Original Research Article

Impact of Gas Flaring on Physico-Chemical Properties of Soil under Tea Plantation in Assam

ABSTRACT

Gas flaring is a major contributor to the emission of toxic gases and other gaseous pollutants into the atmosphere. A study entitled "Impact of gas flaring on physico-chemical properties of soil under tea plantation in Assam" The experimental plot was laid out in 5 x 2 factorial RCBD. The experiment was carried out in small tea grower's gardens adjacent to OCS-6 at Merbil Majuli and Kothaloni OCS in Dibrugarh district of Assam in the year 2019-20. The experimental plots were laid out at 11 metres away from the gas flaring point. Plots were selected at an interval of 20 metres within the experimental design i.e. D_1 (11-31m), D_2 (31-51m), D_3 (51-71m), D_4 (71-91m) and D_C (120-140m) where, D_C denotes control plot. Soil samples for the study were obtained for two tea growing season i.e. rainy and autumn season from the selected gardens. Soil physical parameters such as bulk density, porosity, hydraulic conductivity, soil temperature and soil moisture and chemical parameters such as pH, organic carbon content, available NPK and electrical conductivity of both effected and control plots were evaluated in the laboratory to check the effect of gas flaring and the results obtained were compared with those from the control plot. The results showed that the soil temperature, soil moisture content, soil organic carbon and available NPK of both Merbil Majuli and Kothaloni were significantly affected by gas flaring with respect to distances. But, the bulk density, soil porosity, hydraulic conductivity, soil pH and electrical conductivity of soil were not affected by gas flaring.

Keywords: Gas Flaring, Tea soil, Soil temperature, Soil moisture, Available NPK

1. INTRODUCTION

Gas flaring is done for the easy disposal of the products of oil drilling operations. It is burning of natural gas and other petroleum hydrocarbons in flare stacks. When gas is burnt, a number of combustible products are formed. Gas stream leaks out of the open territories which includes essentially of methane which is entirely ignitable and form explosive mixtures once exposed to the outside. A gas flare found at oil and gas wells, rigs, refineries, chemical plants, gas plants, and landfills are petrochemical eliminate gas (Akpojivi et al., 2005) [1].

Gas flaring is likely to affect adversely physical, chemical and biological properties of soil. Soil properties such as pH, organic carbon content, major nutrient content viz. N, P and K and dehydrogenase enzyme activity are reported to be affected by gas flaring (Akpojivi et al., 2005). Contamination due to natural gas production operations is severely affecting the tea industry of Assam by causing reduction in production and quality of tea due to its close proximity to oil fields.

In upper Assam oil fields, large quantities of gas keep on spouting out from the oil fields every day. A small fraction of this gas is used in factories for manufacture of tea, in generation of electricity and domestic purposes and rest is flared out. The harmful effect of flaring is widespread, particularly its effects in the ecosystem. Investigation of different scientists on impact of gas flaring on soil health revealed that flaring and venting of related gas contributed to greenhouse gas emissions with negative effects on the earth (Ismail et al., 2012). [7]

Recently, specific attention is received in paddy and tea plantation, since most of the oil fields are located in tea and paddy growing belts. But little research works have been done on this aspect. There is an urgent need to study the impact of gas flaring on tea plantation with a holistic approach to find a solution to this problem. Therefore, through this research work an attempt has been made to study the impact of gas flaring released nearby oil fields on soil health under tea plantations adjacent to oil field.

2. MATERIAL AND METHODS

Soil samples were collected from tea growing areas adjacent to Merbil Majuli OCS-6 and Kothaloni OCS, Dibrugarh, Assam in the year 2019-20. Experiment design RCBD with 5 distances and 3 replications was laid out in both the locations. Collection of soil samples were carried out in two seasons viz. Rain flush (S_1) and Autumn flush (S_2). In each season samples were collected at four distances from the flare site with an interval of 20 m at distances D_1 (11-31m), D_2 (31-51m), D_3 (51-71m) and D4 (71-91m) starting from the gas flaring point in Merbil Majuli OCS-6 and distances of D_1 (36-56m), D_2 (56-76m), D_3 (76-96m) and D_4 (96-116m) in Kothaloni OCS. Soil sample was also collected from control plot observed at 150-170m from the flare point. The laboratory works were carried out in the Department of Tea Husbandry & Technology, Assam Agricultural University, Jorhat-13, Assam.

2.1 Soil Physical properties

2.1.1 Bulk density

For determining bulk density the gravimetric method was used, as described by Blake and Hartge, 1986. [4] The determination of bulk density consists of drying (105°C) and weighing a soil sample, the volume of which is known (core method) or must be determined. It is expressed in Mg m^{-3}.

$$\text{Bulk Density} = \frac{\text{Weight of dry soil (Mg)}}{\text{volume of dry soil (m}^{-3}\text{)}}$$

2.1.2 Porosity

Total porosity was determined by using Keen Rackzowski box following the method as described Baruah and Borthakur (1997). [3] It is expressed in terms of ratio or percentage
f = Vf/Vt
Where, f = porosity, Vt = soil bulk volume and Vf = volume of the pores

2.1.3 Hydraulic Conductivity

Hydraulic conductivity was determined by the constant head parameter using undisturbed soil core samplers as described by Baruah and Borthakur(1997) and expressed as cm min-1 as shown below:

KS = QL/At ΔH

Where, KS = Hydraulic conductivity, Q = Volume of water collected (cm3), L = Length of soil column (cm), A = Cross sectional area of the soil column (cm2) equivalent to area of core, t = Time (minute), ΔH = Hydraulic head difference (cm).

2.1.4 Soil temperature

Soil temperature was measured by using soil thermometer

2.1.5 Soil moisture

The amount of water is determined by subtracting the dry weight from the initial weight, and the moisture content is then calculated as the amount of water divided by the dry weight.

2.2 Soil Chemical properties

2.2.1 Soil pH

Determination of soil pH was conducted using a glass electrode pH meter, Jackson (1973). [8]

2.2.2 Organic carbon content

Soil organic carbon was determined by using Titrimetric determination (Walkley and Black, 1934) [9] and was expressed in percentage.

2.2.3 Electrical conductivity

Electrical conductivity of the soil was measured at a soil: water ratio of 1:2.5 by the help of EC meter (Jackson, 1973) and was expressed as deciSiemens/metre (dSm-1).

2.2.4 Available nitrogen

The estimation of available nitrogen was done by Kjeldahl’s method as described by Jackson (1973).

2.2.5 Available phosphorous

The estimation of available phosphorous was determined by Bray’s method as described by Jackson (1973) and was determined in kg ha-1.

2.2.6 Available potassium

The estimation of Available potassium was determined by extracting the soil with ammonium acetate and the potassium is determined by flame photometric method as described by Jackson (1973).

3. RESULTS AND DISCUSSION

3.1 Soil Physical parameters

3.1.1 Bulk density

Bulk density of soil of both Merbil Majuli and Kothaloni had no significant variation for both distances and seasons from the gas flaring site. (Table 1 & 2)

3.1.2 Soil porosity

Soil porosity of both the locations had no significant variation for both distances and seasons from the gas flaring site. (Table 1 & 2)

3.1.3 Hydraulic conductivity

Hydraulic conductivity of soil of both the locations had no significant variation for both distances and seasons from the gas flaring site. (Table 1 & 2)

3.1.4 Soil temperature

Soil temperature at both the locations varied significantly for different distances from the gas flaring site but no significant variation was observed among the seasons at Merbil Majuli, during both rainy season (S_1) and autumn season (S_2). The soil temperature was recorded lowest (25.23^oC & 26.22^oC) at distance D_C (150-170 m), whereas highest (29.33^oC & 30.33^oC) was recorded at distance D_1 (11-31m). In case of Kothaloni during both rainy and autumn season the soil temperature was recorded lowest (26.77^oC & 27.00^oC) at distance D_C (150-170m), whereas highest (29.33^oC & 29.00^oC) was recorded at distance D_1 (36-56m). (Table 1 & 2)

3.1.5 Soil Moisture

Soil moisture varied significantly with distance from the gas flaring site but no significant variation was observed among the seasons. At Merbil Majuli, the soil moisture was recorded lowest (11.71% & 11.93%) at distance D_1 (11-31 m) at both the seasons, whereas highest (15.55% & 14.26%) was recorded at distance D_C (150-170 m) at both the seasons. In Kothaloni the soil moisture was recorded lowest (11.51% & 11.37%) at distance D_1 (36-56m) during both rainy (S_1) and autumn season (S_2), whereas it was recorded highest (15.38% & 15.32%) at distance D_C (150-170m). (Table 1 & 2)

3.2 Soil chemical parameters

3.2.1 Soil pH

Soil pH of both Merbil Majuli and Kothaloni had no significant variation for both distances and seasons from the gas flaring site. (Table 3 & 4)

3.2.2 Soil organic carbon

Soil organic carbon varied significantly at various distances from the gas flaring site but no significant variation was observed among the seasons. At Merbil Majuli the soil organic carbon was recorded lowest (0.80% & 0.79%) at distance D_1 (11-31 m) at both the seaosns, whereas highest (0.87% & 0.85%) was recorded at distance D_C (150-170 m). In Kothaloni the soil organic carbon was recorded lowest (0.82% & 0.82%) at distance D_1 (36-56m) and highest (0.83% & 0.85%) at distance D_C (150-170m) for both seasons. (Table 3 & 4)

3.2.3 Electrical conductivity

Electrical conductivity of soil of both Merbil Majuli and Kothaloni had no significant variation for both distances and seasons from the gas flaring site. (Table 3 & 4)

3.2.4 Available nitrogen

Available nitrogen in soil showed significant variation for distances from the gas flaring site but no significant variation was observed among the seasons. At Merbil Majuli during both rainy season (S_1) and autumn season (S_2) the available nitrogen in soil was recorded lowest (245.66kg/ha & 242.66 kg/ha) at distance D_1 (11-31 m), whereas highest (255.00 kg/ha & 252.00 kg/ha) was recorded at distance D_C (150-170 m). For rainy and autumn season at Kothaloni the available nitrogen was lowest (242.00kg/ha & 244.00 kg/ha) at distance D_1 (36-56m) and highest (245.33kg/ha & 245.67 kg/ha) at distance D_C (150-170m) at rainy and autumn seasons. (Table 3 & 4)

3.2.5 Available phosphorus

Available phosphorus in soil varied significantly at various distances from the gas flaring site but no significant variation was observed among the seasons. At Merbil Majuli, during rainy season (S_1) and autumn season (S_2) the available phosphorus in soil was recorded lowest (13.80kg/ha & 13.81 kg/ha) at distance D_1 (11-31m), whereas highest (14.88 kg/ha & 14.85 kg/ha) was recorded at distance D_C (150-170 m). In Kothaloni the available phosphorus was recorded lowest (14.04kg/ha & 14.09kg/ha) at distance D_1 (36-56m) and highest (14.11kg/ha & 14.13kg/ha) at distance D_C (150-170m) at rainy and autumn season. (Table 3 & 4)

3.2.6 Available potassium

Available potassium in soil varied significantly at various distances from the gas flaring site but no significant variation was observed among seasons. At Merbil Majuli, during both rainy season (S_1) and autumn season (S_2) the available potassium in soil was recorded lowest (255.00 kg/ha & 254.33 kg/ha) at distance D_1 (11-31m), whereas highest (269.44 kg/ha & 267.25 kg/ha) was recorded at distance D_C (150-170m). In Kothaloni the available potassium was recorded lowest (251.67 kg/ha & 252.67kg/ha) at distance D_1 (36-56 m) and highest (256.00 kg/ha & 261.33 kg/ha) at distance D_C (150-170m) at rainy and autumn season. (Table 3 & 4)

Gas flaring activities carried out in the oil fields near the tea gardens may affect the soil physico-chemical properties. Considering the aspects mentioned above the present research work was conducted to study the impact of gas flaring released by nearby oil fields with probable effect on soil physico-chemical properties under tea plantation. Results from both the location of study, Merbil Majuli OCS-6 and Kothaloni OCS corroborated with each other. The results revealed that the impact was more pronounced in the vicinity of flaring site. Affect was observed on some of the soil physical parameters such as soil temperature, increases (29.33^{o}C & 30.33^{o}C and 29.33^{o}C & 29.00^{o}C respectively for Merbil Majuli OCS-6 and Kothaloni OCS) near the flaring site in both the seasons and decreases (25.23^{o}C & 26.22^{o}C and 26.77 ^{o}C & 27.00^{o}C) significantly away from the flaring site it might be due to the dark colour of the soil which absorbs more heat, Atuma et al. (2013).[2] The soil moisture decreases (11.71% & 11.93% and 11.51% & 11.37% respectively for Merbil Majuli OCS-6 and Kothaloni OCS) near the flaring site and increases (15.5% & 14.26% and 15.38% & 15.32%) significantly away from the flaring site. Increase in soil temperature near the flare site might have decreased the soil moisture, Ernest et al. (2015).[6] Some of the soil chemical parameters like soil organic carbon content was low (0.80% & 0.79% and 0.82% &

0.82% respectively for Merbil Majuli OCS-6 and Kothaloni OCS) near the flaring point and increases (0.87% & 0.85% and 0.83% & 0.85%) significantly away from the flaring point, it might be due to the less return of plant residues into soil closer to the flare stack, due to which the return of nutrients to the soil got reduced resulting in an impoverished soil, Ejiogu et al. (2019) [5] and available NPK in the soil was recorded low (245.66kg/ha & 242.66kg/ha and 282.00 & 244.00), (13.80kg/ha & 13.81kg/ha and 14.04kg/ha & 14.09kg/ha), (255.00 kg/ha & 254.33 kg/ha and 259.67kg/ha & 252.67 kg/ha respectively for Merbil Majuli OCS-6 and Kothaloni OCS) near the flaring site and increases (255.00 kg/ha & 252.00 kg/ha and 245.33kg/ha & 245.67kg/ha), (14.88kg/ha & 14.85kg/ha and 14.11 kg/ha & 14.13kg/ha), (269.44 kg/ha & 267.25 kg/ha and 256.00kg/ha & 261.33kg/ha) away from the flaring site. It might be due to low soil organic matter content. The acidic condition of the soil and induced decomposer microbial activity in the flare zone have affected the available NPK content of the soil, Akpojivi et al. (2005). But flaring had no significant affect on bulk density, soil porosity, hydraulic conductivity, soil pH and electrical conductivity of soil in both the locations of study.

Table 1. Effect of gas flaring on soil physical parameters of Merbil Majuli OCS-6

Distances	Bulk Density (Mg/m3)		Soil Porosity (%)		Hydraulic conductivity (cm/min)		Soil Temperature (^oC)		Soil Moisture (%)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
D1(11-31 m)	1.22	1.23	45.00	44.10	0.33	0.32	29.33	30.33	11.71	11.93
D2(31-51 m)	1.21	1.22	45.00	45.13	0.31	0.32	28.66	29.00	12.32	12.30
D3(51-71 m)	1.22	1.22	46.23	46.06	0.31	0.32	27.33	27.66	12.88	11.75
D4 (71-91 m)	1.21	1.21	47.20	47.14	0.31	0.32	26.33	26.66	15.47	14.16
$\mathbf{D_C}$ (150-170 m)	1.22	1.21	48.25	48.10	0.30	0.31	25.33	26.22	15.55	14.26
CD(factor D)	NS		NS		NS		0.857		1.742	
CD(factor S)	NS		NS		NS		NS		NS	

Significant at 5% probability level

Table 2. Effect of gas flaring on soil physical parameters of Kothaloni OCS

Distances	Bulk Density (Mg/m3)		Soil Porosity (%)		Hydraulic conductivity (cm/min)		Soil Temperature (^oC)		Soil Moisture (%)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
D1(36-56 m)	1.19	1.18	46.06	46.67	0.32	0.33	1.19	1.18	46.06	46.67
D2 (56-76 m)	1.18	1.19	46.73	46.76	0.32	0.32	1.18	1.19	46.73	46.76
D3 (76-96 m)	1.20	1.19	46.33	45.97	0.32	0.31	1.20	1.19	46.33	45.97
D4 (96-116 m)	1.20	1.17	46.67	48.33	0.32	0.31	1.20	1.17	46.67	48.33
DC(150-170 m)	1.18	1.16	47.33	48.23	0.31	0.31	1.18	1.16	47.33	48.23
CD(factor D)	NS		NS		NS		0.655		1.88	
CD(factor S)	NS		NS		NS		NS		NS	

Significant at 5% probability level

Distances	Soil pH		Soil Organic Carbon (%)		Electrical Conductivity (dS/m)		Available Nitrogen (kg/ha)		Available Phosphorus (kg/ha)		Available Potassium (kg/ha)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
D1 (11-31 m)	5.00	4.92	0.80	0.79	0.35	0.34	245.66	242.66	13.80	13.81	255.00	254.33
D2 (31-51 m)	5.13	5.07	0.81	0.80	0.40	0.36	248.66	247.00	14.36	14.27	257.00	257.00
D3 (51-71 m)	5.15	5.19	0.85	0.83	0.32	0.30	251.66	248.00	14.39	14.82	264.00	262.00
D4 (71-91 m)	5.19	5.11	0.85	0.84	0.29	0.27	254.00	249.33	14.87	14.82	269.00	267.00
D$_C$(150-170 m)	5.24	5.11	0.87	0.85	0.24	0.26	255.00	252.00	14.88	14.85	269.44	267.25
CD (factor D)	NS		0.02		NS		1.588		0.478		1.965	
CD (factor S)	NS		NS		NS		NS		NS		NS	

Table 3. Effect of gas flaring on soil chemical parameters of Merbil Majuli OCS-6

**Significant at 5% probability level*

Table 4. Effect of gas flaring on soil chemical parameters of Kothaloni OCS

Distances	Soil pH		Soil Organic Carbon (%)		Electrical Conductivity (dS/m)		Available Nitrogen (kg/ha)		Available Phosphorus (kg/ha)		Available Potassium (kg/ha)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
D1 (36-56 m)	5.15	5.11	0.82	0.82	0.35	0.33	242.00	244.00	14.04	14.09	251.67	252.67
D2 (56-76 m)	4.97	4.98	0.82	0.84	0.39	0.35	243.00	252.00	13.90	14.22	260.00	262.00
D3 (76-96 m)	5.18	5.14	0.83	0.80	0.31	0.30	241.33	249.33	14.43	14.03	254.67	257.33
D4 (96-116 m)	5.11	5.03	0.81	0.83	0.27	0.27	249.33	277.00	14.03	14.14	256.33	259.00
DC (150-170 m)	4.97	5.04	0.83	0.85	0.39	0.30	245.33	245.67	14.11	14.13	256.00	261.33
CD (factor D)	0.03		NS		1.590		0.465		1.955		0.03	
CD (factor S)	NS		NS		NS		NS		NS		NS	

Significant at 5% probability level

4. CONCLUSION

The present investigation revealed that the gas flaring had significant effect on some physical and chemical properties of tea soil i.e. soil temperature, soil moisture, soil organic carbon and available NPK beyond 71m and 96m from the gas flaring point and some other properties of soil such as bulk density, soil porosity, hydraulic conductivity, soil pH and electrical conductivity were not affected by gas flaring at any distance from the flaring point.

The study is inconclusive about affect of gas flaring on total soil health for over a longer period of time. It needs to be studied thoroughly with a holistic approach.

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