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Heavy metal contamination in water, sediments and *Planiliza subviridis* tissue in the Donan River, Indonesia

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Abstract

Heavy metals like cadmium (Cd) and lead (Pb) are pollutants that are toxic, difficult to decompose and accumulate in biota. One of the biota that lives in the waters is mullet fish. This fish is demersal, has a relatively long life period, has a specific tolerance to the aquatic environment and highly consumable in Indonesia. Therefore need to know the metal content of Cd and Pb in water, sediments and mullet fish and their relationship in Indonesia. The study used a survey method with purposive random sampling at four stations, three replications. The study was conducted from June to November 2019. Analysis of data was descriptive, *F*-test and correlation. The results showed that the heavy metal content of Cd and Pb between stations in the water media, sediment and in mullet fish there was a significant difference. The highest Cd and Pb were showed in station III, coming from the oil industry, domestic waste and transportation activities. The heavy metal content of Cd and Pb in water, sediment and mullet fish (*Planiliza subviridis*) in the Donan River, Cilacap shows results exceeding the allowed threshold and danger to human health.

Key words: *cadmium, Donan River Cilacap, lead, Planiliza subviridis, sediment, water*

INTRODUCTION

Heavy metal contamination in the aquatic environment has become a worldwide concern, due to the toxicity of the heavy metal. Heavy metals can also accumulate and have harmful effects on aquatic organisms (fauna, flora and microorganisms) [GUPTA *et al*. 2019; KUMAR *et al*. 2019a; SIREGAR *et al.* 2019a]. Humans can be exposed to this toxic metal through the consumption of contaminated water and food can also be a source of bioaccumulation of heavy metals that affect aquatic life [BELABED *et al*. 2017; KUMAR *et al*. 2019b]. Heavy metal, including Zn, Fe, and Cu [CHEN *et al*. 2016], pollution can be toxic if it is above threshold limit value (TLV) [KUCUKSEZGIN *et al*. 2006].

Heavy metals are dangerous pollutants that are persistent and toxic, that cannot be metabolized and cannot be excreted through biological processes, because heavy metals can accumulate in various components of the ecosystem (water, sediment, flora, and fauna) [PRAYOGO *et al.* 2016; SIREGAR, PRAYOGO 2017; SIREGAR *et al.* 2018]. Heavy metal contamination of plants and trophic chains can cause environmental problems and endanger human health [LENOBLE *et al*. 2013; SRIVASTAV *et al*. 2018]. In addition, heavy metals can cause harmful effects on physiological functions, individual growth rates, reproduction and death in aquatic organisms [MAURYA *et al*. 2019; NAZIR *et al*. 2015].

Sediments are environments where micropollutants can be accumulated for a long period of time, thus sediment analysis is a good indicator for determining pollution levels [BUGGY, TOBIN 2008]. Coastal areas which are known as urban and industrial areas are highly polluted by high heavy metal waste due to anthropic activities [PEKEY 2006; SIREGAR *et al*. 2019b]. In this case, the study focused on the Donan River, Segara Anakan Cilacap, Indonesia.

The Donan River is located in the Plawangan Timur area of Segara Anakan Cilacap [NADIA *et al*. 2017]. Along the Donan River is one of the centers of community activity in Cilacap. These activities include cement industry, industrial estate, oil refinery, Sleko Port, ship workshops, settlements, agriculture and shipping lines for industry, public transportation and fishing boats.

The Donan River has now become an area that is utilized in various activities, namely industrial activities, agriculture, fisheries, ports and domestic activities. The use of these activities can cause heavy metal pollution in waters, one of which is Pb, Cu and Cd logan. The biggest impact that is happening in the Donan River today is the pollution of water bodies that originate from the disposal of oil industry waste. The results of water quality monitoring conducted in 2000–2004 showed that in the Donan River Pb content was around 56.8 ppm, Cu was around 3.6 ppm and Cd was around 3.6 ppm [RISTANTI *et al*. 2013]. Other results show that the highest Pb content in the Donan River around the Tanjung Intan Port area of Cilacap is 0.165–0.309 ppm [RISTANTI *et al*. 2013]. The Donan River has indicated the presence of metal weight of Pb, where the average content of heavy metal Pb in water was 0.0176 mg·dm^{-3} and 3.4478 mg·dm^{-3} in sediments. In addition, according to PRASTYO *et al*. [2017] the Cu content in August–October is quite high and has exceeded the quality standard (around 2.3032–2.6021 mg·kg^{-1}). This value indicates that the concentration of Cu has exceeded the quality standards set by the FAO/WHO that is equal to 1.0 mg kg^{-1}.

Waste entering the waters contains organic and inorganic materials. Inorganic materials contained from these activities include heavy metals cadmium (Cd) and lead (Pb). This is based on port activities that produce waste (Cd and Pb) fuel and lubricants originating from fishing motorboats. The use of coal fuel in the cement industry [DARMONO 2001]. The contamination of the Donan River waters by inorganic Cd and Pb metals causes biota along these waters to potentially absorb metal in the body. One of the biota that is able to regulate the metal is mullet (*Planiliza subviridis*). Fish absorb metal from the waters into the body through the gills, the surface of the skin and food. Metal absorption through gills and contaminated feed is then transported by blood distributed throughout the body. The metal will accumulate in the liver, kidneys, pancreas, gills and meat. The use of fish meat for the fulfillment of animal protein sources by surrounding communities has a negative impact on health because of the dangers of the metal. Therefore, this research needs to be done. The objective of the research were to determine the content of heavy metals Cd and Pb in water, sediment and fish between stations on the Donan River, Segara Anakan, Cilacap from June to November 2019.

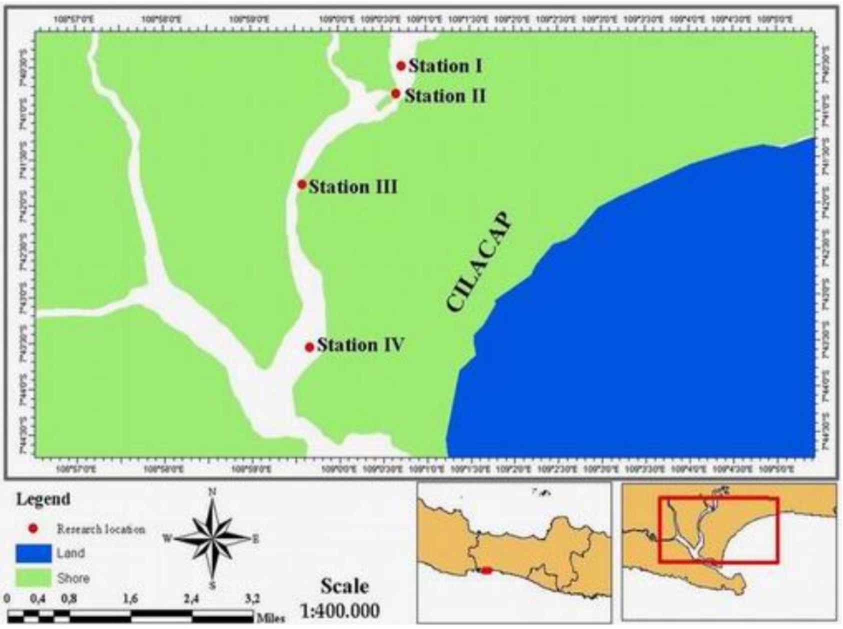

Fig. 1. Sample mapping in the Donan River, Cilacap Indonesia: source: own elaboration

MATERIAL AND METHODS

This research was use survey method. The sampling technique uses purposive random sampling (representing the surrounding area). The research sites included four sampling stations on the Segara Anakan River in Cilacap, namely station I is the upstream area of the Donan River around Tritih Kulon Village, station II is the area around the cement industry, station III is the area of oil refinery and station IV is downstream of the Donan River around the Port of Sleko (Fig. 1). Determination of sampling stations based on environmental conditions on the Donan River and the presence of sources of pollutants. Water, sediment and *Planiliza subviridis* samples were taken in a composite manner at three points at each station, and sampling was repeated three times at one week intervals.

SAMPLING OF CADMIUM AND LEAD

600 cm^3 of water was taken into a sample bottle, then added 0.75 cm^3 of concentrated HNO_3. Sediment samples were taken as much as ±250 g using Ekman Grab at a depth of 15–20 cm. Fish samples are taken using a net, the meat is taken and mashed, then put in a plastic bag. Furthermore, the sample is cooled in an ice box and analysed in a laboratory [NADIA *et al*. 2017].

SAMPLE PREPARATION FOR CD AND PB METAL

A sample of water is taken as much as 100 cm^3, put in an Erlenmeyer flask, shake until homogeneous. Add concentrated HNO_3 as much as 5 cm^3, heat it slowly until the volume becomes 15–20 cm^3 and a change in colour from originally turbid to clear. If it is not complete (not clear) then add 5 cm^3 of concentrated HNO_3 and heat it again, after that the sample is cooled and added with 50 cm^3 of distilled water. The sample was put into a 100 cm^3 measuring cup through filter paper Whatman No. 40 and added distilled water until the volume becomes 100 cm^3, the sample is ready to be analysed by atomic absorption spectrometry (AAS). Sediment and fish samples are first cleaned and dried, then mashed in a porcelain cup. Samples are taken ±5 g, put in a porcelain cup, then heated in a muffle furnace with a temperature of 500°C for 5 h. The obtained ash was dissolved in aqua regia of 5 cm^3 and heated until the ash dissolved, transfer it to a 25 cm^3 volumetric flask and add 5 cm^3 of 1 M HNO_3, then add distilled water to a measuring flask to a volume of 25 cm^3. The solution was filtered with Whatman No. paper 41. Filtrate is ready to be analysed by AAS [NADIA *et al*. 2017].

STANDARD CURVES OF Cd AND Pb

The Cd metal standard solution is needed to find out the equation of the Cd metal standard curve used to calculate the Cd metal content of the analysed sample. A standard solution of Cd 1000 mg·dm^{-3}, made by dissolving Cd $(NO_3)_2$ as much as 0.15984 g in 100 cm^3 of nitric acid 0.1 N. Furthermore, the solution was diluted and made in various concentrations, namely 0.25; 0.50; 1,00; 2.00; 3.00; 4.00; 5.00 mg·dm^{-3}, then each concentration is measured using the AAS and a standard Cd metal curve will be obtained [ELMER 1996].

Pb metal standard solution is needed to find out the equation of the standard Pb metal curve used to calculate the Pb metal content of the analysed sample. Standard solution of Pb 1000 mg·dm^{-3}, made by dissolving Pb $(NO_3)_2$ as much as 0.15984 g in 100 cm^3 of 0.1 N nitric acid. Furthermore, the solution was diluted and made in various concentrations, namely 0.25; 0.50; 1,00; 2.00; 3.00; 4.00; 5,00 mg·dm^{-3}, then the absorbance of each concentration is measured using an AAS tool and a standard Pb metal curve will be obtained [ELMER 1996].

Cd AND Pb ANALYSIS

The metal content of Cd and Pb in water, sediment and mullet media was measured by the Flame Atomic Absorption Spectrometry method using a set of AAS tools that had a precision level of 10^{-4} mg·dm^{-3}. The resulting filtrate, each smoked with a respirator tube of 20 cm^3 and put in a Nabulyzer, then atomized and evaporated. The vapours that are formed are burned with a burner flame and followed by the atomization process, then irradiated with cathode rays at certain wavelengths. Cd metal is measured at a wavelength of 228.8 nm and a strong current of 3.5 mA. Pb metal is measured at a wavelength of 217 nm and a strong current of 3.5 mA. The light absorption results will be captured by the detector. The absorbance value of the sample or standard solution will appear on the AAS screen, along with the line equation.

DATA ANALYSIS

Concentration of Cd and Pb heavy metal content in water media, sediments and mullet fish were analysed by ANOVA statistical analysis with *F* test (SPSS) to determine differences in Cd and Pb heavy metal content in water, sediment and mullet fish between stations. If the results are different, then proceed with the least significant difference test (LSD). Pearson correlation analysis to determine the relationship between heavy metal content in water with sediment and mullet fish.

RESULTS AND DISCUSSION

CONTENT OF HEAVY METAL Cd AND Pb IN WATER

The heavy metal content of Cd in water media between stations has a significant difference (*F*-test = 56.91) (Fig. 2). This is due to the source of Cd metal contamination and water temperature. Station I is still relatively natural waters. Its location is far from industry and the lack of domestic activity causes low Cd metal content in the water media at this station. This is consistent with the statement of RISTANTI *et al*. [2014] also states that the content of heavy metals in waters is strongly influenced by the source. The main cause of heavy metal contamination in aquatic environments is the presence of human activities (anthropogenic).

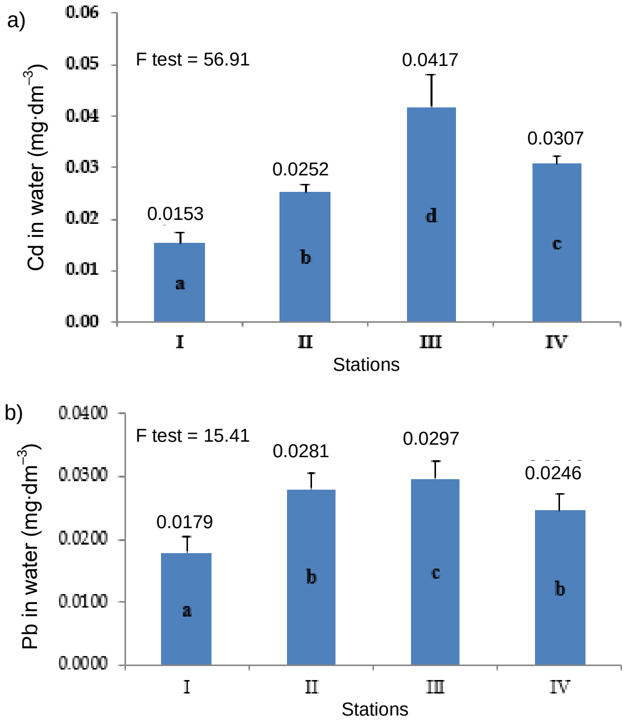

Fig. 2. Heavy metals content in water media on the River Donan, Cilacap: a) cadmium, b) lead; a, b, c, d at bars mean homogenous groups; source: own study

The content of Cd metals at station III and stations II and IV has a significant difference due to the amount of waste input containing Cd metal likely to be greater at station III coming from the oil industry, domestic waste and transportation activities. This is in accordance with MARZUKI [2014], the activity of oil refineries, tankers carrying crude oil and processed oil, oil spills either intentionally or unintentionally have the potential to cause water pollution, where each oil spill in it contains heavy metals such as cadmium. AMALIA *et al*. [2016] also stated that diesel fuel spills from fishing boats, household waste, engine lubricants resulting from transportation activities and the removal of ship coatings paint are sources of contaminated Cd metals in the waters. Same cases found in Seybouse watershed, North Africa, that the anthropogenic impacts are marked by high contaminations of Meboudja wadi particularly in downstream areas of the steel factory and the nearby industrial areas. The direct industrial discharges into the water and atmosphere (iron, lead, cadmium) as well as urban disposals and agricultural activities are at the origin of contaminations [BELABED *et al*. 2017].

The Cd metal content in the water media at all Sungai Donan Cilacap stations has exceeded the threshold value according to FAO [2019], which is 0.001 mg·dm^{-3}. This is because the Donan River has been used as a dumping ground for anthropogenic activities such as waste of several types of industry, domestic and water transportation.

The Pb heavy metal content in water media showed significantly different results (*F*-test = 15.41) (Fig. 2). This is caused by the surrounding activities that produce heavy metal Pb and COD values. Increased levels of heavy metals in water are caused by the entry of industrial, mining, agricultural and domestic wastes that contain heavy metals. The waste that contains the most heavy metals is industrial waste at station II and station III. This is due to heavy metal compounds often used in industrial activities, both as raw materials, additives and catalysts [NUGRAHA 2009]. Port activity at station IV is the cause of the high Pb metal content in the waters. Fuel oil from ships in general gets additional tetraethyl containing Pb to improve quality. Heavy metal Pb as an anti-oil solver (such as Pb tetraethyl and tetramethyl) is then released into the atmosphere through a smoke removal device and this section is then dissolved in water. In addition, at station I, there are domestic activities that produce heavy metal waste which is also the cause of the entry of heavy metals in waters [IKA *et al*. 2012].

The Pb heavy metal content in the water media at all Sungai Donan Cilacap stations has exceeded the threshold according to FAO [2019], which is 0.008 mg·dm^{-3}. This is because the Donan River has been used as a dumping ground for anthropogenic activities such as waste of several types of industry, domestic and water transportation.

CONTENT OF HEAVY METAL Cd AND Pb IN SEDIMENT

The Cd heavy metal content in sediment media between stations had a significant difference (*F*-test = 5.13) (Fig. 3). This is due to differences in sources of heavy metal contamination, heavy metal content of Cd in water media, TSS and COD. Station I is still relatively natural waters. Its location is far from industry and the lack of domestic activity causes low Cd metal content in sediments at this station. Station III is an oil industry area, near settlements and used as a transportation route. This results in a high Cd metal content in sediments at station III. The activities of oil refineries, tankers carrying crude oil and processed oil, diesel spills from fishing boats, household waste, engine lubricants resulting from transportation activities and the removal of shipbuilding paints are sources of Cd metal contamination in waters [AMALIA *et al*. 2016].

The Cd metal content in water media also influences the Cd metal content in sediments. Increased heavy metals in water media will increase heavy metals in sediments

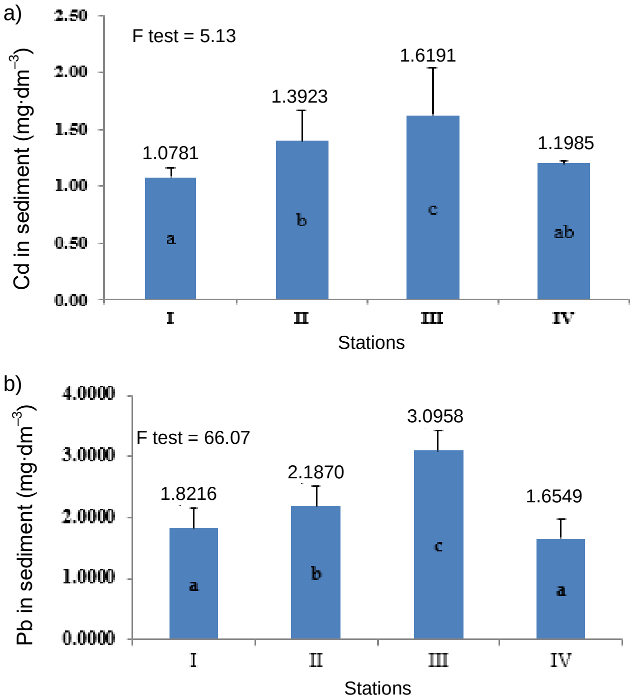

Fig. 3. Heavy metals content in sediment on the Donan River, Cilacap: a) cadmium, b) lead; a, b, c, d at bars mean homogenous groups; source: own study

because heavy metals will experience precipitation. This is consistent with the statement of NADIA *et al*. [2017], that heavy metals have properties that tend to form complexes, then bond and settle in sediments. This causes the heavy metal content in sediments to be higher than the heavy metal content in the water column.

TSS can affect the content of heavy metals in sediments. TSS at station III has a higher value than other stations. This suspended solid affects the dissolved heavy metal adsorption process. Heavy metals which are adsorption by suspended solids will go to the bottom of the water and settle, causing the heavy metal content in the sediment to be higher [RACHMAWATIE *et al*. 2009].

COD also affects the metal content of Cd in sediments. COD shows the levels of organic matter. If the COD value is high, there is a tendency that the content of heavy metals in the sediment will be high. COD measurement results show that the highest COD is at station III. According to RISTANTI *et al*. [2014], organic matter is the most important geochemical component in controlling the binding of heavy metals from estuary sediments. Metal compounds that are dissolved in water are adsorbed by particulates and are deposited in sediments. Heavy metals contained in the water column will undergo a process of combining with other compounds in the form of both organic and inorganic materials which will increase the density, then will accelerate the deposition process. The form of heavy metals bound in the sediment will be relatively more stable than in the form of ions dissolved in water [HIDAYATI *et al*. 2014]. This shows that the sediment is a place of accumulation of heavy metals in the waters.

Factors that can affect the metal content of Cd in sediments are current, organic matter content and type of sediment. Currents will affect the stirring process, sedimentation or sedimentation rate and affect the size of sediment grains deposited in the river. Heavy metals have properties that easily bind organic material and settle to the bottom of the water and bind with sediment particles, so that the concentration of heavy metals in sediments is higher than in water [KINASIH *et al.* 2015]. WARDANI *et al.* [2014] states that the type of sediment can affect the levels of heavy metals in it, with the category of heavy metal content in mud > sandy mud > sandy.

The Cd metal content in sediment media at all stations has exceeded the threshold value according to CCME [1999], which is 0.7 mg·kg^{-1}. This is because the Donan River has been used as a waste disposal site from anthropogenic activities, such as wastes of several types of industry, domestic and water transportation.

The Pb heavy metal content in sediment media between stations was significantly different (*F*-test = 66.07) (Fig. 3). This is due to the influence of activities around the station that produces Pb heavy metal waste, chemical oxygen demand (COD) and total suspended solid (TSS). The Pb heavy metal content in sediments can be influenced by anthropogenic activity around the sampling location. At station I there is domestic activity, stations II and III are industrial estates and station III is port areas. The highest Pb heavy metal content in sediments is highest at station III around the PT industry. Pertamina (oil mining). The industry is a source of Pb heavy metal pollutants in the waters of the Donan River. This is in accordance with the statement of WULANDARI [2008] the type of waste generated from the oil industry is oil sludge. Oil sludge is the residual waste oil that enters the drain. Oil sludge consists of oil (hydrocarbon), water, ash, tank rust, sand and other chemicals. The content of hydrocarbons include benzene, toluene, ethylbenzene, xylenes and metals such as lead.

TSS have an effect on increasing the content of heavy metals in sediments. The content of heavy metals will increase with increasing suspended particles. Station I total suspended solid (TSS) (279.0 mg·dm^{-3}) increased at station II and station III (302.5 mg·dm^{-3}; 312.0 mg·dm^{-3}) thereby increasing the Pb heavy metal content in sediments from the station I, station II, and station III. Particles in waters have the ability to adsorb dissolved metals. The destabilization process causes the concentration of dissolved metals in the estuary to experience a reduction (removal) and increase its concentration in the sediment [OUALI *et al.* 2018].

The increase and decrease of heavy metals in water causes an increase in metals in sediments due to the dilution, deposition and binding of organic matter [PRIANTO *et al.* 2008]. In addition there is also the influence of environmental factors and different types of sediment in each sampling. An aquatic environment will generally be found in metal compounds whose existence is influenced by environmental factors such as temperature, pH, DO and sedimentary characteristics [DARMONO 2001].

Pb heavy metal content in sediment media in the Donan Cilacap River at each station is still below the threshold (25 mg·kg^{-1}) [SEPA 2000]. This is caused by the influence of the season on the time of sediment sampling. Seasonal effects can increase the value of heavy metal content in sediment, which is low in the dry season and high in the rainy season [PRASTYO *et al.* 2017]. The high content of heavy metals in the rainy season is due to the rate of soil erosion carried into river waters [PRASTYO *et al.* 2017].

CONTENT OF HEAVY METAL Cd AND Pb IN FISH

The heavy metal content in mullets between stations had a significant difference (*F*-test = 42.11) – Figure 4. This is due to the Cd metal content in water media, Cd metal content in sediments and water temperature. Waters that have been contaminated with a heavy metal will also contaminate the fish that live in it by the heavy metal [MASRIADI *et al.* 2019]. The results of measuring the metal content of Cd in the highest water media at station III, then followed by station IV, station II and lowest at station I. The increase in heavy metals in water will be followed by an increase in heavy metals in fish. According to ARKIANTI *et al.* [2019], the levels of heavy metals contained in the body of fish are higher when compared to the levels of heavy metals found in their environment. Furthermore SUPRIYANTINI and ENDRAWATI [2015], also stated that the metals in the biota's body are in line with the concentration of metals in their environment. Water organisms take heavy metals from water bodies and concentrate them in the body up to 100–1000 times larger than their environment [IRAWATI *et al.* 2018].

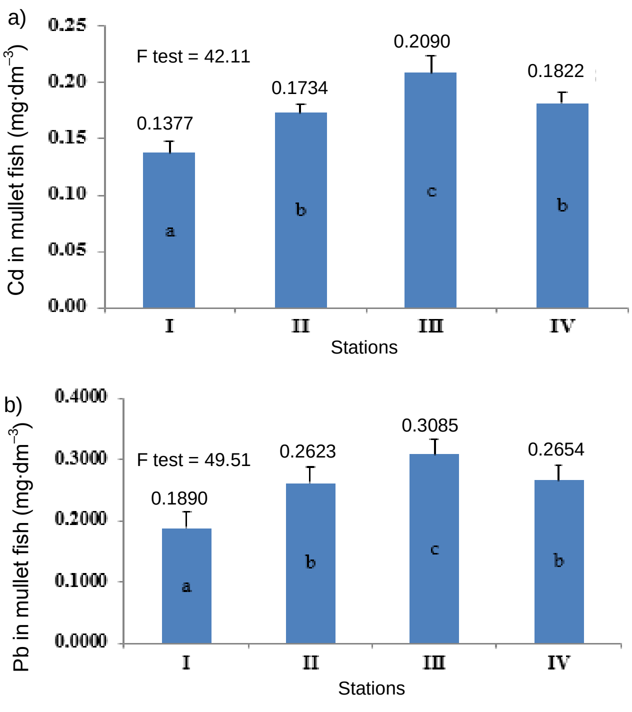

Fig. 4. Heavy metals content in mullet fish on the Donan River, Cilacap: a) cadmium, b) lead; a, b, c, d at bars mean homogenous groups; source: own study

The Cd metal content in sediments can also indirectly affect the Cd metal content in fish. Cd metal enters the body of the fish through water, sediment and food consumed by the fish. Heavy metals that enter the water will generally settle to the bottom of the water, then the metal will accumulate in sediment and detritus. If fish belong to sediment and detritus-eating groups, the chance of heavy metals to enter the body will be even greater. According to SURYONO *et al*. [2018], mullets are fish that get their food by filtering water and eating detritus that is in the mud so that the fish is easily contaminated by heavy metals contained in water or sediments.

Water temperature can also affect the metal content of Cd in mullets. The range of temperature values at station III is higher compared to other stations. Increased water temperatures tend to increase the accumulation of heavy metals in fish bodies [HANIFAH *et al*. 2019]. This is because the increase in temperature can increase the speed of metabolism and respiration, so the amount of absorption of heavy metals into the body of the fish also increases [MANULLANG *et al*. 2014].

Factors that can affect the Cd metal content in fish are fish species (size and weight weight), physical chemistry and the duration of exposure [NADIA *et al*. 2017]. Biomagnification also influences the content of heavy metals in fish's body. This is in accordance with the opinion of ARKIANTI *et al*. [2019], that the process of biomagnification in waters causes heavy metal concentrations to continue to increase. Biomagnification itself is the process by which pollutants increase in concentration with the increasing position of living things in a food chain. Heavy metals in the water and sediments are absorbed by bacteria, phytoplankton, and zooplankton, then eaten by fish.

The Cd metal content in mullets at all stations has exceeded the threshold value set by FAO/WHO [1999], which is 0.01 $mg \cdot kg^{-1}$. This is because the Donan River has been used as an anthropogenic waste disposal site, such as the waste of several types of industry, domestic and water transportation.

The correlation coefficient Pearson (R) = 0.815, shows that the Cd metal content in water media with mullet fish has a positive relationship or is directly proportional to the very strong closeness. According to HAFIZULHAQ *et al*. [2017], guidelines for providing interpretation of correlation coefficients as follows: 0.00–0.199 = very low, 0.20–0.399 = low, 0.40–0.599 = moderate, 0.60–0.799 = strong, 0.80–1,000 = very strong. Positive values on the correlation coefficient indicate that if the Cd metal content in water rises, it will be followed by an increase in the Cd metal content in mullets. This case found in Gulf Annaba polluted with lead, chopper and cadmium. The flathead grey mullet (*Mugil cephalus*) live in Gulf Annaba found that increase of metal in water significant increased in the sediment metal and a significant increase in muscle metal levels [OUALI *et al*. 2018]. This proved that pollution in the Donan River can affect the metal level in mullet.

The Pb heavy metal content in the mullet media in the Donan River Cilacap shows significantly different results (Fig. 4). The Pb heavy metal content in the mullet media between station I and station II, station I and station III, station II and station III was significantly different (P < 0.05). The difference in Pb heavy metal content in mullets can be influenced by heavy metal content in water and sediment, temperature, and tides.

The heavy metal content of Pb in water and sediment affects the heavy metal content of Pb in mullet fish. This is due to the presence of heavy metal content in water and sediments that are absorbed by bacteria, phytoplankton and zooplankton. Then the small fish eat the bacteria and plankton resulting in the accumulation of heavy metals in the body's tissues. Station III is a source of Pb metal pollutants, namely the oil mining industry, where the waste of production results flows near the sampling site. Although the content of heavy metals in the river is relatively small, it is very easy to absorb and accumulate biologically by aquatic organisms [NADIA *et al*. 2017].

The condition of waters with low salinity will reduce the chloride ion which causes inhibition of the chloride complex, so that the concentration of free heavy metals will increase. The existence of tides and movements in the waters when fish sampling also affects the high content of heavy metals in the body of the fish. If at the time of the tide fish are taken then the state of the water at that time is possible to contain high heavy metals. The existence of these tides moves the water mass horizontally, resulting in mixing [HANANINGTYAS 2017]. The difference in the heavy metal content of Pb at each station is also influenced by changes in water temperature. This is due to the increase in water temperature can increase the metabolic rate of organisms so that the bioaccumulation of organisms is greater [SAENAB *et al*. 2014].

Based on the analysis of the correlation coefficient Pearson between the content of heavy metal Pb in water and the heavy metal content of Pb in mullet fish (R = 0.671) with a coefficient of determination (R^2) of 0.449. This value indicates that 44.9% of the Pb heavy metal content in sediments is influenced by the Pb heavy metal content in water, while 55.1% is influenced by other factors. The correlation coefficient (R) shows that the relationship between Pb metal in water and mullet fish is included in the strong category.

These conditions can illustrate that heavy metal content in mullets is thought to enter the body of the fish through various transportation routes in the water [PRASTYO *et al*. 2017]. The process of absorption of Pb heavy metals by fish through three main processes namely from water through the gills, absorption from water into the surface of the body and through the food chain. The speed of absorption of heavy metals is influenced by changes in physical chemical factors such as pH, salinity, physiological characteristics and behaviour of the fish [PRABOWO 2005].

CONCLUSIONS

The heavy metal Cd and Pb in water, sediment and mullet fish (*Planiliza subviridis*) in the Donan River, Cilacap showed high levels. This is because the source of pollution from each location was very high. The levels of heavy metals Cd and Pb in the Donan River, Cilacap show results that exceed safe thresholds for human consumption due to international standard, so they must be avoided for consumption.

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