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PETROLEUM HYDROCARBON CONTAMINATION IN URBAN SOILS A CASE STUDY

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ABSTRACT

In recent years, economic boom in fast developing countries has been witnessed with spectacular progress in industrialization and concurrent progress in modern agriculture. Such development is however not without any socio-political and environmental side effects. Due to industrialization and urbanization, pollution in various areas has been increased day by day. So in this report we discussed about the soil pollution because of hydrocarbons. This report was carried out to compare the hydrocarbons effect on soil due to various hydrocarbon activities. Petrol bunks of different places like pendurthi, seethammadhara, barex, diesel shed near 104 junction, maddilapalem, and inside diesel shed of Visakhapatnam were recognized and soil samples were collected. These samples are sieved and subjected to systematic analysis like pH, organic carbon, moisture content, shear strength, bulk density, texture and water holding capacity. Based on the values of the physico-chemical parameters, the quality of soil was inferred and discussed.

KEY WORDS: Visakhapatnam, Hydro Carbons, Petrol Bunks, Physico-chemical Parameters.

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INTRODUCTION

Soil is nature's gift; it cannot be produced within human life span (Khanif 2010). Modern society emits and discharges many potentially toxic chemicals to the environment. Soil often acts as the ultimate 'sink' of environmental pollution, because clay minerals and humic materials have a large number of surfaces, chemical groups and organic particles to which pollutants can attach. Contaminated soils can pose a problem for society if agricultural functions, human health or ecological systems are adversely affected (Nico M van Straalen and Dick Roelofs 2008).

In recent years there has been a high demand for crude oil as a primary source of energy in civilized societies. Its market value and consumption of its end products have caused a huge increase in production of crude oil. This further encouraged more refineries and petro chemical industries and the need to exploit and drill for more oil to some extent ignoring the consequence of such activities on the environment and human life (Mostafa Chorom, 2010).

Pollution of the soil environment with petroleum and refinery products is one of the factors expressing anthropopression. Due to its toxicity, widespread presence and complex nature, this type of pollution is a serious problem, one reason being that as the modern civilization, urbanization and mechanization develop; the use of petroleum and petroleum-based products grows. Contamination of soils with crude oil and refinery products is becoming an ever-increasing problem. Major points of soil pollution with refinery products are petrol stations, garages servicing cars and tractors, seaport areas (Wyszkowski *et al.,* 2004)

Oil is known to exert adverse effects on soil properties and plant community. Beyond 3% concentration, oil has been reported to be increasingly deleterious to soil biota and crop growth (Baker, 1976; Amadi et al., 1993; Osuji et al., 2005). The high hydrocarbon levels extracted from oil spill affected area provide evidence of severe hydrocarbon contamination at the site. These conditions generally imply low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood in the affected area (Leo C. Osuji and Iruka Nwoye, 2007). Based on the above discussion the present study has been taken up to interpret the hydrocarbon dispersion at various depths in the soil within 1km radius from the occurrence of pollution.

MATERIALS AND METHODS

The soil samples in the present study were collected from different locations of Visakhapatnam. Samples were collected from all directions of the selected sampling site with 1km away from the petrol bunks. After selecting the sampling sites, the surface litter was removed and two types of soils are collected i.e.; top soil and 5cm depth soil. Spade is used to dig the soil. The soils were collected in sterile polythene bags. 1 kg of soil was collected, sealed and properly labeled as per the codes given below.

2.1 Sample Codes:

Codes For Directions: East - E, West – W, North – N, South – S.

Sampling Codes: Top soil – T, Depth soil - D

2.2 Sampling Points:

1. Pendurti new petrol bunk
2. Vizag central petrol bunk
3. CMR central petrol bunk.
4. Seethammadhara petrol bunk.
5. Diesel shed surroundings.
6. Diesel shed.

The soils were taken to the laboratory. The samples were air dried and sieved under 2 mm sieve and analyzed for the parameters like Soil texture, pH, Bulk Density, Water Holding Capacity, Shear Strength, Moisture Content, Organic Carbon.

RESULTS AND DISCUSSIONS

Various physic-chemical parameters are tested in the soil samples that are collected from various petrol bunks and their surroundings in Visakhapatnam (Table - 1).

The results show that the sand content in most of the surface soils was less than the control, which was due to higher content of clay resulting from the sedimentation. All the samples are mostly fine and coarse type sand whereas clay type was present in control soil. Soil texture directly influences soil-water relationships, aeration and root penetration through its relationship with interparticle pore space indirectly. It also affects the nutritional status of soil, the clay fraction being main source of many plant nutrients and of cation exchange activity. Sandy soils are nutrient-deficient due to high porosity. The relative proportions of the mineral and organic solids to the liquid or gas–filled pore space are determined by the particle size distribution of the mineral matter (soil texture) and the binding of these fundamental particles into larger units or aggregates.

The pH of soil samples range between 6.28-7.48 which happens to be the range for neutral to alkaline soils (graph – 1). The pH of the oil-impacted soils at both depths was significantly lower than the background soils but differences between the two depths were not significant. Oiling must have discouraged the leaching of basic salts which are responsible for raising pH in the control. The binding of the oil with soil particulate matter in the affected area probably posed a major resistance to the removal of such basic ions. While the oil may have had some direct impact in lowering the pH, it is more likely that production of organic acids by microbial metabolism is responsible for the difference. The pH of the soil should be adjusted by aeration to complete the microbial mediated oxidation of organic acids while agricultural lime may be added to provide some buffering capacity to the soil. Similarly, soil-pH might have affected nutrient availability. The pH is not only essential for determining the availability of many soil nutrients but also in determining the fate of many soil pollutants, their breakdown and possible movement through the soil.

The bulk density of the samples was recorded in the range of 1.07-1.64 gm/cc. The relationships between soil physical properties and landscape attributes including elevation, slope, soil type and land use type were explored. Our study indicated that, among all these factors, land use type significantly affected bulk density values. The water holding capacity was range from 12.56- 49.987 (graphs – 2). It improves the soil hydraulic conductivity by improving the water movement through pore spaces and fractures. The high water holding capacity is seen in barex area petrol bunk soil as the humus content is high in garden soil. The water holding capacity of all the samples is relatively good. An increase of the soil organic matter also improves the soil water holding capacity.

The shear strength of the samples was ranged from 1.0021-1.0955 (graph – 3). The soil would be expected to behave as though it was saturated. In other words the negative pore-water pressure acts throughout the predominantly water filled pores as in the saturated soil condition. Consequently an increase in matric suction produces the same increase in shear strength as does an increase in net normal stress. At matric suctions higher than the air-entry value of the soil, the soil starts to desaturate. The negative pore-water pressure does not act throughout the entire pores as in the saturated soil condition. Therefore, the contribution of matric suction towards the strength of the soil is less than the contribution of the net normal stress at the same stress level. In other words the increase in shear strength with respect to matric suction is less than the increase with respect to net normal stress.

The moisture content ranges from 10.312-22.136% (graph – 4). The higher moisture content of in oiled surface and subsurface soils can be attributed to insufficient aeration of the soil that might have arisen from the displacement of air in the soils; this probably encouraged water logging and reduced rate of evaporation. Partial coating of soil surfaces by the hydrophobic hydrocarbons might reduce the water holding capacity of the soil due to some significant reduction in the binding property of clay. Usually, such "partial coats" lead to a breakdown of soil structure and the dispersion of soil particles, which reduce percolation and retention of water. Soils develop severe and persistent water repellency following contamination with crude oil. High moisture content might reduce microbial activities not as a result of the water itself but rather by the indirect hindrance to the movement of air which would reduce oxygen supply.

Organic carbon content accounts for as much as one third or more than any other single factor, for the stability of soil aggregates. Furthermore, organic carbon supplies energy for most of the microorganisms. The study conducted by K. Swapnavahini et al., 2009 has reported various organic contents of the soils with different activity zones that states that the organic matter is a key parameter that supports the type of vegetation in a given area. The organic carbon content ranged from 2.10-4.92% (graph – 6). The soils organic carbon ranged from medium to low which decrease soil fertility, nutrient holding capacity and plant growth. The most plausible connection perhaps might be that the spilled oil impaired the metabolic processes that would have facilitated the agronomic addition of organic carbon from the petroleum hydrocarbons by reducing the carbon-mineralizing capacity of the microflora. It is most likely that while these organisms might have been stimulated by the presence of the spilled-oil on site, their proliferation did not adequately cope with the business of breaking down the excess carbonaceous substrate, perhaps due to various factors that might include the environmental conditions of weathering and climatic predispositions as well as the physico-chemical properties earlier discussed.

CONCLUSION

The pH is not only essential for determining the availability of many soil nutrients but also in determining the fate of many soil pollutants, their breakdown and possible movement through the soil. Land use type significantly affected bulk density values. The water holding capacity of all the samples is relatively good. The higher moisture content of oiled surface and subsurface soils can be attributed to insufficient aeration of the soil that might have arisen from the displacement of air in the soils; this probably encouraged water logging and reduced rate of evaporation. The soils organic carbon ranged from medium to low which decrease soil fertility, nutrient holding capacity and plant growth.

The qualitative study based on observations of soil and different cultures we were able to draw the following conclusions. Among all these factors, land use type significantly affected soil. It is essential to recognize the effects of landscape attributes on soil physical properties. The high hydrocarbon pollution levels were extracted from the soil samples that have provided evidence of severe hydrocarbon contamination on the site. It has shown the decrease in pH, water holding capacity, organic carbon and moisture content of soil samples when compared to the control soil samples. It shows the contamination of soil due to hydro carbons. These conditions generally imply low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood in the affected area. The public awareness on the importance of soil resource for food production and human survival should be provided through the education system. Research for public good on sustainable soil management must be given top priority.

CODE	TEXTURE	pH	BULK DENSITY (gm/cc)	WATER HOLDING CAPACITY (%)	SHEAR STRENGTH	MOISTURE CONTENT (%)	ORGANIC CARBON (%)
Various parameters of soil samples that are collected from pendurthi petrol bunk surroundings.							
ET1	CLAY	7.32	1.64	21.433	1.0096	12.137	2.10
ED1	SILT	7.40	1.57	19.508	1.0087	11.298	2.34
WT1	FINE	7.23	1.57	25.717	1.0070	14.848	2.28
WD1	SILT	7.32	1.42	34.597	1.0092	13.818	2.52
NT1	FINE	6.96	1.34	23.550	1.0070	10.312	2.28
ND1	FINE	7.12	1.30	29.099	1.0081	13.686	2.46
ST1	CLAY	6.54	1.35	26.519	1.0037	12.637	2.04
SD1	CLAY	6.60	1.3184	32.282	1.0092	15.606	2.46
Various parameters of soil samples that are collected from petrol bunk near vizag central (BAREX)							
ET2	FINE	6.92	1.60	27.307	1.0096	15.918	2.64
ED2	SILT	7.12	1.42	34.250	1.0210	19.789	3.0

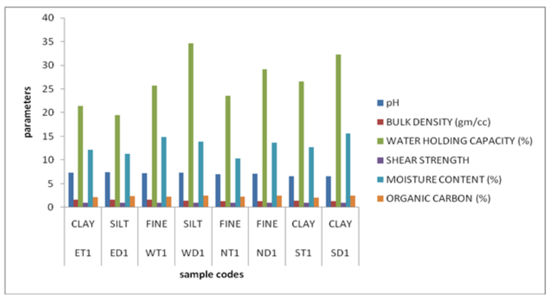
WT2	FINE	7.36	1.54	26.564	1.0143	14.824	2.88
WD2	SILT	7.25	1.52	28.976	1.0141	16.080	3.48
NT2	FINE	6.35	1.07	49.987	1.0270	24.089	3.6
ND2	SILT	6.28	1.13	39.772	1.0253	19.910	3.72
ST2	COARSE	7.45	1.26	29.671	1.0200	18.675	3.24
SD2	FINE	7.36	1.14	34.981	1.0456	19.849	3.3
Various parameters of soil samples that are collected from petrol bunk near CMR central (MADDILAPALEM).							
ET3	COARSE	7.12	1.42	30.420	1.0059	15.012	2.52
ED3	FINE	6.95	1.32	30.550	1.0955	17.049	2.70
WT3	COARSE	7.25	1.48	18.608	1.0041	10.743	2.64
WD3	COARSE	7.15	1.32	12.560	1.0063	11.730	2.94
NT3	COARSE	6.87	1.28	27.859	1.0021	14.937	2.10
ND3	FINE	6.65	1.25	30.237	1.0114	17.598	2.46
ST3	COARSE	6.52	1.43	26.114	1.0035	15.324	3.66
SD3	FINE	6.64	1.56	34.560	1.0124	16.652	3.24
Various parameters of soil samples that are collected from petrol bunk near SEETHAMMADHARA.							

ET4	COARSE	6.92	1.24	36.001	1.0108	17.565	4.02
ED4	FINE	7.24	1.30	25.573	1.0110	12.185	4.20
WT4	FINE	6.51	1.38	22.861	1.0089	13.308	3.18
WD4	SILT	6.73	1.29	30.879	1.0077	14.949	3.36
NT4	COARSE	6.84	1.38	22.960	1.0072	14.191	3.48
ND4	SILT	6.96	1.47	25.748	1.0078	13.465	3.66
ST4	FINE	7.53	1.31	28.424	1.0123	13.778	3.12
SD4	FINE	7.41	1.34	24.396	1.0076	13.326	3.30
Various parameters of soil samples that are collected from DIESEL SHED and its surroundings.							
ET5	COARSE	6.54	1.43	21.429	1.0062	11.437	2.94
ED5	COARSE	6.61	1.24	35.970	1.0123	17.168	3.12
WT5	COARSE	6.65	1.16	28.408	1.0088	14.688	3.30
WD5	FINE	6.84	1.21	32.395	1.0107	15.786	3.48
NT5	FINE	6.63	1.32	34.690	1.0098	18.148	3.24
ND5	SILT	6.78	1.50	29.240	1.0083	13.363	3.60
ST5	FINE	7.2	1.39	22.959	1.0033	12.448	3.42

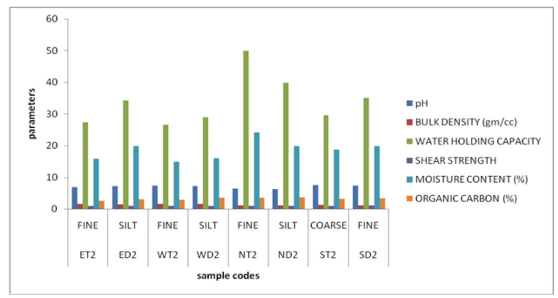
SD5	FINE	6.91	1.37	32.087	1.0109	15.969	3.66
Various parameters of soil samples that are collected from DIESEL SHED.							
T6	COARSE	7.48	1.13	42.556	1.0141	20.615	4.92
D6	COARSE	7.36	1.17	37.902	1.0107	22.136	3.90

Table – 1 VARIOUS PARAMETERS OF SOIL SAMPLES

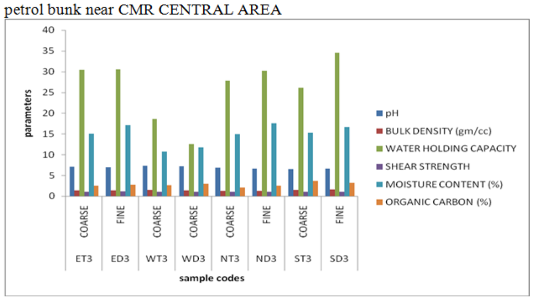
GRAPH 1: Graphical representations of various parameters of soil samples from Petrol Bunk in Pendurthi Area.



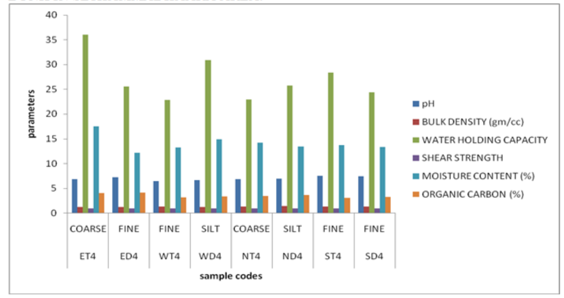
GRAPH 2: Graphical representations of various parameters of soil samples from petrol bunk near VIZAG CENTRAL AREA.



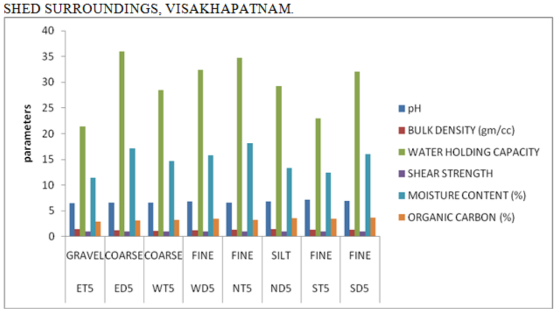
GRAPH 3: Graphical representations of various parameters of soil samples from petrol bunk near CMR CENTRAL AREA



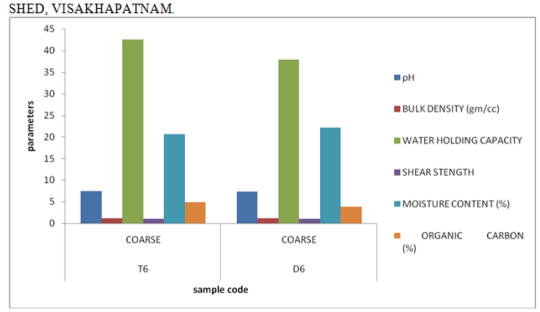
GRAPH 4: Graphical representations of various parameters of soil samples from PETROL BUNK IN SETHAMMADHAARA AREA.



GRAPH 5: Graphical representations of various parameters of soil samples from DIESEL SHED SURROUNDINGS, VISAKHAPATNAM.



GRAPH 6: Graphical representations of various parameters of soil samples from DIESEL SHED, VISAKHAPATNAM.



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