# Distribution of lead (Pb) in macrozoobenthos as the impact of Kamojang geothermal power plant activity in Cikaro River, Bandung Regency, Indonesia

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**Abstract**. This research aimed to determine the concentration of lead (Pb) contained in macrozoobenthos in Cikaro River of Bandung Regency, Indonesia. The method used in this study is the survey method. Water, sediment and macrozoobenthos sampling were done purposively from 4 stations with 3 repetitions. Lead analysis was carried out at Institute of Ecology, while macrozoobenthos analysis was carried out in Aquatic Resources Management Laboratory and sediment analyzed in Soil Chemistry Laboratory, all at Universitas Padjadjaran. The results showed that there were found 9 species of macrozoobenthos during the research i.e. *Filopaludina javanica*, *Fluminicola fusca*, *Gyraulus circumstriatus, Pleurocera acuta*, *Pleurocera virginica*, *Pomacea canaliculata*, *Pseudosuccinea columella* of the class Gastropoda; *Corbicula fluminea* of the class Bivalvia; and *Parathelphusa convexa* of the class Malacostraca. Lead contents in the macrozoobenthos was higher than those of the sediment; it ranged around 0.226-0.312 mg $kg^{-1}$ on macroozobenthos and 0.052-0.128 mg $kg^{-1}$ in the sediment. The fact indicated that lead in the environment had accumulated in the macrozoobenthos. Meanwhile lead concentration in the water was less than 0.024 mg $L^{-1}$ which was considered below hazard threshold value as specified in the Indonesian Government Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control measuring at 0.05 mg $L^{-1}$.

**Key Words**: heavy metal, lead, macrozoobenthos, Cikaro River, accumulation.

**Introduction**. Kamojang Geothermal Power Plant is one of the largest geothermal plants in Indonesia, located in Ibun District, Bandung Regency, West Java Province. This instalation is managed by PT Pertamina and PT Indonesia Power. The potential of energy produced is 5,411 MW or about 20% of total geothermal potential in Indonesia. In operation, this Instalation generates liquid and solid waste. Liquid waste is stored in reservoirs before it is reinjected into the earth, but if the waste generated beyond the capacity of the reservoirs, the waste will enter Cikaro Lake which will eventually flow into Cikaro River (Agustina 2011). While solid waste comes from the sediment generated from the processing of liquid waste and silica crust from installation pipes (Asy'hari & Amirulloh 2010). In solid waste there are heavy metal components, including lead (Pb).

Upper Cikaro River is an area adjacent to Kamojang geothermal power plant location. Cikaro River catchment area have relatively heterogeneous land use characteristics including rice fields, residential areas, plantations, moorlands, bushes and forests. One of the problems that need attention in Cikaro River is the contamination of lead from Kamojang geothermal power waste. Research conducted by Agustina (2011) in April-June 2011 showed that the concentration of lead in water in Lake Cikaro ranged from 0.01 to 0.0769 mg $L^{-1}$.

The lead is one of the accumulative metals. In the form of organic or inorganic compounds, lead is potentially damaging to biological systems, which affect almost every organ and system in the body. The main target is the nervous system. Lead can enter the body tissues of aquatic organisms through food chains, gills and diffusion through the skin surface (Palar 2008).

The heavy metals in the waters will settle to the bottom of the water and form sediment. Badrun (2008) states that sediment is fixed so that it can accumulate any contaminant that comes (heavy metals, organic, and other wastes). As a result, organisms living in the bottom of the water have the potential to accumulate heavy metals that have been deposited in the bottom of the waters. One of the potentially affected biotic organisms is macrozoobenthos, due to its relatively settled nature at the bottom of the waters.

Macrozoobenthos has relatively slow and sedentary movements and relatively long life cycle, so that organisms have the ability to respond to water quality conditions continuously (Setiawan 2009). Macrozoobenthos is also often used as a bioindicator of water quality because it is very sensitive to changes in water quality, and is always in contact with waste into its habitat so that this group of organisms is very appropriate to be used as an environmental bioindicator (Tidjani et al 2016). Makrozoobenthos is often used as a bioindicator of water quality because it is widespread, has a large number of species and responds to environmental stresses in wide spectrum.

If lead is absorbed into the body then it can not be destroyed (is non degredable); moreover, it is toxic and can cause death. Although the toxicity generated from heavy metals to aquatic organisms are different. The destruction of one group of organisms leads to the disruption of the food chain and will disrupt the order of the aquatic ecosystem (Palar 2008).

Based on this, it is necessary to conduct research on the distribution of heavy metal lead (Pb) derived from the waste Kamojang geothermal power in Cikaro River, Regency of Bandung, West Java.

## Material and Method

***Time and location***. This research was conducted at Cikaro River, Bandung, West Java from 12th March to 5th May 2017. The research location consisted of 4 stations (Figure 1), namely:

1. Station 1 with coordinate points 7$^o$9'13.91'' S and 107$^o$47'15.66" E, is a stagnant water area located in Laksana village, this area being not affected by Kamojang geothermal power waste. The distance of this station to Kamojang geothermal power is ±0.5 km;

2. Station 2 is a Cikaro WPS (Water Pump Station) with coordinate points 7$^o$08'27.2'' S and 107$^o$46'59.9" E, located in Laksana village; it is an area directly affected by Kamojang geothermal power waste. In this area there is a pipe that drains the waste heat to Lake Cikaro;

3. Station 3 with coordinate points 7$^o$06'21.23" S and 107$^o$45'56,44" E, represents Cikaro River flow in Paseh village. In this area the flowing water comes from the mixing of water mass from station 1 and station 2. The distance of station 3 to instalation of Kamojang geothermal power is ±1 km;

4. Station 4 with coordinate points 7$^o$04'19.24" S and 107$^o$45'50.48" E, represents Cikaro River flow located in Lampegan village. The distance of station 4 to instalation of Kamojang geothermal power is ±2 km.

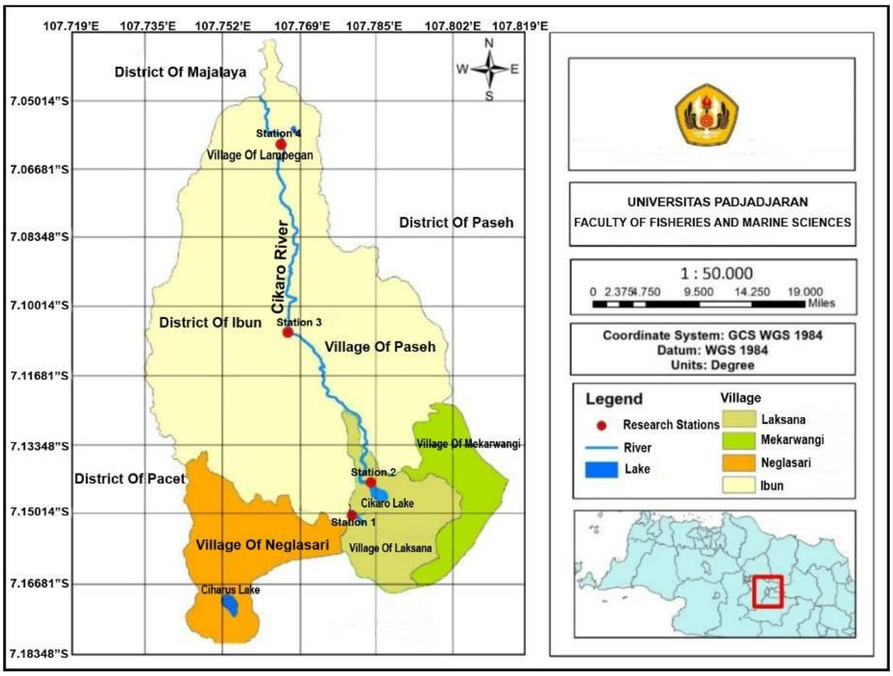


Figure 1. Research stations

***Tools and materials***. The main tools and materials used in this study are shown in Table 1.

Table 1

Tools and materials used in the study

| *No.* | *Parameter* | *Tools/materials* |
|---|---|---|
| 1. | Macrozoobenthos | Ekman grab and surber nets, strainer (mesh size < 1 mm), magnifying glass, plastic container and label paper, macrozoobenthos sample |
| 2. | Lead | Crusher, polypropylene bottle, bulb pipette and 10 mL pipette, stirring rod, 50 mL flask, funnel, hot plate, filter paper, oven and Atomic Absorption Spectrophotometer (AAS), sediment and macrozoobenthos sample, concentrated $HNO_3$, lead (Pb) blank solution |
| 3. | Others water quality parameters | Water sampler, DO meter, pH meter, thermometer, alleged balls, water samples, aquadest |

***Research methods***. The method used in this research is survey method with explorative approach. Samples are taken composite, from three points on each station. Sampling was done 3 times during a week. The procedure of sampling macrozoobenthos refers to SNI method No. 19-3957-1995 on the procedure of taking plankton and makrozoobenthos in the waters.

The abundance of macrozoobenthos was calculated using the following formula:

$$K = \frac{10000 \, x \, a}{b}$$

where: K = abundance (individual $m^{-2}$);
a = number of identified macrozoobenthos (individual);
b = area of surber / ekman grab mount ($cm^2$) x number of composited samples.

Macrozoobenthos diversity was calculated using the following formula:

$$H' = -\sum_{i=1}^{s} (pi \log_2 pi)$$

where: H '= Shannon-Wiener's diversity index;
s = the number of species of macrozoobenthos;
p = proportion of the number of individuals in macrozoobenthos species.

Other water quality parameters measured include physical parameters i.e temperature and current velocity and chemical parameters i.e pH and dissolved oxygen (DO).

***Data analysis***. Data analysis was done by a descriptively. The data obtained are presented in tables and graphs, then sampling stations compared to each other. In the water quality analysis, the data obtained are compared with the recommended quality standard of Indonesian Government Regulation no. 82, the year 2001. Meanwhile, macrozoobenthos communities were compared between stations to see the difference and the pattern of its distribution.

## Result and Discussion

***Macrozoobenthos community structure***. The results showed that nine species of macrozoobenthos were identified consisting of seven species of the Gastropod, one species of Bivalve, and one species of Malacostraca (Table 2). According to Perkins (1974) macrozoobenthos found with a number of species ranging from 0 to 10 at a location indicates that the diversity at the site is low and indicates that the site is beginning to have significant disturbances.

According to Table 2, macrozoobenthos were found to be dominated by the Gastropoda. Gastropods are organisms that have a wide range of spreads ranging from rocky substrates, sandy to muddy, but Gastropods prefer muddy substrates. While Bivalve class is represented by organisms which can grow and develop well on muddy substrates with high organic material as a food source (Yunitawati et al 2012).

Table 2

Abundance and diversity of macrozoobenthos

| *No.* | *Class* | *Taxon* | *Abundance (ind m$^{-2}$) in each station* | | | |
|---|---|---|---|---|---|---|
| | | | *1* | *2* | *3* | *4* |
| 1 | Gastropoda | *Filopaludina javanica* | 142 | 0 | 83 | 103 |
| 2 | | *Pseudosuccinea columella* | 75 | 58 | 47 | 17 |
| 3 | | *Pleurocera virginica* | 50 | 0 | 0 | 0 |
| 4 | | *Pomacea canaliculata* | 0 | 100 | 7 | 0 |
| 5 | | *Fluminicola fusca* | 0 | 0 | 7 | 7 |
| 6 | | *Pleurocera acuta* | 33 | 0 | 17 | 13 |
| 7 | | *Gyraulus circumstriatus* | 8 | 0 | 0 | 0 |
| 8 | Bivalvia | *Corbicula fluminea* | 350 | 0 | 0 | 0 |
| 9 | Malacostraca | *Parathelphusa convexa* | 8 | 0 | 0 | 0 |
| Total (ind m$^{-2}$) | | | 666 | 158 | 161 | 140 |
| Shannon Wiener diversity index (H') | | | 1.37 | 0.66 | 1.20 | 0.85 |

The abundance of macrozoobenthos in Cikaro River ranges from 140 to 666 ind m$^{-2}$. This shows that its abundance in the Cikaro River is low. The low abundance indicates that the water conditions in the Cikaro River begin to decline in quality which can lead to environmental changes as the habitats of aquatic organisms. Based on the calculation of macrozoobenthos Shannon-Wiener diversity index at all station ranged from 0.66 to 1.37 (Table 2). According to Lee et al (1978) criteria of the diversity index, macrozoobenthos in the Cikaro River belong to the medium diversity index, because it has a value of $1 < H' \leq 3$. A medium diversity index also indicates that the Cikaro River has been mildly contaminated and started suffering ecological pressures that affect the diversity of macrozoobenthos in the area to be low.

Diversity index can also describe the degree of pollution in a water body. At the time of observation, the macrozoobenthos found in the Cikaro River was dominated by the Gastropoda. This indicates that macrozoobenthos in the Cikaro River are of moderate (facultative) species. Wilhm (1975) states that the types of snails, insects and crustaceans are macrozoobenthos belonging to the species with medium resistance and tend to favor clear waters. This shows that the quality of waters in the Cikaro River began to decline in quality.

***Lead (Pb) concentration in the waters and sediments***. Based on the results, the concentration of lead in water samples taken from 4 sampling stations showed the same value that is < 0.024 mg $L^{-1}$. This is because the minimum limit of detection of metal values in the AAS (Atomic Absorption Spectrometer) machine used is 0.024 mg $L^{-1}$. So that the concentration of lead in the water at all four stations is low and still in accordance with the quality standard stated in the Government Regulation RI No. 82/2001 i.e < 0.05 mg $L^{-1}$.

One of the factors that causes low Pb concentration in water is that incoming waste has a low Pb concentration. The results of lead concentration measured on water conducted in April-June 2011 showed that the concentration of lead in Lake Cikaro ranged from 0.01 to 0.0769 mg $L^{-1}$ (Agustina 2011). The low concentration of lead in water is also caused by the fact that most of the metal ions are adsorbed by the organisms living in the water, one of which is macrozoobenthos.

Other factors that determine the concentration of heavy metals in water are temperature and pH. The higher the temperature, the higher the solubility of heavy metals in water. At neutral and alkaline pH, heavy metals are easier to settle. This can be seen from the high concentration of Pb metal in the sediment. The measured Pb metal concentrations in the sediments ranged from 0.052 to 0.128 mg $kg^{-1}$ as can be seen in Figure 2.

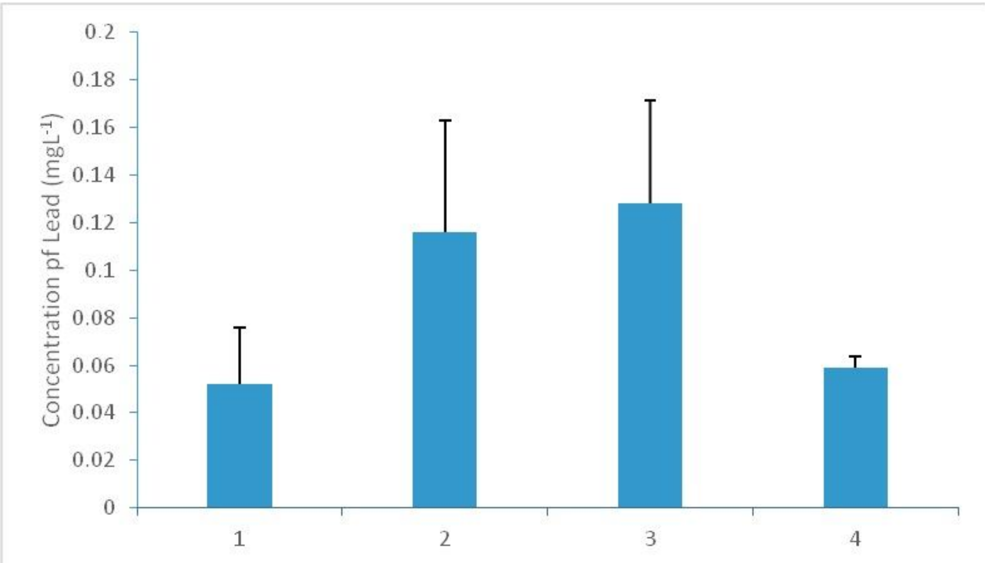


Figure 2. Concentration of lead (Pb) in the sediment of Cikaro River (1-4 = station numbers).

Based on Figure 2, the concentration of Pb in the sediment at station 3 has the highest average of 0.128 mg $kg^{-1}$. The high concentration of Pb in the sediment at station 3 is caused by the amount of contamination material entering the waters. In addition to liquid waste from the Kamojang geothermal plant, station 3 received domestic waste, livestock, plantations, and small-scale garment industries. Besides that, the pH value also affects the ammount of Pb in the sediment. The average pH value at station 3 is 7.2. This indicates that the Pb has been deposited. According to Tidjani et al (2016), Pb would be easier to settle in sediments at neutral or alkaline pH.

The lowest Pb concentration in the sediment is at station 1, of 0.052 mg $kg^{-1}$. Although this location was not directly affected by Kamojang geothermal plant waste, the Pb found in this location came from domestic waste and corrosion of household water pipes containing Pb. The average value of pH at station 1 is 6.3. This value indicates that pH tends to be acidic. In acidic conditions the level of solubility of metals in water increases. This can be seen from the low Pb concentration in the sediment but its high concentration in macrozoobenthos. So this indicates that Pb has been accumulated in macrozoobenthos.

Based on Figure 2, the concentration of Pb in sediments at all stations is still low although in Indonesia there is no applicable quality standard for heavy metals in sediments. When referring to the ANZECC (2000), regarding the sediment quality guidelines, the Pb concentrations in the Cikaro River sediments are still within the standard quality range defined by < 50 mg $kg^{-1}$. Although the concentration in the sediment is relatively low, it is still necessary to be aware of the heavy metals that easily accumulate so that the concentration of Pb in the sediment continues to increase over time.

***Lead (Pb) concentration in macrozoobenthos***. The concentration of Pb in macrozoobenthos in Cikaro River ranged from 0.226 to 0.312 mg $kg^{-1}$ (Figure 3). When compared with the Pb found in macrozoobenthos habitat, i.e in sediment (Figure 2), it can be concluded that the Pb found in sediment has been accumulated in the macrozoobenthos body.

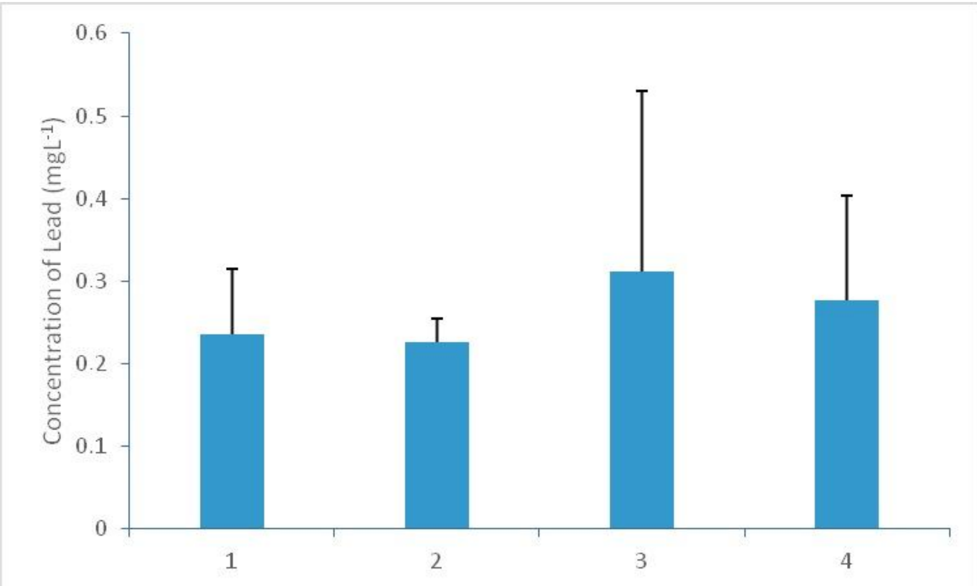


Figure 3. Concentration of lead (Pb) in macrozoobenthos in Cikaro River (1-4 = station numbers).

Based on Figure 3, it can be seen that the highest concentration of Pb on macrozoobenthos is found in station 3 that is 0.312 mg $kg^{-1}$. The high concentration of this metal in macrozoobenthos at station 3 is in line with the higher concentration of Pb in the sediment. The metal deposited in the sediment will enter the body of macrozoobenthos along with the detritus as food sources for macrozoobenthos. The high value is also evidenced in the diversity of macrozoobenthos in station 3 which is dominated by gastropods. According to Moloukhia & Sleem (2011), gastropods can accumulate heavy metals more than 90% in their soft tissues. Heavy metals will accumulate in fish tissues and organs through the food chain. Obeidi et al (2015) stated that Pb concentrations in *Pomadasys kaakan* fish muscle tissue will reach 6.01±0.710 mg $kg^{-1}$ whereas in liver tissue the concentration reaches 6.12±0.902 mg $kg^{-1}$.

The lowest concentration of Pb in macrozoobenthos is at station 2 that is 0.226 mg kg$^{-1}$. The low value corresponds to the low number of macrozoobenthos found in station 2 compared to other stations. In addition, no significant current in the lake will drive ionic heavy metal bounded by suspended particles and tend to settle. This is evidenced by the high concentration of Pb in the sediments at this station.

In general, the concentration of Pb on macrozoobenthos in Cikaro River is still low and below the threshold standard in several countries, such as Singapore. Agri-Food and Veterinary Authority of Singapore in 2005 determined that the standard of Pb which is still allowed to be contained in bivalves, molluscs, sea cucumbers and crustaceans is 2 mg kg$^{-1}$.

Although the Pb concentration was still below the threshold value, continuous exposure over time can lead to accumulation. Exposure to heavy metals will damage health. Heavy metal will form compounds that can drive in damaging the life of an organism (Darmono 2001). Thus, the destruction of one group of organisms lead to destroyed of the food chain and will damaged the order of the aquatic ecosystem (Palar 2008).

***Physicochemical parameters***. The measurement of physical and chemical parameters consisted of temperature, current, dissolved oxygen (DO) and acidity degree (pH). The measurement results are presented in Table 3.

Table 3

Physico-chemical parameters values

| *Parameters and units* | *Station* | | | | *PP 82/2001** *(class III)* |
|---|---|---|---|---|---|
| | *Station 1* | *Station 2* | *Station 3* | *Station 4* | |
| Temperature ($^{o}$C) | 23.2±1.59 | 25.1±1.40 | 24.2±1.15 | 26.7±2.06 | Deviation 3 |
| Current (m s$^{-1}$) | 0.00 | 0.00 | 0.3±0.05 | 0.4±0.01 | - |
| DO (mg L$^{-1}$) | 7.3±0.31 | 6.3±0.45 | 6.1±0.89 | 6.8±0.85 | 3.0 |
| pH | 6.3±0.14 | 6.5±0.16 | 7.2±0.42 | 7.0±0.06 | 6-9 |

Noted * Indonesian Government Regulation No. 82 of 2001.

In general, the water quality at all stations is still in the normal category and in accordance with the standard class III as defined in the Indonesian Government Regulation No. 82 of 2001 on the Management of Water Quality and Control of Water Pollution.

**Conclusions**. Macrozoobenthos on the Cikaro River have been exposed to heavy metal lead (Pb). The results show that the range of Pb contained in macrozoobenthos ranges from 0.226 to 0.312 mg kg$^{-1}$. The highest mean value is at station 3 whereas the lowest is at station 2. The concentration of Pb in the sediment ranges from 0.052 to 0.128 mg kg$^{-1}$, with the lowest average value at station 1 and the highest is at the station 3. The concentration of Pb in water at all stations shows the same value that is < 0.024 mg L$^{-1}$ which means that concentration is still within the range of environmental quality standard as determined by Indonesian Government Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control that is < 0.05 mg L$^{-1}$. Other water quality parameters showed similar result.

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