Measurement of Metal Contamination of Groundwater by Electrolysis Method and Atomic Absorption Spectroscopy

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***Abstract*— Industrial activities and building construction in urban areas have reduced green land. It poses a problem for humans, especially the issue of environmental pollution. Industrial waste containing heavy metals can contaminate groundwater. This research aims to know the metal contamination of groundwater samples in the Jakarta area using the electrolysis and atomic absorption spectrophotometer. The test results showed that two samples contained metals that exceeded the threshold value. Metallic concentrations Ca, Mg, Fe, Cu, Cd, Zn for four samples are still below the maximum allowable threshold value. However, the sodium content on groundwater samples from the area Kosambi, West of Jakarta as 392.4 mg/L, and groundwater from Cilincing, North of Jakarta with sodium as 208.4 mg/L has exceeded the threshold value of the sodium at 200 mg/L. Besides, Mn metal content for Kosambi area of 5.22 mg/L and water samples in Cilincing area of 4.89 mg/L has exceeded the value of Mn content limit which is allowed to be 0.5 mg/L.**

***Keywords*— Metal, Contamination, Ground Water, Electrolysis, Atomic Absorption Spectroscopy**

I. INTRODUCTION

Construction of buildings and industrial areas in open land or agricultural land has caused a decline in the field of open land and subsequently harm followed by soil contamination, which reduces the quality and quantity of clean and healthy groundwater, which disrupts comfort and human health or other living things. Industrial waste [1, 2] containing several harmful chemical elements can pollute the quality of groundwater. One of the most dangerous water pollution that often occurs nowadays both in Indonesia and in other countries is water pollution by heavy metals [3, 4]. Some types of heavy metal pollutants that are toxic to human health and animals such as copper (Cu) [5, 6], cobalt (Co) [7, 8], lead (Pb) [8, 9], cadmium (Cd) [10, 11], silver (Ag) , nickel (Ni) [8, 12], chrome (Cr), mercury (Hg) [13], arsenic (As) [14], zinc (Zn) [12], iron (Fe) [8], and manganese (Mn) [15]. When the heavy metals pollute the water that is subsequently consumed by the human body, it will accumulate in a long time that is an accumulative toxin, meaning organs can not decompose it.

This research is conducted based on the problem of water pollution [16, 17] by heavy metals that happening in the present time where many residents use groundwater for drinking water. In DKI Jakarta, groundwater has been buried by heavy metals that can harm the human body. Therefore, the problem will be done a qualitative test of metal content in groundwater samples in DKI Jakarta region by using electrolysis method with electrolyzer device and then the concentration of metal concentrations will be measured using the atomic absorption spectrophotometer. Groundwater is all the water contained in the ground level B in the zone of saturation. Groundwater is formed from rainwater and water surface infiltrate to the zone of aeration and then absorbed deeper until it reaches the area of saturated water and becomes groundwater.

Groundwater is one of the facets in the hydrological cycle from the stage sequence of water from the atmosphere to the earth and back to the atmosphere, evaporation of land or sea or inland water, condensation forming clouds, outpouring, the easing in the groundwater and evaporation again.

Contamination is a material that exists in food or beverages undesirable and there may be consequences of various phases from the raw materials, production processes, packaging, transportation or from environmental. One type of pollutants that can endanger to human health is heavy metals. Heavy metals are chemical elements, having high atomic weights and types of masses, which can be toxic to living

creatures. Substances that are toxic and that often pollute the environment such as mercury (Hg), lead (Pb), cadmium (Cd), and copper (Cu). Heavy metals such as Hg, Pb, and Cd are not required by the human body so that when the metal contaminates food or beverage, the body will remove it partially. The rest will accumulate on certain parts of the body, such as the kidneys, liver, nails, fatty tissues, and hair [18].

Electrolysis is the most effective Food and Drugs Administration (FDA) method of the United States Food and Drug Supervision Bureau to test the quality of water [19]. The medical bureau reports that there is a connection between contaminated water and its effect on the health of the body as well as about the colour of contaminated water after the electrolysis process. Electrolysis is one type of electrochemical cells (other than volta cells). In the electrolysis cell, used the direct current to establish a non-spontaneous redox reaction. Thus, the electrolysis cell is the opposite of the volta cell, which occurs the change in electrical energy into chemical energy. The electrolysis method is conducted by reducing the dissolved metal ions into a metal precipitate. Metal ions that are in the form of cations when dialled with a certain large electric current within a certain time, the reduction reaction will occur into metals with the number of oxidation of zero.

The method of analysis of atomic absorption spectrophotometry [20] is based on the absorption of radiation energy at specific wavelengths by neutral atoms in its ground state in the form of gas. The absorption of radiation energy with a specific wavelength (λ) resulted in the occurrence of electronic transitions from the basic energy level which is the most stable electron configuration to a higher energy level (excited state) when the energy is suitable.

II. MATERIALS AND METHODS

All materials used in this research is a groundwater sample. The determination of the sampling location was conducted by random cluster sampling. The working procedure was preceded by a groundwater sampling of 200 mL. The water is then inserted into an empty glass. Afterwards, the electrolyzer device is inserted into the beaker glass, which has been filled with sample water. Electrolyzer itself has four legs so that every two feet consisting of anode and cathode are inserted into the water sample. So the experiment was done at once simultaneously with two samples of groundwater on two different glasses. After the two feet of the electrode is in a glass of groundwater samples, then begin the process of electrolysis. The experiments themselves performed more or less done within 1-3 minutes, according to the manual instructions of the electrolyzer device. During the electrolysis process is observed a chemical reaction that occurs in water samples. This observation includes the discolouration that occurs in water and begins until the formation of deposits and also changes in water temperature during the reaction process. After approximately 3 minutes, the electrolysis process is discontinued. Then the water from the glass is filtered with *Whatman* paper to see the colour of the precipitate more clearly. It was observed and recorded, the result is the colour of sedimentation and water temperature samples before and after the process of electrolysis. The experiment itself was repeated by four attempts for every groundwater sample.

The procedure of measuring metal content by the atomic absorption spectrophotometer was conducted in this research.

1. Before use to measure metal levels, this device should carry out sensitivity and precision test.
2. The cathode light source should be adjusted to the metallic element that will be measured its concentration.
3. Acetylene gas burners that are inserted into the burner furnace and prepared a standardized solution of the element to be tested with multiple concentration values for sensitivity detection tests.
4. The sensitivity of the test equipment is determined by measuring the absorption of the solution by three times the measurement. In contrast, the precision of the test equipment is determined by calculating the standard deviation as six times the absorption of the solution.

5. After the instrument sensitivity test was obtained, the value of absorbance standard solution then measured sample solution to obtain the absorption result compared with the value of absorption of the solution standard.
6. Reading of the device on the computer monitor screen in the form of absorption value elements of the water samples in the form of absorption value is then processed with software to calculate the concentration.

III. RESULTS AND DISCUSSION

A. Testing Result by Electrolysis Process

This research gives a testing result of samples by the electrolysis process (Table I).

a. Groundwater samples from Pasar Minggu, South of Jakarta
Electrolysis process of groundwater samples from Pasar Minggu result that deposits are formed only slightly after 3 minutes. The initial temperature before the water electrolysis process is 25 °C. After the process, the electrolysis temperature is 45 ºC. The previously clear water samples became slightly cloudy. The colour of the deposition is black brownish.

b. Groundwater samples from Cilincing, North of Jakarta
Groundwater samples from Cilincing result rapid electrolysis process form of deposits. The reaction in two minutes of the electrolysis process. The initial temperature of 25 ºC into 84 °C at the end of the process. The deposits are formed in black and greenish colour. The water becomes very cloudy before it is clear before the electrolysis process.

c. Groundwater samples from Cakung, East of Jakarta
The results of observations on this groundwater sample from Cakung that the sediment began to form after two minutes of processing. The initial temperature was 25 ºC into 65 °C at the end of the process. The deposits formed are black brownish.

d. Groundwater samples from Kosambi, West of Jakarta
In testing with electrolysis, this groundwater sample from Kosambi reacts in a short time, only one and a half minutes has formed a precipitate and a very rapid rise in temperature. During the process, a burst on the surface of the water sample occurs, before the water spills the process is stopped. Deposits are formed and deep green-black. The temperature of the water was previously 25 ºC to 96 °C.

TABLE I
GROUNDWATER ANALYSIS BY ELECTROLYSIS PROCESS

Groundwater Sample	Process Timing (minute)	Initial Temperature (^{0}C)	Final Temperature (^{0}C)	Sediment Colour
Pasar Minggu	3	25	45	Black brownish
Cilincing	2	25	84	Black greenish
Cakung	2	25	65	Black brownish
Kosambi	1.5	25	96	Black greenish

The colour of the precipitated electrolysis is matched with the metal's standard colour. From the test results determined that the metals to be tested are sodium, magnesium, calcium and heavy metals which are dangerous if in high levels in the human body namely iron (Fe), copper (Cu), zinc (Zn), cadmium (Cd), and manganese (Mn).

B. Measurement Result by Atomic Absorption Spectroscopy

The results of measurements of the concentrations of metals in the four groundwater samples can be made in Table II.

TABLE III
GROUNDWATER ANALYSIS BY ATOMIC ABSORPTION SPECTROSCOPY

Groundwater Sample	Concentration (mg/L)							
	Fe	**Mg**	**Ca**	**Na**	**Cd**	**Cu**	**Zn**	**Mg**
Pasar Minggu	0	7.6	29.5	48.5	0	0	0	0.02
Cilincing	0.1	73.6	65.1	208.4	0	0	0	4.89
Cakung	0.1	2.2	2.8	176.1	0	0	0	0
Kosambi	0	44.7	55.2	392.4	0	0	0	5.22

The results of the measurement obtained in Table II that the iron content for the water samples of Cakung and Cilincing following the maximum recommended limit based on the Decree of the Minister of State
Population and Environment of the Republic of Indonesia Number: KEP-02/MENKLH/I/1988 about Guidelines of Raw Determination for Environmental Quality is 0.1 mg/L whereas for water samples in Pasar Minggu and Kosambi there is no iron content.

Based on data on the measurement of Na content in Kosambi sample obtained a very high level of Na. The maximum allowable limit on the Regulation of the Minister of Health of the Republic of Indonesia Number: 416/MENKES/PER/IX/1990 about Terms and Conditions of Water Quality Monitoring is 200 mg/L while the groundwater of Kosambi is almost twice from the threshold. For the Cilincing area also slightly exceeds the threshold value so that the groundwater of Kosambi and Cilincing areas is not qualified as drinking water. This high metal level can also be possible because of the location of water samples of soil not far from the industrial area. This groundwater sample from Kosambi is not far from the chemical plant. Excess sodium can cause fluid concentration in the body more concentrated so that it will give heart work that eventually causes hypertension and stroke [21].

Based on the results of Ca and Mg levels in four samples of groundwater obtained by the results compared to Decree of the Minister of State Population and Environment Number: KEP-02/MENKLH/I/1988 obtained that the four samples tested are still below the threshold value. Standard quality standards of Ca's recommended level is 75 mg/L. The maximum allowable limit is 200 mg/L. For elemental Mg the recommended content of 30 mg/L currently, the maximum limit is 150 mg/L.

The measurement results showed that the four water samples did not contain metallic Cd, Cu, and Zn. So the results meet the threshold of allowable rates as set Decree of the Minister of State Population and Environment Number: KEP-02/MENKLH/I/1988, which is 0 mg/L. But for the Zn element should the appropriate groundwater quality of water contains 1 mg/L, i.e. the value of the recommended rate is on groundwater. The zinc (Zn) element itself in the human body contributes to the immune system and is necessary for the synthesis of DNA and is also a role in normal growth and development during childhood and adulthood [22, 23]. Deficiency of zinc can lead to a delay in growth, hair loss, impotence, wounds in the eyes and skin, as well as a loss of appetite [24, 25].

The measurement data result that manganese levels in groundwater in Kosambi and Cilincing exceed the maximum allowable limits according to Decree of the Minister of State Population and Environment Number: KEP-02/MENLH/I/1988 is 0.5 mg/L while the recommended rate is 0.05 mg/L and the groundwater samples of Pasar Minggu and Cakung are slightly below the recommended rate so that water samples of Cakung and Cilincing are not eligible for drinking water.

IV. CONCLUSIONS

From the measurement and analysis of the level of contamination of metal elements in the groundwater samples in DKI Jakarta was taken the following conclusions.

1. Testing and measuring of the metal content of the groundwater can be done by the electrolysis method for its quality test while the magnitude of metal concentrations in groundwater samples can be measured quantitatively with Atomic Absorption Spectrophotometry.
2. The metal content of Fe, Mg, Ca, Cd, Cu, Zn for all four samples of water is still below the maximum allowable threshold. The maximum allowable limit for Fe as 1 mg/L, Mg as 150 mg/L, Ca as 200 mg/L, Cd and Cu as 0 mg/L, Zn as 15 mg/L.
3. Mn metal content for the Kosambi area water samples of 5.22 mg/L and Cilincing amounted to 4.89 mg/L exceeding the maximum allowable threshold following Decree of the Minister of State Population and Environment Number: KEP-02/MENKLH/I/1988 about Guidelines of Raw Determination for Environmental Quality Group A is 0.5 mg/L. So water in Kosambi and Cilincing has been buried in heavy metals Mn can not worth using for drinking water because excessive levels of Mn in the body can be toxic.
4. Sodium (Na) concentrations in groundwater samples from the areas of Kosambi and Cilincing, exceeding the maximum allowable limit following the Regulation of the Minister of Health of the Republic of Indonesia Number: 416/MENKES/PER/IX/1990 about terms and Conditions of Water Quality Monitoring is 200 mg/L. Groundwater for the Pasar Minggu and Cakung area is eligible for drinking water and clean water. While the groundwater from Kosambi and Cilincing is not feasible to drink.

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