


# Surface Water Quality Assessment: A Case Study of Merbok River, Kuala Muda, Kedah



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**Abstract** This paper presents a case study on surface water quality assessment at Merbok river, Kuala Muda, Kedah. The study provides an insight on the feasibility of environmental pollution monitoring through in-situ water quality measurement. The study was conducted in the span of five months from November 2020 to March 2021 where the water quality samples were taken twice daily using water quality system and turbidity probes of EUTECH CyberScan PCD650 and EUTECH-TN100 respectively. The measured water quality parameters are pH, dissolved oxygen, conductivity, total dissolved solids, salinity, resistivity, and turbidity. Results from the sampling analysis have shown that water quality parameters of Merbok River are categorized as Class III according to the National Water Quality Standards (NWQS). The study identified a spike in pH (8.9) and dissolved oxygen in February possibly caused from dumping of industrial waste. Turbidity shows an increase during monsoon season followed by an increase in conductivity, resistivity and salinity in the dry season which implies surface runoff from industrial discharges. The state of Merbok

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River requires necessary attention from authorities and policy makers, to prevent future contamination that degrades the diverse ecosystem.

**Keywords** Sustainability · Mangrove estuarine · Environmental pollution · Water pollution

## 1 Introduction

Surface water quality is sensitive to land use changes that has been ongoing since the era of industrialization and urbanization. It is evident that human activities are the cause of the increase in pollution and nutrients in rivers, groundwater, and estuaries [1, 2]. The contaminated water is prone to spread water-borne diseases from the disposal of manure, garbage, industrial wastes and runoff [3]. These discharge contains nutrients such as nitrogen, and phosphorus were an excess in nutrients could host problems in estuarine and fresh water systems, leading to a hypoxia condition from low dissolved oxygen concentration [4].

Estuaries are complicated in terms of biological, chemical, and physical characteristics as it is a mix of freshwater and saltwater of different density and water masses. The estuarine ecosystem acts as a shelter of various flora and fauna, and as a source of food, transportation, and development sites for humans. It is vital to monitor the ecosystem continuously to detect changes in water quality and take immediate action to prevent future damage.

The change and status of water quality can be reflected through long term monitoring of substantial water quality parameters. Dissolved oxygen (DO) is the amount of oxygen present in the water. Dissolved oxygen is essential for aquatic organisms to survive. It is the most important measure of water quality as it indicates the water bodies' ability to sustain aquatic life. Another crucial parameter is the power of hydrogen (pH) that defines the acidity or alkalinity of water. In rivers, pH sets as the foundation of support for the availability of nutrients.

In addition, to understand the amount of impurities present in water, salinity (SAL) quantifies the dissolved salt content in water and total dissolved solid (TDS) derives the amount of organic matter in the water solution. Since dissolved salts and other organic chemicals can conduct electric current, thus conductivity correlates with TDS and increases with salinity. Electrical conductivity (EC) measures the ability of water to pass an electrical current. Both conductivity and TDS are water quality parameters used as the salinity indicator. The two parameters are not only affected by salinity, but also material contents which can be expressed as  $TDS = k EC$  (25 °C), given that the value  $k$  is characterized with the concentration of ions in water [5]. Subsequent water quality variables are resistivity (RES), which is the opposite of conductivity; it signifies the ability of water to resist an electric current. Water of higher concentration of dissolved salts will have lower resistivity.

Turbidity (TUR) is the water quality parameter used to describe the clarity and haziness of water. A high turbidity contains a high intensity of clay, slit and organic

matter. The level of turbidity affects light transmission in water which affects photosynthesis rate of aquatic plants in water, hence consequently affecting dissolved oxygen levels [6].

In the present study, sampling analysis and daily observation was carried out in Merbok River, Kuala Muda, Kedah to assess the variation of water quality parameters. The water quality parameters as described above shall be used as variables for the assessment of this study as these water quality parameters could easily reveal the condition of water bodies. This study is helpful to understand the environment impacts and evaluate the water quality status in understanding possible threats to the ecosystem.

## 2 Materials and Methods

### 2.1 Study Area

This study was conducted at Merbok River situated between latitudes  $5^{\circ} 39' N$  and  $541' N$  and longitudes  $100^{\circ} 20' E$  to  $100^{\circ} 24' E$  in the northwest of Peninsular Malaysia of Kuala Muda District, Kedah (Fig. 1). There are two sampling sites in this study, namely Site A (Fig. 2) at Laguna Jetty Point and Site B (Fig. 3) 1.0 km from Site A. The river is about 35 km long, 2.5 km wide and approximately 3–15 m deep. Merbok River is tidally influenced, with most of the river being a mangrove estuarine. The main sources of the river are from Bongkok River and Puntar River, Gurun.

The climate characteristics of Merbok River is dry and wet twice per year. Dry seasons occurs during December, January and February while rainfall is highest



**Fig. 1** Location of study area at Merbok River, Kuala Muda District, Kedah



**Fig. 2** Aerial view of the location of site A, Laguna Jetty Point



**Fig. 3** Aerial view of site B ( $5^{\circ} 41.4$  N;  $100^{\circ} 29.28$  E)

during November in the north east monsoon and May in the south west monsoon [7]. The annual rainfall varies between 200 and 250 cm with average daily temperature ranges between 22 and 32 °C and average humidity in the range of 80–90%. Tidal range of Merbok River has a mean of 1.7 m with mean neap tide of 0.8 m and mean spring tide of 2.3 m [8].

The Merbok river catchment was chosen in this study due to its increase in land use activities over the years. Major activities around the catchment are oil palm and rubber plantations in the upper and middle catchment. Whereas the middle and lower catchment is saturated with residential areas and urbanization. The lower catchment is then distributed with swamp and mangroves. The tributaries are currently suffering from point source pollutions originating from household sullage, wastewater treatment plant and industrial runoffs. Other polluting sources are coming from restaurants, development areas, disposal sites, and aquacultural activities [9]. The increase in economic and population growth has taken a toll on the ecosystem balance of Merbok basin, particular on the surrounding mangrove habitat.

**Table 1** National water quality standards for Malaysia (INWQS) [11]

Parameter	Unit	Class					
		I	IIA	IIB	III	IV	V
pH	–	6.5–8.5	6–9	6–9	5–9	5–9	–
DO	mg/l	7	5–7	5–7	3–5	<3	<1
EC	μS/cm	1000	1000	–	–	6000	–
TDS	mg/l	500	1000	–	–	4000	–
SAL	mg/l	0.5	1	–	–	2	–
TUR	NTU	5	50	50	–	–	–
TEMP	°C	–	Normal + °C	–	Normal + °C	–	–

## 2.2 Sampling Protocol

Two points were designated around Laguna Jetty Point (5° 41.63 N, 100° 26.60 E) for daily water sample collection. The water samples were collected at depths 0.5 m from water surface, and at riverbanks between 07:00 and 10:00 AM in the morning and 06:00 and 09:00 PM in the evening from November 2020 to March 2021.

In-situ water quality parameters that are pH, temperature (TEMP), dissolved oxygen (DO), conductivity (COND), total dissolved solids (TDS), and salinity (SAL) were measured using the EUTECH CyberScan PCD650 multiparameter meter, while turbidity (TUR) is analyzed using the EUTECH-TN100 turbidity meter. Calibration is performed every three days according to the standards of pH buffer 4,7 and 10, saturation of dissolved oxygen at 80–100% at sea level, 12,880 μS/cm conductivity standard, and turbidity calibrated to 0.2 NTU, 20 NTU, 100 NTU, 1000 NTU to ensure equipment accuracy.

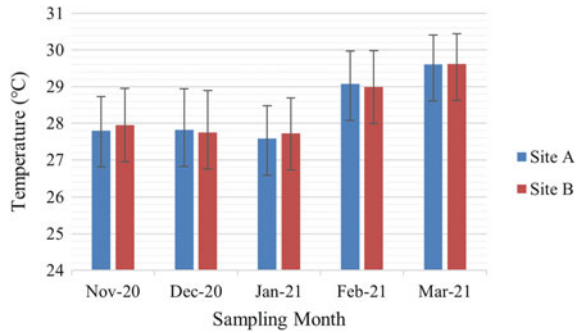
Water quality analysis is a fundamental assessment of the level of pollution of the water body. The Malaysian Department of Environment (DOE) has categorized water quality into 5 groups (Table 1) that have different purposes. Class I is classified as unpolluted and safe for drinking; Class II is fit for recreational use yet require conventional treatment; Class III is considered as polluted water supply hence requires extensive treatment; Class IV is only for irrigation or domestic use whereas Class V cannot be utilized for any purposes [10].

## 3 Results and Discussion

### 3.1 Temperature, pH and Dissolved Oxygen

Throughout the sampling period from November to March, wet season occurred from November 2020 to January 2021 while the dry season happened during February and March. The average water temperature of samples is shown in Fig. 4, ranging

**Fig. 4** The mean value of daily water temperature from sampling points



between 27.0 and 31.0 °C. Temperature is lower during the wet season where rainfall is regular.

The measured values of pH, DO, TDS, salinity, and turbidity are tabulated in Table 2 with their respective mean value and standard deviation. It can be deduced that the water quality in Merbok River is semi-polluted. Based on daily observations, the surface of the water is only cloudy or hazy during monsoon seasons and relatively calm throughout the dry season. Litter and garbage were seen occasionally flooding the area specifically after rainfall. Most of the time, the riverbank area is filled with lively aquatic life such as prawns and school of fishes; jellyfish was sighted twice during the end of February. Laguna Merbok Jetty Point (Site A) is a recreational spot that is usually crowded with jogging residents, whereas Site B is a common fish netting spot for fishermen.

The range of pH value of Merbok River along the study period is 6.5–8.9 pH, with an average of 7.08. The average pH value is within the neutral range as per the NWQS and ideal for biological productivity that is between pH 7.0–8.5 [12]. Nevertheless, it was observed that there is a significant spike in pH during February followed by a spike in saturated dissolved oxygen. The high value of pH is likely due to point source pollution from agricultural or wastewater runoff. High pH values can also be associated with a high photosynthesis rate from dense phytoplankton blooms. However, the increase in pH levels was then lowered in the following month. Minor changes in pH levels could have long term effects on nutrient solubility. The minor increase of pH could also form an oligotrophic state that is high in dissolved oxygen, this could cause the water to become eutrophic when the demand of dissolved oxygens increases with the growth of algae [13] (Fig. 5).

**Table 2** The average and standard deviation (average ± standard deviation) of measured pH, DO, TDS, salinity, and turbidity in Merbok River

Sampling site	pH	DO (mg/l)	TDS (mg/l)	Salinity (mg/l)	TUR (NTU)
Site A	7.04 ± 0.27	3.57 ± 1.74	14.50 ± 10.21	18.76 ± 14.11	31.49 ± 65.63
Site B	7.13 ± 0.35	3.94 ± 2.24	18.23 ± 10.32	23.99 ± 14.59	25.29 ± 50.08
Classification	I	III	–	–	II

**Fig. 5** The mean value of daily pH from sampling points

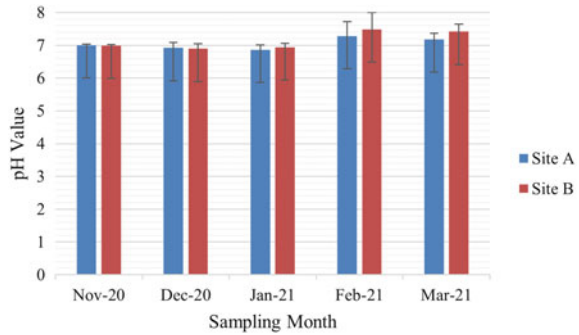
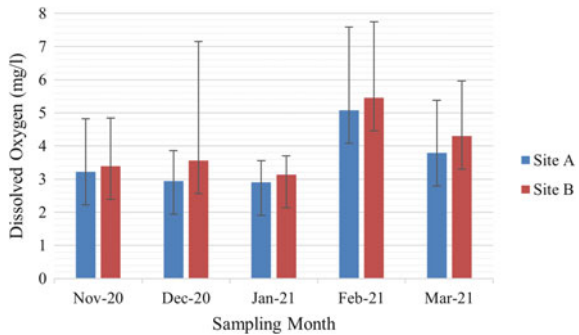


Figure 6 shows the average range of DO values at Merbok River that is between (1.40 and 13.35 mg/l) with an average of 3.71 mg/l. Similar DO results were recorded by Fatema et al. [14] in 2011. During the study period, the highest DO value was recorded in February which corresponded with the increase of pH value. Overall, throughout the study period the DO levels are classified in Class III, hence suggesting the semi-polluted condition of Merbok River. Along the duration of study, an occurrence of fishes crowding to the water surface in November was observed. Fishes ventilate at the top layer of water for respiration where the surface contains higher concentration of dissolved oxygen. The event signifies the hypoxic water condition from low levels of oxygen in water. The low DO level in water bodies is associated to the increase of oxygen demand caused from the increased concentration of anaerobic bacteria and organic matter in water [15]. Prolonged conditions of low dissolved oxygen saturation could impair river ecology, prompting serious hypoxia events [16].

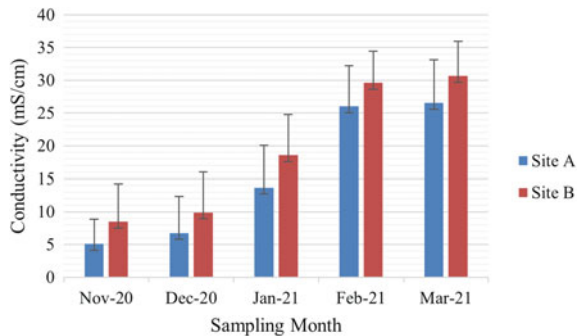
**Fig. 6** The mean value of daily dissolved oxygen from sampling points



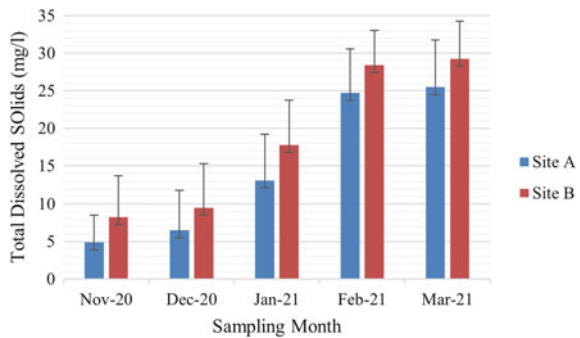
### 3.2 Conductivity, Total Dissolved Solids, Salinity and Resistivity

Figures 7, 8, 9 and 10 measures the conductivity value, total dissolved solids, salinity (NaCl) and resistivity in Merbok River from November 2020 to March 2021. It is observed that the trend of conductivity, TDS and salinity are similar. The three water quality parameters peaked during March and have similar range of mean values.

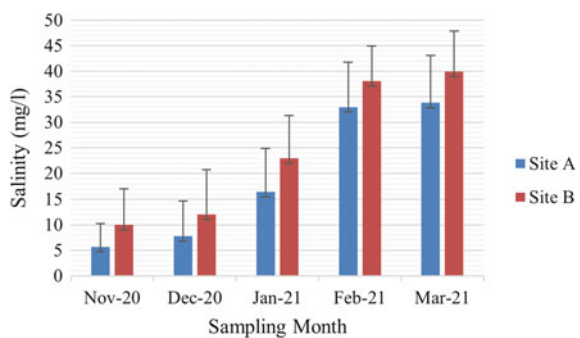
**Fig. 7** The mean value of daily conductivity from sampling points



**Fig. 8** The mean value of daily total dissolved solids from sampling points

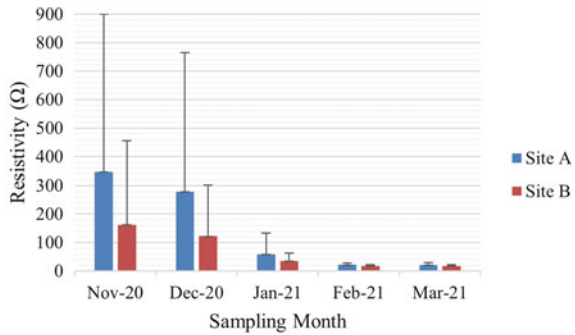


**Fig. 9** The mean value of daily salinity from sampling points





**Fig. 10** The mean value of daily resistivity from sampling points



Significant changes in conductivity indicates that there are impurities coming from pollution source or discharge present in the water. This is due to the additional increase of chloride, phosphate and nitrate ions from sewage leakage or agricultural waste [17]. Moreover, higher temperature could also lead to higher conductivity. The increase in temperature increases the mobility of ions in water. In this study, during February and March the dry season, temperature has increased by 2 °C, therefore an increase in conductivity is observed.

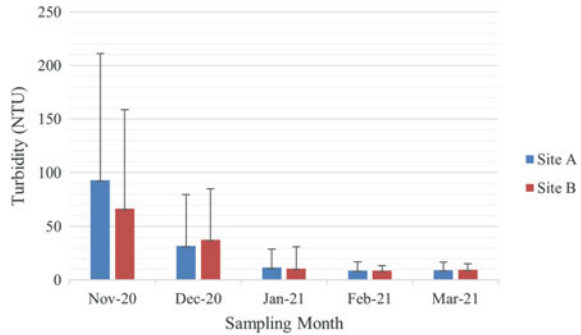
Salinity analysis from Fig. 9 shows that the value of salinity in ppt (mg/l) is between 0.188 and 59.22 ppt with an average of 21.38 ppt. Generally, the range of salinity for estuaries is between 0.5 and 35 ppt. The average value of salinity is still within threshold limit. However, the rise in salinity was observed during March where there is little rainfall in the dry season. Findings from our study correlates with the results by Manikannan et al. [18] where salinity levels are maximum during summer (dry season) and lowest in the monsoon season. Rising level of salinity is reflected from the increase in evaporation and precipitation rate [19]. High level of salinity could decrease the performance and survival of organisms [20].

In this study, it is evident that the relation between resistivity and salinity is inversely proportional. Resistivity was the lowest during January, February and March, while salinity and conductivity was the highest during that time. After a heavy rainfall, the values of conductivity, total dissolved solids and salinity are the lowest. It is concluded that during the monsoon season where rainfall is peak, conductivity is decreased since the salinity of water is diluted [17].

### 3.3 Turbidity

Continued in this section is the measure of turbidity throughout the study period. As depicted in Fig. 11, turbidity could range from as low as 1.13 NTU to 555 NTU. Low turbidity was observed during the dry season, starting from January. High turbidity is common during the monsoon season where rainfall is the heaviest in November.

**Fig. 11** The mean value of daily turbidity from sampling points



The average turbidity of Merbok River throughout the study period is 28.39 NTU falling into Class II as per the NWQS.

The observed results matches the research conclusion by Ismail et al. [21] during 2018, where suspended sediment concentration and suspended sediment load increases significantly during the wet season compared to the dry season, hence increases the turbidity. Surface runoffs are a major contributing factor to the elevated levels of sediment and turbidity. These runoff are due to industrial discharges into the river [22]. The extreme rise in turbidity poses risk to underwater organism, high level of turbidity shades sunlight from penetrating into the water, which encourages the smothering of benthic habitats such as mollusks and polychaetes. Moreover, the disturbance of sediments in water tend to absorb heat, causing an increase in water temperature that would reduce the dissolving rate of oxygen. The high concentration of particulate matter affects ecological productivity, and reducing the resiliency of aquatic life [23].

## 4 Conclusion

From the five month in-situ sampling at Merbok River, daily observations and values of pH, water temperature, dissolved oxygen, conductivity, total dissolved solids, salinity, resistivity and turbidity, the river is categorized as semi-polluted (Class III). Water quality between Site A and Site B are similar in average, yet aquatic life were found to be more dominant at Site B since dissolved oxygen levels were higher and hence fishery activities were more common at Site B. The predominant fluctuating factor of the river are pH, dissolved oxygen and turbidity which are heavily influenced by weather and seasonal factors coupled with underlying point source pollution from industrial activities.

The occasional peak in pH and dissolved oxygen from an undetected source poses a long-term risk on the aquatic life in Merbok River, as this phenomenon encourages the growth of algae and increases the demand for dissolved oxygen. When the supply of oxygen gets depleted, yet the demand remains high, this might

create an imbalance where the ecosystem could become eutrophic. Moreover, the high level of turbidity specifically during the wet season could affect the future coastal and estuarine fisheries. With ongoing urbanization and industrialization taking place surrounding the area, water quality might deteriorate further.

Forth coming work such as soil sampling analysis of the sediments and collection of nitrogen or phosphate concentration could be carried out to understand heavy metal concentration and nutrient levels within the Merbok estuary. Future research and strategies to improve the coastal ecosystem should be implemented to preserve the dynamic ecosystem at Merbok River, where mangroves and aquatic life are dominant in the area.

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