Original Research Article

IMPACT ASSESSMENT OF SOIL PARAMETERS AFFECTED BY GAS FLARING IN TEA GARDEN IN DIBRUGARH DISTRICT OF ASSAM, INDIA

ABSTRACT

The experiment studied the physical and chemical properties of soil of tea garden 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 of the flare site in two different seasons namely autumn and rainy. Soil physical and chemical parameters such as soil temperature, soil moisture ,bulk density, porosity, hydraulic conductivity, 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.

Comment [U1]: Add a problem statement so that there is a reason for the importance of this research

***Keywords**: Gas flare, tea, physical and chemical soil parameters*

1.INTRODUCTION

Tea is grown in about 45 countries having geographical variations ranging from 42^{o} N to 38^{o} S latitudes. Assam is famous for tea plantation and its climate and rainfall makes it an abundant tea producing state. 172 years old tea industry in Assam plays an important role in the socio-economic development of Assam.

Comment [U2]: Where does the literature come from?

Assam is also 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. 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].

Less 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 impact assessment of soil physical and chemical properties of soil.

2.MATERIAL AND METHODS

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Location selected was a tea garden south of Kothaloni OCS, Dibrugarh district and the study was done during September 2019-March 2020. Randomized Complete Block Design was selected as experimental design taking five distances viz., (40-50) metres, (50-60) metres, (60-70) metres, (70-80) metres and control site (150-160) metres away from the gas flaring site and two seasons namely 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. D_C denoted control site.

Comment [U3]: show the literature on which the treatment is based

2.1 Soil physical parameters

2.1.1 Soil temperature

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

2.1.2 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 (%).

2.1.3 Bulk density

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

2.1.4 Porosity

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

2.1.5 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 Soil chemical parameters

2.2.1 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.

2.2.2 Available phosphorus

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

2.2.3 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.

2.2.4 Electrical Conductivity

Soil: water ratio of1:2.5 with the help of EC meter [15] determined the electrical conductivity of the soil and it can be expressed as dS/m.

2.2.5 Soil pH

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

2.2.6 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 DISCUSSIONS

Comment [U4]: Please rewrite the results and discussion. each result contained in the table is given an analysis and discussed what reasons caused the data to be like that, then compare or strengthen it by comparing with other researchers' research

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 D3 and D4, D4 and DC. Highest mean temperature value was found to be highest at distance D1 (29.83°C) which decreased with increased distances from the flaring siteand the lowest value was found in DC (26.49°C) as recorded in Table 1. This was 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 D3 and D4, D3 and DC, D4 and DC. A minimum mean value was recorded at D1 (11.48%) which gradually increased with increase in distances from the flare site and the highest value was found in DC (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

Bulk density of soil had shown no significant variations along distances, seasons and interaction of distance and season (Table 3).

3.1.4 Porosity

There was no significant differences seen in distance, season and interaction of distance and season in porosity of soil (Table 4).

3.1.5 Hydraulic conductivity

Hydraulic conductivity of soil had shown no significant variations along distances, seasons and interaction of distance and season (Table 5).

3.2 Soil chemical parameters

3.2.1 Available nitrogen

There was no significant differences seen in distance, season and interaction of distance and season in available nitrogen of soil (Table 6).

3.2.2 Available phosphorus

Available phosphorus of soil had shown no significant variations along distances, seasons and interaction of distance and season (Table 7) .

3.2.3 Available potassium

There was no significant differences seen in distance, season and interaction of distance and season in available potassium of soil (Table 8).

3.2.4 Electrical Conductivity

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

3.2.5 Soil pH

There was no significant differences seen in distance, season and interaction of distance and season in soil pH (Table 10).

3.2.6 Organic carbon content

Soil organic carbon had shown no significant variations along distances, seasons and interaction of distance and season (Table 11).

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

Seasons / Distances (m)	Soil temperature (°C) Rainy season (S1)	Autumn season (S2)	Mean	
D1(40-50)	29.33	30.33	29.83	
D2(50-60)	28.66	29.00	28.83	
D3(60-70)	27.33	27.66	27.49	
D4(70-80)	26.66	27.00	26.83	
DC(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 (%)		Mean	
	Rainy season (S1)	Autumn season (S2)		
D1(40-50)	11.61	11.36	11.48	
D2(50-60)	12.33	12.31	12.32	
D3(60-70)	15.27	14.83	15.05	
D4(70-80)	15.12	15.03	15.07	
DC(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)		Mean	
	Rainy season(S1)	Autumn season (S2)		
D1(40-50)	1.15	1.18	1.16	
D2(50-60)	1.19	1.19	1.19	
D3(60-70)	1.20	1.18	1.19	
D4(70-80)	1.14	1.19	1.16	
DC(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	
D_1(40-50)	46.36	45.23	45.79	
D_2(50-60)	45.90	45.90	45.90	
D_3(60-70)	45.45	46.36	45.90	
D_4(70-80)	45.90	45.71	45.80	
D_C(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
D_1(40-50)	0.32	0.33	0.32
D_2(50-60)	0.32	0.32	0.32
D_3(60-70)	0.32	0.31	0.32
D_4(70-80)	0.32	0.31	0.31

D_C(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)**		**Mean**
	Rainy season (S1)	**Autumn season (S2)**	
D_1(40-50)	243.66	242.33	242.99
D_2(50-60)	242.66	245.00	243.83
D_3(60-70)	241.66	245.33	243.49
D_4(70-80)	246.00	241.33	243.66
D_C(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

Distances (m) \ Seasons	Available Phosphorous content (kg/ha)		Mean	
	Rainy season (S1)	Autumn season (S2)		
D1(40-50)	14.26	14.42	14.34	
D2(50-60)	14.19	14.11	14.15	
D3(60-70)	14.58	14.51	14.54	
D4(70-80)	13.94	14.04	13.99	
DC(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

Distances (m) \ Seasons	Available potassium content (kg/ha)		Mean	
	Rainy season (S1)	Autumn season (S2)		
D1(40-50)	259.66	259.00	259.33	
D2(50-60)	251.33	257.33	254.33	
D3(60-70)	253.33	255.66	254.50	
D4(70-80)	257.33	264.00	260.66	
DC(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		Mean
	Rainy season (S1)	**Autumn season (S2)**	
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 (%)		Mean	
	Rainy season (S1)	Autumn season (S2)		
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*

4. CONCLUSION

It can be concluded that no significant variations were observed in soil physical and chemical parameters but the soil temperature and soil moisture were decreased and increased respectively with distances away from the gas flaring site. Concrete barricade around the flare stake may be one of the reasons for low impact of gas flaring on the studied area.

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