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Assessment of Water Quality and Heavy Metals in Labu River, Selangor

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Abstract

Freshwater is the necessities for all human beings as this source is used in daily activities. Hence, river water quality needs to be preserved from contaminations for sustainable water management. Prolong to that; water quality monitoring is crucial to protect the water security and to improve the surrounding environment of water bodies. Here, Langat catchment is an important reservoir for water supply in Hulu Langat District in Selangor, Malaysia. There are two main tributaries of this catchment, which are Semenyih River and Labu River. Here, this paper aims to determine the status of Labu River based on the Water Quality Index (WQI) from the Department of Environment (DOE) and National Water Quality Standard (NWQS) set by the Ministry of Health (MOH), Malaysia. The sampling of water quality was conducted at three stations along the Labu River during October 2018. Several parameters included temperature, pH, dissolved oxygen, conductivity, total suspended solids, total dissolved oxygen, biochemical oxygen demand, ammonia nitrogen, nitrite, nitrate, and heavy metals were determined in this research study. These parameters were analyzed in-situ and in Environmental Laboratory, Faculty of Civil Engineering, Universiti Teknologi MARA. From the results obtained, the water quality index of Labu River can be classified as in-class III, which is between 51.9 to 76.5 (extensive treatment required). Here, the Labu River is considered as slightly polluted as several activities mainly due to industrial, agriculture and wastes from sanitary landfills were observed along the river stretch. Furthermore, the concentration of heavy metals in Labu River such as Iron (Fe) - 1.21 mg/L, Cadmium (Cd) - 0.073 mg/L, Manganese (Mn) - 0.374 mg/L and Lead (Pb) - 0.554 mg/L had exceeded the limit provided in National Water Quality Standard (NWQS) for Malaysia. From the outcome of the research, necessary treatment is needed to reduce these pollutants as this river is an essential source of water supply in the Hulu Langat District in Selangor, Malaysia. Here, best management practice is required to rehabilitate the river to its natural state.

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1. Introduction

Water is known as a renewable resource as this water needs to undergo several processes in the hydrology cycle (Awang et. al., 2015). The hydrological cycle involves a process of evaporation, transpiration, evapotranspiration, condensation, precipitation, and runoff, which ended up in the ocean (Awang, et. al., 2015). It has been calculated that human living can use only 0.3% from 70% of fresh water for their daily activities (Leong and Lai, 2017). Based on this, the water reservoir is significant for drinking water supply. There are plenty of different sources of water that are available, which are stream,

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lake, sea, river, wells, and rainwater. However, these water bodies need to be preserved from any contamination to maintain the quality of water.

In line with Sustainable Development Goals No. 6 to ensure availability and sustainable management of water and sanitation for all, water security is essential (Bhaiduri et. al., 2016). Here, sustainable water management needs to be implemented to address the growing demand for water. High population growth significantly impacts the water bodies like the development would take place along the rives stretch. Hence, it is crucial to guard our water resource for a safe drinking water supply.

Implementation of Sustainable Development Goals (SDGs) is highly essential. This work can be facilitated through scientific research and evidence that can support the assessment and policy agreement done by the key players in the water sectors. The critical role in monitoring the water can be enhanced using earth observation technologies. It is vital to link SDGs to public benefits for the societal process of development (Bhaiduri et. al., 2016). In this case, clean water is a necessity for people. Thus, the protection of the water bodies is a must through the long-term integrated water resources management on a broader scale (Leong and Lai, 2017; Ghani et al. 2019).

1.1 Study Area

Langat catchment is in the southern part of the Selangor state in the Hulu Langat district. There are three main tributaries of this basin; Langat River, Semenyih River and Labu River. The sources of water from Langat catchment are used to supply drinking water to Putrajaya, Bandar BaruBangi, Dengkil and Kajang town. Labu Riveris in the Langat catchment basin, with an area of 2938 km^2 consisting of the BatangLabuRiver dan Labu River (Leong and Lai, 2017). The system receives run-off from the hills in Labu near Kampung Tengah, forming the BatangLabu River that flows across the countryside, farming, and small towns. The river collides with the Batang Nilai River and forms Labu River.

River monitoring is needed to forecast the water quality of the river status and the rehabilitation program to be implemented in this water body. Hence this paper focused on the monitoring of water quality of the Labu River as this river plays an integral part as one of the significant water supplies for the Langat catchment. In this research study, the water quality of the LabuRiver has been determined. Seven (7) parameter has been considered in this process which is dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, ammonia nitrogen (NH_3-N), phosphorus (PO_4), Total suspended solids (TSS), Nitrite (NO_2-N) and Nitrate (NO_3-N). The river status has been classified according to the Water Quality Index (WQI) (DOE, 2010; Hassan et. al., 2015). Heavy metals parameter such as Cadmium (Cd), Lead (Pb), Iron (Fe), Magnesium (Mg) and Manganese (Mn) were also being analyzed and has been compared with Interim National Water Quality Standard Malaysia (INWQS) (MOH, 2010).

2. Methodology

The research focused on the Labu River, which is in Sepang, Selangor. LabuRiver is one of the main tributaries of Sungai Langat. This river is one of the water tributaries of Langat catchment that supplies raw water to approximately 1.2 million people within the basin, including towns of Cheras, Kajang, Bangi and Putrajaya.
LabuRiver stretch with an area of 2938 km^2 is the result of two rivers joined, which is the BatangLabuRiver and Batang Nilai River (Leong and Lai, 2017). BatangLabu River, which is about 17.9km that flows through the hills area near Kampung Tengah at Labu flow along the village area, farming area, small-town area and finally joined with the Batang Nilai River which have a length of 6.4km^2 to form Labu River. LabuRiver also has a direct intake from a nearby landfill, which is AmparTenang Sanitary Landfill.

Figure 1: Sungai Labu (Google Map, 2017).

Table 1: Coordinate of the sampling point

Location	Coordinate
P1	2°48'23.1"N 101°41'25.0"E
P2	2°49'02.6"N 101°40'46.8"E
P3	2°49'08.0"N 101°40'39.0"E

1.2 Water Sampling

Water sampling is needed as a part of the monitoring system to observe the condition of water quality and the status of the river. Therefore, the sampling point should be uniformly distributed throughout the system and include the state at most unfavorable places in the order.

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There were three types of sampling method which grab or catch samples, composite sample and integrated samples (Corrosionpedia, 2018). To assess water quality of the river, grab samples are the most suitable method since pH, dissolved oxygen and total residual chlorine can rapidly change in water once the sample has been removed from the flow (Corrosionpedia, 2018). Water sampling is crucial to assess river water quality. The objectives of sampling are to obtain reliable and useful data to evaluate the impact of human activities on water quality. Furthermore, water sampling can represent the current state of water quality and observation of the sources and pathways of pollutants can also be monitored.

1.3 In-situ and Laboratory Analysis

In situ testing of samples on-site is for monitoring real-time measurement of water quality. In situ test parameters shows the value of the physical and chemical characteristic of the river, which is dissolved oxygen (DO), temperature, pH, conductivity and turbidity that can be directly measured on-site. In situ tests were conducted using handled multi-parameter instrument with a digital sensor (HORIBA).

The laboratory test is used to analyze water samples for the parameter that needs chemical agents and laboratory equipment. Here, the parameter involved is BOD, COD, nitrite, nitrate, ammonia nitrogen, TSS, TDS and phosphorus. Heavy metals such as cadmium, lead, iron, and manganese were also being analyzed (MOH, 2010). The test was conducted in Environmental Laboratory, Faculty of Civil Engineering, Universiti Teknologi MARA, Shah Alam, Selangor.

3. Results And Discussion

The parameter measured in this research is based on physical, chemical and heavy metals characteristics. The result was obtained from in- situ and laboratory tests by taking a sample from the selected site location, which is Labu River, Sepang, Selangor. Waterquality parameters and concentration of heavy metals data were recorded and being compared to the National Water Quality Standard Malaysia (DOE, 2010; MOH, 2010). The tests were done based on the procedure from (APHA, 2005) and the results were compared to the previous research (Hoo et. al., 2001).

1.4 In-situ and Laboratory Reading

In- situ, reading was taken on site. It represents a real-time measurement. There are several parameters obtained in-situ, which are temperature, pH, conductivity, turbidity, dissolved oxygen and total dissolved solids. Data on the in-situ tests were summarized in Table 2.

Table 2: In-situ data for Labu River

Location	**Parameter**					
	Temperature (^{o}C)	**pH**	**Conductivity (µS/cm)**	**Turbidity (NTU)**	**Dissolved Oxygen (DO) (mg/L)**	**Total Dissolved Solids (TDS) (mg/L)**
P1	26.56	7.21	0.097	568	20.92	63
P2	29.94	6.92	0.409	759	17.39	250
P3	32.93	6.53	0.522	868	12.34	790

A laboratory test was conducted to examine the parameter data that cannot be obtained by in- situ analyses. This parameter needs chemical reagent and laboratory equipment for evaluation. Laboratory tests involved BOD, COD, nitrite, nitrate, ammonia nitrogen, TSS, TDS and heavy metals test.

Table 3: Laboratory data for Labu River

Parameter	**Unit**	**Point Location**		
		P1	**P2**	**P3**
Chemical Oxygen Demand (BOD)	mg/L	1.08	4.39	5.67
Chemical Oxygen Demand (COD)	mg/L	2.32	6.10	7.56
Nitrite	mg/L	0.022	0.048	0.064
Nitrate	mg/L	0.033	0.110	0.190
Ammonia-nitrogen	mg/L	1.22	2.57	3.29
Total suspended solid	mg/L	22.4	34.8	45.9
Iron	mg/L	0.78	0.92	1.21
Cadmium	µg/L	2.34	4.77	6.73
Manganese	mg/L	0.023	0.273	0.374
Lead	µg/L	157.2	367.0	553.8

The current pH value obtained from the in-situ test for P1 is 7.21, while the pH value for P2 and P3 is 6.92 and 6.53, respectively. In this study, the highest value of pH is obtained at upstream and the lowest value is obtained downstream and this phenomenon might cause by the input of water coming to LabuRiver. The decrease in pH value would cause by higher dilution from the rain as the water is not concentrated as it flows along the river stretch. However, all the results obtained are within the standard range between 5.5 and 9.0 based on NWQS (DOE, 2010) for Malaysian rivers. Generally, the pH concentration increases as a result of the photosynthetic algae activities that consume carbon dioxide (Owa, 2013). High pH causes a bitter taste, as for that treatment for the drinking water supply is necessary to neutralize the pH value. However, low pH can be harmful to animal and aquatic plants in the water as this condition is acidic for the surrounding environment.

The amount of dissolved oxygen at P1 (20.22mg/L) is higher than P2 (17.39mg/L) and P3 (12.34mg/L). Dissolved oxygen is the amount of oxygen that dissipated in water and it plays a vital role in aquatic life. In a healthy river, diffusion from the atmosphere and the product of photosynthesis would significantly increase the dissolved oxygen in the water. Here, the aquatic organisms would fully utilize the DO and the organics nutrients in the riverbed. In their life cycle, this biota would later decay and washed downstream, and consume oxygen during their breakdown (Owa, 2013). It can be observed that dissolved oxygen was closely related to temperature (Owa, 2013). Here, in this study, the highest temperature obtained was P3 (32.93ºC) (Table 2). The high temperature can affect the dissolved oxygen in the water, photosynthesis of aquatic plants and metabolic rates of aquatic organisms (Owa, 2013). Warm water has less ability to hold oxygen; therefore, it would reduce DO. The depletion of DO in water stimulates the deterioration rate of bacteria against nitrite to nitrate and sulfates to sulfides (Akpan and Ajayi, 2016). Long term effect of the oxygen depletion is that this condition would eventually create a foul smell.

The current study shows that the value for downstream (P3) is the highest (0.522 µS/cm), while the value for upstream P1 is the lowest (0.097 µS/cm). This condition may be related to the release of low inorganic ions in the upstream, and the river gets more ionic loading when flowing downstream (Yusof et. al., 2019). The acquisition of this pattern may also be related to the release of inorganic wastes containing ionic sources such as calcium, chloride, aluminium, nitrate, sulfate, iron, magnesium, and sodium from the nearby small industries. Besides, organic compounds such as oil, alcohol, phenol, and sugar also can influence water conductivity (Ahmed et. al., 2019). The conductivity has a strong correlation with metal ions such as iron, manganese, cadmium and lead.

The value of turbidity at P3 is the highest, which is 868 NTU (refer Table 2) compared to P1 and P2, which are 568 NTU and 759 NTU respectively, but it does not exceed the limit provided by (DOE, 2010). Turbidity is a measure of water clarity. It affects the rate of growth of algae and other aquatic plants in the river. Furthermore, an increase in turbidity causes decreases in the amount of light absorption for photosynthesis (Owa, 2013). The incoming water from the nearby livestock farms, heavy precipitation and organic contamination, can deliberately cause high turbidity. The deposition from stormwater runoff may produce excessive-high suspended matter. This factor of high turbidity would increase the water temperature as suspended particles may absorb more heat. The high content of particulate matter, including clay, silt and algae, would make the water appear cloudy or murky (Owa, 2013).

The amount of TDS recorded in Table 2 for upstream (P1) is 63 mg/L, middle stream (P2) is 250 mg/L, and downstream P3 is 790 mg/L. This pattern may be related to high conductivity at the downstream. TDS are present in water naturally or as the result of impurities coming from industry or mining. These activities produced high contains mineral, organic and inorganic molecules such as nutrients and contaminants (Ting et. al., 2019). However, high mineral contents such as calcium and magnesium in water, as called hard water, are good for our body.

1.5 Water Quality Index (WQI)

According to DOE, the Water Quality Index (WQI) is a method that combined numerous water quality parameters into one concise value that represents the status of the river (DOE, 2010). WQI can be defined as a number on a scale from 0 to 100 that is used to show the water quality (DOE, 2010). Water Quality Index (WQI) can be computed based on six parameters, which are pH, Total Suspended Solid, Biochemical Oxygen Demand, Chemical Oxygen Demand, Dissolved Oxygen and Ammonia Nitrogen. Table 4 is the result of the WQIforLabu River.

Hence, this study found out that all the sample point locations collected in LabuRiver water quality are in class III due to many factors. The effluent coming from the sanitary landfill, industrial area and wastewater from the residential area can be observed along the Labu River. From the WQI, Labu River can be classified as Class III, which required extensive treatment for water supply. This result is similar to the findings by (Hoo et. al., 2001). The river condition is caused by development around the river stretch.

Table 4: WQI for Labu River

Parameter	**Unit**	**Point Location**		
		P1	**P2**	**P3**
Dissolved Oxygen	mg/L	0.1	0.1	0.1
Biochemical Oxygen Demand	mg/L	95.83	81.83	78.5
Chemical Oxygen Demand	mg/L	96.01	76.61	89.04
Ammonia-nitrogen	mg/L	43.43	18.71	7.81
Total Suspended Solid	mg/L	85.03	78.80	73.98

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pH	99.8	99.5	97.2
WQI	65.54	55.18	53.86
WQI Classification	III	III	III

In the relationships of the study obtained by the previous researcher, the water quality did not improve and showed the decreasing trends between upstream and downstream water quality. This finding also suggested that the Batang Nilai River has contributed directly to the degradation of the water quality of the Labu River (Hoo et. al., 2001). There are several developments such as housing areas, economic activities, weather and the river condition that contributed to the effects on the quality of water in Labu River (Hoo et. al., 2001). Several mitigation measures need to be considered as this river status remained unchanged (polluted). Frequent monitoring needs to be emphasized to control pollutants that go into this catchment as this stretch is essential as a drinking water supply.

1.6 Heavy Metal Analysis

Heavy metal concentration in the water is a good indicator of the degree of water contamination. This indicator can be compared with the National Protection Agency (EPA, 2019).Heavy metal concentration in Labu River is illustrated in Table 5.

The value for iron concentration for P1 (0.78 mg/L) and P2 (0.92 mg/L) are slightly lower than Raw Water Standard for Drinking Water provided (4) (1.00 mg/L), in contrast, value for P3 (1.21 mg/L) is higher than the standard provided. A high concentration of iron in water would significantly harmful to the aquatic life and ecosystem. This heavy metal can be categorized as a secondary contaminant in drinking water (EPA, 2019).

Iron carries bacteria that feed off the iron to survive. These small organisms can be harmful when digested. Iron overload can lead to hemochromatosis, which can lead to liver, heart and pancreatic damage, as well as diabetes (Tchounwon et. al., 2012).The concentration of cadmium at P1 is the lowest compared to P2 and P3. Concentration of cadmium at P3 (0.073 mg/L) is higher than allowable concentration provided by (MOH, 2010) (0.003 mg/L). Cadmium is a heavy metal with a high toxicity level. Cadmium is toxic at low exposure levels and has acute and chronic effects on health and the environment. Exposure to cadmium can lead to health effects, including cancer. Acute inhalation to cadmium can result in flu-like symptoms. The prolonged exposure can damage the lungs while chronic can result in kidney, bone and lung disease (Tchounwon et. al., 2012).

At the upstream (P1), the concentration of manganese is the lowest, which is only 0.157 mg/L. However, further downstream (P3), the level of manganese also increases, which is 0.374 mg/L and exceed the limit provided in Raw Water Standard for Drinking Water (MOH, 2010). The current value for the concentration of lead at each point location is at P3, which is 0.554 mg/L, which was slightly higher than the standard value provided by MOH (2010) (0.500 mg/L). This scenario, due to the sample location, is near the sanitary landfill, which contains wastes, batteries, or from the leachate coming from metal pipes.

Generally, downstream recording the highest heavy metal concentration of the study. In general, the average distribution of heavy metals of Labu River for iron is 0.78 to 1.21 mg/L, cadmium (0. 033- 0.073mg/L), manganese (0. 023- 0.374mg/L), and lead (0.157- 0.554mg/L). High concentrations of heavy metals, especially Iron and Lead, represent that the water quality in the ecosystem may be harmful to the health of the aquatic organism. Aquatic organisms may experience adverse effects due to the high loading of heavy metals in the environment.

Table 5: Heavy metals concentration in Sungai Labu

Parameter	**Unit**	**Point Location**			**Recommended Raw Water Quality Standard for Drinking**
		P1	**P2**	**P3**	
Iron	mg/L	0.78	0.92	1.21	1.00
Cadmium	mg/L	0.033	0.047	0.073	0.003
Manganese	mg/L	0.023	0.273	0.374	0.20
Lead	mg/L	0.157	0.367	0.554	0.050

4. Conclusion

As for the conclusion, the status level of the LabuRiver is classified as Class III (extensive treatment is needed from drinking water supply). More works need to be done to rehabilitate this river to its natural condition. Best management practice needs to be implanted to preserve this river as the main water supply in Langat catchment for Hulu Langat district, Selangor.

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References

[1] Awang, H., Daud, Z., & Hatta, Z.M. (2015). Hydrology Properties and Water Quality Assessment of the Sembrong Dam, Johor, Malaysia. Procedia - Social and Behavioral Sciences, 195, 2868-2873.

May-June 2020
ISSN: 0193-4120 Page No. 4062-4067

[2] Leong, W.K., & Lai, S.H. (2017). Application of Water Evaluation and Planning Model for Integrated Water Resources Management: Case Study of Langat River Basin, Malaysia. IOP Conf. Series: Materials Science and Engineering, 210, 012024

[3] Bhaiduri, A., Bogardi, J., Siddiqi, A., Voigt, H., Vörösmarty, C., Pahl-Wostl, C., Bunn, S.E., Shrivastava, P., Lawford, R., Foster, S., Kremer, H., Renaud, F.G., Bruns, A., & Osuna, V.R. (2016). Achieving Sustainable Development Goals from a Water Perspective. Frontiers in Environmental Sciences, 4(64), 1-13

[4] DOE. (2010). Retrieved from Official Portal of Department of Environmental: https://www.doe.gov.my/portalv1/en/info-umum/pemantauan-kualiti-air-dan-marin/303

[5] Hasan, H.H., Jamil, N. R., &Aini, N. (2015). Water quality index and sediment loading analysis in Pelus River, Perak, Malaysia. Procedia Environmental Sciences, 30, 133-138.

[6] Hussain, A., Razak, H.A., Mkpojiogu, E.O.C. (2017). The Perceived Usability Of Automated Testing Tools For Mobile Applications. Journal of Engineering Science and Technology, 12 (Special Issue 4), pp. 89-97.

[7] MOH. (2010). Retrieved from Engineering Service Division, Ministry of Health Malaysia: http://kmam.moh.gov.my/public-user/drinking-water-quality-standard.html

[8] Ghani, A.B.A., Mahat, N.I., Hussain, A., Mokhtar, S.S.M. (2019). Water Sustainability In Campus: A Framework In Optimizing Social Cost. International Journal of Recent Technology and Engineering, 8 (2 Special Issue 2), pp. 183-186.

[9] GOOGLE MAP. (2017). Retrieved from 2017: https://www.google.com/maps/dir/2.9198401,101.780868/GOOGLE+MAP+SUNGAI+LABU

[10] Corrosionpedia. (2018). Retrieved from 2018 Corrosionpedia Inc.: https://www.corrosionpedia.com/definition/597/grab-sample

[11] APHA. (2005). Standard Methods for the Examination of Water & Wastewater (Volume 21). USA: American Public Health Association

[12] Lim, S.H., Samat, A., Othman, M.R. (2001). Kesihatan ekosistem Sungai Labudariaspekkualitiairnya. Malaysian Journal of Analytical Sciences, 7(1), 157-168.

[13] Owa, F. (2013). Water Pollution: Sources, Effects, Control and Management. Mediterranean Journal of Social Sciences, 4(8), 65-68.

[14] Akpan, D., & Ajayi, O. (2016). Adverse Effect of Water Contamination or Pollution to Human Health and safety in the Nigeria Delta- Nigeria: An environmental Case Study. Journal of Environment and Earth Science, 6, 10, 91-94.

[15] Yusof, N.F., Lihan, T., Idris, W.M.R., Rahman, Z.A., Mustapha, M.A., & Yusof, M.A.W. (2019). Prediction of Soil Erosion in Pansoon Sub-basin, Malaysia using RUSLE integrated in Geographical Information System. SainsMalaysiana, 48(11), 2565-2574.

[16] Ahmed, M.F., Mokhtar, M.B., Alam, L., Mohamed, C.A.R., & Ta, G.C. (2019). Non-carcinogenic Health Risk Assessment of Aluminium Ingestion via Drinking Water in Malaysia. Exposure and Health, 11(2), 167-180.

[17] Ting, H., Khairul Anuar, K., Umar, M., Zango, M.U., Abubakar Sadiq, M., Kamarudin, A. (2019). Microbially Induced Carbonate Precipitations to Improve Residual Soils at Various Temperature. Bulletin of the Geological Society of Malaysia, 67, 75-81

[18] EPA. (2019). Metals Caddis (Volume 2) USA: EPA Retrieved from 2019: https://www.epa.gov/caddis-vol2/metals

[19] Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K., & Sutton, D.J. (2012). Heavy Metals Toxicity and the Environment. NIH Public Access, 101, 133-164