Screening of Volatile Organic Compounds Using Gore-Sorber Method for Predicting Hydrocarbon Generation

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Abstract

Purpose – This paper aims to detect or identify the presence of hydrocarbon infiltration on sampling point in the Rambe River area according to the obtained VOCs and the adsorbed SVOCs.

Design/Methodology/Approach – The Gore-sorber method has been used to capture volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) as indicators of subsurface hydrocarbon generation and entrapment. This method is usually used in environmental surveys for the oil investigations in certain areas for surface survey screening, designed to collect a broad range of VOCs and (SVOCs) at lower concentrations, quickly and inexpensively. The results also indicated a general correlation between the GORE-SORBER and reference method data. The research was conducted in Rambe River Village, Tebing Tinggi sub-district of Tanjung Jabung Barat district, Jambi Province Indonesia. The collection of the Gore-Sorber modules were analyzed using a gas chromatography-mass spectrometer thermal desorption (GC/MS).

Findings – The results showed that from all sampling points in Tebing Tinggi areas, the dominant components detected are carbonyl sulphide, dimethyl sulfide, ethane, propane, butane, 2-methyl butane, pentane, and carbon sulfide with carbon chain in the range C2-C5. These hydrocarbon gases (C1-C4) which may be from thermogenic or microbial processes. The highest concentrations of carbonyl sulfide were 392.67 ng and dimethyl disulfide 261.90 ng.

Originality/Value – In addition to estimate and predict the petroleum formation, this article provides information about the presence of oil fields in the area of the Sungai Rambe Village

Keywords VOCs, Gore-sorber, hydrocarbon generation

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1. Introduction

Indonesia is known as a country that has abundant natural resources, whether it is natural resources that are above or below the soil surface. Petroleum is one of the natural resources. In some areas, there is a region of oil gassing, in which the oil spill could indicate an oil reservoir in the soil. According to Koesoemadinata (1990), Southern Sumatra and Central Sumatra are parts of Western Indonesia with oil content. The basin in central Sumatra is one of the largest oil producers in Indonesia, especially in the Sungai Rambe Village, Tebing Tinggi, Tanjung Jabung Barat District, Jambi Province (Purwono, 2008). Currently, the Sungai Rambe Village is the area with the best hydrocarbon potential and it is still exploratory and further research is needed to determine the prospective hydrocarbon area (Suwarna, 1992). It requires a more efficient method of oil identification and has a cheaper cost of production. In this case, the identification of petroleum can be done by using the Gore Module as an alternative for identification.

The Gore-Module is a method used to detect or identify the presence of hydrocarbon infiltration in the soil and can be used to detect volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). This tool can absorb various VOCs and SVOCs in the range from C2 to C20. The detected compounds are such as 1,3,5-trimethylbenzene, toluene, and benzene. These compounds are a dominant compound when used Gore-Sorber as a sensor to detect the presence of oil content in the soil. VOCs can be detected by gas chromatography-mass spectrometry-thermal desorption. This technique is focused on VOCs in the gas stream before being injected into gas chromatography. It can be used to lower the detection limits of the gas chromatography method and can improve chromatographic performance by reducing the peak width.

The relationship between passive soil evaporation and the grab sampling technique to determine the VOC on the soil surface have been investigated. The passive evaporation of soil is caused by the vapor displacement and the homogeneous distribution of the analyte. This method can also be used to determine the contaminants in the soil. Abrams *et al.* (2009) reported the development of a method for collecting and analyzing various gasoline hydrocarbons (C5-C12) from seabed sediments as an indicator of subsurface hydrocarbons using Gore-Sorber and gas chromatography-flame ionization detection (GC-FID). Advances in passive sampling in environmental studies have been examined by Wasik *et al.* (2007). On the measurement of passive evaporation on the sediment and soil, the Gore Sorber Module device was used. Steam consisting of air and water vapor occurs naturally by organic compounds. The hydrocarbon compounds in the soil or the earth's surface can migrate from the source rock through the fractures and the pores of the reservoir rock to a higher place from C2 to C20. It can be concluded that the advantages of this method were low cost, simple method, do not need expensive and complicated equipment, no power requirements, unattended operation and the ability to produce accurate results.

This study focuses on the application of the Gore-Module method to detect or identify the presence of hydrocarbon infiltration on sampling point in the Rambe River area. Furthermore, the data obtained can be used to collect or report the compounds of VOCs and the adsorbed SVOCs.

2. Experimental methods

The location of the research was conducted in Rambe River Village, Tebing Tinggi, Tanjung Jabung Barat District, Jambi Province, Indonesia.

2.1. Preparation of materials

The tools and materials used in this work were AGI Module, push rod, retrieval cable, GPS, bacteria, digital camera, nitrile glove, field book, tissue, ribbon flag, cloth glove, compass, maps and instruments such as GCMS-thermal desorption and LC-MS.

2.2. Procedure

The sample points were determined first using GPS. Then, pushrod was used to create a hole depth in the range of 45–50 cm and 1–1.5 cm in width. After the hole was formed, the module was prepared from each box on a regular basis while the sample serial number was recorded. After the module was taken from the bottle, the bottle was put back into the bottle box. It should be noted that the sample should be placed upside down to make it visible. This empty looking bottle would help find the correct sample container at the time of collection.

The length of the rope was cut about 1.5 meters and tied loosely at the end of the module. At the time of collection, the rope was certainly long enough so that the end of the rope can be found outside the hole. Then the end of the pushrod was plugged in the bottom of the module. The module was pushed into the hole by using pushrod. When pushing the module into the hole, the module planting position should be straight. Before the output, pushrod from the ground in the play first to extend out of the hole. Pushrod was pulled slowly from the hole to leave the module in place.

In this work, there were four sampling points determined than analyzed, i.e B-103, B-106, B-110, and B-27.

3. Results and discussion

According to GC-MS, the mass number diagram of the VOCs and the chromatogram form of all sampling can be seen in Figure 1(A) and 1(B), respectively. Some of the VOCs components detected by GC-MS at B-103 were dimethyl disulfide, carbonyl sulfide, ethane, 2-methyl butane, decanal, nonanal, pentane, furan, caryophyllene, pentadecane, 1-butane, butane, propene, tridecane, and propane. The highest component was detected on B-103 as shown in Figure 1. The highest components were dimethyl disulfide ($C_2H_6S_2$) of 23.43 ng, carbonyl sulfide (CS) of 17.11 ng and ethane (C_2H_6) of 16.12 ng. This three VOCs were the components of petroleum because dimethyl sulfide and carbonyl sulfide have a structure containing sulfuric (S). Sulfur is a non-hydrocarbon compound in petroleum exists in the form of organosulfur compounds. One of them is dimethyl disulfide and carbonyl sulfide compounds that are often found in petroleum. Furthermore, ethane (C_2H_6) was detected as the main straight chain hydrocarbons. Ethane was grouped in natural gas because it has a low boiling point. Ethane is commonly found with petroleum in a dissolved state. Of all the components detected at B-103, the presence of natural gas with higher hydrocarbon compounds was indicated from a high ethane content and other gaseous components such as propane (C_3H_8) and butane (C_4H_{10}). It can be said that components contained in this sampling point was an indicator of typical components of petroleum.

At sampling point of B-106, it was also detected some components of VOCs. Many of the VOCs components were detected at B-106, i.e, decanal, ethane, carbonyl sulfide, nonanal, butane, 1-butene, octane, 1-pentene, benzothiazole, furan, 2-methyl butane, carbon disulfide, and propane. Some of these components are included in petroleum. The mass amount of decanal, ethane and carbonyl sulfide at B-106 were 16.27, 12.08 and 10.75 ng, respectively. Nonanal and decanal are a by-product component of the alteration process. Alteration is a change in mineralogy composition of rocks (in solid state) due to the influence of a high temperature and pressure. It was the same result with the previous point. At B-106 the detected components also indicated the presence of natural gas with high ethane count and other gaseous components i.e propane and butane. The VOCs components detected at B-106 can be inferred to contain petroleum since almost all components were typical of petroleum.

At sampling point of B-110, many of the VOCs components were detected by GC-MS. Some components of the VOCs were typical components of petroleum. The three compounds were similar to compounds detected in the previous point i.e. ethane of 18.97 ng, carbonyl

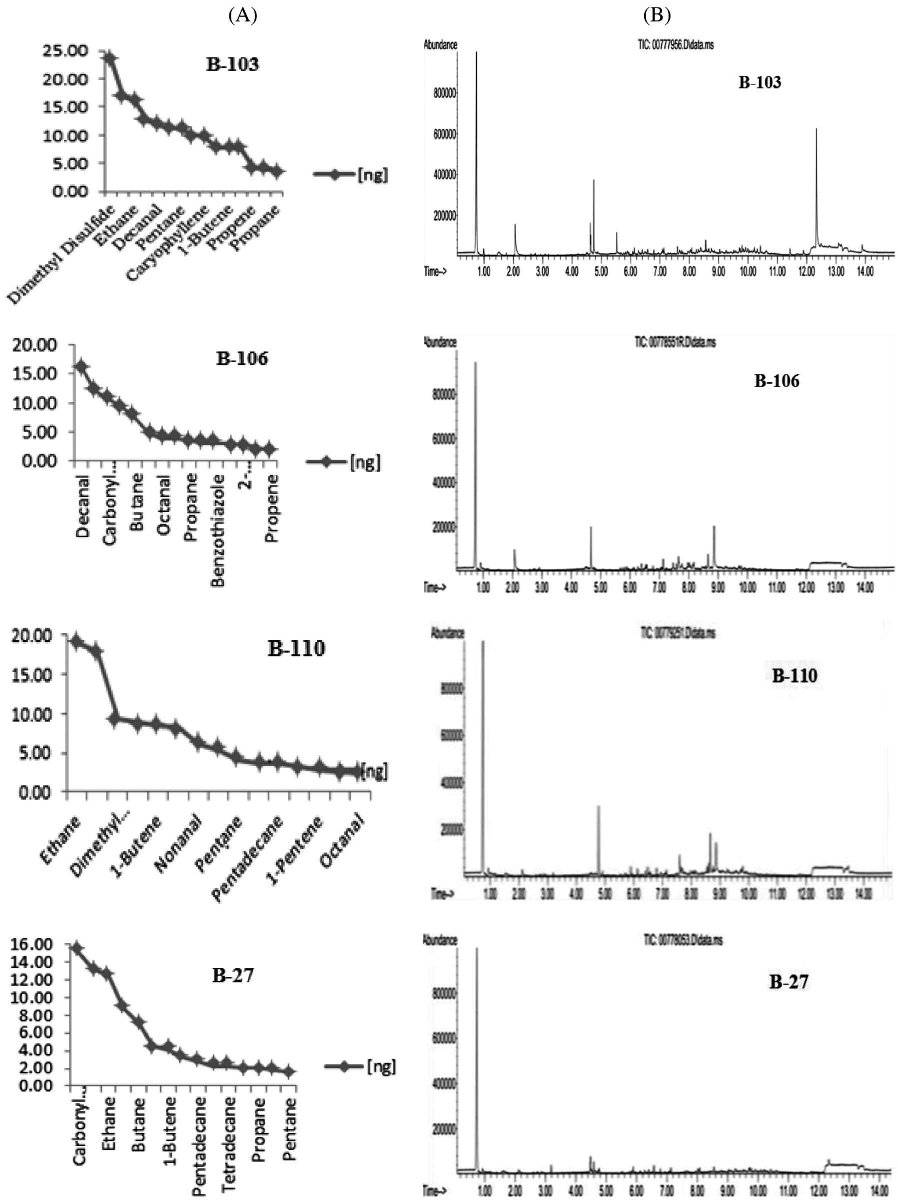


Figure 1.
(A) VOCs diagram and (B) GC-chromatogram of some sampling points for rambe samples collected from the different site but with same sampling depths

sulfide of 18.02 ng, and dimethyl sulfide of 9.36 ng. Some of the VOCs components were also detected at B-27 such as carbonyl sulfide, nonanal, ethane, decanal, butane, dimethyl sulfide, 1-butene, octane, pentadecane, 2-methyl butane, tetradecane, propene, propane, hexadecane, and pentane. Carbonyl sulfide, nonanal, and ethane have a high mass amount compared to that of other compounds, i.e 15.20, 13.08, and 12.71 ng respectively. All components are typical compounds of petroleum. Hydrocarbon components detected at B-27 showed hydrocarbon in the range of C1–C4 in the form of natural gas. In addition, it also detected components which were typical of petroleum so that it can be concluded that this sampling point contained petroleum range hydrocarbon.

Based on all location points that have been analyzed using GC-MS, most of the detected VOCs were not much different. The difference occurred only in the amount of mass of each component. It indicated that these components migrated during migration. Several factors made a difference in the amount of mass obtained, i.e the molecular weight and the magnitude of the fractures present in the earth. At the time of migration, some VOCs migrated slowly or quickly. It was because the molecular weight of each component was different. Components that have a lighter molecular weight will migrate faster, for example, hydrocarbons that have shorter carbon chains (C2-C5). Conversely, the heavy molecular weight component will migrate slowly, i.e a hydrocarbon having a long carbon chain (C10-C20). In addition, the other factor was the magnitude of the fracture which also affected the amount of VOCs mass obtained. Because at the time of migration, many components were inhibited on the fractures so that components that were not inhibited would migrate faster. The components that migrate from all points consist of large hydrocarbons and non-hydrocarbons of petroleum as shown in Table 1.

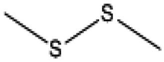
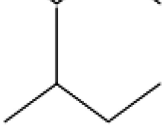
No.	Component	Formula	Chemical Structure	Mass (ng)
1	Carbonylsulfide	CSO		392.67
2	Dimetyl disulfide	$C_2H_6S_2$		261.90
3	Etane	C_2H_6		122.88
4	Propane	C_3H_8		98.28
5	Butane	C_4H_{10}		73.09
6	2-metilbutane	C_5H_{12}		66.98
7	Pentane	C_5H_{12}		63.84
8	Carbon disufide	CS_2		61.08

Table 1. The dominant VOCs that indicating the formation of petroleum

No.	Sampling Point	VOCs total (ng)
1	B-103	204.90
2	B-106	118.68
3	B-110	139.63
4	B-27	101.14

Table 2. VOC mass total

From the characterization of results were above, all sampling points have potency indicating of petroleum because many hydrocarbon compounds detected at these points. The total mass of VOCs detected at each point can be seen in Table 2. Each sampling point has a total mass of different hydrocarbons. A point with a high VOCs mass was B-103 so it can be concluded that point was supposedly very potential compared with other points. While B-27 has a very low VOCs total so that the potential for oil in the area was very small compared to other points. However, these data were also supported again with data from the precision seismic method so that exploration can be more accurate and good.

4. Conclusions

From all sampling points, the petroleum component in the non-hydrocarbon form was found in the form of 392.67 ng carbonyl sulfide compounds, dimethyl disulide 261.90 ng and carbon disulfide. In addition, the petroleum component in the form of hydrocarbons ie alkane groups is found in the form of ethane, propane, butane, 2-methyl butane, and pentane. It can be concluded that the existing petroleum in Rambe River Village was a type of paraffin hydrocarbon and there were also signs of natural gas.

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