The speed of heavy metal cadmium seepage on "E" and "F" fields in residential area around Kanal Banjir Barat river of Semarang City.

Danusaputro H., Gernowo R., Setyawan A., Bonita B.
Physics Department, Science and Mathematics Faculty, Diponegoro University
E-mail: hernowo.danusaputro@gmail.com

Abstract. Research on the analysis of cadmium heavy metal seepage velocity using the geoelectric configuration method of dipole-dipole, hydrological data, AAS test in Semarang city in order to know the existence of pollutants below the surface has been done. To know the seepage velocity is calculated by the formula of Darcy and the relation of seepage velocity with heavy metal concentration. This research used the geoelectric method of dipole-dipole configuration to determine the presence of pollutants in the bottom layer. This research, conducted in Kanal Banjir Barat River in "E" and "F" Residential Areas. In both field "E" and "F", acquisitions were made with three geologists each. Based on the result of AAS test the concentration of heavy metal cadmium located in river water and well water is between 0,096 - 0,108 mg / L. Based on low resistivity values, the height difference between wells and rivers and AAS test results shows that seepage from the river to residents' wells with an average seepage velocity at location “E” of $2.9 \times 10^{-7}$ cm/s and at location “F” of $1.5 \times 10^{-7}$ cm/s.

Keywords: Kanal Banjir Barat River, dipole-dipole configuration, AAS test, seepage velocity

1. Introduction
Kanal Banjir Barat River is a river stream located in the area of Semarang City, where the river is included in the class 1 which is used as a drinking water [1]. The construction of industrial plants located in the Kanal Banjir Barat River area which then dispose of its waste into the river stream, so that it can change the water quality standard and can cause water pollution of the river[2]. According to the Law of the Republic of Indonesia No 4 of 1982 [3], pollution is the entry or inclusion of living organisms, energy substances and / or other components into the environment, and or change of environmental order down to a certain level that causes the environment to be less or no longer functioning in accordance with its designation. The water that can pass through the ground is almost always linear, ie the path or water line is the line with the last shape or smooth curve [4]. This research uses geoelectric method in order to know the subsurface layer and the existence of pollutant[5]. Supporting methods used to determine the value of heavy metal concentrations in rivers and wells are AAS (Atomic Absorption Spectrophotometer) [6].

2. Methodology Research
Data acquisition conducted in November 2016 until January 2017 at residence area around Kanal Banjir Kanal river. The geoelectric measurements of the dipole-dipole configuration are done
manually with the resistivity meter. The geoelectric configuration of the dipole-dipole configuration using four electrodes, each of which acts as a current electrode and a potential electrode [7]. Of the four electrodes are separated by distance a multiplied by n. For a value is 6 meters and the value of n is 6 meters. The length of the stretch of each track is 54 meters with the number of passes being 3 parallel trajectories.

AAS (Atomic Absorption Spectrophotometry) is a method of measurement based on the amount of radiation absorbed by atoms when a certain amount of radiation is passed through the system containing the atoms. This AAS method is one of the analytical methods that can be used to determine the elements in a material and can even analyze the sample in small quantities, because this method has a very high sensitivity, accuracy and selectivity. In this study supported by a sample test of Atomic Absorption Spectrophotometer. AAS is a method of analysis that can be used to determine the elements in a material and can even analyze in small amounts, because this method has a very high sensitivity, precision and selectivity. AAS test is to determine the heavy metal content and heavy metal concentrations located in river water and well water.

Water samples taken at residents wells and Kanal Banjir Barat River were put into a 100ml glass bottle, because at the time of the AAS test the water required was small. The AAS sample assay was performed using a AAS tool under the PinAAcle 90°F brand.

3. Result and discussion

The result of the research on field E shows that the pattern of heavy metal dispersion is indicated by low resistivity value indicated by blue color located at depth of 1 meter to 5 meter and on stretch of 12 meter to 42 meter. Figure 1 shows the distribution of pollutants from the first to the third trajectory.

![Figure 1. Distribution of pollutants in field “E”](image)

The results of the “F” field show that the pattern of heavy metal distribution is indicated by low resistivity value indicated by blue color which is located at depth of 1 meter to 5 meter and at length of stretching between 10 meter to 40 meter.

The results of AAS test are shown in Table 1 which shows Cd concentration. It shows that at the location of rivers and wells there are residents of the same heavy metals. Different concentration values differ due to heavy metals that can accumulate in the soil and dissolve in water and the difference in distance between wells and rivers. The distance of the river with the wells the farther the concentration value will be smaller. The highest concentration of heavy metals Cd at E2 wells was 0.108 mg/L and the lowest concentration of Cd heavy metal at E3 well was 0.096 mg/L. According to Government Regulation no. 28 year 2001 regarding Water Quality Management and Water Pollution
Control that water quality standard containing heavy metal equal to 0.01 mg/L so that water quality in river still in safe level.

| Location | Cd Concentration (ml/L) |
|----------|-------------------------|
| River E  | 0.100                   |
| Well E1  | 0.101                   |
| Well E2  | 0.108                   |
| Well E3  | 0.096                   |
| River F  | 0.101                   |
| Well F1  | 0.105                   |
| Well F2  | 0.106                   |
| Well F3  | 0.104                   |

Seepability or permeability is the ability of the soil to pass water or porous soil properties that allow seepage flow from liquid in the form of water or oil to flow through the pore cavity. Each of the pollutant particles moves from a height A to a lower height B [8]. The resistivity results in depths of 1 to 5 meters is the clay layer and the presence of heavy metals is at a depth of 1 to 5 meters indicated by low resistivity values. According to table 2 the permeability value of the clay layer is 10^-7. The average velocity value at location E is 2.9 x 10^-7 cm/s and at location “F” of 1.5 x 10^-7 cm/s. The pace of this pollutant is affected by the distance and depth of the groundwater level. The farther the distance between the river and the well and the deeper the well water so that the pace of pollutant speed is getting slower. In the calculation of the speed of difference due to differences in the height of the well surface and distance, but it is influenced by the flow of water is not straight or meandering due to differences in the porosity of rocks or layers [8].

Based on subsurface resistivity sections it is interpreted that the dominant layer is clay. Conductivity of rocks that have been contaminated by heavy metals has a higher conductivity than rocks that have not been contaminated by heavy metals. The high conductivity value of the measured resistivity value is so low. Therefore, the polluted resistivity value will be lower than the supposed rock [9]. In this study found clay rock with resistivity values ranging from 0.762 Ωm to 4.53 Ωm it can be indicated the existence of heavy metal pollution located in depth of 1 meter to 5 meters. The difference in water level between river and well is shown in figure 2. The map shows that the river surface is higher than the residents’ wells so it can be concluded that the river water can seep into the well. The nature of the water that flows from high to low place so that the river water flows into the well water [10]. In addition, supported AAS test results. In AAS test results indicate that heavy metals located in river water are equal to heavy metals located in well water with concentration values in the range of 0.100
mg/L to 0.108 mg/L. Based on the AAS test results that in the research area can be indicated the existence of seepage from the river to the well citizens.

Figure 2. Distribution of pollutants in field “F”

In this study obtained the calculation of the speed of seepage of river water into the residents' wells. The average velocity value at location “E” is $2.9 \times 10^{-7}$ cm/s and at location “F” of $1.5 \times 10^{-7}$ cm/s. This seepage velocity value is influenced by the difference of river and well height and the distance between the river and well in the location of the study. For permeability coefficient values are considered homogeneous because the pollutant is in 1 layer of clay so the coefficient is considered homogeneous and the permeability coefficient value is $10^{-7}$ cm/s.

**Table 2. Seepage Speed**

| Location | Distance (m) | Velocity (cm/sec) | Well depth (cm) | Cd concentration(mg/l) |
|----------|-------------|-------------------|-----------------|------------------------|
| Well E1  | 228         | $2.67\times10^{-7}$ | 723             | 0.101                  |
| Well E2  | 130         | $4.06\times10^{-7}$ | 642             | 0.108                  |
| Well E3  | 348         | $1.6\times10^{-7}$  | 672             | 0.096                  |
| Well F1  | 571         | $6.88\times10^{-8}$ | 443             | 0.105                  |
| Well F2  | 534         | $7.64\times10^{-8}$ | 458             | 0.106                  |
| Well F3  | 643         | $6.07\times10^{-8}$ | 440             | 0.104                  |

At the furthest distance from the river to the well which is 348 m at location “E” indicates heavy metal concentration of 0.096 mg/L and the closest distance between the river to the well of 130 at location “E” shows a heavy metal concentration of 0.108 mg/L. At the furthest distance from the river to the well of 643 m at location “F” indicates heavy metal concentration of 0.104 mg/L and the closest distance between the rivers to the well of 534 m at location “F” indicates cadmium concentration of 0.106 mg/L. Based on Table 2 shows that the farther the distance between wells and rivers the smaller the concentration of metal cadmium and the smaller the value of seepage speed.
4. Conclusion
Based on the results and discussion, it can be concluded as follows:

1. In the resistivity section of subsurface layer using geoelectric can show the existence of pollutant. Pollutants are shown with a low resistivity value with a value of resistivity between 0.762 - 4.53 Ωm. This can occur because of the relationship between conductivity and resistivity that is inversely proportional, heavy metal is a good conductor of electricity so it has a low resistivity value, as in the resistivity cross section in the study area.
2. Average velocity value of cadmium at location “E” is $2.9 \times 10^{-7}$ cm/s and at location “F” of $1.5 \times 10^{-7}$ cm/s. This seepage velocity value is influenced by the difference of river and well height and the distance between the river and well in the location of the study.
3. The distance between the river and the well is closer then the heavy metal concentration value is greater and the value of seepage velocity will be greater so that the bigger the value of seepage velocity then the greater the value of heavy metal concentration.

References
[1] Karanth, K.R., 1987, Groundwater Assessment, New Dehli: Tata McGraw-Hill Book Publishing Co.
[2] Loke, M., 1999, Electrical Imaging Surveys for Environmental and Engineering Studies, A Practical Guide to 2D and 3D Surveys.
[3] Laws of the republic Indonesia, 1982. Basic provisions of environmental management No.4/1982
[4] Dias Lopes, Deize, Silva, M.C.P Sandra, Fernandes, Fernades, S. Teixeira, Raquel, Celligoi, Andre, Antonio, Luiz Henrique Dall. 2012. Geophysical Technique and Groundwater Monitoring to Detect Leachate Contamination in The Surrounding Area of A Landfill – Londrina (PR – Brazil), Elsevier. 113, 481 – 487.
[5] Prapitari, Aspia, Yulianto, Tony. 2013. Use of 3 Dimensional Resistivity Geolocation Method to Know the Distribution of Waste at TPA Jatibarang Semarang City. Youngster Physics Journal.
[6] Yulianti, Dwi and Sunardi. 2010. Identification of Metal Pollution on Kaligarang River with Method of Activation Analysis of Netron Cepat (AANC). Vol. 8 No. 1 Juni 2010.
[7] Hamzah, Umar, Jeeva, Mark, Ali, Nur Atikah Mohd. 2014. Electrical Resistivity Techniques and Chemical Analysis in the Study of Leachate Migration at Sungai Sedu Landfill. Asian Journal of Applied Science. 7, 518 – 535.
[8] Setiawan, H., 2013, Accumulation and Distribution of Heavy Metal on Mangrove Vegetation in Coastal Waters of South Sulawesi, Balai Penelitian Kehutanan Makasar, Vol VIII No 1.
[9] Soehoed, 2012, Overview High Behavior Water Pressure and Seepage on Dams using Tool Dom without Turap, Jurusan Teknik Sipil Univeristas Kristen Imanuel Yogyakarta, Majalah Ilmiah UKRIM Edisi I/Th XVII, Hal 31 – 44.
[10] Telford, W.M., L.P. Geldart, R.E. Sheriff, and D.A. Keys. 1990. Applied Geophysics. London: Cambridge University Press.