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# METAL CONTAMINATION RESULTING CHANGES IN PHYSICO-CHEMICAL PARAMETERS OF SURFACE SOIL AROUND OIL INSTALLATIONS OF SIVASAGAR DISTRICT OF ASSAM, INDIA

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## ABSTRACT

**Among the natural resources that are in the womb of nature crude oil is the most important mineral that is being used by all the nations of the world. Crude oil which is a conglomeration of variety of minerals when mixed with soil and water of the drilling sites, it changes the physico-chemical parameters of the soil and water. When penetrates into the soil, it directly affects its quality. In this study an increase in pH of the soil samples were recorded and expected because drilling fluids are rich in calcium which is a direct result of the use of calcium as an additive for preventing corrosion of the pipes. The present data indicates that Pb present in the soil samples ranges from 18.3 mg/Kg to 94.0mg/Kg which shows a deviation from the amount present in the control sample. The investigation shows that the amount of Co present in the soil of the adjoining areas of the oil drilling sites possess ten times more Co levels compared to control area. An increase in the amount of Cd can be seen with the maximum value of 49.6 mg/kg. An increase in the amount of Zn present in the soil is a major concern having a maximum value of 404.5 mg/Kg. For Mn the experimentally found ranges are 72.5 mg/kg to 510 mg/Kg.**

**KEY WORDS :** Drilling operation, Heavy metal, Pollution, Toxic

## INTRODUCTION

Crude oil and petroleum products are complex mixtures of hundreds of hydrocarbon compounds, ranging from light and volatile, short chained organic compounds to heavy, long chained, branched compounds. Hydrocarbons are mainly mixtures of straight and branched chain hydrocarbons, cycloalkanes and aromatic hydrocarbons. Crude oil is not a single chemical but is a collection of hundreds of widely different properties (Kisic *et al.,* 2009). It is such a mineral that the human civilization cannot dream of a single moment without its presence. Most crude oils from over millions of years from the remains of tiny aquatic plants and animals that are exposed to the combined effects of time and temperature. Crude oils are mixtures of different compounds most of which make up four main hydrocarbon groups (Hardaway *et al.,* 2004). Crude oil is the most important and predominant energy resource for humans and the raw material of various petroleum products which are essential for daily life (Sarma *et al.,* 2016).

The hydrocarbon industry all over the world is given paramount importance from global energy scenario point of view. In India, this industry is a premier industrial sector both from country's economic as well as energy requirement considerations. This in country production of hydrocarbon is much less than the requirement. Since there is a wide gapbetween supply and demand of hydrocarbon, therefore search for this fossil fuel is continuing since few decades and it will continue in a more vigorous manner in coming days. The waste drilling fluid, oily sludge and more specifically the formation water which are the byproducts generated along with various operations in hydrocarbon industry are major sources of pollutions. These pollutants find their way and transverse to various environmental receptors causing potential danger of polluting the same. The

water bodies, both surface and underground are more susceptible to such pollution in oil fields (Sahoo and Baruah, 2013).

80 elements of the periodic table are considered as metals out of which less than 30 elements have been showing the toxic effects. Heavy metals are characterized by strong attraction to biological tissue with slow elimination. Almost all metals are toxic at high levels and some are severely poisonous even at a very low concentration. Activities like mining and industrial processing are the main sources of heavy metal contamination in the environment. Under certain conditions these metals can accumulate to toxic concentration levels as they are non-bio degradable and non-thermo degradable.

It is undisputable that oil spill impacted lands and waters do experience declining productivity in farming and fishing. The immediate effect is the destruction of crops and marine life in the long run; it reduces the nutrient value of the soil and makes the waters inhabitable by fishes.

A pollutant is any substance in the environment, which causes objectionable effects, impairing the welfare of the environment, reducing the quality of life and may eventually cause death. Such a substance has to be present in the environment beyond a set or tolerance limit (Nagajyoti *et al.*, 2011). Assam and Assam Arakan Basin lies in the northeastern part of India and extends up to Myanmar and Bangladesh. It includes Assam plains, Cachar, Meghalaya, Nagaland, Mizoram, Manipur, Tripura and parts of Arunachal Pradesh encompassing an area of about 1.17 lakh square km in India. It is an established petroleum province and one of the oldest producing basins of the world. In oil and gas industry drilling is the only direct method of ascertaining the presence of hydrocarbons at a particular place. During the exploration and exploitation of petroleum resources of an area, the surrounding area has contaminated. The major waste products during drilling operations are generally brine, oil bearing water, the drilling mud, drill cuttings and various chemicals that are used during drilling and production operations besides emissions from gas flame (Begum, 2012).

## MATERIALS AND METHODS

A study was undertaken in the vicinity of oil drilling sites of Deudubi, Bhatiapar, Gaurisagar, Lakwa, Dimual, Patsaku, Laipling and Bordeudhai Nakatari in Sivasagar district of Assam to investigate some physico-chemical parameters through survey and filling up of questionnaires. An effort has been made to investigate factual information regarding crude oil pollution and its impact on soil and its physico-chemical properties in eight crude oil spill areas of major oil fields of upper Assam has selected. The experimentally calculated data are compared with control samples which were collected from a non-polluted area.

The aim of the present study was to investigate the different chemical forms of heavy metals in soil around oil installations, i.e. GGS and to assess the availability of certain metals like Cadmium (Cd), Cobalt (Co), Zinc (Zn), Manganese (Mn), Lead (Pb) in soil. The samples were collected in different seasons during 2015-2018. The study area of the present investigation are Deudubi oil field, Bhatia par oil field, Gaurisagar oil field, Lakwa oil field, Dimual oil field, Patsaku oil field, Laipling Oil field, Bordeudhai Nakatari oil field of Sivasagar district of upper Assam where oil exploration activities were conducted by oil and natural gas corporation limited (ONGCL) the soil samples from the study area were collected in a clean and dry wide mouthed transparent polythene bag (zipper bag) the sample packets were properly labeled indicating sample name, location of collection and the date of collection.

**Fig. 1.** Oil drilling affected soil

The soil samples were air dried and kept for some time to 100 °C for the removal of water. The samples were grounded with mortar to the definite mesh size and were utilized for further analysis. The soil pH was measured at the laboratory with the help of Deluxe pH meter-101. The heavy metals were estimated by using atomic absorption

spectrophotometry (AAS) with IS 3025 (Flame–AAS) instrument using the hollow cathode lamp as light source. Numerous studies have confirmed that the combination of these binary types of contaminants could present a great environmental threat to all biotic components of the ecosystem.

**Fig 2.** Oil drilling affected soil

## RESULTS AND DISCUSSION

The concentrations of five heavy metals (Cd, Co, Mn, Zn, Pb) in surface soil of different locations are listed in the Table 1. The ranges of the metal concentrations of the polluted area and their mean values are listed in Table 2. The analysis of the samples were carried out as per the standard experiments by APHA (1995) guidelines. The parameters which are concerned with the surface soil are pH, Cadmium (Cd), Cobalt(Co), Zinc(Zn), Manganese (Mn), Lead (Pb) were analyzed in the soil samples and compared with the control sample where no oil installations are present.

In the soil samples the element wise variations of the metal concentrations were analyzed and found to be complicated. The element wise variations in metal concentrations in different locations are as follows-

(1) For the area GAS2 the order of variation of concentration is in the order Zn > Mn > Cd > Mn > Co.

(2) For DMS2 area the order is Mn>Zn>Co>Pb>Cd which is same as the control sample.

**Table 2.** Concentrations of the metals are in mg/Kg unit

| Metal | Range (polluted) | Mean | Control |
|---|---|---|---|
| Cd | 14.5-39.6 | 24.6 | 7.8 |
| Co | 14.0-118.0 | 47.85 | 12.0 |
| Mn | 177.5-404.5 | 254.5 | 34.0 |
| Zn | 83.5-510.0 | 185.3 | 72.5 |
| Pb | 18.3-121.0 | 57.16 | 52 |

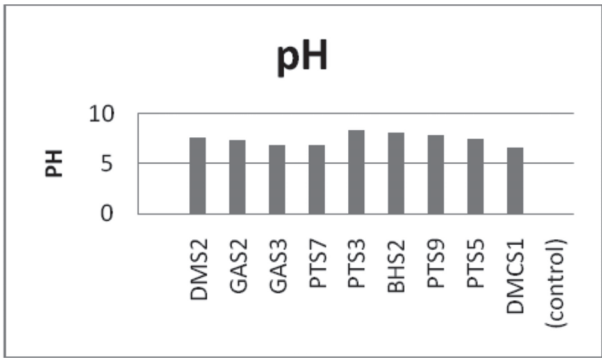


**Fig. 3.** pH vs location

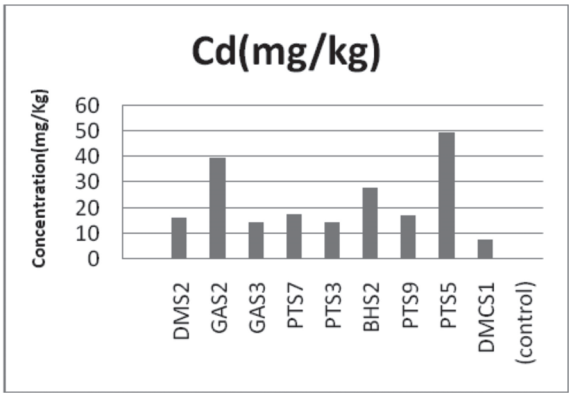


**Fig. 4.** Concentration of Cd (mg/Kg) vs location

**Table 1.** Concentrations of the metals are in mg/Kg unit

| Sample | pH | Cd | Co | Mn | Zn | Pb |
|---|---|---|---|---|---|---|
| DMS2 | 7.68 | 16.2 | 53.5 | 177.5 | 129.0 | 38.5 |
| GAS2 | 7.40 | 39.6 | 18.0 | 248.0 | 305.0 | 46.9 |
| GAS3 | 6.90 | 14.6 | 24.0 | 254.0 | 134.0 | 64.0 |
| PTS7 | 6.86 | 17.8 | 14.0 | 404.5 | 95.0 | 21.6 |
| PTS3 | 8.42 | 14.5 | 33.0 | 263.2 | 104.0 | 94.0 |
| BHS2 | 8.12 | 27.8 | 107.8 | 224.2 | 83.5 | 18.3 |
| PTS9 | 7.85 | 17.0 | 14.5 | 235.5 | 122.0 | 53.0 |
| PTS5 | 7.46 | 49.6 | 118.0 | 229.7 | 510.0 | 121.0 |
| DMCScontrol | 6.59 | 7.8 | 12.0 | 34.0 | 72.5 | 5.2 |

(3) For GAS3 and PTS3 Mn>Zn>Pb>Co>Cd is showing the metal concentration variation.
(4) For PTS7 area the order is Mn > Zn > Pb > Cd > Co which is same as the PTS9 area.
5) For the mean values of the metal concentrations it canbe observed that compared to the other metal concentrations Mn and Zn concentration values are comparatively high.

From the above data it can be observed that the pH of the soil samples collected ranges from 6.59 to 8.42. An increase in pH was recorded maximum in PTS3 of Patsaku area. Table 1 describes statistically significant differences in soil pH, compared to control sample. An increase in pH was recorded involving application of drilling fluids which was expected because drilling fluids are rich in calcium. Increased calcium levels in drilling fluids are a direct result of the use of calcium as an additive for preventing corrosion of oil/gas pumping pipes and for raising fluid density during drilling (Kisic *et al.*, 2009).

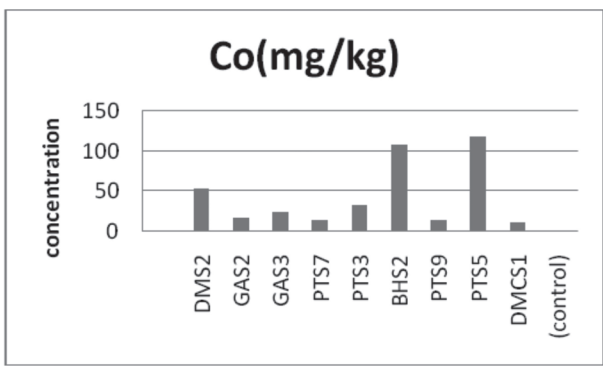


**Fig. 5.** Concentration of Co (mg/Kg) vs location

Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reason. The term heavy metals refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Nagajyoti *et al.*, 2011). Moreover, toxic heavy metals enter the food chain due to the uptake and accumulation by crops, posing a potential threat to human health. The spillage of oil, untreated formation and drilling water from oil is a major threat to the human ecosystem. During the monsoon, the water flows through the low lying area and causes extensive damage to water bodies and agricultural (grazing land). The overflowing water acts as a carrier of the contaminated brines and other waste products from these oil installations. The metals under consideration were selected on the basis of site specific geochemical studies and their expected relationship with the oil field development activities. This results showed a considerable amount of the presence of the metals in the soil. The reason behind this occurrence is the wide use of chemicals containing heavy metals discharged into the environment as a result of the petroleum production and exploration activities (Kotoky *et al.*, 2009).

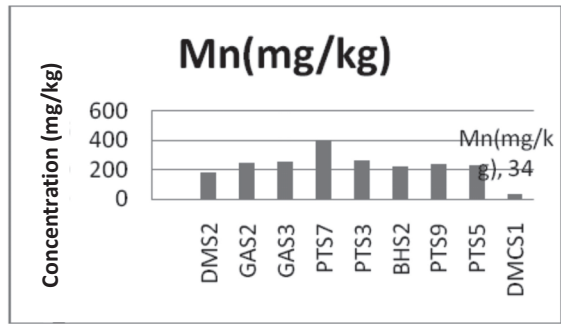


**Fig. 6.** Concentration of Mn (mg/Kg) vs location

The amount of lead in soil of the sampled areas varies from 5.2- 121.0 mg/kg. These values are higher than toxicity Characteristic Leachate Limits (TCL) of 5.00 mg/kg for Lead. Lead is toxic to many plants species, although a few are relatively tolerant, when ingested, lead can cause a disease called Plumbism, lead also is known to damage the brain, the central nervous system, kidney, liver and the reproductive system. Waste products from the use of chemicals like pipe lax, lube 106 and other lubricants like diesel oil which are used in the production of petroleum result in pollution of soils by lead. Natural occurring concentration by lead in soil ranges from 2 to 20 mg/kg (Asia *et al.*, 2007).

Zinc can be a pollutant, especially in areas close to industrial plants engaged in processing of petroleum because zinc is directly added to the drilling fluids

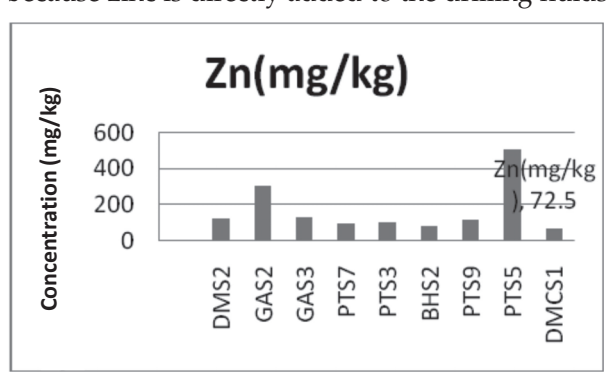


**Fig. 6.** Concentration of Zn (mg/Kg) vs location

as zinc carbonate and act as corrosion inhibitor for mud formations and part of the zinc can be trapped by the soil layer. Zinc is an essential element in our diet too little zinc can cause problems but too much zinc is also harmful. Large doses taken by mouth even for a short time can cause stomach cramps, nausea and vomiting. Taken longer, it can cause anemia and decrease the levels of good cholesterol. Inhaling large amounts of zinc (as dusts or fumes) can cause a specific short term disease called metal fume fever (Asia *et al.,* 2007).

Cadmium above the permissible limit can potentially cause nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbance, liver injury and shock and ranal failure along with kidney, liver, bone and blood damage from a lifetime exposure (Chakraborty *et al.,* 2010).

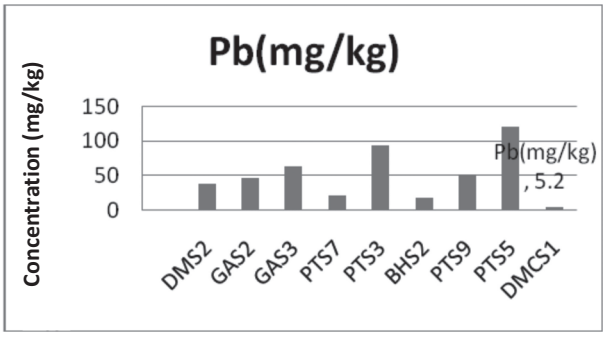


**Fig. 7.** Concentration of Pb (mg/Kg) vs location

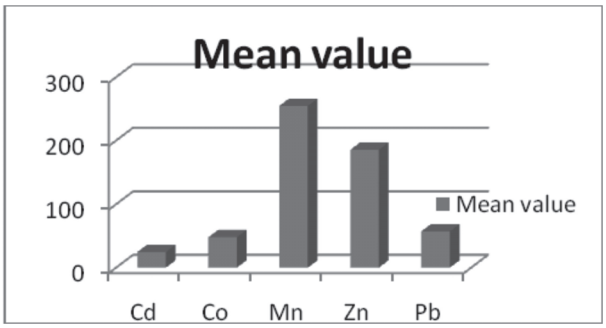


**Fig. 8.** Mean values of the metal concentrations

Manganese is a metal having relatively low toxicity to human being can cause acute poisoning effect at higher concentrations. The neurological disorder known as magnesium results from exposure of Mn dust fume to occupational workers. Effects of Mn can decrease the systolic blood pressure, disturbed excretion of 17-ketosteroids, change in erythroporsis and granulocyte formation (Sarma *et al.,* 2005).

## CONCLUSION

Oil drilling sites are a major source of PAH and heavy metal pollution but suffers from poor management and lack of environmental controls which in turn may have a significant impact on the surrounding environment (Sarma *et al.,* 2005). In upper Assam area the crude oil drilling sites of Sivasagar district are mostly adjacent to the rice fields and tea gardens. So it is a common feature that these regions suffer from accidental spillage during drilling and subsequent contamination of tea and rice fields. The tea plants normally grow in acidic soil and become prone to accumulate heavy metals which are toxic in their system. The exploration and production activities associated with oil drilling have introduced a lot of heavy metals into the surface soil and surface water as well as ground water of the drilling sites. It is suggested that remediation process such as bioremediation process be carried out so as to render the polluted surface soil and surface water as well as ground water fit for the use of mankind especially for agricultural and domestic purposes.

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