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Impact Assessment of Soil Parameters Affected by Gas Flaring in Tea Garden in Dibrugarh District of Assam, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The gas flare is considered as the challenging and environmental problem and hence this experiment was taken to study the physical and chemical properties of soil of tea garden effected by gas flare located in south of Kothaloni OCS in Dibrugarh district of Assam during September 2019-March 2020. The design selected was Randomized Complete Block Design (RCBD). The soil samples were collected from (40-50) metres, (50-60) metres, (60-70) metres, (70-80) metres and control site (150-160) metres away from the flare site in two different seasons namely autumn and rainy seasons. Soil physical parameters such as soil temperature, soil moisture ,bulk density, porosity, hydraulic conductivity and soil chemical parameters sucha as pH, organic carbon content, electrical conductivity, available nutrients (NPK) were studied. Soil temperature recorded highest (29.83°C) at distance (40-50) metres away from the gas flaring site and decreased with its increased distances from the flaring site while soil moisture recorded lowest (11.48%) at distance (40-50) metres which increased with far away distances from the flaring site. Rest of the studied soil parameters *viz*., bulk density, porosity, hydraulic conductivity, pH, organic carbon content, electrical conductivity and available nutrients (NPK) recorded non significant variations along distances and seasons.

Keywords: Gas flare; tea; physical and chemical soil parameters.

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1.INTRODUCTION

Assam is famous for oil industries and many tea estates are located near the oil industries. Low pressure natural gas is burnt in the air during the crude oil extraction process [1]. Gas flaring affected the soil physical and chemical properties in its vicinity [2]. Odjugo and Osemwenkhae [3] reported that the air and soil temperature, bulk density and sand content of the soil increased near the flaring site. Okeke and Okpala [4] reported that soil quality parameters such as bulk density and temperature decreased while moisture content and organic matter increased with distances away from the flare point. Soil nutrients were found to be lower near the gas flaring site in comparison to the control sites Izombe and Eket area of the Niger Delta [4]. Variations in the soil characteristics mainly the characteristics that were related to nutrients affected the productivity of crop indirectly [4]. In the vicinity of gas flaring site, soil temperature was reported to be high and it affected the top soil. Soil moisture was found to be decreased near the gas flare due to the heat from the flare and increased in the distances away from the gas flare [5]. Exchangeable cation or base was low in soils in vicinity of gas flaring site [6,7]. Hydraulic conductivity of soil was found to be increased [8,9] and soil organic carbon to be decreased [3,10] near the gas flaring site. Atuma and Ojeh [10] reported that the soils near gas flaring site of Ebedei in Niger Delta had low electrical conductivity, Phosphorous, Nitrogen, Potassium and Sodium. Soil pH in Nigeria were more acidic and available nitrogen, total organic carbon and available phosphorus of the soil decreased near the flaring site [11,12].

Research work is limited in this area, a study was thus conducted to know the effect of gas flaring in soil of tea garden south of Kothaloni OCS in Dibrugarh district of Assam, India with the objective of its impact on soil physical and chemical properties.

2. MATERIALS AND METHODS

2.1 Characteristics of Study Area

Location selected was a tea garden south of Kothaloni OCS, Dibrugarh district and the study was done during September 2019-March 2020. The location was situated at 27°37′97″N latitude and 95°09′30″E longitude at an elevation of 108 m above mean sea level. The mean minimum and maximum temperature of the studied area was 19.30^{o}C and 29.40^{o}C respectively.

2.2 Experimental Techniques

2.2.1 Sampling sites

Randomized Complete Block Design was selected as experimental design. Soil samples were collected from five distances viz., D1(40-50) metres, D2(50-60) metres, D3(60-70) metres, D4(70-80) metres and control site DC (150-160) metres away from the gas flaring site in rainy and autumn seasons. The garden was selected at 40 metres away from the flare site because of the presence of a pond in between the tea garden and the flare site.

Soil samples were collected by using soil auger and the laboratory works were done in the laboratory of Department of Tea husbandry and Technology, Assam Agricultural UniversityJorhat, Assam,India.

2.2.2 Soil physical parameters

2.2.2.1 Soil temperature

Soil temperature was measured by using soil thermometer and expressed as degree Celsius (°C).

2.2.2.2 Soil moisture

Subtracting the dry weight from the initial weight gives the amount of water which is further divided by dry weight to give the moisture content. It was expressed as percentage (%).

2.2.2.3 Bulk density

Bulk density was determined by using gravimetric method with core sampler method [13] and expressed as g cm^{-3}.

2.2.2.4 Porosity

Porosity was determined using the formula {1-(Bulk density/Particle density)}×100 and was expressed as percentage (%).

2.2.2.5 Hydraulic conductivity

Hydraulic conductivity (K_S) measurement was carried out by the constant head parameter using undisturbed soil cores as mentioned by Baruah and Borthakur [14]. Its unit is cm min^{-1} and expressed as

$$K=QL/At\Delta H$$

Where,
Q= Volume of water collected (cm^3), A= Cross sectional area of the soil column (cm^2) equivalent to area of core, L= Length of soil column (cm), t= Time (time in minute)

ΔH= Hydraulic head difference (cm)

2.2.3 Soil chemical parameters

2.2.3.1 Available nitrogen

The estimation of available nitrogen was done by Modified Kjeldahl method as described by Jackson [15] and can be expressed as kg/ha.

2.2.3.2 Available phosphorus

The estimation of available phosphorus was done by Bray's No.1 method as described by Jackson [15] and can be expressed as kg/ha.

2.2.3.3 Available potassium

The estimation of available potassium was done by Flame Photometric method as described by Jackson [15] and can be expressed as kg/ha.

2.2.3.4 Electrical Conductivity

Soil: water ratio of 1:2.5 with the help of EC meter [15] determined the electrical conductivity of the soil and it can be expressed as dS/m.

2.2.3.5 Soil pH

Soil pH was determined electrochemically with the help of glass electrode pH meter as suggested by Jackson [15].

2.2.3.6 Organic carbon content

Soil organic carbon was determined by Walkley and Black's titration method as described by Jackson [15] and can be expressed as percentage (%).

3. RESULTS AND DISCUSSION

3.1 Physical parametrs of soil

3.1.1 Soil temperature

Soil temperature had shown significant variation among distances. Significant variations were observed between all the distances except D_3 and D_4, D_4 and D_C. Mean temperature value was found to be highest at distance D_1 (29.83°C) which decreased with increased distances from the flaring site and the lowest value was found in D_C (26.49°C) as recorded in Table 1. The dark colour of the soil may be one of the reasons for higher soil temperature near the gas flaring site that absorbed more heat [10]. The findings were supported by the findings of Odjugo and Osemwenkhae [3], Okeke and Okpala [4] and Orji et al. [5]. There was no significant variation observed in seasons.

3.1.2 Soil moisture

Soil moisture had shown significant variation among distances. Significant variations were observed between all the distances except D_3 and D_4, D_3 and D_C, D_4 and D_C. A minimum mean value was recorded at D_1 (11.48%) which gradually increased with increase in distances from the flare site and the highest value was found in D_C (15.35%) as mentioned in Table 2. The increased soil temperature decreased the water viscosity by allowing more water to percolate through the soil profile and thus reduced the soil moisture [16,17]. These findings are in confirmation with the study of Odjugo and Osemwenkhae [3], Okeke and Okpala [4] and Orji et al. [5]. Soil moisture had no significant variations in seasons.

3.1.3 Bulk density and porosity of soil

Bulk density and porosity of soil had shown no significant variations along distances and seasons as mentioned in Table 3 and 4 respectively.

3.1.4 Hydraulic conductivity

Hydraulic conductivity of soil had shown no significant variations along distances and seasons in south of Kothaloni OCS (Table 5).

3.2 Soil chemical parameters

3.2.1 Available nutrients (nitrogen, phosphorus and potassium)

There was no significant differences seen in distance and season in available nitrogen, phosphorus and potassium of soil as shown in Table 6,7 and 8 respectively.

3.2.2 Electrical Conductivity

Electrical conductivity of soil had shown no significant variations along distances and seasons (Table 9).

Table 1. Soil temperature of tea as affected by gas flaring

Seasons / Distances (m)	Soil temperature (°C)			
	Rainy season(S1)	**Autumn season (S2)**		**Mean**
D_1(40-50)	29.33	30.33		29.83
D_2(50-60)	28.66	29.00		28.83
D_3(60-70)	27.33	27.66		27.49
D_4(70-80)	26.66	27.00		26.83
D_C(150-160)	26.33	26.66		26.49
Mean	27.66	28.13		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance (D)	0.77	0.36	0.26	S
Season (S)	N/A	0.23	0.16	NS
Distance X Season (DXS)	N/A	0.51	0.36	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 2. Soil moisture of tea as affected by gas flaring

Seasons / Distances (m)	Soil moisture (%)			
	Rainy season (S1)	**Autumn season(S2)**	**Mean**	
D_1(40-50)	11.61	11.36	11.48	
D_2(50-60)	12.33	12.31	12.32	
D_3(60-70)	15.27	14.83	15.05	
D_4(70-80)	15.12	15.03	15.07	
D_C(150-160)	15.38	15.32	15.35	
Mean	13.94	13.77		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	0.50	0.24	0.17	S
Season(S)	N/A	0.15	0.11	NS
Distance X Season (DXS)	N/A	0.34	0.29	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 3. Bulk density of soil as affected by gas flaring

Seasons / Distances (m)	Bulk density (g/cm^3)			
	Rainy season(S1)	**Autumn season(S2)**		**Mean**
D_1(40-50)	1.15	1.18		1.16
D_2(50-60)	1.19	1.19		1.19
D_3(60-70)	1.20	1.18		1.19
D_4(70-80)	1.14	1.19		1.16
D_C(150-160)	1.18	1.15		1.16
Mean	1.17	1.17		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.013	0.009	NS
Season(S)	N/A	0.008	0.006	NS
Distance X Season(DXS)	N/A	0.018	0.013	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 4. Porosity of soil as affected by gas flaring

Seasons / Distances (m)	Porosity (%)			
	Rainy season (S1)	**Autumn season (S2)**	**Mean**	
D1(40-50)	46.36	45.23	45.79	
D2(50-60)	45.90	45.90	45.90	
D3(60-70)	45.45	46.36	45.90	
D4(70-80)	45.90	45.71	45.80	
DC(150-160)	45.23	46.36	45.79	
Mean	45.76	45.91		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.51	0.36	NS
Season(S)	N/A	0.32	0.23	NS
Distance X Season(DXS)	N/A	0.72	0.51	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 5. Hydraulic conductivity of soil as affected by gas flaring

Seasons / Distances(m)	Hydraulic conductivity (cm/min)			
	Rainy season(S1)	**Autumn season (S2)**		**Mean**
D1(40-50)	0.32	0.33		0.32
D2(50-60)	0.32	0.32		0.32
D3(60-70)	0.32	0.31		0.32
D4(70-80)	0.32	0.31		0.31
DC(150-160)	0.31	0.31		0.31
Mean	0.31	0.31		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.00	0.00	NS
Season(S)	N/A	0.00	0.00	NS
Distance X Season (DXS)	N/A	0.01	0.00	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 6. Available nitrogen of soil as affected by gas flaring

Seasons / Distances (m)	Available Nitrogen (kg/ha)			
	Rainy season (S1)	**Autumn season (S2)**	**Mean**	
D1(40-50)	243.66	242.33	242.99	
D2(50-60)	242.66	245.00	243.83	
D3(60-70)	241.66	245.33	243.49	
D4(70-80)	246.00	241.33	243.66	
DC(150-160)	243.33	244.00	243.66	
Mean	243.46	243.59		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	1.611	1.139	NS
Season(S)	N/A	1.019	0.721	NS
Distance X Season (DXS)	N/A	2.279	1.611	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 7. Available phosphorous of soil as affected by gas flaring

Seasons / Distances (m)	Available Phosphorous content (kg/ha)			Mean
	Rainy season (S1)	**Autumn season (S2)**		
D_1(40-50)	14.26	14.42		14.34
D_2(50-60)	14.19	14.11		14.15
D_3(60-70)	14.58	14.51		14.54
D_4(70-80)	13.94	14.04		13.99
D_C(150-160)	14.21	14.23		14.22
Mean	14.23	14.26		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.17	0.12	NS
Season(S)	N/A	0.11	0.08	NS
Distance X Season(DXS)	N/A	0.25	0.17	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 8. Available potassium of soil as affected by gas flaring

Seasons / Distances (m)	Available potassium content(kg/ha)		Mean	
	Rainy season (S1)	**Autumn season (S2)**		
D_1(40-50)	259.66	259.00	259.33	
D_2(50-60)	251.33	257.33	254.33	
D_3(60-70)	253.33	255.66	254.50	
D_4(70-80)	257.33	264.00	260.66	
D_C(150-160)	256.00	261.33	258.66	
Mean	255.53	259.46		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	4.56	3.22	NS
Season(S)	N/A	2.88	2.04	NS
Distance X Season (DXS)	N/A	6.45	4.56	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 9. Soil electrical conductivity as affected by gas flaring

Seasons / Distances (m)	Soil electrical conductivity (dS/m)			Mean
	Rainy season(S1)	**Autumn season(S2)**		
D_1(40-50)	0.34	0.33		0.33
D_2(50-60)	0.35	0.34		0.34
D_3(60-70)	0.33	0.31		0.32
D_4(70-80)	0.32	0.32		0.32
D_C(150-160)	0.39	0.30		0.34
Mean	0.34	0.32		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.03	0.02	NS
Season(S)	N/A	0.02	0.01	NS
Distance X Season (DXS)	N/A	0.04	0.03	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 10. Soil pH as affected by gas flaring

Seasons / Distances (m)	Soil pH			
	Rainy season(S1)	**Autumn season (S2)**		**Mean**
D_1(40-50)	5.14	5.07		5.10
D_2(50-60)	4.97	4.99		4.98
D_3(60-70)	5.17	5.11		5.14
D_4(70-80)	5.18	5.14		5.16
D_C(150-160)	4.97	5.11		5.04
Mean	5.08	5.08		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.15	0.10	NS
Season(S)	N/A	0.09	0.06	NS
Distance X Season (DXS)	N/A	0.21	0.15	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

Table 11. Soil organic carbon content as affected by gas flaring

Seasons / Distances(m)	Soil organic carbon content (%)			
	Rainy season (S1)	**Autumn season (S2)**		**Mean**
D_1(40-50)	0.85	0.82		0.83
D_2(50-60)	0.80	0.82		0.81
D_3(60-70)	0.82	0.83		0.82
D_4(70-80)	0.80	0.80		0.80
D_C(150-160)	0.82	0.85		0.83
Mean	0.81	0.82		
Factors	**C.D.**	**SE(d)**	**SE(m)**	**Significance**
Distance(D)	N/A	0.02	0.01	NS
Season(S)	N/A	0.01	0.01	NS
Distance X Season (DXS)	N/A	0.03	0.02	NS

**S= Significant at 5% probability level; NS = Non Significant; N/A= Not Applicable*

3.2.3 Soil pH

Soil pH of South of Kothaloni OCS had shown no significant differences in distance and season (Table 10).

3.2.4 Organic carbon content

Soil organic carbon had shown no significant variations along distances and seasons in South of Kothaloni OCS (Table 11).

4. CONCLUSION

It can be concluded that gas flare had impacted soil temperature and soil moisture in this study. The soil temperature and soil moisture were decreased and increased respectively with distances away from the gas flaring site. There were no significant variations observed in other parameters of soil namely bulk density, porosity, hydraulic conductivity, pH, organic carbon content, electrical conductivity and available nutrients (NPK). Concrete barricade around the flare stake may be one of the reasons for low impact of gas flaring in the studied area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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