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Crude Oil Spill and Its Environmental Impact in Bodo Community, Rivers State

*Ndubuisi, E.C,Lekie. B., Amadi, F.N and Mofunlewi,S.
The University of Port Harcourt, Faculty of Engineering, Department of Petroleum and Gas Engineering, East-West Road, Choba, Port Harcourt, Nigeria, P M B 5323, Choba..

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ABSTRACT
No doubt, oil is one of the influential commodities in the world market today hence, it is also a highly-priced product of the extractive industry. However, the process involved in its exploration, extraction, and transportation most often impinge on the environment, especially whenever an oil spill occurs, and it usually causes serious economic problems, contaminates drinking water, and causes general discomfort and disruption of normal life. This study aimed to evaluate the degree of damage caused by the oil spill in Bodo city, Gokana, Ogoni, Niger - Delta, in the southern region of Nigeria. Soil samples were collected 15cm from the top in an oil-polluted area, and experimentally analyzed for total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, pH, electrical conductivity, cation exchange capacity, and heavy metals were conducted. Results showed that the pH for contaminated and uncontaminated were 5.3 and 5.7, electrical conductivity was 7.22sm/cm contaminated and 3.21sm/cm uncontaminated; cation exchange capacity for contaminated was 46.01meq/100g and 29.04 meq/100g for uncontaminated; total organic carbon was 0.4788 contaminated. and 1.1072 uncontaminated. The total petroleum hydrocarbon of the affected soil revealed a high level of petroleum hydrocarbon contamination that far exceeds compliance limits. The gas chromatographic analyses conducted on the samples showed a significant contamination range. It also showed a significant concentration of polycyclic aromatic hydrocarbons (PAHs) with 1,4-Bis(trimethylsilyl) benzene being the most abundant in the contaminated area which is the most prone to biodegradation and attenuation. Heavy metals were detected in higher concentrations in oil-polluted areas than, in non-oil-polluted areas, some of the metals were very high in concentration. These results suggest that at the time of sample collection, the spilled oil was still fresh on site, therefore, there is a need to carry out bioremediation on the land.

KEYWORDS: Biodegradation, Contaminated, Chromatographic, Electrical conductivity, Heavy metals

I. INTRODUCTION

[1]. The petroleum industry, also known as the oil industry, includes the global processes of exploration, drilling and completion, production, refining, transportation, and marketing of petroleum products. The largest volume of refining products is fuel oil and petrol. Petroleum is also the raw material for many chemical products, including pharmaceuticals, solvents, fertilizers, pesticides, synthetic fragrances, and plastics. The industry is usually divided into three major components: upstream, midstream, and downstream. Upstream regards exploration and extraction of crude oil, midstream encompasses transportation and storage of crude, and downstream concerns refining crude oil into various end products. Petroleum is vital to many industries, and is necessary for the maintenance of industrial civilization in its current configuration, making it a critical concern for many nations. Oil accounts for a large percentage of the world's energy consumption.

[2,3,4,5,6].Despite the importance of petroleum if not properly handled, it causes pollution to the environment. There are various ways oil spill can occur such as mechanical failure, operational error natural hazard, and corrosion of pipelines, third party activity and sabotage.

[7]. The trends have been poor implementation of memorandum of understanding (M.O.U) between oil companies and host communities, lack of employmentand environmental degradation. Apart from the loss of lives and property through pipeline fire, the runoff from impacted sites usually degrades the quality of our freshwater sources which serves the domestic rural water supply needs of most communities in

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Nigeria. Oil pollution is one major challenge for which no effective and final solution has been found anywhere in the world in spite of efforts to control it. It is indeed extremely difficult to separate oil spill incidents from oil exploration and exploitation.

[8]. It was reported that whenever there is an incident of oil spillage, it usually causes various economic problem, contaminate drinking, water, and, cause general discomfort and disruption of normal life.

[9].From the discovery of the first commercially viable well in Ogoni land, in Niger Delta, Nigeria in 1957 to date, the issues of oil production and its effect on the environment had been the source of constant friction between Shell Petroleum industry and their host communities. The oil Spillage in Ogoniland is due to drilling and production, pipeline leakage, and pipeline vandalization by the local inhabitant, artisanal refinery, etc. These oil-related activities have affected fishing and farming activities in the host communities which are the main occupation in the coastal area of Ogoniland. In 1976, daily production of oil across the nine oil fields made of over 135 live wells was 350,000 barrels per day, making it among the highest oil-producing area in Niger Delta. An oil spill is the release of petroleum hydrocarbon into the environment when it occurred the characteristics of the oil affects the way the oil spreads as well as the hazard it might pose to the simulated environment.

[10]. Pollutants as such liquid discharge and oil spills have been introduced to the land, air, and water as a result of the activities of the oil company.

[11]. Thus, when there is an oil spill on water, spreading takes place immediately. The gaseous and liquid components evaporate while some get dissolved in water and even oxidize and some undergo bacterial changes and eventually sink to the bottom by gravitational action. The soil is then contaminated with gross affecting the terrestrial life. As the evaporation of the volatile lower molecular weight components affects aerial life, the dissolution of the less volatile components, with the resulting emulsified water, affects aquatic life.

[12]. Aquatic life has also been destroyed by the pollution of traditional fishing grounds, exacerbating hunger and poverty in fishing communities.

[13]. All these could force affected communities to aggress. According to the author, the experience of local fishermen and farmers is as follows: “having lost their traditional subsistence lifestyle to pollution and other drastic changes in their immediate environment, oil-producing communities are now forced to buy their food.

The heavier crude fractions are more likely to cause more mechanical damage than the lighter fractions, which are not as damaging physically but more toxic. The extent of contamination to the environment by these petroleum hydrocarbons is however determined by their concentration in the soil. When their concentrations reach a certain level, they become toxic to the resident fora and fauna. Therefore, the concentration of total petroleum hydrocarbon (TPH), polycyclic aromatic hydrocarbon (PAHs), and heavy metals and risk assessment will be evaluated in this study to ascertain the extent of the damage associated with the oil spilled.

THEORETICAL BACKGROUND OF ALIPHATIC AND AROMATIC HYDROCARBONS,

Aliphatic hydrocarbons are alkane molecules that do not include atoms different from C and H; they are made entirely of carbons and hydrogens. Atoms are linked together through covalent bonds, which are formed when atoms share their valence electrons. Aliphatic compounds can sometimes be linear, branched, or cyclic molecules. They can also include elements like aliphatic alcohols, which are aliphatic molecules containing the hydroxyl group −OH−OH. Aliphatic rings are cyclic alkane compounds carbon atoms are joined together to form a closed loop. Aromatic hydrocarbons are organic molecules that are made of C and H atoms only and that include conjugated systems. They are always cyclic compounds that contain alternating single and double bonds. Benzene is the simplest aromatic
compound. Heteroaromaticcompounds are
aromatic molecules that contain different atoms integrated into the conjugated ring. Pyridine is a heteroaromatic compound because it has a nitrogen atom in its benzene ring.

OIL SPILL AND NOTABLE OIL SPILLED INCIDENCE IN OGONILAND

[14]. An oil spill is the release of liquid Petroleum into the environment due to drilling and production activities, pipeline leakage, pipeline vandalization, artisanal refinery, etc. oil spill may be due to the release of crude oil from tankers, offshore platforms, drilling rings (blow out, and mud waste), a spill of refinery production, etc. Oil spillage is categorized into four groups: minor, medium, major, and disaster. This research work

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aimed at evaluating the environmental pollution caused by crude oil spillage in one of the oil-bearing communities(Bodo city) in Ogoniland in Rivers State.

The main objectives are to: determine the aliphatic and aromatic hydrocarbons (such as Total Petroleum Hydrocarbon (TPH); evaluate the polycyclic aromatic hydrocarbon (PAH); determine the heavy metals using Atomic Absorption Spectrophotometer (AAS) andalsoto determine the electrical conductivity and Cation Exchange Capacity (CEC).

STUDY AREA

The area understudy in this research is Bodo west oil field one of the four major oil fields in Oganiland. The oil field is in Gokana Local Government Area, Rivers State, Nigeria. Bodo west oil field is in the Bodo city community which has a boundary with Bonny Island as shown in plate 1.

Plate 1: Samples Collected Area in BodoCity

SAMPLE COLLECTION

Two soil samples were collected from two different locations in Bodo west oil field in Bodo city, Gokana local government area, Rivers State, Nigeria. One from the contaminated location and the other from the uncontaminated location, as shown in Plate 1 the samples were collected 15cm from the top.

EQUIPMENT

The following equipment and apparatus were used for the experiment \

Table 1: Equipment/Apparatus used

Item	Equipment/Apparatus	Type/Model	Function
1	pH meter	**Systronics pH system 362** 	Used to determine the degree of acidity and alkalinity of a liquid
2	Electrical Conductivity	Systronics Conductivity Meter 306	Used to measure the electrical conductivity of materials

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3	Flame Photometer		Used to determine Cation Exchange Capacity (CEC)

EXPERIMENTAL PROCEDURES

pH Analysis

The pH of the biochar was measured by adding 1 g of each sample in 20 ml of deionized water (1:20 w/v) and was measured using a pH meter (Systronics pH system 362).

Organic Carbon (OC) Analysis by Modified Walkley-Black titration

0.5 g of the dried, ground sample was treated with 5 ml of 0.4 N potassium dichromate solution ($K_2Cr_2O_7$) followed by the addition of 10 ml of concentrated sulfuric acid. The mixture was gently swirled and left at room temperature in a fume hood for 16-18 hours and then, 100 ml of tripled tilled water was added to the mixture. The excess dichromate was back-titrated potentiometrically with the standard 0.2 N ferrous ammonium sulfate ($Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$) solution.

Blank titration of the acidic dichromate with ferrous ammonium sulfate solution was performed at the beginning of the batch analysis using the same procedure with no sample added. One ml of 0.2 N ferrous ammonium sulfate is equivalent to 0.009807 gr of $K_2Cr_2O_7$ or 0.0006 gr of carbon. The organic carbon content in the sample was calculated as:

$$\text{Organic carbon (\%)} = (B - S) \times 0.0006)/ m)*100 \quad (1)$$

ELECTRICALCONDUCTIVITY ANALYSIS

The Electrical conductivity (EC) of the samples was measured at room temperature after suspending each sample in deionized water for 24 h in a (1:10 ratio biochar: deionized water) using an EC meter (Systronics conductivity meter 306).

CATION EXCHANGE CAPACITY ANALYSIS

The cation exchange capacity of the biochar samples was determined by saturating the sample exchange complex with 1N sodium acetate solution (pH 8.2). One g of each sample was leached with sodium acetate solution (pH 8.2) for the replacement of exchangeable cations by Na^+ ions. The excess salts were washed down by ethanol and the adsorbed Na^+ ions were released by NH_4^+ ions, using 1N ammonium acetate (pH 7.0) solution. The Na^+ ions so released from the exchange spots were measured by using a flame photometer (Rhoades, 1982

TOTAL PETROLEUM HYDROCARBON (TPH) AND POLYCYCLIC AROMATIC HYDROCARBON (PAH) ANALYSIS

TPH and PAH were run using Agilent Gas Chromatography-Mass Spectroscopy.

The sample was analyzed using Agilent technologies 7890A GC and 5977B MSD with Experimental conditions of GC-MS system as follows: Hp 5-MS capillary standard non-polar column, dimension: 30M, ID: 0.25 mm, Film thickness: 0.25µm. The flow rate of the mobile phase (carrier gas: He) was set at 1.0 ml/min. In the gas chromatography part, the temperature programmed (oven temperature) was 40°C raised to 250°C at 5°C/min, and the injection volume was 1 µl. Samples dissolved in methanol were run fully scan at a range of 40-650 m/z and the results were

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compared by using Nist mass Spectral library search programmed.

HEAVY METAL ANALYSIS

Ten grams (10g) of the granulated sample was weighed into a beaker and 100ml of distilled water was added. An additional 5 ml of concentrated nitric acid and boiling chips were added. The mixture in the beaker was heated continuously with the addition of small volumes of nitric acid until digestion was complete. Complete digestion was marked by a clear solution. The digested samples were evaporated to a final volume of 10 - 20ml, thereafter, the solution was transferred to a 100ml volumetric flask and diluted to mark. Concentrations of the heavy metals in the extract were determined thereafter using a Perkin Elmer model 2280/2380 Atomic Absorption Spectrophotometer. Readings were taken at appropriate wavelengths for each metal.

II. RESULTS

Experimental analyses of the oil-spilled and non-oil-spilled contaminated areaswere carried out to ascertain the degree of contamination. However, a discussion of the experimental results is done in this chapter

CATION EXCHANGE CAPACITY

Cation exchange capacity (CEC) is a measure of the total negative charges within the soil that adsorb plant nutrient cations such as calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^{+}). As such, the CEC is a property of soil that describes its capacity to supply nutrient cations to the soil solution for plant uptake. The results in Figure 1 shows that the oil spilled has contaminated the environment to the highest degree

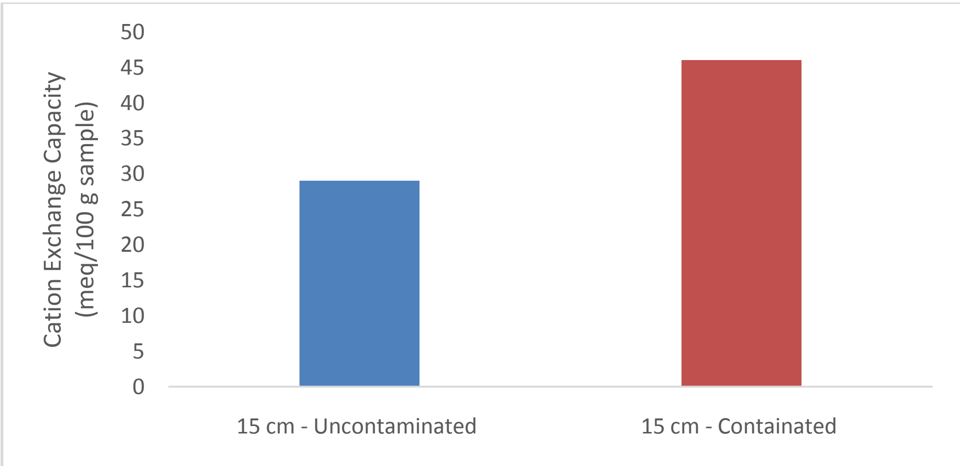

Figure 1: Results of Cation Exchange Capacity of contaminated and uncontaminated Samples

pH RESULTS

The results of pH of the contaminated and uncommented samples as shown in Figure 4.2. The pH value for the soil samples were 5.3 contaminated and 5.7 uncontaminated, this show that the contaminated area is more acidic than the uncontaminated area. It can be deducted from this result that a variety of contaminations may be attributed to oil spills of petroleum hydrocarbon in the soil.

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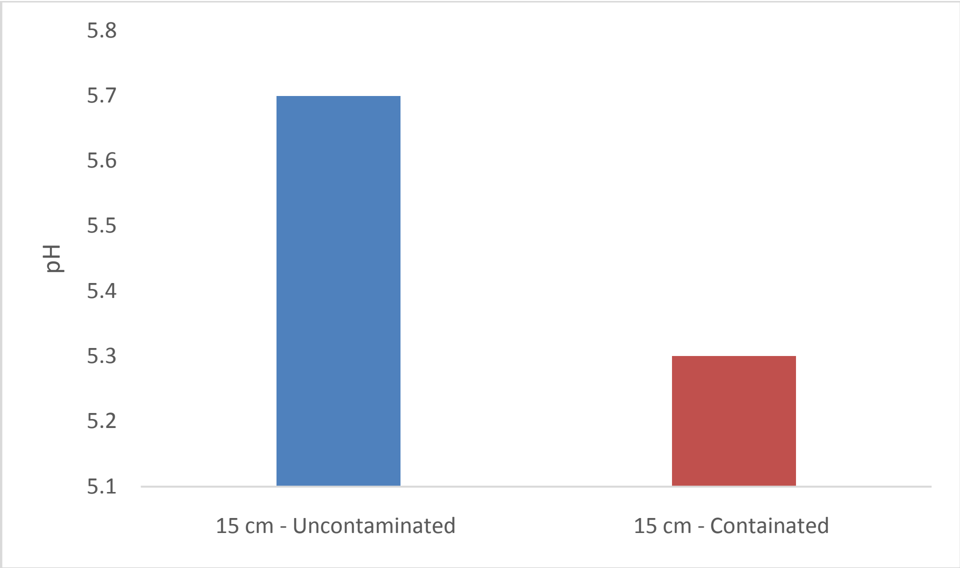

Figure 2: Results of pH of contaminated and uncontaminated Samples

ELECTRICAL CONDUCTIVITY

Electrical conductivity is the measure of the ability of a substance to conduct electricity, from the soil samples the electrical conductivity was 7.22ms/cm contaminated and 3.21ms/cm uncontaminated as shown in Figure 3. Thus, this high value of electrical conductivity in the contaminated area is due to heavy metals and compounds present in the soil from the oil spilled.

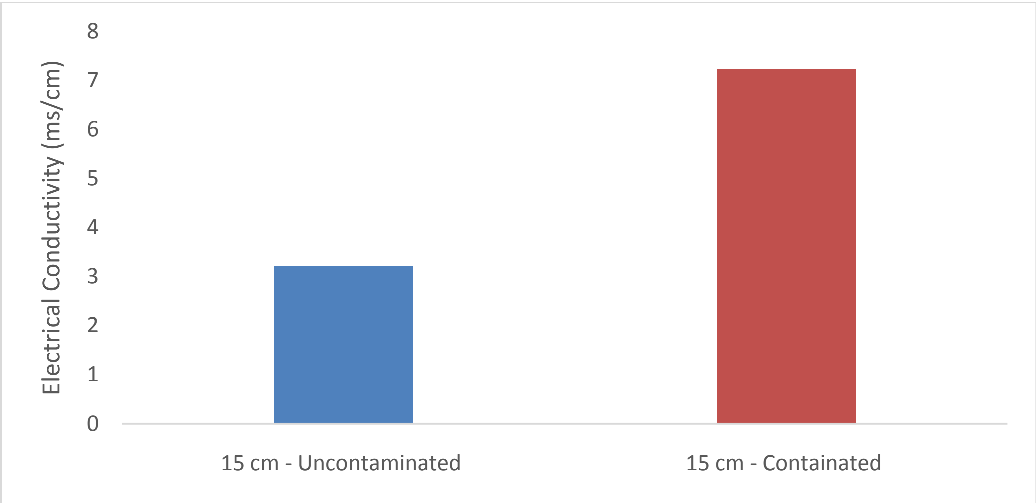

Figure 3: Results of Electrical Conductivity of contaminated and uncontaminated Samples

TOTAL ORGANIC CARBON (TOC)

Total organic carbon (TOC) is used to measure the total amount of organic compounds in water. It has been used to determine purification levels of a substance, from the soil samples the value for a total organic compound for the contaminated area is 0.4788 while for the uncontaminated area is 1.2072 as shown in Figure.4. The deduction of the results shows the level of toxicity in the oil spilled contaminated area.

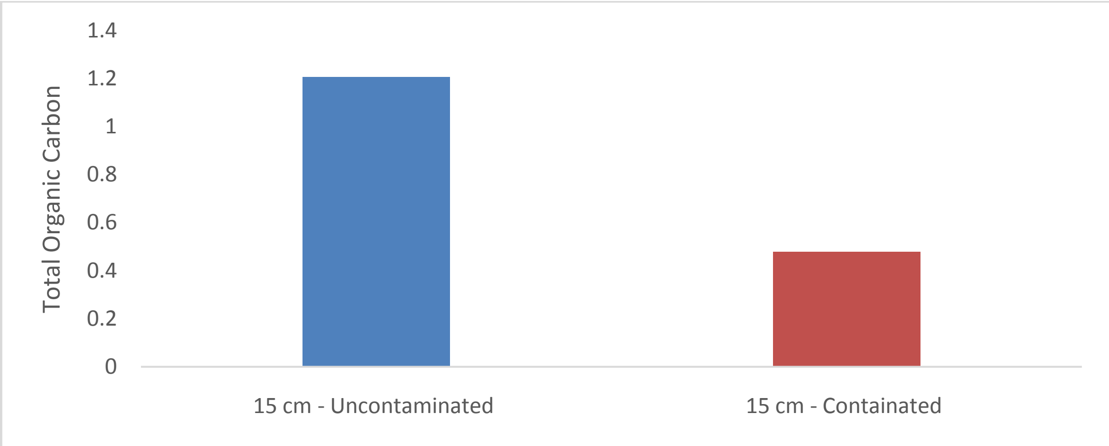

Figure 4: Results of Total Organic Carbon (TOC) of contaminated and uncontaminated Samples

HEAVY METALS

Heavy metals were detected in higher concentrations in the contaminated soil than in the uncontaminated as shown in Figure 5. This result shows a major difference in concentrations of the heavy metals in the contaminated area to the uncontaminated area. Many studies on the Niger - Delta such as NDES (1999) have shown that soils naturally have varying but trace amounts of heavy metals even in an undisturbed environment. Therefore, it is normal to have obtained these varying amounts of heavy metals at the study site.

Enhanced higher concentrations of metals in the contaminated soils may result in absorption by plants, which may bring about possible bioaccumulation by such plants and the animals that depend on the plants. For survival, all of these may lead to toxic reactions along the food chain (Osuji and Onojake, 2004). Therefore, in appraising the potential hazards of these heavy metals associated with crude oil, it is pertinent to consider appropriate de-pollution measures to check the possible bio-magnification of these metals.

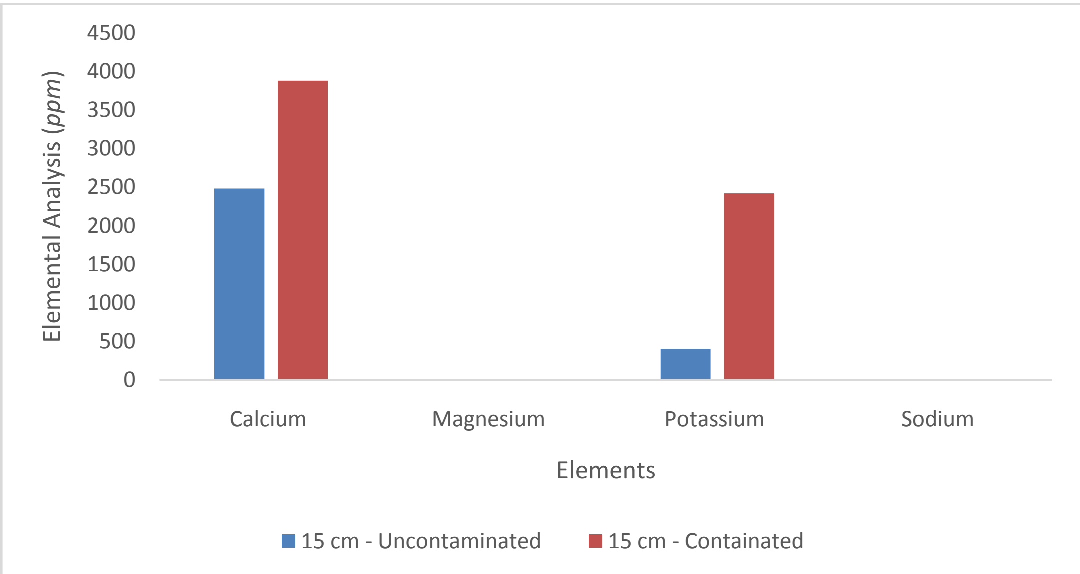

Figure 5: Results of Total Heavy Metals of contaminated and uncontaminated Samples

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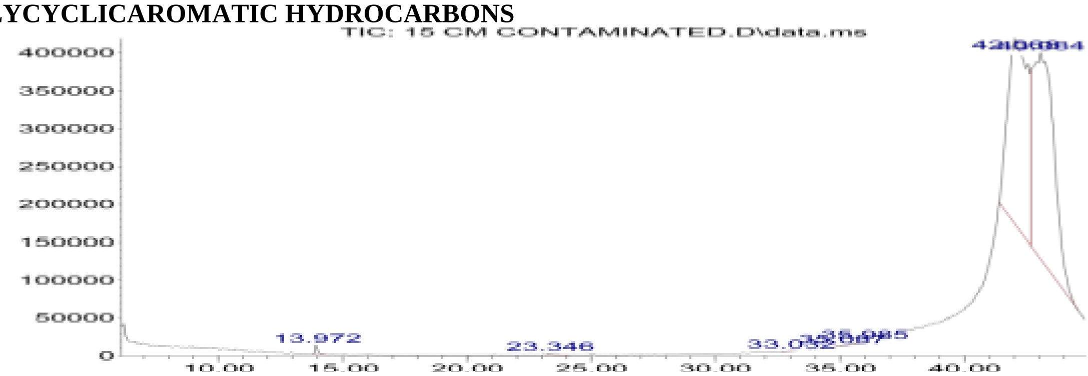
POLYCYCLICAROMATIC HYDROCARBONS

The results obtained for the polycyclic aromatic hydrocarbons (PAHs) revealed that most of the toxic aromatic hydrocarbons are higher in concentration in the contaminated area than in the uncontaminated area as shown in Figure 6. Also, 1,4-Bis(trimethylsilyl)benzene was the most abundant in the contaminated area while 1,2-Benzenediol, 4-(2-amino-1-hydr oxypropyl), and 2-Amino-1-(o-methoxyphenyl)propane least abundance PAH fraction. BTEX level in oils is an important parameter due to its toxicity and environmental concerns. BTEXs are hazardous carcinogenic and neurotoxic compounds and are classified as priority pollutants by the EPA (Wang et al., 1995). The presence of peaks in the Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) fingerprints of the samples also suggests that the oil was only slightly degraded, as these hydrocarbon fractions are highly volatile and easily degraded under aerobic conditions. Kaplan et al. (1996) used these hydrocarbon fracti4ns to determine whether an oil spill is recent or not.

POLYCYCLICAROMATIC HYDROCARBONS



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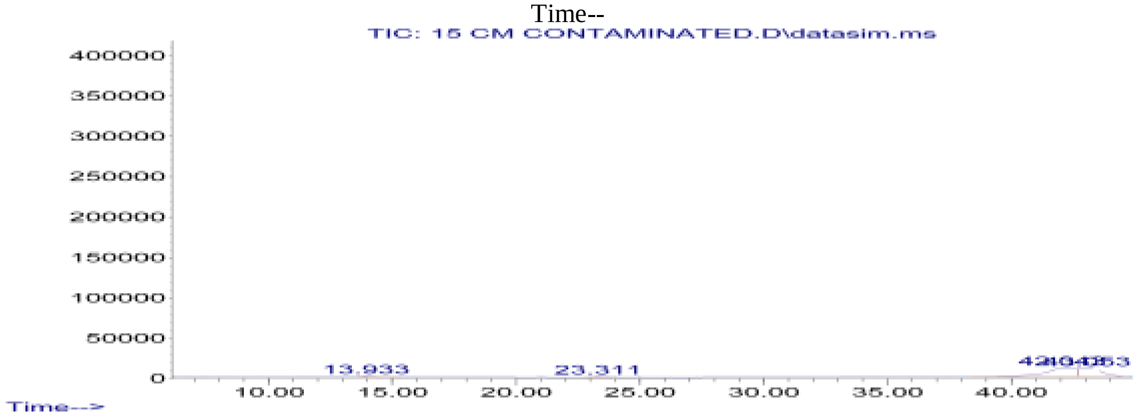

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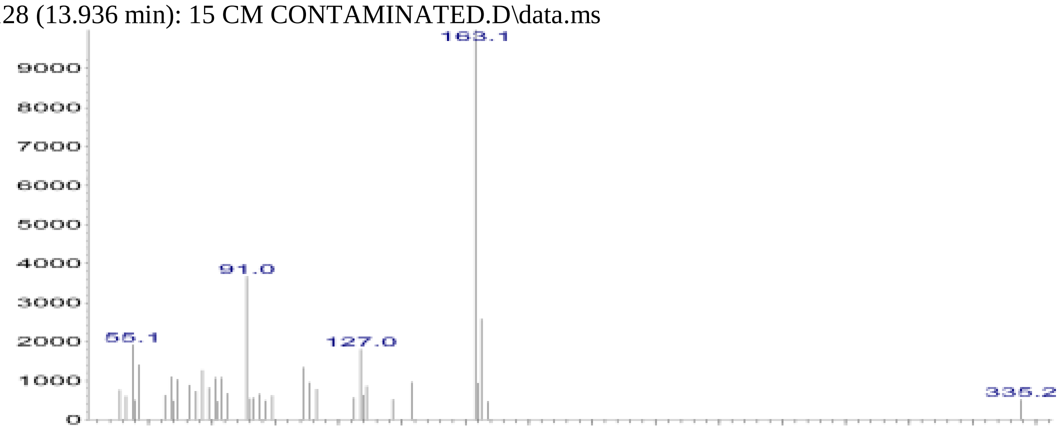

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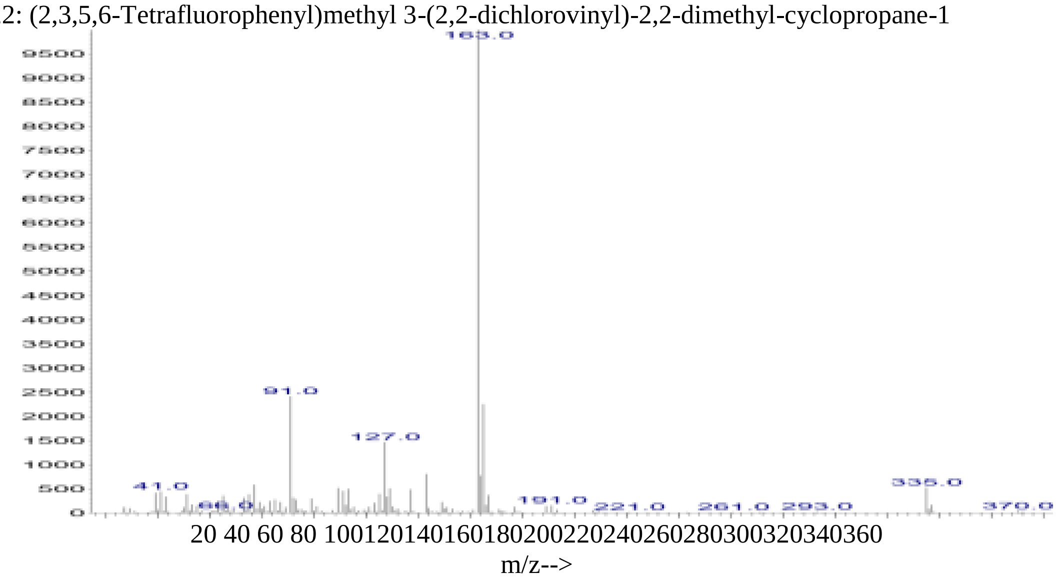

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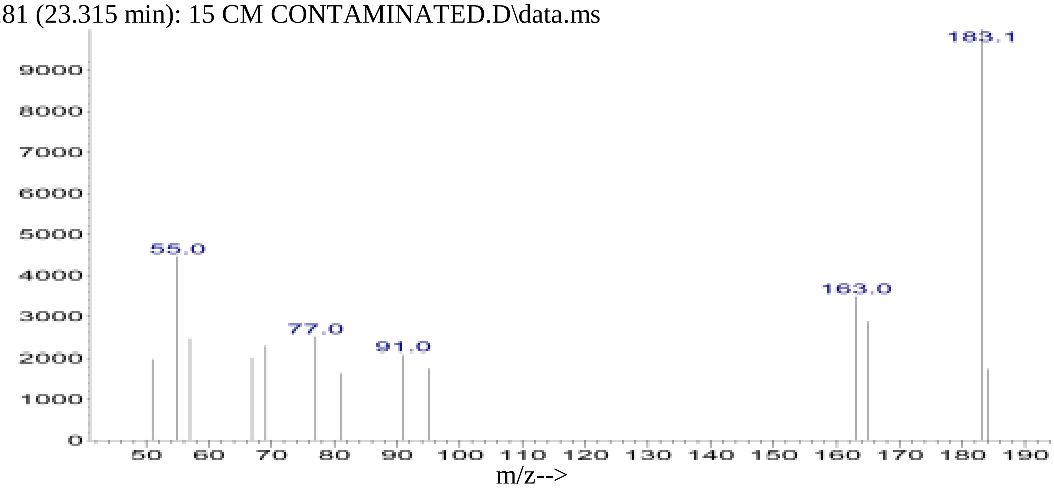

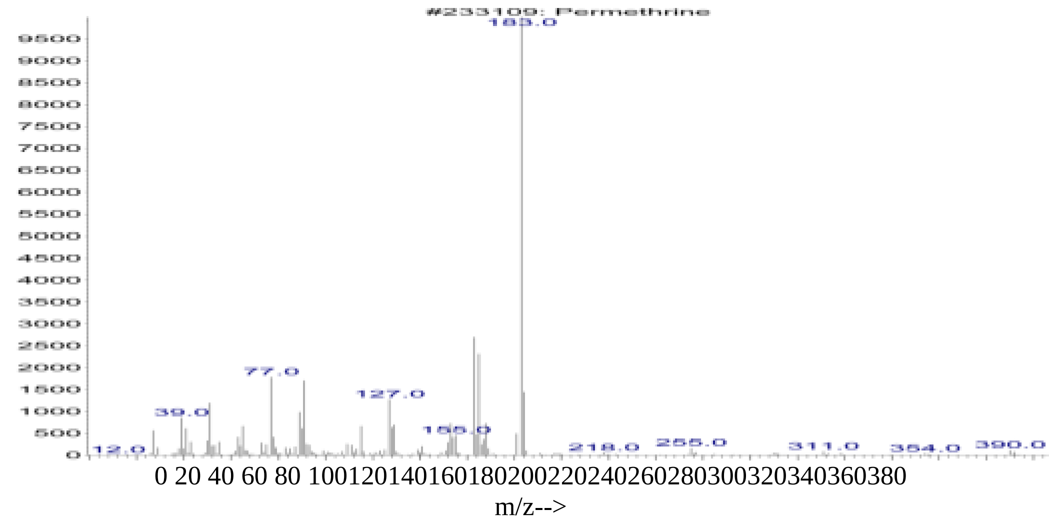

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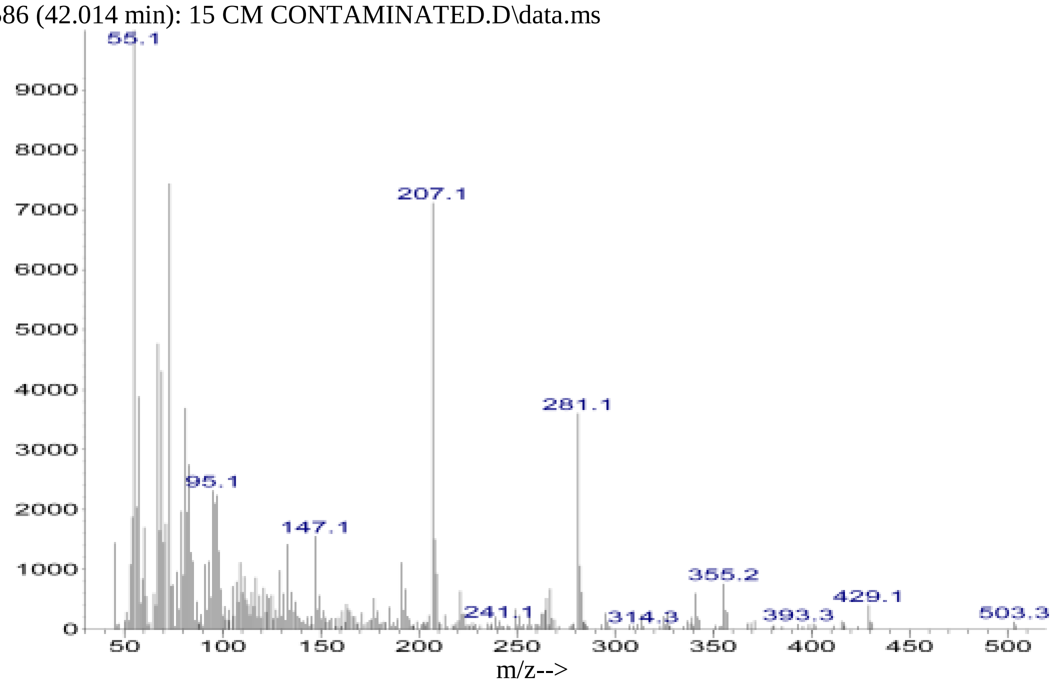

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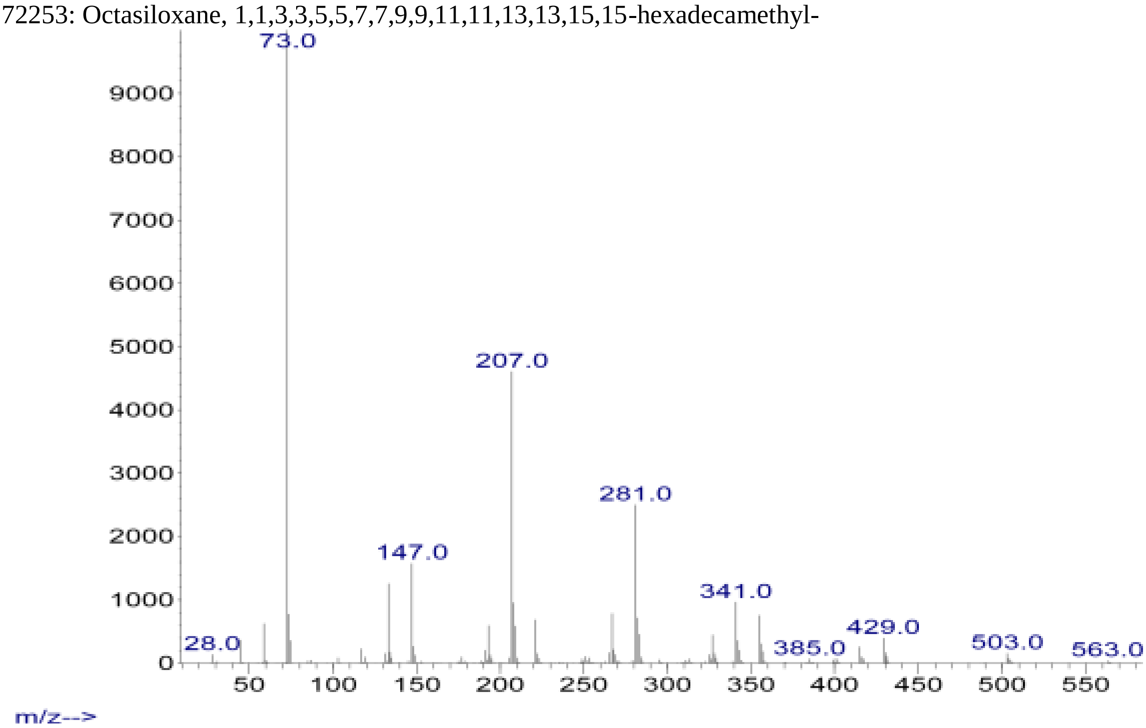

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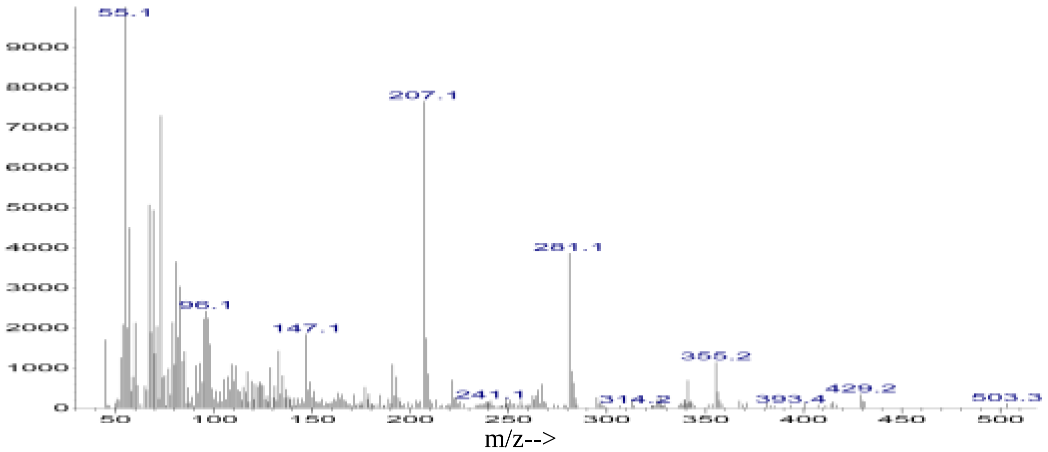

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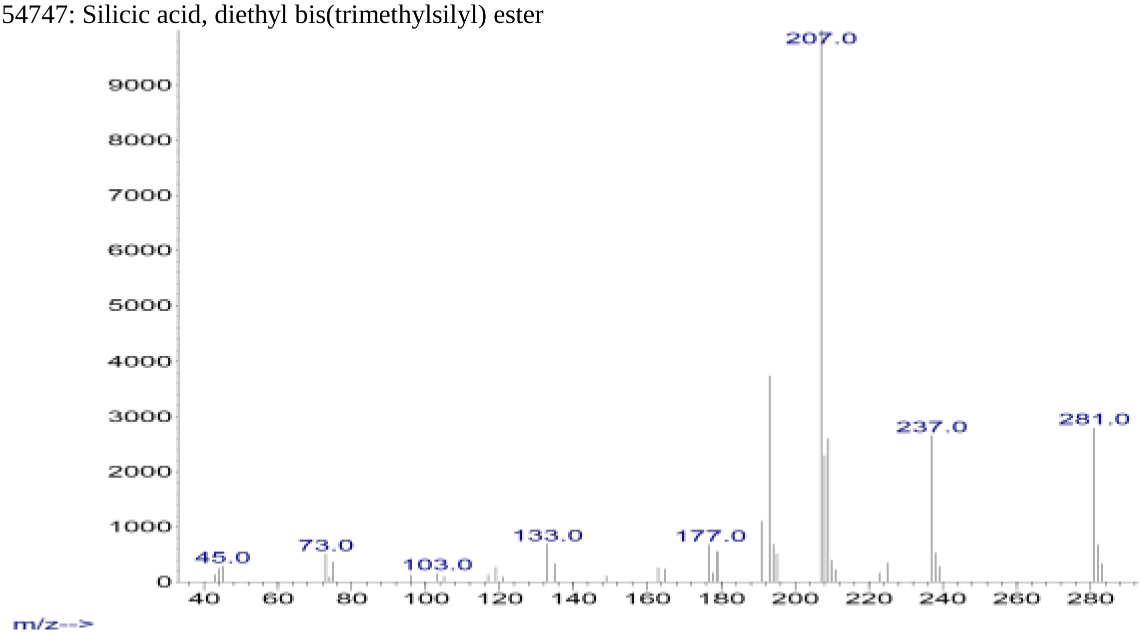

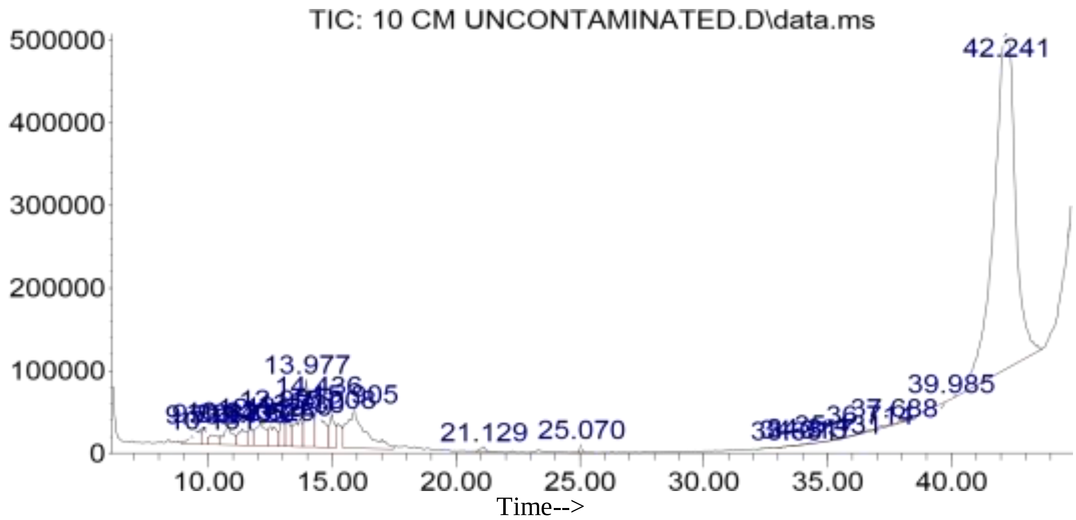

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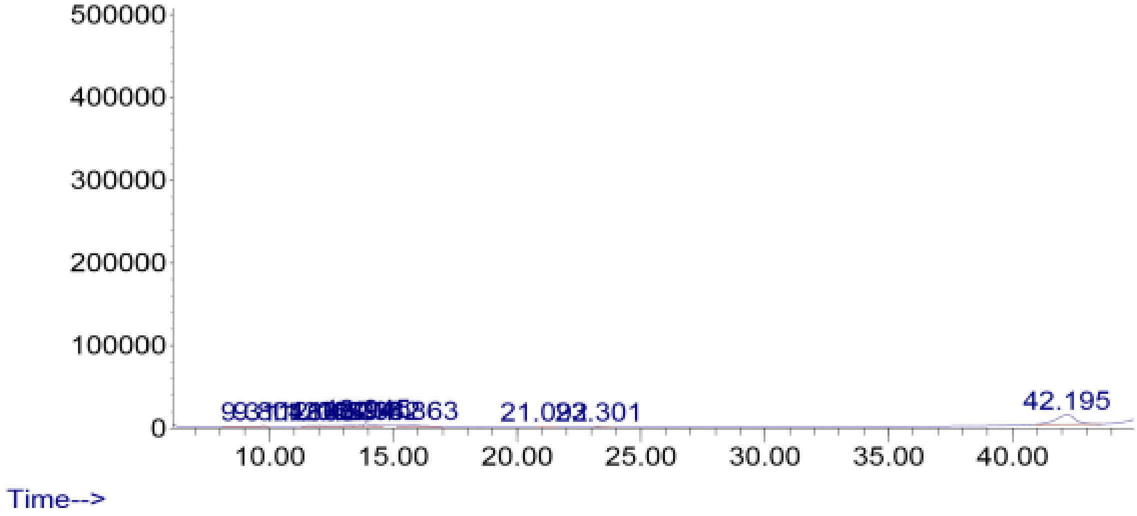

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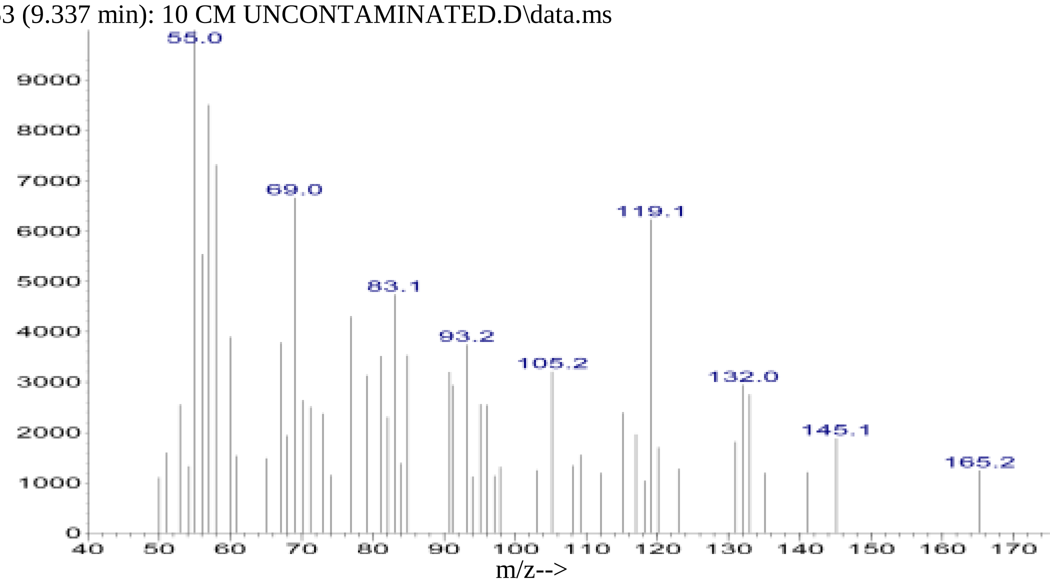

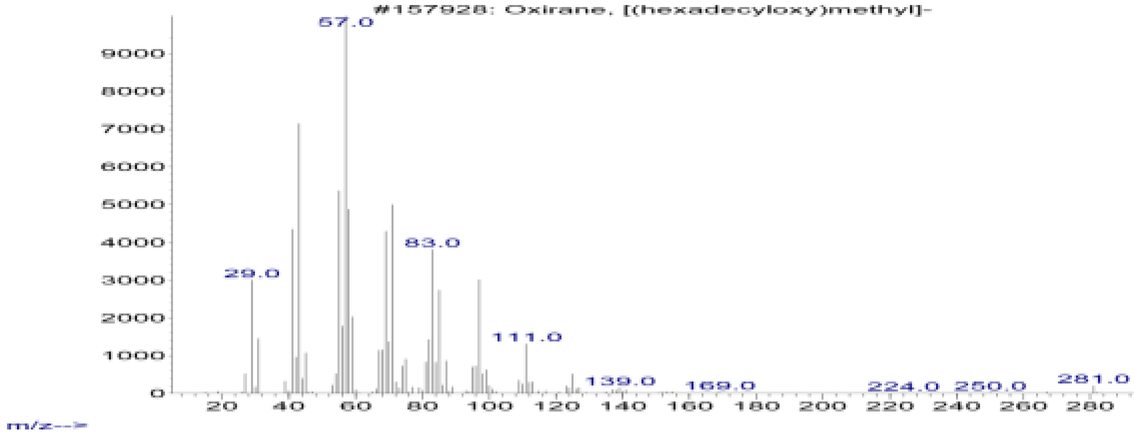

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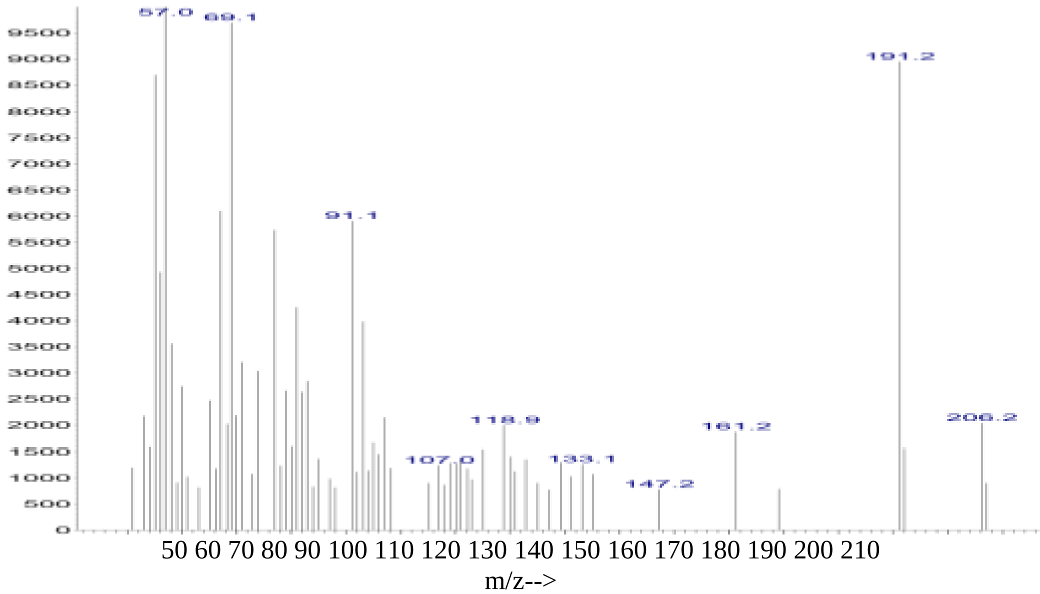

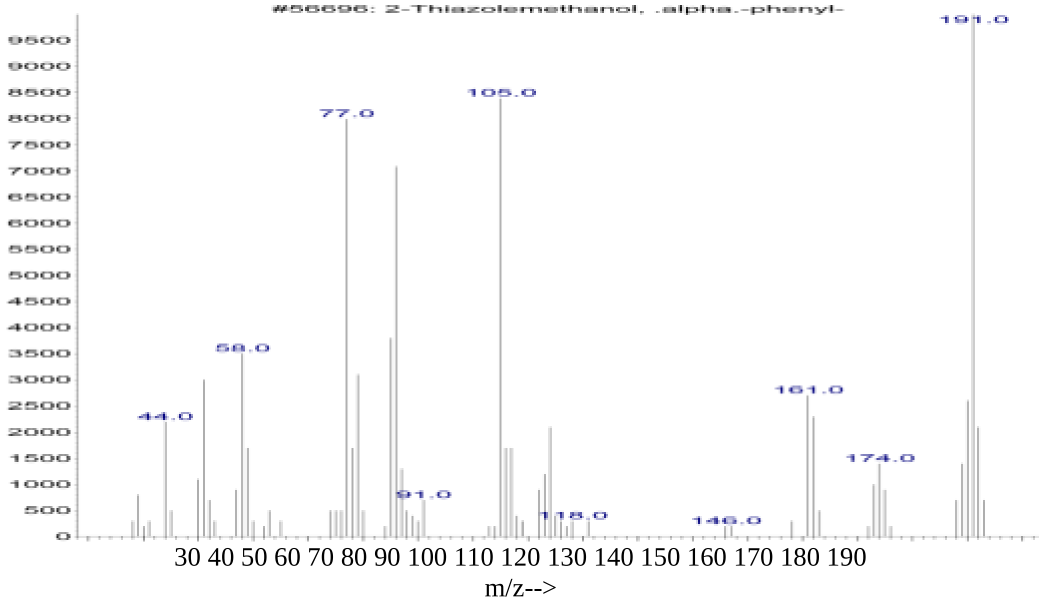

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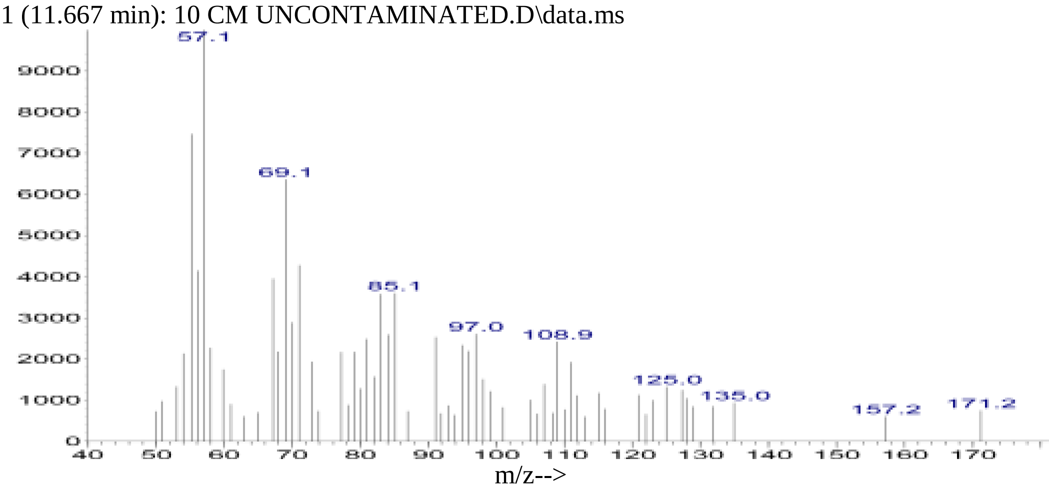

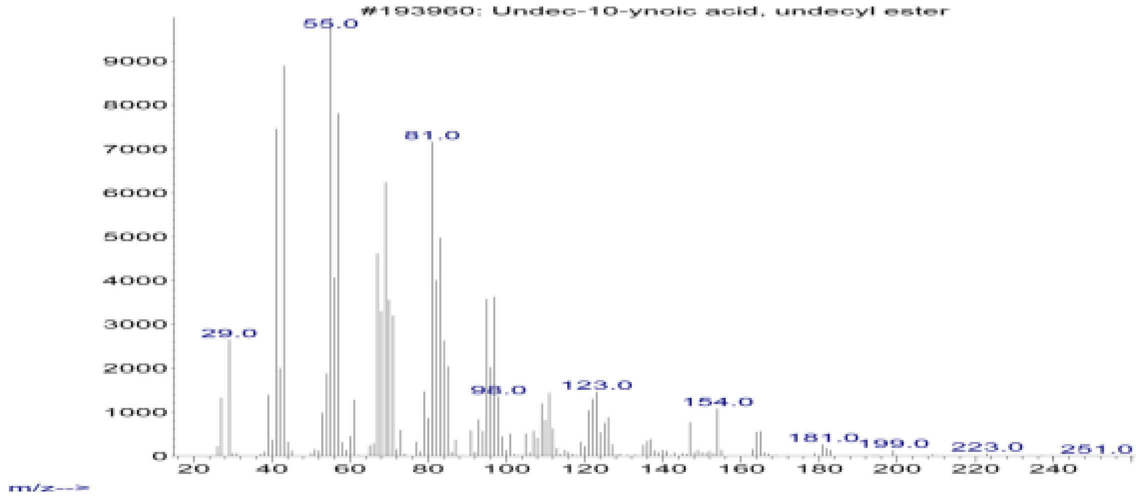

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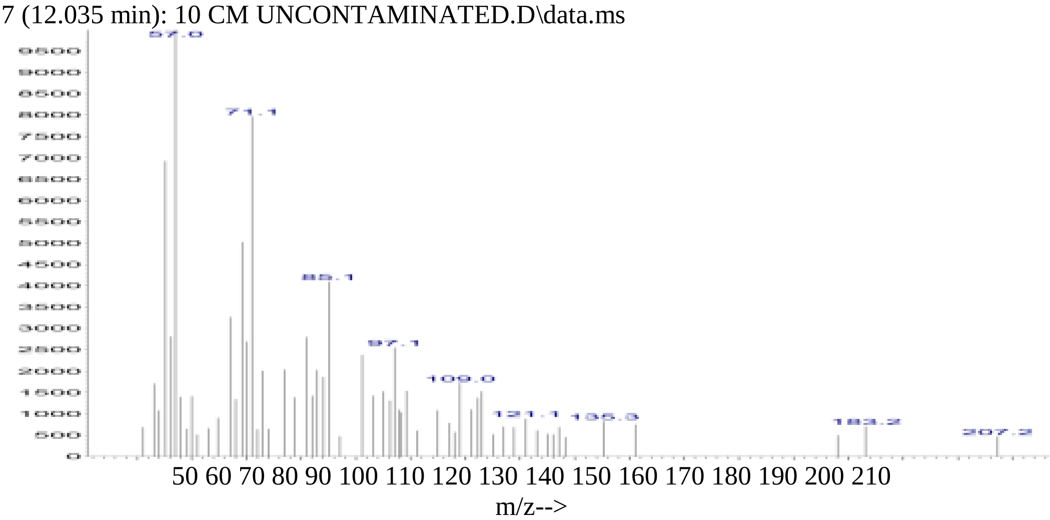

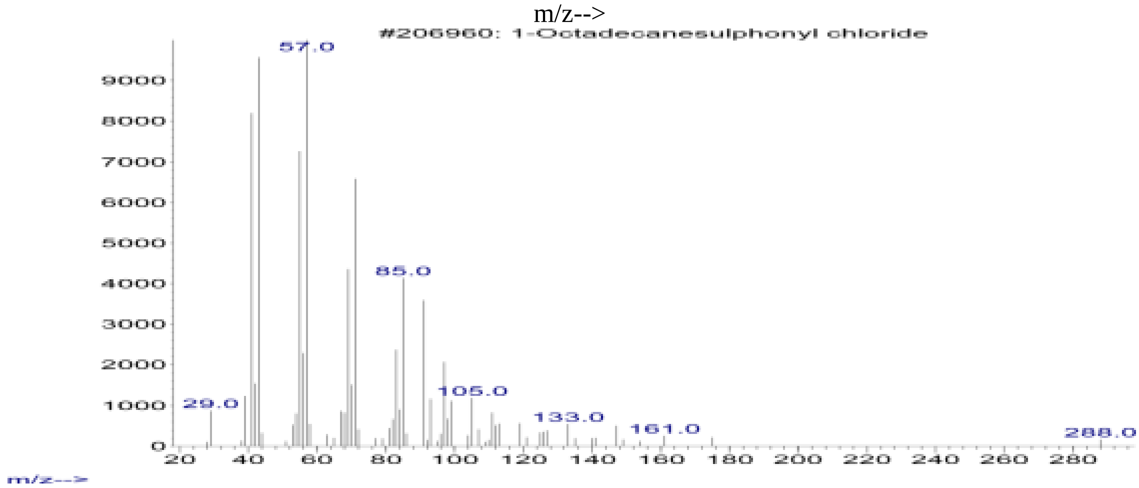

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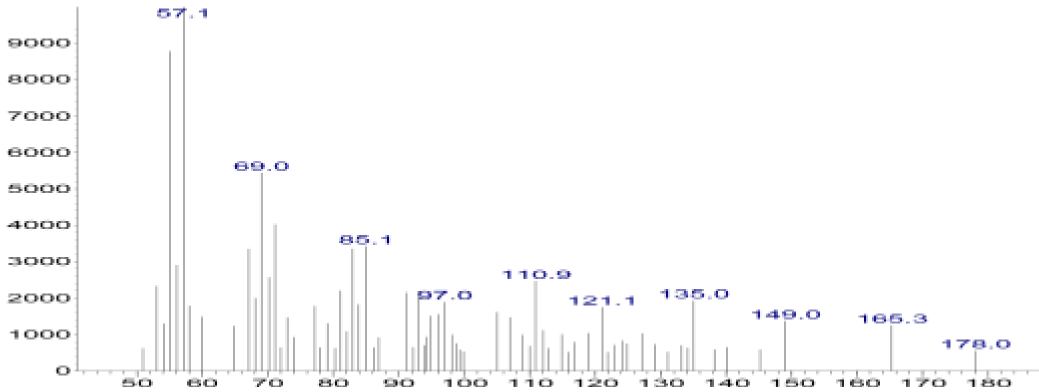

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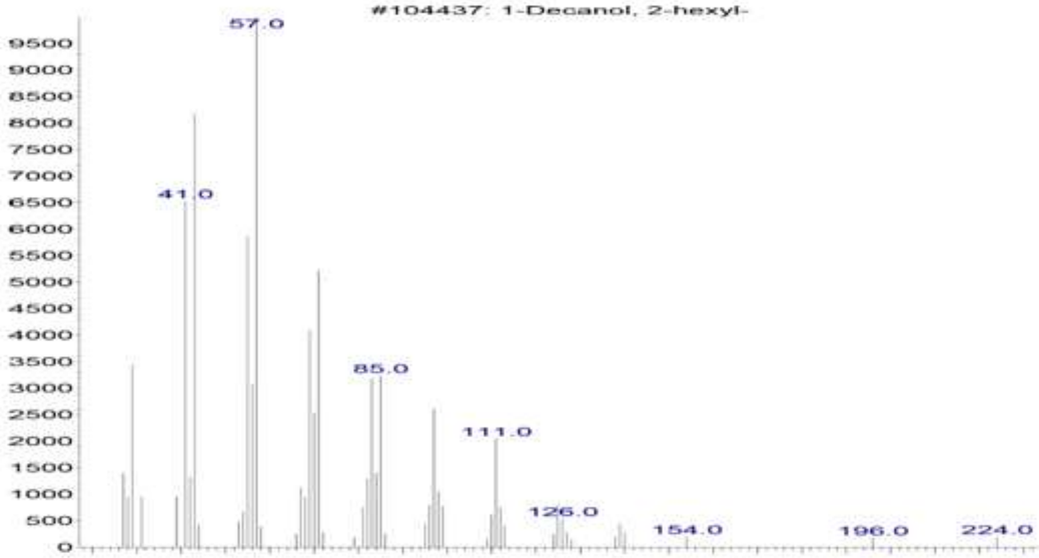

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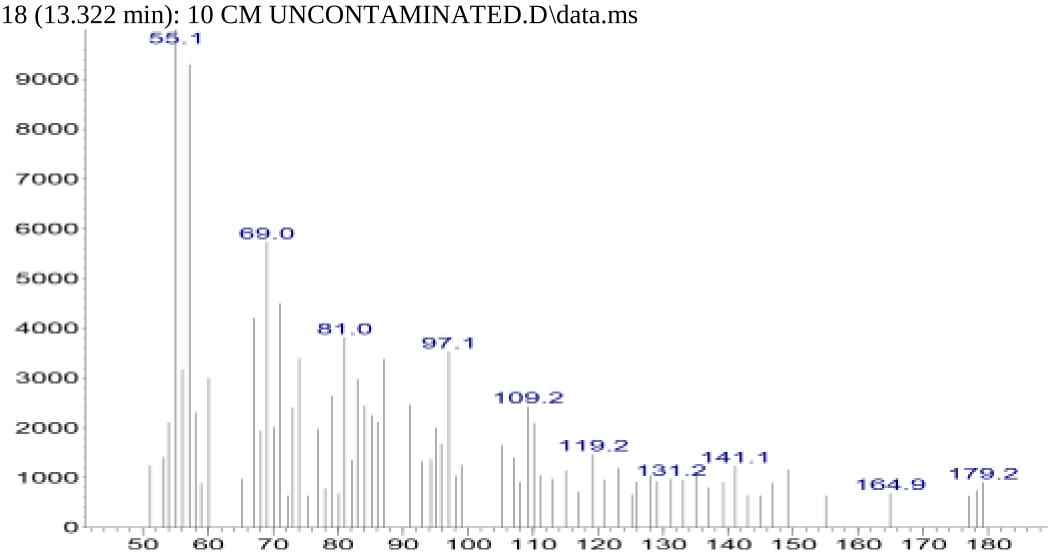

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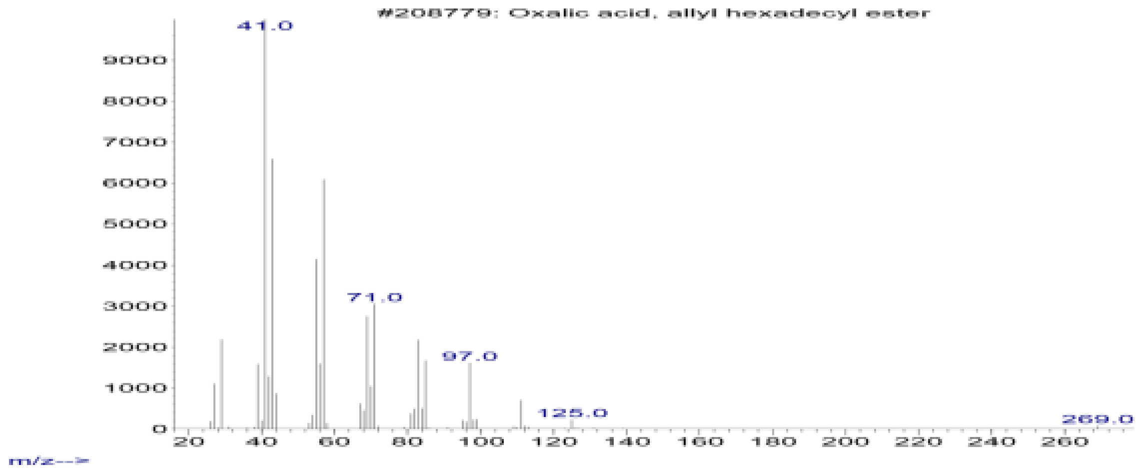

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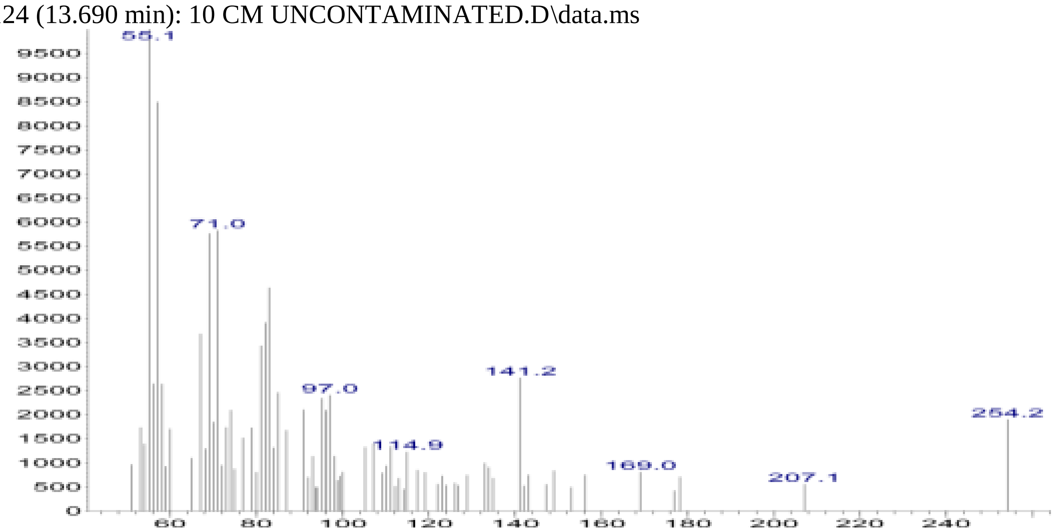

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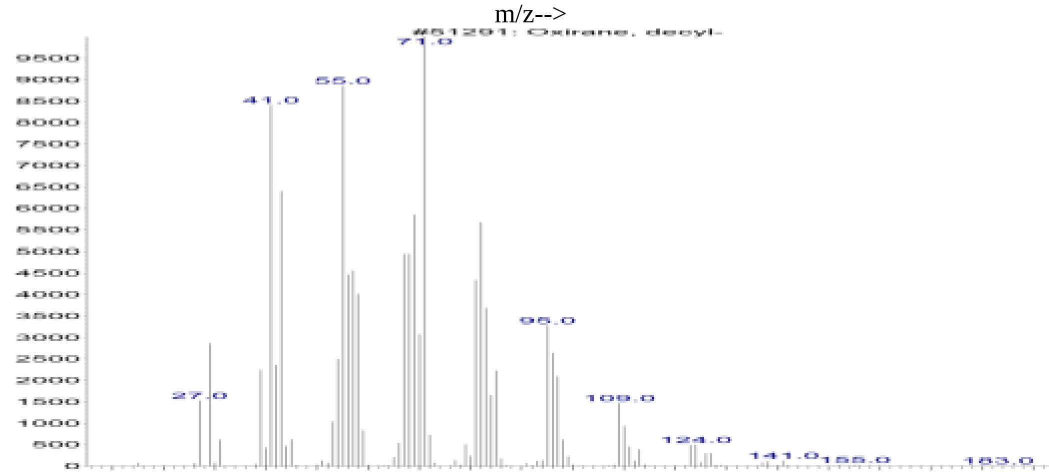

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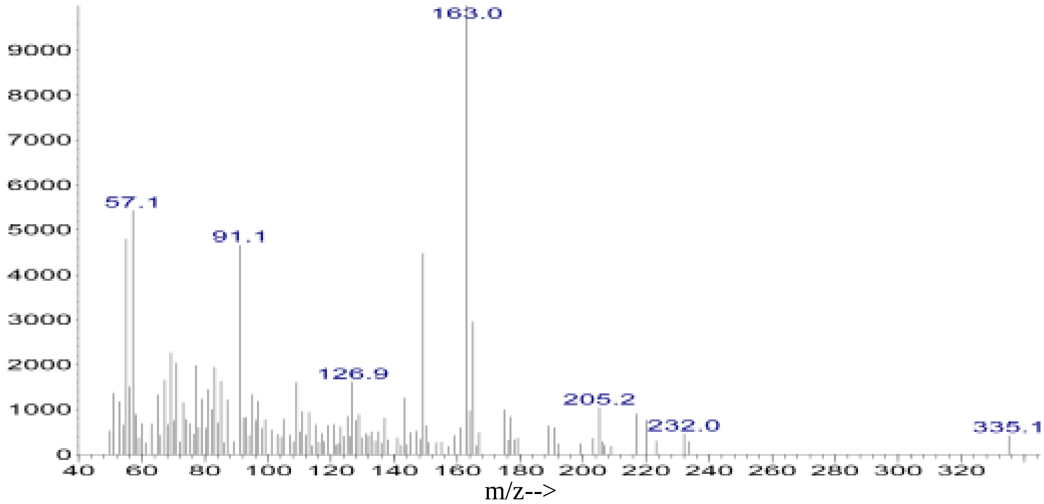

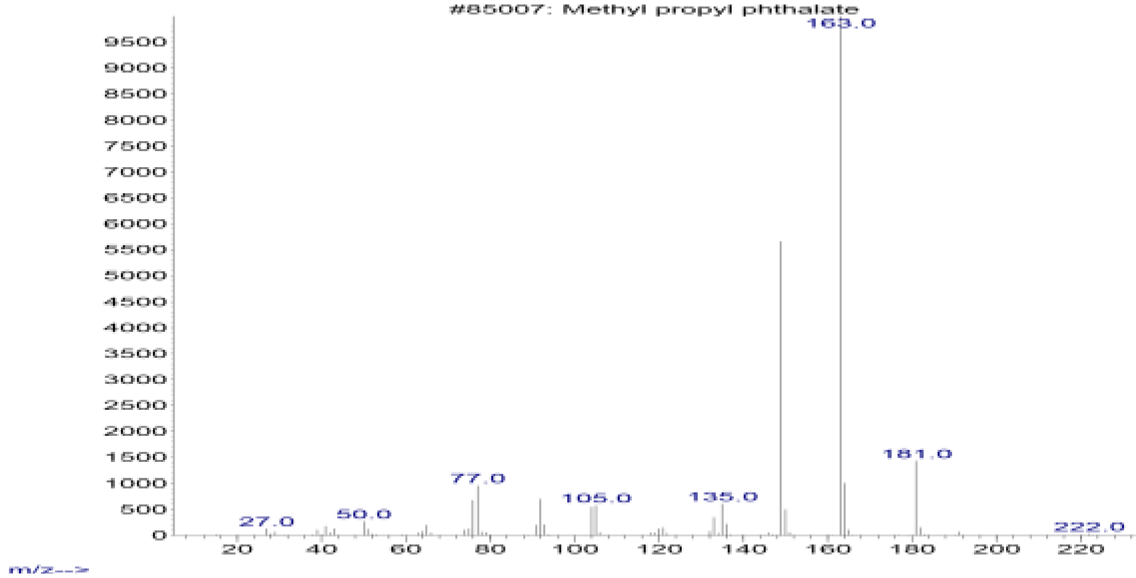

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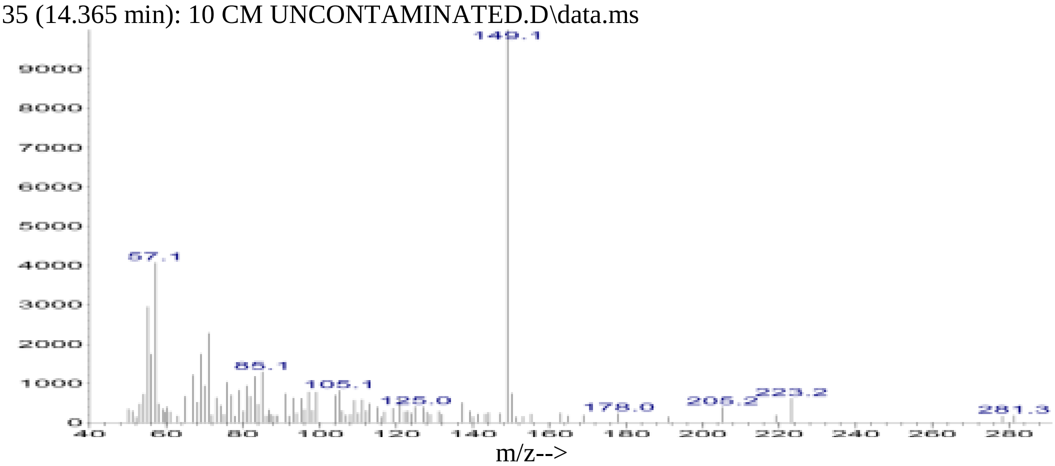

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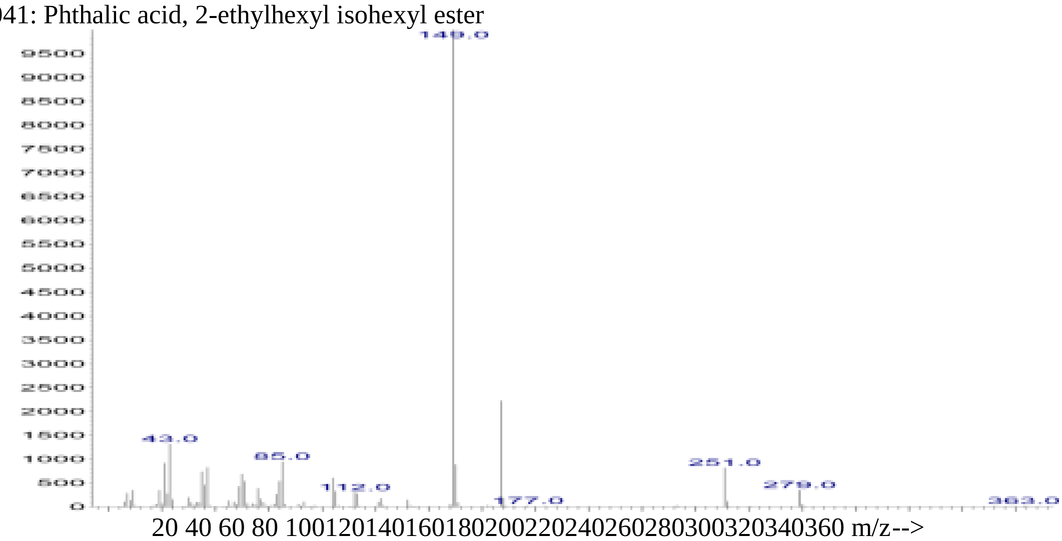
#215041: Phthalic acid, 2-ethylhexyl isohexyl ester



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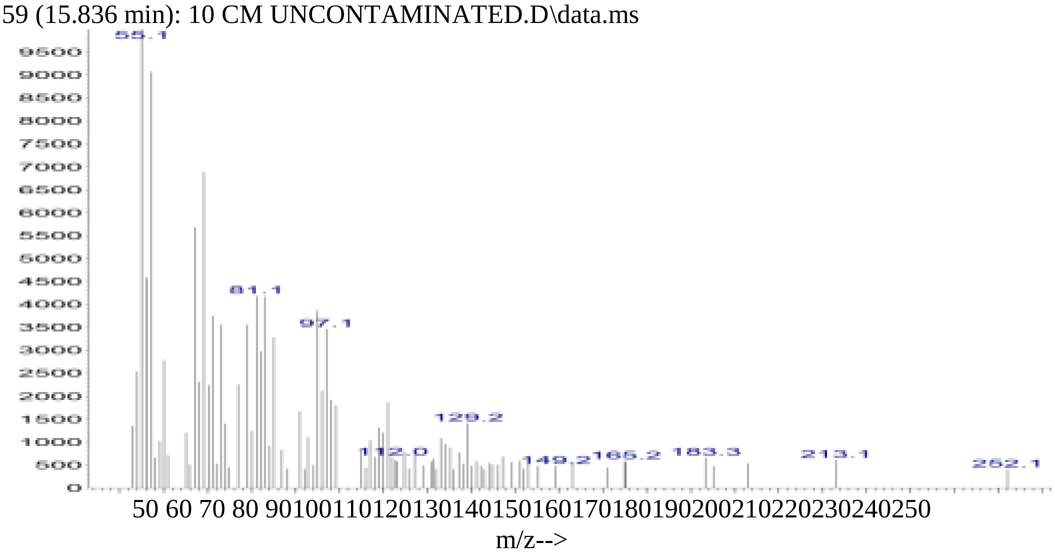

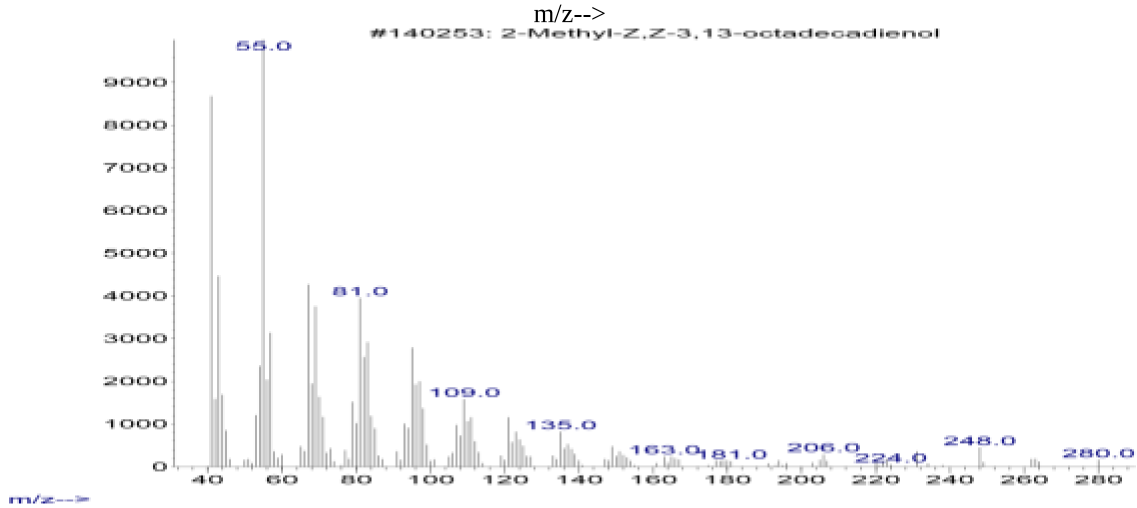

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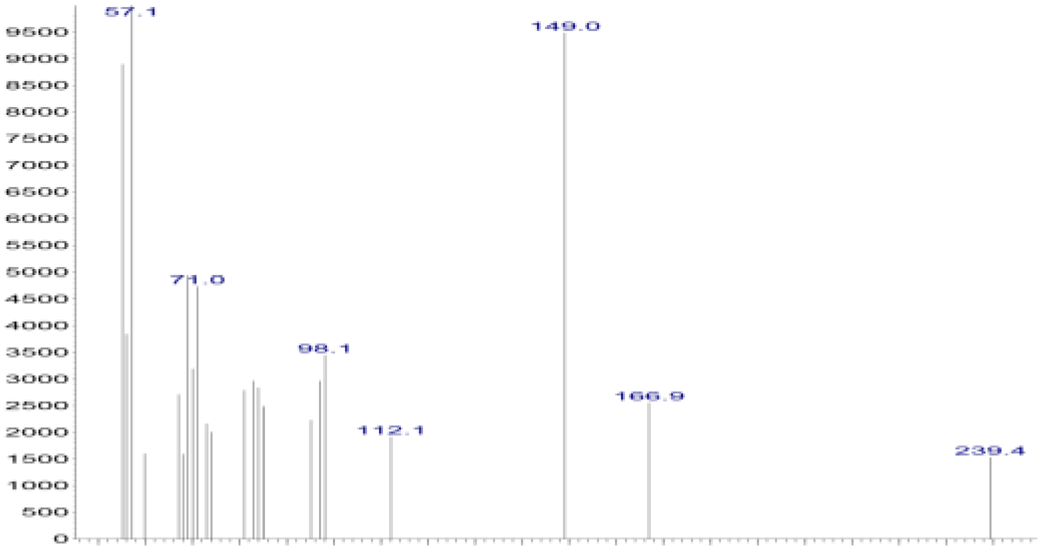

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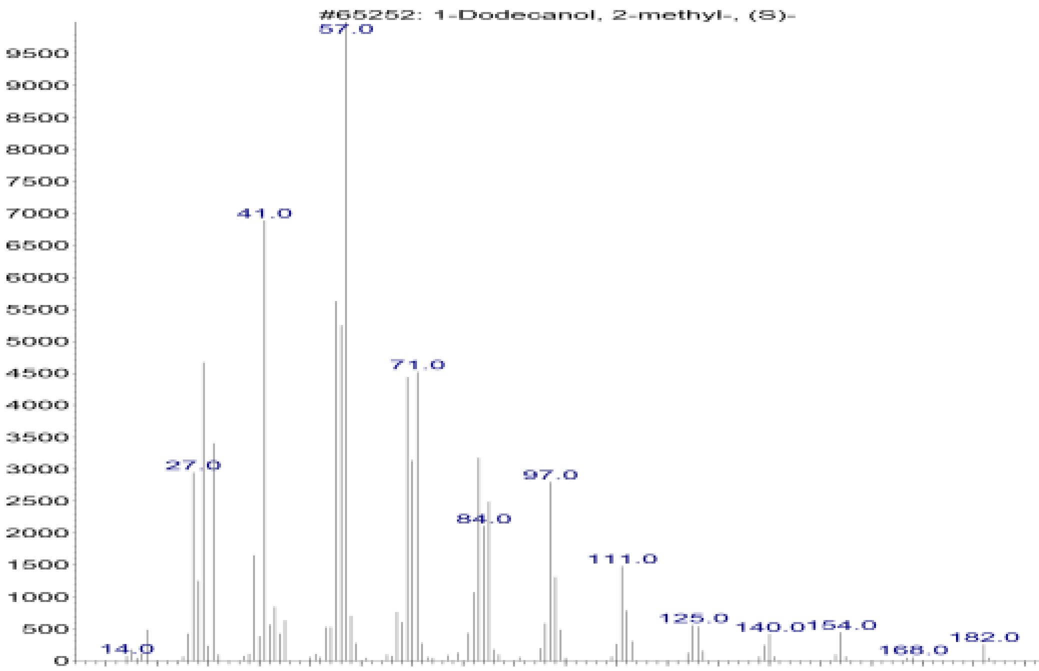

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m/z-->

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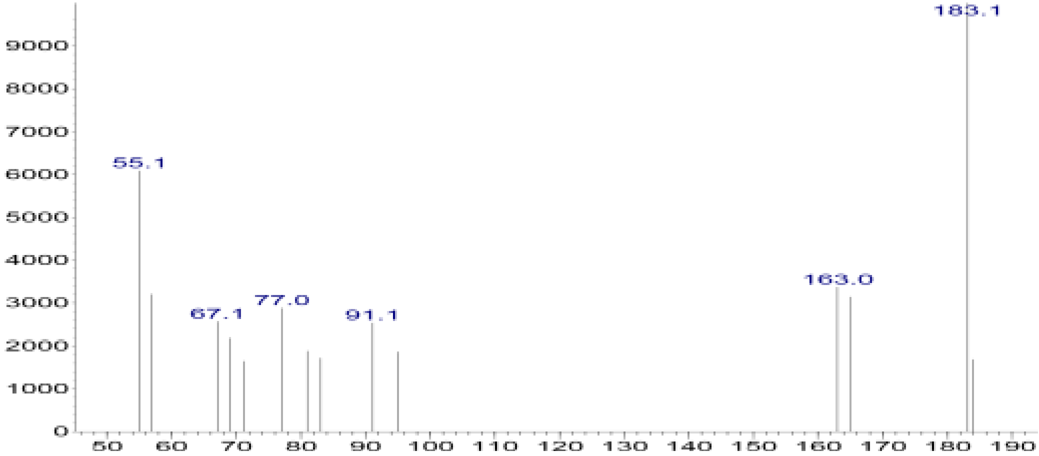
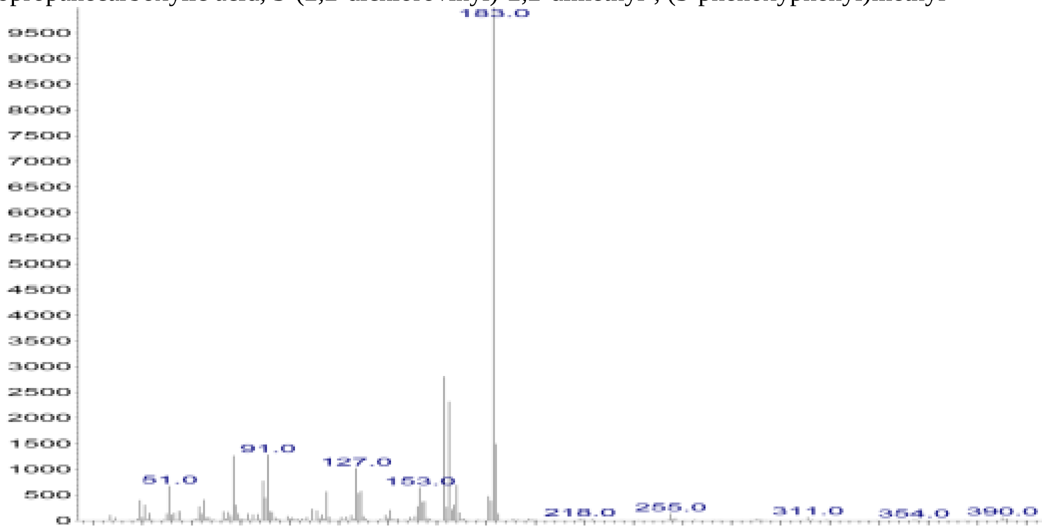


m/z-->

8: Cyclopropanecarboxylic acid, 3-(2,2-dichlorovinyl)-2,2-dimethyl-, (3-phenoxyphenyl)methyl



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m/z-->

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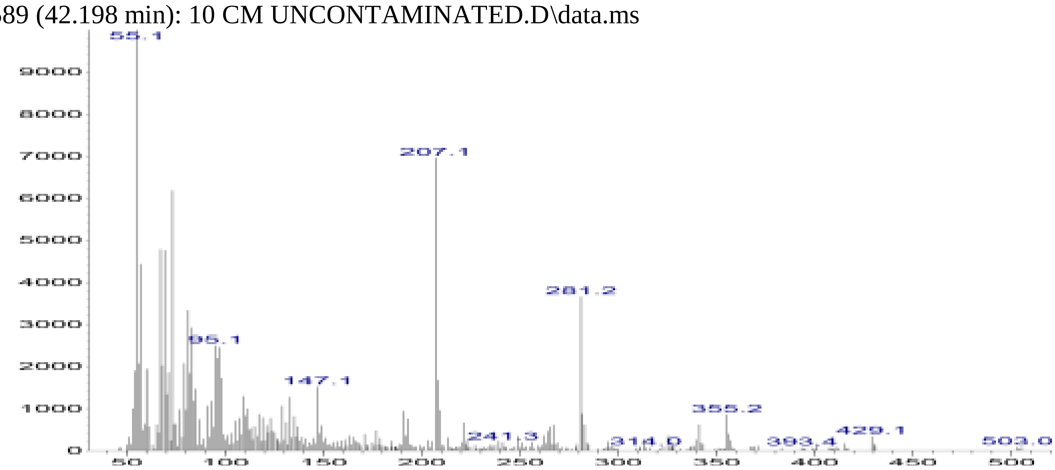

m/z-->

#210562: 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester

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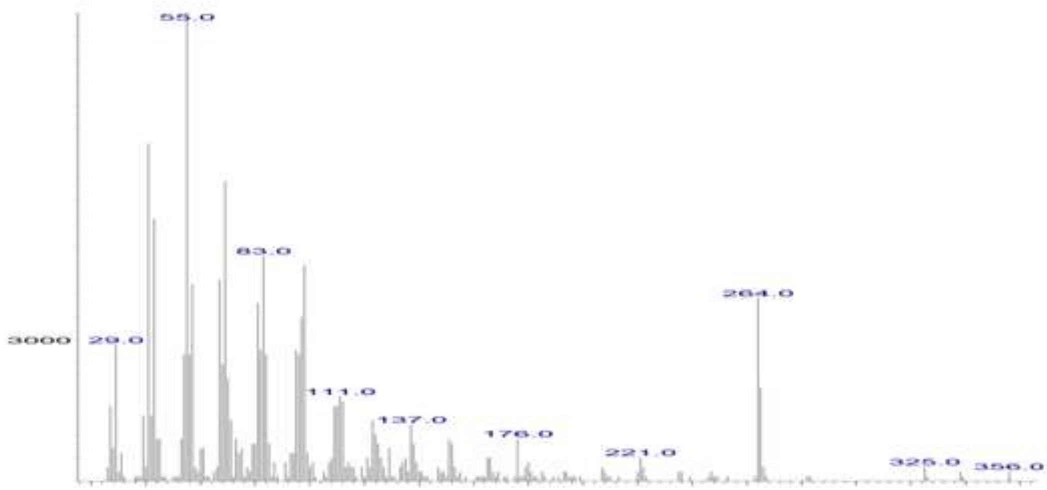

m/z-->

#210562: 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester

TOTAL PETROLEUM HYDROCARBON

Results of the total petroleum hydrocarbon (TPH) and the contents of the oil-impacted soils and unaffected areas are presented in Table 2 and Table 3. The gas chromatographic analyses conducted on the samples showed an abundance of the organic compounds, it showed a substantial concentration of the polycyclic aromatic hydrocarbons, and also a significant concentration of benzene, toluene, ethyl benzene, and xylene fractions. These results show that the spilled oil was still fresh on site with a high level of hydrocarbon fractions in the range. Hence this high concentration of organic compounds and the inorganic compounds deposition on the environment is due to the spilled oil.

Table 2: Total Petroleum Hydrocarbon Contaminated Soil Sample

Layer Component Type Concn. Error Units Mole% Error

1	SiO2	Calc 35.005 2.172	wt.%	40.535 2.516
1	V2O5	Calc 0.118 0.046	wt.%	0.045 0.018
1	Cr2O3	Calc 0.018 0.028	wt.%	0.008 0.013
1	MnO	Calc 0.139 0.027	wt.%	0.136 0.027
1	Fe2O3	Calc 15.417 0.151	wt.%	6.717 0.066
1	Co3O4	Calc 0.079 0.046	wt.%	0.023 0.013
1	NiO	Calc 0.000 0.000	wt.%	0.000 0.000
1	CuO	Calc 0.268 0.027	wt.%	0.234 0.024
1	Nb2O3	Calc 0.091 0.035	wt.%	0.027 0.011
1	MoO3	Calc 0.055 0.042	wt.%	0.026 0.020
1	WO3	Calc 0.006 0.105	wt.%	0.002 0.031
1	P2O5	Calc 0.000 0.000	wt.%	0.000 0.000
1	SO3	Calc 7.379 0.513	wt.%	6.412 0.446
1	CaO	Calc 5.430 0.227	wt.%	6.737 0.281
1	MgO	Calc 0.000 0.000	wt.%	0.000 0.000
1	K2O	Calc 2.915 0.211	wt.%	2.153 0.156
1	BaO	Calc 0.000 0.000	wt.%	0.000 0.000
1	Al2O3	Calc 19.323 5.549	wt.%	13.186 3.787
1	Ta2O5	Calc 0.040 0.099	wt.%	0.006 0.016
1	TiO2	Calc 2.441 0.108	wt.%	2.127 0.094
1	ZnO	Calc 0.173 0.024	wt.%	0.148 0.021
1	Ag2O	Calc 0.098 0.231	wt.%	0.029 0.069
1	Cl	Calc 10.898 0.365	wt.%	21.388 0.716
1	ZrO2	Calc 0.106 0.035	wt.%	0.060 0.020

Table 3: Total Petroleum Hydrocarbon Uncontaminated Soil Sample

Layer Component Type Conc Error Units Mole% Error

1	SiO2	Calc 70.520 1.886	wt.%	78.504 2.100
1	V2O5	Calc 0.048 0.019	wt.%	0.018 0.007
1	Cr2O3	Calc 0.077 0.011	wt.%	0.034 0.005
1	MnO	Calc 0.219 0.012	wt.%	0.207 0.012
1	Fe2O3	Calc 5.316 0.050	wt.%	2.227 0.021
1	Co3O4	Calc 0.017 0.015	wt.%	0.005 0.004
1	NiO	Calc 0.018 0.007	wt.%	0.016 0.007
1	CuO	Calc 0.107 0.007	wt.%	0.090 0.006
1	Nb2O3	Calc 0.018 0.008	wt.%	0.005 0.002
1	MoO3	Calc 0.006 0.010	wt.%	0.003 0.005
1	WO3	Calc 0.000 0.000	wt.%	0.000 0.000
1	P2O5	Calc 0.235 0.528	wt.%	0.111 0.249
1	SO3	Calc 0.440 0.127	wt.%	0.368 0.106
1	CaO	Calc 3.472 0.106	wt.%	4.141 0.126
1	MgO	Calc 0.000 0.000	wt.%	0.000 0.000
1	K2O	Calc 0.485 0.064	wt.%	0.344 0.045
1	BaO	Calc 0.034 0.142	wt.%	0.015 0.062
1	Al2O3	Calc 15.557 3.853	wt.%	10.206 2.527
1	Ta2O5	Calc 0.081 0.026	wt.%	0.012 0.004
1	TiO2	Calc 2.176 0.056	wt.%	1.822 0.047
1	ZnO	Calc 0.026 0.005	wt.%	0.021 0.004
1	Ag2O	Calc 0.055 0.057	wt.%	0.016 0.016
1	Cl	Calc 0.925 0.074	wt.%	1.746 0.140
1	ZrO2	Calc 0.166 0.010	wt.%	0.090 0.006
1	SnO2	Calc 0.000 0.000	wt.%	0.000 0.000

III. CONCLUSION

The study was able to achieve its targeted objective in the determination of the aliphatic and aromatic hydrocarbons (such as Total Petroleum Hydrocarbon (TPH); Evaluate the polycyclic aromatic hydrocarbon (PAH). To evaluate the heavy metals as well as to determine the electrical conductivity and Cation Exchange Capacity (CEC).

1. The research has shown that Bodo land in Ogoniland is acidic.
2. Contain high electrical conductivity;
3. It has total organic carbon, cation exchange capacity;
4. There is the presence of Polycyclic Aromatic Hydrocarbons (PAH);
5. Total petroleum hydrocarbon (TPH) and heavy metals are high.

ACKNOWLEDGMENTS

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