Water Quality and Trophic Status Study in Sembrong Reservoir during Monsoon Season

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Abstract. Sembrong is one of the reservoirs in Johor that supplies raw water to consumer for daily activities usage. Cleanliness and quality of water must be maintained to ensure that contamination is not applicable. This study is to determine the effects of sedimentation on water quality due to the deposition of sediment in the reservoir and to identify the rate of ammonia based on the location of the study area. There are several parameters required to obtain the data and reading for this study namely the temperature, dissolved oxygen, pH value, ammonia nitrogen and trophic status parameter that are consisting of Chlorophyll, total phosphorus and secchi depth. Seventeen (17) locations along Sembrong reservoir had been identified for sampling activities. From the result obtained, the reading of temperature and pH value has less significant differences between the locations involved. However, for dissolved oxygen, the highest readings were taken at location 6 and 7 which are 9.12 mg/L and 9.05 mg/L respectively compared to other location with the average reading of 8 mg/L. For ammonia nitrogen, the highest reading was at location 1 which is 2.24 mg/L, while the lowest reading at location 13 and 14 with 0.29 mg/L. Chlorophyll readings showed the highest reading of 92.33 μg/L at location 2 which is near to the inlet area while the lowest reading were taken at location 14 with 55.97 μg/L. For total phosphorus, location 1 has the highest reading of 19.50 μg/L compared to location 15 with 9.15 μg/L. The overall result indicates that the reading is high near the inlet and decreasing at the next location. So roughly, the river that connects to the Sembrong reservoir was carrying contaminants.

1. Introduction
Malaysia is the recipient of heavy rains around the end of September until the end of March with an average amount of rainfall could reach up to 2500 mm at one duration and can lead to flooding. Surface water runoff from precipitation process will carry the soil, sand and foreign substances direct into the river and reservoir. There are several main causes of water pollution in Malaysia, which are from industrial waste and manufacturing, farming and agricultural activities and domestic waste [1]. Nutrient enrichment could be observed from the excessive growth of aquatic plants, especially water hyacinth. It will affect the quality of water due to the nutrient enrichment that caused cultural Eutrophication [2]. However, the Sembrong agricultural activities around the reservoir area are the main factors that contribute to the poor water quality. This is based on observations on site and a topographic map of the area. The lower price of chemical fertilizers and easy to get compare to the organic fertilizers is one of the factors that lead to the usage of chemicals as fertilizers in agriculture. Chemicals found in agricultural
fertilizers such as ammonia will encourage the growth of algae and plants in the water and will affect marine ecosystems such as the fish that are permanent residents in water [3].

2. Literature Reviews
The main factors of water pollution caused by human activities affect the water quality is decreases to a certain level so that water is not able to function as a water supply for wildlife [4]. However, several main causes of water pollution in Malaysia were namely industrial waste and manufacturing, farming and agricultural activities and domestic waste [1]. Water from precipitation process is combined together with surface substances such as soil is flow direct into the river and reservoir and act as sediment. These things can affect mainly in agricultural areas where chemical fertilizers is used that are mixed with the soil and carried by water into the river. This result in impaired water quality and will affects aquatic life.

Water quality parameter is the one thing that are monitored and recorded for the purpose of determination of the basic level of water quality characteristics [5]. Water quality parameters are divided into three categories which is physical, chemical and biological parameters. In this study is more focus on physical and chemical parameter involved the pH value, dissolve oxygen, temperature, Ammonia Nitrogen and Trophic status parameters. However, the trophic status index is performed to determine the content of water bodies. Carlson’s Trophic State Index is divided into three main mechanisms which is total phosphorus, chlorophyll and secchi depth is the parameter that can be determine the trophic class [6]. The level of Trophic Status Index is shown in table 1.

Table 1. Classes and level for Trophic Status Index [7]

| Classes      | Level             |
|--------------|-------------------|
| Oligotrophic | TSI < 40          |
| Mesotrophic  | 40 < TSI < 50     |
| Eutrophic    | TSI > 50          |

\[
TSI (SD) = 60 - 14.41 \ln (SD) \quad (1)
\]
\[
TSI (Chl-a) = 9.81 \ln (Chl-a) + 30.6 \quad (2)
\]
\[
TSI (TP) = 14.42 \ln (TP) + 4.15 \quad (3)
\]
\[
TSI = \left[ \frac{TSI (TP) + TSI(CA) + TSI(SD)}{3} \right] \quad (4)
\]

where SD = Secchi depth (m), TP = total phosphorus and Chl-a = chlorophyll-a

The element of nitrogen is the indicator to determine the level of oxygen in the water. Water that has organic nitrogen and ammonia nitrogen is considered unsafe because of high pollution occurs. The ammonia nitrogen is caused by unelean animals, coal, domestic sewage and fertilizer use in agriculture and will encourage the growth of algae resulting in uncontrolled and eutrophication process happens quickly. Nitrogen and phosphorus are found from the use of pesticides, fertilizers and animal manure [8]. The Phosphorus also led to eutrophication and can stimulate the growth of aquatic green like algae. Chlorophyll is a mechanism that acts to give the green color to plants that produced by the microscopic plants which is algae in water. The high presence of chlorophyll in the water will effect changes in smell and taste, reduce filter runs, increase the use of chlorine and improve the content trihalomethene (THM) precursor.
3. Methodology
The purpose of this study is to determine the effects of sedimentation on water quality due to the deposit of sediment and to identify the rate of ammonia based on the point at the study area.

3.1. Water Sampling and In-situ Testing
Sembrong reservoir area is involved of 8.5 km² and 17770 m length and suitable for flood mitigation. Water samples were taken at each of the selected seventeen (17) locations starting from the inlet until the outlet of reservoir (figure 1). GPS handheld was used to determine the coordinate for every location involved.

Figure 1. Location of water sampling at three (3) different zones
Table 2. General characteristics of sampling stations in Sembrong reservoir

| Zone | Station | Coordinates of sampling location | Description of station |
|------|---------|----------------------------------|------------------------|
| Zone I | 1 | N 02° 00' 01.1" E 103° 12' 16.6" | This station is located near to the inlet of Sungai Sembrong. The stations are surrounded by farming and agricultural activities. Riparian vegetation consists of *Eichhornia crassipes* and grass. |
| | 2 | N 01° 59' 50.4" E 103° 12' 08.0" | |
| | 3 | N 01° 59' 41.8" E 103° 12' 01.4" | |
| | 4 | N 01° 59' 33.1" E 103° 11' 54.1" | |
| | 5 | N 01° 59' 24.4" E 103° 11' 45.6" | |
| | 6 | N 01° 59' 12.8" E 103° 11' 36.7" | |
| Zone II | 7 | N 01° 58' 58.5" E 103° 11' 24.7" | This station located near to the spillway of reservoir. |
| | 8 | N 01° 58' 49.2" E 103° 11' 19.4" | |
| | 9 | N 01° 58' 52.8" E 103° 11' 13.1" | |
| | 10 | N 01° 58' 53.4" E 103° 11' 06.5" | |
| | 11 | N 01° 59' 03.5" E 103° 10' 44.7" | |
| Zone III | 12 | N 01° 59' 24.7" E 103° 10' 32.3" | This station is located near to the inlet of Sungai Merpoh. There were many stump and dead trees at this area. |
| | 13 | N 01° 59' 38.6" E 103° 10' 26.0" | |
| | 14 | N 01° 59' 55.8" E 103° 10' 18.5" | |
| | 15 | N 02° 00' 11.3" E 103° 10' 11.5" | |
| | 16 | N 02° 00' 22.0" E 103° 10' 05.7" | |
| | 17 | N 02° 00' 34.8" E 103° 10' 01.4" | |

In-situ testing were done involving parameters of temperature, dissolved oxygen, pH and secchi depth that were taken directly at the water surface of Sembrong reservoir using YSI 550A.

3.2. Experiment in Laboratory

This experiment involves determining the parameters of the water quality such as Ammonia Nitrogen (NH₃-N), Total Phosphorus, and Chlorophyll. All experiments were carried out according to the procedures manual spectrophotometer DR6000.

Ammonia Nitrogen contains the contaminated from agricultural fertilizers, animal waste and pesticides. The reagents that involves are Nessler Reagent, Mineral Stabilizer and Polyvinyl Alcohol Dispersing Agent. Water samples will turn orange or dark yellow if the Ammonia content is high in water samples.

Total phosphorus testing was conducted using a reagent tube (total and acid hydrolysis test vial), 1.5N Sodium Hydroxide Standard Solution and PhosVer 3 Reagent. The concentration of total phosphorus in water samples will be indicated by the colour changes to blue water sample after the reagents are mixed thoroughly saturated with water samples.

Chlorophyll is the green pigment that plays a role in the process of photosynthesis to absorb and convert light energy into chemical energy that found in plants, algae and photosynthetic bacteria. However, Chlorophyll is not soluble in water, but soluble in ethanol, methanol, ether, acetone, benzene and chloroform. There are several steps to extract the chlorophyll. The calculation involving the rate of chlorophyll a, μg/L content:

\[
\text{Chlorophyll } a, \mu g/L = \frac{Ca \times (volume\ of\ extraction, mL)}{volume\ of\ sample, L \times (light\ path)} \tag{1}
\]

\[
Ca = 11.64A663 - 2.16A645 + 0.10A630 \tag{2}
\]
4. Results and Discussion

4.1. Physical Parameters
Figure 2 shows the reading of water temperature and dissolve oxygen at 17 different sampling locations. The concentration of dissolved oxygen was high at low temperature as at location 5 to 16 compared with other locations. It can be related with the water quality in Sembrong reservoir’s area where it shows that the water quality is in good condition due to the fresh oxygen in water bodies that can supply to aquatic life. However, at location 1 to 4, the temperature was high. It may be caused by several factors including pollution from chemicals and foreign substances that were present in the river connected to Sembrong reservoir that serves as a supplier of water in the reservoir.

![Figure 2. Reading of temperature and dissolve oxygen against sampling point location](image)

4.2. Parameters of Trophic status Index
Three parameters that involve in Trophic status index were Chlorophyll, Total Phosphorus and Secchi Depth. Figure 3 shows the concentration of Chlorophyll, Total Phosphorus and secchi depth of Sembrong reservoir.

![Figure 3. Reading of Chlorophyll, Total Phosphorus and Secchi Depth against sampling point location](image)
The concentration of Chlorophyll in Sembrong reservoir was high from location 1 until location 8. Chlorophyll contaminant was expected coming from the river stream and flowing into the reservoir. The line graph shows a decreased horizontally from location 1 to 17. However the location of water discharge gate are located between the location 8 and 9 make the concentration of chlorophyll decrease suddenly because of two factor which is this location involve of the flush out of water and there is a cleaning tool water content between these locations. Total phosphorus also was higher at beginning point against every location because that area was near to the inlet. Then all contaminants can be detected with a high reading with 19.6 μg/L at location 1 compared with location 17 which was not involved in the inlet area with the value is 12.1 μg/L. Secchi depth is also one of the parameters for the Trophic status index where the transparency level of water level were measured. If the measurement of secchi depth is low, then the water turbidity is high. Secchi depth is a mechanism to allow light to penetrate through the water structure [9]. Secchi depth readings at location 1 is low at 0.21 m compared with location 17 at 0.34 m. After all parameters tested either in situ or in the laboratory, then the data will be calculated using a Carlson formula as below. Trophic status index can be classified into three classes either Oligotrophic, Mesotrophic and Eutrophic [10]. As a conclusion, Sembrong reservoir are in class Eutrophic (table 1).

4.3. Ammonical Nitrogen (NH3-N)
Concentration of ammonia nitrogen was shown in Figure 4 at 17 sampling locations. Location 1 shows the highest ammonia content which is 2.24 mg/L because it located at upper stream of Sembrong reservoir. However, the ammonia nitrogen reading started to decline from sampling location 2 because it is located further from the inlet of Sembrong reservoir. Started from location 10, the reading of ammonia nitrogen is low which is below than 0.5 mg/L. It was expected that the river that connected to the Sembrong reservoir had transport the contaminants and pollutant.

![Figure 4. Ammonia nitrogen at seventeen (17) sampling location](image)

4.4 Summary of Results
Figure 5 shows the summary of the study. From the results obtained, the trophic Status Index was in class of Eutrophic (TSI>50) where it decreased the transparency of water, dominance to blue-green algal and having extensive macrophyte problem.
5. Conclusions
From this study, it can be concluded that the water quality in Sembrong reservoir was not in a good condition during monsoon season as the chlorophyll contents, total phosphorus and ammonia nitrogen were high. The reading of each parameter was high at the location near to the inlet compared to reading at the location near to the outlet.

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References
[1] Haliza A R 2007 Suatu Tinjauan Terhadap Isu Pencemaran Sungai Di Malaysia Persidangan Geografi. Pulau Pinang:Universiti Sains Malaysia
[2] Sharip Z, Schooler S S, Hipsey M R and Hobbs R J 2012 Eutrophication, agriculture and water level control shift aquatic plant communities from floating-leaved to submerged macrophytes in Lake Chini, Malaysia Biological Invasions 14 1029
[3] Bhuiyan M A, Parvez L Islam, M Dampare, S B and Suzuki S 2010 Heavy metal pollution of coal mine-affected agricultural soils in the northern part of Bangladesh. J. of Hazardous Materials 173 384
[4] Herlambang A 2011 Pencemaran air dan strategi penggulangannya Jurnal Air Indonesia 2
[5] Carter L W 1985 River Water Quality and Monitoring 1st ed.121 South Main Street, Chelsea, (Michigan: Lewis Publisher, Inc)
[6] Osgood R A 1982 Using Differences Among Carlson's Trophic State Index Values in Regional Water Quality Assessment
[7] Carlson R E 1977 A trophic state index for lakes *Limnology and Oceanography* **22** 361
[8] Hill M K 2004 Understanding Environmental Pollution 2nd ed. The Pitt Building, Trumpington Street, Cambridge, (U.K.: Press Syndicate of the University of Cambridge)
[9] Smith D G and Hoover M 2000 Standardization of Secchi disk measurements, including use of a viewer box. In *Proceedings of the 2000 National Water Quality Monitoring Conference*
[10] Zakeyuddin, M S, Sah A S R M, Mohammad M S, Fadzil N F M, Hashim Z H and Omar W M W 2016 Spatial and temporal variations of water quality and trophic status in Bukit Merah Reservoir Perak *Sains Malaysiana* **45** 853