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Assessing The River Water Quality of Sungai Masai, Johor by Using Water Quality Index (WQI)

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Abstract: The water quality problem has begun to receive significant attention from society in Malaysia as the water pollution issue has arisen over the years. Thus, determining the status of raw water quality is crucial to ensure the level of raw water quality has met the usable standard. This study aimed to identify the land activities near the Sungai Masai, Johor. Then, determine the water quality parameter of Sungai Masai, Johor and classify it according to the Water Quality Index (WQI) Malaysia. Complete characterization and classification of the water quality were compared with the standard from the Department of Environment (DOE) for Sungai Masai and were determined by conducting an experiment. Results show that water quality under three different types of land activities around Sungai Masai can be classified as Slightly Polluted or Class III, with WQI values ranging from 59.34 to 74.47. It can be concluded that the surrounding area around Sungai Masai has led this river to be highly contaminated. However, water from Sungai Masai can be used as drinking water, but it requires further treatment before consumption. The water was suitable only for fishery activities and agricultural irrigation if untreated. To improve the quality of research, the parameter for heavy metals should be conducted in the Industrial area to determine whether industrial waste may end up accumulating in the soil and sediment of water bodies or not.

Keywords: Sungai Masai, water quality parameter, land activities, water quality index

1. Introduction

Lakes, rivers, streams, wetlands, and groundwater are essential public resources. Protecting water resources will protect human health, ecosystems and the economy. Data from the Department of Environment (DOE) stated, in 2017, there were 579 rivers in 2008, but only 477 rivers exist until now [1]. Among the cause of pollution problems such as sewage leakage, industrial waste dumped into the water resources, deforestation, household chemicals and agriculture [2]. Water quality has deteriorated due to fast urbanization and population increase, particularly in industrial regions that have created human waste, including home, commercial, industrial, and transportation pollutants, which occur in water bodies [3]. Besides that, numerous sources, such as domestic waste, toxic waste, chemical storage and usage sites, leaking fuel on storage tanks, and purposeful dumping of dangerous chemicals can contaminate groundwater and surface water [4].

The disposal of sewage wastewater also contributes to pollution [5]. Greywater and blackwater are both components of sewage that will lower the purity of the water. Untreated greywater and blackwater can negatively impact plants, encourage algae blooms, and make the soil more resistant to water. In contrast, greywater refers to water used in homes or offices for things like dishwashers, washing machines, and showers. Alternatively, rivers and other water sources can get contaminated by sewage that has not been properly treated when it enters through leaks or flooding [6].

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On top of that, river pollution brings a serious impact on plants and organisms in the water bodies, which the effect is damaging not only to individual species and populations but also the natural biological communities. The agricultural sector is the major source of nutrient runoff (nitrogen and phosphorus) into the river, contributing to eutrophication. The organic pollutants nitrogen and phosphorus are essential in promoting plant growth. However, excess nutrients will further promote the algae growth and seaweeds in the river. As a result, it contributes to the depletion of dissolved oxygen levels in the water bodies after the bacteria degradation of the algae, which continues to affect fish and aquatic life extent of hypoxia and cause massive fish kills.

A previous study by the Academy of Science Malaysia (2019) has been conducted on the Johor River in 2019 has discovered that the 3 rivers in the vicinity, namely Sungai Kim-Kim, Sungai Masai and Sungai Tukang Batu were already contaminated in 2017 [7]. Berita Harian reported on the condition of the Sungai Masai here, which has become contaminated with white spots, causing alarm among fishermen and locals [8]. Sungai Masai is significant for traditional fishermen who depend on the river to earn their income and livelihood. Numerous human activities release different contaminants into aquatic habitats, endangering the health of living things and degrading the aquatic ecosystem by making water bodies unusable.

Based on the problem that occurred, river water pollution is a severe problem in Malaysia due to urbanization and human activities, it negatively influences the sustainability of water resources. To ensure the quality of water resources is safe for man and aquatic life, this research was conducted to identify the land activities near the Sungai Masai, Johor, to determine the water quality parameters of Sungai Masai and to classify the water quality of the Sungai Masai according to the Water Quality Index by the Department of Environment (DOE). It is important to keep fresh water that is clean, safe, and sufficient for human survival as well as the survival of other living organisms in the ecosystem.

2. Materials and Methods

This section provides details on methodologies used to gather primary data to achieve the project's objectives.

2.1 Study Area and Sampling Points

The river is near urban areas which is 1.5 km in length, densely populated and industrial areas such as food industries and industrial manufacturing and intensively developed, wedged between Sungai Kim Kim and Sungai Masai River systems. Fig. 1 shows Pasir Gudang as a densely built-up area with an industrial zone, multifamily housing units, and the selected sampling station for analysis.

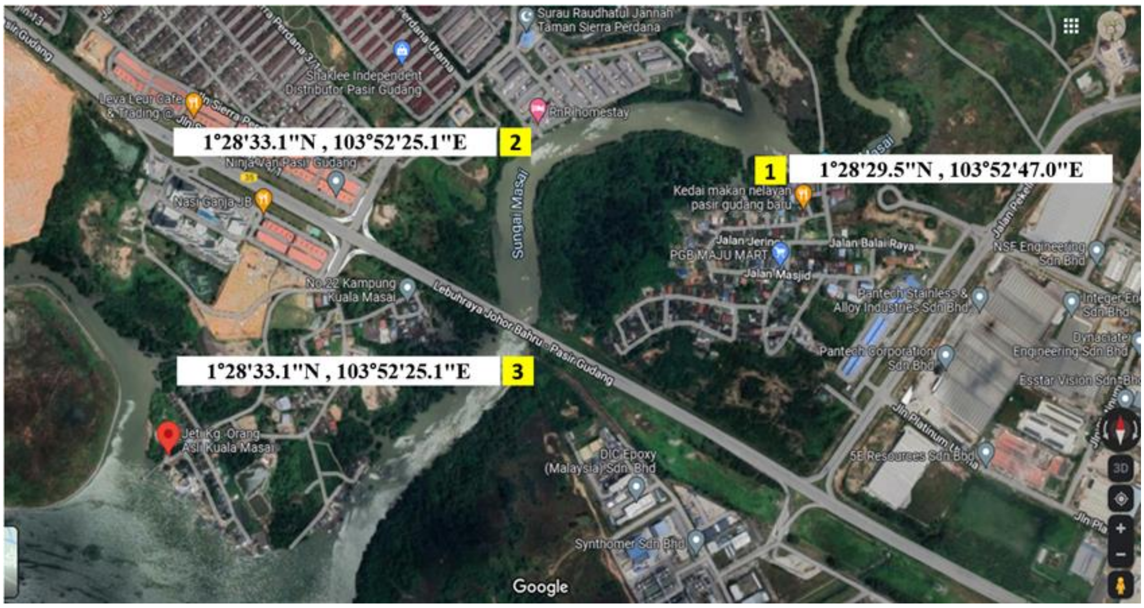

Fig. 1 - Study area of Sungai Masai, Johor

Observations on land activities near Sungai Masai, Johor, were conducted to closely observe all activities in the study area. Three stations were chosen as a study area for the water quality assessment of Sungai Masai. The 3 stations, as shown in Fig.1 for observation and data collection, are:

i. Station 1: Jeti Nelayan Kampung Pasir Gudang Baru.

   A few small boats parked at the jetty have been used as fishing boats to catch fish in the sea or river nearby. There is a public market, chicken processing stalls and a food stall next to Jeti and were found the drain around the stall was full of food waste and garbage. Seeing that these drains are connected to the Sungai

Masai, all the rubbish in the drain will directly flow into the river, especially during rainy days. There is small sugarcane cultivation next to the river where the drain around the cultivation contains waste such as dry leaves and sugarcane tops. In the Villagers' area, some villagers who live next to the Sungai Masai tend to drain their domestic wastewater directly into a river through PVC pipe.

ii. Station 2: Residential Area (Taman Sierra Perdana).

There is a terrace house area next to Sungai Masai. The surrounding areas are packed with business activities such as workshops, grocery stores, hardware stores, food courts and carwash. It has been found that the carwash was doing washing activities and draining their waste into the street so the water would go down the storm drain same goes for washing the dishes directly flowing to the drain without installing a filter box at the Medan Selera. Runoff and wash water that enters storm drains do not flow to a wastewater treatment plant; instead, they go to the river, stream, lakes and groundwater [9]. Even more concerning is when drainage in residential areas discharges into a Sungai Masai.

iii. Industrial Area

There is no other activity that could affect water quality except industrial activities. There are more than ten factories built near the Sungai Masai. The sample location for station 3 is quite far, which is 1 km from an industrial area. There is no sign or issue regarding the pollutants being dumped into the drainage that could clog the drain or pollute the river.

2.2 Sample Collection

The water sampling point was selected by different types of activities in the study area. Each of the stations was chosen based on the preliminary observations that were carried out beforehand. Water samples were collected for three consecutive weeks in November 2022 from three stations of Sungai Masai first station was a Jeti Nelayan Kampung Pasir Gudang Baru. The second station was residential, and the third was an industrial area. The water samples from the three stations were collected once a week for three weeks during both dry and rainy days. The sampling was done during the low tide cycle, where the time taken for water sampling was around 8 am to 10 am to obtain water samples at maximum concentration solution. Approximately 1 litre of water was collected in every station as a sample using the grab sampling technique. The water sample was collected using a container made from HDPE Plastic (High-Density Polyethylene). Then, the water sample was kept in ice and brought to the laboratory to test six WQI parameters.

2.3 Data Analysis

The experiment was carried out which are Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Ammoniacal Nitrogen (NH_3^-N), Dissolved Oxygen (DO) and the pH scale using the method mentioned in Table 1. Once the data was collected, the sample was analyzed according to the requisite parameter, following standard procedures and protocols.

Table 1 - Method and equipment for the experiment

Characteristic	Equipment	Method	Unit
pH	Multiparameter	APHA 2012	-
DO	Multiparameter	APHA 2012	mg/L
BOD_5	Incubator	EPA method 405.1	mg/L
COD	DR4000 spectrophotometer	Reactor Digestion Method (Method 8000)	mg/L
NH_3^-N	HACH model DR6000	APHA 45500-NH3-BH	mg/L
TSS	Filtration pump	Photometric method (Method 8006)	mg/L

2.4 Water Classification

Data were processed and calculated for WQI using equation below:

$$WQI = 0.22SI_{DO} + 0.19SI_{BOD} + 0.16SI_{COD} + 0.15SI_{AN} + 0.16SI_{SS} + 0.12SI_{pH} \quad (1)$$

After the value was obtained from Equation 1, had been an indicator to determine water quality based on Table 2, Table 3, and Table 4.

Table 2 - DOE Water Quality Index Classification (DOE Water Quality Index Classification)

Parameter	Unit	Class				
		I	II	III	IV	V
Ammoniacal Nitrogen (NH_3-N)	mg/L	<0.1	-0.3	0.3-0.9	0.9-2.7	>2.7
Biochemical Oxygen Demand (BOD)	mg/L	<1	1-3	3-6	6-12	>12
Chemical Oxygen Demand (COD)	mg/L	<10	10-25	25-50	50-100	-100
Dissolved Oxygen (DO)	mg/L	>7	5-7	3-5	1-3	<1
pH	-	>7	6-7	5-6	<5	>5
Total Suspended Solid (TSS)	mg/L	<25	25-50	50-150	150-300	>300
WQI	-	<92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

Table 3 - Pollution status (DOE Water Quality Index Classification)

Sub Index & WQI	Index Range		
	Clean	Slightly Polluted	Very Polluted
BOD	91 – 100	80 – 90	0 – 79
Ammoniacal Nitrogen	92 - 100	71 – 91	0 - 70
Suspended Solids	76 – 100	70 – 75	0 – 69
WQI	81 – 100	60 – 80	0 - 59

Table 4 - Water classes and their uses (DOE Water Quality Index Classification)

Class	Uses
Class I	Conservation of natural environment
	Water Supply I – Practically no treatment necessary
Class IIA	Water Supply II – Conventional treatment
	Fishery II – Sensitive aquatic species
Class IIB	Recreational use body contract
Class III	Water Supply III – Extensive treatment required
	Fishery III – Common of economic value and tolerant species, livestock drinking
Class IV	Irrigation
Class V	None of the above

3. Results and Discussion

3.1 Physico-Chemical Water Quality

In terms of DO level, all stations have a dissolved oxygen concentration below 6.5 mg/l, were under Class III and Class IV of the DOE (2006) making them unsuitable for aquatic living. By referring to the range of tolerance for DO in aquatic life a large population of various fish is from 4 to 5 mg/L [10]. When the DO drops below 3 mg/L, even the hardy fish die. This is probably because of the weather during sampling time. According to Sipaúba-Tavares et al. (2011), leaching by rainfall cause nutrient loading in the water and further promote the growth of microorganisms, and plants consume the DO in the water [11]. While the increase in cloud coverage reduces the amount of light that can penetrate the water to drive photosynthesis when the sky is overcast.

Next, the highest BOD levels are stations in Stations 1 and 3, where the BOD value is 7 mg/l, categorized in class IV, probably because of wastewater generated from chicken processing stalls, public markets and food stalls around the river which contains large amounts of proteins, fats, and carbohydrates resulting from meat, blood, skin, and feathers, leading to high BOD. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life.

Other than that, the COD level is higher in Station 3 (42 mg/L) and can be classified in class III compared to other stations. It is due to sampling water during rainy days; the residuals of domestic and industrial waste from Stations 1, 2 and 3 typically contain high levels of decaying plant matter, human waste was washed off and leached into the river, causing the COD level to increase at the downstream river.

In addition, in terms of pH, all the stations indicated a neutral characteristic in the water sample. The pH value varied at these water sampling locations and ranged between 7.01 to 8.40. Throughout this study, Stations 1, 2 and 3 from Sungai Masai are categorized in Class I according to the DOE standard of water quality, where practically no treatment is necessary. The overall pH value in Sungai Masai is in an acceptable range, which is 6 to 8 for aquatic life.

Furthermore, the results for NH_3N level for some of the stations are in good quality, except readings was highest at station 1 during weeks 1, week 2 and week 3, at 1.81 mg/L, 0.27 mg/L and 0.38mg/L respectively, which indicates poor quality are not in the acceptable range for freshwater aquaculture and is in moderate quality only. These high levels of Ammoniacal Nitrogen are likely due to using fertilizers in agricultural areas near station 1, with NH3-N penetrating the ground after precipitation events. Agriculture techniques on a sugarcane field, such as fertilization and spraying, may enhance leaching and water pollution with nutrients and agrochemicals, resulting in ecotoxicity, eutrophication, and acidification [12].

Lastly, the highest TSS value during the first week was recorded at Station 1 (20 mg/L), with a high of 18 mg/l recorded at Stations 2 and 3 during the second and third weeks. Sediment's most pervasive effects are related to particles eroded from agricultural land nearby. TSS level readings obtained at all three locations were below the 25 mg/L minimum standards set by the Malaysian DOE WQI for Class I water.

3.2 Water Quality Index (WQI)

The WQI values for three locations were obtained by substituting sub-index values for each parameter involved in the WQI formula.

3.2.1 Station 1

Based on the results from Fig. 2, it can be concluded that the water quality in Station 1 is slightly polluted despite the weather conditions, which shows that this river's water quality is in Class III. This is because Station 1 is an area that has various human activities, such as a public market, chicken and fish processing stalls and agriculture activities near Sungai Masai. They discharge wastewater from stalls through the drains. Wastewater from chicken processing that is deposited directly into a river without any pre-treatment methods significantly decreases the river's water quality. Hence, human activities contribute to affecting the river water quality. This situation is proved by the studies conducted by Camara M, which reported wastewater discharges from the food court and the public market will lower the water quality of an area [13]. On the other hand, other studies claimed that if the usage of chemicals in fertilizer and pesticides are uncontrolled, it will adversely affect the river water quality [14].

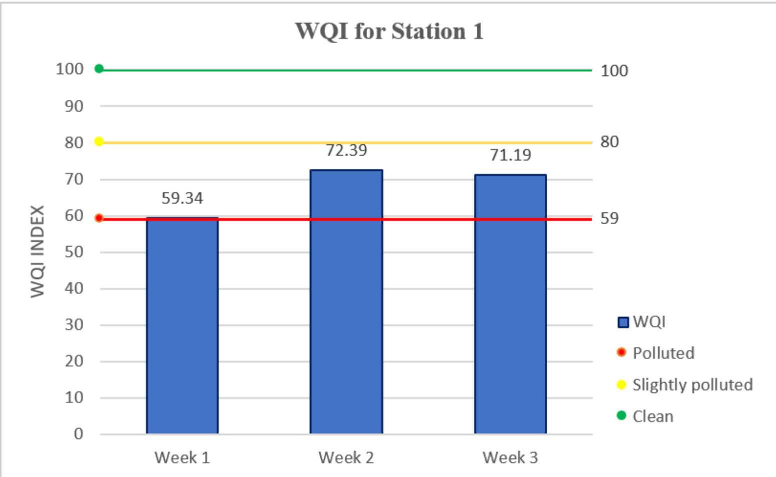

Fig. 2 - WQI for Station 1 in 3 weeks

3.2.2 Station 2

For Station 2, the result from Fig. 3 indicates that the WQI, concluded that the water quality in Station 2 is slightly polluted, which shows that this river's water quality is in Class III. The high value of WQI for station 2 is because water quality in residential areas is affected by human interference. The main source of water quality degradation in station 2 includes various activities, such as common household cleaners and detergent from washing cars flowing into the drainage connected to the river, including the village housing area that connects the wastewater pipes to flow directly into a river. Other than that, stormwater drainage in the residential area carries sand, domestic waste, and petroleum residues enter the river. According to Melati (2020), the result of the study showed that residents/villagers around the river had used materials that had the potential to reduce the water quality, namely detergent, soap and bleaching materials [15].

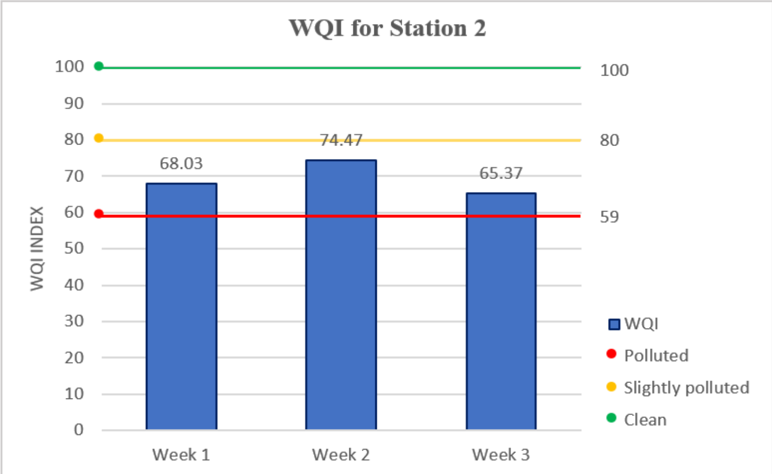

Fig. 3 - WQI for Station 2 in three weeks

3.2.3 Station 3

Lastly, the result from Fig. 4, water quality in Station 3, demonstrates that the condition of the river is slightly polluted. From the observation, it can be seen that there are no other activities surrounding the area of Station 3 other than industrial activities. There is no sign that the industrial activities in Station 3 generated any biodegradable or non-biodegradable waste in the river, such as plastic, paper, leather or wool, that affects the river's water quality. However, the river was categorized in Class III during the sampling period because the activities in the upstream cities degrade in quality as it passes through cities downstream. The amount of water discharged from dams/lakes and return flows from upstream cities are significant factors determining water quality in downstream towns [16]. Conflicts between upstream and downstream are frequently caused by upstream pollution degrading downstream water quality.

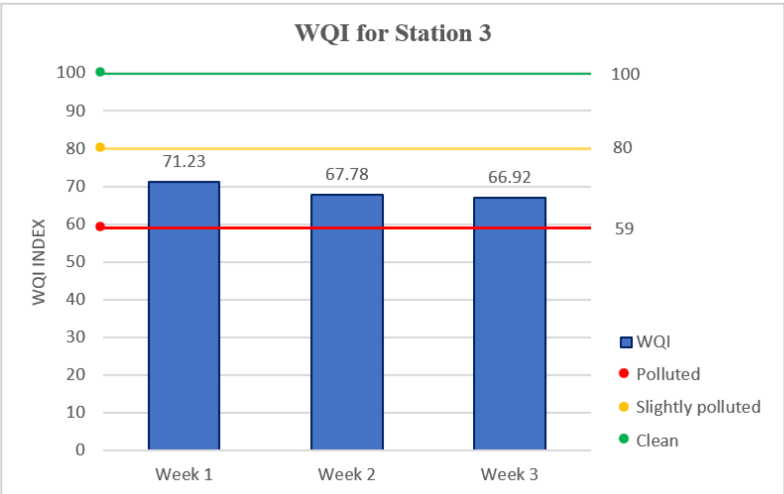

Fig. 4 - WQI for Station 3 in three weeks

4. Conclusion

Six water quality parameters were analyzed to determine the water quality status in Sungai Masai, Johor, Malaysia, including DO, BOD, COD, NH_3N, pH and TSS. The results revealed that the water quality in the study area does not meet the standards for aquatic living specified by Malaysian DOE WQI for some of the analyzed parameters: DO, BOD and AN. However, the overall water quality under three different types of land activities around Sungai Masai can be classified as Slightly Polluted or Class III, with WQI values ranging from 59.34 to 74.47. Another finding from this research is water quality in downstream towns is significantly influenced by return flows from upstream cities and the volume of water discharged from river. The degradation of downstream water quality due to upstream pollution frequently results in conflicts between upstream and downstream. However, water from Sungai Masai can be used as drinking water, but it requires further treatment before consumption. The water was suitable only for fishery activities and agricultural irrigation if untreated. Therefore, continuous monitoring of healthy water quality in the study area must be conducted, as some locals continue to use the river water as a source of their income through fishing activities.

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