Preliminary Investigation of Groundwater Resources in the Wetland Area, Dumai

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Abstract. The wetland area in Sumatra island is commonly covered by peatland with the varies depth. Most common problem faced in these areas is the groundwater resources of the shallow aquifer which are not safe for human consumption. In the other hand the wetland area near the coast are intruded by the seawater. This study is actually a preliminary investigation of the groundwater resources in the surrounded wetland area of Dumai city, Indonesia. In this preliminary study, the groundwater samples were collected and measured their in-situ physical characteristics. Furthermore, the groundwater in the shallow aquifer is contaminated by varies amount of seawater content that are indicated by the higher value of TDS. However, the sea level intrusion in the shallow aquifer is not directly correlated with the distance from the beach line. Generally, the groundwater is not safe for human consumption at the distance of 3-5 km from the beach line.

1. Introduction
Fresh water is one type of water-based resource that is of good quality and is commonly used by humans for consumption or in carrying out their daily activities including sanitation [1]. For drinking water consumption, according to the Ministry of Health, the requirements for drinking water are tasteless, odourless, colourless, and does not contain heavy metals [2]. Although water from natural sources can be drunk by humans, there is a risk that this water has been contaminated by bacteria such as Escherichia coli [3], harmful substances, or contaminated by heavy metal and by the sea water intrusion [4,5]. Water resources is most important part for the development of the geo-tourism in everywhere [6,7].

Riau Province, which is located on land of sediment deposits, has a large expanse of peat soil. This peat wetland extends from the coastal zone to even in the middle of the Riau province [8]. This peat wetland is the main ecosystem for flora and fauna. Giam Siak Kecil is one of the peat areas in the Riau region which has been designated as a world lung reserve site by WHO. However, since the nineties, the island of Sumatra in general and Riau in particular, have always experienced haze disasters caused by irresponsible and inhumane hands. Burning of primary forest or secondary forest land will usually add more just to convert the land into oil palm plantation areas [9]. In addition, the problem that often arises in peat wetlands is that water sources are always contaminated by the state of the peat soil itself.

Dumai City and its surrounding areas have quite thick peatlands. Due to the thickness of the existing peat soil, this condition allows frequent fires or burning in the summer, in the context of expanding plantations or clearing land. Water sources are also difficult to find in order to meet daily needs. In addition, the city of Dumai and its surrounding areas are directly adjacent to the sea, so it is possible that groundwater aquifers have been intruded by sea water. Thus, there are multiple problems concerning clean water sources in the research area and its surroundings.
Some geophysical methods have been used to investigate the slope stability [9] and to investigate groundwater potential in the high land area and even in the low land area [10,11,12]. The geophysical and water analysis has been used also in the investigation of the water source of hot spring in Rokan Hulu, Indonesia [13]. The groundwater quality is found varies by the condition of surrounding area such as for agriculture, mine purposes or because of the nature condition of their environment [14,15,16].

The study of water sustainability model for estimation of groundwater have been successfully done and published. The study should be done in order to predict the groundwater movement and its possibility influence by the physical characters of the soil [17,18].

The purpose of this research is to determine the potential groundwater and groundwater zones that have been contaminated by sea water. After obtaining the purpose of this research, the aim of the study was determined to model the geological and hydrogeological conditions of wet peatlands in the area around the city of Dumai in order to obtain a strategy to obtain water sources for an effective and efficient fire suppression process in the research area specifically and in Riau Province generally.

2. Methodology

The study area is located in Dumai city which is located at the Dumai strait (Figure 1). It is located of about 180 km from Pekanbaru the capital of Riau Province. In this preliminary investigation, only water samples have been collected. The study will be continued for the geophysical investigation which will use the active geophysical method.

![Figure 1. The location of water sample.](image)

In this research, water samples were collected directly from the existing wells. The wells are belonging to the community in the rural and urban area. The community used the water for their daily activity even for the consumption in some locations. Water sample were collected using peristatic pump. The water sample was then measured it temperature, pH, salinity, TDS and conductivity. The other portion of water sample was kept in the plastic bottle and added acid and transported to the Lab. During the transportation, the temperature of water sample was maintained of about 40°C.

Besides, the physical well condition was measured such as, longitude, latitude, depth to water table and the depth of the well. These data are important to obtain the characteristic of groundwater flow.
direction. However, in this study the chemical analysis of groundwater was still not conducted yet due to the time constrain.

3. Results and Discussion

Figure 1 is the location of water sample taken from the existing wells. A total of 25 water samples have been collected during the preliminary investigation. Water samples were collected from the near beach line and landward area until of about 18 km from the beach line. The study area is consisted of the urban community at the central of study area and the rural community in the surrounding area. At the southeastern area, the Palm Oil plantation is dominant covering the land surface. The palm oil plantation is also found at the Northwestern area.

Figure 2 shows the elevation of area study. In this figure, the low land area with the elevation of about less than 8 meter above mean sea level is dominating in the urban community. Whilst in the southern area, the land surface is getting higher of about more than 20 meter above mean sea level. The water samples location were dominated at the area with elevation less than 8 meter above mean sea level.

![Figure 2 Ground surface elevation of study area](image)

The depth of water to the water table with the referencing of mean sea level was measured for each well. From these data, the direction of groundwater flow was obtained to about 17° from the north to the east. The groundwater flows a little bit difference in the area around the WS15, WS25 and WS16. At these zones the groundwater flow was predicted to the north direction.

Figure 3 shows the pH level in the groundwater sample. The map (figure 3) clearly shows that the pH level is relatively high in the WS17 (more than 7.5). Whilst at the northwest area, the pH level is less than 5, which indicating that the groundwater is not suitable for human consumption. The low level of pH value is also observed at the area around the palm oil plantation which is the areas are covered by peat soil.
Figure 3. The pH map of groundwater the study area

Table 1. The physical condition of water sample

| Samp. ID | Latitude (N) | Longitude (E) | Depth (m) | Time | Temp. (Celsius) | Conduct. (μS/cm) | TDS (ppt) | Sal. (%) | pH   |
|----------|--------------|---------------|-----------|------|----------------|-----------------|-----------|----------|------|
| WS1      | 1.58909      | 101.39074     | 12        | 9.12 | 26.8           | 217             | 105       | 0.01     | 4.65 |
| WS2      | 1.58609      | 101.39626     | 18        | 9.37 | 27             | 66              | 31        | 0        | 5.43 |
| WS3      | 1.62636      | 101.37411     | 70        | 10   | 27.1           | 159             | 79        | 0        | 4.8  |
| WS4      | 1.62834      | 101.34998     | 2         | 10.56| 27.8           | 290             | 145       | 0.01     | 5.54 |
| WS5      | 1.65744      | 101.35529     | 3         | 11.24| 28.7           | 1014            | 524       | 0.05     | 3.52 |
| WS6      | 1.65746      | 101.3552      | 20        | 11.49| 28.9           | 2900            | 1550      | 0.16     | 5.75 |
| WS7      | 1.69468      | 101.37593     | 3         | 12.06| 29             | 438             | 221       | 0.02     | 4.3  |
| WS8      | 1.72429      | 101.37551     | 15        | 12.3 | 28.1           | 494             | 247       | 0.02     | 5.74 |
| WS9      | 1.70439      | 101.39518     | 4         | 12.43| 29             | 183             | 91        | 0        | 5.4  |
| WS10     | 1.68022      | 101.43782     | 4         | 15.2 | 32.3           | 3580            | 1800      | 0.19     | 7.2  |
| WS11     | 1.67029      | 101.43471     | 17.14     | 29.7 | 15070          | 7670            | 0.95      | 7.3  |
| WS12     | 1.66316      | 101.45768     | 15        | 17.41| 29.5           | 681             | 355       | 0.03     | 6.48 |
| WS13     | 1.65612      | 101.50572     | 3         | 10.9 | 28.7           | 1510            | 750       | 0.07     | 5.8  |
| WS14     | 1.66027      | 101.47827     | 25        | 10.37| 28.9           | 1055            | 527       | 0.05     | 7.21 |
| WS15     | 1.63928      | 101.45127     | 8         | 11.12| 30.1           | 360             | 180       | 0.01     | 7.54 |
| WS16     | 1.61004      | 101.42849     | 11.49     | 31   | 1806           | 907             | 0.09      | 6.01 |
| WS17     | 1.60249      | 101.40717     | 80        | 12.19| 34             | 1343            | 662       | 0.06     | 7.87 |
| WS18     | 1.63429      | 101.38057     | 5         | 12.51| 30.1           | 268             | 134       | 0.01     | 6.16 |
| WS19     | 1.66395      | 101.39004     | 13.36     | 32.1 | 543            | 271             | 0.02      | 6.8  |
| WS20     | 1.67181      | 101.41449     | 13.53     | 30.4 | 432            | 218             | 0.02      | 6.56 |
| WS21     | 1.68399      | 101.42868     | 5         | 14.15| 30.1           | 545             | 278       | 0.02     | 6.28 |
| WS22     | 1.68086      | 101.44912     | 14.33     | 31.5 | 2240           | 1120            | 0.11      | 6.44 |
| WS23     | 1.65498      | 101.44031     | 15        | 15.02| 31.2           | 907             | 455       | 0.04     | 6.4  |
| WS24     | 1.6467       | 101.4078      | 16.13     | 32.5 | 81             | 40              | 0         | 6.85 |
| WS25     | 1.61904      | 101.44178     | 8         | 17.38| 29.2           | 154             | 77        | 0        | 5.75 |
The Total of Dissolved Value (TDS value) in groundwater of the study area is highest at the WS11 (7670 ppt) which is the depth of this well is less than 10 m deep (Table 1). While the lowest value of TDS level is found in the WS2 (31 ppm). The well of WS2 is located about 12 km from the beach line on the elevation 25 m above mean sea level. The depth of this well is 18 m below the ground surface. In general, the wells depth which are positioned above the mean sea level were found with the lower TDS value which is safe for human consumption. While the well depth is positioned below the sea level will have the higher TDS value.

The salinity of groundwater sample has the same trend with the TDS value. The Salinity was found higher at the well which higher TDS value. This condition imply that the dominant factor influence the TDS in the water sample is the salt mineral content in the sea water that is intruding the Dumai area, especially at the zone less than 8 km from the beach line.

4. Conclusion
The preliminary study on the groundwater investigation in the wetland of Dumai area was successfully done. The study shows that the groundwater is dominated by the highest TDS value at the area less than 6 km from the beach line. Generally, the TDS value is relatively safe for human consumption at the well’s depth above mean sea level. This preliminary research will be continued with the investigation using geophysical method to obtain the subsurface data for the hydrology modeling of the study area.

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