Water Quality Characteristics of Sembrong Dam Reservoir, Johor, Malaysia

S Mohd-Asharuddin1, N Zayadi1, W Rasit1 and N Othman1
1Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, MALAYSIA

E-mail: hf140120@siswa.uthm.edu.my

Abstract. A study of water quality and heavy metal content in Sembrong Dam water was conducted from April – August 2015. A total of 12 water quality parameters and 6 heavy metals were measured and classified based on the Interim National Water Quality Standard of Malaysia (INWQS). The measured and analyzed parameter variables were divided into three main categories which include physical, chemical and heavy metal contents. Physical and chemical parameter variables were temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), turbidity, pH, nitrate, phosphate, ammonium, conductivity and salinity. The heavy metals measured were copper (Cu), lead (Pb), aluminium (Al), chromium (Cr), ferum (Fe) and zinc (Zn). According to INWQS, the water salinity, conductivity, BOD, TSS and nitrate level fall under Class I, while the Ph, DO and turbidity lie under Class IIA. Furthermore, values of COD and ammonium were classified under Class III. The result also indicates that the Sembrong Dam water are not polluted with heavy metals since all heavy metal readings recorded were falls far below Class I.

Keywords: water quality, heavy metal, dam water.

1. Introduction
Surface water resources have played an important function as basic national water resource. The quality of water is affected by a wide spectrum of natural and human influences. The major natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available [1]. In general, sources of pollutant in water are known as point and non-point sources. Nowadays, water quality monitoring has become a major concern to determine current condition and long term pattern for future management of any dam or reservoir [2].

According to UNEP (2003), dams serve to function as a visible tool for supplying freshwater resources which contributing to the development of socio-economic through supplying drinking water [3]. In Malaysia, example of dam namely Tasik Chini Dam (Pahang), Sembrong Dam (Johor) and Bakun Dam (Sarawak). Water pollution is becoming a serious problem in Malaysia and post a negative impacts on the sustainability of water resources plants and organisms, people's health and the country's economy. Therefore, quality of dam water should be monitored to the acceptable standard to ensure safe water that enter water treatment intake.

Sembrong dam is flood-control dam which is tapped by Syarikat Air Johor for water supply purpose since 1984. The reservoir provides a clean water supply to 240 000 consumers in the district of Kluang [4]. Due to indiscriminate farming, agricultural activities and the planting of oil palm trees...
which covers at least 87% of the dam’s 130 km² catchment area, this water reservoir is slowly endangered due to eutrophication or better known as algae bloom. The purpose of the study is to examine the water quality status through several physic-chemical parameters as well as heavy metals concentration.

2. Methodology

2.1 Study Area
Sembrong dam is located about 10km from Ayer Hitam, Johor. The dam lies at the coordinate of 2°01’35”N - 1°58’29”N latitude and 103°09’32”E - 103°12’57”N longitude [4]. The reservoir surface area is 8.5 km², with capacity of 18 million m³ along with a catchment area of 130 km² and dam height of 11 m. This reservoir is surrounded by agricultural farms and animal husbandry as pollutant sources and there is no buffer zone between these and the water body [5]. There are two major tributaries flowing into the reservoir which are Sembrong River and Marpo River [2].

2.2 Sampling and preservation
Surface water was collected in 500 ml HDPE bottle. The water were collected about 10cm below the water surface. The sample were stored in an icebox and transported back to the lab for analysis on the same day [6].

2.3 In-situ analysis
In-situ parameters studied were temperature, dissolved oxygen (DO), pH, and turbidity. These parameters were measured using YSI 650 Multiparameter Water Quality Monitoring Unit.

2.4 Ex-situ analysis
Metal analysis was carried out using Inductive Coupled Plasma Mass Spectrometry (ICP-MS) (Perkin Elmer, USA). Physico-chemical characteristics were measured.

3. Results and discussion

3.1 Water Quality Status
Results of the mean values of the physic-chemical parameters and heavy metal concentrations determined in the water of Sembrong dam are listed in Table 1. Values of water temperature recorded for Sembrong dam were ranged from 28.2 – 29.3°C with an average of 29.13°C. The temperature values did not indicate any spatial change but showing temporal variation. All temperature readings recorded was lower than INWQS normal level [7]. Based on Table 3, the mean temperature obtained in this study was slightly lower than a study conducted in 2011, which is 29.51°C [2] but in the range of temperature reported by [3]. Increase in temperature resulting in increase of metabolic activity of organism which will reduce the DO [8].

The pH values were recorded in the range of 6.73 – 7.82. All samples had neutral pH and lies in Class I according to the INWQS. In unpolluted waters, pH is controlled by the ionic balance between the carbon dioxide, carbonate and bicarbonate ions. The daily variations of pH value may due to photosynthesis and respiration cycles of algae in the waters [1].

The DO concentration ranged from 5.64 – 6.05 mg/L with average concentration of 5.86 mg/L. The average value obtained falls under Class IIA of INWQS. High value of DO recorded is possibly due to the photosynthesis of algae during blooms. Moreover, since algae having short life, thus decomposition consumes oxygen levels [5].

The water turbidity readings were varied from 23.8 to 28.8 NTU. The average value was 26.8 NTU which lies into Class I of INWQS for Malaysian surface water. Water turbidity reading indicates the scattering or absorption of incident light by the particles [9]. In this study, the turbidity of the water
might be due to suspended solids which consist of particles from the eroded soil transported through surface runoff from the watershed upstream.

Table 1. The range, reading and mean values of water quality parameters recorded at different sampling time.

| Parameter                  | In-situ study | Ex-situ study | Mean | INWQS Class |
|----------------------------|---------------|---------------|------|-------------|
|                            | April 2015 -  | April 2015 -  |       |             |
|                            | August 2015   | August 2015   | Mean |             |
|                            | (4/8/2015)    | (11/8/2015)   | Mean |             |
|                            | (18/8/2015)   | (24/8/2015)   | Mean |             |
| Temperature (°C)           | 28.62 - 30.92 | 28.20 - 30.42 | 29.13 |             |
| Salinity (%)               | —             | 0.10 - 0.60   | 0.10 | I           |
| pH                         | 7.79 - 8.71   | 6.72 - 7.57   | 7.30 | IIA         |
| Turbidity (NTU)            | 5.99 - 17.56  | 28.60 - 26.30 | 26.80 | IIA         |
| Conductivity (µm/cm)       | —             | 196.80 - 195.50 | 195.18 | I           |
| DO (mg/L)                  | 5.02 - 7.94   | 5.64 - 6.05   | 5.86 | IIA         |
| COD (mg/L)                 | —             | 60.87 - 43.86 | 54.69 | III         |
| BOD (mg/L)                 | —             | 2.74 - 2.00   | 2.55 | I           |
| TSS (mg/L)                 | —             | 19.50 - 21.20 | 20.65 | I           |
| Nitrate (mg/L)             | —             | 0.62 - 0.48   | 0.31 | I           |
| Ammonia (mg/L)             | —             | 1.12 - 1.18   | 1.14 | III         |
| Total phosphate (mg/L)     | —             | 0.84 - 1.60   | 1.05 |             |

Table 2. Interim National Water Quality Standards for Malaysia (INWQS), (DOE, 2005).

| Parameters                  | CLASSES |
|-----------------------------|---------|
| Ammonical Nitrogen (mg/L)   | I       |
| Natural levels or absent    | —       |
| BOD (mg/L)                  | I       |
| Natural levels or absent    | —       |
| COD (mg/L)                  | II      |
| Natural levels or absent    | —       |
| DO (mg/L)                   | III     |
| Natural levels or absent    | —       |
| pH                          | IV      |
| Natural levels or absent    | —       |
| Electric Conductivity (µm/cm) | V       |
| Natural levels or absent    | —       |
| Salinity (%)                | V       |
| Natural levels or absent    | —       |
| Total Dissolved Solids (mg/L) | V       |
| Natural levels or absent    | —       |
| Total Suspended Solids (mg/L) | V       |
| Natural levels or absent    | —       |
| Temperature (°C)            | V       |
| Natural levels or absent    | —       |
| Turbidity (NTU)             | V       |
| Natural levels or absent    | —       |
| Nitrate                     | V       |
| Natural levels or absent    | —       |
| Phosphorous                 | V       |
| Natural levels or absent    | —       |
Table 3. Water quality parameters in 3 different dams in Malaysia.

| Parameter     | Tasik Chini Dam [3] | St 12, Bakun Dam [9] | Sembrong Dam [2] |
|---------------|---------------------|----------------------|------------------|
| Sampling period | Oct 2004 - May 2005 | 6 Jan - 8 Jan 2012   | 22 Nov - 25 Nov 2011 |
| Temperature (°C) | 28.66 - 31.39       | 22.94                | 29.51            |
| pH            | 6.52 - 6.61         | 6.41                 | 7.04             |
| Turbidity (NTU) | 0 - 38.29           | 93.69                |                  |
| DO (mg/L)     | 5.10 - 6.54         | 9.34                 | 7.25             |
| COD (mg/L)    | 12.90 - 22.76       | —                    | —                |
| BOD (mg/L)    | 1.01 - 1.89         | —                    | 3.73             |
| TSS (mg/L)    | 6.49 - 11.36        | —                    | 17.2             |
| Nitrate (mg/L)| 0.032 - 0.706       | —                    |                  |
| Total phosphate (mg/L) | 0.051 - 0.083 | —                    | 0.18             |

Conductivity of the water samples fall between 194-196.8 µs/cm. The mean of water conductivity was 195.18 µs/cm and classified in Class I. The average conductivity value obtained was higher compared to the average conductivity reported by [2].

The total suspended solid (TSS) of the water samples collected were recorded in high value which ranged from 19.50 – 21.30 mg/L. The average concentration recorded was 20.65 mg/L and falls in Class I. The INWQS standard for acceptable range of TSS is 25-50 mg/L while the INWQS threshold level of TSS for supporting aquatic life in fresh water ecosystems is 150 mg/L [3].

The average ammonia value in the Sembrong water samples was 1.14 mg/L. The highest value was 1.18 mg/L while the lowest value was 1.12 mg/L. The ammonia level falls under Class III of INWQS. The high ammonia value in the water could be due to high TSS level content due to backflow from Sembrong River during wet season which might generating more NH3 this stimulating the water ammonia content [3].

The mean recorded for nitrate concentration was 0.31 mg/L. The concentration lies in the range of 0.18– 0.62 mg/L. The nitrate ion is usually originated from anthropogenic activities including agricultural works, domestic sewage and other effluents containing nitrogenous compounds [3]. Based on INWQS classification, the nitrate concentration in the Sembrong dam falls into Class I.

The range of total phosphate were recorded between 0.84 – 1.60 mg/L. Total phosphate represented by organic and inorganic dissolved phosphorus and phosphate which is bounded to particulate matter [8]. High total phosphate value was due to agricultural discharge brough by the runoff in major rivers [3].

The average value of BOD in the water samples was 2.55 mg/L ranging from 2.00 – 3.05 mg/L. Improper sanitation systems at the nearby village and camp could result in extra biological loading which affecting the value of BOD [8]. The INWQS level for Malaysia surface water is 6 mg/L which indicates the BOD levels of the study are within the acceptable standard of INWQS.

The COD level of the water samples were measured to be varies from 43.86 – 61.40 mg/L with average value of 54.69 mg/L which falls under Class III of INWQS. Metal concentration of water is a indicators of degree of contamination. Figure 1 shows the concentration of heavy metals in water of the area under investigation. In comparison with Interim National Water Quality Standards Malaysian (INWQS) in Table 4, the data shows that the heavy metals concentration in Sembrong dam water falls far below class I which shows that the study area is not polluted with heavy metals.
Figure 1. The average value of heavy metals concentration in Sembrong dam water.

Table 4. Interim National Water Quality Standards for Malaysia (INWQS) for heavy metals.

| Parameters | Unit | CLASSES |
|------------|------|---------|
|            |      | I       | II A/ II B | III  | IV   | V    |
| Al         | mg/l | —       | 0.05      | 0.4 (0.05) | 0.1  |      |
| As         | mg/l | 0.05    | —         | —     | —    | —    |
| Ba         | mg/l | 1       | —         | —     | —    | —    |
| Cd         | mg/l | 0.01    | 0.01* (0.001) | 0.01 |      |      |
| Cr (IV)    | mg/l | N       | 0.05      | 1.4 (0.05) | 0.1  | L    |
| Cu         | mg/l | A       | 0.02      | —     | 0.2  | E    |
| Ca         | mg/l | T       | —         | —     | —    | V    |
| K          | mg/l | R       | —         | —     | —    | L    |
| Fe         | mg/l | A       | 1         | —     | 1 (leaf) 5 (others) | S |
| Pb         | mg/l | L       | 0.05      | 0.02* (0.01) | 5    |      |
| Mn         | mg/l | 0.1     | 0.1       | 0.2   |      | A    |
| Hg         | mg/l | L       | 0.001     | 0.004 (0.0001) | 0.002 | B    |
| Ni         | mg/l | E       | 0.05      | 0.9*  | 0.2  | O    |
| Se         | mg/l | V       | 0.01      | 0.25 (0.04) | 0.02 | V    |
| Ag         | mg/l | E       | 0.05      | 0.0002 | —    | E    |
| Sn         | mg/l | L       | —         | 0.004 | —    |      |
| U          | mg/l | S       | —         | —     | —    | IV   |
| Zn         | mg/l | 5       | 0.4*      | —     |      |      |
| Ba         | mg/l | 1       | — (3.4)   | 0.8   |      |      |
| Cl         | mg/l | 200     | —         | 80    |      |      |
| NO₃        | mg/l | 7       | —         | 5     |      |      |

4. Conclusion
The preliminary results obtained in this study show that some of the water quality parameters are quite high and fall in Class III according to INWQS. Therefore more research needs to be carried out to access pollution impact of the study area for the innovation steps to be taken to improve current water treatment system for sustainable clean water supply.
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