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To cite this article: N Kasmuri et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 646 012015

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Assessment of water quality and heavy metals in Semenyih River

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Abstract. Semenyih River has been considered one of Malaysia's most important rivers, particularly in the Selangor Region. This river has been the primary water supply for Putrajaya's domestic and industrial activities in Sepang and Hulu Langat District. However, due to the rapid development near the Semenyih River, this stream's quality has been heavily affected. Therefore, this research aimed to determine the Water Quality Index (WQI) and heavy metals concentration in the upstream, middle stream, and downstream of the Semenyih River. The upstream is located at Pening River Village, the middle stream situated at Semenyih Town, and downstream located at Buah River Village. The WQI set by the Department of Environmental Malaysia (DOE) has been used to classify Semenyih River. In-situ and laboratory tests were done in quantifying the WQI. Heavy metals concentration such as chromium, iron, manganese, zinc, and lead were tested for the river samples. From the results obtained, all intake points had fallen into Class III, in which extensive treatment is needed for water supply. Meanwhile, for heavy metals, the downstream sample had shown the highest concentration of heavy metals compared to the upstream and middle stream. Thus, the Semenyih River's rehabilitation is urgently required to reduce the pollution in preserving the water supply in the Selangor region.

1. Introduction
Water pollution has triggered an alarm to water resources' sustainability, which affects the drinking water supply. This phenomenon has declined water quality in the rivers, lakes, and oceans, which consequently produced harm to the human health and environmental ecosystem [1]. Contamination in water comprises untreated wastewater effluents, malpractice of industrial waste, oil pollution, dumping of rubbish on the marine ecosystem, atmospheric deposition, radioactive waste, underground storage leakages, global warming and eutrophication [2]. These factors have significantly impacted the quality of water in the surface water system.
It has been classified that water is a fundamental component for human and living creatures to survive. This element is very crucial and has been considered as the basic needs of living things. However, the high quality of the water needs to be maintained for safe consumption. Despite that, recent research has verified that surface water, such as rivers in Malaysia, is generally considered as polluted. Klang River in Selangor, Juru River in Penang, and the Segget River in Johor have been the main examples of the water quality deterioration [3]. Hence, monitoring water quality on the surface water system is a must to ensure water security. Goals 6 for Sustainable Development Goals (SDGs) are to acquire sustainable management for safe drinking and improve water quality by eliminating dumping and minimizing hazardous chemicals and materials [4]. In prompt to that, the pollution index is compulsory to classify the level of contaminants in the surface water body and to manage the pollution issues systematically.

Emerging technologies on the purification of water have been developed recently [5] to ensure that water is safe to be used. The characteristics of water, such as physical, chemical, and biological characteristics, need to be determined according to the regulation standard [6]. These parameters need to be put into consideration for the determination of water purity before being consumed. If the water quality does not meet the standard, it may affect the human health and water ecosystem.

Moreover, pollutants of heavy metals from industrial processes can accumulate in nearby lakes and rivers, bringing damage to the ecology of marine and aquatic organisms. The existence of heavy metals in this biota's food chain would lead to the disastrous consequence to the human and animals [1]. Some heavy metals do have bio-importance as trace elements, but the high concentration of these heavy metals gives toxic effects to the human biological function [7]. Therefore, it is important to determine the concentration of heavy metals in the water and trace their origin. This paper aims to evaluate the water quality index (WQI) for the Semenyih River and determine the river's heavy metals concentration.

2. Material and method

2.1 Area of study
Semenyih River, located in Semenyih, Selangor, Malaysia, was selected as a study location (see figure 1). There were three different points for water sampling: the upstream, middle stream, and downstream. The upper stream is located at Pening River Village (3.013551, 101.866018), the middle stream located at Semenyih Town (2.950790, 101.84685), and downstream located at Buah River Village, Dengkil (2.892094, 101.749845). Figure 1 shows the Semenyih River site, which shows the intake point of the upstream, middle stream, and downstream (yellow, red, and green), respectively. The legends for each point were also labeled and inserted on the map [8].

Water sampling was done using a container attached with a long rope for easier collection. The samples were taken three times a day for four weeks at the intake point (upstream, middle stream, and downstream) using the grab sampling method [9]. The grab sampling was done in the running river stream over a period that did not exceed 15 minutes [9] in October 2016 and 2017. All the results were compared with the WQI from DOE [6]. In-situ tests for the physical characteristics of the water sample were determined on-site. Later, the water samples were transferred into a bottle for further testing in the Environmental Laboratory, Universiti Teknologi MARA, Shah Alam. The bottles were labeled and kept at 4°C in the refrigerator. The samples taken were tested in the laboratory within 24 hours after collection on-site.

2.2 In-situ parameter
The water samples were tested in-situ for physical parameters including dissolved oxygen (DO), pH, and temperature using portable HORIBA instruments [10].

2.3 Laboratory parameter
For laboratory testing, the water samples were tested for biochemical oxygen demand (BOD$_3$), chemical oxygen demand (COD), suspended solids (SS), and ammonia-nitrogen (NH$_3$-N) following the Standard
Methods [11]. Meanwhile, for heavy metals, the concentration of manganese (Mn), chromium (Cr), lead (Pb), zinc (Zn), and iron (Fe) were determined using HACH spectrophotometer [12]. These concentrations were based on the Drinking Water Quality Standard [13]. All the samples were tested in triplicate.

2.4 WQI calculation
The tests' results were used to calculate each sub-index value of individual parameters in determining the WQI for six parameters based on the River Water Quality Standards for Malaysia [6]. Furthermore, the river quality status was decided based the Interim National Water Quality Standards for Malaysia (INWQS), where it is categorized from Class I until Class V [6].

![Map of Semenyih River](image)

**Figure 1.** Location of Semenyih River with intake point of the upper stream (yellow), middle stream (red), and downstream (green) [8].

<table>
<thead>
<tr>
<th></th>
<th>Upper stream</th>
<th>Middle stream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pinggiran Danau Atv and Go Kart</td>
<td>D’selera FC Restaurant</td>
<td>Lembaga Perlesenan Tenaga Atom</td>
</tr>
<tr>
<td>B</td>
<td>Rev Speed Auto Service</td>
<td>Sekolah Kebangsaan Semenyih</td>
<td>Bukit Unggul Country Club</td>
</tr>
<tr>
<td>C</td>
<td>Eternity Memoria Park</td>
<td>Raja Muda Musa Mosque Semenyih</td>
<td>Goat’s Farm</td>
</tr>
<tr>
<td>G</td>
<td>Community Hall Semenyih</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Results and discussion

3.1 Results for in-situ and laboratory test

Tables 1 and 2 show the results for in-situ tests in the upper stream, middle stream, and downstream of intake points in the same month of October 2016 and 2017. The results have been obtained for four weeks in 5 consecutive days in the same month at triplicate values. It can be determined that the turbidity value in the downstream was the highest compared to the upper stream and middle stream in both years. table 3 and table 4 show the laboratory tests results in the upper stream, middle stream, and downstream intake points for October 2016 and 2017. From the results obtained, total suspended solids in the middle stream were the highest among the three intake points for both years. However, for the chemical oxygen demand (COD) and the ammonia-nitrogen values were the highest in the downstream, 25.4 mg/L, and 3.56 mg/L in the year 2016 compared to the COD of 21 mg/L and ammonia-nitrogen, 0.81 mg/L in 2017. The data from table 1 until table 4 were used to calculate the WQI for each intake point for both years.

**Table 1.** Results of in-situ test for the upper stream, middle stream, and downstream intake points in October 2016.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Intake point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upstream</td>
</tr>
<tr>
<td>pH</td>
<td>7.80</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28.81</td>
</tr>
<tr>
<td>Turbidity</td>
<td>213</td>
</tr>
</tbody>
</table>

**Table 2.** Results of in-situ test for the upper stream, middle stream, and downstream intake points in October 2017.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Intake point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upstream</td>
</tr>
<tr>
<td>pH</td>
<td>8.16</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28.87</td>
</tr>
<tr>
<td>Turbidity</td>
<td>217</td>
</tr>
</tbody>
</table>

**Table 3.** Results of laboratory test for the upper stream, middle stream, and downstream intake points in October 2016.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Intake point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upstream</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>13.6</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>13.6</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>5.60</td>
</tr>
<tr>
<td>Ammonia-nitrogen (mg/L)</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Table 4. Results of laboratory test for the upper stream, middle stream, and downstream intake points in October 2017.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Upstream</th>
<th>Middle stream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (mg/L)</td>
<td>13</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>11</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>6.96</td>
<td>9.18</td>
<td>2.4</td>
</tr>
<tr>
<td>Ammonia-nitrogen (mg/L)</td>
<td>0.57</td>
<td>0.49</td>
<td>0.81</td>
</tr>
</tbody>
</table>

3.2 Water Quality Index (WQI)

Based on figure 2, the WQI level for 2017 slightly increased from the year 2016. Referring to [6] for the water quality classification of WQI, the upstream and middle streams fell under the index range of slightly polluted. In contrast, the downstream is more polluted in the year 2016. As for the year 2017, the WQI obtained for all intake points fell into Class III based on [6] WQI classification, which indicated that the river water is polluted. Moreover, the water quality classifications became worse as the water passed from the upstream to downstream of the river, due to the river currents carrying pollutants to the downstream and the developments that drastically increased along the river stretch.

![Figure 2. Water Quality Index for Semenyih River from 2016 to 2017.](image)

Based on figure 3, the WQI for upstream of the river decreased from 2016 to 2017. However, both WQI values for upstream intake point fell under Class III, indicating that the river was slightly polluted. As for the middle stream, the WQI for the year 2017 slightly decreased from 2016, but still under Class III, which is classified as slightly polluted. Meanwhile, there was a high increase for WQI downstream from the year 2016 to 2017. This shows that the WQI of the river downstream has improved in 2017. However, overall, the river became more polluted in 2017, and fell under Class III for WQI.
classification. Overall, WQI for Semenyih River can be classified under Class III, where the river was slightly polluted, and an extensive treatment will be required.

![Water Quality Index](image)

**Figure 3.** Water Quality Index for Semenyih River from 2016 to 2017 (upper stream, middle stream, and downstream).

### 3.3 Heavy metal concentrations

The level of heavy metals concentrations for the middle stream is shown in figure 4, where the level of iron (Fe) concentration is higher than the other metals. Lead (Pb) shows the lowest concentration compared to all the heavy metals tested in the samples. The content of lead in water may be contributed by automobile exhausts since the middle stream is located in Semenyih Town, where the number of automobiles such as cars, motorcycles, and buses are the highest. On the other hand, the high level of Fe concentration in the river may be due to the effluents resulting from wastewater and urban runoff from Semenyih and Bangi towns.

As for zinc (Zn), it is allegedly attributed to industrial and municipal activities. However, since the middle stream is located in Semenyih Town, the main source of Zn could be from metallic roofs coated with zinc used by many buildings and houses in the surrounding area. Same for the upstream, the middle-stream river is not polluted by chromium (Cr). Furthermore, manganese (Mn) content in the river may come from sources such as bedrock weathering, surface runoff, municipal waste, and food industry activities. The Mn content in the middle stream of the river may come from the food industry activity situated near the area.

For downstream, there is a high presence of Mn, Fe, and Zn in the river, as shown in figure 4. The presence of Fe and Zn in the river could be due to the pollutants being carried over from upstream; thus, it worsened at the downstream. Furthermore, the increased level of Fe concentration in the river was also due to the effluent from the livestock farm, which was located near the intake point from farming activities. The increased level of Mn concentration came from water discharge from industrial activities or leachate from landfills and soil. There was an abandoned landfill site near the study area. There was a slight presence of lead (Pb) in the river from industrial effluents and mining activities. Furthermore,
lead is commonly deposited in parking and roads, which can be carried by surface runoff that flows into the river (refer to figure 5).

4. Conclusion

From this study, the Water Quality Index (WQI) for all intake points (upstream, middle stream, and downstream) had fallen into Class III, in which extensive treatment is needed for water supply. Meanwhile, for heavy metals, the downstream sample has shown the highest concentration compared to the upstream and middle stream. Furthermore, the major pollutants along the river have been identified.
Most of the contaminants came from industrial activity and municipal wastes, which were not properly managed. Therefore, the Semenyih River's rehabilitation is urgently required to reduce the pollution to preserve the water supply in the Selangor region.

Acknowledgment
The authors wish to express their sincere gratitude to the Faculty of Civil Engineering staff, Universiti Teknologi MARA, Shah Alam, for their assistance throughout the analysis of data. They also gratefully acknowledged the Ministry of Higher Education (MOHE) and Universiti Teknologi MARA, Shah Alam, for providing FRGS-RACER Grant (600-IRMI/FRGS-RACER 5/3 (065/2019) to financially support this study.

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