INTL J BONOROWO WETLANDS
Volume 12, Number 2, December 2022
Pages: 56-62

P-ISSN: 2775-8052
E-ISSN: 2775-8044
DOI: 10.13057/bonorowo/w120201

Analysis of water quality and heavy metal content of chromium in water, sediment, and flesh of tilapia (*Oreochromis niloticus*) in the Premulung River, Surakarta, Central Java, Indonesia

INTAN SRI PITASARI[1], **PRABANG SETYONO**[1,2,♥], **WIRYANTO**[1]
[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: prabangsetyono@gmail.com
[2]Department of Environmental Science, Faculty of Mathematics and Natural Science, Universitas Sebelas Maret. Jl. Ir. Sutami No. 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 16 April 2022. Revision accepted: 26 July 2022.

Abstract. *Pitasari IS, Setyono P, Wiryanto. 2022. Analysis of water quality and heavy metal content of chromium in water, sediment, and flesh of tilapia (*Oreochromis niloticus*) in the Premulung River, Surakarta, Central Java, Indonesia. Intl J Bonorowo Wetlands 12: 56-62.* The river is a lotic ecosystem that plays an essential role in living things' lives, including as a habitat for aquatic organisms, drainage channels, and water sources for human needs. The Premulung River crosses the city of Surakarta, Central Java, Indonesia. The area along the Premulung River is surrounded by settlements, markets, textile industries, batik, screen printing, and hospitals, which produce waste that has the potential to pollute and degrade water quality. This study is aimed to determine the water quality and content of heavy chromium metal (Cr) in water, sediment, and tilapia meat (*Oreochromis niloticus* Linnaeus, 1758) in the Premulung River, Surakarta City, as well as the relationship between chromium content in water, in sediment and fish meat. This research was conducted by field observation at three stations of the Premulung River flows, namely under the Kleco Bridge, Griyan, and Jongke. The parameter data of temperature, TDS, pH, DO, BOD, COD, and Cr water compared to PPRI No. 82 of 2001 (class 2 water); chromium sediment compared to ANZECC Year 2000; Fish meat chromium compared to CFSA 2012. The Premulung River water quality was analyzed using the STORET method, while the Pearson correlation analyzed the relationship between chromium in water, sediment, and fish meat. The results showed that the water quality of the Premulung River in Surakarta City was moderately polluted. The heavy metal content of Premulung River chromium water (ttd to 0.0344) mg/L and chromium sediment (1.307-4.948) mg/kg still meets the standard quality, while the tilapia meat chromium (1.958-3.535) mg/kg exceeds the standard quality. The relationship between chromium water content was very strong and directly proportional (r= 0.997) with chromium fish meat, while chromium sediment with chromium fish meat was inversely proportional (r= -0.470).

Keywords: Chromium, Cr, *Oreochromis niloticus*, Premulung River, water quality

INTRODUCTION

Rivers have an essential role in the life of living things, including humans. Apart from being a drainage channel, the river can be used as a source of drinking water. However, due to human activities and rapid industrial development, domestic and industrial waste affects the river water environment, thus disrupting its designation (Krupnova et al. 2018; Primadiani et al. 2018; Yousif et al. 2021; Samudra et al. 2022).

According to Sudarmaji et al. (2006), Kapahi and Sachdeva (2019), and Sari et al. (2019), large natural waters can be contaminated by heavy metals resulting from human activities, such as domestic and industrial waste. Heavy metals that are often found in industrial waste are lead (Pb), mercury (Hg), cadmium (Cd), arsenic (As), and chromium (Cr) (Ida 2012; Palar 2012). Heavy metals will undergo a bioaccumulation process in water, sediment, and food chain flows (Yi and Zhang 2012; Bui et al. 2016).

The Premulung River crosses Surakarta City, flows from the Kartasura area of Sukoharjo Regency, and continues eastward through Kleco, Pajang, Sondakan, Tipes Villages, and finally empties into Bengawan Solo. The width of this river is between 5-12 m, with a depth of 0.7-12 m (Martini 2001). The area along the Premulung River has many residential areas and textile and batik industries. The flow of this river water is not bright and clear and often looks colored and has odors. According to Astirin et al. (2002), the Premulung River is household and industrial waste disposal. This waste potentially contains pollutants such as heavy metals. Chromium is a heavy metal pollutant due to fabric coloring activities in the textile, batik, tanning leather, and metal coating industries (Ackerley et al. 2004).

Fish accumulate heavy metals in their organs and tissues through different pathways, namely respiration, ingestion, and biological membranes (Abdulali et al. 2011; Dhanakumar et al. 2015; Abarshi et al. 2017; Ouma et al. 2019). Therefore, many studies that examine the level of metal pollution in fish consumption are related to the selection of fish as an indicator of pollution in an aquatic ecosystem despite a source of protein and omega 3 (Bhuvaneshwari et al. 2012; Laibu et al. 2018; Rajeshkumar and Li 2018).

Communities around the Premulung River watershed have fishing habits for the river fish, one of which is tilapia, to be processed into daily food. However, the consumption of fish contaminated with heavy chromium metal can cause ulcers on the nose and skin, skin hyperpigmentation, skin cancer, and renal tubular necrosis indications (Puspita et al. 2011). Based on those facts, it is necessary to research to determine water quality and heavy chromium (Cr) metal content in water, sediment, and meat of tilapia (*O. niloticus*) caught in the Premulung River, Surakarta City.

MATERIALS AND METHODS

Research time and place

The study was conducted in June 2016. The sampling of river water, sediment, and tilapia, as well as the measurement of parameters such as pH, temperature, DO, and TDS, were carried out in three sections of the Premulung River, namely Kleco Bridge (station 1), Griyan (station 2), and Jongke (station 3). In addition, BOD, COD, and heavy chromium (Cr) metal parameters were tested in the Center for Environmental Health Engineering and Disease Control (BBTKLPP) laboratory in Yogyakarta, Indonesia.

Research tools and materials

For this study, the tools are; fishing rods, buckets, transparent plastic, markers, ice boxes, and water samplers. Also, DO meters, pH meters, TDS meters, thermometers, hygrometers, Eickman grabs, bottles, Polarized Zeeman Atomic Absorption Spectrophotometry (AAS) HITACHI type Z-2000, MARS microwave digester. Other tools include a vessel, fume hood, oven, Erlenmeyer, beaker, water bath, polyethylene bottle, measuring cup, filter paper, stopwatch, funnel, micropipette, analytical balance, flakon bottle, knife, porcelain cup, and grinder.

The materials used in this study included: samples of river water, sediment, tilapia, 1,000 mg/L Cr base liquor, concentrated nitric acid (HNO_3), aquabides, aquades, and Whattman filter paper no. 42, digester solution (high and low concentrations within), sulfuric acid reagent (H_2SO_4), potassium hydrogen phthalate, standard solution, and microbial seed suspension solution.

Procedure

River water sampling

The integrated sampling method conducted the river water sampling manually, taking water samples instantaneously from different places. Water samples were taken from each station with three replications on the left edge, right, and center. Water samples were taken using a water sampler. The water sample is then put in the bottles.

Sediment sampling

Sediment sampling using the Eickman Grab was conducted by determining two plots at each station with an area of 15 cm x 15 cm and a depth of 3-5 cm (Sulistyo 2014). The sampling method is by lowering the Eickman Grab in an open and straight position, slowly falling until it feels like it has touched the riverbed. Next, the Eickman Grab was shaken to cover his mouth, then pulled back up. Finally, the Eickman grab is opened. The sediment sample is poured into a container, put in a plastic bag, and labeled according to the location code for the laboratory analysis.

Tilapia fish sampling

Tilapia samples were taken using a fishing rod. The sample of tilapia's body length was 10 to 20 cm selected. Fish samples were put in an ice box to maintain the freshness level.

Temperature measurement

The water river temperature parameters were measured directly in the field using a thermometer with Celsius (°C) units, while the air temperature was measured using a hygrometer. The thermometer is immediately immersed in the test sample and left for 2 to 5 minutes until it shows a stable value. The reading of the thermometer scale is recorded without lifting the thermometer from the water (SNI 2005).

pH measurement

The pH parameter is measured directly using a pH meter. The electrode is first calibrated. Then, the instrument is turned on, and the electrode is inserted into the sample. The numbers on the pH-meter display indicate the magnitude of the pH value (SNI 2004).

TDS measurement

The TDS parameter is measured directly using a TDS meter. The detector is first calibrated. Then, the instrument is turned on, and the detector is inserted into the sample. The number on the TDS-meter screen shows the magnitude of the TDS value in mg/L.

DO measurement

The DO parameter is measured directly using a DO meter. The detector is first calibrated. Then, the instrument is turned on, and the detector is inserted into the sample. The number on the DO-meter screen shows the DO value in mg/L.

BOD measurement

Two DO bottles were prepared, each marked with the notation A1 and A2. The sample solution was put into each bottle of DO A1 and A2 until it overflowed, then the bottle was closed carefully to avoid air bubbles forming. Shaking was carried out several times, then mineral-free water was added around the closed DO bottle mouth. Bottle A2 was stored in an incubator at 20°C ± 1°C for five days. On the other hand, dissolved oxygen was measured in the solution in bottle A1 with a calibrated DO meter. The measurement result is the value of dissolved oxygen opening (zero) day (A1). Dissolved oxygen measurements at opening days should be made no later than 30 minutes after dilution. The above process was repeated for A2 bottles, which had been incubated for five days ± 6 hours. The measurements obtained are dissolved oxygen values for five days (A2).

The sample solution preparation methods mentioned above were repeated to determine blanks using a diluent solution without a sample. The measurement results obtained are the value of dissolved oxygen for opening (zero) days (B1) and the value of dissolved oxygen for five days (B2). The same sample solution preparation was performed again to determine standard controls using a glucose-glutamic acid solution. The measurement results obtained are the value of dissolved oxygen for opening (zero) days (C1) and the value of dissolved oxygen for five days (C2). The BOD value is calculated by the BOD5 formula (SNI 2009a).

COD measurement

according to the character of the sample test, a total of 2.5 mL of the sample was diluted. Next, those samples were put into a borosilicate tube, then 1.5 mL of high or low-digesting solution and 3.5 mL of acid reagent were added until the color of the solution became orange/orange-greenish. The tube was closed and shaken slowly until homogeneous, then placed in the COD reactor, heated at a temperature of 150°C, refluxed for 2 hours, and then cooled at room temperature.

The refluxed sample was slowly cooled to room temperature to prevent the formation of a precipitate. If necessary, the cover sample is occasionally opened during the cooling process to contain gas pressure. The suspension is allowed to settle and ensure that the measured part is completely clear. The absorption sample was measured at a predetermined wavelength (600 nm). The COD value is calculated based on the linear equation of the calibration curve (SNI 2009b).

Measurement of chromium (Cr) in water

The heavy metal chromium in river water was analyzed by adding 50 mL of water sample (sample test) into a 100 mL beaker or 100 mL Erlenmeyer and 5 mL of concentrated HNO_3. Those solutions were covered with a watch glass and then heated slowly until the remaining volume was 15 mL, conducted on a fume hood. Next, while the digestion is not complete (not clear), 5 mL of concentrated HNO_3 is added, covered with a watch glass, and then heated again (not boiling). This process is repeated until all the metal dissolves, known from the color of the sample test precipitate, and becomes clear (slightly white). Afterward, the watch glass was rinsed, and the rinsed water was put into the beaker. Then the sample test was transferred to a 50 mL volumetric flask (filtered if necessary), and distilled water was added until the tera-mark was homogenized. Afterward, the absorption was read at 359.3 nm using the Atomic Absorption Spectrophotometry (AAS) instrument.

Measurement of chromium (Cr) in sediment

The sediment sample was oven-dried for 24 hours to reduce its water content, then mashed using a porcelain dish and a grinder to form a fine dry sample. A total of 0.5 g of dry sample was put in a *vessel*, 10 mL of concentrated nitric acid (HNO_3) was added, and the *vessel* was tightly closed and put in a MARS microwave digester for digestion. Furthermore, the sample was filtered to obtain 100 mL of liquid sediment sample; then, the absorbance was read at λ 359.3 nm using Flame Atomic Absorption Spectrophotometry (FAAS) flames.

Measurement of chromium (Cr) in fish meat

The fish samples were cleaned for scales; the fish meat was taken and washed with water. Next, fish meat samples were baked in an oven for 24 hours; then, the samples were mashed using a porcelain dish and a grinder to form dried fish meat samples. A total of 0.5 g of dry sample was put in a *vessel*, added 10 mL of nitric acid (HNO_3) concentration tightly closed, and put in a MARS microwave digester for the destruction process. Next, the sample was filtered to obtain 10 mL of liquid tilapia meat sample, diluted 50x. The absorbance was read at λ 359.3 using a carbon furnace Graphite Furnace Atomic Absorption Spectrophotometry (AAS) instrument.

Data analysis

The data from the measurement of temperature, pH, DO, TDS, BOD, COD, and Chromium heavy metal for each sample were compared with PPRI No. 82 of 2001 (2001). Concerning Water Quality Management and Water Pollution Control (second-class water quality standard), the PPRI stated that chromium (Cr) water standard quality is 0.05 mg/L. While the concentration of standard chromium heavy metal in the sediment compared to ANZECC (2000) was 80 mg/kg. Then the concentration of Chromium heavy metal in tilapia (*O. niloticus*) was compared with CFSA GB 2762-2012 the Year 2012 (2012). The maximum limit of Chromium heavy metal contamination in fish and its processed products is 2.0 mg/kg. Furthermore, Pearson correlation analysis was performed using the SPSS 16 program to determine the relationship between environmental parameters and chromium concentrations in water, sediment, and tilapia meat.

The determination of water quality status using the STORET method is based on the Decree of the Minister of Environment No. 115 of 2003 concerning Guidelines for Determining the Status of Water Quality. That is done by comparing the data from the measurement of water quality parameters with the quality standard according to the PPRI No. 1 water class. 82 of 2001 (2001). Score 0 if the measurement results meet the standard water quality value (measurement result ≤ standard quality). Suppose the measurement result does not meet the standard water quality (measurement result > standard quality). The overall score is shown in Table 1, presented below.

Table 1. Value system parameters to determine the water quality status

Sample amount	Score	Parameters		
		Physics	Chemistry	Biology
<10	Max	-1	-2	-3
	Min	-1	-2	-3
	Average	-3	-6	-9
≥10	Max	-2	-4	-6
	Min	-2	-4	-6
	Average	-6	-12	-18

Note: The scoring system used is the US-EPA value system which classifies water quality classes into four: Class A: very good, score = 0 (meets standard quality) (i), Class B: good, score = -1 to -10 (lightly polluted) (ii), Class C: moderate, score = -11 to -30 (moderately polluted) (iii), Class D: poor, score ≥ -31 (severely polluted) (iv)

RESULTS AND DISCUSSIONS

Water quality of Premulung River, Surakarta City

Based on the research obtained, compared with PPRI No. 82 of 2001 (2001), environmental parameter data at the sampling station are presented in Table 2.

Furthermore, the STORET method is used to determine water quality status. The results of calculating the water quality status at the three research stations according to the STORET method value are presented in Table 3.

Table 3 shows that the Premulung River water in Surakarta City is of moderately polluted water quality, with a score value of -11 to -30. There was an increase in scores from station 1, station 2, to station 3. That indicates that further downstream, there is an increase in pollution by community waste from around the Premulung River, domestic, household, hospital, and textile industry, and even batik and screen-printing wastes. This river flow often looks dirty by plastic and household organic waste such as food and vegetable residue. Some parts of the river flow look purple to black, reducing the water's aesthetics.

The heavy metal chromium (Cr) content in water, sediment, and tilapia meat

This study measured the total content of heavy metal chromium (Cr) in water, sediment, and tilapia meat in the Premulung River, Surakarta City. The average total heavy metal chromium (Cr) concentration in water, sediment, and flesh of tilapia (*O. niloticus*) is presented in Table 4.

Content of heavy metal chromium in water

Table 4 shows that heavy metal chromium content in the three stations has not exceeded the maximum chromium water threshold according to PPRI No. 82 of 2001 (2001), which is equal to 0.05 mg/L. The dilution process of rainwater influenced the chromium concentration measured in water because the day before sampling, it was raining at the research location. The amount of rainwater in the river causes the volume of the river water to increase so that the measured concentration of heavy metals is lower due to the dilution process.

The average chromium concentration in the water at station 1 usually was higher than in station 2 and station 3. This phenomenon was influenced by the Premulung River's presence, which flows from Sukoharjo Regency to Surakarta City. At station 1, the water flow was polluted by waste from residential and industrial activities, which was carried into Surakarta City. Also, there is a dam that collects water at station 1. As a result, much water-dissolved chromium is estimated to be accumulated in station 1. As a result, less water-dissolved chromium will flow to station 2 and station 3.

The heavy metal content of chromium in sediment

Table 4 shows that the chromium content in the sediment at the three stations is still far below the maximum chromium in sediment according to ANZECC (2000), which is 80 mg/kg. However, the average chromium concentration in sediment at station 3 was higher than in station 1 and station 2. That is because the waters around station 3 contain high organic matter, indicated by high levels of BOD and COD and low DO (Table 2). In the Premulung River water, which is in the weak-basal (alkaline) condition, the chromium (III) ions will form complex ingredients with organic materials and are deposited on the bottom of the river, according to Palar (2012).

The sediment at station 3 is estimated to contain high organic materials in finer particle size than station 1 and station 2, so it is strongly adsorbed to heavy metals. According to Rahardjo et al. (2014), the smaller/finer sediment particle size has a higher metal accumulation ability than the coarser particles.

Table 3. Premulung River water quality status in Surakarta City, Central Java, Indonesia, according to the STORET method

Premulung-River section	Score	Water quality
Station 1	-26	Moderately polluted
Station 2	-27	Moderately polluted
Station 3	-28	Moderately polluted

Table 2. The average measurement of environmental parameters results in the Premulung River, Surakarta City, Central Java, Indonesia

Parameters	Premulung River sections			Quality standard
	Station 1	Station 2	Station 3	
Air temperature (°C)	33.6	33.9	32.9	-
Water temperature (°C)	30.47	29.23	30.47	±3
TDS (mg/L)	223.67	264.67	270	1000
pH	7.48	7.78	7.82	6-9
DO (mg/L)	2.63	3.46	2.3	4
BOD (mg/L)	6.33	5.13	9.97	3
COD (mg/L)	23.83	24.33	28.53	25
Cr (mg/L)	0.0344	<0.0213 (ttd)	<0.0213 (ttd)	0.05

Note: * PPRI No. 82 of 2001 (2001) (Class 2 water quality)

The content of heavy metal chromium in tilapia meat

Table 4 shows the chromium content in tilapia meat at station 1 was higher than in station 2 and station 3. Tilapia caught at station 1 was primarily found in the dam area, with a large body size of an average body length of 20 cm, so it is estimated that the tilapia are mature and have lived in these waters for a long time. Therefore, those tilapias could have been exposed to chromium metal longer than stations 2 and 3, which are at juvenile stages. These juvenile tilapias are smaller, with an average body length of 14 cm and 12 cm.

According to Yi and Zhang's (2012) research, there is a positive correlation between fish body size and length with the accumulation of chromium in fish meat. Therefore, the larger fish are more tolerant of chromium than the small fish. In addition, tilapia aged 120 days were more tolerant of chromium and could accumulate 60.92 mg/kg compared to tilapia aged 60 days which only could accumulate chromium of 36.86 mg/kg (Javed and Shaukat 2013).

The content of heavy metal chromium in tilapia meat that exceeded the standard quality from the three research stations was caught at station 1 and station 2 with chromium concentrations of 3.535 mg/kg and 2.089 mg/kg. These results have not exceeded the maximum tolerance limit for tilapia. Based on research by Javed and Shaukat (2013), the lethal concentration (LC_{50}) of chromium in tilapia is 141.06 mg/L. Tilapia accumulated chromium in its body up to 66.28 mg/kg concentration.

The concentration of chromium in tilapia meat in this study has exceeded the limit for Cr metal contamination in the food, according to the China National Center for Food Safety Risk Assessment (CFSA), which is 2.0 mg/kg for fish meat. Based on this, it is necessary to consider the feasibility of tilapia caught in the Premulung River for human consumption because it was detected to contain chromium exceeding the metal contamination standard limit. That correlates with the intake of total chromium in food recommended for consumption of 30-100 g/day (Eisler 1986). Furthermore, consumption of high concentrations of fish contaminated with heavy metal chromium could cause skin ulcers, skin hyperpigmentation, skin cancer, and an indication of renal tubular necrosis (Puspita et al. 2011).

Correlation between abiotic parameters and chromium content in water, sediment, and tilapia meat

Pearson correlations between environmental parameters and chromium concentrations in water, sediment, and tilapia meat (*O. niloticus*) are presented in Table 5. This table shows a positive correlation between temperature and sediment of chromium concentration (r= 0.591) and temperature with chromium in tilapia meat (r= 0.434). The higher the temperature would lead to the higher accumulation of chromium in the sediment and fish meat. According to Mahida (1984), a 10°C temperature will increase twice the water's chemical and biological reactions. Thus, the increase in temperature causes an increase in the accumulation of heavy metals in the tissues. Temperature affects chemical reactions and metabolism in the organism's body (Odum and Barrett 2004).

TDS with concentrations of chromium in water and fish meat had a very strong negative correlation (r= -0.815) and a perfect negative correlation (r= -1.00), while chromium in sediments had a moderate positive correlation (r= 0.499). The higher the dissolved solids content in the water, the accumulation of chromium by the sediment will also increase.

According to Sulistyo (2014), the leading cause of TDS is inorganic ions in the water. Some of the chromium metal in water is a form of dissolved inorganic chromium ions, so when the TDS is higher, it is estimated that the dissolved chromium metal is higher too. The results showed a negative correlation between TDS and chromium in water. A negative correlation means a non-unidirectional relationship; when the TDS level is high, the concentration of chromium in the water will decrease, and less chromium will be absorbed in the fish's body.

Table 4. The average heavy metal chromium (Cr) concentration in water, sediment, and flesh of tilapia (*Oreochromis niloticus*)

Component	**Premulung River Section**			**Quality Standard**
	Station 1	**Station 1**	**Station 1**	
Cr water (mg/L)	0.0344	<0.0213 (ttd)	<0.0213 (ttd)	0.05*
Cr sediment (mg/kg)	1.740	1.307	4.948	80**
Cr tilapia meat (mg/kg)	3.535	2.089	1.958	2.0***

Note:* PPRI No. 82 of 2001 (2001) (class 2 water); **ANZECC (2000); *** CFSA (2012)
Not detected (ttd) for very low concentrations <0.0213 mg/L

Table 5. Pearson correlation between environmental parameters and Cr concentration in water, sediment, tilapia meat

Parameters	**Pearson correlation coefficient**		
	Cr water	**Cr sediment**	**Cr meat**
Temperature	-0.029	0.591	0.434
TDS	-0.815**	0.497	-1.000*
pH	-0.387	0.499	-0.999
DO	0.085	-0.791	-0.168
BOD	-0.139	0.991	-0.351
COD	-0.645	0.979	-0.641

Note:* significant at 0.05 level; **significantat the 0.01 level

Dissolved solids consist of organic and inorganic compounds soluble in water, minerals, and salts. Inorganic compounds that often exist in water are ions (Fardiaz 1992). According to Eisler (1986), chromium (III) is slightly soluble in water and tends to form complex compounds with negatively charged organic compounds or inorganic compounds in colloids or particles and then settle to the bottom of the water.

The chromium pH parameter in water and fish meat had a weak negative correlation (r= -0,387) and a very strong negative correlation (r= -0,999). A negative correlation means that the higher the pH value, the higher the chromium concentration in the water will decrease. Because the increasing water pH will change the stability of the carbonate to form the hydroxide, which forms metal bonds with particles in the water river to settle, and mud is formed. Increasing the water pH reduces chromium concentration in the water and fish meat.

The correlation between pH and chromium in sediments has a unidirectional correlation of 0.499, which means the higher the pH in the water, the higher concentration of chromium in the sediment will also increase. Therefore, in basal (alkaline) water conditions, chromium (III) ions will be deposited at the bottom of the river (Palar 2012).

The DO parameter strongly correlates with chromium sediment (r= -0.791), which means in waters with low dissolved oxygen levels, indicating that pollution occurs with high organic matter and lower solubility of chromium metal. The chromium metal with these organic compounds would form complex compounds with a more considerable molecular weight that will settle down to the bottom of the river.

The BOD parameter has a very strong positive correlation with sediment chromium (r= 0.991), which means that the higher the BOD level in the water, the higher the chromium concentration in the sediment. Chromium (III) forms complex compounds with organic materials that are readily adsorbed to the surface of sediment particles. BOD indicates the amount of dissolved oxygen required for the oxidation of organic matter through the degradation process of microorganisms (Fardiaz 1992). When the BOD level is high, it is indicated that the organic matter content in the waters is also high

The COD and chromium parameters in the sediment have a very strong positive correlation (r= 0.979). A positive correlation means that the relationship is unidirectional, i.e., when the COD level is high, the concentration of chromium metal in the sediment is also high. COD with chromium in water and fish meat has a strong correlation, but the value is negative/not directly (r= -0.645) and (r= -0.641). Therefore, when the COD value in the waters increases, chromium concentration will decrease, leading to less chromium being absorbed by fish.

Correlation between chromium content in water and sediment with fish meat

The Pearson correlation between chromium content in water and sediment with chromium in tilapia meat (*O. niloticus*) is presented in Table 6.

Table 6. Pearson correlation between chromium content in water and sediment with chromium in tilapia meat

Parameters	**Pearson correlation**
	Cr tilapia meat
Chromium in water	0.997*
Chromium in sediment	-0.470

Note:*significant level at 0.05

Table 6 shows that chromium content in water and tilapia fish meat has a very strong positive correlation, which means that increasing the concentration of chromium dissolved in water will significantly increase chromium concentration in fish meat. On the other hand, chromium content in the sediment and tilapia meat has a moderate negative correlation. Therefore, increasing the chromium concentration in the sediment will decrease the chromium concentration in tilapia meat.

According to Javed and Shauket's (2013) research, increasing the chromium concentration in the waters would increase the chromium concentration absorbed by fish, thereby increasing the accumulation of chromium in fish meat. That is affected by the tilapia behavior that lives floating in water rivers directly in contact with chromium dissolved in water. The fish's high mobility, especially in chromium-polluted waters, could cause an increase in the accumulation of chromium in their body tissues.

The above research could be concluded that: (i) The water quality of the Premulung River in Surakarta City is of the moderately polluted quality standard according to the STORET method. (ii) The chromium (Cr) heavy metal content in the waters of the Premulung River in Surakarta City of (ttd to 0.0344) mg/L meets the standard quality (0.05 mg/L) of PPRI No. 82 of 2001 (2001) water class 2. The sediment of (1,307- 4,948) mg/kg also meets the standard quality (80 mg/kg) of ANZECC (2000). While the tilapia meat (*O. niloticus*) of (1.958-3.535) mg/kg exceeds the standard quality (2.0 mg/kg) to CFSA (2012). (iii) The relationship between chromium content in water is very strong and directly proportional (r= 0.997) with chromium in tilapia meat (*O. niloticus*). In contrast, the relationship between chromium in sediments and the tilapia meat (*O. niloticus*) was inversely proportional (r= -0.470).

REFERENCES

Abarshi MM, Dantala EO, Mada SB. 2017. Bioaccumulation of heavy metals insome tissues of croaker fish from oil spilled rivers of Niger Delta region, Nigeria. Asian Pac J Trop Biomed 7: 563-568. DOI: 10.1016/j.apjtb.2017.05.008.

Abdulali T, Shuhaimi M, Ahmad A. 2011. Heavy metals concentration in different organs of tilapia fish (*Oreochromis niloticus*) from selected areas of Bangi, Selangor, Malaysia. Afr J Biotechnol 10 (55): 11562-11566. DOI: 10.5897/AJB11.1663.

Ackerley DF, Gonzales CF, Park CH, Blake R, Keyhan M, Martin A. 2004. Chromat reducing properties of soluble flavoprotein from *Pseudomonas putida* and *Escherichia coli*. Appl Environ Biol 70 (2): 873-882. DOI: 10.1128/AEM.70.2.873-882.2004.

Astirin OK, Setyawan AD, Harini M. 2002. Keragaman plankton sebagai indikator kualitas sungai di Kota Surakarta. Biodiversitas 3 (2): 236-241. DOI: 10.13057/biodiv/d030205. [Indonesian]

Australian and New Zealand Environment and Conservation Council (ANZECC). 2000. ANZECC interim sediment quality guidelines. Report for the Environmental Research Institute of the Supervising Scientist. Sydney, Australia.

Bhuvaneshwari R, Mamtha N, Selvam P, Rajendran RB. 2012. Bioaccumulation of metals in muscle, liver, and gills of six commercial fish species at Anaikarai Dam of River Kaveri, South India. Intl J Appl Biol Pharmac Technol 3 (1): 8-14.

Bui X, Vo T, Ngo H, Guo W, Nguyen T. 2016. Multicriteria assessment of advanced treatment technologies for micropollutants removal at large-scale applications. Sci Total Environ 563: 1050-1067. DOI: 10.1016/j.scitotenv.2016.04.191.

China National Center For Food Safety Risk Assessment (CFSA). 2012. National Food Safety Standard : Maximum levels of contaminant in food GB 2762-2012. Ministry of Health, Beijing, China.

Dhanakumar S, Solaraj G, Mohanraj R. 2015. Heavy metal partitioning in sediments and bioaccumulation in commercial fish species of three major reservoirs of river Cauvery delta region, India. Exotocol Environ Saf 113: 145-151. DOI: 10.1016/j.ecoenv.2014.11.032.

Eisler R. 1986. Chromium hazards to fish, wildlife, and invertebrates: A synoptic review. U. S. Fish Wildl Serv Biol Rep 85 (16): 1-66. DOI: 10.5962/bhl.title.11339.

Fardiaz S. 1992. Polusi Air dan Udara. Kanisius, Yogyakarta. [Indonesian]

Ida CJ. 2012. Heavy metals in Suchindramkulam (a Lentic Water Body) of Kanyakumari District, Tamil Nadu, India. J Trop Exp Biol 8 (3-4): 141-145.

Javed M, Shaukat T. 2013. Acute toxicity of chromium fot *Ctenopharyngodon idella, Cyprinus carpio,* and *Tilapia nilotica*. Intl J Agric Biol 15: 590-594.

Kapahi M, Sachdeva S. 2019. Bioremediation options for heavy metal pollution. J Health Pollut 9 (24): 191203. DOI: 10.5696/2156-9614-9.24.191203.

Krupnova TG, Mashkova IV, Kostryukova AM, Egorov NO, Gavrilkina SV. 2018. Bioconcentration of heavy metals in aquatic macrophytes of South Urals region lakes. Biodiversitas 19: 296-302. DOI: 10.13057/biodiv/d190140.

Laibu PK, Maingi J, Kebira A. 2018. Determination of bacterial composition, heavy metal contamination and physicochemical parameters of fishpondwater in Abothuguchi Central, Meru County, Kenya. Bioteknologi 15: 66-79. DOI: 10.13057/biofar/c150103.

Mahida UN. 1984. Pencemaran Air dan Pemanfaatan Limbah Industri. CV Rajawali, Jakarta.

Martini KS. 2001. Pengaruh Parameter BOD, COD, pH, Fenol, dan Bakteri Coli Pada Air Sungai Terhadap Kualitas Air Sumur di sekitar Aliran Sungai Premulung Kota Surakarta. [Thesis]. Program Pasca Sarjana, Universitas Sebelas Maret, Surakarta. [Indonesian]

Odum E, Barrett GW. 2004. Fundamentals of Ecology. 5th ed. Cengage Learning, Boston, M.A., USA

Ouma KO, Otieno SA, Sharma RR. 2019. Effects of selected heavy metals on morphology of *Oreochromis niloticus* and *Clarias gariepinus* along Ruiru River, Kenya. Bonorowo Wetlands 9: 92-107. DOI: 10.13057/bonorowo/w090204.

Palar H. 2012. Pencemaran dan Toksikologi Logam Berat. Rineka Cipta, Jakarta. [Indonesian]

Peraturan Pemerintah Republik Indonesia (PPRI) Nomor 82 Tahun 2001. 2001. Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air. Kementerian Lingkungan Hidup, Jakarta. [Indonesian]

Primadiani D, Iskandar J, Sunardi. 2018. Local knowledge of Karangwangi People of Cianjur District, West Java, Indonesia on water pollution of the Cikawung River. Asian J Ethnobiol 1: 9-14. DOI: 10.13057/asianjethnobiol/y010102.

Puspita UR, Siregar, Hidayah. 2011. Kemampuan tumbuhan air sebagai agen fitoremediator logam berat timbal (Cr) yang terdapat pada limbah cair industri batik. Berkala Perikanan Terburuk 39 (1): 58-64.

Rahardjo D, Kisworo, Suhardi. 2014. Profil Cemaran Krom Pada Air Permukaan, Sedimen, Air Tanah dan Biota serta Akumulasi Pada Rambut dan Kuku Warga Masyarakat di Sekitar Kawasan Industri Kulit Desa Banyakan, Siti Mulyo, Piyungan Bantul. Laporan Ahir LPPM Universitas Kristen Duta Wacana, Yogyakarta. [Indonesian]

Rajeshkumar S, Li X. 2018. Bioaccumulation of heavy metals in fish species from the Meiliang Bay,Taihu Lake, China. Toxicol Rep 5: 288-295. DOI: 10.1016/j.toxrep.2018.01.007.

Samudra SR, Fitriadi R, Baedowi M, Sari LK. 2022. Pollution level of Banjaran River, Banyumas District, Indonesia: A study based on the Saprobic Index of periphytic microalgae. Biodiversitas 23: 1527-1534. DOI: 10.13057/biodiv/d230342.

Sari N, Patria MP, Soesilo TEB, Tejakusuma IG. 2019. The structure of mangrove communities in response towater quality in Jakarta Bay, Indonesia. Biodiversitas 20: 1873-1879. DOI: 10.13057/biodiv/d200712.

Standar Nasional Indonesia (SNI). 2004. Tata Cara Pengambilan Contoh Dalam Rangka Pemantauan Kualitas Air Pada Suatu Daerah Pengaliran Sungai. Badan Standarisasi Nasional, Jakarta. [Indonesian]

Standar Nasional Indonesia (SNI). 2005. Cara Uji Suhu dengan Termometer. Badan Standarisasi Nasional, Jakarta. [Indonesian]

Standar Nasional Indonesia (SNI). 2009a. Cara Uji Kebutuhan Oksigen Biokimia (BOD). Badan Standarisasi Nasional, Jakarta. [Indonesian]

Standar Nasional Indonesia. 2009b. Cara Uji Kebutuhan Oksigen Kimiawi (COD) dengan Refluks Tertutup secara Spektofotometri. Badan Standarisasi Nasional, Jakarta. [Indonesian]

Sudarmaji, Mukono J, Corie IP. 2006. Toksikologi logam berat B3 dan dampaknya terhadap kesehatan. J Kesehatan Lingkungan 2 (2): 129-142. [Indonesian]

Sulistyo T. 2014. Keanekaragaman Makrobentos dan Analisis Kandungan Logam Berat (Fe, Cd) Sebagai Indikator Pencemaran Di Bengawan Solo Wilayah Surakarta. [Hon. Thesis] Jurusan Biologi Fakultas Matematika dan Ilmu Pengetahuan Alam UNS, Surakarta. [Indonesian]

Yi YJ, Zhang SH. 2012. The relationships between fish heavy metal concentrations and fish size in the upper and middle reach of Yangtze River. Proc Environ Sci 13: 1699-1707. DOI: 10.1016/j.proenv.2012.01.163.

Yousif RA, Choudhary MI, Ahmed S, Ahmed Q. 2021. Review: Bioaccumulation of heavy metals in fish and other aquatic organisms from Karachi Coast, Pakistan. Nusantara Biosci 13: 73-84. DOI: 10.13057/nusbiosci/n130111.