Journal of Aquaculture and Fish Health Vol. 13(2) - June 2024
P-ISSN: 2301-7309 / E-ISSN: 2528-0864
doi : 10.20473/jafh.v13i2.46862

Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap

Norman Arie Prayogo[1*], Nuning Vita Hidayati[1], Asrul Sahri Siregar[1], Purnama Sukardi[2] and Ren Fitriadi[2]

[1]Program of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Universitas Jenderal Soedirman. Jl. Dr Soeparno, Purwokerto Utara, Banyumas, Central Java 53122, Indonesia
[2]Aquaculture Study Program, Faculty of Fisheries and Marine Sciences, Jenderal Soedirman University, Jl. Dr Soeparno, North Purwokerto, Banyumas, Central Java 53122, Indonesia

*Correspondence :
norman_s2biologi@yahoo.com

Received : 2023-06-22
Accepted : 2024-02-28

Keywords :
Atomic Absorbtion Spechtrophotometry, Cadmium and cuprum, Heavy metals, Sediments, Water

Abstract

Heavy metals are widely known pollutants with a bioaccumulative nature that can be transferred and accumulated in biota, such as mullet fish (*Mugil* sp.). The heavy metals Cd and Cu have different anthropogenic and natural sources. Heavy metals can potentially absorb existing biota, such as mullet fish. Fish absorb metals from the water in the body through gills, skin surfaces, and food. This study aims to identify Cd and Cu metals in distributed water, sediment, and mullet fish in the Plawangan Timur, Segara Anakan lagoon, Cilacap, Central Java, and the relationship between aquatic media and sediment and mullet fish. The study used a research method with a targeted random sampling method at five stations with four replications. The survey was conducted from April to September 2022. The data obtained were analyzed descriptively using the ANOVA test, including F-test, regression, and correlation. The results showed that the Cd and Cu content in water, sediment, and mullet fish showed variation values between stations. The correlation between the Cd and Cu metals in water, sediment, and mullet fish showed a positive correlation with moderate to strong proximity. The content of heavy metal Cd in mullet fish media in Plawangan Timur Segara Anakan Cilacap has exceeded the specified quality standard based on the national standard of water quality, while heavy metal Cu in mullet fish is still below the specified quality standard namely 0.01 mg/dm^3.

INTRODUCTION

The lagoon in the Plawangan Timur area received input from the Donan River, the Kembang Kuning River, and the Sapuregel River (Siregar *et al.*, 2007; Subianto *et al.*, 2008). Environmental conditions in the East Plawangan area are the center of community activity in Cilacap, including PT. Solusi Bangun Indonesia Tbk., Cilacap Industrial Area (KIC), Pertamina Oil Refinery IV Cilacap Processing Unit, Sleko Port and other industries housing, agriculture and shipping routes for

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

industry, public transportation and fishing boats (Siregar *et al*., 2020). High activity in the east Plawangan area can cause a buildup of heavy metals and changes in the physical and chemical properties of the surrounding waters. In addition, increasing human activity in this region can cause anthropogenic stress and water pollution (Hidayati *et al*., 2023).

Heavy metals that end up in the water are deposited, diluted and dispersed, and then absorbed by organisms living in these waters (Murtini and Pernginangin, 2006). A settling process occurs when the industrial waste is discharged into the water. This leads to an increase in the sediment content (Begum *et al*., 2009). The heavy metal contents in sediments are generally higher than in water and biota (Tarigan and Edward, 2003). Sediment plays an important role as a buffer for compounds including Cd and Cu. Compounds in water will settle and accumulate in sediment and certain amounts can become pollutants so it is very necessary to test samples from sediment. Apart from that, sediment is an abiotic factor that can have an impact on the life of the organism within it (Yu *et al*., 2001).

The level of water pollution can be determined by analyzing the heavy metal content accumulated in aquatic biota. Heavy metal content that exceeds the safe threshold can be used as analysis data for water pollution. Analysis of the Cu and Cd metal content in the aquatic environment was carried out to determine the level of heavy metal pollution in an organism and the waters where it lives (Prastyo et al., 2017). It was further explained that the heavy metal content in water and organisms is toxic and can cause disease for those who use and consume them (Mitra et al., 2022). The impact of high Cu and Cd contents, which in high concentrations can harm biocoenosis. Heavy metals can be dispersed in water, sediments, and biomedia (Deng *et al*., 2020). According to Ellis *et al.*(1993), the distribution of heavy metals in water bodies is essentially characterized by heavy metals dispersed in biotic and abiotic elements in different amounts, which are influenced by environmental conditions. The distribution of heavy metals in water, sediments, and biomedia will continue to increase improvement the amount of heavy metals that get into the water. In addition, the distribution of heavy metals is also influenced by changes in water's physical and chemical properties.

In Plawangan Timur, Segara Anakan, Cilacap, the heavy metals have the potential to be absorbed into existing biota, such as mullet fish (Siregar *et al*., 2020). Belanak fish was chosen as an indicator because of the habit of people around the waters of East Plawangan who consume mullet fish (Putra & Rahayu, 2016). Belanak fish absorb metals from the water in the body through gills, skin surfaces, and food. The metal uptake via the gills and contaminated food is then transported through the blood and distributed throughout the body. The use of fish meat to meet animal protein sources by the surrounding community will have negative health effects. This research aims to determine the distribution content of heavy metals Cd and Cu in water media, sediments, and mullets between stations in the lagoon of Plawangan Timur Segara Anakan, Cilacap, Central Java.

METHODOLOGY

Ethical Approval

All research procedures are carried out according to standards without damaging or polluting of environment and testing laboratory.

Place and Time

This research was conducted in May-September 2022. Water, sediment, and mullet fish samples were collected in the waters of East Plawangan, Segara Anakan, Cilacap. Meanwhile, cu and cd analysis was carried out at the Aquatic Animal Interaction Laboratory, Fisheries and Marine

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

doi : 10.20473/jafh.v13i2.46862

Science Faculty, and Integrated Research, Jenderal Soedirman University.

Research Materials

Materials used in this research were Petri dish, oven (Memmert, UN55), Micropastle, microtube 1,5 eppendorf, NHO_3, H_2SO_4, aquadest, Whatman paper, bottle, atomic absorption spectrophotometer (ZA3000, Hitachi).

Research Design

The method used in this research is a survey method. The sampling technique uses purposive random sampling (representing the surrounding area) (Siregar *et al.*, 2020). The research area includes five sampling stations in the lagoon of Plawangan Timur Segara, Anakan, Cilacap, and Central Java. Sampling of water, sediment, and mullet fish was repeated three times at one-week intervals. Station I is an estuary, with Kembang Kuning River flowing into it (108096'02 "BT; 07070'04" LS), Station II is the confluence of the Sapuregel (108095'06 "East Longitude; 07071'06" LS), Station III is the confluence of the Kembang Kuning river and the Sapuregel River (108096 '05 "East Longitude; 07071'05" LS), Station IV is the confluence of the Donan River (108099'01 "BT; 07072'03" LS) and Station V is the confluence of the Kembang Kuning, Sapuregel and Donan Rivers (108098 '05 "East Longitude; 07073'05" LS). The sampling was carried out on water, sediments, and mullet fish media was performed in a composite at three points at each station, and sampling was repeated four times.

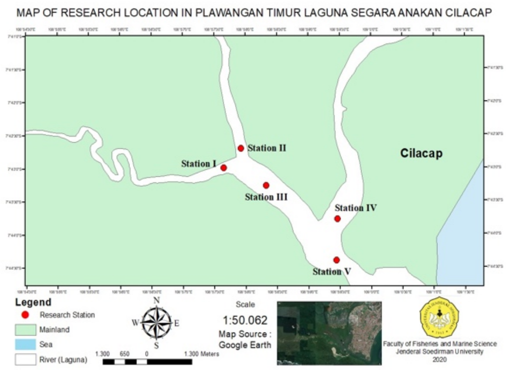

Figure 1. Map of the research areas in Plawangan Timur Laguna Segara Anakan Cilacap.

Work Procedure

Collection and Preservation of Samples for Analysis of Cd and Cu metals

Sample 600 ml of water was placed in the sample bottle, and then HNO_3 was added concentrated not less than 0.75 ml ± 250 grams sediment samples were taken with Ekman Grab at a depth of 15 to 20 cm. Fish samples were taken with a net, the meat removed and mashed, and then placed in a plastic bag. In addition, the sample is cooled in the refrigerator and analyzed in the laboratory (SNI, 2009).

Preparations Samples for Cd and Cu Analysis

100 ml of water samples were taken, put in the Erlenmeyer, and shaken until it was homogeneous. Add HNO_3 concentrated to 5 ml, heat slowly until the volume reaches 15-20 ml and the color changes from cloudy to clear. If the digestion is incomplete (not clear), 5 ml of HNO_3 is added again, concentrated, and repeated, then the sample is cooled, and 50 ml of distilled water is added. The sample obtained was then filtered with Whatman filter paper no. 40, then put into a 100 ml measuring cup and mixed with distilled water until the volume is 100 ml, the sample is ready for Atomic Absorption

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

doi : 10.20473/jafh.v13i2.46862

Spectrophotometry analysis (SNI, 2009). The sediment and mullet samples were first cleaned and dried and then mashed in a china masher. Sediment and mullet are cleaned and dried, then crushed. ± 5 g were taken and heated for 5 hours in a muffle furnace at 500 °C. The ash obtained was dissolved in 5 ml of distilled water and heated until dissolved, then transferred to a 25 ml volumetric flask and added 5 ml of 1 M HNO_3. Distilled water was given in a volume of 25 ml. The solution was filtered with Whatman no. 41. The filtrate was analyzed by AAS (SNI, 2009).

Analysis of Cd and Cu

To calculate the Cd content curve, an equation was performed, prepared with standard solutions. A standard solution of 1000 mg/L Cd was prepared by dissolving 0.18545 g of $CdSO_4$ in 100 ml of 0.1 N HNO_3. Then the solution was diluted and made in various concentrations, e.g., 0, 0.25, 0.50, 1.00, 2.00, 3.00, 4.00, and 5.00 mg/L. After that, the absorbance concentration was measured using the AAS, Perkin Elmer PinAAcle 900T, and a standard curve for Cd was obtained (Elmer, 1996; APHA, 2017).

To calculate the Cu content, perform a curve equation for heavy metal Cu prepared with standard solutions. A standard solution of Cu 1000 mg/L was prepared by dissolving 0.18545 g of CdSO4 in 100 ml of 0.1 N HNO3. Then, the solution was diluted and made in various concentrations, e.g., 0.25, 0.50, 1.00, 2.00, 3.00, 4.00, and 5.00 mg/L. After that, the absorbance concentration was measured using the AAS, Perkin Elmer PinAAcle 900T, and a standard curve for Cu was obtained (BSN, 2009).

The analysis method was validated using Canadian Certified Reference Materials (CCRM) STSD-3 for the sediments and DORM-4 certified reference material for the fish samples (National Research Council of Canada). The accuracy and precision of the analysis were ensured by analyzing the certified reference material under the same conditions. The limit of detection (LOD) for each metal was defined as the smallest mass of the compound, resulting in an S/N ratio that was equal to or greater than 3. The limit of quantitation (LOQ) was defined as the concentration in a standard yielding an S/N ratio of 10 :1. The LOD for Cd is 0.00048 mg/L for water, 0.0006 mg/g dry weight (dw) for sediment and 0.00011 mg/g dry weight (dw) while the LOD for Cu is 0.0014 mg/L for water, 0.0001 mg/g dry weight (dw) for sediment, and 0.0039 mg/g dry weight (dw) for fish.

Measurement of the Cd and Cu content

Cd metal in water, sediment, and mullet was measured by spectrometric methods and using a set of AAS instruments. Cd was detected at a wavelength of 228.8 nm with a current of 10 mA. The detector records the light absorption. The absorbance values of the sample and standard solutions appear on the AAS. Existing values form the equation of the line.

Cu concentrations in water, sediment, and whole blood dishes were measured with flame AAS using a set of AAS tools. The Cu is measured at a wavelength of 324.7 nm. The detector records the results of the lamp absorption. The same treatment is carried out with the sample for the Cu standard solution. The absorbance value of the sample and the Cu standard solution is displayed on the AAS screen along with the line equation (BSN, 2009).

Data Analysis

Data on Cu in water, sediment, and mullet were tested by statistical analysis ANOVA, F test (SPSS Statistics 2.1 Version). If the results were different, then continue with the LSD (Least Significant Difference) test. Correlation analysis was used to see the relationship between heavy metal content in water, sediment, and mullet.

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

doi : 10.20473/jafh.v13i2.46862

RESULTS AND DISCUSSIONS

Heavy Metal Content of Cd and Cu in Water Media

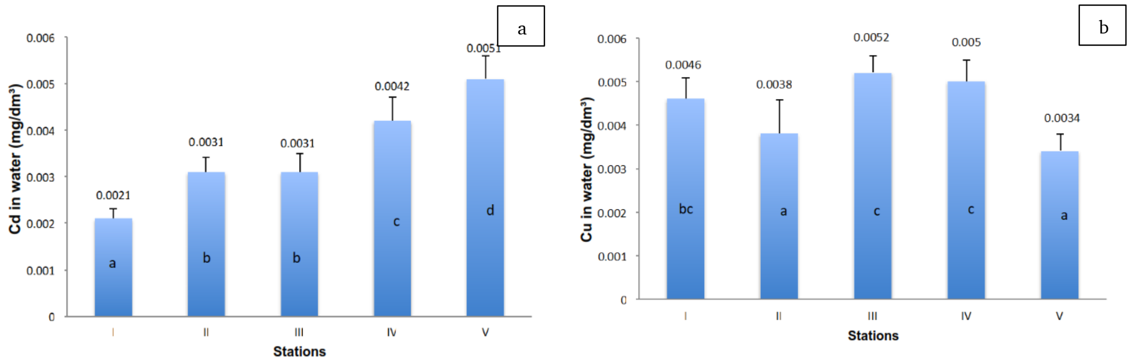

Figure 2. Heavy metals content (a) Cd, (b) Cu in water medium between stations in the lagoon of Plawangan Timur Segara Anakan, Cilacap (letters show significantly different).

The content of Cd in water media shows a different distribution pattern between the stations. The content of Cd in water media is significantly different between stations IV and V at other stations (P <0.05) (Fig.2a). This is caused by the source of the Cd contamination and environmental factors. The high content of Cd in water media at stations IV and V is related to the activities in the PT. Cement Nusantara, which includes the cement-making process and the distribution of cement raw materials, both the process of loading lime from Nusakambangan Island to the port in the industrial area of Semen Nusantara, and loading and unloading coal raw materials and production products. According to Darmono (2001), in the production process, the cement industry uses a lot of petroleum, which contains Cd from 0.03 to 2.10 mg/L, as fuel and coal, and Cd metal from 0.01 to 300.00 mg/kg as raw material.

The tides that occur with the Cd metal content from agricultural activities and household waste at stations IV and V result in high CD content in the aquatic media. The Cd metal content in agriculture comes from the use of phosphate and superphosphate fertilizers, as well as pesticides. This is in line with the statement by Darmono (2001) that phosphate fertilizers have a content of Cd ± 100 mg Cd/kg and that Cd metal is also contained in polycyclic aromatics in pesticides. In addition, Connel and Miller (1995) found that the waste from household activities contained heavy metals such as Cu, Pb, Cd, Zn, Co, Ni, and Cr.

Akbar *et al*. (2014) found the heavy metal content in water strongly depends on the source. The presence of human (anthropogenic) activities was the main source of heavy metal contamination in water. According to Marzuki (2014), crude and oil tankers, oil refineries, and accidental or deliberate oil spills can lead to water pollution, with any oil spill containing Cd. Amalia *et al*. (2016) also stated that diesel spills from household waste, engine lubricants, fishing boats, and the release of paint on the hull are sources of Cd metal contaminants in water. Accidental or intentional oil spills can lead to water pollution, with each of the oil spills containing heavy metals like cadmium. Diesel waste from fishing boats, household waste, engine lubricants from transportation activities, and the release of marine coatings are sources of Cd contamination in water. Accidental or intentional oil spills can lead to water pollution, with all oil spills containing heavy metals such as Cd.

The Cu content in water shows a different distribution pattern between the stations. Figure 2b shows that the Cu content in the water medium differs

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

significantly between stations III and IV at other stations (P <0.05). This is likely due to the difference in the amount of input and the source of the heavy Cu metal contamination. The amount of waste that contains Cu is likely to be greater at Stations III and IV due to the shipping, loading, and unloading of coal and household activities. This result is consistent with the view of Komarawidjaja *et al.* (2017) that high or low heavy metal concentrations are caused by the amount of waste in the water.

Ship transportation activities, loading and unloading activities for coal, and household activities at Stations III and IV are the most potential sources of Cu. Ship transportation activities contribute to the introduction of Cu into the water by releasing antifouling paint on the ship's hull. When loading and unloading coal, which involves moving coal from barges to bulk carriers and then to large trucks, coal falls into the water, and the concentration of Cu heavy metals in the water increases. It is believed that this leads to the concentration of Cu heavy metals in the water being higher at stations III and IV than at other stations. According to Rajeskhumar and Li (2018), high marine activity, use of antifouling paint on ships, and oil pollution from ships. Workhunpiset (2018) states that domestic waste originating from cables, wires, electrical equipment, and phosphate fertilizers can also cause high levels of Cu concentration.

Cd and Cu content in sediment

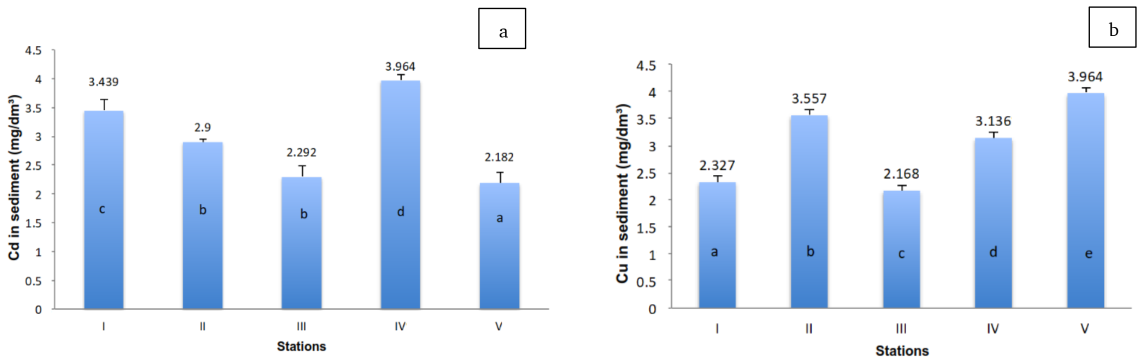

Figure 3. Content of Cd (a) and Cu (b) in the sediment between stations in the lagoon of Plawangan Timur Segara Anakan, Cilacap. (letters indicate significantly different).

The content of Cd in the sediment media shows a different distribution pattern between the stations. Figure 3a shows that the Cd in the sediment media between stations I and IV differed significantly from those of other stations (P <0.05). This is due to different sources of heavy metal contamination and environmental factors. Station I is a water transport route from the East Plawangan Area to West Plawangan (the mouth of the Kembang Kuning River). Station IV is the mouth of the Donan, an oil industrial area near residential areas that serves as a transport route. Oil refineries, tankers with crude oil and refined oil, spilled diesel from fishing boats, household waste, engine lubricants from transportation activities, and the release of paint on the hull are sources of Cd metal contamination in the aquatic environment (Amalia *et al.*, 2016). The Cd content in water also influences the Cd content in the sediment. Due to the increase in heavy metals in aquatic media, heavy metals in sediment increase as heavy metals are deposited.

The Cd content in sediments affects chemical oxygen demand (COD) values. COD indicates the content of non-biodegradable organic material. The

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

higher COD value will correlate with higher heavy metal content in the sediment. The highest COD values is at station III. According to Akbar *et al*. (2014), organic matter is the main geochemical component in controlling the binding of heavy metals in estuary sediments. Heavy metals dissolved in water are adsorbed by particles and deposited in the sediment. Heavy metals in the water column are combined with organic and inorganic materials, their density is increased, and then the deposition process is accelerated. The bond of heavy metals in sediments will be more stable than ions that dissolve in water (Hidayati *et al*., 2014).

The Cu content in the sediment media shows a different distribution pattern between stations 5, shows that the Cu content in the sediment media between stations V, IV, and II differed significantly from other stations (P <0.05). This is likely due to differences in the amount of input, the source of heavy metal contamination, and Cu and COD levels. At Station V (the confluence of the three estuaries of the Kembang Kuning, Sapuregel, and Donan Rivers), the amount of waste containing the heavy metal Cu is likely to be significant From shipping activities to loading and unloading coal to household activities. This is thought to cause the heavy metal Cu concentration at station V to be higher and significantly different than that of other stations. In line with the statement of Komarawidjaja *et al*. (2017), high or low concentrations of heavy metals are caused by the amount of waste input into the water.

In addition, the transportation activities of fishing boats, ferries, and the loading and unloading of coal in Station V are the most potential sources of Cu. Ship transportation activities bring heavy metal Cu into the water by releasing antifouling paint on the hulls of boats and ships. The loading and unloading of coal, when coal is moved from barges to bulk carriers and then onto large trucks, causes the coal to fall into the water, increasing the heavy metal Cu content in the water. According to Rajeskhumar and Li (2018), they also state that the high activity of shipping, the use of antifouling paint on ships, oil spills on ships, and the loading and unloading of coal all cause high Cu content.

The COD content at station II (mouth of the Sapuregel) was 52.9 ppm, and station V (confluence of 3 river mouths, namely Kembang Kuning, Sapuregel, and Donan) was 51.1 ppm higher than the COD content at other stations. When the COD content is high, the heavy metal content in the sediment tends to be high. According to Akbar *et al*. (2014), organic matter is the main geochemical component in controlling the binding of heavy metals from estuary sediments. Metal compounds dissolved in water are adsorbed by particles and deposited in the sediment. The heavy metals in the water column combine with other compounds in the form of organic and inorganic materials and then accelerate the precipitation. The form of the heavy metals bound in sediments is relatively more stable than the form of the ions dissolved in water (Hidayati *et al*., 2014). This shows that sediment is a place for heavy metals to accumulate in water.

The heavy metal content of Cu in water media at Station III (the confluence area of 2 estuaries, namely the Kembang Kuning and Sapuregel rivers) is lower and differs significantly from Stations II, IV, and V. Heavy metal concentrations in water influence the heavy metal concentrations in the water. Sediment, because heavy metals in the water bind to organic substances and then settle in the sediment, which increases the concentration of heavy metals in the sediment. It is believed that this leads to the Cu concentration of heavy metals in the sediment being lower in Station III and significantly different from Station IV. According to Ong *et al*. (2015), heavy metals that enter the waters will bind to organic material, which will then settle in

doi : 10.20473/jafh.v13i2.46862

the sediments. The deposition of heavy metals together with organic material will affect the quality of sediments and the levels of heavy metals in the sediments.

Cd and Cu content in mullet fish (*Mugil*)

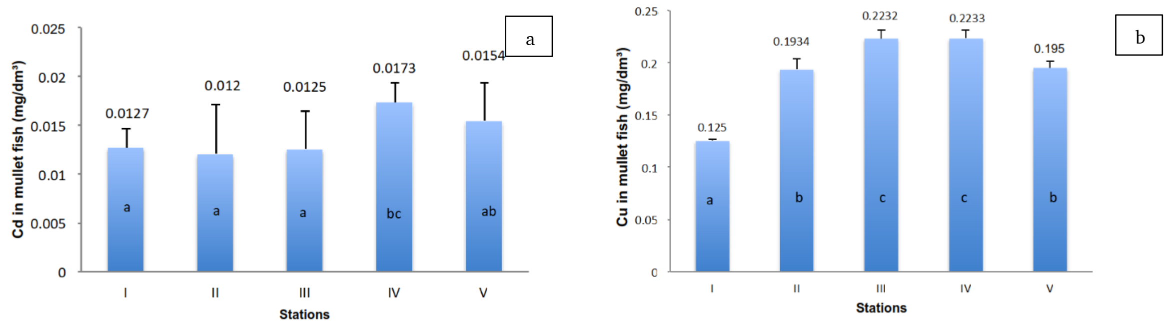

Figure 4. Content of Cd (a) and Cu (b) in the mullet fish media between stations in the lagoon of Plawangan Timur Segara Anakan, Cilacap. (letters indicate significantly different).

The Cd in mullet fish in the lagoon of Plawangan Timur Segara Anakan, Cilacap, shows a different distribution pattern between the stations. Figure 4 shows that the heavy metal content in the hardener differs significantly between station IV and other stations ($P < 0.05$). This correlated with the Cd content in the water, the Cd content in the sediment, and the water temperature. Heavy metal in water contaminates the fish living in it with the heavy metal (Masriadi *et al.*, 2019). The results of the measurement of the Cd content in the highest water medium at station IV. The increasing heavy metals in the water were followed by an increase in the heavy metals in fish. The heavy metal in fish is higher than the heavy metal in the environment (Arkianti *et al.*, 2019). In addition, Supriyantini and Endrawati (2015) stated that the metals in the body of the biota correspond to the metal concentrations in the environment. Aquatic organisms absorb heavy metals from water and accumulate in the body up to 100-1000 times higher than environment (Irawati *et al.*, 2018).

The Cd content in the sediments can influence the Cd content in fish. Cd enters into the fish body through water, sediments, and food consumed by fish. Heavy metals that enter the water generally end up at the bottom of the water and then accumulate in debris and sediments. When fish eat waste and sediment, heavy metals are more likely to get into their bodies. According to Suryono *et al.* (2018), mullet fish are fish that get their food by filtering water and eating waste in the mud, so the fish is easily contaminated by heavy metals in water and sediments.

The high Cd content in the mullet in Station IV was related to the high Cd content in the water and sediment. Palar (2004) states that Cd can exist in a stable form in water, so the Cd content in water and sediment is relatively high, which in turn is taken up and accumulated by organisms. In addition, the Cd in an organism undergoes a process of biotransformation and bioaccumulation. According to Soegianto *et al.* (2002) and Darmono (2001), Cd^{2+} metal ions dissolved in water are a form of availability (bioavailability) of Cd metal in water that water Biota can directly absorb. That being said, Cd metal is known to have the potential to harm aquatic life because it has the most significant penetration capacity in the tissue of the organism compared to other metals. The content of Cd in red mullet fish will also continue to increase as a result of the biomagnification process. This phenomenon is in line with Palar (2004), who states that the level of

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

organisms in the food chain also determines the amount of Cd that accumulates in body tissues. Organisms with higher levels usually have higher levels of Cd in the body than organisms with lower levels. The Cd content in mullet fish will also continue to increase as a result of the biomagnification process. Organisms with higher concentrations usually have higher levels of Cd in the body than organisms with lower concentrations. This shows that the level of organisms in the food chain system also determines the amount of Cd that accumulates in body tissue.

The content of Cu in mullet fish in the lagoon of Plawangan Timur Segara Anakan in Cilacap shows a different distribution pattern between the stations. Fig 4b shows that the heavy metal content in the hardener between stations III and IV differs significantly from other stations ($P < 0.05$). This is probably because the Cu concentration in the water is highest at stations III and IV compared to other stations. The heavy metal content in the water affects the heavy metal content of the mullet fish as it gets its food by filtering the water around it. This is related to the statement by Jiao *et al.* (2018) that an increase in the heavy metal content in the water is followed by an increase in the heavy metal content in the aquatic biota because heavy metals accumulate in the body of the biota via the food chain. According to Krishnakumar *et al.* (2018), different types of shellfish filter food out of water as it is fed as filter feed. Heavy metals dissolved in water can get into the body of red mullet fish, and heavy metals bound in their diet, such as phytoplankton, also accumulate in body tissue. According to Wang and Lu (2017), the ability of biota to accumulate heavy metals affects the concentration of heavy metals in the body. Hossen *et al.* (2015) stated that the ability of biota to accumulate heavy metals depends on type and will increase as the biota grows.

The content of Cd and Cu in mullets in all Plawangan Timur Segara Cilacap stations has exceeded the threshold value according to FAO (2019), which is 0.01 mg/dm^3 and 1.0 mg/dm^3.

Relationship between Cd and Cu content in aquatic media with sediment and mullet fish

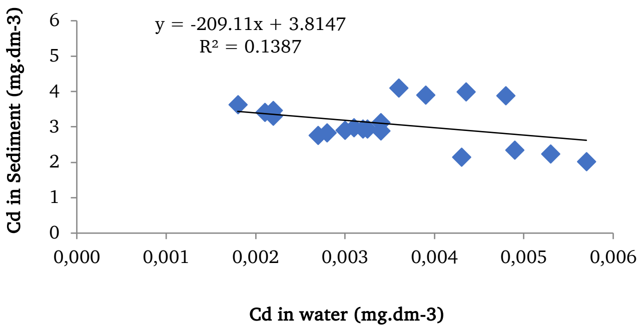

Figure 5. The relationship between the content of Cd between water and sediment medium ($R = 0.372$).

Fig. 5 shows the relationship between the Cd content in water media and sediment the equation obtained is $y=209.11x + 3.8147$. The coefficient of determination (R^2) = 0.1387, which means that the Cd metal influences 13.87% of the Cd content in the sediment in the water, while the sediment influences the remaining 86.13% of the Cd metal content in the water influences other factors. Rivers, organic matter content, and sediment type influence the Cd metal content in sediment. The current influences, the rate of sedimentation, the stirring process, and the grain size of the sediment deposited in the river. Heavy

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

metals have properties that easily bind organic substances, settle at the bottom of the water, and bind to sediment particles. The heavy metal concentration in the sediment was higher than in the water (Kinasih *et al*., 2015). Wardani *et al*. (2014) found that the type of sediment can affect the heavy metal content, with the heavy metals category included in sludge> sand sludge> sand. The correlation coefficient (R) = 0.372 indicates that the content of Cd metal in water media with sediment has a positive relationship or is directly proportional to low proximity (Hafizulhaq *et al*., 2017). A positive value for the correlation coefficient indicates that as the Cd content in the water increases, the Cd metal content in the sediment increases.

The relationship between Cd in water media with mullet fish (*P. subviridis*)

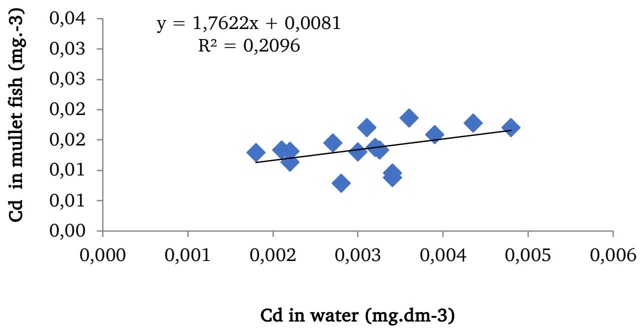

Figure 6. The relationship between the Cd content in water and mullet fish (R = 0.458).

Fig 6 shows the relationship between the content of Cd in water media with sulfur, the obtained equation is y = 1.7622x + 0.0081. The coefficient of determination (R^2) = 0.2096, which means that the Cd metal content influences 20.96% of the Cd content in the hardener in the water, while the remaining 79.04% of the Cd content are heavy metals in the hardener is influenced by other factors. Factors that can influence the content of Cd metal in fish are fish species (size and weight), water physics and chemical factors, and exposure time (Nurfitriani, 2017). Biomagnification also affects the heavy metal content in fish bodies. This is consistent with the view of Arkianti *et al*. (2019) that the biomagnification process in water ensures that heavy metal concentrations continue to rise. Biomagnification itself is a process in which the concentration of pollutants increases with the increasing position of living beings in a food chain. Heavy metals in water and sediments are absorbed by bacteria, phytoplankton, and zooplankton and then eaten by fish. The correlation coefficient (R) = 0.458 indicates that the content of Cd metal in water media has a positive relationship with Mulfish or is directly proportional to the moderate proximity (Hafizulhaq *et al*., 2017). A positive value for the correlation coefficient indicates that the higher the Cd content in the water, the higher the Cd metal content in mullet fish.

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

doi : 10.20473/jafh.v13i2.46862

Relationship between Cu in water media with sediment

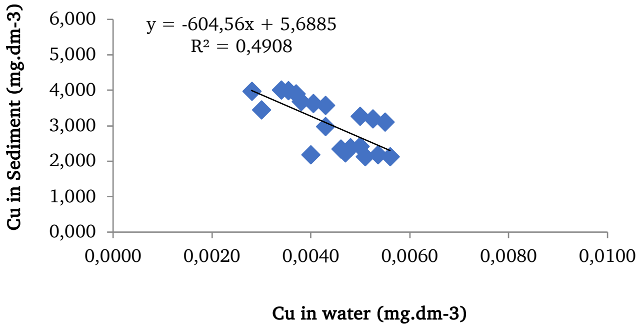

Figure 7. The relationship between the Cu content In water medium with sediment (R = 0.701).

Fig. 7 shows the relationship between the Cu content in water media and sediment, the equation obtained is y=-604,56x + 5,6885. The coefficient of determination (R^2) = 0.4908, which means that Cu influences 49.08% of the Cu metal content in the sediment in the water, while the remaining 40.92% of the Cu content in the sediment is influenced by other factors. The factors that can influence the Cu content in the sediment are rivers, organic matter content, and sediment type. The current influences the stirring process, the rate of deposition or sedimentation, and the grain size of the sediment deposited in the river. Heavy metals have properties that easily bind organic substances, settle at the bottom of the water, and bind to sediment particles. So that the heavy metal concentration in the sediment is higher than in the water (Kinasih *et al.*, 2015). Wardani *et al.* (2014) found that the type of sediment can affect the heavy metal content, with the heavy metals category included in sludge> sand sludge> sand. A positive value for the correlation coefficient indicates that as the Cu metal content in the water increases, the Cu metal content in the sediment increases with the category heavy metals in Mud> Sand Mud> Sand. The correlation coefficient (R) = 0.701 indicates that the Cu content in water media with sediment has a positive relationship or is directly proportional to the strong adhesion (Hafizulhaq *et al.*, 2017). A positive value on the correlation coefficient indicates that if the Cu content in the water increases, it will be followed by an increase in the Cd content in the sediment.

Relationship of Cu in water media with mullet fish (*Mugil* sp)

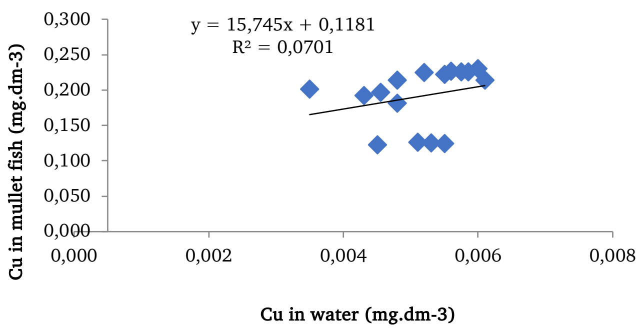

Figure 8. The relationship between the Cu content in aquatic media and mullet fish (R = 0.265).

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

Fig. 8 shows the relationship between the Cu content in water media, the obtained equation is y = 15.745x + 0.181. The coefficient of determination (R^2) = 0.0701, which means that the Cu content influences 7.01% of the Cu content in mullet fish in the water, while the remaining 92.99% of the heavy metal content is of Cu in mullet fish influenced by other factors. Factors that can influence the content of Cu in fish are fish species (size and weight), water physics and chemical factors, and exposure time (Nurfitriani, 2017). Biomagnification also affects the heavy metal content in fish bodies. This is consistent with the view of Arkianti *et al.* (2019) that the biomagnification process in water ensures that heavy metal concentrations continue to rise. Biomagnification itself is a process in which the concentration of pollutants increases with the increasing position of living beings in a food chain. Heavy metals in water and sediments are absorbed by bacteria, phytoplankton, and zooplankton and then eaten by fish. The correlation coefficient (R) = 0.265 indicates that the content of Cu in water media with mullet fish has a positive relationship or is directly proportional to low proximity (Hafizulhaq *et al*., 2017). A positive value for the correlation coefficient shows that as the Cu content in the water increases, the Cu content in mullet fish increases.

CONCLUSION

Based on the results and the discussion, various conclusions can be drawn that the content of Cd and Cu between stations in water media, sediment, and mullet fish was relatively different. The correlation between the content of Cd and Cu in water, sediment, and mullet fish in the lagoon of Plawangan Timur Segara Anakan, Cilacap, has a positive correlation with moderate to strong proximity. The content of Cd in mullet fish in Plawangan Timur Segara Anakan Cilacap has exceeded the specified quality standard, while heavy metal Cu in mullet fish is still below the specified quality standard. This is because the source of pollution from each location is very high. The levels of heavy metals Cd and Cu in East Plawangan Segara Anakan, Cilacap showed results that exceeded the safe threshold for human consumption due to international standards, so they should be avoided for consumption.

CONFLICT OF INTEREST

There is no conflict of interest in this manuscript between all authors upon writing and publishing this manuscript.

AUTHOR CONTRIBUTION

The contribution of each author is as follows: Nuning Vita Hidayati, Purnama Sukardi dan Ren Fitriadi drafting, and manuscript preparation. Norman Arie Prayogo and Asrul Sahri Siregar participated in the conception and experimental design.

ACKNOWLEDGMENT

The authors would like to thank Jenderal Soedirman University, Banyumas, Indonesia, for providing Research Program Grants for basic research in the Fiscal Year of 2021 (UNSOED Grants) as financial support for this research.

REFERENCES

Akbar, A.W., Daud, A. and Mallongi, A., 2014. Environmental risk analysis of heavy metal cadmium (Cd) in marine sediments in the coastal area of Makassar City. Thesis. Department of Environmental Health, Faculty of Health, Hasanuddin University, Makassar.

Amalia, W.R., Halang, B. and Naparin, A., 2016. Cadmium (Cd) content in the water, meat, and gill microanatomy of Kelabau fish (*Osteochillus melanopleurus*) at the mouth of the Martapura River. *National seminar procedures "Conversion of academic work into works of high economic value*". 84-92

APHA (American Public Health Association), 2017. Standard Methods for the Study of Water and Wastewater, 23ed. American Public Health Association, American Water works Association, Federation for the Aquatic Environment, Washington DC. 1546 pp.

Arkianti, N., Dewi, N.K. and Martuti, N.K.T., 2019. Heavy metal lead (Pb) content in fish in the Lamat River, Magelang Regency. *Life Science*, *8*(1), pp.54-63. https://doi.org/10.15294/lifesci.v8i1.29998

Begum, A., Krishna, H. and Khan, I., 2009. Analysis of heavy metals in water, sediments and fish samples from Madivalam lakes in Bangalore, Karnataka. *International Journal of ChemTech Research, 1*(2), pp.245-249. https://sphinxsai.com/pdf/jct_Ap_Ju_09/CT=24%20Abida%20Begum%20(245-249).pdf

BSN (National Standardization Authority). 2009. Water and wastewater - Part 8: Test method for copper (Cu) using atomic absorption spectrophotometry (SSA) -Nyala, SNI 6989.6: 2009 National Standardization Body, Jakarta.

Connell, D.W. and Miller, F.J., 1995. Pollution Chemistry and Entoxicology. Koestoes Yanti (Editor). University of Indonesia Press, Jakarta. p.520.

Darmono, 2001. Metals in the biological system of living things. University of Indonesia Press, Jakarta. p.140.

Deng, M., Yang, X., Dai, X., Zhang, Q., Malik, A. and Sadeghpour, A., 2020. Heavy metal pollution risk assessments and their transportation in sediment and overlay water for the typical Chinese reservoirs. *Ecological Indicators, 112*, 106166. https://doi.org/10.1016/j.ecolind.2020.106166

Ellis, K.V., White, G. and Warn, A.E., 1993. Surface water pollution and its control. Mac Millan, London. p.373. https://doi.org/10.1007/978-1-349-09071-6

Elmer, P., 1996. Analitycal Method Atomic Absorption Spectroscopy. Parkin-Elmer Corporation, Germany. p.515.

FAO (Food and Agriculture Organization), 2019. World Health Organization, Food and Agriculture Organization of the United Nations & International Program on Chemical Safety Expert Committee on Food Additives Geneva. ILSI. ISBN 9241561971.

Hafizulhaq, M., Haeruddin and Sedjati, S., 2017. Correlation of Pb and Cd metal concentrations with the macrozoobenthic community structure in the Plumbon River, Mangkang, Semarang, Central Java. *Management of Aquatic Resources Journal (MAQUARES), 6*(3), pp.264-273. https://doi.org/10.14710/marj.v6i3.20585

Hidayati, N.V., Kartikaputri, A.D., Hernayanti and Mahdiana, A., 2023. Water Quality and Pollution Level in Plawangan Barat, Segara Anakan, Cilacap Based on Pollution Index Approach. *Omni-Akuatika*, *19*(2), pp.147-159. http://dx.doi.org/10.20884/1.oa.2023.19.2.1045

Hidayati, N.V., Siregar, A.S., Sari, L.K. and Putra, G.Y., 2014. Estimation of heavy metal contamination levels of Pb, Cd and Cr in water and sediments in Segara Anakan Waters, Cilacap. *Omni-Aquatika, 10*(1), pp.30-39. http://dx.doi.org/10.20884/1.oa.2014.10.1.14

Hossen, M.F., Hamdan, S. and Rahman, M.R., 2015. Review on the Risk Assessment of Heavy Metals in Malaysian Clams. *The Scientific World Journal, 2015*, 905497. https://doi.org/10.1155/2015/905497

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

Irawati, Y., Lumbanbatu, D.T.F. and Sulistiono, 2018. Heavy metal totok clams (Gelonia erosa) to the east of Segara Anakan and west of the Donan River, Cilacap. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *21*(2), pp.232-242. https://doi.org/10.17844/jphpi.v21i2.22843

Jiao, Z., Li, H., Song, M. and Wang, L., 2018. Ecological risk assessment of heavy metals in water and sediments of the Pearl River Estuary, China. *IOP Conference Series: Materials Science and Engineering*, *394*, 052055. https://doi.org/10.1088/1757-899X/394/5/052055

Kinasih, A.R.N., Purnomo, P.W. and Ruswahyuni, 2015. Analysis of the relationship between sediment textures and organic materials, heavy metals (Pb and Cd) and macrozoobenthos in the Betahwalang River, Demak. *Management of Aquatic Resources Journal (MAQUARES)*, *4*(3), pp.99-107. https://doi.org/10.14710/marj.v4i3.9325

Komarawidjaja, W., Riyadi, A. and Garno, Y.S., 2017. Status of heavy metals in the coastal waters of North Aceh and Lhokseumawe City. *Journal of Environmental Technology*, *18*(2), pp.251-258. https://doi.org/10.29122/jtl.v18i2.2040

Krishnakumar, P.K., Qurban, M.A. and Sasikumar, G., 2018. Biomonitoring of trace metals in the coastal waters using bivalve molluscs. *Trace Elements: Human Health and Environment*, *153*.

Marzuki, I., 2014. Heavy metal analysis of marine sediments off the coast of Melawai, Balikpapan, East Kalimantan. *International Conference of the Indonesian Chemical Society*.

Masriadi, Patang and Ernawati, 2019. Analysis of the distribution rate of cadmium contamination (Cd) in the Jeneberang River, Gowa Regency. *Jurnal Pendidikan Teknologi Pertanian,* *5*(2), pp.14-25. https://doi.org/10.26858/jptp.v5i2.9624

Murtini, J. and Peranginangin, R., 2006. Heavy metal concentrations in Meritrix meritrix and seawater in Banjarmasin waters. *Journal of Fisheries Science,* *8*(2), pp.177-184. https://doi.org/10.22146/jfs.138

Nurfitriani, S., 2017. Bioaccumulation of heavy metal lead (Pb) in tilapia (*Oreochromis niloticus* Linn.) In ponds around the mouth of the Pangkajene River, Pangkajene Regency and Pangkep Islands. Essay. Hassanuddin University. p.62.

Ong, M.C., Joseph, B., Shazili, N.A.M., Ghazali, A. and Mohamad, M.N., 2015. Concentration of heavy metals in surface sediments on Bidong Island, South China Sea off the east coast of the Malaysian Peninsula. *Asian Journal of Earth Sciences, 8*(3), pp.74-82. http://dx.doi.org/10.3923/ajes.2015.74.82

Palar, H., 2004. Pollution and toxicology of heavy metals. Rineka Cipta, Jakarta. 152 p.

Prastyo, Y., Batu, D.T.F.L. and Sulistiono, 2017. Kandungan Logam Berat Cu dan Cd pada Ikan Belanak (*Chelon subviridis*) di Estuari Sungai Donan, Segara Anakan Timur, Cilacap, Jawa Tengah. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *20*(1), pp.18-27. https://doi.org/10.17844/jphpi.v20i1.16393

Rajeskhumar, S. and Li, X., 2018. Bioaccumulation of heavy metals in fish species from Meiliang Bay, Taihu Lake, China. *Toxicology Reports, 5,* pp.288-295. https://doi.org/10.1016/j.toxrep.2018.01.007

Siregar, A.S., Hilmi, E. and Sukardi, P., 2007. Patterns of water quality

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.

distribution in the lagoon of Segara Anakan, Cilacap. *Sains Akuatik, 10*(2), pp.127-133.

Siregar, A.S., Sulistyo, I. and Prayogo, N.A., 2020. Heavy metal contamination in water, sediments and *Planiliza subviridis* tissues in Donan, Indonesia. *Journal of Water and Land Development, 45*(IV-VI), pp.157-175. https://doi.org/10.24425/jwld.2020.133057

SNI (Indonesian National Standard), 2009. Testing of water and cadmium (Cd) and plumbum (Pb) waste with an atomic absorption spectrophotometer (AAS). National Standardization Agency-6989.16., Jakarta.

Soegianto, A., Nurtiati and Wardhani, S.I., 2002. Cadmium toxicity to shrimp *Macrobrachium sitangese* de Man. (Crustacea: Decapoda) Grown on medium with different salt content. *Jurnal MIPA Unair*, *7*(1), pp.15-18.

Subianto, Ruswahyuni and Cahyono, D.G., 2008. Composition and distribution of pelagic fish larvae in the Plawangan Estuary Timur, Segara Anakan, Cilacap. *Saintek Perikanan : Indonesian Journal of Fisheries Science and Technology, 4*(1), pp.62-68. https://doi.org/10.14710/ijfst.4.1.62-68

Supriyantini, E. and Endrawati, H., 2015. Content of heavy metal iron (Fe) in water, sediments and green shells (*Perna Viridis*) in Tanjung Emas Waters, Semarang. *Tropical Marine Journal, 18*(1), pp.38-45. https://doi.org/10.14710/jkt.v18i1.512

Suryono, C.A., Susilo, E.S., Arinianzah, A.R., Setyati, W.A., Irwani and Suryono, 2018. Copper contamination by *Mugil dussumieri* (Actinopterygii: Mugilidae, Forsskal, 1775) caught in the waters of Semarang, Indonesia. *Tropical Marine Journal, 21*(2), pp.91-96. https://doi.org/10.14710/jkt.v21i2.2402

Tarigan, Z. and Edward, 2003. Concentrations of the heavy metals Pb, Cd, Cu, Zn, and Ni in seawater and sediments in the Membramo River, Papua, related to fishing interests. *Makara Sains, 7*(3), pp.119-127. https://scholarhub.ui.ac.id/science/vol7/iss3/14/

Wang, W.X. and Lu, G., 2017. Heavy metals in bivalve mollusks. *Chemical Contaminants and Residues in Food (Second Edition),* pp.553-594. https://doi.org/10.1016/B978-0-08-100674-0.00021-7

Wardani, D.A.K., Dewi, N.K. and Utami, N.R., 2014. Accumulation of heavy metal lead (Pb) in green mussels (*Perna viridis*) in the mouth of the West Semarang Flood Canal. *Life Science, 3*(1), pp.1-8. http://journal.unnes.ac.id/sju/UnnesJLifeSci/article/view/2976

Worakhunpiset, S., 2018. Trace elements in marine sediments and organisms in the Gulf of Thailand. *International Journal for Environmental Research and Public Health, 15*(4), 810. https://doi.org/10.3390/ijerph15040810

Yu, K.C., Tsai, L.J., Chen, S.H. and Ho, T.H., 2001. Correlation analyses on binding behavior of heavy metals with sediment matrices. *Water Research*, *35*(10), pp.2417-2428. https://doi.org/10.1016/S0043-1354(00)00518-2

Cite this document as Prayogo, N.A., Hidayati, N.V., Siregar, A.S., Sukardi, P. and Fitriadi, R., 2024. Spatial Distribution Of Heavy Metals Cd And Cu In Water, Sediment, And Mullet Fish (*Mugil* sp.) In Pelawangan East Segara Anakan Cilacap. *Journal of Aquaculture and Fish Health*, *13*(2), pp.171-185.