The Fish Quality Of Coastal Waters Likely Exposed To Oil Spill

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Abstract: The recent oil spill incident in coastal area of Karawang Regency in West Java, Indonesia spread to the surroundings coastal waters of Bekasi and Seribu Islands. These coastal waters are connected and are fishing ground of most artisanal fishermen in these coastal area. It is, therefore worthwhile to examine the fish quality collected from the exposed area after the incident. This study was carried out to provide information on heavy metal concentrations in the muscles of several fish species, including crabs and shellfish. The fish, crabs and shellfish samples were collected with the help of local fishermen. The concentrations of Arsenic (As), Cadmium (Cd), Mercury (Hg), and Lead (Pb) were determined in the muscles of collected fish, crabs and shellfish. The concentration of heavy metals were measured in the laboratory by atomic absorption spectrophotometry after digestion of the samples using kjeldahl heating digester. The results showed the concentration of all metals in the present study were lower than the limits permitted by Indonesian national standard. Therefore, it seems that no problems on human health would be raised from the consumption of the collected fish from the Karawang, Bekasi and Seribu Island coastal waters, from the heavy metal content point of view.

Index Terms: Coastal pollution, consumption safety, edible fish, human health.

1 INTRODUCTION

Oil spill is one of incidents with contamination risk to waters and organism living in. The effect of entering petroleum (oil) to the waters and beaches ecosystems have different consequence based on concentration, composition, and elements in the ecosystems [1]. In the beaches, oil spill impacts are aesthetically eyesore to views and leave a strong smell of oil. In a higher concentration, we also can see the death of seabirds, fish, crab, or other organisms even if the organisms can survive but dangerous to eat. In the waters, is feared has a bad effect from the chemical composition of oil on organisms directly (death) or indirectly (accumulation). Indonesian waters have experienced several oil spills, one of which is in the oil exploration area. Recently, oil spill incident has occurred on the coast of Karawang Regency (West Java Province) and have spread around the coastal waters of Bekasi Regency (West Java Province) and Seribu Island (Special Capital Region of Jakarta Provice). These coastal waters between the three locations are interconnected and became the fishing ground for most artisanal fishermen. Artisanal fisherman is a fisherman with own small boat and usually operated by himself for fishing activities at sea, using simple fishing gear (such as fishing rods, clown nets, gilnet), using a profit-sharing sales system, and selling fish within a limited local market. Based on the criteria and the activity of this fisherman, artisanal is categorized as small scale fisheries [2] [3] [4] [5]. Small-scale fisheries are fisheries with fishermen who conducte fishing. activities using fishing vessels with the maximum size of 10 gross tons [6] [7]. The catches of fishermen are sold with local scale for widely consumption of the people around the areas. Food safety is needed to prevent biology or chemical objects that can disturb, harm and endanger for human health. The worthiness consumption assessment refer to SNI 2729: 2013 concerning Fresh Fish and SNI 7387:2009 concerning Metal Content in Food. In addition, the maintain of the fish quality bring the price in the highest condition [8].

2 MATHERIAL AND METHODS

2.1 Study Location

The research was conducted in the coastal area of Karawang Regency on October 3-5, 2019 (Fig. 1). Karawang regency is located in the northern part of West Java Province with geographical between 107^{o}02' - 107^{o}40' East Longitude and 5^{o}56' - 6^{o}34' South Latitude. This Regency covers 1753.27 km2 or 3.73% of the area of West Java Province. Most of its area is coastal plains that lie on the northern coast. The sampling locations were Ciparage, Sungaibuntu, Sedari, Tanjungpakis, Sukajaya, Sukakerta, and Cilamaya Village (Fig. 1).

2.2 Data Collection

Specimens were collected by fishing directly and buying from local fishermen and fish farmers (culture). The sampling location was chosen by purposive sampling method with criteria area exposed by oil spill. The specimens were put in an icebox filled with ice to maintain the freshness and were transported to IPB Integrated Laboratory for analysis. Each specimen was identified and weighed individually. For heavy metal analysis, a weight of 250 grams is required, so that each species are composite. Heavy metals were analyzed using the Atomic Absorption Spectrophotometer (AAS) technique referring to the Official Methods of Analysis of AOAC International 18th Edition (2005).

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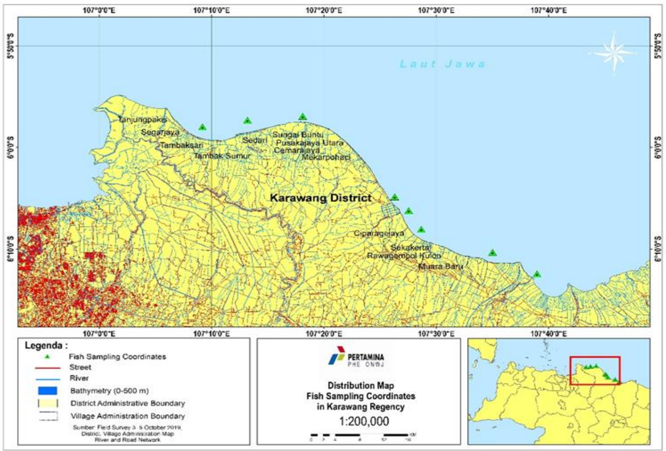

Fig 1. *Location of fish sampling in Karawang Regency*

2.3 Data Analysis

Data were analyzed descriptively by comparing the value of the measurement results to the quality standard. The values of several parameters were compared by referring to the quality and safety requirements of fresh fish (SNI 2729: 2013) and the maximum limit of As, Cd, Hg, Pb contamination in food (SNI 7387: 2009). If one parameter exceeded the quality standard, then it should be assumed that the fish is not suitable for consumption.

3 Result And Discussion

SNI (Indonesia National Standard) for Fresh Fish and SNI for Metal Content in Food does not list any parameter content in fish directly related to crude oil content. The use of organoleptic parameters, microbial contamination, chemistry, chemical residues, biological toxins, and parasites listed on the SNI for Fresh Fish cannot be applied in this case, because the oil spill did not produce these parameters. Therefore, to show the extent of the effect of oil spills on marine fish and fish cultivated in ponds, an approach to the use of parameters on SNI for Fresh Fish and SNI for Metal Content in Food is likely to occur in an oil spill in the form of metal contaminants such as arsenic (As), cadmium (Cd), mercury (Hg), tin (Sn), and lead (Pb). The measurement results of several heavy metal parameters in biota from all locations in Karawang regency are shown in Table 1. These results are compared with quality standards (SNI 2729:2013 and SNI 7387:2009) to determine feasibility to consume. Based on SNI 2729:2013 for fish, the standard values of metal contens (mg/kg) for As, Cd, Hg, Sn, and Pb are 1.0, 0.5, 1.0, 40, and 0.4 (mg/kg) respectively. The standard values for bivalve, sea cucumbers, shrimp, and other crustaceans are reffered to SNI 7387:2009. As, Cd, Hg, and Pb have standard value of 1.0, 1.0, 1.0, and 1.5 (mg/kg) for shellfish and sea cucumbers; and 1.0, 1.0, 1.0, and 0.5 (mg/kg) for shrimp and other crustaceans.

Table 1. *The feasibility analysis of fish, shrimp, crab, and shellfish.*

No	Sampling Location	Species	As	Cd	Hg	Sn	Pb	Feasibility to Consume[a)]
1	Ciparage Village	Mangrove Crab (Scylla sp.)	0.051	0.66	0.021	<0.4	<0.5	Worth to consume
		Milkfish (Chanos chanos)	<0.004	<0.05	0.015	<0.4	<0.5	Worth to consume
		Vannamei Shrimp (Litopenaeus vannamei)	0.006	<0.05	0.011	0.42	<0.5	Worth to consume
		Blood Shells (Anadara sp.)	<0.004	<0.05	0.002	0.48	<0.5	Worth to consume
2	Sungaibuntu Village	Mangrove Crab (Scylla sp.)	<0.004	<0.05	0.006	0.48	<0.5	Worth to consume
		Milkfish (Chanos chanos)	<0.004	<0.05	0.005	<0.4	<0.5	Worth to consume
		Vannamei Shrimp (Litopenaeus vannamei)	<0.004	<0.05	0.002	<0.4	<0.5	Worth to consume
		Cuttlefish (Sepia sp)	<0.004	<0.05	0.004	<0.4	<0.5	Worth to consume
		Feather Clams (Anadara sp)	<0.004	<0.05	0.004	<0.4	<0.5	Worth to consume
3	Sedari Village	Vannamei Shrimp (Litopenaeus vannamei)	<0.004	<0.05	0.009	<0.4	<0.5	Worth to consume
		Gulama Fish (Pennahia anea)	<0.004	<0.05	0.142	<0.4	<0.5	Worth to consume
		Milkfish (Chanos chanos)	<0.004	<0.05	0.005	<0.4	<0.5	Worth to consume
		Cuttlefish (Sepia sp)	<0.004	0.15	0.043	<0.4	<0.5	Worth to consume
		Tiger Prawns (Penaeus monodon)	0.027	<0.5	0.012	<0.4	<0.5	Worth to consume
		Green Mussels (Perna viridis)	0.008	<0.05	0.002	<0.4	<0.5	Worth to consume
		Nile tilapia (Oreochromis mossambicus)	0.004	<0.05	0.008	<0.4	<0.5	Worth to consume
4	Tanjungpakis Village	White Prawn (Penaeus merguiensis)	0.006	<0.05	0.014	<0.4	<0.5	Worth to consume
		Daun Baru Fish (Drepane punctate)	0.56	<0.008	0.04	3.93	<0.041	Worth to consume
		Grunt (Pomadasys sp.)	0.79	<0.008	0.04	1.47	<0.041	Worth to consume

No	Sampling Location	Species	As	Cd	Hg	Sn	Pb	Feasibility to Consume[a)]
		Giligan Fish (Family Sciaenidae)	0.44	<0.008	0.04	1.69	<0.041	Worth to consume
5	Sukajaya Village	Betotot Fish (Lutjanus sp)	<0.004	<0.05	0.006	<0.4	<0.5	Worth to consume
6	Sukakerta Village	Silver Silago (Sillago sihama)	<0.004	<0.05	0.028	<0.4	<0.5	Worth to consume
7	Cilamaya Village	Milkfish (Chanos chanos)	<0.004	<0.05	<0.002	.0.4	<0.5	Worth to consume
		Sardine (Sardinella lemuru)	<0.004	<0.05	0.05	<0.4	<0.5	Worth to consume
		Yellowtail Fusilier (Caesio sp)	<0.004	<0.05	0.127	<0.4	<0.5	Worth to consume
		Black-Tipped Rock Cod (Ephinephelus sp)	<0.004	<0.05	0.127	<0.4	<0.5	Worth to consume
		Tiger Prawn (Penaeus monodon)	<0.004	<0.05	0.002	3.13	<0.5	Worth to consume
		SNI 2729:2013[b]	1.0	0.5	1.0	40	0.4	
		SNI 7387:2009[c]	1,0	1.0	1.0	-	1.5	
		SNI 7387:2009[d]	1,0	1.0	1.0	-	0.5	

Note:
-) not analyzed or no quality standard requirements
[a]) SNI 2729:2013 Fresh fish and SNI 7387:2009 Metal content in food
[b])Metal Content (mg/kg) for fish (SNI 2729:2013)
[c])Metal Content (mg/kg) for shellfish (bivalve) molluscs and sea cucumbers (SNI 7387:2009)
[d])Metal Content (mg/kg) for shrimp and other crustaceans (SNI 7387:2009)

Based on Table 1, the heavy metal contents of Arsenic (As), Cadmium (Cd), Mercury (Hg), Tin (Sn), and Lead (Pb) in several fish, bivalve, shrimp, crab, and shellfish are very low even sometimes less than the detection limit or not detected. The heavy metal content detected in fish, shrimp, crab, and shellfish may not have come from the oil spill. This assessment is based on the results of heavy metal content with the highest concentrations found in fish and other biotas, namely As and Hg with a range of <0.004 - 0.79 and <0.002 - 0.142 mg/kg. All biota has the value of heavy metal content which is still below the quality standard value. The sample analysis was carried out in a composite manner on all organs of the body, including fish, shrimp, crab, and shellfish. Thus, for biota that has economic value, it is still suitable for consumption. The content of heavy metals in the waters is not only affected by oil spills. Industrial activities and ship transportation can be the main sources of heavy metal pollution in the waters [9] [10]. Cadmium has widespread use in industrial products, including batteries, pigments, plastic stabilizers, electroplating material and alloys [11]. The several sources of cadmium (Cd) contaminants are electroplating, the pigment of color paint in the sulfide form, metal alloys (as Zn metal coatings), batteries, heat retardants in the Polyvinyl Chloride industry, and industrial equipment [12]. Mercury (Hg) pollutants were originated from NaOH industry, electrical equipment, paint, medicine, bio-oxide (fungicides, herbicides, insecticides), and paper [13]. The originate of lead (Pb) pollutants can come from the disposal of ship fuel waste containing tetraethyl lead, batteries, pigments, cable covering, paint, and explosives [13]. Arsenic (As) releases to atmospheric may also occur when industrial processes, mining, coal combustion, smelting and refining, and waste incineration [14]. The Arsenic will be entered to waters by rain falls. These several sources make the heavy metals entering the waters and give an impact on aquatic biota. The metal content in the waters will enter the biota body and sediments. Heavy metals in water bodies will undergo a process of deposition and accumulate in marine biota [15]. Metals can enter the body in three ways, namely food ingestion, transfer of dissolved metal ions across the lipophilic membrane, and adsorption on the membrane surface [16]. Metals such as Pb, Cd, Hg, As, and Ni pose a toxic effect on organisms even at very low level. High concentration of metals in the aquatic environment could cause a hazard for natural ecosystem function and human health risk, due to toxic effects, long persistence, bioaccumulative properties, and biomagnification in the food chain [17]. [18] explained that there are two main ways metals contamination in fish and other biota, namely through the aquatic food chain with direct consumption of water and food through the digestive tract and non-food pathways across permeable membranes such as muscles and gills. [19] suggested that directly contact the transfer of chemical substances from the water environment into the body surface. [20][21] the metal accumulation is obtained from food. Heavy metals found in fish meat are probably related to dietary habits and fish distribution patterns [22]. [23] stated that heavy metals that enter large animals such as fish and shrimp come from food and particulates in water and sediment. In addition, [24] metal accumulation in fish depends on location, eating habits, tropical level, age, size, length of exposure to metals, and activity of homeostatic regulation. The size differences of the organism causes different biomagnification level, the large organisms tend to have higher value of heavy metal content [25]. Fishes have the ability to accumulate heavy metals in their tissues by absorption along the surface of the gills and walls of the kidneys, liver and intestines to a higher level than the heavy metal concentrations in the environment [26]. The level of heavy metal accumulation in fish body tissues from large to small was found in the liver, kidneys, gills, and meat [27]. Meat has the lowest concentration of all metals. The liver is the target organ for the accumulation of Zn, Cu, and Pb. However Cd showed a higher concentration in gills [28]. In addition, the bioaccumulation process of heavy metals in biota can also reduce the content of heavy metals in water [29]. Analysis of heavy metal content in meat can be used to investigate the transfer of heavy metals into the human body through fish consumption [21]. The existence of heavy metals in the human body can cause health problems. Fish is a food that has a high nutritional level and is a source of animal protein, because it contains amino acids. Although fish is source of animal protein, they are currently affected by existence of mechanized agricultural activities and rapid industrialization, increasing concentrations of heavy metal contents in fishes [30]. The maximum consumption value is used as a reference to avoid the negative effects of heavy metals entering the body [31]. [32] fish can be used as an estimator of the impact of hazards for human consumption. In addition, fish is also can used as an indicator in monitoring the level of heavy metal pollution. To guarantee food safety, information of heavy metal concentration in marine consumption comodity is needed to know by society. Food safety can keep away a threat that can harm, disturb, and endanger for human health. The results of this study showed that several fish, shrimp, crab, and shellfish have metal concentrations of Arsenic (As), Cadmium (Cd), Mercury (Hg), Tin (Sn), and Lead (Pb) have no value exceeds the standard guideline values and therefore will not pose a health hazard to consumers. Thus the oil spill that occurs in the northern Karawang waters does not affect the metal content contained in marine biota, i.e. fish, shrimp, crab, and shellfish.

4 Conclusion

Several fish, shrimp, crab, and shellfish were taken from marine waters and ponds in Karawang Regency declared fit for consumption based on SNI 2729:2013 concerning Fresh Fish and SNI 7387:2009 concerning Metal Content on Food. Thus the oil spill occurred in the northern of Karawang waters did not affect the metal content contained in aquatic biota.

References

[1] Michel J, Fingas M. 2016. Oil Spills: Causes, consequences, prevention, and countermeasures. In Fossil Fuels: Current Status and Future Directions. World Scientific Series in Current Energy Issues. 159-201.

[2] Charles TA. 2001. Sustainable Fishery System. Blackwell Science. London.

[3] Berkes F, Mahon R, McConney P, Pollnac R, and Pomeroy R. 2001. Managing Small-scale Fisheries Alternative Directions and Methods. Canada (US): The International Development Research Centre.

[4] Satria A. 2002. Pengantar Sosiologi Masyarakat Pesisir. Jakarta (ID): Cidesindo.

[5] Luky A. 2007. A Snapshot on Small Scale Fisheries. Sebuah Pengantaar Focus Group Discussion. PKSPL IPB. Bogor.

[6] Garcia SM, Allison EH, Andrew NJ, Bene C, Bianchi G, de-Graaf GJ, Kalikoski D, Mahon R, and Orensanz JM. 2008. Towards integrated assessment and advice in small scale físheríes: principles and processes. FAO Físheríes and Aquaculture Technical Paper. FAO. Rome.

[7] Batista VS, Fabre NN, Malhado ACM, and Ladle RJ. 2013. Tropical artisanal coastal fisheríes: Challenges and future directions. Fish Science & Aquaculture 22(1):1-15.

[8] Prihamdoko, Jahi A, Gani DS, Purnaba IGP, Adrianto L, dan Tjitradjaja I. 2011. Faktor-faktor yang mempengaruhi perilaku nelayan artisanal dalam pemanfaatan sumberdaya perikanan di pantai utara Provinsi Jawa Barat. Makara, Sosial Humaniora. 15(2): 117-126.

[9] Rumahlatu D. 2011. Kandungan logam berat kadmium pada air, sedimen dan Eadema setosum (Echinodermata, Echinoidea) di Perairan Pulau Ambon. Ilmu Kelautan. 16 (2): 78-85.

[10] Kumar B, Sajwan KS, and Mukherjee DP. 2012. Distribution of heavy metals in valuable coastal fishes from North East Coast of India. Turkish Journal of Fisheries and Aquatic Sciences 12:81-88.

[11] Wallen J, Wightmans AS, and Penning W. 1984. Environmental Effects of Cadmium in Freshwater. Freshwater Biological Association No. 23.

[12] Darmono. 1995. Logam dalam Sistem Biologi Makhluk Hidup. UI Press. Jakarta

[13] Hutagalung HP.1984. Logam berat dalam lingkungan laut. Oseana. 9(1):11-20.

[14] Janga YC, Somannaa Y, and Kimb H. 2016. Source, distribution, toxicity and remediation of arsenic in the environment – a review. International Journal of Applied Environmental Sciences 11(2):559-581.

[15] Syakti AD, Nuning VH, and Asrul SS. 2012. Agen Pencemaran Laut. Bogor (ID): IPB Pr..

[16] Squadrone S, Prearo M, Brizio P, Gavielli S, Pellegrino M, Scanzio T, Guarise S, Benedetto, and Abete MC. 2013. Heavy metals distribution in muscle, liver, kidney and gill of European catfish (Silurus glanis) from Italian Rivers. Chemosphere. 90: 358-365.

[17] Gheorghe S, Stoica C, Vasile GG, Nita-Lazar M, Stanescu E, and Lucaciu IE. 2017. Metals Toxic Effects in Aquatic Ecosystems: Modulators of Water Quality. https://www.intechopen.com/ books/water-quality/metals-toxic-effects-in-aquatic-ecosystems-modulators-of-water-quality.

[18] Ribeiro CAL, Vollaire Y, and Chardi AS. 2005. Bioaccumulation and the effects of organochlorine pesticides PAH and heavy metals in the eel (Anguilla Anguilla) at the Camargue Nature Reserve, France. Aquatic Toxicology. 74: 53-69.

[19] Priatna DE, Purnomo T, Kuswanti N. 2016. Kadar logam berat timbal (Pb) pada air dan ikan bader (Barbonymus gonionotus) di sungai Brantas wilayah Mojokerto. Lentera Bio. 5(1): 48-53.

[20] Vijayakumar P, Lavanya R, Veerappan N, and Balasubramanian T. 2011. Heavy metal concentrations in three commercial fish species in Cuddalore Coast, Tamil Nadu, India. The Journal of Experimental Life Science. 2(8): 20-23.

[21] Fathi HB, Othman MS, Mazlan G, Arshad A, Amin SMN, and Simon KD. 2013. Trace metals in muscle, liver and gill tissues of marine fishes from mersing, eastern coast of Peninsular Malaysia: concentration and assessment of human health risk. AJAVA 8(2):227-236.

[22]] Law AT, and Singh A. 1991. Relationships between heavy metal content and body weight of fish from the Kelang estuary, Malaysia. Mar Pol Bull. 22:86-89.

[23] Prabowo R. 2005. Akumulasi kadmium pada daging ikan bandeng. Jurnal Ilmu-Ilmu Pertanian 1(2):58-74.

[24] Sankar TV, Zynudheen AA, Anandan R, and Nair PGC. 2006. Distribution of organochlorine pesticides and heavy metal residues in fish and shellfish from Calicut region, Kerala, India. Chemosphere. 65(4): 583-590.

[25]] Fauziah AR, Rahardja BS, and Cahyoko Y. 2012. Korelasi ukuran kerang darah (Anadara ganosa) dengan kandungan logam berat merkuri (Hg) di Muara Sungai

Ketingan, Sidoarjo, Jawa Timur. Jurnal of Marine and Coastal Science 1(1):34-44.
[26] Annabi A, Said K, and Messaoudi I. 2013. Cadmium bioaccumulation, histopathology and detoxifying mechanisms in fish. American Journal of Research Communication. 1(4):60-79.
[27] Ahmed Q, Khan D, and Naeema E. 2014. Concentration of heavy metals (Fe, Mn, Zn, Cd, Pb, and Cu) in muscle, liver dan gills of adult Sardinella albelia (Valenciennes 1847) from gwadar water of Balochistan, Pakistan. Federal Urdu University Art Science and Technology. Journal of Biology 4(2):95-204.
[28] Bawuro AA, Voegborlo RB, and Adimado AA. 2018. Bioaccumulation of heavy metals in some tissues of fish in Lake Geriyo, Adamawa State, Nigeria. Journal of Environmental and Public Health.
[29] Cahyani N, Lumban Batu DTF, and Sulistiono. 2016. Kandungan logam berat Pb, Hg, Cd, dan Cu pada daging ikan Rejung (Sillago sihama) di estuari Sungai Donan, Cilacap, Jawa Tengah. Jurnal Pengolahan Hasil Perikanan Indonesia 19(3):267–276.
[30] Jeyaraj N, Suhaila A, Divya A, Kumar SP, Kumar L, and Ravikumar S. 2015. Heavy metal concentration in fishes from the Coastal Waters of Kasaragod, Northwest Part of Kerala, India. Int J Curr Res Biosci Plant Biol. 2(6):14-20.
[31] Prastyo Y, Lumban Batu DTF, dan Sulistiono. 2017. Kandungan logam berat Cu dan Cd pada ikan belanak di estuari Sungai Donan, Cilacap, Jawa Tengah. Jurnal Pengolahan Hasil Perairan Indonesia. 20(1): 18-27.
[32] Barak NAE, and Mason CF. 1990. Mercury, cadmium and lead concentrations in five species of freshwater fish from Eastern England. Sci. Total Environ. 92:257–263.