Quantification of volatile organic compounds (VOCs) to predict petroleum at Sungai Rambai in Jambi province

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Abstract. The potential of petroleum sources in the Sungai Rambe area of Jambi Province can be predicted by using the Gore Sorber established method. An adsorbent device for taking patented passive samples can be used to collect and informing of the bind hydrocarbon compounds (VOCs) and investigate subsurface conditions to predict petroleum formation. This research was conducted by implanting the device into the soil for 21 days and analyzed directly using GC-MS to analyse the structure and hydrocarbon compounds contained in petroleum. Some of the compounds detected using Gore-Sorber include; alphapinene, dimethyl sulfide, carbonyl sulfide, dimethyl-disulfide, butane and ethane. These components are typical chemical compounds of a combination in petroleum. Quantification of each component was 206.34 ng Alpha Pinene, 196.65 ng Dimethyl Sulfide and 205.8 ng Dimethyl Disulfide. The three components are petroleum hydrocarbon and non-hydrocarbon components.

1. Introduction

Petroleum has an important role in the world economy. They are as the main source of the liquid fuels for transportation, chemical manufacturing, power generation and other uses [1]. Demand for oil, gas and other energy sources grew dramatically so that the impact on the world energy consumption is expected to increase by 37% in 2035. This is driven by the world population which is predicted to increase by 25% in the next 20 years. Indonesia as the fourth largest population in the world is known for its total primary energy consumption increasing by more than 50% from 2000-2010. At present, Indonesia’s oil production reaches almost 860.000 barrels of oil per day [2].

To meet oil needs, oil exploration must be carried out. Exploration activities to find the source of the existence of petroleum as the main energy source for industry, transportation and household, besides that oil also a source of foreign exchange for the country. Exploration is carried out in the research area to find out the initial information about the potential presence of petroleum [3].

Several regions in Indonesia have petroleum seepage areas which indicate a petroleum reservoir in the soil. One of the areas that show an indication of petroleum is the Tebing Tinggi area in Tanjung Jabung Barat District. Volatile Organic Compounds (VOCs) and Semivolatile Organic Compounds (SVOCs) can be detected or identified using the Gore Sorber method. As the research has been done, the compounds detected using the Gore Sorber method include carbonyl sulfide, dimethyl sulfide, ethane, propane, butane, 2-methyl butane, pentane and carbon sulphide with C2-C5 carbon chains [4].

Geographical location of Sungai Rambai is in the south bordering the sub-district of Tebing Tinggi. That is the reason why Sungai Rambai needs to be explored further to see the potential of petroleum reserves because the research location is close to the previous location, it is in Tebing Tinggi. Previous
studies showed that the number of VOC indicates an area that contained petroleum. So, this research uses the Gore Sorber method using Gas Chromatography-Mass Spectrometry (GC-MS) to determine the quantification of VOC content at several points in the area of Sungai Rambai.

2. Experimental Methods

2.1. Materials
The tools and materials used in this research were AGI module, pushrod, cable retrieval, Global Positioning System (GPS), digital camera, gloves, flag tape, compass and GC-MS Thermal Desorption.

2.2. Exploration area

![Figure 1. Map of Tanjung Jabung Barat District](image)

This research was located in Jambi Province at Sungai Rambai, Tanjung Jabung Barat District, Senyerang sub-district. Geographical location of Sungai Rambai is in the south bordering the sub-district of Tebing Tinggi, the north bordering Riau Province, the east bordering Pengabuan sub-district and west bordering Riau Province and Tebing Tinggi sub-district [5].

2.3. Methods
This method uses an AGI module containing absorber, which contains the same amount of engineered sorbent material, specifically used for the affinity of various volatile organic compounds (C₂₀), and reduces moisture absorption. This module consists of a Gore-TEX membrane tube that has a length of about 1 meter and a diameter of ¼ inch. This membrane made from a component of polytetrafluoroethylene (ePTFE) which does not react with any compound and is resistant to water. Inside the membrane, there are adsorbents that can bind various VOCs [6].

2.3.1. Planting the AGI module. Determination of location coordinates for planting AGI Modules using GPS. The pushrod was used to make holes with a length of about 45-50 cm and a width of 1-1.5
One glass bottle containing the module was taken from the module box and the serial number is recorded. The top of the module was tied with a 1.5 m long rope and the tip of the pushrod is placed at the base of the module (pushrod as a push module into the hole). Record the location point, module serial number, date, time of planting and pay attention to the area that was odourless or contaminated with waste, marked to find the module at the time of collection and leave the module embedded for 21 days.

2.3.2. Retrieval of The AGI module. After 21 days, the module was taken using GPS to find the location of the module point by looking for the end of the rope. Cut the strap from the module and make sure the module serial number was in good condition. The nitrile gloves were used to pull and clean the module from the ground. Replace the module in a bottle and close the bottle tightly, and then place the module bottle into the storage box.

2.3.3. GC-MS characterization. AGI module was taken from the storage box and the module was removed from the bottle. The bottom of the module was opened and the adsorbent was taken. The adsorbent was dissolved with Methanol solvent to be characterized by the GC-MS instrument.

3. Results and Discussion

3.1. Characterization results at point 1

GC-MS characterization results in point 1 can be seen in Figure 2 and Figure 3, which shows the chromatogram and the mass number of VOC compounds. In Figure 2 there are several dominant peaks in certain retention times which are identified components, including alpha-pinene, carbonyl sulfide, butane, ethane, decanal, nonanal, dimethyl disulfide, 1-butane, 2-methylbenzene, pentane, propane, 1-pentene, propane, tetradecane, octanal dan hexadecane.

![Figure 2. Chromatogram at Point 1](image)

The highest component at point 1 shown in figure 3. These compounds are alpha-pinene, carbonyl sulfide and butane with a mass of 46.03 ng, 18.15 ng, and 17.22 ng. These compounds are the dominant compounds and appear first with a faster retention time than other compounds. The same compounds are also produced from other studies on soil and litter samples that represent different types of compounds. One of the identified compounds with GC-MS was alpha-pinene, which is included in the high-quality rating with a retention time below 5 min [7].
3.2. Characterization results at point 2
The results of the Chromatogram in Figure 4 show some dominant peaks in certain retention times. Several components of compounds detected after analysis with GC-MS were alpha-pinene, dimethyl disulfide, ethane, carbonyl sulfide, butane, nonanal, decanal, propane, 1-butene, octanal, beta-pinene, carbon disulfide, propane, 1-undecane, 1-pentene, caryophyllene and pentane.

Surveys have been carried out in areas that have not yet been explored in Tasmania to Victoria Australia using the gore module. The results show that the area has the potential of petroleum which is seen from the total mass response of alkanes (butane, pentane, methylcyclopentane, cyclohexane, methylcyclohexane, cycloheptane, heptane, octane, decane, undecane, dodecane, tridecane, pentadecane, hexadecane, heptadecane, and octadecane) with the highest number of 405 ng analyzed using the GC-MS instrument [8].
The number of VOC compounds contained in point 2 shown in Figure 5. The most dominant compounds in these locations include alpha-pinene, dimethyl disulfide and ethane with a mass of 160.31 ng, 30.71 ng and 27.46 ng respectively.

3.3. Characterization results at point 3
GC-MS analysis results at point 3 shown in Figure 6. Components of compounds detected in a certain retention time range are alpha-pinene, dimethyl sulfide, dimethyl disulfide, butane, carbonyl sulfide, ethane, 1,3,5 trimethylbenzene, 1-butane, pentane, decanal, nonanal, octanal, 1-ethyl-2/3-methylbenzene, caryophyllene, carbon disulfide, propene and propane.
The graph of the number of VOCs in Figure 7 shows that the most dominant compounds at point 3 are dimethyl sulfide, dimethyl disulfide and butane with a mass of 196.65 ng, 175.09, and 42.61 ng respectively.

3.4. Quantification of VOC in Sungai Rambai
The Gore Sorber method which was used in this research has successfully detected VOC which indicate the potential of petroleum. This is in accordance with the advantages of using gore sorber, which can detect various VOC compounds. Besides the installation is fast and easy, and inexpensive and environmentally friendly [9]. This method also makes it easy to use a sampler. VOC compounds determination using the Gore Module when compare with conventional low-flow purging and sampling methods results in equivalent or better data quality using the gore module [10].

Based on the results of the VOC chromatogram from three location points shows the similarity. Compounds around the observation area are in the C$_2$-C$_{20}$ range. The results obtained were mostly found in retention times under 20 minutes. Chromatograms detected have different retention times according to the physical-chemical properties of chemical compounds and the percentage of VOCs contained in petroleum.

Gore Sorber method in geochemical exploration to determine the presence and distribution of hydrocarbons in the Assam-Arakan basin show results in one dominant point of C$_3$-C$_5$ and C$_{10}$-C$_{15}$ hydrocarbons, which indicates the presence of petroleum [11]. Petroleum analysis using gas chromatography produced two adjacent peaks. The two highest peaks are C$_{17}$ and C$_{18}$, there is a retention time of less than 20 minutes [12]. Abrams research shows that the GC content has a number of carbon chains ranging from C$_3$ to C$_{14}$ with a high number of C$_5$-C$_9$. Consideration of the use of hydrocarbons in accordance with volatility generally has a dominant amount in the C$_5$-C$_8$ component, but some have reached C$_9$ or more [13].

This study shows the components that migrate from all points are hydrocarbons from petroleum and there also non-hydrocarbon components from petroleum which can be seen in the following table.
Table 1. Dominant VOC compounds that indicate the presence of petroleum

| No | Compounds         | Molecule Formula | Chemical Structure | Amount (ng) |
|----|-------------------|------------------|--------------------|-------------|
| 1  | Alpha-Pinene      | C\(_{10}\)H\(_{16}\) |                    | 206.34      |
| 2  | Dimethyl Sulfide  | (CH\(_3\))S      |                    | 196.65      |
| 3  | Carbonyl Sulfide  | CSO              |                    | 76.22       |
| 4  | Dimethyl Disulfide| C\(_2\)H\(_6\)S\(_2\) |                | 205.8       |
| 5  | Butane            | C\(_4\)H\(_10\)   |                    | 73.76       |
| 6  | Ethane            | C\(_2\)H\(_6\)    |                    | 73.34       |

Table 1 shows the most dominant mass quantification of VOC compounds at three points indicating the most petroleum. When compared with previous studies, the results obtained were ethane, alpha-pinene, butane, dimethyl sulfide, carbonyl sulfide, carbon disulfide, dimethyl disulfide, decanal, octanal and nonanal [14]. This shows that the compounds obtained in this study are similar to previous studies and indicate the presence of petroleum formations in the area of Sungai Rambai.

4. Conclusions

Based on the research that has been done, Sungai Rambai detected the dominant compounds are alpha-pinene, dimethyl sulfide, carbonyl sulfide, dimethyl disulfide, butane and ethane. These components are typical of petroleum compounds seen from the highest component, alpha-pinene 206.34 ng, dimethyl sulfide 196.65 ng and dimethyl disulfide 205.8 ng. The three compounds are components of petroleum compounds in the form of hydrocarbons and non-hydrocarbons. So it can be concluded that three points in Sungai Rambai have signs of petroleum.

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