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Assessment of Water Quality Parameters due to High and low Flow for Batu Pahat River, Johor

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Abstract: Development and urbanization have increased pollutants entering the river in recent years. A rise in the number of pollutants entering the river body threatens the river, which serves as an essential water resource. These pollutions originate in a variety of locations, including industry, agriculture, and livestock. The Batu Pahat River is classified as a Class II river, meaning it's slightly polluted. The deterioration of water quality in the Batu Pahat River prompted this investigation to assess the river's water quality status under high and low flow conditions. There are 11 checkpoints along Batu Pahat River. River flow discharge can affect water quality. During low flow, less water is available to dilute pollutions, resulting in a higher concentration of pollution. Therefore, a correlation analysis between water quality index and flow rate is necessary. Water quality sampling was performed at a particular river-side checkpoint. Each checkpoint has different pollutant and land-use characteristics observed. The DOE Malaysia Standard was used to calculate the water quality index. Based on the water quality result, water quality status for Batu Pahat River can be classified as Class III. During low and high flow conditions, most checkpoints changed the Water Quality Index. At low tide and high tide, the discharge was calculated to determine the water released. The Pearson Correlation Coefficient was thus used to determine the correlations between the water quality index and flow rate. There is a positive connection between low- and high-flow water quality with 0.4007 and 0.327 respectively. Most standards considered the correlation analysis a weak correlation. This indicates that flow discharge only had some impact on the water quality index.

Keywords: Water Quality Index, Flow Discharge

1. Introduction

Due to over-exploitation and deteriorating natural resources, the environmental problem affecting rivers has emerged as the most significant concern. Water is supplied from rivers, accounting for 97% of total water supply and extraction. But the condition of Malaysia's rivers continues to deteriorate. Although river streams are Malaysia's source of life, with a total surface area of 329,750 km2, they also

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serve as waste disposal means. River streams provide water for industrial, domestic, recreational and waste disposal purposes.

Historically, the river was significant for water resources, but it was recently endangered due to an increase in pollutant load. The requirement for efficient watershed management is critical to ensure proper river management and control. River pollution contribute from various sources can be divided into two categories: Point Sources (PS) and Nonpoint Sources. PS is releasing pollutants from discrete conveyances, such as a discharge pipe. Among the most important point source dischargers are industries and treatment facilities that discharge treated wastewater into the environment. Instead of pollution from identifiable sources such as discharge pipes, nonpoint sources are a mixture of pollutants from a wide region. Runoff is usually associated with nonpoint source pollution, as water discharges into streams or rivers after collecting pollutants from sources.

River water quality has been substantially degraded due to pollution from both point and non-point sources. Water quality study has been carried out at a number of locations across Malaysia. It is the goal of water quality research to acquire quantitative information on the physical, chemical, and biological properties of water via the use of statistical sampling techniques.

1.1 Problem Statement

In recent past, the Batu Pahat River has had several water quality issues. Batu Pahat River iron and aluminium concentrations are very high, reaching 110 mg/l and 290 mg/l. It was found that pH levels were as low as 2.5, much lower than the limitations established by the Class II National Water Quality Standards. Because of this, the functioning of water treatment facilities at the Sri Gading and Parit Raja treatment plant, providing sufficient potable water for the Batu Pahat district, has been severely disrupted, leading to major disruptions in water supply. The increase in people living contributes to the decline in water quality. As a result, more pollution will be released into the environment and the main issue that may arise is water quality degradation. One of the answers to this issue is to conduct water quality monitoring by determining the Batu Pahat River Water Quality Index. Thus, the study determined that the Water Quality Index value at a particular pollution checkpoint on the Batu Pahat River was calculated to determine the river's index range. The index range is used for future implementation to improve overall water quality.

1.2 Objective

The objectives of this research are to determine the water quality status of the Batu Pahat River based on Malaysia Water Quality Index (WQI). Second, to measure water discharge during low tide and high tide. Lastly is to correlate the effect of water discharge and water quality concentration

2. Methodology

2.1 Study Area

The Batu Pahat River begins in the Sungai Simpang Kiri and Sungai Simpang Kanan near Tongkang Pechah and runs through Batu Pahat until it reaches the mouth of the river at Pantai Minyak Beku on Malaysia's west coast. The river's length is 12 km. According to Johor's DID, the river gets 2057 mm annual precipitation. In this research, the river was divided into three major types of land use, commercial, residential and agricultural activities, with six distinct types of activities. Commercial land use examples include fish, workshops, restaurants, and wet market. Residential land-use activities include residential areas. Farming and animal activities were conducted on agricultural land.

2.2 Sampling Point

A total of 11 checkpoints was selected across the Batu Pahat River. Each checkpoint has different land use and pollution types. Checkpoints have their pollution type, Point Source (PS) and Non-Point Sources (NPS). Each checkpoint was coordinated using Google Map. Coordinate and land use for each checkpoint explained on the Table 1.

Table 1: Checkpoint Coordinates and Characteristic

Location	Coordinates	Characteristic and Land use
C1	1.831082, 102.921027	Non-Point solution Industrial area pollution
C2	1.838550, 102.922677	Non-Point Solution Residential area pollution
C3	1.846025, 102.924662	Point Source Solution Restaurant pollution
C4	1.847866, 102.924321	Point Solution Supermarket pollution
C5	1.853761, 102.924946	Point Solution. Restaurant/residential area pollution
C6	1.858676, 102.924595	Point Solution City pollution
C7	1.860812, 102.924466	Point Solution Workshop pollution
C8	1.862264, 102.923130	Point Solution Village Pollution
C9	1.866866, 102.915432	Point Solution Residential and palm pollution
C10	1.872753, 102.915032	Point Solution Agriculture pollution
C11	1.884495, 102.914150	Point Solution Agricultures and livestock pollution

2.3 Water Quality Sampling

Water Quality Sampling took place two weeks from 1 May 2021 to 15 May 2021. Before water sampling, the appropriate time for water sampling was set to differentiate the flow. Mostly, at 2pm during low flow, the high flow is 5pm. To get the best water sample, a water sample must be taken at the river's centre flow and half the stream's high. The first step of water sampling begins measuring the river's total length. Checkpoint 3 to 11 was measured using measuring tape. For checkpoint 1 and checkpoint 2, it was not enough to measure the river width so a manual range finder was used. After that, the river's centre width determined and marked, and the water sample was taken using a bottle tied to a rope. The water sample was then stored in an icebox to maintain temporary water quality. Finally, water sample was stored in the cold room at Tun Hussein Onn Environment Laboratory University. There are 22 water samples taken for the WQI.

2.4 Water Quality Analysis

To determine the water quality parameter value, water quality analysis was performed. Six metres of water quality are used to analyse water quality: ammonia, biological oxygen demand, chemical oxygen demand, dissolved oxygen, pH and TSS.A pH-meter was used in the pH-meter laboratory. For each water sample, pH was collected and compared at low tide and high tide. The dissolved oxygen was measured using a DO metre. The dissolved oxygen was collected from low to high tide. To detect the parameter value, USEPA Nessler was used to determine the ammonia (NH3-N) for each water sample. Ammonia was recorded and compared. The BOD value was determined using dilution technique to measure biological oxygen demand. After 5 days, DO readings were obtained and the BOD value was determined using standard BOD method. In this study, the USEPA Reactor Digestion Method was used to obtain the Chemical Oxygen Demand for each water sample. The data is collected and compare the difference between each checkpoint. For each sample, DRB6000 also used Total Suspended Solid.

2.5 Water Quality Index

The Water Quality Index determined by using six main water quality parameters based on Malaysia

Water Quality Index which is Ammonia, Biological Oxygen Demand, Chemical Oxygen Demand, Dissolved Oxygen, pH, and TSS.

$$WQI = (0.22 \times SIDO) + (0.19 \times SIBOD) + (0.16 \times SICOD) + (0.15 \times SIAN) + (0.16 \times SISS) + (0.12 \times SIpH) \quad \text{Eq. 1}$$

In Malaysia, we used DOE Water Quality Index Classification. Based on Table 2, Water Quality Index (WQI) in Malaysia is divided to 5 classes which is depend on the 6 parameters values

Table 2: DOE Water Quality Index Classification

Parameter		**Classes**	**Classes**	**Classes**	**Classes**	**Classes**
		I	II	III	IV	V
Ammonia Nitrogen	mg/L	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
Biochemical Oxygen Demand	mg/L	<1	1-3	3-6	6-12	>12
Chemical Oxygen Demand	mg/L	<10	10-25	25-50	50-100	>100
Dissolved Oxygen	mg/L	>7	5-7	3-5	1-3	<1
pH	-	>7	6-7	5-6	<5	>5
Total Suspended Solid	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

Index range is divided to three type which is clean, slightly polluted and polluted. Based on Table 3, this index range was effected by 3 parameter which is Biochemical Oxygen Demand, Ammonia Nitrogen and Total Suspended Solid.

Table 3: DOE Water Quality Classification Based On Water Quality Index

Sub Index & Water Quality Index	Unit	Index Range	Index Range	Index Range
		Clean	Slightly Polluted	Polluted
Biochemical Oxygen Demand (BOD)	mg/L	91-100	80-90	0-79
Ammonia Nitrogen (NH3-N)	mg/L	92-100	71-91	0-70
Suspended Solid (SS)	mg/L	76-100	70-75	0-69
Water Quality Index (WQI)	-	81-100	60-80	0-59

2.6 Flow Discharge Measurement

The velocity at each checkpoint was measured using a current metre. The current metre displays 10 seconds average stream velocity. A current metre was taken at the same water sampling position at the centre of the river. The current metre depth must be at least half the river depth. This is because to get the most accurate velocity at the river flow. The velocity was taken during low tide and high tide. A measuring tape for small width and laser range finder for the larger river width was used to find river width. In finding the river depth, a weight rope was used to determine river depth. The rope was placed in water until the reach the river's base. A measuring tape was used to measure the rope. The river depth finding method was conducted at 1⁄4 river width, 1⁄2 river width, and 3⁄4 river width. This is method was used to calculate the cross-sectional area of the river. For checkpoint 1 and checkpoint 2 that has a large value of depth, a depth sounder was used. The approach used to measure cross-sectional area is to locate several points on the bottom of the stream by measuring regularly from the tagline. There are 3 observation points, n for each checkpoint. The formula used to calculate the sectional area:

$$A = H_1\left(\frac{B}{4}\right) + H_2\left(\frac{B}{2}\right) + H_3\left(\frac{B}{4}\right) \text{ Eq. 2}$$

To calculate the river discharge, this study uses the area-velocity method. The method of area-velocity is based on determining the mean discharge using the velocity and cross-sectional area. If the mean streamflow velocity is normal in flow direction and the cross-sectional area of flow is known, the product of these variables determines the stream discharge

$$Q = AV \text{ Eq. 3}$$

2.7 Statistical Analysis

Pearson's Correlation Analysis was used to calculate the correlation between Water Quality Index (WQI) and Flow Discharge, Q. The Pearson r correlation is used to determine how closely two variables are related. Pearson's Correlation Method is suitable as both Water Quality Index (WQI) and Flow Discharge variables the two variable were regularly distributed for Pearson r correlation. The Pearson Correlation Formula:

$$r = \frac{N\sum xy-(\sum x)(\sum y)}{\sqrt{(N\sum x^2-(\sum x)^2)(N\sum y^2-(\sum y)^2)}} \text{ Eq. 4}$$

3. Results and Discussion

3.1 Water quality index result

The Water Quality Index Data is divided into two types which are low flow data and high flow data shown in Table 4 and Table 5.

Table 4: Water Quality Index Data for Low Flow

CP	pH	Dissolve Oxygen (mg/L)	Biochemical Oxygen Demand (mg/L)	Ammonia Nitrate (mg/L)	Total Suspended Solid (mg/L)	Chemical Oxygen Demand (mg/L)	Water Quality Index (mg/L)
1	3.42	7.67	2.11	0.37	7	5	83.76
2	3.38	4.82	3.21	0.88	9	7	62.53
3	2.46	4.44	2.71	2.53	19	22	59.23
4	7.29	3.36	16.95	22.6	414	210	29.52
5	4.18	3.77	4.87	2.06	51	50	52.32
6	3.97	5.16	3.59	2.22	53	39	59.66
7	7.27	3.77	3.41	3.50	19	23	64.68
8	7.30	5.71	4.02	1.91	37	41	71.50
9	6.83	4.60	5.65	1.92	61	37	65.50
10	3.90	8.33	2.88	0.79	5	9	80.78
11	3.70	7.98	4.11	0.59	21	25	76.21

The lowest pH for all low flow checkpoints at Checkpoint 3 is 2.46. Checkpoint 3 was known for pollution from the restaurants. The water sample was considered a low pH acid solution. Checkpoint 4 has the lowest dissolved oxygen due to fresh-market pollution. In terms of Biochemical Oxygen Demand, checkpoint 4 has the highest BOD value compared to other checkpoints, which means less for oxygen-demanding species to feed on and less water quality. Checkpoint 4 has the highest value of Ammonia Nitrate, Chemical Oxygen Demand and Total Suspended Solid compared to the other checkpoint. Checkpoint 4 also has the lowest water quality index value of 29.52 while the highest water quality index value is 83.76 at Checkpoint 1.

Table 5: Water Quality Index Data for High Flow

CP	pH	Dissolve Oxygen (mg/L)	Biochemical Oxygen Demand (mg/L)	Ammonia Nitrate (mg/L)	Total Suspended Solid (mg/L)	Chemical Oxygen Demand (mg/L)	Water Quality Index (mg/L)
1	4.10	7.18	1.82	0.21	3	4	85.40
2	3.64	5.38	3.11	0.51	6	4	66.23
3	3.07	5.36	2.51	2.06	12	15	66.91
4	7.32	3.81	15.80	19.41	325	94	36.31
5	3.49	4.86	3.33	1.08	42	39	62.76
6	3.62	7.95	1.84	1.10	23	28	73.91
7	7.33	5.55	2.06	3.09	9	11	76.00
8	7.10	6.12	3.48	1.01	16	18	82.48
9	4.15	5.42	3.94	0.81	25	10	74.83
10	2.98	9.05	1.54	0.33	4	4	84.22
11	3.28	8.02	3.66	0.28	17	9	78.54

For the water quality index parameter, checkpoint 4 has the highest value of Biochemical Oxygen Demand, Ammonia Nitrate, Total Suspended Solid and Chemical Oxygen Demand which is 15.80, 19.41, 325 and 94 respectively. This results in the lowest Water Quality Index compared to other checkpoints. For ph-value, Checkpoint 10 is 2.98 lowest. Moreover, Checkpoint 4 has the lowest Dissolved Oxygen value, 3.81. The highest water quality index is checkpoint 1 which is 85.40

3.2 Water quality index analysis

The classification for each flow is compared in terms of DOE Water Quality Index Classification and DOE Water Quality Classification Based on Water Quality Index is classified in Table 6 and 7.

Table 6: DOE Water Quality Index Classification

Low Flow	WQI	Classes	High Flow	WQI	Classes
1	83.76	I	1	85.40	I
2	62.53	III	2	66.23	III
3	59.23	III	3	66.91	III
4	29.52	V	4	36.31	IV
5	52.32	III	5	62.76	III
6	59.66	III	6	73.91	III
7	64.68	III	7	76.00	III
8	71.50	III	8	82.48	II
9	65.50	III	9	74.83	III
10	80.78	II	10	84.22	II
11	76.21	III	11	78.54	II

There are a few checkpoints that have changes of classes between low flow and high flow such as checkpoint 4, checkpoint 8 and checkpoint 11.

Table 7: DOE water quality classification based on water quality index

Low Flow	WQI	Index Range	High Flow	WQI	Index Range
1	83.76	Clean	1	85.40	Clean
2	62.53	Slightly Polluted	2	66.23	Slightly Polluted
3	59.23	Polluted	3	66.91	Slightly Polluted
4	29.52	Polluted	4	36.31	Polluted

5	52.32	Polluted	5	62.76	Slightly Polluted
6	59.66	Polluted	6	73.91	Slightly Polluted
7	64.68	Slightly Polluted	7	76.00	Slightly Polluted
8	71.50	Slightly Polluted	8	82.48	Clean
9	65.50	Slightly Polluted	9	74.83	Slightly Polluted
10	80.78	Clean	10	84.22	Clean
11	76.21	Slightly Polluted	11	78.54	Slightly Polluted

During low flow, checkpoint 3, 4, 5 and 6 are considered as polluted water quality while checkpoint 2, 7, 8 and 6 categorised as slightly polluted water quality. Only checkpoint 10 is considered clean. During high flow, only checkpoint 4 is categorised as polluted while checkpoint 1 and 2 considered as clean water quality. Checkpoint 2, 3, 5, 6, 7, 9 and 11 has a slightly polluted water quality. Based on the table above, Checkpoint for 3, 5, 6 and 8 have a change of DOE Water Quality Classification Based on Water Quality Index during low flow and high flow. WQI values vary depending on the land use at each sampling site, resulting in a range of values for each location. According to the Water Quality Index, checkpoint 4 has the lowest water quality index since it was sampled near a fresh market. Almost every day, the fresh market is open, and the majority of the pollution generated by the fresh market is disposed of at checkpoint 4. Due to a limited cross-sectional area at checkpoint 4, the pollution from the fresh market flow via the river will be kept to an absolute minimum With regard to checkpoint 1 (Non-Point Sources), which is situated near Pantai Minyak Beku, because of the wide cross-sectional area of the region, pollution from the industrial area may flow across the ocean and decrease the burden of pollutants when it reaches checkpoint 1.

3.3 Correlation analysis during low flow (Table 8)

Table 8: WQI and flow discharge for low flow

Checkpoint	Water Quality Index	Flow of Discharge (m3/s)
1	83.76	96.71
2	62.53	41.23
3	59.23	1.21
4	29.52	0.043
5	52.32	2.01
6	59.66	0.19
7	64.68	0.65
8	71.50	1.75
9	65.50	0.63
10	80.78	0.33
11	76.21	0.11

Although technically a positive correlation, the relationship between the Water Quality Index and Flow of Discharge variables is weak. This means flow discharge has slightly effect the water quality index for each checkpoint.

3.4 Correlation analysis during high flow (Table 9)

Table 9: WQI and Flow Discharge for High Flow

Checkpoint	Water Quality Index	Flow of Discharge (m3/s)
1	85.40	141.21
2	66.23	60.75
3	66.91	2.24
4	36.31	0.095
5	62.76	2.59
6	73.91	0.42
7	76.00	1.15
8	82.48	2.98
9	74.83	1.14
10	65.50	0.55
11	80.78	0.22

Although technically a positive correlation, the relationship between the Water Quality Index and Flow of Discharge variables is weak. Although a weak correlation, the flow of discharge is slightly affected the Water Quality Index

3.5 Discussion

The Water Quality Index during low tide and high tide was calculated and analysed. Checkpoint 4 during low tide and the high tide has the lowest WQI compare to others checkpoint. This is because the pollution from the fresh market directly affected the WQI value. Checkpoint 1 has the highest WQI value for both low and high tide. From the 22 checkpoints measured, there is a total of 5 checkpoints categorised as polluted water, 12 checkpoints as slightly polluted and 5 checkpoint categorised as clean. From the correlation analysis data, the flow of discharge slightly affects the water quality index. When the flow of discharge is increased, the water quality index also increases.

4. Conclusion

In conclusion, it is critical to understand the connection between the Water Quality Index (WQI) and the flow discharge, Q, of a river's water supply. Water quality monitoring is essential since such activities pose a danger to aquatic creatures as well as human health, making it necessary. According to the objectives, the achievement of objective one, which is the determination of the WQI parameter value of Sungai Batu Pahat has been shown. Based on the 11 values of WQI during low tide, 4 out of 11 classified as polluted, 5 out of 11 classified as slightly polluted and the remaining 2 checkpoints classified as clean. For high tide, 3 out of 11 checkpoints classified as clean, 6 out of 11 classified as slightly polluted and only one is polluted. Following that, the second objectives in this study which was to determine the flow of discharge at each checkpoint were accomplished. The flow discharged during low and high was calculated and compared. Checkpoint 1 has the highest flow of discharge while checkpoint 4 has the lowest flow of discharge. Lastly, for the last objective, it has also been determined that flow discharge has a small impact on the Water Quality Index via correlation analysis. When the flow discharge is increased, the Water Quality Index will also increase.

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