ISSN 2541-223X
Volume 4 2022

ANALYSIS OF HEAVY METAL EXPOSURE ON HAIR OF RESIDENTS AROUND GUNUNG TUGEL FINAL DISPOSAL SITE AT BANYUMAS REGENCY

F M Iresha[1*], Kasam[1], D S Nuramadhani[1], A Rahmat[2]

[1] Program Studi Teknik Lingkungan, Fakultas Teknik Sipil dan Perencanaan, Universitas Islam Indonesia, Yogyakarta

[2] Badan Riset dan Inovasi Nasional, Indonesia

ABSTRACT

Final Disposal Site (FDS) which is a place that is produced from landfills or the final stage in waste processing. Gunung Tugel FDS which is located in Kedungrandu Village, Patikraja District, Banyumas Regency has a source of waste originating from settlements, markets, shops and also industry of 260 m3/day. The existing facilities at the Gunung Tugel FDS have not been maximized because they use the open dumping method, namely the discarded waste is allowed to accumulate without any further processing other than that there is no leachate or leachate disposal. Leachate that is not treated can infiltrate into the ground and contaminate the surrounding groundwater. The study was conducted to determine the concentration of heavy metals Zinc (Zn) and Chromium (Cr) in the hair of the community around the Gunung Tugel FDS, Banyumas Regency and analyze the relationship between length of stay, source of drinking water consumption and the amount of drinking water consumption with heavy metal content in the community around the Gunung Tugel FDS, Banyumas Regency. The number of samples was determined using the distance of residence from the FDS, namely 16 samples. The distance used has 4 retrieval points and 4 repetitions which are at a distance of 500 meters, 1000 meters, 1500 meters and 2000 meters. The results of the analysis of the concentration of Zn in the hair of the people around the Gunung Tugel FDS reached 85.52 - 339.64 µg/g and the concentration of Cr in the sample was in the range of 1.8±0.3 ppm. At point 1 the average concentration obtained is 609.87 mg/kg, this shows that the closer the distance, the faster the exposure to heavy metals produced by the landfill.

Keywords: Heavy Metal, exposure, disposal

1. INTRODUCTION

Final Disposal Site (FDS) which is a place that is generated from landfills or the final stage in waste processing. Garbage is a solid or general pollutant that can cause a decrease in environmental quality, can cause disease, reduce resources and increase pollution (Bahar, 1985). Gunung Tugel FDS is located in Kedungrandu Village, Patikraja District, Banyumas Regency. The sources of waste in Gunung Tugel FDS are residential areas, then markets, shops, and industries. Gunung Tugel FDS produces 260 m3/day of waste and the highest composition is produced by 61.91% organic waste (Cahyono et al., 1999).[1]

[1] *Corresponding author's email: fajri.mulya@uii.ac.id
DOI: https://doi.org/10.20885/icsbe.vol4.art22

The facilities at the Gunung Tugel FDS have not been maximized because they use the open dumping method, namely the discarded waste is allowed to accumulate without any further processing, besides that there is no disposal for leachate. Leachate that is not treated can seep into the ground and contaminate the surrounding groundwater. Leachate which has the characteristics of high levels of physical and chemical parameters and also contains harmful heavy metals. The heavy metals found in leachate are copper (Cu), chromium (Cr), iron (Fe), zinc (Zn), lead (Pb), cadmium (Cd), arsenic (As) and manganese (Mn). The heavy metals contained in the leachate come from the accumulation of garbage that has been disposed of. Leachate which is a type of pollutant has a high potential to pollute the environment, such as surface water contamination. The leachate can also seep into groundwater, causing direct soil and groundwater pollution (Tchobanoglous & Kreith, 1993). Leachate water can also contaminate sources for drinking water at a distance of 100 meters from the pollutant source (Mahardika et al., 2010).

The effects caused by heavy metals in general are cancer, kidney and chronic health problems due to carcinogenic heavy metals. However, each heavy metal has a different effect when it enters the human body, while non-essential heavy metals (micro elements) are very dangerous and can cause poisoning (toxic) to humans such as lead (Pb), mercury (Hg), arsenic. (As) and Cadmium (Cd) (Yudo, 2006). Therefore, there is a need for research to determine the concentration of heavy metal content of Zinc (Zn) and Chromium (Cr) in humans around the Mount Tugel FDS, Banyumas Regency, in addition to analyzing the relationship between length of stay, source of drinking water consumption and amount of consumption drinking water with heavy metal content in the community around Mount Tugel FDS, Banyumas Regency.

2. RESEARCH METHODS

The location of this research was conducted at Gunung Tugel FDS which is located in Kedungrandu Village, Patikraja District, Banyumas Regency, Central Java by using primary data from direct observation and hair sampling in people who living surrounding in the Gunung Tugel FDS area. The research was conducted in March-August 2022.

The method used is quantitative using data in the form of numbers generated from instruments related to obtaining data for sure and purposive sampling method in the form of samples taken by researchers. According to Hardani et al. (2020), quantitative methods produce data in the form of numbers. The population used is all people who live around Gunung Tugel FDS, Banyumas Regency. The number of samples was determined using the distance of residence from the FDS, namely 16 samples. The distance used has 4 taking points and 4 repetitions which are at a distance of 500 meters, 1000 meters, 1500 meters, and 2000 meters.

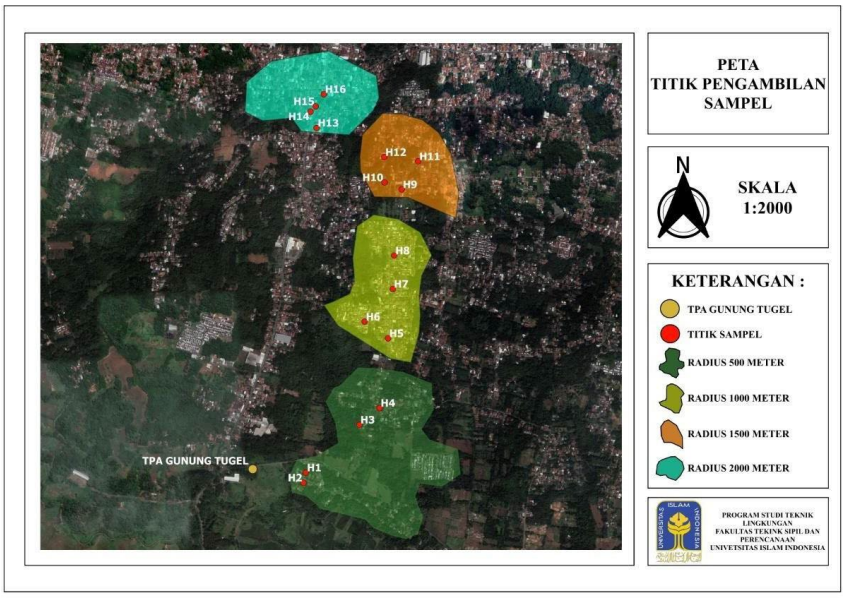


Figure 1. Map of Sampling Locations

The sampling technique was carried out randomly based on the inclusion criteria and according to the respondents who agreed to take hair samples. Each community who is willing to become a respondent will have their hair cut from the base of the scalp by 1-2 cm for analysis.

3.1 Analysis of Heavy Metal Content

3.1.1 ICP-MS (Inductively Coupled Plasma-Mass Spectrometry)

The method used in analyzing hair samples uses the ICP-MS (Inductively Coupled Plasma-Mass Spectrometry) instrument which will be carried out at the Environmental Quality Laboratory, Faculty of Civil Engineering and Planning, Islamic University of Indonesia. Sample preparation using the ICP-MS method to analyze the Cr content was carried out by washing hair samples using baby shampoo, to remove organic compounds followed by washing using acetone to remove external contamination. The hair samples were then rinsed three times using ultrapure distilled water. Then the sample was dried in a desiccator for 1 day for the destruction process. The dried sample was weighed and then put into a porcelain dish. The sample is heated in a furnace at a temperature of 600C for 4 hours until it becomes ash. The ash from the sample was dissolved using a mixture of HNO3 : HCl = 1: 3 solution about 10 ml until dissolved. Then the sample was heated on a hotplate until the solution became clear and colorless. After that, the sample was cooled and diluted to 25 ml in the measuring cylinder for the homogenization process and put into the sample bottle provided. Subsequently, the samples were filtered using filter paper and analyzed using the ICP-MS instrument (Wongsasuluk et al., 2018; Li et al., 2020).

3.1.2 AAS (Atomic Absorption Spectrophotometer)

Sample preparation using the AAS instrument to analyze the Zn content was carried out by washing the sample and soaking it in 10 ml of acetone for 15 minutes and stirring it in a 100 ml measuring cup. The hair samples were then rinsed three times using ultrapure distilled water. Then the sample was dried in a desiccator for 3 days for the destruction process. The dried sample was weighed and then put into a porcelain dish. The sample is heated in a furnace at 6000C for 4 hours until it becomes ash. The ash from the sample

was dissolved using a mixture of HNO3: HCl = 1: 3 solution for about 10 ml until dissolved. Then the sample was heated on a hotplate until the solution became clear and colorless. After that, the sample was cooled and diluted to 25 ml in the measuring cylinder for the homogenization process and put into the sample bottle provided. Subsequently, the samples were filtered using filter paper and analyzed using the AAS instrument (Wongsasuluk et al., 2018; Li et al., 2020).

3.2 Data Analysis Method

The data analysis method used is the AAS instrument and the ICP-MS instrument. The results of measuring the concentration of each instrument are then calculated. The results of the analysis of the hair test obtained the concentration and then will be compared with the existing quality standards.

4. RESULTS AND DISCUSSION

4.1 Characteristics of Respondents

Characteristics of respondents used to facilitate sampling are based on length of stay, gender, age, drinking water consumption and distance from settlement to FDS.

The majority of people in the Gunung Tugel FDS area have lived in the area since birth, so that the average age and length of stay of the community is almost the same (Table 1). Based on Table 1. it can be seen that the majority of respondents have a length of stay of 1-10 years and 11-30 years with a percentage of 38% each from 16 respondents.

Table 1. Characteristics of Respondents Based on Length of Stay

Length of Stay (Years)	Number of people	Percentage (%)
1-10	6	38
11-30	6	38
≥ 30	4	25
Total	16	100

Characteristics of respondents by gender are presented in Table 2. Based on Table 2, it can be seen that the respondents based on gender with the largest number of male respondents with a percentage of 69% and female respondents as many as 5 people with a percentage of 31% this is influenced by the sampling factor which the majority is housed in the male respondent's house.

Table 2. Characteristics of Respondents by Gender

Gender	Number of people	Percentage (%)
Male	11	69
Female	5	31
Total	16	100

Characteristics of respondents were classified by age to determine the range for hair sampling. Based on Table 3. it is known that there are 8 respondents in the age range of 20-40 years and in the range of 41-60 years 8 people with the same percentage of both, namely 50%.

Table 3. Characteristics of Respondents by Age

Age (Years)	Number of people	Percentage (%)
20-40	8	50
41-60	8	50
Total	16	100

Characteristics of respondents are classified based on drinking water consumption, in order to know the water used for daily needs using water sourced from groundwater, Municipal Water Corporation (Perusahaan Air Minum/ PDAM) or using from 2 sources, namely groundwater and PDAM. Based on Table 4. the majority of respondents use PDAM water sources with a percentage of 44% for consumption as drinking water.

Table 4. Characteristics of Respondents Based on Sources of Drinking Water Consumption

Sources of Drinking Water	Number of people	Percentage (%)
Groundwater	5	31
PDAM	7	44
Groundwater and PDAM	4	25
Total	16	100

4.2 Concentration of Zinc (Zn) in Humans

Heavy metal Zn is an essential heavy metal, which is needed by living organisms such as plants. If the heavy metal that enters in excess will make the heavy metal Zn toxic (Kcaribu, 2008). Zn metal tends to follow the flow of water and affects dilution when water enters, for example rainwater, because it can lead to a decrease in heavy metal concentrations (Sunti et al., 2012).

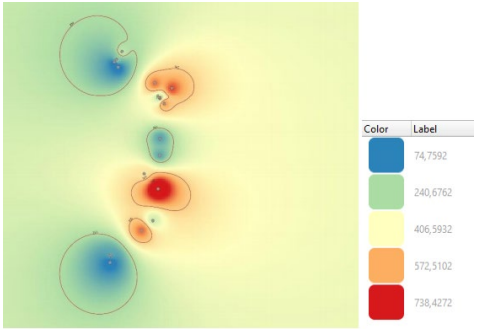
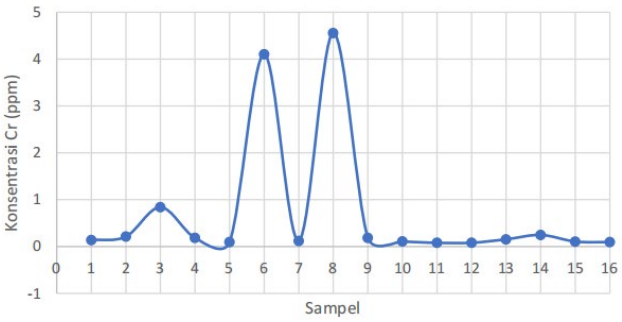


Figure 2. Concentration of Zn in hair

Based on Figure 2. the concentration of Zn in the hair of the community around the Mount Tugel FDS based on analysis using the AAS instrument ranged from 0.086 - 0.947 mg/L. According to research by Samanta et al. (2004) there are 6 samples included in the range (85.52 - 339.64 µg/g), 4 samples were below the range and 6 samples were above the range.

4.3 Concentration of Chromium (Cr) in Humans

Cr metal that enters the body in excess will cause respiratory tract disorders in the form of increasing the risk of lung cancer, in the skin in the form of wounds on the skin surface and abnormalities in the kidneys.



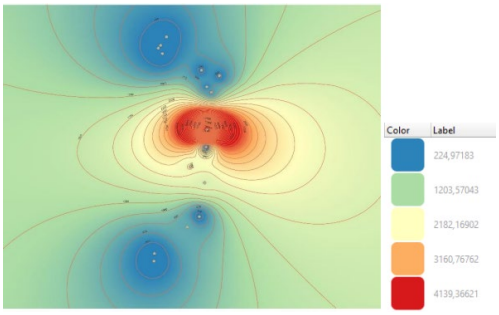


Figure 3. Concentration of Cr in hair

Based on Figure 3. the concentration of Cr in the hair of respondents around the Gunung Tugel FDS using the ICP-MS instrument ranged from 0.0807 to 4.5574 ppm. According to research by Sukumar & Subramanian (2007) there is 1 sample in the range (1.8±0.3 ppm), 13 samples are below the range and 2 samples are above the range. Based on these results when associated with the results of the questionnaire, the high concentration produced is influenced by several factors, namely based on the length of stay of the community, the dominant sample is that people from birth have lived around Gunung Tugel FDS so that the older they get, the greater the heavy metals that accumulate in the body. then the distance between Gunung Tugel FDS, at point 1 is closest to Gunung Tugel FDS so that it allows greater exposure to heavy metals. In addition, another factor that can affect the high concentration of heavy metals is the consumption of drinking water sourced from well water or ground water.

ISSN 2541-223X
Volume 4 2022

4.4 Relationship Between Length of Stay, Source of Drinking Water Consumption and Heavy Metal Concentrations

Table 5. Relationship between length of stay, source of drinking water consumption and heavy metal concentrations of Zn and Cr

Kode Sampel	Konsentrasi Zn (mg/kg)	Konsentrasi Cr (mg/kg)	Jarak				Sumber Konsumsi Air Minum			Lama Tinggal	Usia (Tahun)
			500 m	1000 m	1500 m	2000 m	Air Tanah	Air PAM	Keduanya		
H1	445,93	646,265		□			□			40 tahun	59
H2				□			□			4 tahun	52
H3				□			□			4 tahun	21
H4				□					□	15 tahun	42
H5					□		□			21 tahun	42
H6	265,27	4583,36			□			□		41 tahun	41
H7					□				□	26 tahun	26
H8					□				□	8 tahun	26
H9	541,14	292,79	□					□		50 tahun	50
H10			□					□		40 tahun	43
H11			□					□		29 tahun	29
H12			□					□		30 tahun	30
H13	149,23	61,39				□		□		10 tahun	36
H14						□		□		15 tahun	41
H15						□			□	10 tahun	32
H16						□	□			6 tahun	28

Table 5 shows that at point 1 the average concentration obtained is 609.87 mg/kg, this shows that the distance between residence and FDS has a relationship, the closer the distance, the faster the exposure to heavy metals produced by FDS will be. In addition, the longer people live in FDS areas, the more often they are exposed to heavy metal contamination, even though in recent years the consumption of drinking water used has come from PDAM. At point 3 the average concentration is 318.38 mg/kg even though the distance is quite far, but the consumption of drinking water using ground water and PDAM water allows contamination.

The Cr concentration shown in Table 5. is still a very high concentration. At point 3 the average concentration produced is very high. Judging from the distance to the FDS, it is quite a distance but the consumption of drinking water used comes from well water and PDAM water. Even though you don't use well water often, there is a small chance of being contaminated with heavy metals. At point 2 the average concentration produced is still high because the dominant drinking water consumption comes from ground water.

For point 1 the average is still high even though the use of groundwater is rarely used, but there is a possibility of accumulation of heavy metals.

4.5 Correlation of Distance with Concentration (Zn)

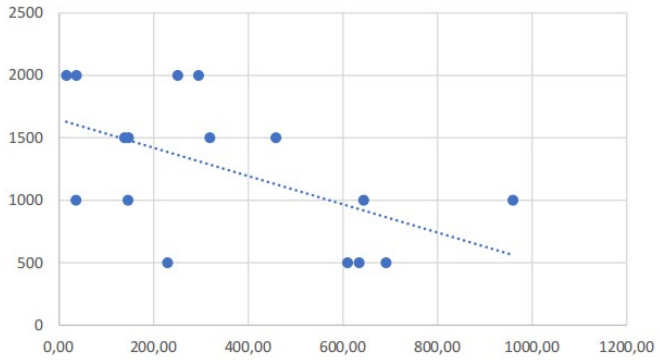


Figure 4. Correlation between sampling distance and Zn concentration

Based on Figure 4. the results of the correlation between the sampling distance and the concentration of Zn, have a moderate correlation of -0.5536 which is between 0.40 - 0.599 while the correlation between variables is in the opposite direction because the results obtained are negative (-).

4.6 Correlation of Length of Stay with Zn Concentration

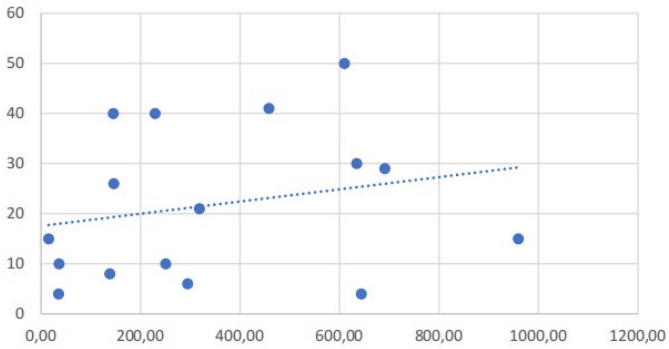
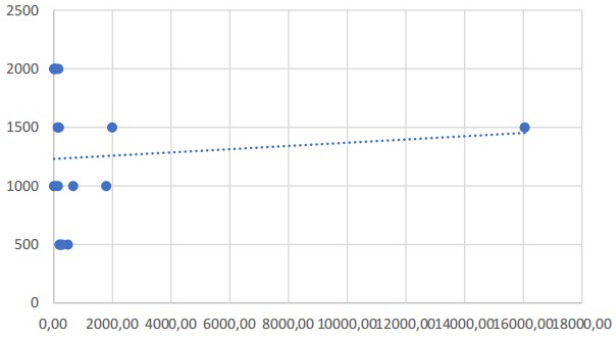


Figure 5. Correlation of Length of Stay with Zn Concentration

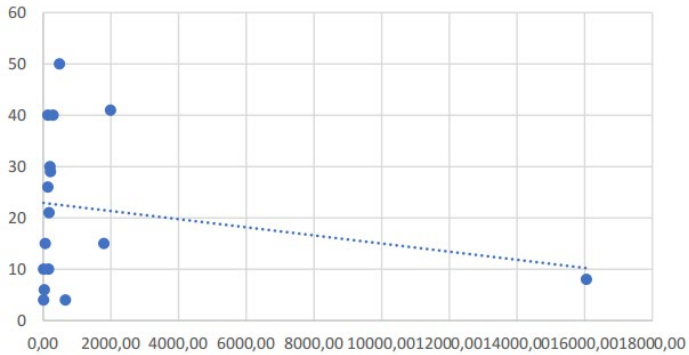
Based on Figure 5. the correlation between the length of stay of the community and the concentration of Zn, has a weak correlation of 0.22852, which is between 0.20 – 0.399, while the correlation between variables is unidirectional because the results obtained are positive.

4.7 Correlation of Distance with Cr Concentration



Based on Figure 6. the correlation between sampling distance and Cr concentration has a very weak correlation of 0.09473, which is between 0.00 - 0.199, while the correlation between variables is unidirectional because the results obtained are positive.

4.8 Correlation of Length of Stay with Cr Concentration



Based on Figure 7. the correlation between the length of stay of the community and the concentration of Cr, has a weak correlation of -0.2076 which is between 0.20 - 0.399 while the correlation between the variables is not unidirectional because the results obtained are negative.

CONCLUSION

The concentration of heavy metal Zn was between 15.19 – 959.43 mg/kg with an average of 350.40 mg/kg using the AAS instrument. The concentration of heavy metal Cr was between 5.88 – 16047.03 mg/kg with an average of 1395.95 mg/kg using the ICP-MS instrument. The closer the distance between community settlements and FDS, the more frequent the impact. The correlation between the concentration of heavy metal Zn and distance has a moderate correlation of -0.5336 with the correlation between variables in the opposite direction. The concentration of Zn with length of stay has a weak correlation of 0.22852 with a correlation between variables in the same direction. The concentration of Cr with distance has a very weak correlation of 0.09473 with a correlation between unidirectional variables. The concentration of Cr with length of stay has a weak correlation of -0.2076 with the correlation between variables not in the same direction.

5. REFERENCE

Bahar, Y. H. (1985). Teknologi Penanganan dan Pemanfaatan Sampah, hasil sayembara penulisan naskah ilmiah th. 1985/1986. Jakarta : Waca Utama Pramesti.

Cahyono, T.B., Triyantoro & Z. Budiono. (1999). Kaji Tindak Pengelolaan Sampah di

Kabupaten Banyumas Tahun 1998/1999. Purwokerto: Depkes RI. Pusat Pendidikan Kesehatan.

Hardani, H., Andriani, H., Fardani, R. A., Ustiawaty, J., Utami, E. F., Sukmana, D. J., & Istiqomah, R. R. (2020). Metode penelitian kualitatif & kuantitatif. Yogyakarta: Pustaka Ilmu.

Kacaribu, K. (2008). Kandungan Kadar Seng dan Besi dalam Air Minum dari Depot Air Minum Isi Ulang Air Pegunungan Sibulangit di Kota Medan. Pascasarjana Universitas Sumatera Utara Medan.

Li, Y., Yu, Y., Zheng, N., Hou, S., Song, X., & Dong, W. (2020). Metallic elements in human hair from residents in smelting districts in northeast China: Environmental factors and differences in ingestion media. Environmental Research, 182,108914. https://doi.org/10.1016/j.envres.2019.108914

Mahardika, A., Muhammad D.Z., & Akhmad A.L. (2010). Mendeteksi Dampak Polutan Sampah Terhadap Air Tanah Permukiman di Sekitar Tempat Pembuangan Akhir (FDS) dengan Menggunakan Metode Geolistrik. Program Kreativitas Mahasiswa-Gagasan Tertulis. Malang: Universitas Negeri Malang.

Samanta, G., Sharma, R., Roychowdhury, T., & Chakraborti, D. (2004). Arsenic and other elements in hair, nails, and skin-scales of arsenic victims in West Bengal, India. Science of the Total Environment, 326(1–3), 33–47. https://doi.org/10.1016/j.scitotenv.2003.12.00

Sukumar, A., & Subramanian, R. (2007). Relative element levels in the paired samples of scalp hair and fingernails of patients from New Delhi. Science of the Total Environment, 372(2–3), 474–479. https://doi.org/10.1016/j.scitotenv.2006.10.020

Sunti, I., Anwar, D & Syamsuar, M. (2012). Studi Kandungan Logam Berat Seng (Zn) Dalam Air Dan Kerang Baja-Baja (Anodonta Woodiana) Di Sungai Pangkajene Kabupaten Pangkep. Universitas Hasanuddin. Semarang.

Tchobanoglous, G. & Kreith, F. (2002). Handbook of Solid Waste Management. McGraw-Hill. New York.

Wongsasuluk, P., ChoFDSntarat, S., Siriwong, W., & Robson, M. (2018). Using hair and fingernails in binary logistic regression for bio-monitoring of heavy metals/metalloid in groundwater in intensively agricultural areas, Thailand. Environmental Research, 162, 106–118. https://doi.org/10.1016/j.envres.2017.11.024.

Yudo S. (2006). Kondisi pencemaran logam berat di Perairan Sungai DKI Jakarta. Jurnal Akuakultur Indonesia,2(1), 1-15. https://doi.org/10.29122/jai.v2i1.2275.