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ASSESSMENT OF WATER QUALITY AND HEAVY METALS IN DRAINAGE CANAL

Noraini Ruslan[*1,2], Jannatulhawa Jasni[*3], Nurul Fatini Yusri[*4]

[*1]Student, Department Of Biological Sciences And Biotechnology, Faculty Of Science And Technology, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia.

[*2]Lecturer, Department Of Technology And Natural Resources, Faculty Of Applied Sciences And Technology, Universiti Tun Hussien Onn Malaysia, Pagoh, Johor, Malaysia.

[*3]Student, Research Center For Sustainable Process Technology, Faculty Of Engineering And Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia.

[*4]Student, Department Of Chemical And Biological Engineering, The University Of Sheffield, S1 4NL, Sheffield United Kingdom.

ABSTRACT

Alur Ilmu is a concrete-cement drainage canal built since the construction of the Universiti Kebangsaan Malaysia in 1970s for rain, storm, and groundwater; flowing towards the main discharge point that joins the Langat River Selangor. In this study, water quality parameters (i.e. DO, BOD, COD, Ammoniacal Nitrogen, TSS, pH) and heavy metal (i.e. Zinc, Cadmium, Copper, Plumbum, Manganese, Ferum, Chromium, Nickel) were assessed along the Alur Ilmu canal at five stations from upstream to downstream and compared with Malaysian Water Quality Index. Overall, all the research stations were in Class III (slightly polluted), and there were highly significant differences for all the water quality parameters ($p < 0.001$) across five stations except for BOD, COD and TSS. The concentration means of heavy metals analyzed were below the recommendation of Standard for Water and Packaged Drinking Water (Food Act 1985) for Malaysia except for Fe (>0.30 mg/L) and Mn (>0.001 mg/L). However, the mean concentration of Fe and Mn in Alur Ilmu were still acceptable by USEPA; Mn (<0.50 mg/L) and Fe (<1.0 mg/L). In conclusion, this study gives a baseline toward future better conservation and management of Alur Ilmu as it has potential as cultural identity and recreational uses in UKM.

Keywords: Alur Ilmu, Water Quality Assessment, Heavy Metal Concentration, Water Quality Index, Drainage Canal.

I. INTRODUCTION

Accessible and safe water supply are crucial for humanity and every lives on the Earth. Increasing human population, urbanization and rapid industrialization are among substantial factors putting pressure on water resources and increasing the unregulated or illegal discharge of contaminated water within and beyond national borders [1]. Uncontrolled disposals cause serious water pollution and heavy metal contamination which can influence human health [2]. This has presented a global threat to human well-being and other living things [3].

Declining in water quality has become a worldwide concerns as humanity depends largely on safe, reliable, acceptable and adequate water supply for survival [4]. People most affected are those who live close by to contaminated waterways and those who have no alternative access to safe water. Currently, about 2.1 billion people do not have access to safely managed water, 159 million people drink contaminated water and 844 million people do not have any basic drinking water service [5]. Contaminated water can transmit various serious disease such as typhoid, dysentery, polio, cholera and diarrhea [6]. Diarrhea is the second highest leading cause of death among children particularly under 5 years old (i.e. 370,000 children death in 2019 due to diarrhea) [7].

Water contamination has become a challenging global issue that arises from human society's misconduct especially in water usage. Notably, increasing presence of heavy metals in environment cause greater concern to human health due to increasing anthropogenic activities [8][9]. Heavy metals are toxic to human kind and can bioaccumulated in our body system if swallowed [10]. Toxicity of heavy metals depends on kind of metal, compound, from the amount which are deposited in organism and from time extension action of metal [11].

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Some heavy metals can cause chronic toxicity to the body even in small quantities (e.g. lead, arsenic, cadmium, chromium, silver, mercury) whereas some did not have any significant effect in a minute volume (e.g. Ferum) [12][13]. For example, a man died from gastrointestinal bleeding 1 month after ingesting only 4.1 mg/(kg body mass) of Cr (VI) as chromic acid, H_2CrO_4 [14]. Due to misconception as water is limitless and cheap resource, people have never paid serious attention to water protection throughout centuries, particularly in the process of their urbanization and industrialization. Heavily polluted oceans and lakes by raw sewage, oil spills, lack of sewage collection and disposal, shortage of water supply and prevalence of waterborne diseases in many underdeveloped countries also reflects that our available water resources are in danger [15].

Water quality and heavy metal assessment is the foundation on which water quality management is based on to ensure safe water supply. The Water Quality Index (WQI) can be used as a basis for assessment of a watercourse in relation to pollution load categorization and designation of classes of beneficial uses. The WQI was derived using Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3N), Suspended Solids (SS) and pH [16]. Water quality indices aim at giving a single value to the water quality of a source, by reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data Water Quality Index (WQI). WQI is refers to quality value to an aggregate set of measured parameters. It usually consists of subindex values assigned to each pre-identified parameter by comparing its measurement with a parameter-specific rating curve, optionally weighted, and combined to the final index [17]. Thus, water quality and heavy metal assessment give the information that permits rational decisions to be made on the describing water resources and identifying actual and emerging problems of water pollution. From that information, we can formulate plans and setting priorities for water quality management and programs. The primary objective for this study is to determine the level of water quality (using WQI) and heavy metal concentration (using Inductively Coupled Plasma Mass Spectrometry or ICP-MS) in Alur Ilmu.

II. METHODOLOGY

Alur Ilmu is a concrete-cement canal built since the construction of the UKM Bangi campus, Malaysia, in the early 1970s for rain, storm, and groundwater, flowing towards the main discharge point that joins the Langat River Selangor. It has length approximately about 1km and has an average velocity on dry days about 0.011 m/s [18]. Water of Alur Ilmu is coming from the hill in front of the Nuclear Science Program Building. Rain water and ground water from the upstream of Alur Ilmu flow through water channel near the building of Faculty of Science and Technology, Faculty of Economics and Business, Tun Sri Lanang Library, PUSANIKA, Faculty of Social Sciences and Humanities, Faculty of Islamic Studies, UKM Mosque and then eventually flowed into the Langat River [18]. Sampling activities were conducted three times in this study (i.e. 25 July 2013, 21 August 2013, 13 November 2013). Five selected stations were chosen located along the Alur Ilmu stream (Figure 1). All the five stations of Alur Ilmu located at the upstream, middle stream and downstream. The distance between each sampling station was approximately 200 m. Three replicates of water samples were taken for each station. Water sampling locations are shown in the Table 1.

Six parameters were taken to determine the quality of water for Alur Ilmu stations which are Total Suspended Solid (TSS), pH, Ammoniacal Nitrogen (NH_3N), Biochemical Oxygen Demand (BOD), Chemical Oxygen demand (COD) and Dissolved Oxygen (DO). In-situ measurement of temperature, dissolved oxygen (DO), electrical conductivity and pH were taken using YSI Model 556 Multi Probe System (MPS). All water samples were taken to the laboratory to determine the BOD (i.e. 5 Day BOD test) [19], COD (i.e. Reactor Digestion Method) [20], TSS (i.e. Dried at 103º C – 105º C method) [19], Ammoniacal Nitrogen (i.e. Nessler Method) [20] and heavy metal concentration levels (i.e. Zinc, Cadmium, Copper, Plumbum, Manganese, Ferum, Chromium, Nickel) using ICP-MS (USEPA 1997).

TABLE 1: Water sampling stations in this study

Stations	Area Description
Station 1 2.9252753º (Latitude) 101.7821036º (Longitude)	This station is the source of Alur Ilmu. It is located in front of to the Nuclear Science Program Building. This station was selected because it is the upstream of the Alur Ilmu. It gets water from the hill, Fernarium and rainfall.
Station 2 2.9254018º (Latitude) 101.7821036º (Longitude)	The second station is located near the Faculty of Science and Technology and cafeteria nearby. This station was selected for evaluation of water quality because it was believed that the station receives wastewater from nearby cafeteria and street runoff.
Station 3 2.9245969º (Latitude) 101.7803972º (Longitude)	The third station is located in the Faculty of Social Sciences and Humanities and Pusanika. It is the mainstream of Alur Ilmu. This station was chosen because it received lots of wastewater and domestic sewage from nearby restaurants in Pusanika and Pusanika Building.
Station 4 2.9340822º (Latitude) 101.7740642 º(Longitude)	The fourth station is located at the junction of the main roundabout at the entrance to UKM. This station area receives many water from street runoff and rainfall.
Station 5 2.9344944º (Latitude) 101.7755947º (Longitude)	The fifth station is the downstream of Alur Ilmu. It is located near the UKM entrance gate. Water from Alur Ilmu will go through this station before entering the Langat River.

III. DATA ANALYSIS

Statistical analysis was performed using the Statistical Packages for the Social Sciences (SPSS) 21. One-way ANOVA was carried out to shows significant difference in means between the values of each parameter between the five sampling stations.

IV. RESULTS AND DISCUSSION

a. Water Quality Index

Result showed, there was a significant differences in mean of water quality parameters among five sampling stations except for BOD, COD and TSS ($F_{4,40} \leq 2.45$, $p > 0.05$) (Table 2). Station 5 showed significantly higher mean of water temperature (30.17°C±0.94), conductivity (166.33uS/cm±11.67) and pH (8.01±0.40) (Table 2). Station 1 showed significantly higher DO (70.98%±29.36) but lowest temperature (27.44°C±0.33) and conductivity (42.33uS/cm±21.25).

Station 3 showed significantly higher ammoniacal nitrogen (0.36mg/L±0.16) but lowest DO concentration (22.04%±13.73). Overall, results showed the average value of WQI at all five sampling stations was Class III and categorized as slightly polluted. Station 1 showed significantly higher WQI value (68.89±2.24), meanwhile Station 3 showed vice versa (64.61±2.78)(Figure 1).

Generally, the results of WQI showed Station 1 pose better water quality as it is found in the upper stream and did not receive much incoming pollution from any sources. However, from the observation on the site, the lower WQI value contributed by clearing bushes around the station 1 area. Furthermore, there were a lot of rubbish, plastic materials and food scraps. Station 3 were recorded as the lowest WQI values due to incoming pollutant from nearby human activities (i.e. next to Cafeteria). During the sampling, it could be seen that, there were a lot of oils, waste dumps and dead insects such as cockroaches at station 3 and soap bubbles from the

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wash water discharge at station 2. The cafeterias have a high potential of generating various types of pollutants into Alur Ilmu such as food waste, oil, grease, and trash which can be seen physically on the water surface. Station 4 and Station 5 is slightly different from the other stations because the water depth is shallower, the width of the river is smaller, and the water velocity is faster (Figure 2).

According to [21], cold water contains more oxygen because oxygen is more readily soluble in water at the lower temperature. Generally, lower DO value can cause lower WQI value. Meanwhile, higher DO value can improve WQI value (Arman et al., 2013). The DO value depends on the activities at the stations. Waste is the main cause of the decline DO value at Alur Ilmu due to the high organic pollutants from the nearby cafeterias. The rubbish, detergent, grease as well as suspended solids tend to accumulate on the surface of the river which are directly affect the surrounding oxygen from dissolving into the river [22]. Sewage, domestic sewage and solid waste can cause water pollution and bad odour. Disposal of waste into river is one of the contributors to the decline in water quality and dissolved oxygen due to the presence of organic and inorganic materials. If the river is too small while the organic materials is too high, more oxygen will be used in water for the process of stabilization and hence, the dissolved oxygen is reduced and not enough for the aquatic life [23].

b. Heavy metal concentration

Results showed that Ferum (Fe) has the highest heavy metal concentration mean with average of 357.707 ppb while Cadmium (Cd) shows the lowest reading with average of 0.065 ppb. The average distribution and mean concentration of heavy metals (ppb) in Alur Ilmu by station follows this series which Ferum (Fe) >Manganese (Mg) >Zinc (Zn) >Chromium (Cr) >Nickel (Ni) >Copper (Cu) >Plumbum (Pb) >Cadmium (Cd) (Table 3). The concentration of Cd (0.000 mg/L), Cr (0.002 mg/L), Ni (0.001 – 0.002 mg/L), Pb (0.000 – 0.001 mg/L), Zn (0.046 – 0.061 mg/L) and Cu (0.001 – 0.002 mg/L) were below the recommended by Standard for Water and Packaged Drinking Water (Food Act 1985) except for Mn and Fe. The concentration of Mn (0.013 – 0.142 mg/L) and Fe (0.117 – 0.447 mg/L) concentration were found to be exceeding Standard for Water and Packaged Drinking Water (Food Act 1985) as it more than 0.001 mg/L and 0.30 mg/L respectively. The high Mn levels in Alur Ilmu most probably due to the influence of refuse dump and domestic sewage sources which has Mn as an active component such as petroleum product. Fe found in fresh and ground water have no health effect on consumer although in high concentration, but it gives rise to consumer complaints due to its ability to discolor aerobic waters at concentrations above 0.3 mg/l [24]. However, the mean concentration of Fe and Mn in Alur Ilmu are still acceptable by USEPA which stated as Mn (<0.50 mg/L) and Fe (<1.0 mg/L).

TABLE 2: One-way ANOVA results for all parameters used in this water quality study across all five sampling stations. Symbol * denotes significant figure.

	Sum of Squares	df	Mean Square	F	Sig.
*Temperature (°C)	50.179	4	12.545	17.419	.000
	28.806	40	.720		
	78.985	44			
*Conductivity (uS/cm)	126642.762	4	31660.691	91.293	.000
	13872.109	40	346.803		
	140514.871	44			
*DO (%)	229.966	4	57.491	16.959	.000
	135.603	40	3.390		
	365.568	44			
BOD (mg/L)	6.562	4	1.640	2.454	.061
	26.734	40	.668		
	33.295	44			
COD (mg/L)	1639.778	4	409.944	2.088	.100

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	7854.222 9494.000	40 44	196.356		
TSS (mg/L)	368.906 2259.662 2628.568	4 40 44	92.226 56.492	1.633	.185
*pH	27.876 9.723 37.598	4 40 44	6.969 .243	28.670	.000
*Ammoniacal Nitrogen (mg/L)	.208 .388 .596	4 40 44	.052 .010	5.371	.001

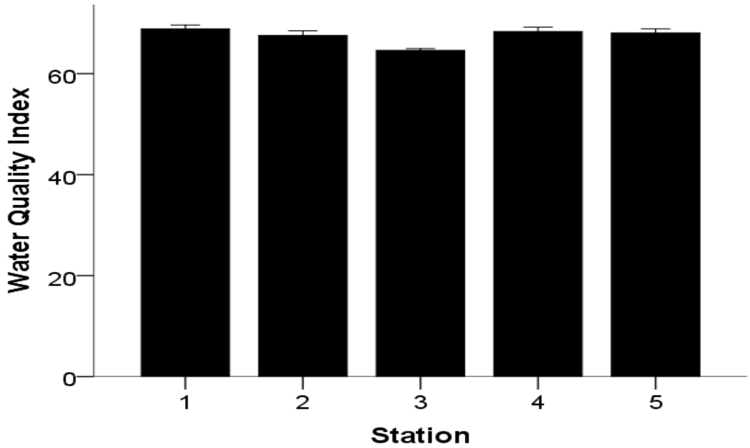

Figure 1: Mean (±1SE) of Water Quality Index among five sampling stations in Alur Ilmu, UKM

a)

b)

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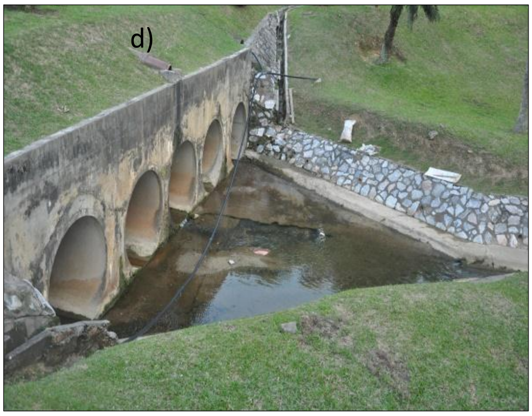
c)

d)



e)

Figure 2: Location of sampling station 1(a), 2(b), 3(c), 4(d) and 5(e) in Alur Ilmu, UKM

TABLE 3: Distribution and mean concentration of heavy metals 9ppb) in water samples across all five stations

Stations	Heavy Metal Mean Concentration (ppb)							
	Zn	Cd	Cu	Pb	Mn	Fe	Cr	Ni
1	45.831± 8.816	0.190± 0.179	1.761± 0.442	0.845± 0.283	12.705± 2.328	447.209± 34.068	1.777± 0.211	1.449± 0.151
2	47.188± 12.256	0.040± 0.010	1.403± 0.550	0.215± 0.052	47.253± 6.720	116.996± 6.535	1.750± 0.140	1.465± 0.235
3	61.420± 8.139	0.035± 0.007	1.398± 0.422	0.282± 0.074	142.512± 15.013	530.327± 32.315	1.897± 0.358	1.701± 0.057

4	59.526± 3.529	0.038± 0.017	1.772± 0.191	0.319± 0.035	78.708± 4.589	469.915± 17.058	1.968± 0.293	1.810± 0.047
5	56.316± 4.924	0.023± 0.010	1.627± 0.174	0.264± 0.139	16.118± 11.001	224.090± 30.437	2.183± 0.587	2.023± 0.400

V. CONCLUSION

From the studies, good water quality index was found in upstream Alur Ilmu as it is less polluted by incoming pollutant from human activities rather than midstream and downstream. Reduction in WQI value in Alur Ilmu was found mainly due to human activities such as dumping waste into the water canal. In conclusion, Alur Ilmu was classified as class III (slightly polluted) and were not contaminated by heavy metal pollution(i.e. Zinc, Cadmium, Copper, Plumbum, Manganese, Ferum, Chromium, Nickel). Therefore, Alur Ilmu can be used in future as water supply if only conventional treatment (class II) and extensive treatment (class III) are applied. This study also gives a baseline toward future better conservation and management of Alur Ilmu as it has potential as cultural identity and recreational uses in UKM.

VI. REFERENCES

[1] CP Liyanage and K Yamada. Impact of Population Growth on the Water Quality of Natural Water Bodies. Sustainability. 2017; 9, 1405.

[2] N Vongdala, H Tran, TD Xuan, R Teschke and TD Khanh. Heavy Metal Accumulation in Water, Soil, and Plants of Municipal Solid Waste Landfill in Vientiane, Laos. Int J Environ Res Public Health. 2019; 16(1), 22.

[3] J Briffa, E Sinagra and R Blundell. Heavy metal pollution in the environment and their toxicological effects on humans. Heliyon. 2020; 6(9), e04691.

[4] MO Dinka. Safe Drinking Water: Concepts, Benefits, Principles and Standards. 2018. In: Glavan, M., Ed., Water Challenges of an Urbanizing World, IntechOpen, London, 163-181.

[5] WHO. 2.1 billion people lack safe drinking water at home, more than twice as many lack safe sanitation. Available at: https://www.who.int, accessed August 2021.

[6] WHO. Drinking-water. Available at: https://www.who.int, accessed August 2021.

[7] WHO. Diarrhoea. Available at: https://www.who.int, accessed August 2021.

[8] X Yan, M Liu, J Zhong, J Guo and W Wu. How Human Activities Affect Heavy Metal Contamination of Soil and Sediment in a Long-Term Reclaimed Area of the Liaohe River Delta, North China. Sustainability. 2018; 10, 338.

[9] H Ali, E Khan and I Ilahi. Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation. Journal of Chemistry. 2019; 6730305.

[10] GA Engwa, PU Ferdinand, FN Nwalo and MN Unachukwu. 2019. Mechanism and Health Effects of Heavy Metal Toxicity in Humans, Poisoning in the Modern World - New Tricks for an Old Dog?, Ozgur Karcioglu and Banu Arslan, IntechOpen,

[11] GK Kinuthia, V Ngure, D Beti, R Lugalia, A Wangila and L Kamau. Levels of heavy metals in wastewater and soil samples from open drainage channels in Nairobi, Kenya: community health implication. Scientific Reports. 2020; 10, 8434.

[12] The Wisconsin Department of Natural Resources. Iron In Drinking Water. Available at: https://dnr.wi.gov, accessed August 2021.

[13] World Health Organization, International Atomic Energy Agency & Food and Agriculture Organization of the United Nations. Trace elements in human nutrition and health. World Health Organization. Available at: https://apps.who.int/iris/handle/10665/37931, accessed August 2021.

[14] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for chromium. Available at: https://www.atsdr.cdc.gov/toxprofiles/tp7.pdf, accessed August 2021.

[15] LCM Lebreton, J van der Zwet. J Damsteeg, B Slat, A Andrady and J Reisser. River plastic emissions to the world's oceans. Nature Communications. 2017; 8, 15611.

[16] DOE. Water Quality Index Malaysia. Kuala Lumpur: Department of Environment Ministry of Science, Technology and Environment. 2006.

[17] Z Zainuddin. Benchmarking River Quality in Malaysia. Available at: http://irep.iium.edu.my/2954/1/Feature-BenchmarkingRiverWater3pp.pdf, accessed August 2021.

[18] TH Heong, CF Hoe, CW Leng, M Mokhtar and OY Yong. . Kajian Kualiti Air Alur Ilmu di Kampus UKM, Bangi: Ke Arah Pendekatan Pengurusan Sumber Air Bersepadu. Malaysian Journal of Analytical Sciences. 2005; 9(3), 388-395.

[19] APHA. Standards Method for the Examination of Water and Watewater. 21st edition. 2005. Washington: American Public Health Association.

[20] HACH. HACH Method in DR5000 Spectrophotometer Procedures Manual. 2005. Loveland: HACH Company.

[21] SG Reebs. Oxygen and Fish Behaviour. 2009. New Brunswick: Universite de Moncton.

[22] MIM Said, MHM Hussin, NZA Salmiati and S Azman. Comparison Between Water Quality Index (WQI) and Biological Water Quality Index (BWQI) for Water Quality Assessment: Case Study of Melana River, Johor. The Malaysian Journal of Analytical Sciences. 2013; 17(2), 224 – 229.

[23] D Chapman. Water Quality Assessment: A Guide to Use Biota, Sediments and Water in Environmental Monitoring. 1996. London: World Health Organization.

[24] WHO. Guidelines for drinking water quality third edition. 2005. Geneva: World Health Organization.