



## Physicochemical characterisation of petroleum hydrocarbon contaminated land of Guru Gobind Singh refinery's peripheral area, Punjab

Sharma, S.S. <sup>1</sup> and Vashishtha, A.<sup>2</sup>

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### Abstract

Petroleum hydrocarbons are a critical environmental contaminant and pose a serious hazard to the living system as petroleum hydrocarbons are identified as carcinogenic and neurotoxic organic pollutants. Therefore, remedial methods are required to dispose of it. With a modern understanding of nature and microorganisms, bioremediation is the preferred method for soil pollution control. However, before the implementation of successful bioremediation technology, it is required to assess various physico-chemical parameters of contaminated soil. In the present study, various physico-chemical parameters, including pH, electrical conductivity, water holding capacity, organic carbon, organic matter, available nitrogen, carbonate, bicarbonate, potassium and sodium contents of the petroleum hydrocarbon contaminated soil were estimated. The results suggested a rise in all the estimated parameters for the petroleum hydrocarbon contaminated soil.

**Key words:** Contaminated soil, Petroleum Hydrocarbon pollution, Physico-chemical parameters of soil

### Introduction

Petroleum derivatives are the primary source of energy for automobiles in the entire world. Therefore, they are transported within the territory of a nation to meet the demands. The usable petroleum derivatives are produced through a rigorous refining process in a large industrial facility known as oil refineries. Transportation and storage are two functional aspects associated with petroleum derivatives, which further threaten accidental spillage. Accidental oil spillage frequently causes petroleum hydrocarbon contamination in soil, and it professes a significant threat to the environment and negatively affects human health as petroleum hydrocarbons are identified as carcinogenic and neurotoxic organic pollutants (Fowzia and Fakhruddin, 2018). Unquestionably, bioremediation is an exceptionally efficient and cost-effective technique for such environmental contamination (Bhardwaj *et al.*, 2020). The successful implementation of bioremediation techniques requires a piece of accurate information and monitoring of the physico-chemical parameters of the contaminated land (Dhir, 2017). The present study was carried

out with such objectives and tried to convey accurate information of the petroleum hydrocarbon contaminated land of Guru Gobind Singh Refinery's peripheral area. Guru Gobind Singh Refinery, Bathinda, Punjab, was established in 2012 by a joint venture of Hindustan Petroleum Corporation Ltd. and Mittal Energy Investment Pvt. Ltd, Singapore. During the refinery operation, a large amount of refined petroleum derivatives are being transported to its catchment area through oil tankers. In occasional cases, the transportation of oil causes the oil spillage to its peripheral area. Therefore, oil spillage sites are a significant issue for the ecosystem and human health.

### Materials and Methods

The petroleum hydrocarbon contaminated soil was studied for physico-chemical characterisation, and standard soil analysis methods were used. The soil samples were taken from the selective sites, *i.e.*, spillage sites of the nearby areas of the Guru Gobind Singh Refinery, Bathinda, Punjab. In a sample, almost 100-gram soil up to the depth of 10 cm was collected in the polyethene zip bag. Three replicated samples from a sampling site were collected to get the statistically significant results. In the laboratory, the soil samples were air-dried

### Author's Address

<sup>1</sup>DAV College, Sri Ganganagar, Rajasthan, India

<sup>2</sup>Maharaja Ganga Singh University, Bikaner, Rajasthan, India

E-mail: [sssharma.mdc@gmail.com](mailto:sssharma.mdc@gmail.com)



and sieved through 2 mm pore size to remove the unwanted particles (Allen *et al.*, 1974). The samples were stored at 4<sup>0</sup> C for physico-chemical characterisation. The physical properties of soil, like electrical conductivity and water holding capacity, were determined along with the chemical properties like pH, organic carbon, organic matter, available nitrogen, carbonate, bicarbonate, potassium, and sodium contents in the soil.

Furthermore, A paste of air-dried soil samples was prepared in distilled water in the ratio of 1:10 (soil: water). This paste was stirred to make a homogenous slurry and then allowed to stand for at least 1-2 hours; after that, the pH was determined by the pH meter (Systronics-361), electrical conductivity was determined by EC-TDS meter (Systronics-307). The water holding capacity was measured by calculating the difference between water-saturated soil and oven-dried soil. Available Sodium and Potassium contents in soils were determined by the flame photometer. The Organic

Carbon and Organic Matter in soil were determined by the rapid titration method (Walkley and Black, 1934). The available Nitrogen in soils was determined by the procedure given by Subbiah and Asija (1956). Carbonate and bicarbonate were determined by titration using a standard acid solution. The chloride content in the soil was determined by titration of the soil extract against standard AgNO<sub>3</sub> solution using potassium chromate as an indicator.

## Results and Discussion

Physico-chemical characteristics of the soil play an essential role in bioremediation; therefore, physico-chemical parameters determined in the study are helpful for the standardisation of the bioremediation process for the treatment of petroleum hydrocarbon contaminated soil. The various physico-chemical parameters of soil samples collected in the study area are summarised in Table-1.

**Table 1: Physico-chemical properties of petroleum hydrocarbon contaminated soil**

S.N.	Soil Sample	Control	Petroleum Contaminated Sites		
		(S-0)	(S-1)	(S-2)	(S-3)
1	pH	8.5	7.5	7.3	7.8
2	E.C. (dS/m)	0.68	1.17	0.76	1.19
3	CO <sub>3</sub> <sup>-2</sup> (PPM)	20.1	26.5	27.5	31.5
4	HCO-3 (PPM)	218.5	375.5	385.4	506.6
5	Cl <sup>-</sup> (PPM)	16.4	56.5	63.5	48.7
6	Na <sup>+</sup> (PPM)	2.4	7.7	4.8	5.7
7	K <sup>+</sup> (PPM)	0.47	1.45	1.25	1.37
8	WHC (%)	28.5	18.5	11.45	20.55
9	Total Organic Matter (PPM)	3.19	6.62	7.68	4.65
10	Total Organic Carbon (PPM)	1.36	3.26	3.90	2.46
11	Total Nitrogen (PPM)	0.020	0.15	0.14	0.075

pH is a conclusive factor for microbial activity in the soil and the biodegradation process, and a pH range of 5-8 is needed for microbial activity (Atlas, 1988). It is found that all the samples are representing a distinct pH value. The highest pH value was observed 7.8 in sample S-3, and the lowest pH value was observed 7.3 in sample S-2. Besides, the control sample S-0 represents a pH value of 8.5, slightly higher than all contaminated sites (Table-1). Thus, the soil is being affected by the petroleum hydrocarbon contamination and tends

to keep lowering the pH. A pH range of 6-8 is the most appropriate for bioremediation of petroleum hydrocarbon, and this range is preferred by most microorganisms (Vidali, 2001; US EPA, 2006).

The Electrical Conductivity (EC) estimation unveils that petroleum hydrocarbon contaminated soils remain with higher EC than the control site (Table-1). The value for EC varies between 0.76 to 1.19 dS/m in contaminated sampling sites and for control site 0.68 dS/m. The high electrical conductivity in the petroleum hydrocarbon



contaminated soil was found due to a high metal ion concentration introduced by hydrocarbon contamination in the soil (Odu, 1985; Onojake and Osuji, 2012). Carbonate and Bicarbonates are the important constituents of the soil, and it helps to maintain the soil alkalinity (Brady, 2017). The Carbonate and Bicarbonates estimation exhibit that petroleum hydrocarbon contaminated sites have higher values than the control site. Similarly, chloride content also showing the same trend. It is predicted that petroleum hydrocarbon contamination in soil is causing a decomposition and leaching impact to release the chemical species. The alkali metal ions concentration exhibit that petroleum hydrocarbon contaminated soil retains the higher concentrations ranging from 4.8 to 7.7 ppm for Sodium ions ( $\text{Na}^+$ ) and from 1.25 to 1.45 ppm for Potassium ions ( $\text{K}^+$ ) than the control site (Table-1). As petroleum hydrocarbons possess a considerable amount of ions that could bond with the existing ions in the soil; thus, the contaminated soil's ion concentrations and electrical conductivity increase (Devatha *et al.*, 2019).

The Water Holding Capacity (WHC) estimation reveals that contaminated sites represent values between 11.45% to 20.55%, and the control site represents the WHC value of 28.5%. Thus, the WHC of all the contaminated sites was found significantly lower than the control site. Water Holding Capacity (WHC) a function of the particle size and porosity of the soil, and it is a crucial parameter for microbial activity. The presence of contaminants can change the WHC and significantly affect soil chemistry (Bhardwaj *et al.*, 2020). Accordingly, the presence of petroleum hydrocarbon contamination in the soil decreases the WHC of soil as hydrocarbons increase the hydrophobicity and clog the soil to make the water and air too difficult to move (Massoud, 1972). The Organic Matter and Organic Carbon contents

estimation confirm that petroleum hydrocarbon contaminated soils represent higher concentrations ranging from 4.65 to 7.68 ppm for Total Organic Matter and 2.46 to 3.90 ppm for Total Organic Carbon than control site (Table-1). The Organic matter in the soil is generally derived from biotas, such as peat formation with time, plant fine roots turnover, microbial biomass and others; however, higher concentrations in petroleum spillage sites is significantly contributed by petroleum hydrocarbon decomposition (Wang *et al.*, 2013). The organic carbon is directly proportional to oil or petroleum hydrocarbon contamination (Udo and Fayemi, 1975). Accordingly, the increase in organic carbon indicates the rise in oil contamination in the soil (Clayden, 2012; McMurphy, 2000).

Nitrogen is also an essential attribute in soil chemistry that contribute to soil fertility (Vlassak, 1970). The nitrogen content in the contaminated soil was found to be slightly higher than in control. The control site bears 0.02 ppm, and petroleum hydrocarbon contaminated sites bear 0.075 to 0.15 ppm soil nitrogen concentration. Some researchers found no significant difference in nitrate and phosphate content between petroleum hydrocarbon contaminated and uncontaminated soils. However, they do not confirm the reason for their result but suggested that it might be due to the extent of contamination and some soil and microbial properties (Akoachere *et al.*, 2008).

## Conclusions

From the present research investigation, it is evident that contamination of soil with petroleum hydrocarbons significantly alters the physico-chemical characterises of the soil. Moreover, petroleum hydrocarbons contamination has increased the physico-chemical parameters considerably, and increased parameters are a concern for bioremediation.

## References

- Akoachere, J. T. K., Akenji, T. N., Yongabi, F. N., Nkwelang, G. and Ndip, R. N. 2008. Lubricating oil-degrading bacteria in soils from filling stations and automechanic workshops in Buea, Cameroon: occurrence and characteristics of isolates. *African Journal of Biotechnology*. 7(11): 1700- 1706.
- Allen, S. E., Grimshaw, H. M., Parkinson, J. A. and Quarmby, C. 1974. Chemistry analysis of ecological materials. Blackwell Scientific Publications. London. Pp 41.
- Atlas, R. M. 1988. Microbiology- fundamentals and applications. 2nd edition. Macmillan Publishing Co, New York, pp 352-354.



- Bhardwaj, S., Khanna, D. R., Ruhela, M., Bhutiani, R., Bhardwaj, R. and Ahamad, F. 2020. Assessment of the soil quality of Haridwar Uttarakhand India: A comparative study. *Environment Conservation Journal*, 21(3): 155-164. <https://doi.org/10.36953/ECJ.2020.21319>
- Brady, N. C. 2017. Nature and Properties of Soils, 15th Edition, Pearson Education.
- Clayden, J., Greeves, N. and Warren, S. 2012. Organic Chemistry, Oxford University Press.
- Devatha, C. P., Vishnu Vishal, A. and Purna, C. R. 2019. Investigation of physical and chemical characteristics on soil due to crude oil contamination and its remediation. *Journal of Applied Water Science*, 9: 89. <https://doi.org/10.1007/s13201-019-0970-4>
- Dhir, B. 2017. Bioremediation Technologies for the Removal of Pollutants. In: Kumar R., Sharma A., Ahluwalia S. (eds) Advances in Environmental Biotechnology. Springer, Singapore. [https://doi.org/10.1007/978-981-10-4041-2\\_5](https://doi.org/10.1007/978-981-10-4041-2_5)
- Fowzia, A. and Fakhruddin, A. N. M. 2018. A Review on Environmental Contamination of Petroleum Hydrocarbons and its Biodegradation. *International Journal of Environmental Science and Natural Resources*, 11(3): 555811. DOI: 10.19080/IJESNR.2018.11.555811.
- Massoud, F. 1972. Some physical properties of highly calcareous soils and their related management practices. FAO/UNDP Regional Seminar on Reclamation and Management of Calcareous Soils. Cairo, Egypt. November 7-December 2, 1972.
- McMurry, J. 2000. Organic Chemistry. 5th ed. Cole: Thomson Learning. Pp 7581.
- Odu, C. T. 1985. Environmental study (soil and vegetation) of the Nigerian Agip Oil company operation area, Nigerian Agip Oil Company Press.
- Onojake, M. C. and Osuji, L. C. 2012. Assessment of the physico-chemical properties of hydrocarbon contaminated soil. *Archives of Applied Science Resources*, 4(1): 48-58.
- Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science*, 25: 259-260.
- Udo, E. J. and Fayemi, A. A. 1975. The effect of oil pollution of soil on germination, growth and nutrient uptake of corn. *Journal of Environmental Quality*, 4: 537-540.
- US EPA. 2006, Landfarming. State of Mississippi. Department of Environmental Quality.
- Vidali, M. 2001. Bioremediation: An overview. Pure and Applied Chemistry. 73(7) 1163-1172.
- Vlassak, K. 1970. Total soil nitrogen and nitrogen mineralization. *Plant Soil* 32: 27-32. <https://doi.org/10.1007/BF01372843>
- Walkley, A. and Black, C. A. 1934. An examination for Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 34: 29-38.
- Wang, Y., Feng, J., Lin, Q., Lyu, X., Wang, X., & Wang, G. 2013. Effects of crude oil contamination on soil physical and chemical properties in Momoge wetland of China. *Chinese geographical science*, 23(6), 708-715.

