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Concentration of Heavy Metals Pb, Cr, and Hg in Demersal and Pelagic Fish in the Ciliwung River

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Abstract

The objective of this research was to know the concentration of Pb, Cr, and Hg in Fish in the Ciliwung River. The observation of Heavy Metals concentration in Fish showed that only Hg in internal organ of Demersal Fish was significantly different according to the location and replication ($P < 0.05$), while Heavy Metals of Pb and Cr in Demersal and Pelagic Fish were not different according to the location and replication. It means that human activities such as industrial, settlement, agriculture and transportation along the Ciliwung River affect adsorption/absorption of Hg by Fish. Generally, Pb, Cr, and Hg concentration in the internal organ of Demersal and Pelagic Fish were higher than in the Fish Meat, because internal organ are the target organ of Heavy Metals substances in Fish. In general, metal concentrations of Pb, Cr, and Hg in the meat and organs of Demersal Fish were higher than that in the meat and organs of Pelagic Fish. This was due to the activity of Demersal Fish that forage and are active in bottom waters close to sources of heavy metal pollutants (sediment). The Result of observation show that in general, the contribution of human activities in the DKI Jakarta area to the presence of Pb, Cr, and Hg in the waters, sediment and Fish of the Ciliwung River was greater than in the Bogor and Depok areas.

Keyword: *Heavy metals Pb, Cr, Hg, Demersal and Pelagic Fish, Ciliwung River*

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INTRODUCTION

The heavy metals of Lead (Pb), Chrom (Cr), and Merkuri (Hg) are widely substances used in the industrial sectors including textile, manufacturing, printing, pharmacy, pesticide, painting, heavy equipment and leathering. This industrial activities potentially contributed to the heavy metals pollution have been found located at around of Ciliwung River. Generally, the waste water coming from that industrial activities discharge to stream without treatment causing the seriously River Pollution. The discharge of that industrial waste water continously causing accumulation of heavy metals in the sediment and aquatic organism such as Plankton, Benthos, and Fish. The research on Pb, Cr, and Hg concentration in the aquatic organism are very important to know their effect on aquatic ecosystem. Due to their accumulation effects in the water environment, at the little concentration in water their will be accumulative and increasing their concentration in the sediment and making significant effect to the Plankton, Benthos, and Fish through food chain mechanism

The aim of this research is:
1. To know the concentration of Pb, Cr, and Hg in Dispersal and Pelagic Fish.
2. To know the concentration of Pb, Cr, and Hg in Fish Organs and Fish Meat.

Hypothesis:
1. Concentrations of Heavy Metals Pb, Cr, and Hg in Dispersal and Pelagic Fish significantly differ between research station;
2. Concentrations of Heavy Metals Pb, Cr, and Hg in Fish Organs and Fish Meat significantly differ between observation time;

METHOD

1. Sampling Location

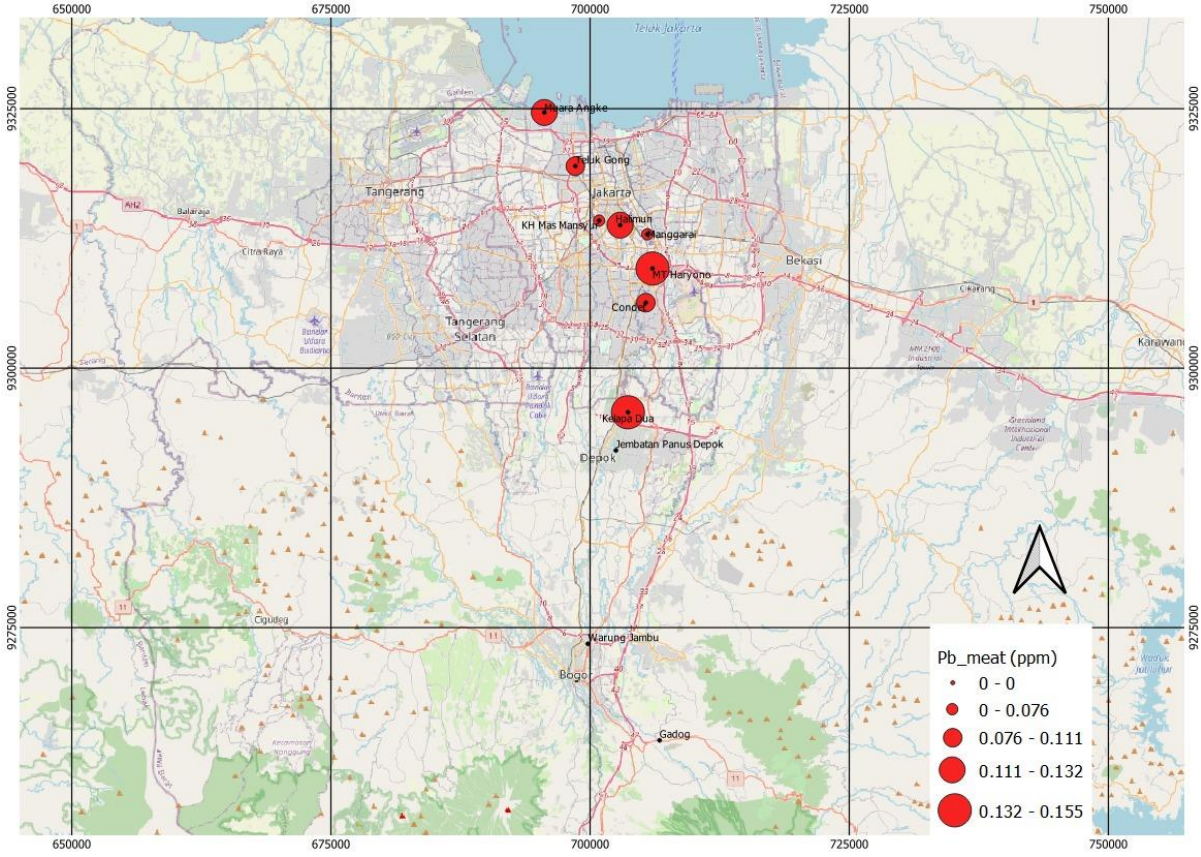
Research has been carried out at 11 observation stations from upstream to estuary divided into 4 River segment (Table 1 and Figure 1).

Table 1. Location for sampling water, sediment, Plankton, Benthos, and Fish at Ciliwung River

Station	Segment	Location	Consideration
1	1 (Upstream)	Gadog-Bogor District	Control Area
2	1 (Upstream)	Warung Jambu-Bogor City	Industrial Area
3	1 (Upstream)	Panus Bridge, Depok City	Border Area between Bogor and Jakarta
4	2 (Middlestream)	Kelapa Dua, Bogor Highway	Monitoring Station of DKI Jakarta Government
5	2 (Middlestream)	Intake PAM-Condet	Monitoring Station of DKI Jakarta Government
6	2 (Middlestream)	MT Haryono Street	Monitoring Station of DKI Jakarta Government
7	3 (Middlestream)	Manggarai Floodgate	Monitoring Station of DKI Jakarta Government
8	3 (Middlestream)	Halimun Street	Monitoring Station of DKI Jakarta Government
9	3 (Middlestream)	KH Mas Mansyur Street	Monitoring Station of DKI Jakarta Government
10	4 (Estuary)	Teluk Gong Street	Monitoring Station of DKI Jakarta Government
11	4 (Estuary)	Muara Angke	Monitoring Station of DKI Jakarta Government

Sampling to represent the rainy season was carried out in December, January, February, while sampling to represent the dry season was carried out in May, June, and July.

Figure 1. Sampling location at Ciliwung River



2. Research Materials

The materials used in this research include : samples of Fish from 11 observation stations, distilled water, formalin 4 %, glacial acetic acid, methyl alcohol 70 %, plastic bags, labels, reagent for water and heavy metal analysis such as concentrated H_2SO_4, concentrated HNO_3, $KMnO_4$, $NH_20H.Cl$, $K_2Cr_2O_7$, $SnCl_2$, and filter paper.

3. Research Tools

The equipment used in this research included: Fishing net with a diameter of 2.9 m and a net mesh of 1.5 cm, a magnifying glass, cooler box, separator funnel, vacum pump, erlenmeyer, pipette, funnel, oven, cooler, Van dorn bottle.

a. Method of Collecting Data:

Fish sample was collected using Fishing net. Samples of Fish that are still alive were brought to the laboratory for identification. Sampling of Fish were carried out every two weeks along six months (two seasons) to know wheter there is an effect of season on the level of River pollution. Identification of Fish were carried out in the laboratory of the Faculty of Biology Nasional University of Jakarta, while the analysis of Heavy Metal Concentration were carried out in the Environmental Laboratory of DKI Jakarta Government.

b. Laboratory analysis

Analysis of heavy metal concentration in Fish refers to APHA, AWWA, and WPCP (1992) in the 18th edition of the Standard Method For the Examination of Water and Wastewater.

c. Statistic analysis

To determine whether there are differences in the concentration of Heavy Metals Pb, Cr, and Hg in Demersal and Pelagic Fish, and in Fish Organs and Fish Meat at various locations and sampling times, a Randomized Block Design was used through a two way ANOVA Test (Hinkelman and Kempthorne, 2008).

RESULT

The results of the research on the concentration of Pb, Cr, and Hg in Demersal Fish of the Ciliwung River can be seen in table 2.

Table 2. The average concentration of Pb, Cr, and Hg (ppm) in the Demersal Fish of the Ciliwung River according to sampling locations

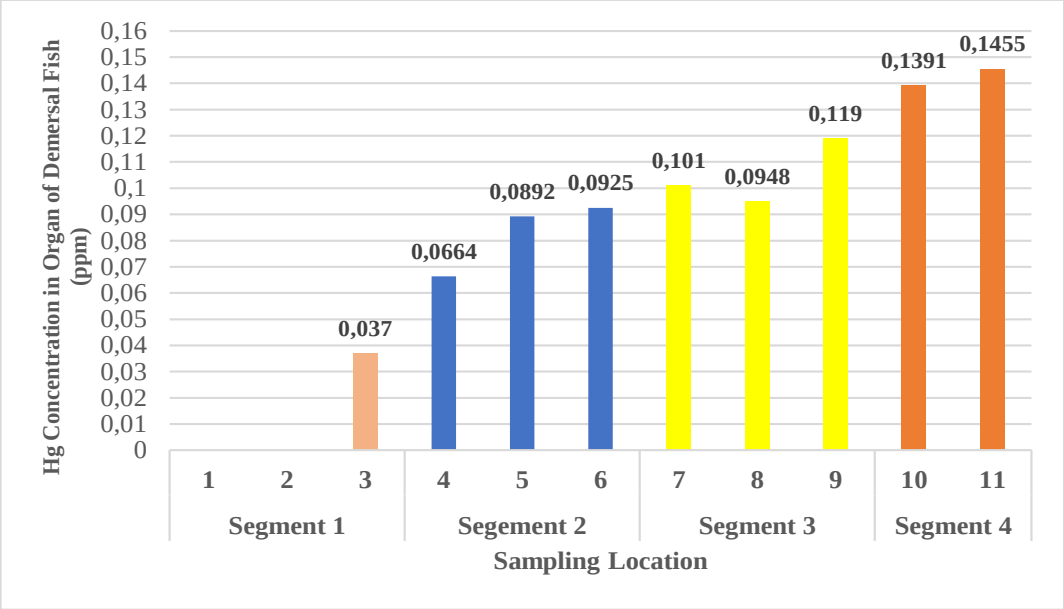
Heavy Metals	**Sampling Locations**										
	St. 1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10	St.11
Meat											
Pb	nd	nd	nd	0.1412	0.1039	0.1552	0.0665	0.1131	0.0757	0.1111	0.1324
Cr	nd	nd	nd	0.1394	0.1851	0.2052	0.1259	0.2482	0.1307	0.1694	0.1379
Hg	nd	nd	0.0320	0.0332	0.0853	0.0729	0.0754	0.0806	0.0809	0.1046	0.1267
Organ											
Pb	nd	nd	nd	0.1102	0.1205	0.1899	0.1062	0.0988	0.1072	0.1226	0.1444
Cr	nd	nd	nd	0.2176	0.5055	0.3150	0.2156	0.2622	0.2794	0.2757	0.2571
Hg	nd	nd	0.0370	0.0664	0.0892	0.0925	0.1010	0.0948	0.1190	0.1391	0.1455

Note: St.1 = Gadog-Bogor District
St.2 = Warung Jambu, Bogor City
St.3 = Panus Bridge, Depok City
St.4 = Kelapa Dua, Bogor Street
St.5 = Intake PAM Condet
St.6 = MT Haryono Street
St.7 = Manggarai floodgate
St.8 = Halimun Street
St.9 = KH Mas Mansyur Street
St.10 = Teluk Gong Street
St. 11 = Muara Angke
nd = not detected

Based on table 2, it seems that heavy metals Pb, Cr, and Hg in organ and meat of Demersal Fish were detected on Station 3 (Panus Bridge, Depok City), while on Station 1 (Gadog-Bogor District) and Station 2 (Warung Jambu, Bogor City) were not found of Demersal Fish.

The results of ANOVA showed that the concentrations of Pb, Cr, and Hg in meat of Demersal Fish of the Ciliwung River were not significantly different between research locations ($P > 0.05$). Concentration of Pb and Cr in organ of Demersal Fish were not significantly different, ($P > 0.05$), while concentration of Hg in organ of Demersal Fish was significantly different ($P < 0.05$) as shown in Figure 2.

Figure 2. Average concentration of Hg in Organ of Demersal Fish of the Ciliwung River by sampling location



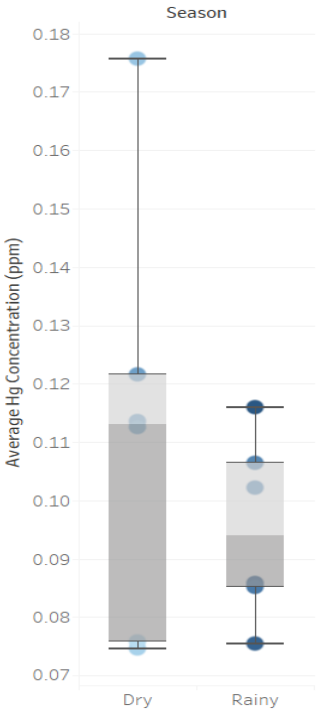
The results of the Research on the concentrations of Pb, Cr, and Hg in Demersal Fish of the Ciliwung River according to replications can be seen in table 3.

Table 3. The average concentration of Pb, Cr, and Hg (ppm) in Demersal Fish of the Ciliwung River by season

Heavy Metal	Season and Replication											
	Dry						Rainy					
	1	2	3	4	5	6	7	8	9	10	11	12
Meat												
Pb	0.0487	0.0991	0.1414	0.0816	0.0779	0.1401	0.0645	0.0611	0.0686	0.0954	0.1230	0.3520
Cr	0.1120	0.1279	0.1607	0.1577	0.1410	0.2807	0.0801	0.0921	0.1377	0.2926	0.2107	0.2639
Hg	0.0670	0.0687	0.0868	0.0890	0.1004	0.1097	0.0881	0.0782	0.0666	0.0753	0.0659	0.0704
Organ												
Pb	0.2470	0.0860	0.1375	0.1636	0.0875	0.0883	0.0786	0.0656	0.0840	0.0857	0.1479	0.2080
Cr	0.3698	0.1250	0.3095	0.2735	0.2702	0.2143	0.6164	0.2802	0.1741	0.2886	0.2087	0.3373
Hg	0.0758	0.0746	0.1757	0.1125	0.1135	0.1216	0.1021	0.1064	0.0851	0.0858	0.0754	0.1159

The results of ANOVA showed that the concentration of Pb, Cr, and Hg in Meat of Demersal Fish in the Ciliwung River according to replication were not significantly different ($P > 0.05$). Concentration of Pb and Cr in organ of Demersal Fish in the Ciliwung River according to replication were not significantly different ($P > 0.05$), while concentration of Hg in organ of Demersal Fish it was significantly different according to replication ($P < 0.05$). It can be seen in figure 3. It showed that average concentration of Hg in dry season was higher and more varied.

Figure 3. Average concentration of Hg in Organ of Demersal Fish in the Ciliwung River according to season



The results of the research on the concentrations of Pb, Cr, and Hg in Pelagic Fish in the Ciliwung River according to the station can be seen in table 4.

Table 4. Average concentrations of Pb, Cr, and Hg (ppm) in Pelagic Fish in the Ciliwung River according to the sampling locations

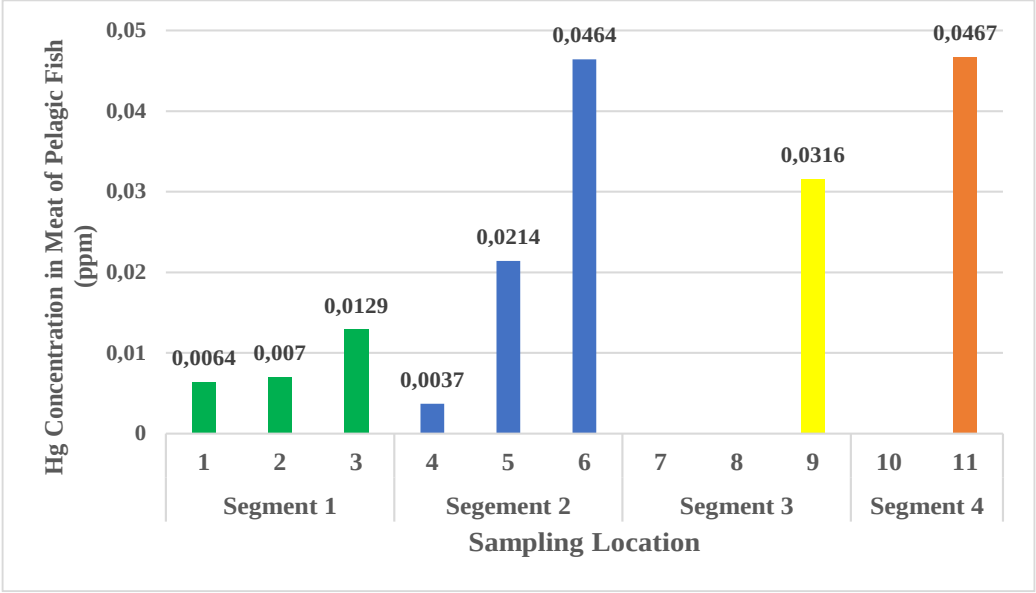
Heavy Metal	**Sampling Locations**										
	St. 1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10	St.11
Meat											
Pb	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	-	0.0310	-	0.0527
Cr	0.0000	0.0452	0.0435	0.0000	0.1823	0.1070	-	-	0.0140	-	0.0983
Hg	0.0064	0.0070	0.0129	0.0037	0.0214	0.0464	-	-	0.0316	-	0.0467
Organ											
Pb	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	-	0.0317	-	0.0710
Cr	0.0155	0.4470	0.0782	0.0000	0.1450	0.1620	-	-	0.0890	-	0.1013
Hg	0.0085	0.0091	0.0172	0.0042	0.0286	0.0598	-	-	0.0442	-	0.0920

Note: St.1 = Gadog-Bogor District
St.2 = Warung Jambu, Bogor City
St.3 = Panus Bridge, Depok City
St.4 = Kelapa Dua, Bogor Street
St.5 = Intake PAM Condet
St.6 = MT Haryono Street
St.7 = Manggarai floodgate
St.8 = Halimun Street
St.9 = KH Mas Mansyur Street
St.10 = Teluk Gong Street
St. 11 = Muara Angke
- = no data

Statistical test results (Anova) showed that the concentrations of Pb dan Cr in Meat of Pelagic Fish in the Ciliwung River were not significantly different between the sampling locations (P>0.05),

while for Hg was significantly different (P<0.05). For more details can be seen in Figure 4. Otherwise, concentration of Pb, Cr, and Hg in organ of Pelagic Fish were not significantly different (P>0.05).

Figure 4. Average concentration of Hg in Meat of Pelagic Fish in the Ciliwung River according to sampling location



The results of the research on the concentrations of Pb, Cr, and Hg in Pelagic Fish in the Ciliwung River according to replications can be seen in table 5.

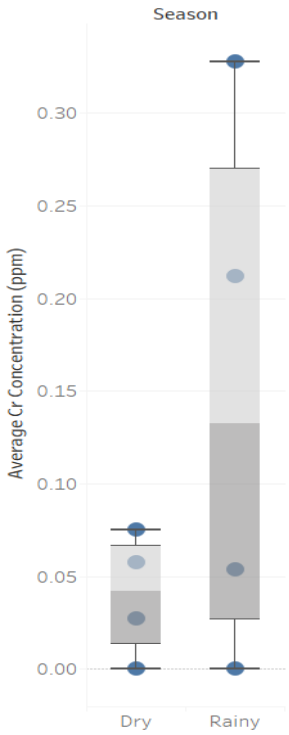
Table 5. Average concentrations of Pb, Cr, and Hg (ppm) in Pelagic Fish in the Ciliwung River by season

Heavy Metals	Season and Replication											
	Dry Season						Rainy Season					
	1	2	3	4	5	6	7	8	9	10	11	12
Meat												
Pb	0.0000	0.0310	0.0000	0.0190	0.0000	0.0000	0.0600	0.0000	0.0000	0.0000	0.0000	-
Cr	0.0574	0.0272	0.0000	0.0000	0.0750	0.0000	0.2120	0.0000	0.3280	0.0000	0.0535	-
Hg	0.0136	0.0225	0.0161	0.0249	0.0208	0.0241	0.0263	0.0027	0.0383	0.0075	0.0301	-
Organ												
Pb	0.0000	0.0317	0.0000	0.0405	0.0000	0.0000	0.0660	0.0000	0.0000	0.0000	0.0000	-
Cr	0.0544	0.0595	0.5123	0.0520	0.0950	0.0420	0.4575	0.0000	0.3370	0.0000	0.1005	-
Hg	0.0190	0.0590	0.0199	0.0314	0.0318	0.0294	0.0276	0.0041	0.0473	0.0084	0.0386	-

Note: - = no data

Statistical results showed that the concentrations of Pb, Cr, and Hg in organ of Pelagic Fish in the Ciliwung River were not significantly different between months (P > 0.05). Concentration of Pb and Hg in Meat of Pelagic Fish in the Ciliwung River also were not significantly (P > 0.05), while for Cr it was significantly different (P < 0.05). For more details can be seen in figure 5. It showed that average concentration of Cr in rainy season was higher and more varied.

Figure 5. Average concentration of Cr in Meat of Pelagic Fish in the Ciliwung River according to seasons



DISCUSSION

Based on Figure 2, it can be seen that in the upstream (segment 1) concentration Hg in organ of Demersal Fish was detected at station 3 (Panus Bridge, Depok City). At segment 2 showed that increasing concentration Hg in organ of Demersal Fish sharply. It showed that demersal Fish in the Ciliwung River found between Kelapa Dua, Bogor Street until MT Haryono Street, Cawang, in their organ has been accumulatived Hg significantly. This shows the contribution of human activities such as Industry and Settlements to the presence of Hg in water. In segment 3 although the data fluctuated, it seems that the concentration of Hg in organ of Demersal fish higher than segment 1 and 2. The concentration of Hg in organ of Demersal Fish tends to increase due to the accumulation of Industrial and Residential activities that contribute to the presence of Hg in the water between Station 7 (Manggarai Floodgate) and Station 9 (KH Mas Mansyur Street). In segment 4 concentration Hg in organ of Demersal Fish was increased until estuary area due to accumulative effect. The research results also show that there is a difference in the pattern between the metals Hg in Organ and Cr in Meat of Demersal and Pelagic Fish associated with the season. Concentration of Hg in organ of Demersal Fish higher in the dry season than in the rainy season, while the concentration of Cr in Pelagic Fish Meat was higher in the rainy season than in the dry season.

The Result of observation show that in general, the contribution of human activities in the DKI Jakarta area to the presence of Pb, Cr, and Hg in the waters, sediment and Fish of the Ciliwung River was greater than in the Bogor and Depok areas.

According to Phillips (980), contribution of human activities in heavy metal pollution can be in the form of urban, industrial, mining and agricultural waste. Industrial waste generally contains more heavy metal elements. According to Bryan (1986), the biggest source of heavy metals comes from human activities, both on land and at sea. This is because heavy metal compounds or elements are widely used in Industry as raw materials, catalysts, fungicides and additives. Pb was widely used in batteries, pigments, explosive materials, solders, cable coatings and paints. Meanwhile, Hg was

widely used in the production of chlorine alkali, electrical equipment, paints, drugs and biocides (fungicides, herbicides and pesticides).

In general, it is seen that the concentration of Pb, Cr, and Hg in organ of Demersal Fish is higher than in the Meat of Demersal Fish. This is due to organ (liver and kidney) are target organ for heavy metals accumulative in the body.

The results of research also showed that the concentration of Cr in the Meat of Pelagic Fish fluctuated during the rainy season and the dry season. Concentrations of Cr in organ of Pelagic Fish generally higher than in the meat of Fish.

In general, metal concentrations of Pb, Cr, and Hg in the meat and organs of Demersal Fish were higher than that in the meat and organs of Pelagic Fish. This was due to the activity of Demersal Fish that forage and are active in bottom waters close to sources of heavy metal pollutants (sediment).

According to Darmono (1995), Heavy Metals enter the body tissues through food web, gill and diffusion through the skin surface of Fish mechanisms. Phytoplankton as a primer producen will be consume by Zooplankton, and Zooplankton will be consume by a little Fish and then a little Fish finally consume by bigger Fish. Darmono and Arifin (1989) state that there are 3 (three) theory about heavy metals absorption by Biotic Organisms, namely:

(1) Heavy metals absorption through transport mechanism in relation with osmoregulation, namely the regulation of osmotic pressure by organisms against the surrounding water.
(2) Binding of Heavy Metals ions touch certain parts of the tissue surface and enter the cytoplasm.
(3) Metal in the form of small crystals or solution which is immediately captured by epithelial cells and endocytosis the metals is brought in and released into the cytoplasm.

Biological accumulation can occur through direct absorption of heavy metals in water, so that organisms that live in heavily polluted waters by heavy metals, in their body tissues will also contain high heavy metals (Kristoforava, 1981 in Sanusi, 1985). In addition, the accumulation process can occur because heavy metals form complex compounds with organic substances contained in the organism's body (Saeni, 1989). Through the ligand bond, the complex compound formed is called Metallotionin (MTN) which is toxic to Fish (Darmono and Arifin, 1989).

Moore and Ramamoorthy (1984) state that heavy metals in the water of body River tend to make binding with organic matter, and then doing settled, dilution, and dispersion process. Finally , the heavy metals will be able to absorbed by aquatic organism such Fish.

According to Purwanti research (1995), Fish that live in Pb polluted waters, their liver will be found accumulation of heavy metal Pb. The concentration of heavy metals in water also affects the amount of heavy metal accumulation in Fish liver. The higher the concentration of heavy metals in the water, the accumulation of heavy metals in the liver of Red *Tilapia* (Nila Merah) Fish will also be higher.

The results showed higher concentrations of Pb, Cr, and Hg in the organs (intestinum and gills) of Fish compared to Fish Meat, in line with the Research of Suwirma *et al* (1980) regarding accumulation of heavy metals Pb in the organs of Kembung, Bawal dan Mujair Fish.The results showed that the accumulation of Pb in the three types of Fish was in accordance with the order in bone>gills>stomach>meat.

CONCLUSION

Based on the results of the research that has been done, it can be concluded as follows:

1. Hg concentration in the organs of Demersal Fish in the Ciliwung River was significantly different between sampling locations (station 1 to 11).
2. Hg concentrations in the organs of Demersal Fish between research times (rainy season and dry season) was significantly different, while in the meat of Demersal Fish, in the organs and meat of Pelagic Fish were not significantly different.

3. Pb concentration in Demersal and Pelagic Fish between study times (rainy season and dry season) was not significantly different.
4. Cr concentration in Demersal and Pelagic Fish between study times (rainy season and dry season) was not significantly different.

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REFERENCES

APHA, AWWA and WPCP (1992). Standard methods for the examination of water and wastewater. Marry Ann H.F. (Ed.) 14th ed.APHA. Washington DC.

Bryan, G.W. (1986). Heavy metals contamination in the sea. In: Marine pollution. Johnson, A. (Ed.). Academic Press. London, p.185.

Darmono. (1995). Logam dalam Sistem Biologi Makhluk Hidup. UI Press, Jakarta. H.4

Darmono dan C. Arifin. (1989). Kemungkinan Kontaminasi dan Pencemaran Ikan serta Organisme Laut oleh Logam Berat, Medika, 4: 991.

Hinkelman, K. and Kempthorne, O. (2008). Design and Analysis of Experiment. Vol. 1 Introduction to Experimental Design. 2nd Ed. Wiley Interscience. New Jersey. p. 282-85

Moore, J.W and S. Ramamoorthy. (1984). Heavy metals in natural waters. Applied monitoring and impact. Springer-Verlag, New York. P. 18-60.

Phillips, D.J.H. (1980). Proposal for monitoring studies on the contamination of the East Asian Seas by trace metals and organochlorines. South China Fisheries Development and Coordinating Programme. FAO, Manila, p.7.

Purwanti, K. (1995). Pengaruh Waktu dan Konsentrasi $PbNO_3$ terhadap bioakumulasi timbal dalam hepar ikan nila merah (*O. niloticus*). Skripsi Fakultas Biologi Universitas Nasional Jakarta, h. 33.

Saeni, M.S. (1989). Kimia Lingkungan. Depdikbud dan PAU IPB, Bogor, h.48.

Sanusi, H.S. (1985). Akumulasi Logam Berat Hg dan Cd pada Tubuh Ikan Bandeng (*Chanos chanos* Forshal). Disertasi Doktor Fakultas Pascasarjana, IPB, Bogor, 192th.

Suwirma, S.S, Surtipanti, dan L. Thamsil (1980). Distribusi Logam Berat Hg, Pb, Cd, Cr, Cu dan Zn dalam tubuh Ikan. Majalah BATAN 3:9.