# The Influence of Tidal on Water Quality in Sungai Semerak, Kelantan.

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**Abstract.** A study has been done in Sungai Semerak, Pasir Puteh, Kelantan to understand the influence of tidal on river water quality. This study was carried out from June 2022 until March 2023. The main purpose for studying this river is because Sungai Semerak was one of the cleanest downstream rivers in Kelantan and faced various threats along the river. In-situ analyses were performed using YSI Multiparameter and Ex-situ laboratory analysis for total suspended solids, biochemical oxygen demand, chemical oxygen demand and ammoniacal nitrogen using HACH methods. This study shows that the Water Quality Index (WQI) for Sungai Semerak was classified as Class IV. Comparing WQI during spring and neap tide, the WQI is also in Class IV. From the result obtained from this study, tidal influenced the water quality during spring tide as the reading was higher compared to neap tide. Other factors that influence the water quality may come from human activities in Sungai Semerak, such as fish farming, runoff from the agricultural site, riverside constructions, supply bases and other factors. Further actions need to be taken, and further research needs to be conducted to assess this location to support the sustainability of Sungai.

## 1 Introduction

Water is one of the essential resources in this world. One of the surface water sources is the river. Sungai Semerak River is in the Pasir Puteh district of Kelantan state and is one of the busiest areas on the east coast of Peninsular Malaysia. In developments, in some cases, we need to sacrifice our natural biodiversity on shorelines and estuaries. As we understand, the estuary is an affluent area in biodiversity consisting of marine species, intertidal species, migratory bird species and other species of flora and fauna [1]. Besides rapid development

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in Sungai Semerak estuary, another problem that had to worry about is called seawater intrusion. As reported in mainstream news, Utusan Malaysia in March 2022, the main issue within this state, including the Sungai Semerak river basin, was facing the water becoming brackish and saline, including groundwater that was treating the water supply within this area. These problems worsen during high tide when seawater intrudes into the freshwater zone.

In Kelantan, Sungai Semerak, as declared by the Environmental Department of Malaysia, was one of the cleanest downstream rivers in Kelantan in the year 2021 but now faces various threats of rapid development and future planning for water intake for water supply. The Ministry of Environment and Water (KASA) planned to build a pumping station in Sungai Semerak to support the water supply in this district as an alternative to groundwater sources as it was dependent a long time ago. But the main issue is that the water source is brackish and sometimes becomes saline water. Instead of relating the water issue with surrounding development, tidal fluctuation may influence the water quality within these areas. Tidal influence increases a few water parameter readings in the river due to the high concentration of minerals because the seawater moves further upstream during high tide [2]. As supported by a previous study on the Perai River, tidal affected the downstream river quality during high tide and rainy season [3]. To assess further information about the current situation in Sungai Semerak, a study was conducted to find the water quality index status in Sungai Semerak and relate it with the tide's influence.

## 2 Methodology

### 2.1 Study Area

The Sungai Semerak flowing 30 km from Ulu Sat Forest reserve and Chabang Tongkat Forest reserve as part of the Timur hill range between 5°53'52.07"N 102°29'2.52"E and 5°45'21.58"N 102°18'53.50"E. Sungai Semerak covered in parts of district Pasir Puteh, Bachok and upstream part of Machang. Sungai Semerak is regularly monitored by Jabatan Pengairan dan Saliran Malaysia and Integrated Agriculture Development Area (IADA) to sustain good quality water for irrigation. The most developed area in Sungai Semerak was in the first 12 km until reaching the tidal gate. This area includes fisheries, aquaculture (cages), ship dockyard, supply base port and tourism.

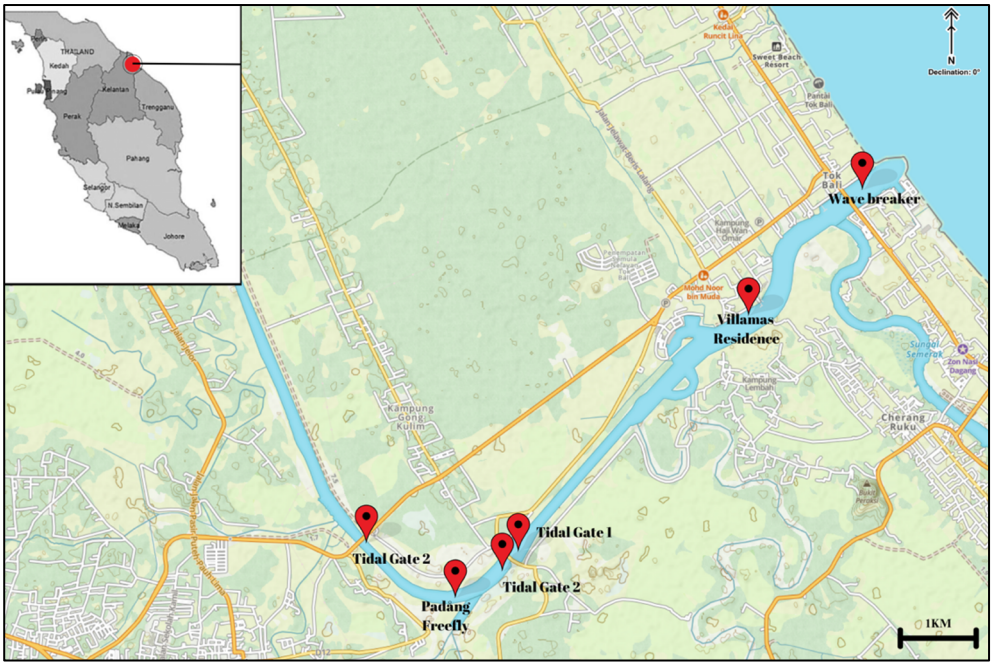


**Fig.1**: The location of Sungai Semerak, Pasir Puteh, Kelantan and the sampling

**Table 1.** Location of each sampling site.

| SAMPLING STATION | WAVE BREAKER | VILLAMAS RESIDENCE TOK BALI | TIDAL GATE KG. GONG KULIM (1) | TIDAL GATE KG. GONG KULIM (2) | PADANG FREEFLY KG. KULIM | KG. KULIM UNDER BRIDGE |
|---|---|---|---|---|---|---|
| COORDINATE | 5°53'50"N<br>102°28'60" E | 5°52'47"N<br>102°28'4" E | 5°50'55.36"N<br>102°26'23.36"E | 5°50'55.36"N<br>102°26'23.36"E | 55°50'43.99"N<br>102°28'60" E | 5°51'6.03"N<br>102°25'14.48"E |

## 2.2 In-situ Water Quality Analysis

This study uses a YSI MPS Multiparameter with a 10-meter probe to acquire the water quality parameter reading of water temperature, dissolved oxygen (DO), conductivity, pH, total dissolved solids (TDS), and salinity. A calibrated multiparameter was used to read water quality readings directly from the estuary and river. The probe's sensors were submerged at 0.5m depth to obtain the values displayed on the main display screen. The readings must stabilise for a few seconds and be repeated thrice [4]. Six sampling site was identified for data collection in Sungai Semerak to study the influence of tides on water quality in Sungai Semerak, as shown in Table 1 and Figure 1.

## 2.3 Ex-situ Water Quality Analysis

Six river water samples were analysed in the Environmental Science laboratory, Faculty of Earth Science, Universiti Malaysia Kelantan, as shown in Figure 2. The parameter involved in this analysis was total suspended solids, Ammoniacal nitrogen, biological oxygen demand (BOD) and chemical oxygen demand (COD) using the HACH method adapted from the standard method recommended by USEPA.

### 2.4 Water Quality Index

The water quality index (WQI) is a tool to express the overall view of water quality in specific locations and times. The WQI was outlined by the National Water Quality Standards (NWQS) by the Department of Environmental (DOE) Malaysia. WQI was calculated based on six parameters of pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended solids and ammoniacal nitrogen.

The WQI was calculated based on a formula suggested by the Department of Environment, Malaysia, as below:

$$WQI=(0.22xSIDO) + (0.19xSIBOD) + (0.16xSICOD) + (0.15xSIAN) + (0.16xSISS) + (0.12xSIpH)$$

Where;
SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH3-N
SISS = Subindex SS
SIpH = Subindex SIpH

**Fig.2.** Image during data collection and laboratory analysis

## 3 Result and Discussions

### 3.1 Average water quality parameters in Sungai Semerak.

Table 2 shows the average water quality data collected from Sungai Semerak during Spring tides and Neap tides. Data gathered from July 2022 until March 2023 shows that parameter data during spring tide have higher readings than data readings during neap tide. Wave Breaker, Villamas Residence Tok Bali and Tidal Gate Kg. Kulim was a saline zone, and the results obtained show higher readings in salinity, TDS, Conductivity and COD. While Tidal Gate (controlled room), Padang Freefly Kg. Kulim and Kg. Kulim underbridge was a freshwater zone that showed higher turbidity and TSS values. From the data gathered, the

tidal influenced the water quality during spring tide as supported by previous studies in Sungai Pengkalan Chepa, in which seasonal variation and tidal influenced the river's water quality [5]. During high and spring tides, seawater was constantly moved into the river, increasing the river's salinity, TDS, and conductivity values [6].

Generally, the temperature along the river and both tide events were not much different because they were within the same river basin and influenced by the North-East Monsoon from October to December yearly [7]. Salinity in the saline zone differed from the freshwater zone due to the constructed tidal gate preventing seawater from further entering the river. In the saline zone, the tide influenced the salinity and increased during high and spring tides while influencing the reading of TDS and conductivity [2].

In the freshwater zone, the TSS value was slightly higher than the saline zone due to runoff from the riparian area of Sungai Semerak, which has been used as a flood mitigation area, primarily a flat soiled zone. This has been supported by a previous study [8], in which the TSS value was higher due to more sediment being washed into the river, especially during rainfall. Differing with the lake and upstream in higher ground, TSS was influenced by water turbulence by movement from higher areas. In the lake, water was more stagnant and apparent due to sediment settlement at the bottom of the lake [9]. Turbidity is also higher in the freshwater zone compared to the saline zone. In the saline zone, the turbidity is also influenced by tide events, which dilute by the inflow of seawater during high tide and spring tide [1]. But in the freshwater zone, the higher turbidity was the same reason as the higher TSS reading.

COD readings during this study were generally higher in the saline zone than in the freshwater zone. The highest COD reading was in Wave Breaker at 83.5mg/L. The highest reading for TDS in this area at 18.5mg/L. Conductivity was also higher in Wave breaker and Tidal Gate 1 at 28.37 µS/cm and 29.57 µS/cm compared to other areas. The main reason for detecting COD levels in rivers was to investigate the pollution status of an area after identifying a possible cause of the pollutant [10]. In Sungai Semerak, the possible pollutants came from spillage oil and debris from the supply base, fish landing port, riverside runoff, and constructions along the river [8]. The average BOD for Sungai Semerak is 7.07 mg/L, which is not influenced by tidal events during this study. BOD was only influenced by seasonal changes, and the main reason for detecting BOD was to assess the organic pollution in water [6]. For ammoniacal nitrogen, the result obtained was less than 0.2 mg/L along the Sungai Semerak as the natural ammonia contained in river water was below 0.1mg/L [11]. Ammoniacal nitrogen in Sungai Semerak was below 0.2mg/L, below 0.9mg/L for the maximum value permissible by the National Water Quality Standard that supports aquatic life [12]. The reason for detecting ammoniacal nitrogen was to measure the impact of runoff from the fish landing side, fish farming, land animal farming, and agriculture sites [8].

**Table 2.** Average water quality parameter in Sungai Semerak (higher values were bold).

| | Saline Zone | | | | | | Freshwater zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOCATIONS** | **WAVE BREAKER** | | **VILLAMAS RESIDENCE TOK BALI** | | **TIDAL GATE KG. GONG KULIM** | | **TIDAL GATE (CONTROLLED ROOM)** | | **PADANG FREEFLY KG. KULIM** | | **KG. KULIM UNDER BRIDGE** | | MEAN | STAND. ERROR |
| **TIDE EVENT** | Spring Tide | Neap Tide | Spring Tide | Neap Tide | Spring Tide | Neap Tide | Spring Tide | Neap Tide | Spring Tide | Neap Tide | Spring Tide | Neap Tide | | |
| **PARAMETER** | | | | | | | | | | | | | | |
| **Temp. (℃)** | 28.95 | 29.05 | 28.69 | 29.07 | 28.95 | 28.99 | 28.07 | 28.22 | 28.41 | 28.74 | 25.11 | 28.97 | 28.43 | 0.32 |
| **DO (mg/L)** | 4.16 | 5.4 | 3.8 | 4.05 | 3.32 | 3.66 | 4.76 | 28.22 | **4.41** | 4.07 | **4.69** | 3.9 | 6.2 | 2.01 |
| **pH** | **7.51** | 7.344 | 7.32 | **7.33** | **7.42** | 4.048 | 7.72 | 7.95 | **7.45** | 7.39 | **7.2** | 7.06 | 7.15 | 0.29 |
| **TDS (g/L)** | 18.3 | 14.51 | 12.66 | 9.39 | **19.52** | 8.56 | **0.23** | 0.09 | **0.15** | 0.08 | **0.13** | 0.06 | 6.97 | 2.24 |
| **Cond. (µS/cm)** | **28.37** | 22.84 | 14.57 | 15.57 | **29.57** | 24.18 | **1.71** | 0.09 | **0.3** | 0.16 | **0.24** | 0.12 | 11.48 | 3.55 |
| **Salinity (PPT)** | **18.7** | 15.46 | 10.02 | 10.14 | **19.52** | 7.53 | **0.91** | 0.08 | **0.12** | 0.04 | **0.09** | 0.03 | 6.89 | 2.24 |
| **Turbidity (NTU)** | **19.9** | 14.61 | **32.82** | 26.96 | **68.72** | 22.66 | **79.99** | 45.17 | **80.08** | 57.38 | **87.6** | 58.925 | 49.57 | 7.52 |
| **TSS (mg/L)** | **43.27** | 30.53 | **36.48** | 27.73 | **78.322** | 24.33 | **76.01** | 29.13 | **151.1** | 45.66 | **92.8** | 57.73 | 57.76 | 10.69 |
| **BOD (mg/L)** | **5.45** | 5.29 | 7.01 | **7.51** | 7.73 | **10.6** | 7.765 | **8.84** | **6.018** | 4.94 | 6 | **7.73** | 7.07 | 0.47 |
| **COD (mg/L)** | **83.5** | 71 | **38.17** | 48.67 | 23.17 | 39.83 | **14.5** | 13.67 | 13 | 16.17 | 14.67 | 15.33 | 32.64 | 6.99 |
| **AN (mg/L)** | **0.12** | 0.07 | **0.2** | 0.13 | **0.16** | 0.09 | **0.18** | 0.08 | **0.18** | 0.08 | **0.17** | 0.09 | 0.13 | 0.01 |

### 3.2 DOE water Quality Classification based on Water Quality Index

Based on the Water Quality Index (WQI) by the Department of Environment, Malaysia in Table 3, the overall value of WQI was calculated at 49.17, which is in class IV and polluted. In the freshwater zone, the value was higher than the saline zone at 52.31 and classified as Class III but still polluted. Compared to WQI during spring and neap tide, the value was like the overall WQI value at class IV, as shown in Table 4 and Table 5.

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**Table 3.** Water Quality Index Classification by the Department of Environment Malaysia.

| PARAMETER | UNIT | CLASS | | | | |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | V |
| AMMONIACAL NITROGEN | mg/L | <0.1 | 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 | mg/L | >7 | 5-7 | 3-5 | 1-3 | <1 |
| pH | mg/L | >7.0 | 6.0-7.0 | 5.0-6.0 | <5.0 | >5.0 |
| Total Suspended Solid | mg/L | <25 | 25-50 | 50-150 | 150-300 | >300 |
| Water Quality Index | | >92.7 | 76.5-92.7 | 51.9-76.5 | 31.0-51.9 | <31.0 |

**Table 4.** Water Quality Index in Sungai Semerak.

| Parameter | Unit | DOE WATER QUALITY INDEX CLASSIFICATION | | | | | | Index Range |
|---|---|---|---|---|---|---|---|---|
| | | Overall | Class | Saline | Class | Freshwater | Class | |
| **Ammoniacal Nitrogen** | mg/L | 0.13 | II | 0.13 | II | 0.13 | II | - |
| **Biochemical Oxygen Demand** | mg/L | 7.07 | IV | 7.26 | IV | 6.88 | IV | - |
| **Chemical Oxygen Demand** | mg/L | 32.64 | III | 50.72 | IV | 14.56 | II | - |
| **Dissolved Oxygen** | mg/L | 4.26 | III | 4.21 | III | 4.35 | III | - |
| **pH** | | 7.46 | I | 7.46 | I | 7.46 | I | - |
| **Total Suspended Solid** | mg/L | 57.76 | III | 40.11 | II | 75.4 | III | - |
| **Water Quality index** | | 49.17 | IV | 47.08 | IV | 52.31 | III | Polluted |

The differences between WQI values during spring tide and neap tide are due to the influence of seawater entering rivers and freshwater runoff during the rainy season [6]. The main problems and sources of pollutants in Sungai Semerak were fish farming, waste runoff from fish landing sites, dockyards, supply-based, riverside constructions, and agriculture activities along Sungai Semerak. Those pollutants may increase the COD, BOD, and other nutrients in rivers, and if no action is taken for a long period, it may worsen [8]. Figure 3 shows the WQI value of Sungai Semerak, comparing the saline and freshwater zones and the value for WQI during Neap and spring tides. Overall, the value of WQI at class IV is still suitable for irrigation, according to DOE [13]. However, this value may vary due to seasonal changes [13]. Usually, WQI Class 1 was found in the upper stream river or catchment area [9]. During low and neap tides, the water quality concentration shows the lowest reading among the tide events [14].

**Table 5.** Water Quality Index during Spring tide and Neap tide.

| Water quality index | value | class |
|---|---|---|
| **Overall** | 49.17 | IV |
| **Spring tide** | 49.01 | IV |
| **Neap tide** | 50.12 | IV |

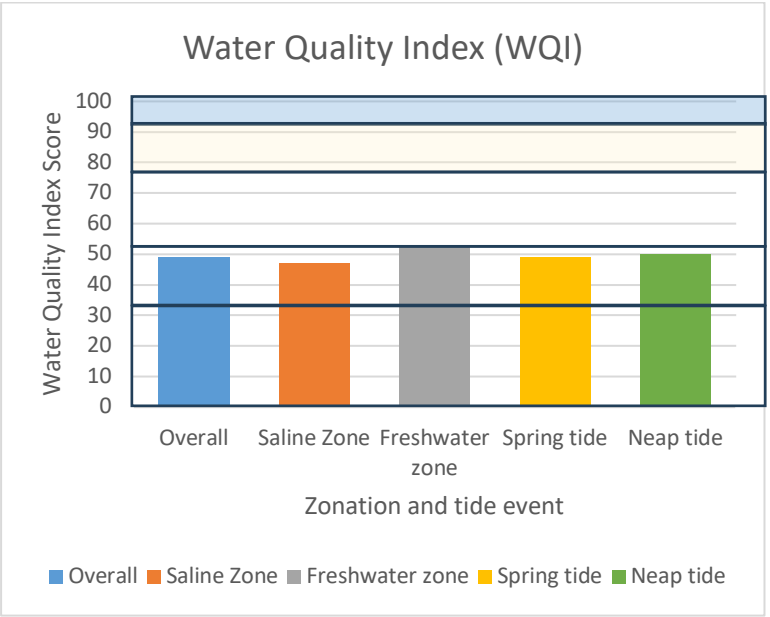


**Fig. 3.** Water quality index in Sungai Semerak.

## 4 Conclusion

Sungai Semerak was among the clean downstream rivers in Kelantan compared to other rivers such as Sungai Kelantan, Sungai Kemasin, Sungai Pengkalan Chepa and Sungai Kolok. However, recent development and rapid growth of local socio-economics activities may be reducing the quality of the river. Overall, the WQI for Sungai Semerak was at Class IV, decreasing from Class III in 2021, as stated in the Department of Environment Malaysia's 2021 Annual Report. Concerning decreasing the water quality and sustainability of the Sungai Semerak basin, further action needs to be taken to ensure the water quality is good and wildlife is not disturbed too much as the mangrove forest and melaleuca forest were a part of the Sungai Semerak basin as it provides a natural habitat for marine life breeding and place for birds as well as migratory birds.

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