Eco. Env. & Cons. 28 (4) : 2022; pp. (2042-2046)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i04.059

Physico-chemical Analysis of Crude Oil Contaminated Soil in and Around Dikom Oil Well of Assam

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(Received 8 April, 2022; Accepted 22 June, 2022)

ABSTACT

North eastern India holds a unique position in the oil map of India because it was the pioneer of Indian oil industry. Exploration, drilling, transportation and accidental spillage in oil field areas often lead to the tremendous effects on soil and water as well as vegetation. A study was conducted to determine the possible effects of crude oil drilling activities in the soil in and around oil well. Soil samples were collected using soil auger during summer and winter seasons at a depth of 0-15cm and a distance of 50m (point A), 100m (point B) and 150meters (point C) from oil spilled site. The soil parameters pH, electrical conductivity, moisture content, porosity, water holding capacity, available nitrogen, phosphorus and potassium were analyzed. The pH of the soil sample recorded from 4.36 to 5.29 in summer and 4.67 to 5.76 in winter season. Soil moisture content, WHC, porosity, EC, phosphorous content was lowest in point A compared to point B, point C and point D(control) in both the seasons. Soil organic carbon (OC), nitrogen, potassium content was recorded highest in point A, point B and point C compared to point D.

Key words: *Crude oil, Vegetation, Accidental spillage, Tremendous.*

Introduction

Soil is a life supporting system for plants, animals and microbes. Crude oil pollution has enormous detrimental influence on the environment and living organisms. The levels of N, P, K, organic and inorganic materials and conductivity are the main components of fertility status of soil Iram and Khan (2018). As a predominant energy resource crude oil is vital for human life and also serve as raw material for various petroleum products. Crude oil pollution in soil is a major environmental problem Dutta *et al*. (2017). Crude oil is known to diminish the availability of plant nutrient in soil Xu and Johnson (1997); Osuji *et al.* (2004); Tanne and Kinako (2008). However, during crude oil exploration a vast amount of drilling mud/fluid is generated which are deposited on the land surface. These waste matters are often very unstable and become source of air, soil and water pollution. These may eventually lead to a loss of biodiversity, amenity and economic wealth Bradshaw (1993). Further, oil spillage, leakage and other release of petroleum occur frequently during its transportation and other activities that result in the contamination of cultivated soil and groundwater, especially when associated with accidental spills Prasad and Katiyar (2010). As crude oil is a mixture of hundreds of chemicals having different properties and toxicities, therefore it has significant impact on soil quality which also leads to the heavy disruption of ecological balance Holcomb (1970). Transportation of crude oil from point source to various components of the ecosystem is one of the major factors that jeopardize the well-being of the environment

Sarma *et al.* (2016). The nature of oil spillage will depend on the local weather condition such as existence or non-existence of snow, drainage ability of soil and absorptive capacity of ground and local topography Greene *et al.* (1975); Sextone and Atlas (1977). Environmental pollution with crude oil is a common phenomenon associated with oil industries operating in Assam, India Baruah and Sarma (1993). Juxtaposition of oil field areas with agricultural field is predominant feature of the area.

Materials and Methods

The study was conducted in and around oil well at Dikom where accidental oil spillage has taken place. Dikom oil well was situated at midst of Dikom Tea Estate at 20 km from Dibrugarh, Assam. The area receives moderate to high rain fall, high relative humidity round the year. The sample taken at 50 metre, 100 metre and 150 metre distance from spilled point is demarcated as point A, point B and Point C respectively. Soil samples were collected at a depth of 0-15 cm by using soil augur. Three subsamples were taken from each point and finally prepared a composite sample for the point by mixing the air-dried powder after sieving. The samples collected from the nearby point where the effect of oil spill remain nil is considered to be the control and demarcated as point D. Plant roots, pebbles and undesirable matters were removed from the soil samples and the samples were allowed to air dry in shade. The dried soil samples were crushed in mortar and pastel and sieved through 2 mm sieve following Devi and Dkhar (2014). The powdered samples were then stored in clean glass vials for further analysis. Soil moisture content, porosity and water holding capacity were determined using the method given by Pandey, Puri and Singh (1996). Soil pH was determined using a double electrode pH meter (digital pH meter 335, Systronic Co. Ltd.), EC on Elico conductivity bridge Jackson (1973), Organic carbon by colorimetric method Walkely and Black (1934). Available nitrogen (N) by the alkaline potassium permanganate ($KMnO_4$) method Subbiah and Asija (1956); available phosphorous by Bray and Kurtz (1945); available potassium by ammonium acetate method Hanway and Heidel, (1952).

Results and Discussion

Soil physico- chemical characteristics recorded under crude oil contamination during summer and winter season are presented in Table 1 and Table 2 respectively. The soil moisture content was found to be less in point A (29.63%) than point B (31.32%), point C (40.56%) and point D (45.96%) of summer season. It indicates that soil was drier in highly polluted areas as compared to less polluted areas. Evidently oil penetration to the soil surface stops both upward and downward movements of water. Wein and Bliss (1973) reported that crude oil affected areas was drier than less affected areas. Porosity and WHC were less in point A (28.56%) (20.98%) respectively compared to point B (32.20%) (31.25%), point C (40.12%) (42.0%) and point D (46.20%) (43.69%) of summer season. Similarly, analysis of winter season soil sample resulted in less moisture content in point A (32.21%) compared to point B (42.10%), point C (56.31%) and point D (58.33%). The present investigation shows the reduction of porosity and water holding capacity in the order of point D (control)> point C (150 m distance from spilled point)>point B (100 m distance from spilled point) > Point A (50m distance from spilled point) in both summer and winter season.

The low soil moisture content in highly polluted site may be due to lower soil moisture recharge caused by hydrophobic nature of the polluted soil Rowell (1977) and De Jong (1980). The study revealed a decreasing trend with the increase of distance from spilled point, which may perhaps be attributed to seepage and leakage of formation water being rich in cations and anions.

pH value ranges from 5.29 to 4.36 in summer season and 5.76 to 4.67 in winter season (Fig. 1). Either very low or very high pH are not suitable for plant growth. The mobility of nutrients is affected by the value of soil pH. Soil nearby spilled point found to be more acidic compared to less polluted sites in

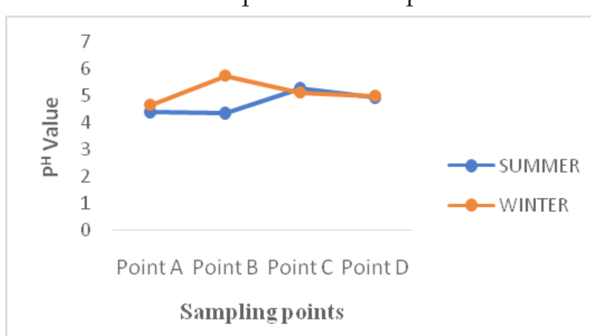

Fig. 1. pH of crude oil contaminated soil in both summer and winter season

Table 1. Physico-chemical characteristics of crude oil contaminated soil during summer

Sample points	Soil Moisture (%)	Porosity (%)	WHC (%)	pH	ECmS/cm	OC%	N (kg/ha)	P (kg/ha)	K (kg/ha)
Point A (50m)	29.63±.09	28.56±.11	20.98±.18	4.41±.25	.02±.01	1.92±.07	598.8±11.73	10.72±1.53	89.49±1.02
Point B (100m)	31.32±.12	32.20±.21	31.25±.19	4.36±.04	.04±.01	1.74±.21	552.4±10.3	20.55±2.45	78.20±1.45
Point C (150m)	40.56±.35	40.12±.14	42.0±.11	5.29±.08	.09±.01	1.72±.06	547.2±.96	21.03±2.26	75.29±1.09
Point D Control	45.96±.05	46.20±.09	43.69±.14	4.95±.05	.12±.10	1.67±.06	540.2±.79	29.3±.89	69.6±1.02

Mean ± SD of Mean

Table 2. Physico-chemical characteristics of crude oil contaminated soil during winter

Sample points	Soil Moisture (%)	Porosity (%)	WHC (%)	pH	ECmS/cm	OC%	N (kg/ha)	P (kg/ha)	K (kg/ha)
Point A (50m)	32.21±.36	29.5±.27	18.20±1.25	4.67±.20	.10±.01	1.99±.07	613.5±1.12	10.72±.25	99.32±1.10
Point B (100m)	42.10±.78	34.2±.98	21.21±.24	5.76±.03	.01±.05	1.88±.21	585.5±1.15	19.66±.89	94.8±2.10
Point C (150m)	56.31±.34	40.12±.69	38.92±.69	5.14±.25	.01±.02	1.85±.24	569.8±.96	27.70±1.20	87.2±1.20
Point D Control	58.33±.68	48.29±.36	40.20±2.5	5.01±.36	.10±.02	1.81±.15	561.1±1.24	38.32±2.10	78.6±.63

Mean ± SD of Mean

both seasons. Alexander (1977) reported that hydrocarbons associated with crude oil are utilized by microbes which form organic acids. Thus, probably acid produced by hydrocarbon utilizing microbes reduce the pH level in polluted sites Nwachukwa and Ugoji (1995). EC content was recorded more in summer season compared to winter season (Fig. 2).

The present study reveals enhancement of soil parameters such as organic carbon, nitrogen, potassium in soil sample during winter season in comparison to summer season (Fig. 3, 4), which could be attributed by deposition of crude oil contaminated waste by monsoonal water to the associated soil system.

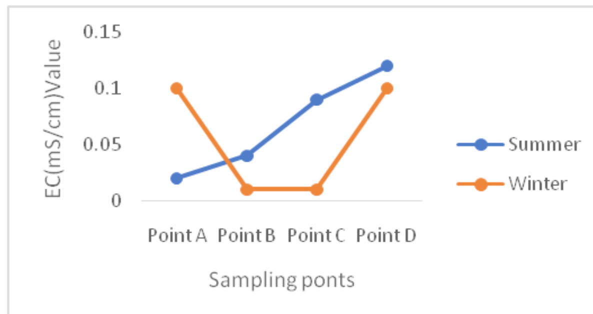

Fig. 2. EC of crude oil contaminated soil in both summer and winter season

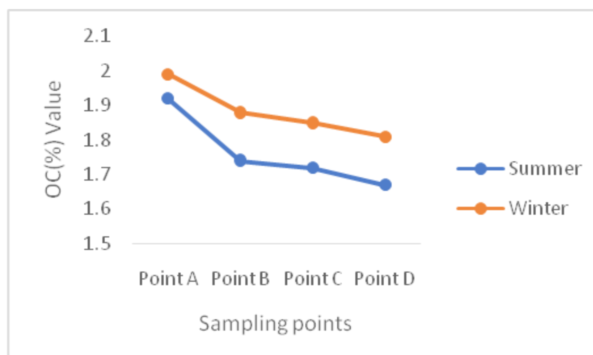

Fig. 3. Organic carbon content of crude oil contaminated soil in both summer and winter season

Available nitrogen increases with increase of oil contamination in soil Udo and Fayemi (1975); Rao (1992). The increase amount of available nitrogen in oil degraded sites is due to fixation of more available nitrogen by microorganism which assimilated more hydrocarbons Schwendinger, (1968). Increase of crude oil level is directly proportional to increase in organic carbon Udo and Fayemi (1975).

Phosphorous level of the soil sample reduced in polluted sites compared to less polluted sites in both

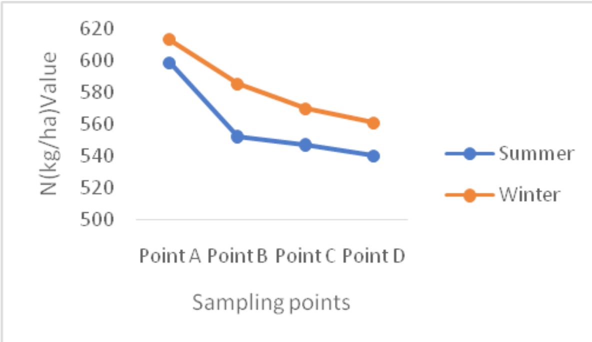

Fig. 4. Nitrogen content of crude oil contaminated soil in both summer and winter season

seasons (Fig. 5). Potassium was found to be high in point A (50m distance from spilled point) compared to Point B (100m distance from spilled point), Point C (150m distance from spilled point) respectively (Fig. 6). It may result due to leakage of saline effluent along with crude oil and therefore ionic concentration may build up more K^+ near spilled points.

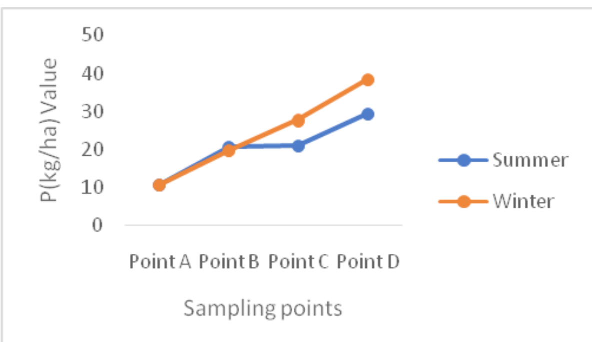

Fig. 5. Phosphorous content of crude oil contaminated soil in both summer and winter season

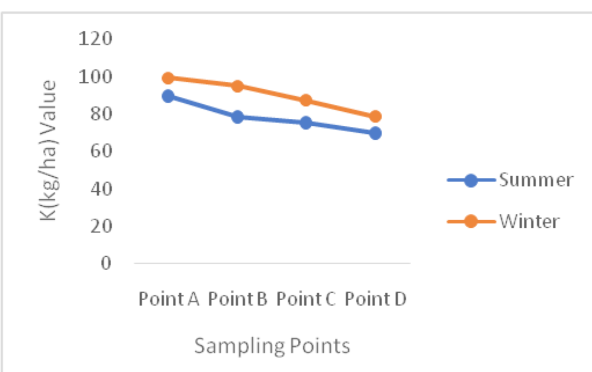

Fig. 6. Potassium content of crude oil contaminated soil in both summer and winter season

Conclusion

The analysis of physico-chemical characteristics of crude oil contaminated soil evidenced impact of oil drilling activities that lead to degradation of soil quality and destroys the equilibrium of plant growth promoting systems and producing long term consequences for sensitive plants like tea and paddy in and around oil spillage Sumithra *et al*. (2013). Thus, it has been observed that the unattended oil drilling activities in the area have contributed to the degradation of agricultural and grazing lands around the oil installations. As crude oil is a mixture of hundreds of chemicals (Polycyclic aromatic hydrocarbons and heavy metals), there is a possibility of bioaccumulation and their entry into the food chain. This is especially relevant in Assam since these oil field areas are mostly adjacent to tea gardens and rice field. This has given a strong foundation on environmental pollution caused by the developmental activities around the oil fields in Assam.

Acknowledgement

The authors are thankful to the Director, Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India for providing facility to carry out the work.

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