 2. shows that 98% of SF ITB students, 98% of housewives, and 99% of the community were aware that education about lead poisoning is necessary. This showed the high awareness of respondents on the importance of educating themselves about lead poisoning. This awareness can be influenced by the respondents' lack of knowledge about lead poisoning and awareness to obtain more information about lead poisoning.

Public Awareness About the Importance of Education on Fish Processing

The result showed that all respondents were aware of the importance of education on how to process fish to minimize lead levels in fish. This was due to the respondents' lack of knowledge about good fish processing methods. This education is needed for the community to minimize lead levels in fish and avoid lead poisoning.

Analysis of Lead Level in Fish

Analysis of lead levels in fresh fish was conducted on six types of fish from distinct locations. Three samples were selected based on the respondents' data regarding the type of fish consumed and visited the location to buy fish, while the other three fish were selected randomly. Verification method, consisted of accuracy and precision, was conducted to verify the laboratory capability to use SNI 2354.5:2011.

In data analysis, it was found that three out of the six samples tested had lead concentrations of more than 0.2 mg/kg (Table 3). In *Peraturan BPOM No. 23/2017* concerning the Limit of Heavy Metal Contamination in Processed Food, it has been regulated that the limit for lead levels in fresh fish is 0.2 mg/kg. Thus, it can be concluded that three out of six samples did not meet the requirements. This can be caused by several external factors including the location of fish farming that was contaminated with lead, sources of fish food, and the market to bought fish was close to sources of lead contamination. Furthermore, there were internal factors that can affect lead levels in fish, which were size, age, and reproductive cycle, so that fish can accumulate lead in their muscles (Rajeshkumar & Li, 2018; Zhao et al., 2012).

Data shows that fish with lead level above the requirements are still being sold in the market. Education about lead level in fish is needed to minimize the consumption of fish with high lead level. Education can be conducted on community based on their current knowledge and their awareness about the importance of education about lead contamination in fish that previously has been explained in this paper.

CONCLUSION

Identification of community knowledge regarding lead accumulation in fish showed that SF ITB students had the highest level of knowledge in the definition of lead (97), lead poisoning (98), the ability of fish to accumulate lead (75), lead poisoning effects, and lead sources. Meanwhile, housewives had the highest level of knowledge about the importance of adequate nutrition to minimize the effects of lead poisoning (82).

All respondents had lack of knowledge regarding BPOM regulations about lead contamination limit in fish and fish processing to minimize lead level in fish. The results of the analysis of lead levels in fresh fish meat showed that three out of six fish samples had lead levels exceeding 0.2 mg/kg, which indicated that the lead levels were exceeding the lead contamination limit as regulated in *Peraturan BPOM No. 23/2017* concerning Limits of Heavy Metal Contamination in Processed Food.

REFERENCES

Badan Standardisasi Nasional. (2011). *Cara uji kimia – bagian 5: Penentuan kadar logam berat timbal (Pb) dan kadmium (Cd) pada produk perikanan*. Jakarta: BSN.

Cunningham E. (2012). What role does nutrition play in the prevention or treatment of childhood lead poisoning?. *Journal of the Academy of Nutrition and Dietetics*, *112*(11), 1916. doi: 10.1016/j.jand.2012.09.003.

de Souza, I. D., de Andrade, A. S., & Dalmolin, R. (2018). Lead-interacting proteins and their implication in lead poisoning. *Critical Reviews in Toxicology*, *48*(5), 375–386. doi: 10.1080/10408444.2018.1429387

Egan, K. B., Tsai, R. J., & Chuke, S. O. (2019). Integrating childhood and adult blood lead surveillance to improve identification and intervention efforts. *Journal of Public Health Management and Practice, 25(1),* S98–S104. doi: 10.1097/PHH.0000000000000872.

Etchevers, A., Bretin, P., Lecoffre, C., Bidondo, M. L., Le Strat, Y., Glorennec, P., & Le Tertre, A. (2014). Blood lead levels and risk factors in young children in France, 2008-2009. *International Journal of Hygiene and Environmental Health*, *217*(4-5), 528–537. doi: 10.1016/j.ijheh.2013.10.002.

Flora, G., Gupta, D., & Tiwari, A. (2012). Toxicity of lead: A review with recent updates. *Interdisciplinary Toxicology*, *5*(2), 47–58. doi: 10.2478/v10102-012-0009-2.

Fløtre, C. H., Varsi, K., Helm, T., Bolann, B., & Bjørke-Monsen, A. L. (2017). Predictors of mercury, lead, cadmium and antimony status in Norwegian never-pregnant women of fertile age. *PLoS ONE*, *12*(12), e0189169. doi: 10.1371/journal.pone.0189169

Gao, Z., Cao, J., Yan, J., Wang, J., Cai, S., & Yan, C. (2017). Blood lead levels and risk factors among preschool children in a lead polluted area in Taizhou, China. *BioMed Research International*. doi: 10.1155/2017/4934198.

Gleason, K. M., Valeri, L., Shankar, A. H., Hasan, M. O., Quamruzzaman, Q., Rodrigues, E. G., Christiani, D. C., Wright, R. O., Bellinger, D. C., & Mazumdar, M. (2016). Stunting is associated with blood lead concentration among Bangladeshi children aged 2-3 years. *Environmental Health : A Global Access Science Source*, *15*(1), 103. doi: 10.1186/s12940-016-0190-4.

Hauptman, M., Bruccoleri, R., & Woolf, A. D. (2017). An update on childhood lead poisoning. *Clinical Pediatric Emergency Medicine*, *18*(3), 181–192. doi: 10.1016/j.cpem.2017.07.010

Maret, W. (2017). The bioinorganic chemistry of lead in the context of its toxicity in lead: its effects on environment and health. *Metal Ions in Life Science, 17*(1), 1-20. doi: 10.1515/9783110434330-001.

Meyer P.A., Brown M.J., Falk H. (2008) Global approach to reducing lead exposure and poisoning. *Mutation Research, 695*(1-2), 166-175. doi: 10.1016/j.mrrev.2008.03.003.

Mitra, P., Sharma, S., Purohit, P., & Sharma, P. (2017). Clinical and molecular aspects of lead toxicity: An update. *Critical Reviews in Clinical Laboratory Sciences*, *54*(7-8), 506–528. doi: 10.1080/10408363.2017.1408562.

Mozaffarian D., Rimm E.B. (2006). Fish intake, contaminants, and human health: Evaluating the risks and the benefits. *JAMA, 296*(15), 1885–1899. doi: 10.1001/jama.296.15.1885.

Pizzol, M., Thomsen, M., & Andersen, M. S. (2010). Long-term human exposure to lead from different media and intake pathways. *The Science of the Total Environment*, *408*(22), 5478–5488. doi: 10.1016/j.scitotenv.2010.07.077.

Rajeshkumar, S., & Li, X. (2018). Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. *Toxicology Reports*, *5*, 288–295. https://doi.org/10.1016/j.toxrep.2018.01.007

Salami I.R.S., Rahmawati S., Sutarto R.I.H., Jaya P.M. (2008). Accumulation of heavy metals in freshwater fish in cage aquaculture at cirata reservoir, West Java, Indonesia. *Annals of the New York Academy of Sciences*. doi: 10.1196/annals.1454.037.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53–55. doi: 10.5116/ijme.4dfb.8dfd

Zhao, S., Feng, C., Quan, W., Chen, X., Niu, J., & Shen, Z. (2012). Role of living environments in the accumulation characteristics of heavy metals in fishes and crabs in the Yangtze River Estuary, China. *Marine Pollution Bulletin*, *64*(6), 1163–1171. doi: 10.1016/j.marpolbul.2012.03.023.