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Assessment of Soil from Fuel Station at Devrukh in Ratnagiri District

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Abstract

Soil contaminated with petroleum hydrocarbons residues has a serious hazard to human health. The present study aims on assessing the physico-chemical characteristics of petroleum contaminated soil from ten different locations of the experimental site in three seasons. The pH of all soil samples was found to be in the range of 6 to 7.5 irrespective of seasons. The organic matter content estimated using Walkley –Black method was around 0.02 to 0.27 gha^{-1} varying from one site to another and in range with the control values (0.02-0.2 gha^{-1}). Though other chemical parameters including heavy metals were higher than the control samples. Heavy metals like Lead (5- 377 ppm), Cadmium (1-5 ppm), Arsenic (3-21 ppm) and Chromium (140 -868 ppm) was present and much higher than the control soil samples; however Mercury was not detected. Hydrocarbon residues in the soil samples from the experimental sites were analyzed using GC-MS reported eight to fifteen different compound at each site, having CH in the range as small as C_8H_{10} to as large as $C_{112}H_{108}$.The present study is a preliminary work to assess the extent of changes in the soil composition.

Keywords: *Hydrocarbon Residues, Organic Matter, Heavy Metals, GC-MS*

1. Introduction

Petroleum hydrocarbons are one of the chemicals, which enter the environment frequently and in large volumes through numerous routes viz. accidents, spills or leak, urban input, industrial releases and commercial or domestic uses. There is a growing public concern over wide variety of toxic chemicals being introduced inadvertently into the environment. Petroleum hydrocarbon residues in soil causes organic pollution of ground water which limits its use, economic loss, environmental problems and decreases the agricultural productivity of the soil. The toxicity of petroleum hydrocarbons to microorganisms, plants, animals and humans is well established (Thapa; *et al.,* 2012). Many soil bacteria and fungi can utilize petroleum hydrocarbons as a carbon source. At the same time, some original microbes gradually get adapted to the long-term oil contaminated soil and developed a superior community which can make use of oil contaminants through special substrate enrichment. Therefore, bioremediation of oil contaminated soil has broad prospects because of its low cost, no secondary pollution, processing in situ and so on (Shaopeng Yan., *et al*., 2013).

In the present study, impact of petroleum residues from a selected petrol station on the soil characteristics in the immediate vicinity was investigated. The petrol pump under study is a medium size petrol station of a surface area approximately 0.5 ha, located away from dwelling houses at the exit from a Devrukh town of the Indian state of Maharashtra (170 3’54’’N, 730 36’ 57’’ E). The petrol station under study sells monthly fuel volume approximately 20,000 litres and has been in service for less than a decade. The present study shows the analytical results of physico-chemical parameters and organic compounds in the soil samples.

2. Materials and Methods

Study area: The adjoining area of a petrol pump in the Devrukh village, District- Ratnagiri located in the suburban region of Konkan, Maharashtra state (India) was selected as the sampling site. Randomly ten soil samples contaminated with petroleum residues from different locations ranging from close proximity to the fuel tank extending to the radius of 10m from the fuel tank within the study area were collected for the study. The samples were labelled, sealed separately in a sterile bag and stored in the laboratory for further use.

Analysis of Physico- chemical and Organic parameters of the soil: Physico-chemical properties of petroleum oil contaminated soil sample was investigated; *viz* pH, moisture, electrical conductivity, Organic carbon, chlorides, carbonate, bicarbonate, calcium, magnesium,

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nitrogen, phosphate, sulphate, sodium and potassium (Gupta P.K., 2007). The heavy metals *viz*, Cd, Cr, Pb, As, Hg, and Fe were acid-extracted and determined by Inductively Coupled Plasma Atomic Emission Spectroscopy (Voica C., *et. al*., 2011). For total petroleum hydrocarbons (TPH) the soil samples were extracted using Soxhlet apparatus and analyzed by Gas chromatography with high resolution mass spectroscopy (GC-HRMS) at SAIF, IIT Mumbai (Modi G., *et al*., 2016). GC was of Agilent, (7890), with FID detector, Head space injector, Combipal auto sampler. MS- Jeol, Model Accu TOF GCV, EI/CI source,
Time of Flight -Analyser. The Mass was in the range of 10 to 2000 *amu*, Mass resolution was 6000, Type of analysis was DIP MS (EI +ve or –ve), and spectra was provided by TIC library search data. Column used was capillary with standard non-polar class, column length was 25 m with internal diameter 0.2 mm, carrier gas was N_2, and conditions were as follows: PTV Temp. Program: 30 °C, hold 1.00 min, 10 °C/min to 270 °C, hold 30 min, split less 80-1M-8-200-3M-8-275-3M-280-EB5.Sample volume was 1µ litre.

3. Results and Discussion

The soil samples from ten different locations around the fuel station (petrol pump) were analyzed for some of the physical and chemical characteristics and the data obtained are presented in the form of graphs to provide best expression and easy understanding. **Soil pH** acts on the growth of plants and microorganisms by affecting availability of nutrients. The pH of control soil and all soil samples contaminated with petroleum hydrocarbon residue was found to be in the range of 6 to 7.5 irrespective of season as well as petroleum contamination (Fig 1). A pH value between 6.5 and 7.5 is considered optimum for the growth of many plants. This outcome indicate that oil spillage on the farmland in Devrukh area have not influenced the pH level in the soil to a greater extent.

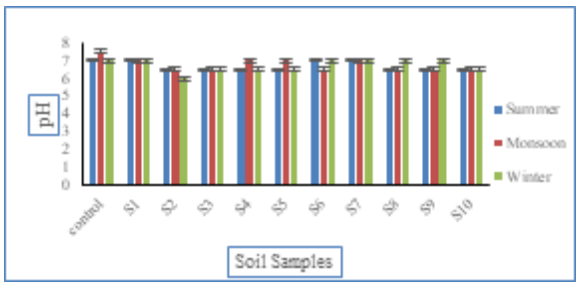

Fig 1: pH of Soil Samples Contaminated with Petroleum Hydrocarbon Residues

Similarly the **Electrical Conductivity (EC)** was highest in the soil sample S1 which is close to the petrol pump (5.11 scm^{-1}) especially during winter season though the values decreased as the samples were collected from other locations i.e. S1 to S10 and lowest EC was observed in S10 (2.04 scm^{-1}) during winter season. During summer season EC of soil samples S1, S2, S3 which are in the proximity of the petrol station was recorded as 4, 4.3, 4.2 scm^{-1} respectively, thus indicating that EC during summer went on decreasing to the farthest sample i.e. S10. During monsoon EC of S1 sample was observed to be highest i.e. 2.21 scm^{-1} and it was in the decreasing order for soil sample S2 to S6 though a small increase was observed in the soil sample S7 and sudden decrease was recorded in soil sample S8 which was the lowest. The samples S9, S10 showed further decrease in the Electrical conductivity. It was noted that EC was highest in the S1, S2 & S3 soil samples irrespective of the season and was more than the values observed in the control soil samples (Fig 2). The high value of electrical conductivity of petroleum contaminated soil may refer to a high presence of charged ions in the soil (Akubugwo EI., *et. al*. 2016). Electrical conductivity represents the presence of salts in the soil,that leads to soil salinity.

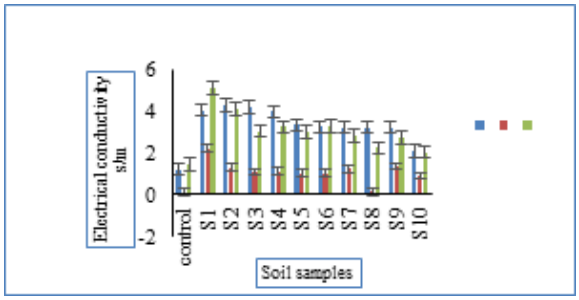

Fig 2: Electrical Conductivity of Soil Samples Contaminated with Petroleum Hydrocarbon Residues

Moisture content of the soil samples also increased from S1 to S10. In the soil samples S1, S2, S3 collected from the proximity of the petrol pump, the moisture content was recorded to be only 30 % during summer and winter season while during the monsoon season it was around 40%, 50%, 60% respectively. In soil sample S4 to S7 the moisture content was found to be constant around 40% while it was observed to be 50% in the soil sample S8 and S9 whereas moisture content of soil sample S10 was found to be 60% and 70% during summer and winter season respectively. During monsoon season moisture content went on increasing from soil sample S1 to S10, the lowest moisture content i.e. 40% was observed in soil sample S1 while highest moisture content i.e. 90% was observed in the soil samples S6, S7, S8, S9 and S10. In the control soil samples moisture content was found to be within

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70% to 80% (Fig 3). Moisture content decreased as petroleum residues increased in the soil. Petrol is hydrophobic in nature and it coats around the soil pores, it disallows free water from interacting with the soil particles (Singh K *et al*, 2017). Low moisture content may not only reduce microbial activities but also reduce oxygen supply to plants.

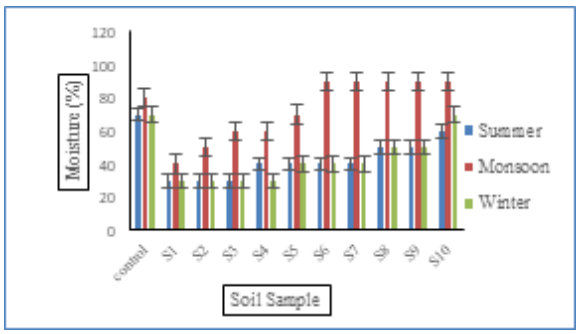

Fig 3: Moisture Content of Soil Samples Contaminated with Petroleum Hydrocarbon Residues

Soil consists of natural **organic matters** which are derived from decaying animal and plant residues and from soil biomass. Several anthropogenic activities also contribute to the soil organic matter (Richardson V; *et al*, 2015). The organic matter content of soil samples also varied corresponding to the distance from the petrol pump with least in S1 which is close to the petrol pump ,though it was not the same in all three seasons. The values increased when compared with the control soil as the samples were collected from location away from the petrol pump i.e. S1 to S10; with highest organic carbon in S1 during monsoon (0.27 gha^{-1}) and winter (0.25 gha^{-1}) and in S2 (0.06 gha^{-1}) during summer. The organic matter content indicate the presence of organic matter in the soil and indirectly present the status of the soil fertility too. Contamination of the soil with petroleum hydrocarbon residue may be assumed to be responsible for the low organic matter content in the experimental soil samples (Table 1). Similarly a reverse trend was observed when **Calcium and Magnesium** content of soil samples were examined and compared with control soil. Calcium and Magnesium in soil sample S1was highest during summer (14.38 $gha^{-1;}$ 11.66 gha^{-1}), monsoon (16 gha^{-1}; 20.24 gha^{-1}) and winter (14.38 gha^{-1}; 13.56 gha^{-1}) season as compared to control samples. In soil sample S10 both Calcium and Magnesium was the least, however season wise variations were not encountered (Table 1). Calcium and Magnesium are considered as secondary nutrients, since plants require them in smaller quantities. Petroleum residues affect the composition of Calcium and magnesium which alters the plant growth (Agbogidi *et al*, 2007). The **Carbonates, Bicarbonates, Sulfates and Phosphates** content in the soil sample S1 was recorded highest though the values decreased as the samples were collected from farther location *i.e.* from S1 to S10, least values were recorded in the control soil. (Table 1). The Carbonate content in soil sample S1 was found lowest in the summer (0.16 gha^{-1}); almost three times in monsoon (0.54 gha^{-1}) and five times in winter season (0.82 gha^{-1}). Among the samples lowest content was in soil sample S10 0.02 gha^{-1}, 0.04 gha^{-1}, 0.02 gha^{-1} during summer, monsoon and winter season respectively. Bicarbonate in the soil sample S1 was 0.54 gha^{-1} during summer and winter while in monsoon (0.42 gha^{-1}). S10 sample showed lowest (0.34 gha^{-1}, 0.02 gha^{-1} and 0.18 gha^{-1}) during summer, monsoon and winter season respectively. Both carbonate and bicarbonate were higher in the soil samples collected from the proximity of the petrol pump that further decreased in the soil samples away from the petrol pump. Similarly sulphate was found highest in the soil sample S1 *i.e.* during summer (0.16 gha^{-1}), more than two times monsoon (0.36 gha^{-1}) and winter (0.42 gha^{-1}) season and the lowest value of sulphate was found in soil samples S9 and S10 during summer (0.6 gha^{-1} and 0.06 gha^{-1} respectively), monsoon (0.06 gha^{-1} and 0.04 gha^{-1} respectively) and winter (0.18 gha^{-1} and 0.18 gha^{-1} respectively) season. Phosphate content was also observed highest in the soil sample S1 during summer (1.3 gha^{-1}), monsoon (0.16gha^{-1}) and winter (0.3 gha^{-1}) season while phosphate content of soil sample S10 observed was lowest during summer (0.1 gha^{-1}), monsoon (0.04 gha^{-1}) and winter (0.02 gha^{-1}) season. Though in control soil samples value for sulfate and phosphate was recorded lesser than the other samples. This may refer to the high concentration of sulfur and phosphorus in the petrol contaminated area which has oxidized to the sulfates and phosphates when exposed to the surface (Abdul *et al*, 2016).

Nitrogen content was higher in the soil samples S1, during all three seasons i.e. summer (1.36 gha^{-1}), monsoon, (1.14 gha^{-1}) and winter (1.26 gha^{-1}). Nitrogen content decreased from soil sample S2 to S10 .The lowest nitrogen observed in the soil sample S10 during summer (0.1 gha^{-1}), monsoon (0.04 gha^{-1}) and winter (0.2 gha^{-1}) season. Control soil was found to be least value of Nitrogen. (Table 1) The increase of nitrogen in petrol contaminated areas may be due to the fixation of atmospheric nitrogen by the microorganisms which assimilated the hydrocarbons. Soil fertility in terms soil nitrogen content showed significant increases for contaminated soil samples. These increases confirmed the relationship between soil pH and soil nitrogen that the increase in pH with the petrol spill contributed to the higher nitrogen value (Dutta M., *et al*, 2017).

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Chlorides content is highly soluble in water and does not adsorb onto the soil particles, does not degrade, and generally inhibits biological processes. The chlorides estimated in soil sample S1 was high as compared to other samples and the control soil from the vicinity (5.16 gha^{-1}). Chlorides decreased from the proximity area to the farthest area from the petrol pump irrespective of season (Table 1). The increase of chlorides in soil with high petrol spill can be related to the increase in electrical conductivity of the soil. Similarly, **Sodium** content was more in S1, S2 and S3 soil samples than that of control soil. Lowest sodium content was observed in the Soil sample S10 during summer (Table 1). The **Potassium** content was higher in the soil sample S1 (0.52 $ppmha^{-1}$) during monsoon than other samples with lowest content in S1 (Table 1). Control soil was found to be less value of potassium content. Accumulation of Na (+) at high concentrations in the cytoplasm results in deleterious effects on cell metabolism. *e.g.*, on photosynthetic activity in plants where as K (+) is an essential elements for the cell metabolism and photosynthesis. Increase of Na (+) and K (+) in soil may be contributed to the metabolic rate of plants growth.

The data obtained for **heavy metals** in the soil samples are presented in Fig 4. Chromium was found in all the soil samples and was highest in the soil sample S1 (868 $ppmha^{-1}$) which was in immediate proximity of the petrol pump and lowest in the soil sample S10 (140 $ppmha^{-1}$). It was also noted that Lead was found only in the soil samples S1 (377 $ppmha^{-1}$) and S2 (5$ppmha^{-1}$) in the proximity of the petrol pump; it was noted that the value of Lead decreased significantly. Arsenic was observed in the soil samples S1 to S7, highest arsenic value was observed in the soil sample S1 (21 $ppmha^{-1}$) collected in the proximity of petrol station and lowest (3$ppmha^{-1}$) in the S10. Iron content was found to be very low in all the soil samples however it was noted that the value of iron went on decreasing from soil sample S1 (2.5 $ppmha^{-1}$) to soil sample S10 (1.23 $ppmha^{-1}$). Similar trend was observed for Cadmium too, highest in the soil sample S1 (5$ppmha^{-1}$) and lowest was in the soil sample S10 (1 $ppmha^{-1}$). Mercury was not detected in any of the soil sample. Chromium was recorded in the control. (Fig 2). This refers to the availability of the Chromium, Lead, Arsenic, Iron, and Cadmium elements in the petroleum spillage area in a certain amount that increased the levels in the soil than their permissible level. According to their effects on environment, majority of the studied metals fall within dangerous categories (Khalilova H., *et al* , 2015).

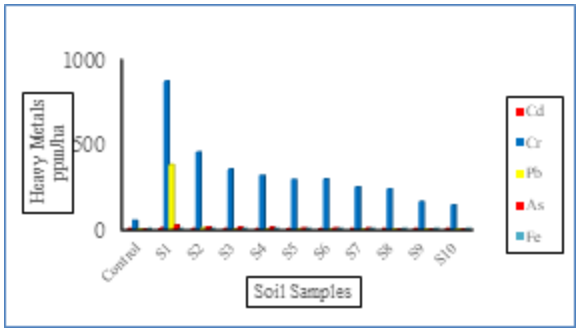

Fig 4: Heavy Metals in Soil Samples Contaminated with Petroleum Hydrocarbon Residues

Organic Compounds: All soil samples were extracted by Soxhlet Extraction, and the extracted petroleum residues were analysed by GCHMS (Gas chromatograph with high resolution mass spectrometer to detect following organic compound. In the Soil sample S1 ten organic compounds were identified and the molecule varied between C_9H_{12} - C_{35} H_{70} hydrocarbon chain, with naphthalene and benzene as repeats, along with unusual acidic compounds (Fig.5). Soil sample S2 was with twelve organic compounds hydrocarbon in the range $C_{14}H_{10}$ - $C_{35}H_{70}$, with methylene fluorene, benzene, naphthalene and anthracene as repeats (Fig: 5).

Soil sample S3 was identified with fifteen organic compounds hydrocarbon range observed was $C_{13}H_{12}$ - $C_{35}H_{70}$ and naphthalene, benzene, anthracene were recorded (Fig:5). In the Soil sample S4 six organic compounds were identified that varied from C_8H_{10}- $C_{35}H_{70}$ hydrocarbon range, and azulene, xylene, octadecadienoic acid, pentatriacontene were observed (Fig:5). In the Soil samples S5, S6 seven organic compounds and in the sample S7 five organic compounds were identified. Sample S5 recorded $C_{10}H_{14}$ - $C_{112}H_{12}$ whereas sample S6 and S7 showed $C_{10}H_8$ - $C_{54}H_{108}$ hydrocarbon range (Fig: 5,6); benzene, naphthalene, tetrapentacontane, indene were commonly observed in these soil samples. In the Soil samples S8 (nine), S9 (four), S10 (twelve) organic compounds were identified which varied in the range of $C_{10}H_{14}$ - $C_{35}H_{70}$, $C_{10}H_8$ - $C_{54}H_{108}$ and $C_{20}H_{42}$ - $C_{44}H_{90}$ respectively; unusual acid, esters, benzene, naphthalene, pyrane, eicosane were observed in these samples (Fig:6). The traces of organic compound may have adsorbed on the stationary phase that could be the reason of repeated elution of same compound with different time. In the ten soil samples the hydrocarbon chain ranged from C_8 H_{10} to $C_{112}H_{108}$, with minimum to maximum 15 organic compounds. (Figure 7 shows GC-MS Spectra of Soil Samples)

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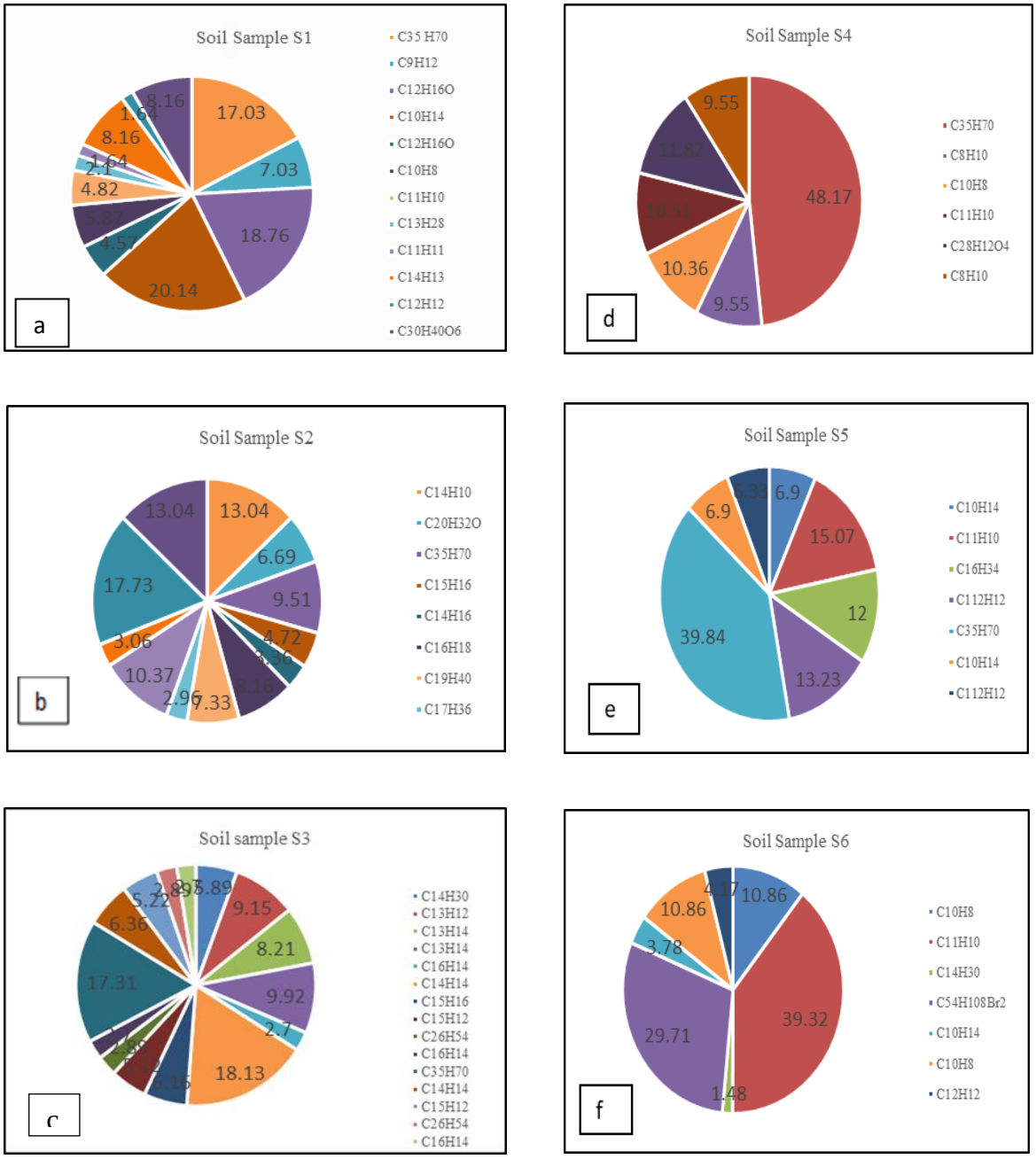

Fig 5: (a, b, c, d, e, f) Organic Hydrocarbons in Soil Samples S1, S2, S3, S4, S5, S6 respectively

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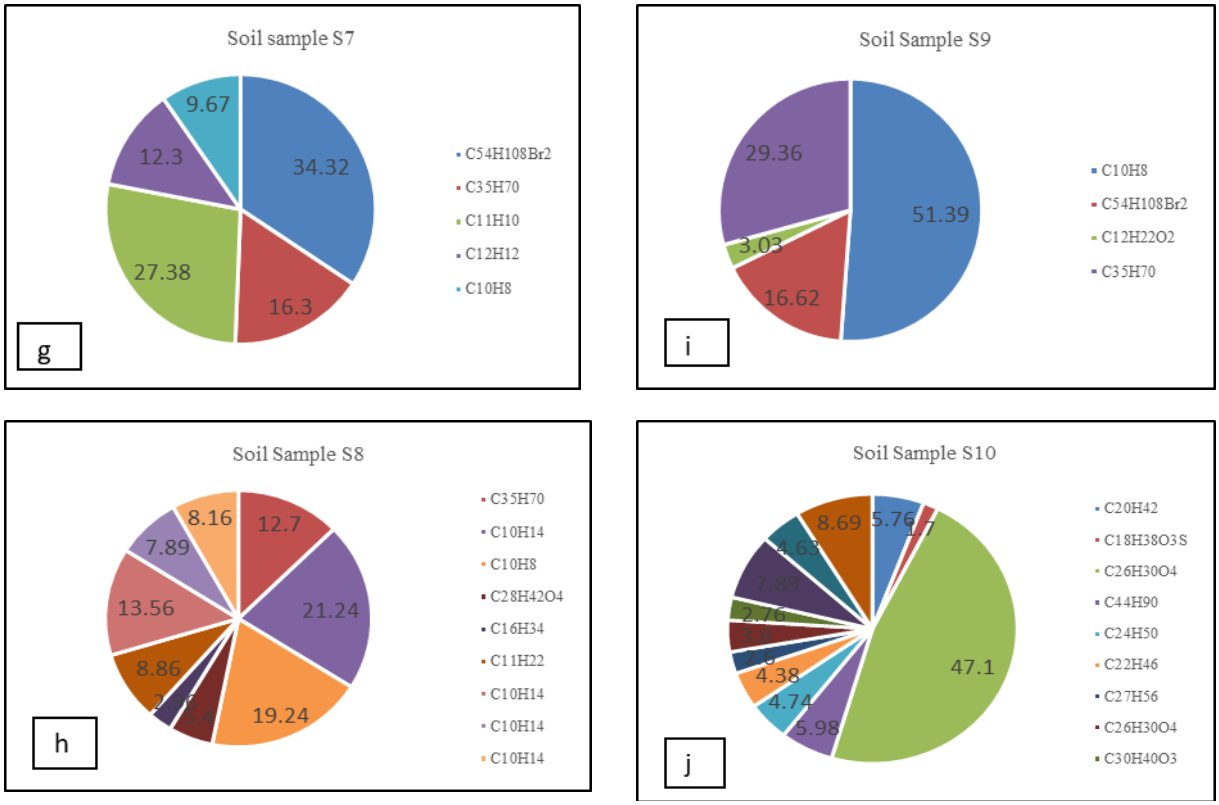

Fig 6: (g, h, i, j) Organic Hydrocarbons in Soil Samples S7, S8, S9, S10 respectively

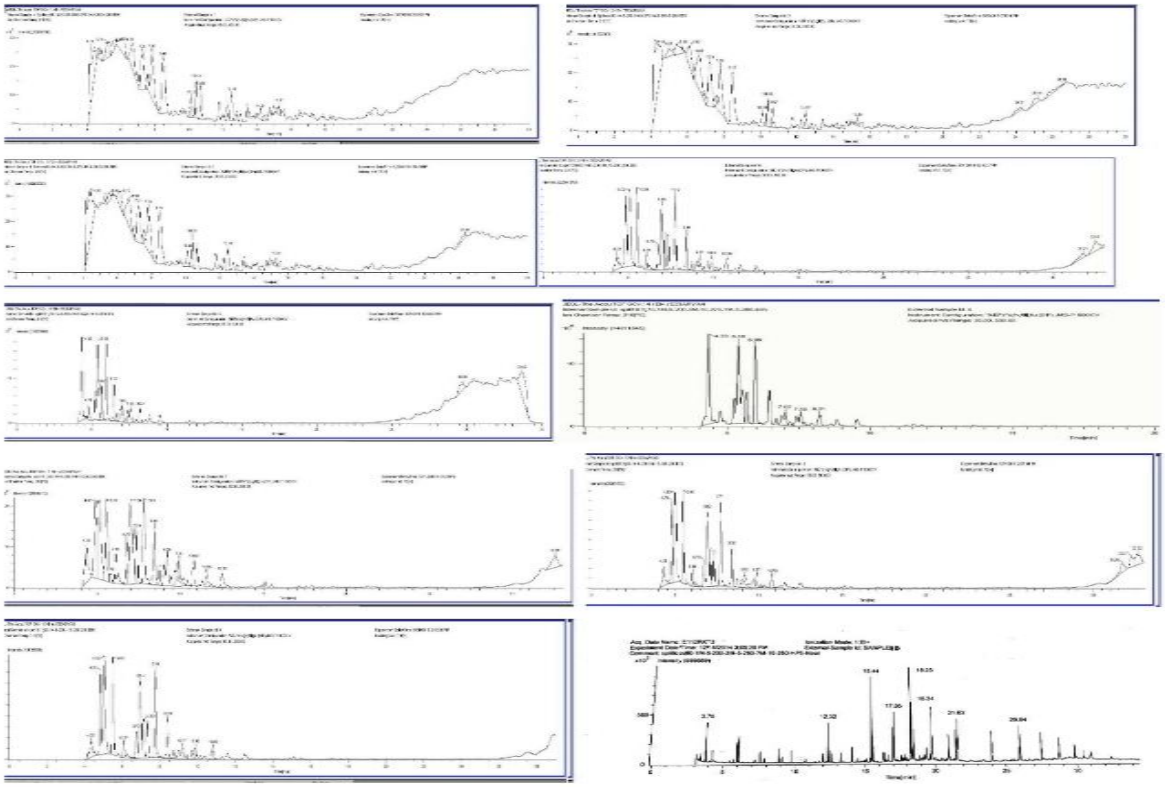

Figure 7: GC-MS Spectra of Soil Samples

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Table 1: Chemical Parameters of soil samples contaminated with petroleum hydrocarbon residues

SNO	Parameters	Season	Control	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	Calcium	Summer	8.4 ± 0.1	14.28 ± 0.1	14.28 ± 0.01	13.2 ± 0.04	13.2 ± 0.04	14.98 ± 0.03	12.48 ± 0.1	12.2 ± 0.1	11.3 ± 0.01	10.26 ± 0.1	10.2 ± 0.1
		Monsoon	8.6 ± 0.2	16 ± 0.01	15.2 ± 0.003	15.2 ± 0.02	13.56 ± 0.02	12.68 ± 0.2	10.46 ± 0.1	10.24 ± 0.2	10.2 ± 0.1	10.2 ± 0.1	10 ± 0.1
		Winter	9.96 ± 0.1	14.28 ± 0.1	12.28 ± 0.02	13.2 ± 0.01	13.56 ± 0.02	12.46 ± 0	12.22 ± 0.1	12.46 ± 0.3	12 ± 0.1	11.66 ± 0.1	10.4 ± 0.03
2	Magnesium	Summer	7 ± 0.2	11.66 ± 0.02	11.12 ± 0.03	10.76 ± 0.02	10.6 ± 0.1	10.36 ± 0.02	8.72 ± 0.1	8.38 ± 0.1	8.06 ± 0.1	8 ± 0.01	7.74 ± 0.02
	(gha-1)	Monsoon	9 ± 0.2	20.24 ± 0.1	21 ± 0.1	19.24 ± 0.03	18.46 ± 0.05	18.2 ± 0.05	18.2 ± 0.01	16.2 ± 0.2	12.2 ± 0.1	12 ± 0	8 ± 0.02
		Winter	4.4 ± 0.02	12.56 ± 0.03	11.12 ± 0	9.26 ± 0.01	8.6 ± 0.1	8.4 ± 0.2	8.02 ± 0.2	8 ± 0.2	6.38 ± 0.1	10 ± 1	5.14 ± 0.02
3	Organic Carbon	Summer	2.4 ± 0.03	4.18 ± 0.1	4.2 ± 0	6.2 ± 0.02	6.2 ± 0.02	6.24 ± 0.1	6.4 ± 0.2	6.72 ± 0.1	8.1 ± 0.1	8.5 ± 0.2	8.5 ± 0.02
	(gha-1)	Monsoon	0.24 ± 0.1	0.58 ± 0.03	0.68 ± 0.02	1.8 ± 0.1	2.02 ± 0.05	2.24 ± 0.01	2.38 ± 0.1	2.72 ± 0	4.9 ± 0.1	4.48 ± 0.1	4.9 ± 0.3
		Winter	2.9 ± 0.01	2.24 ± 0.03	4.98 ± 0.1	4.52 ± 0.03	4.22 ± 0.02	6.06 ± 0.01	6.3 ± 0.1	9.48 ± 0	8.56 ± 0.2	9.68 ± 0.1	10.52 ± 0.1
4	Chlorides	Summer	0.002 ± 0.1	5.18 ± 0.03	5.36 ± 0.03	0.68 ± 0	0.68 ± 0.01	0.002 ± 0.01	0.002 ± 0.3	0.002 ± 0.01	0.002 ± 0.1	0	0
	(gha-1)	Monsoon	0.002 ± 0.2	5.16 ± 0.002	2.38 ± 0.03	0.46 ± 0.02	0.56 ± 0.03	0.002 ± 0.1	0.002 ± 0.1	0.002 ± 0.1	0.002 ± 0.01	0	0.002 ± 0.2
		Winter	0.004 ± 0.1	0.42 ± 0.2	0.22 ± 0.02	0.42 ± 0.02	0.06 ± 0	0.02 ± 0.2	0.02 ± 0.1	0.02 ± 0.01	0.01 ± 0.01	0.002 ± 0.1	0.002 ± 0.1
5	Carbonate	Summer	0.06 ± 0.1	0.16 ± 0	0.14 ± 0.1	0.1 ± 1	0.04 ± 0.03	0.008 ± 0.1	0.002 ± 0.01	0.06 ± 0.01	0.06 ± 0.1	0.06 ± 0.1	0.02 ± 0
	(gha-1)	Monsoon	0.04 ± 0.1	0.54 ± 0	0.4 ± 0	0.34 ± 0.02	0.34 ± 0	0.24 ± 0.2	0.16 ± 0.1	0.1 ± 0.1	0.06 ± 0.01	0.06 ± 0	0.04 ± 0.2
		Winter	0.02 ± 0.1	0.02 ± 0.02	0.1 ± 0.1	0.002 ± 0.1	0.08 ± 0.2	0.06 ± 1	0.04 ± 0.1	0.06 ± 0.2	0.04 ± 0.1	0.04 ± 1	0.02 ± 0.2
6	Bicarbonate	Summer	0.34 ± 0.1	0.54 ± 0.03	0.48 ± 0.1	0.46 ± 0.03	0.4 ± 0.3	0.4 ± 0.02	0.38 ± 0.01	0.38 ± 0.1	0.38 ± 0	0.38 ± 0.1	0.34 ± 0.3
	(gha-1)	Monsoon	0.022 ± 0.1	0.42 ± 0	0.42 ± 0.02	0.32 ± 0.02	0.32 ± 0.01	0.22 ± 0.1	0.16 ± 0.2	0.06 ± 0.1	0.02 ± 0.1	0.02 ± 0.1	0.02 ± 0.2
		Winter	0.16 ± 0.1	0.54 ± 0.03	0.52 ± 0	0.34 ± 0.02	0.26 ± 0.03	0.24 ± 0.2	0.22 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.2	0.18 ± 0.1
7	Sulphate	Summer	0.06 ± 0.1	0.16 ± 0.02	0.18 ± 0.03	0.1 ± 0	0.1 ± 0	0.06 ± 0.01	0.06 ± 0.1	0.06 ± 0.1	0.06 ± 0.1	0.06 ± 0.01	0.06 ± 0.2
	(gha-1)	Monsoon	0.04 ± 0.1	0.36 ± 0.03	0.3 ± 0.1	0.24 ± 0.05	0.16 ± 0.2	0.04 ± 0.1	0.04 ± 0.2	0.1 ± 0.1	0.06 ± 0.1	0.06 ± 1	0.04 ± 0.2
		Winter	0.16 ± 0.1	0.02 ± 0.1	0.7 ± 0.03	0.42 ± 0.1	0.22 ± 0.03	0.2 ± 0.02	0.2 ± 0.2	0.2 ± 0.1	0.18 ± 0.2	0.18 ± 0	0.18 ± 0.1
8	Phosphate	Summer	0.1 ± 0.1	1.7 ± 0.02	0.76 ± 0.1	0.44 ± 0.04	0.26 ± 0.4	0.08 ± 0.05	0.04 ± 0.1	0.04 ± 0.1	0.12 ± 0.1	0.12 ± 0	0.1 ± 0.03
	(gha-1)	Monsoon	0.04 ± 0.1	0.16 ± 0.01	0.14 ± 0.1	0.1 ± 0	0.08 ± 0.4	0.08 ± 0.01	0.06 ± 0.2	0.04 ± 0.2	0.04 ± 0.1	0.04 ± 0.1	0.04 ± 0.1
		Winter	0.02 ± 0.1	0.3 ± 0.02	0.24 ± 0.1	0.22 ± 0.1	0.18 ± 0.2	0.16 ± 0.02	0.12 ± 0.1	0.1 ± 0.1	0.06 ± 0.1	0.2 ± 0.1	0.02 ± 0.04
9	Nitrogen	Summer	0.08 ± 0.1	1.36 ± 0.03	0.9 ± 0.03	0.68 ± 0.02	0.76 ± 0.1	0.08 ± 0.01	0.06 ± 0.01	0.28 ± 0.1	0.26 ± 0.2	0.26 ± 0.1	0.1 ± 0.3
	(gha-1)	Monsoon	0.02 ± 0.1	1.14 ± 0	0.6 ± 0	0.42 ± 0.005	0.24 ± 0.1	0.22 ± 0.01	0.18 ± 0.01	0.1 ± 0.01	0.06 ± 0.1	0.06 ± 0.01	0.04 ± 0.1
		Winter	0.08 ± 0.1	1.26 ± 0	0.9 ± 0.02	0.66 ± 0.01	0.66 ± 0.2	0.56 ± 0.1	0.52 ± 0.01	0.41 ± 0.01	0.26 ± 0.1	0.21 ± 0.01	0.2 ± 0.3
10	Sodium	Summer	0.02 ± 0.1	2.18 ± 0.2	2.16 ± 0.12	2.08 ± 0.04	2.02 ± 0.2	2 ± 0.2	0.2 ± 0.1	0.2 ± 0.01	0.18 ± 0.1	0.16 ± 0.2	0.06 ± 0.1
	(ppmha-1)	Monsoon	0.2 ± 0.1	2.4 ± 0	2.4 ± 0.1	2.32 ± 0.01	2.2 ± 0.1	2.08 ± 0.2	2.02 ± 0.03	2.04 ± 0.01	1.8 ± 0.2	1.4 ± 0.03	0.4 ± 0.1

4. Conclusions

The soil samples from the study sites reflect the extent of alteration in the physical and chemical composition. The presence of heavy metals in the petroleum contaminated soil samples viz Lead, Cadmium, Chromium and Arsenic in notably high concentration may possibly lead to further deterioration of the natural resource and also in the biological flora. Also, organic hydrocarbon residues in the experimental soil samples may pose to be detrimental to the natural flora.

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