Bioaccumulation of Heavy Metals in Fish (Barbodes sp.) Tissues in the Brantas River, Indonesia

by Alfiah Hayati

J. Appl. Environ. Biol. Sci., 7(3)139-143, 2017

© 2017, TextRoad Publication

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Bioaccumulation of Heavy Metals in Fish (*Barbodes sp.*) Tissues in the Brantas River, Indonesia

Alfiah Hayati*, M. Maulana Abdizen, Antien Rekyan Seta, Binti Mar`atus Solikha, Nuril Maulidyah, Nureka Tiantono, Hana Widyana, Inesavira Restinastiti, Deszantara Ziky, Sugiharto, Dwi Winarni

Biology Department, Airlangga University, Surabaya, Indonesia

Received: November 12, 2016
Accepted: January 28, 2017

ABSTRACT

This study aims to determine the content of heavy metals and their effects on fish (Barbodessp) tissues in the Brantasriver. Sampling was performed three times, namely in March, June, and September 2016. The samples of fish in this research that the upstream (Reservoir Karangkates) and downstream of the Brantas river (Kali Surabaya and Kali Jagir). Fish tissues (liver, gonads, and gills) were collected, analyzed the heavy metal and tissues histopathology, stained with Haematoxylin-Eosin. The results showed that all the tissues of fish that live in the upstream and downstream of the Brantas River contain hightheavy metals (Pb and Cr). The highest levels of heavy metals found in succession in the tissues liver, gonads, and gills. Hight levels of heavy metals that damage the structure of cells and tissues of all tissues of the fish. The most damage found in tissues containing the highest levels of heavy metals. Hight of heavy metals in the cells and tissue caused damage and necrosis cells.

KEYWORDS: Brantasriver, heavy metal, liver, gonads, gills.

1. INTRODUCTION

Brantas River is located in East Java, is the second longest river in Java after the Bengawan Solo. Brantas River is a very important densely populated area in East Java, Indonesia for agriculture [1].Theriver plays a role in irrigation along the stream and is habitat for a survival of aquatic biota, including fish [2]. Determination of contamination level of heavy metals throughout the river is important and has a major role in controlling the ecological conditions of its environment [3,4]. Clean up of the contaminations caused by heavy metals based on the natural methods including use of plants such as beech leaves will result in a healthy surrounding life while leaving no negative effects [4].Biota water that serves as a provider of nutrition for the community and as biological indicators of the health of the fish that ecosistem waters [5]. In the river contaminated by heavy metals may lead to biomagnificationand bioaccumulationin the food chain of an water environment. Such contaminants transported from its sources through river system and deposited downstream. Since most of the pollutants could be mixed and became suspended in bottom sediment [6]. The presence of heavy metals in the river can lead to greater environmental problem when the contaminated sediments resuspended and such metals are uptaken by fish. Hence, consumption of such kind of fish may form a significant pathway to metals contamination in the human being and eventually poses greater health risk.

Brantasriver has detected heavy metals (Pb, Cu, Cr, and Cd). Some heavy metals in waters that enter the body organism is able to bind to receptors on the cellular level. Heavy metals are able to bind to estrogen receptors (metalloestrogens)have to be estrogenic, so it will disrupt and inhibit the function of the endocrine system [7]. In the reproductive system, the presence of heavy metals that are estrogenic can lower the reproductive capacity of the organism, if persists may lead to the extinction of an organism [8, 9, 10].

The existence of this precipitation causes the concentration of heavy metals in sediment is higher than the water above it. Presence of heavy metals in the water when it enters the body of fish can accumulate to all the tissues and tissues of fish [11, 12]. Gills and digestive tract is the first organ that is directly relatedto the heavy metal waters [13]. Furthermore, the flow of blood into the cells and tissues of the body, include the reproductive tissues [12]. Heavy metals are toxic and estrogenic can reduce the ability and the survival of fish [12]. Fish populations decline as many fish that heavy metal poisoning, if this was left unchecked can lead to extinct aquatic organisms.

The problem in this study are different levels of heavy metals (Pb and Cr) on the tissues of fish in the upstream and downstream Brantasriver, difference in levels of heavy metals can damage cells of fish in the upstream and

***Corespponding Author:** Alfiah Hayati, Biology Department, Airlangga University, Surabaya, Indonesia.
Email: alfiahayati64@yahoo.com

downstream Brantasriver. This study mainly aimed to investigate the content of heavy metals and their effects on fish (Barbodessp) tissues in the Brantasriver.

2. MATERIALS AND METHODS

The chemicals used include paraffin, alcohol, paraformaldehide solution, xylol, hematoxylin-eosin, tools sed are microtome, microwave, light microscope and inverted microscope (Olympus), and Cold Vapour Atomic Absorption Spectrophotometer (CV-AAS). Sampling was performed three times, namely in March, June and September 2016. The samples of fish*(Barbodes sp.)*collected from the upstream (reservoir Karangkates) and downstream of the Brantas river (Kali Surabaya and Kali Jagir).

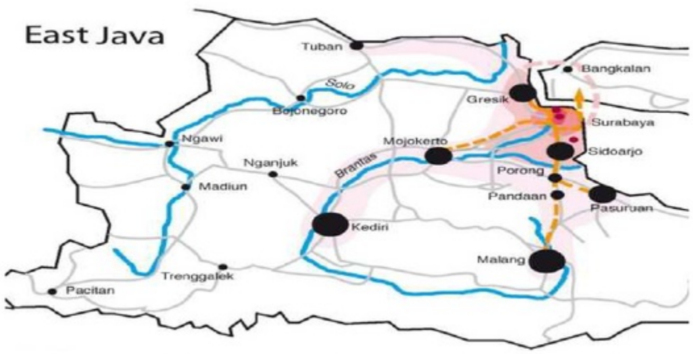

Figure 1. Sampling locations on the Brantasriver (◄)

Fish collection conducted by trawl nets. Specifications nets used to catch fish was as follows. Mesh size (mesh size) is divided into two distinct parts, namely the top and bottom. The upper part is made of yarn strings and has a mesh size of 2 cm, while the bottom nets made of nylon with mesh size 3 cm. Strings used thread size was 60. The difference in the size of the material and size of the net aims to simplify the process of catching fish. At the lower end of the net is equipped with chains bracelet made of iron and attached to each end of the net. The chain serves as ballast. Nets used has a radius of 6 m, with a net weight of approximately 20 Kg.

Fish tissues (liver, gonads, and gills) were collected, then some tissues analyzed lead(Pb) and chromium(Cr) content and others made preparations histopathology. Selected tissueswere dehydrated through graded series of ethanol, sectioned at 4-5 micrometer thickness and stained with Haematoxylin-Eosin. Measurement of levels of heavy metals in the tissues and tissues of the fish with CV-AAS method.

3. RESULTS

Concentrations of heavy metals (Pb and Cr) in the gonads, liver, and gills of fish from the upstream and downstream of the river Brantas in different species are presented in Table 1.

Table 1. Levels of heavy metals in the tissues (gonads, liver, and gills) fish in the upstream (Karang Kates reservoir) and downstream (Kali Surabaya and Kali Jagir) Brantas river

Stasion	Fish Organ	Pb (ppm)		Cr (ppm)	
		Barbodesballeroides	*Barbodesgonionotus*	*Barbodesballeroides*	*Barbodesgonionotus*
KarangKates Reservoir	Gonad	0.21 ± 0.2	0.20 ± 0.2	0.34 ± 0.5	0.28 ± 0.4
	Liver	0.16 ± 0.1	0.19 ± 0.2	0.14 ± 0.2	0.16 ± 0.1
	Gill	0.28 ± 0.3	0.41 ± 0.5	0.39 ± 0.5	0.40 ± 0.6
Kali Surabaya	Gonad	0.31 ± 0.2	0.31 ± 0.3	0.34 ± 0.4	0.36 ± 0.5
	Liver	0.26 ± 0.2	0.23 ± 0.2	0.27 ± 0.3	0.24 ± 0.3
	Gill	0.47 ± 0.5	0.41 ± 0.4	0.60 ± 0.7	0.41 ± 0.5
Kali Jagir	Gonad	0.30 ± 0.0	0.35 ± 0.2	0.25 ± 0.2	0.52 ± 0.7
	Liver	0.31 ± 0.1	0.30 ± 0.2	0.32 ± 0.4	0.26 ± 0.4
	Gill	0.50 ± 0.2	0.53 ± 0.3	0.46 ± 0.5	0.75 ± 1.1

The sensitivity of tissues of all fish species are *Barbodesballeroides* and *Barbodesgonionotus* to heavy metals (Pb and Cr) was almost the same. Accumulated Pb in the gonads of both species ranged from 0.21 to 0.35 ppm, the liver ranged from 0.16 to 0.31 ppm, and gill ranged from 0.28 to 0.53 ppm. While the highest Cr (0.75 ppm) was found on the gills *Barbodesgonionotus* that live in the waters of Kali Jagir, and the lowest (0.14 ppm) was found in the liver *Barbodesballeroides*.

The high levels of heavy metals (Pb and Cr) which accumulatingin fish tissues can disrupt endocrine function of the hypothalamic-pituitary-gonadal. Steroid hormone synthesis and secretion decreased impact on the number of cells gametes. In the gonads of fish can change the structure of cells making up the gonads include spermatogeniccells. Spermatogenic cells exposed metal can inhibit gametogenesis process so that the production of spermatozoa decreased. Toxic nature caused the metal can damage the structure of the seminiferous tubule gonads (testes).

The mechanisms by which heavy metals contaminants can affect fish reproduction are several. Some pollutants are known to influence directly the reproductive cycle of the adult fish. Pollutants accumulated in adult fish may be transported to the gonad during sexual maturation and result in a direct toxic effect on the developing gonad. High levels of heavy metals that damage fish testis (Figure 1).

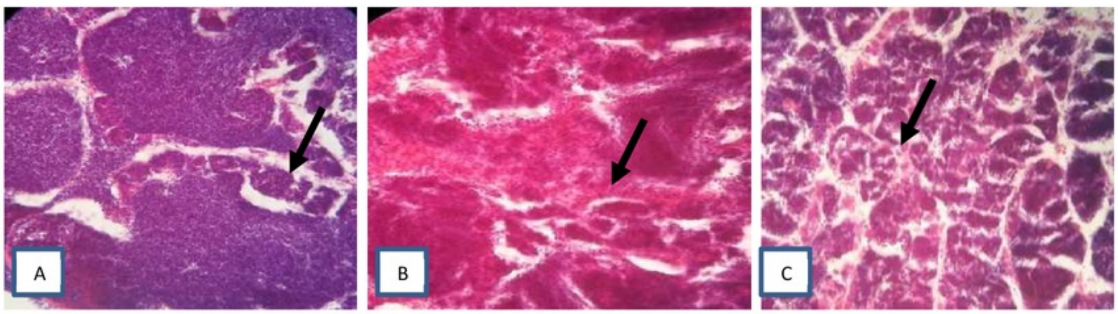

Figure 1. Structure of the gonads (testes) *Barbodessp.*in the different retrieval station, A=Karangkates reservoirstation, B=Kali Surabayastation, C=Kali Jagirstation. Testicular tubular necrotic (↓)

Heavy metals in the form of ions into the cytoplasm of liver cells through the blood stream from the gills. Heavy metal ions in the cells of the liver can increase protein synthesis metalotionin (Mt). This protein will bind to the metal to reduce metal toxicity properties in the target cell. This is because the reactive metal ions can damage cells or necrosis. Hepatic function to neutralize or detoxify toxic materials toxic caused detectable levels of heavy metals lower gonads and gills of fish. However, when the metal content is very high (exceeding quality standards), cause structural changes in constituent cells of the liver (Figure 2).

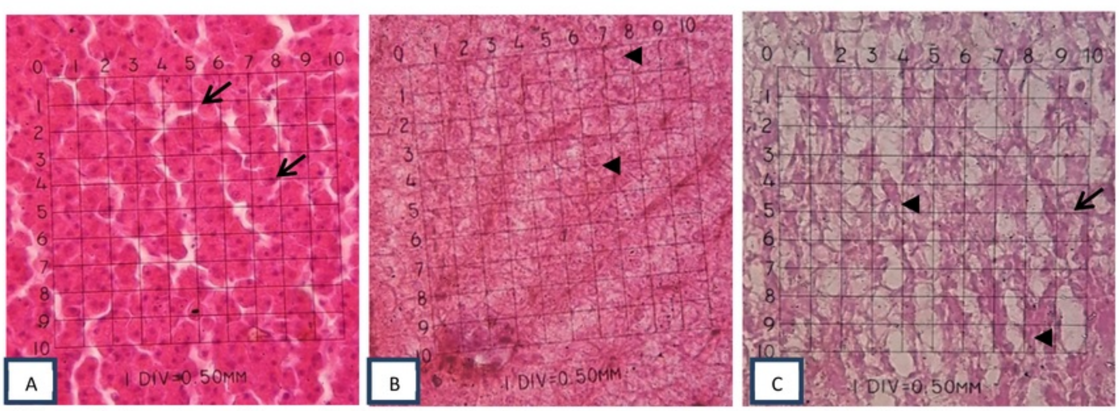

Figure 2. Structure of liver cells *Barbodessp.*in the upstream and downstream of the river Brantas. A= fish in the upstream (Karangkatesreservoir), B = downstream (Kali Surabaya), C= at river downstream (Kali Jagir). Cell necrosis (◄), cell swelling (↑)

In the gills, the heavy metal entered through primary and secondary lamella simultaneously during respiration, then streamed through the bloodstream to the tissues of the fish. The gills are exposed to the metal can damage the gill lamellae. Its toxicity causes increased cell metabolism, so that the cells to swell. But when high metals can cause the fusion of secondary lamella. This situation occurs because of the swelling lamella lamella membrane and lysis of adhesions adjacent membrane, so that the lamella fusion into one. In high concentration of the metals could damage the membrane lamella, that was causing cell death or necrosis (Figure 3).

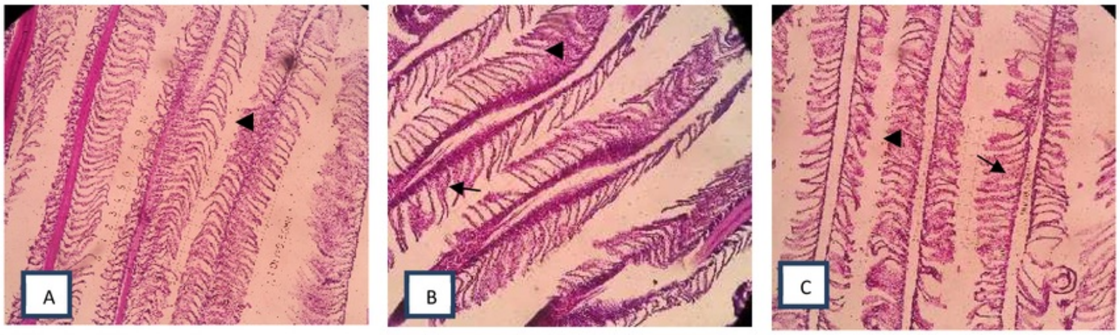

Figure 3. The secondary lamella structure of *Barbodessp.* gills on different stations, A=atKarangkates reservoir, B=at Kali Surabaya, and C=at Kali Jagir. Proliferation of filamentous epithelium and edema (black arrow), fusion between two secondary lamellae (↓)

4. DISCUSSION

Heavy metal sources in the Brantasriver from various waste industry, the settlement and agriculture also contribute to increasing the levels of heavy metals in the Brantas river [1]. Karangkatesreservoir (upstream of Brantasriver) was a reservoir of water from several small streams. Lots of places suspected of being the source of the metal in this place, among which was a reservoir used as a cultivation of freshwater fish. Of fish feed was a source of organic material that is bonded to the metal, because the metal is in the form of compounds which bind water with organic material. Brantasriver downstream, the heavy metal content was higher than the upstream area. It is thought the number of waste disposed therein, so that the river Kali Jagir a final disposal site.

Accumulated heavy metals may lead to structure alterations in the tissues of fish [14]. In order to evaluate the adverse effects of the pollutants on aquatic organisms, there is trend to using biological parameters as biomarkers in aquatic pollution monitoring. As shown in Table 1, all fish organ in the Karangkates reservoir contained the lowest heavy metals concentration, while the highest concentration in Kali Jagir. The all fish contained the lowest concentrations of heavy metals in liver, while almost all fish species showed the highest concentrations in gills. In the organ all of the fish contained the Cr higher than the Pb. The accumulation of metals in *Barbodesballeroides* and *Barbodesgonionotus* showed different in all metals. However it can be noticed that, different tissues exhibited different patterns in heavy metals accumulation. In other words, no single type of fish showed the highest metals in all tissues. The result of this study showed the concentrations of heavy metals in the tissues both species was different.

The gonads, high levels of heavy metals can lower gonadal function in reproduction. Heavy metals exert multiple adverse effects through interfering with tissues functions, generating reactive oxygen species.The presence of ROS showed that heavy metals are toxic compounds that cause environmental pollution in the water. Heavy metals into the aquatic environment can accumulate in the body of aquatic organisms. Growth, osmoregulation and reproduction of these organisms will decrease [15]. In this study, heavy metal content in the liver is smaller than in other tissues (the gonads and gills). The process whereby heavy metals accumulate in the tissues and organs of living organisms dependent species and associated with detoxification mechanisms and metabolism [16]. Detoxification mechanisms that occur in liver cells, so that the heavy metal content in the liver to decrease.

The gill was the first organ that is in direct contact with the heavy metal in the waters. This interaction occurs when fish respiration, metals enter the body along with oxygen through their gills. The damaged gills showed an arrangement of filaments in double rows and the secondary lamellae arise from primer filaments. The gills of heavy metals exposed showed degenerative changes in epithelial cells of secondry filaments, necrotic changes and fusion in secondary lamellar epithelial cells. The gills of heavy metals exposed fish showed dilation and edema in blood vessel of primary gill filament. Hyperplasia of epithelial cells between secondary lamellae led to fusion and separated from pillar system. Vacuolation and necrosis of gills lamellar epithelial cells in the damage gills. Edema and hyperplasia of lamellar epithelial cells was evident in gills of fish exposed to heavy metals. Some studies revealed that interstitial edema is one of the more frequent lesions observed in gill epithelium of fish exposed to heavy metals [14].

5. CONCLUSION

All the tissues of fish containedhight heavy metals (Pb and Cr). The highest concentration of the heavy metal was in the gills, but the lowest concentration was in the liver. The heavy metals in the gonads and liver of fish caused damage and cell necrosis. But in the gills was causedfusion, proliferation of filamentous epithelium, and edema.

6. REFERENCES

[1] Nugrahadi MS. , T. Yanagi, I. Jaenen, S. Adi, and C. Frank, 2011, Influence of Strong Monsoon-dominated Climate on Biogeochemistry of the Heavyly Anthropogenic Impacted Brantas river Estuaries and Madura Strait Coastal water, East Java, Indonesia, *J. Mar. Res. Indonesia*, 36(2): 37-49

[2] Bunn SE. and AH. Arthington, 2002, Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity, *J.Environmental Management,*30: 492-507.

[3] Singh R., N. Gautam, A. Mishra, and R. Gupta, 2011, Heavy metals and living systems, *Indian J Pharmacol*. 43(3): 246–253.

[4] Karimi M, 2012, Detecting the Level of Contaminations Causedby Heavy Metals in the Zayandeh oud Riverand Clean up by Leaves of Beech Tree, *J. Current World Environment*, 7(1): 87-91.

[5] Oliveira S.V. and R.M.V. Cortes, 2006, Environmental indicators of ecological integrity and their developmentfor running waters in northern Portugal, *Limnetica*, 25(1-2): 479-498

[6] Abdullah M.H., , J. Sidi, and AZ. Aris, 2007, Heavy Metals (Cd, Cu, Cr, Pb and Zn) in Meretrix meretrix Roding, Water and Sediments from Estuaries in Sabah, North Borneo, *J. Environmental & Science Education,* 2(3): 69 – 74

[7] Byrne C, SD. Divekar, GB. Storchan, DA. Parodi, and M. Martin, 2013, Metals and Breast Cancer, *J. Mammary Gland Biol Neoplasia*. 18 (1): 63-73

[8] Ebrahimi, M. and M. Taherianfard, 2011, The effects of heavy metals exposure on reproductive systems of cyprinid fish from Kor River, *Iranian Journal of Fisheries Sciences,*10(1)13-24.

[9] Roy S., and JC.Kalita. Identification of Estrogenic Metals in Water Bodies Around Guwahati City, Assam, India. *International Journal of ChemTech Research*. 3, (2), pp 699-702, April-June 2011

[10] Stoica A., Katzenellenbogen B. S. and Martin M., Activation of Estrogen Receptor-by the Metal Cadmium, *Molecular Endocrinology*. 2000, 14 (4): 545-553. 3.

[11] Oladunjoye RY and OO. Fafioye, 2015, Bio-Concentration of Heavy Metal Pollution in Water and Fish of Majidun River, Southwest, Nigeria, *International Journal of Life Science Research*, 3 (3):1-9.

[12] Afshan S., S. Ali, USh. Ameen, M. Farid, S. Bharwana, F. Hannan, and R. Ahmad, 2013, Effect of Different Heavy Metal Pollution on Fish, *Res. J. Chem. Env. Sci*., 2 (1): 74-79.

[13] Akan JC, S. Mohmoud, BS. Yikala, VO. Ogugbuaja, 2012, Bioaccumulation of Some Heavy Metals in Fish Samples from River Benue in Vinikilang, Adamawa State, Nigeria, *American Journal of Analytical Chemistry*, 3: 727-736

[14] Chavan VR and DV.Muley, 2014, Effect of heavy metals on liver and gill of fish Cirrhinusmrigala, *Int.J.Curr.Mic. robiol.App.Sci*. 3(5): 277-288.

[15] Annabi A., K. Said, and I. Messaoudi, 2013, Cadmium: Toxic Effects and Physiological Impairments in Fishes, International Journal of Advanced Researc, 1(3): 372-382.

[16] Jakimska A., P. Konieczka, and Krzysz, 2011, Bioaccumulation of Metals in Tissues of Marine Animals, Part I: the Role and Impact of Heavy Metals on Organisms, . *J. Environ. Stud.* Vol. 20, No. 5 (2011), 1117-1125.

Bioaccumulation of Heavy Metals in Fish (Barbodes sp.) Tissues in the Brantas River, Indonesia

ORIGINALITY REPORT

21%	16%	13%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.tandfonline.com Internet Source	3%
2	www.cwejournal.org Internet Source	2%
3	Pradip Kumar Maurya, D. S. Malik, Krishna Kumar Yadav, Neha Gupta, Sandeep Kumar. " Haematological and histological changes in fish exposed to pesticides from industrial waste water ", Human and Ecological Risk Assessment: An International Journal, 2019 Publication	2%
4	dyuthi.cusat.ac.in Internet Source	2%
5	ccmaserver.nos.noaa.gov Internet Source	2%
6	Submitted to iGroup Student Paper	2%
7	www.journal-aquaticscience.com	

Internet Source

1%

8 www.mrijournal.or.id
Internet Source

1%

9 Soil Biology, 2015.
Publication

1%

10 biotechnologicalresearch.com
Internet Source

1%

11 Walid Ben Ameur, Yassine El Megdiche, Joaquin de Lapuente, Badreddine Barhoumi et al. "Oxidative stress, genotoxicity and histopathology biomarker responses in Mugil cephalus and Dicentrarchus labrax gill exposed to persistent pollutants. A field study in the Bizerte Lagoon: Tunisia", Chemosphere, 2015
Publication

1%

12 Akan, Joseph Clement, Salwa Mohmoud, Bashir Shettima Yikala, and Victor Obioma Ogugbuaja. "Bioaccumulation of Some Heavy Metals in Fish Samples from River Benue in Vinikilang, Adamawa State, Nigeria", American Journal of Analytical Chemistry, 2012.
Publication

1%

13 N. D. Hettige, K. A. W. S. Weerasekara, S. A. M. Azmy, B. K. K. K. Jinadasa, W. D. N, Wickramarachchi. "Bioaccumulation of Trace

<1%

Metals in Cyprinus carpio (Common Carp) from Bomuruella Reservoir, Nuwara-Eliya", Journal of Environmental Professionals Sri Lanka, 2015
Publication

14	www.fulviofrisone.com Internet Source	<1%
15	Pourang, N., C. A. Richardson, S. R. N. Chenery, and H. Nasrollahzedeh. "Assessment of trace elements in the shell layers and soft tissues of the pearl oyster Pinctada radiata using multivariate analyses: a potential proxy for temporal and spatial variations of trace elements", Environmental Monitoring and Assessment, 2014. Publication	<1%
16	www.science.gov Internet Source	<1%
17	Alfiah Hayati, Hanna Pratiwi, Inayatul Khoiriyah, Dwi Winarni, Sugiharto. "Histopathological assessment of cadmium effect on testicles and kidney of Oreochromis niloticus in different salinity", AIP Publishing, 2017 Publication	<1%
18	Levent Bat, Elif Arici. "Heavy Metal Levels in Fish, Molluscs, and Crustacea From Turkish Seas and Potential Risk of Human Health", Elsevier BV, 2018	<1%

Publication

19	Ravendra Kumar Singh, Sugandha L. Chavan, Pravin H. Sapkale. "Heavy Metal Concentrations in Water, Sediments and Body Tissues of Red Worm (Tubifex spp.) Collected from Natural Habitats in Mumbai, India", Environmental Monitoring and Assessment, 2006 Publication	<1%
20	www.bioone.org Internet Source	<1%
21	jeb.co.in Internet Source	<1%
22	Ankur Jaiswal, Arpit Verma, Pallavi Jaiswal. "Detrimental Effects of Heavy Metals in Soil, Plants, and Aquatic Ecosystems and in Humans", Journal of Environmental Pathology, Toxicology and Oncology, 2018 Publication	<1%
23	Sanjeev Debipersadh, Ramganesh Selvarajan, Timothy Sibanda, Richard Naidoo. "Assessing Toxic Elemental Concentrations in Marine Fish Trachurus capensis (Cape Horse Mackerel) and Implications for Public Health", Polish Journal of Environmental Studies, 2018 Publication	<1%

Bioaccumulation of Heavy Metals in Fish (Barbodes sp.) Tissues in the Brantas River, Indonesia

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5