Research Article

Monitoring public health quality: Testing of heavy metal pollution in Cikapundung River water in Bandung city, Indonesia with the atomic absorption spectrophotometer method

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ABSTRACT

Objective: Heavy metal content is an important parameter for determining water quality. Cikapundung River is the main river that passes through the city of Bandung, Indonesia. Technological developments and the modernization of human life have shifted public awareness about the importance of the existence of rivers. The purpose of this study was to determine the health of the people living around the Cikapundung River through water quality checks as seen from heavy metal parameters. This test uses the atomic absorption spectrophotometer (AAS) method. Heavy metals that accumulate in water and are consumed by humans will cause serious toxicity and are harmful to the body. **Materials and Methods:** Water samples come from two different locations on the Cikapundung River. This research includes the sampling of Cikapundung River water with quantitative analysis using the AAS method and data processing. **Results:** The results of testing six heavy metals in Cikapundung River water samples at two locations showed that zinc (Zn) metal was detected at concentrations of 0.05 g/L and 0.06 g/L. **Conclusions:** Detected Zn metal levels are still below the permissible concentration threshold based on Indonesian government regulations.

KEY WORDS: Atomic absorption spectrophotometer methods, Cikapundung River, Heavy metals, Public health, Quantitative analysis, Water quality

INTRODUCTION

The Cikapundung River divides the city of Bandung, in West Java, Indonesia. The river flows from its headwaters in Lembang on the northern edge of the city, to the south, where it empties into the Citarum River. Despite being one of the main sources of Bandung's water supply, the river is classified as heavily polluted.[1] Domestic waste, including human waste and detergents, is the main source of pollution as more people are living along the river banks. Other sources of pollutants are industry agriculture and farming.[2] The Cikapundung River that runs along the city of Bandung, besides functioning properly, it also has become a place to store waste from all kinds of community activities around the watershed. As a result, it can cause changes in water quality and may even have been contaminated by certain chemicals such as heavy metals which can endanger the ecological life.[3]

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Heavy metals are generally poisons that are harmful to the environment in the ecosystem and also to human health. This heavy metal can come from factory waste that may be produced during the production process. In the area of Bandung city, there are many diverse industries. Therefore, this study aims to determine the quality of water in the Cikapundung River in terms of heavy metal parameters.[4] These findings imply that the consumption of polluted water by animals or human beings could be hazardous to their health.[5]

Atomic absorption spectrometric (AAS) methods are very suitable methods for monitoring the levels of heavy metals in natural waters. They provide accurate and rapid determinations, but for the extremely low concentration of these pollutant, a direct apply of AAS is impossible without any previous concentration and separation of analytes from the sample. Today, this

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problem can be solved by very modern expensive instrumentation for pre-concentration and separation of trace metals.[6]

MATERIALS AND METHODS

Sample

Intake of wastewater is divided into two categories, waste produced by industries including the pharmaceutical industry around the Cikapundung River and also waste generated by households or shops. Each location was taken as much as 2 l of water samples. Sampling locations can be seen in Figure 1

Procedures

Recently, increasing attention to the problem of ecosystem balance has focused on understanding the long-term ecological effects of populations and communities exposed to chronic and their consequences for ecosystems. Testing of water sample analysis is carried out using the standard method proposed by the American Public Health Association. The heavy metals tested among others: As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn. Detection of heavy metals in the environment can be done by several methods, for this test carried out by the AAS method. The choice of this method with consideration of the method is relatively simple, flexible, accurate, and free from distractions. Heavy metals easily form complexes with organic elements; therefore, it is necessary to destroy them by digestion with strong acids.[7]

Digestion with Nitric Acid

The water samples in evaporating dishes were taken and acidified to methyl orange with conc. HNO_3. Further, 5 ml conc. nitric acid was added and evaporated to 10 ml. Then, it was transferred to a 125 ml conical flask. About 5 ml of conc. nitric acid and 10 ml of perchloric acid (70%) were added. Then heated gently, until white dense fumes of $HClO_4$ appear. The digested samples were cooled at room temperature, filtered through Whatman No. 41 or sintered glass crucible and finally, the volume was made up to 100 ml with distilled water. Then, this solution was boiled to expel oxides of nitrogen and chlorine. This solution contained 0.8 N in $HClO_4$. The solution was used for the use of determination of heavy metals.[8]

Heavy Metal Analysis

The method employed for analyzing the heavy metal content was using the AAS according to the Lambert-Beer law. This law explains that the amount of light absorbed is proportional to the amount of heavy metals in the material.[9] The real concentration of heavy metal can be discovered using this formula:

$$\text{Real concentration}: \frac{(D-E).\ Fp.\ V}{W\ (g)}$$

Where:

D: Sample concentration µg/L from the AAS reading.

E: Blank sample concentration µg/L from the AAS reading.

Fp: Dilution factor.

V: Final volume of the prepared sample solution (mL).

W: Sample weight (g).

Sample Preparation

Stock solutions for Pb

Stock solution corresponds to 1000 mg/l of Pb.

Weigh to the nearest ±0.0002 mg, apx. 1.0000 mg Pb metal (minimum purity 99.5%) and dilute in a covered 250 ml glass beaker with 10 ml HNO_3. Then, add 100 ml of water. Boil to expel nitrous fumes, cool,

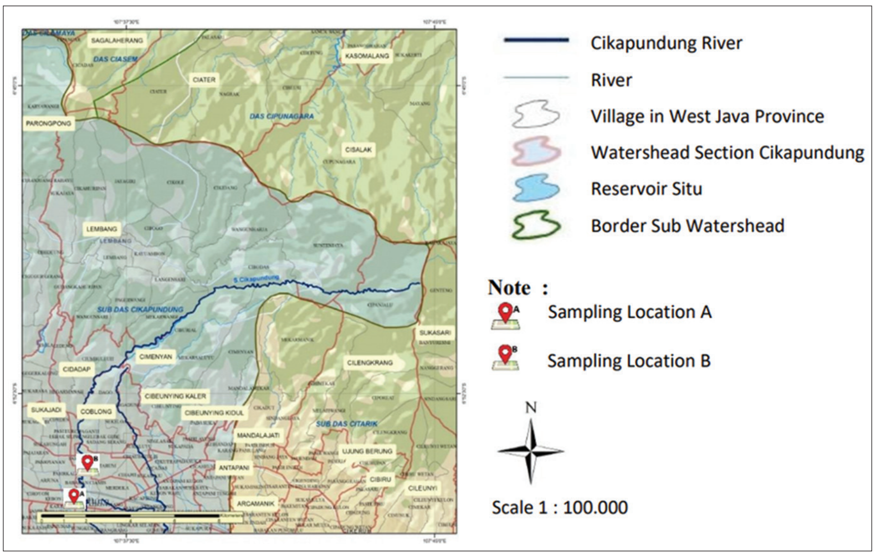

Figure 1: Location A and B are the sampling place at Cikapundung River

transfer to 1000 ml volumetric flask, and fill to the mark with water. Then, make a standard solution that will be used for measurement with a concentration of 10 mg/l of Pb. Pipette 10.00 ml of Pb stock solution into a 1000 ml volumetric flask. Add 20 ml of nitric acid, fill the mark with water and mix well.[7]

Stock Solution for Zn

Stock solution corresponds to 1000 mg/l of Zn.

Weigh to the nearest ±0.0002 g, apx. 1.0000 mg Zn metal (minimum purity 99.5%) and dilute in a covered 250 ml glass beaker with 40 ml HNO_3. Then, add 100 ml of water. Boil to expel nitrous fumes, cool, transfer to 1000 ml volumetric flask, and fill to the mark with water. Then, make a standard solution that will be used for measurement with a concentration of 10 mg/l of Zn. Pipette 10.00 ml of Zn stock solution into a 1000 ml volumetric flask. Add 20 ml of nitric acid, fill to the mark with water and mix well.[7]

Stock solutions for Cd

Stock solution corresponds to 1000 mg/l of Cd.

Weigh to the nearest ± 0.0002 mg, apx. 1.0000 mg Cd metal (minimum purity 99.5%) and dilute in a covered 250 ml glass beaker with 40 ml HNO_3. Then, add 100 ml of water. Boil to expel nitrous fumes, cool, transfer to 1000 ml volumetric flask, and fill to the mark with water. Then, make a standard solution that will be used for measurement with a concentration of 10 mg/l of Cd. Pipette 10.00 ml of Cd stock solution into a 1000 ml volumetric flask. Add 20 ml of nitric acid, fill to the mark with water and mix well.[7]

Stock solutions for Ni

Weigh to the nearest ± 0.0002 mg, apx. 1.0000 mg Ni metal (minimum purity 99.5%) and dilute in a covered 250 ml glass beaker with 40 ml HNO_3. Then, add 100 ml of water. Boil to expel nitrous fumes, cool, transfer to 1000 ml volumetric flask, and fill to the mark with water. Then, make a standard solution that will be used for measurement with a concentration of 10 mg/l of Ni. Pipette 10.00 ml of Ni stock solution into a 1000 ml volumetric flask. Add 20 ml of nitric acid, fill to the mark with water and mix well.[7]

Stock solutions for Cr

Weigh to the nearest ± 0.0002 mg, apx. 1.0000 mg Cr metal (minimum purity 99.5%) and dilute in a covered 250 ml glass beaker with 40 ml HNO_3. Then, add 100 ml of water. Boil to expel nitrous fumes, cool, transfer to 1000 ml volumetric flask, and fill to the mark with water. Then, make a standard solution that will be used for measurement with a concentration of 10 mg/l of Cr. Pipette 10.00 ml of Cr stock solution into a 1000 ml volumetric flask. Add 20 ml of nitric acid, fill to the mark with water and mix well.[7]

Stock solutions for Cu

Stock solution corresponds to 1000 mg/l of Cu.

Weigh to the nearest ± 0.0002 mg, apx. 1.0000 mg Cu metal (minimum purity 99.5%) and dilute it in a covered 250 ml glass beaker with 10 ml HNO_3. Then, add 100 ml of water. Boil to expel nitrous fumes, cool, transfer to 1000 ml a volumetric flask, and fill to the mark with water. Then, make a standard solution that will be used for measurement with a concentration of 10 mg/l of Cu. Pipette 10.00 ml of Cu stock solution into a 1000 ml volumetric flask. Add 20 ml of nitric acid, fill to the mark with water and mix well.[7]

RESULTS AND DISCUSSION

The condition of pollution in the Cikapundung River flow is still not resolved by the government. This pollution is caused by waste originating from households or industries around the river flow. The government program to make the Cikapundung River clean and safe for health continues to be improved.[2] These findings imply that the consumption of polluted water by animals or human beings could be hazardous to their health. The soil contaminated by these effluents will produce unhealthy food as heavy metals can enter the food chain and thus be consumed by human beings.[10]

Heavy metals can bioaccumulate in living organisms and the human body through various processes that cause very adverse side effects. In the human body, these heavy metals are transported and can accumulate in body cells and tissues that bind to proteins, nucleic acids destroy these macromolecules, and interfere with their cellular function. Due to this, heavy metal toxicity can have several negative effects in the human body. It can affect central nervous function which causes mental disorders, damages blood constituents and can damage the lungs, liver, kidneys, and other vital organs which cause several disease conditions.[6] Long-term accumulation of heavy metals in the body can occur and can cause Parkinson's disease and Alzheimer's disease.

Sampling locations are carried out at two points, which represent the type of wastewater produced. Location A is the location around the industry in the Cikapundung watershed, whereas location B is a location that represents waste water from households and offices.

In the digestion process, nitric acid is usually combined with sulfuric acid and/or perchlorate for the digestion of organic samples. The samples that the structure are not aromatic and/or contain high OH functionality. In general, the use of nitric acid followed by perchloric acid is more common.[11]

Table 1: The results of heavy metal testing of Cikapundung river water samples

Name of heavy metal	Location A	Location B
Pb	-	-
Zn	0.05 mg/l	0.06 mg/l
Cd	-	-
Ni	-	-
Cr	-	-
Cu	-	-

The method of sample preparation using a digested system using a combination of nitric-perchloric acid was carried out, following the procedure established by the Analytical Community Association. One gram of sample was placed in a 250 ml digestion tube and 10 ml of concentrated HNO_3 was added. The mixture was boiled gently for 30–45 min to oxidize all easily oxidizable matter.[9] After cooling, 5 ml of 70% $HClO_4$ was added and the mixture was boiled gently until dense white fumes appeared. After cooling, 20 ml of distilled water was added and the mixture was boiled further to release any fumes. The solution was cooled, further filtered through Whatman No. 42 filter paper and <0.451 m Millipore filter paper and transferred quantitatively to a 25 ml volumetric flask by adding distilled water.[12]

The results of testing water samples from two locations in the Cikapundung River basin in the city of Bandung, West Java province, Indonesia can be seen in Table 1.

Zinc (Zn) can be found naturally in river water by the erosion of minerals from rocks and soil, but because Zn ore is only slightly soluble in water. Zn concentrations are naturally found in very low levels. High levels of Zn in water are usually associated with higher concentrations of other metals such as lead and cadmium. Most Zn is put into water through artificial routes such as by-products from steel production or coal-fired power plants, or from burning waste materials. Zn is also used in some fertilizers that can dissolve into ground water. The older galvanized metal pipes and well crates are coated with Zn which can dissolve with soft acid water.

CONCLUSIONS

This research shows that water samples from two locations along the Cikapundung River only contain heavy metal Zn. Levels of heavy metal Zn at sampling locations A and B are 0.05 mg/l and 0.06 mg/l. This level is still below the threshold levels set by the Indonesian government.

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