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Alteration of Six Soil Physical Properties in the Equatorial Climatic (Koppen's Aw) Zone of the Niger Delta, Nigeria as Determined by Gas Flaring Activities

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ABSTRACT

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This paper is on the Alteration of Six Soil Physical Properties in the Equatorial Climatic (Koppen's Aw) Zone of the Niger Delta, Nigeria as Determined by Gas Flaring Activities.To determine the altered properties of the soil at the selected location, soil samples were taken at two depths; 0 – 15 and 15 - 30cm. These depths were taken based on the fact that research most soil nutrients are concentrated within the top half meter of the soil. The first sample point was taken at 200m from the fence wall. Analysis of Variance (ANOVA) was used to determine if there are variations in physical quality within the flare vicinity and with controls at different depths as well as with control points, while student t-test was used to test for difference in heavy metal concentrations between soils from flare sites and control stations. pH recorded an average value of 5.6. Electrical conductivity was recorded as 292.5%. Average values of organic content, clay, silt and sand distributions were recorded as 1.49%, 4.5%, 2.85% and 92.65% respectively. These values exceeded results obtained at control point. The result of the soil is a clear indication that the excessive heat generated by the flare did modify the microclimate the soil nutrient as well. With continuous flare of gas, the study area will over time undergo further alterations in its physical properties and as such, flaring activities should be checked.

Keywords: Contamination; flaring; microclimate; natural gas;organic matter;physical properties

INTRODUCTION

The extraction of crude oil is often accompanied by associated gas which are often separated from the crude, burned and flared (Goselle, 2015; Emejulu and Atuanya, 2022). In terms of natural gas reserve, Nigeria ranks 7th and 1st in the world and Africa respectively and all discoveries are incidental to crude oil exploration (Ibikunle, 2006; Aghalino, 2009; Usman, 2017). Despite the various ways in which natural gas can be used in Nigeria, approximately 75% (by 1998), 63% (by 2000) and 24.30% (by 2010) of the total gas output were flared (Okotie and Ikporo, 2014). Sub-Saharan Africa, excluding South Africa has a high potential of doubling power production if Nigeria's 46% of the total 40 billion cubic meters of gas produced by Africa annually is used to generate power in modern power plants (Kareem *et al*, 2012). Thus, the country loses several billions of naira annually due to gas flaring. Gas flaring constitutes adverse environmental impacts on the local environment through the production of soot as well as the release of emissions which have the potential to contribute to global warming (OGP, 2000). Gas flaring mainly emits Carbon dioxide (CO_2) and Carbon monoxide (CO) along with a variety of volatile organic compounds that include Nitrogen Oxide (NO), Sulphur dioxide (SO_2), toxic heavy metals and black carbon soot which are carcinogens or toxic and are environmentally unfriendly/hazardous (Buzcu-Guven *et al*, 2010; Emejulu and Atuanya, 2022). The soot is usually deposited on building roofs of nearby villages and when it rains, it runs off the roofs of building and pollutes the soil and water aquifers of the people (Aghalino, 2009). Consequently, comparatively acidic, acidic radicals, and both micronutrient elements and heavy metals have been detected in rainwater samples in settlements located close to flaring areas (Ejelonu *et al*, 2011). Aghalino has also reported that the corrugated iron roofs of the people of the oil-bearing enclave now last less than five years whereas before now they last for well over 20 years due to acid rains. Gas flaring has been reported to impact negatively on lung function status of children and adults of gas flaring community by reducing their mean peak expiratory flow rates (Ovuakpoye, 2012). In addition to respiratory diseases, gas flaring has also been linked with cancers, blood disorders and skin diseases (Bassey, 2008).

Studies have shown that gas flaring is harmful to human health (Efekodo, 2001; Otuaga, 2004), agriculture (Odjugo, 2007), and aquatic lives (Alakpodia, 2000; Daudu, 2001; Aregbeyen and Adeoye, 2001; Odjugo, 2007). Gas flaring also has agricultural impacts because it not only alters the microclimate but also the soil physico-chemical properties of the flare sites (Alakpodia, 2000; Odjugo, 2007). Thus, it has been reported that gas flaring reduces within 1km the yield of sweet potato (Udoinyang, 2005), plantain (Akpabio, 2006) and within 2km radius the yield of yam and cassava (Odjugo, 2007). While the previous studies on the environmental impacts of gas flaring on surrounding communities discussed tend to focus on the core oil producing states, little emphasis has been placed on marginal oil producing communities like Ologbo in Edo State which is in the Equitorial (Koppen's Aw) climatic zone. Even the physical properties of the soils of most Niger Delta region have not been adequately studied. Thus, some studies exist on the pollution status of the Niger Delta region, the situation of a number of communities has not been investigated (Ejolonu *et al*, 2011). It is against this background that this study is designed to examine the impact of gas flaring on some physical properties of soil at the flaring vicinity.

Location: the flaring site is about 35km south west of Benin City and it lies between longitude 05^o 39' to 05^o 39.6' and latitude 06^o 4.17' to 06^o 4.6'. It is found within the Equatorial Climatic (Koppen's Aw) zone with two distinct season (rainy and dry) and temperature being high throughout the year with a mean of 28^{o}c (Atedhor, *et al*, 2011; Goselle, 2015). The soil is typical of the Benin Formation characterized by top lateritized reddish-brownish clayey and capping highly porous fresh water bearing friable loose white sands, pebble sands and clays with basal ferrugenized sandstone and locally overlaid by quaternary sediment; deep well drained and deep poorly drained soils; sand, sandy loam, loam sand or sandy clay loam surfaces (Murat, 1972).

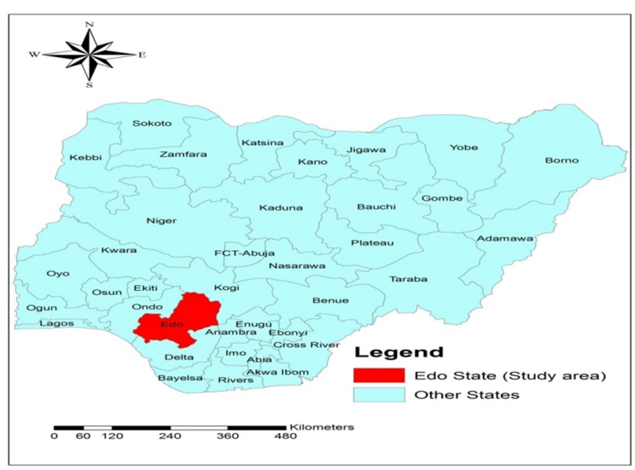

Figure 1: Nigeria showing Edo State.

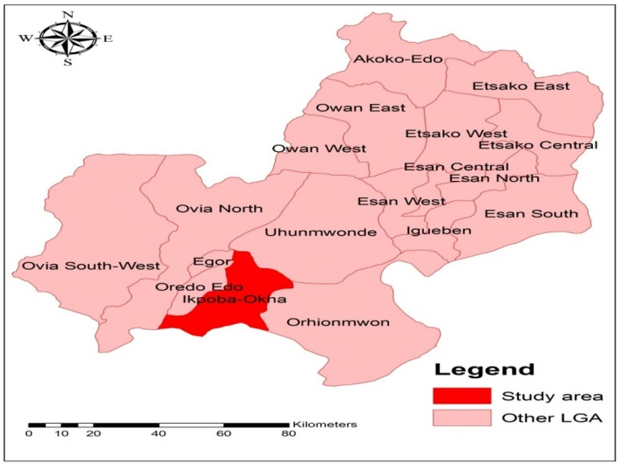

Figure 2: Edo state showing Ikpoba Okha Local Government Area.

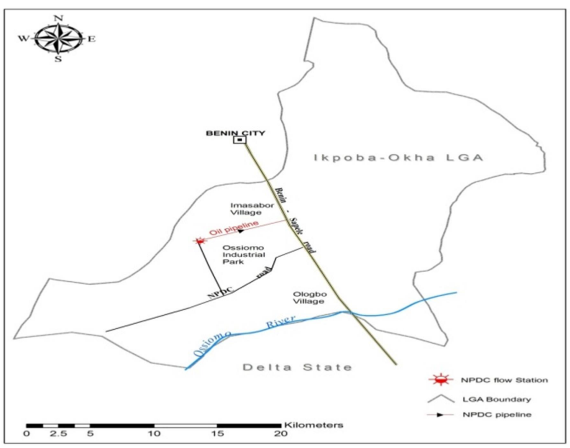

Figure 3: Ikpoba Okha Showing NPDC Flow Station, Ologbo

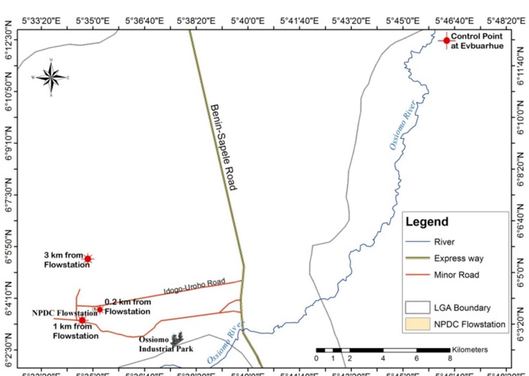

Figure 4: NPDC Flow Station, Ologbo showing sampling points and control point

METHODOLOGY

Data was collected for soil quality within defined distance from the flaring point. It was determined by Goselle (2015) and Goselle and Ibanga (2019) that the space range of 200 meters from the flare stack to about 35,000 meters can be regarded as falling within the zone of influence by gas flaring. This is in tandem with the definition by Argo (2002) of the sample areaas the approach of proximity to flaring facility and Ovuakporaye, (2012) who defined proximity to gas flaring point as any distance within 0.2km to 35km from the flare stack. Following these definitions, a 4km distance from the flare facility was taken as the buffer area for this research. Within this buffered zone (4km), samples were collected for soil analysis at different intervals for the purpose of detecting variations and alterations in their physical properties. In addition, control point was also established. Control point was established at 30km from the fence (bund wall) of the flare facility and 27km from the buffered sampling area (3km). Sampling sites 1,2, and 3 are within the vicinity of the flare facility, while the control point (Evbuarhue) is located 30km from the fence of the flare facility. The distance of the control site was chosen because Onuorah (2000) and Odjugo (2007) noted that the impact of gas flaring on the atmospheric quality is statistically insignificant beyond 15 km and 20 km radius of the flare site. Buffering of sampling area was conducted using the geographic information system (GIS) technology. Within the 4km buffered area, three sample points were established and samples were collected randomly in each point. These points include 200m, 1km and 3km. Similarly, a control point was established, 27km from the buffered area (3km) from Evbuarhue. Soil samples were taken at two depths; 0 – 15 and 15 - 30cm beginning from near the fence of the flare facility (200m). The choice of these depths is based on the fact that research has shown that, 0-15cm and 15-30cm is the root zone and most soil nutrients are concentrated within the top half meter of the soil (Lekwot *et al*. 2014). The soil samples were kept in polythene bags and labeled at the points of collection in order to avoid mix up of samples. A total of eight soil samples were collected; that is, six from the flare vicinity and two from control point. A stainless steel, hand-held Dutch type Soil Auger was used to collect representative soil sample at each soil sampling station in each grid. Soil samples for physical and chemical analyses were collected into polyethylene bags that had been appropriately labeled using masking tape and indelible ink. The soil samples were taken to the laboratory for analysis immediately after collection in order to sustain their soil microorganisms.

Laboratory analysis was done at Martlet Environmental Research Laboratory Limited, Benin City, Edo State using standard methods. Soil samples were air-dried at room temperature for 72 hours before crushing the coarse lumps and were passed through a 2 mm sieve in order to remove impurities. Sand, silt and clay (particle size) were determined by the methods described by Gee and Or (2002). The percentage sand, silt and clay were determined by using the Bouyouios hydrometer method allowing sedimentation of the various separates within intervals. Sodium hexametaphosphate was applied as the dispersant. Soil pH was determined using 1:1 soil to water suspension using electrode pH meter (Mclean, 1982). Organic Carbon was determined by the wet dichromate acid oxidation method (Matersha and Mkhabela, 2001). Electric conductivity was carried out following the methods adopted by Chopra and Kanzar (1988)

Analysis of Variance (ANOVA) was used to determine if there are variations in physico-chemical quality within the flare vicinity and with controls at different depths as well as with control points. A total of 18 parameters analyzed for each depth for the three soil sample locations thus given rise to a total of six (6) depth points and 108 parameters which justify the application of ANOVA technique from which the six (6) parameters needed for this study were isolated and discussed accordingly. The test assesses the likelihood of the *K* samples having been drawn from the same population by decomposing the total variance into within and between groups' components. The ratio of these two components gives the F-ratio and is obtained by dividing the between group by the within groups variances. If the test value of *F* exceeds the critical value, then the null hypothesis which states that there is no significant difference between the means of two samples is rejected.

The general expression for the variance is given by

$$\text{Variance} = \frac{\text{sum of squares}}{\text{degrees of freedom}}$$

The within-groups variance (sj) is found by dividing the sum of squared deviations of all observations about their respective group means by the appropriate degrees of freedom. The latter in this case is *n - k,* where *n* is the total number of observations and *k* the number of groups; with the result that:

$$S_w^2 = \sum_{j=l}^{k} \frac{\sum_{i-l}^{nj} \left(X_{ij} - \overline{X}_j\right)^2}{n-k} = \frac{\text{within - group sum of squares}}{\text{within - group degrees of freedom}}$$

where $\overline{X}_j$ are the group means and *Xij* the observations within each group. Summation is repeated within each group to give the required sum of squares. The between-groups variance $\left(S_w^2\right)$ considers the squared deviations of the group means about the mean for the whole data set *(X).* These squares are also weighted in terms of the number of observation (*nj*,) within each group, and the equation reads:

$$S_b^2 = \frac{\sum_{j=l}^{k} nj\left(\overline{X}_j - \overline{X}_l\right)^2}{k-l} = \frac{\text{between - group sum of square}}{\text{between - group degrees of freedom}}$$

The degrees of freedom are now one less than the number of groups, *(k* - 1). The total sum of squares is the sum of the within- and between-groups squares. The required *F* ratio will be derived as follows:

$$F = \frac{s_b{}^2}{s_w{}^2}$$

The Variability of soil properties was measured by estimating the coefficient of variability (CV). This was ranked according to the procedure of Aweto (1982) where,

CV ≤ 20% = little variability

CV = 20%-50% = moderate variability

CV > 50% = high variability

RESULTS AND DISCUSSION

OBSERVED IMPACT OF AIR EMISSIONS ON SOIL PHYSICAL PROPERTIES (0-15CM)

Impact of air emission on soil physical properties (0-15cm) at different sampling points and control point is represented in Figure 5. Observed soil quality in the vicinity of flow station was compared with soil quality at control site. Values of physical quality of soil within flare vicinity were generally observed to be higher in station 1 than values obtained at the control site. Highest impact of air emission on soil at 0-15cm depth was on electrical conductivity of soil, followed by impact on sand content distribution. The pH at station 1 was recorded as 5.9 which are within the same range with 5.3 recorded at the control site, while electrical conductivity EC was recorded as 330 μs/cm against 300 μs/cm recorded at the control site. Values of organic content, percentages of clay distribution, silt and clay were recorded as 1.37% against 0.62% recorded for the control point, 5% against 4.0% recorded at the control site, 2.6% which is similar to value obtained as control point and 92.4% which is less than 93.4% recorded at the control point respectively.

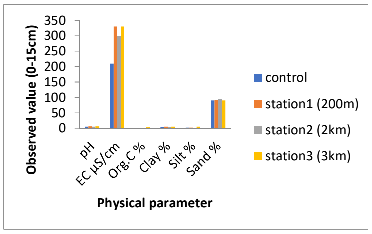

Figure 5: Impact of air emission on soil physical properties at different stations and control point

In station 2, there was a decline in pH to 5.3 which was also similar to pattern obtained at control site. Electrical conductivity of soil EC recorded a value of 210 μs/cm. Organic content of soil, clay, silt and sand distribution were recorded as 0.74%, 4.0%, 1.6% and 94.4% respectively. In station 3, pH was calculated as 5.9 similar to value observed at station 1. Electrical conductivity of soil EC recorded a value of 330 μs/cm. Values of organic content of soil, clay, silt and sand distributions were recorded as 3.22%, 5.0%, 4.6% and 90.4% respectively. The impact of air emission on percentage of silt distribution at 0-15cm was seen to be less when compared to values recorded at stations 1 and 2. The Electrical conductivity of soil ranges from 300μs/cm being the lowest value to highest value of 330 μs/cm in the flared site, while the value is very high compare to the control site with a value of 210 μs/cm This implies that the Electrical Conductivity in the gas flared site is greater than that of the non-flared site. This is in agreement with finding from Atuma and Ojeh, (2013). Similarly, in the vicinity of flare site due to heat effect, the percentage organic carbon has been found lower as a result of which it could not reduce the heat capacity as well as thermal conductivity of soil and cannot support soil microbial activities (Dick and Gregorich, 2004; Koch and Stockfisch, 2006; Emejulu and Atuanya, 2022).In Table 1, the descriptive statistics of soil physical characteristics at 0-15cm within the vicinity of flare facility are presented. Within the vicinity of the flow station, pH recorded an average value of 5.6. Electrical conductivity was recorded as 292.5%. Average values of organic content, clay, silt and sand distributions were recorded as 1.49%, 4.5%, 2.85% and 92.65% respectively. Standard deviation varied from 0.34 for pH, 56.8 for electrical conductivity, 1.2 for soil organic content, 0.57 for clay distribution, 1.25 for silt distribution, and 1.71 for percentage of sand distribution. From Table 1, it can be seen that electrical conductivity of soil was highest at station 1 which is 200m from the flare site of the flow station. This was however followed by EC value determined for station3, with the lowest EC value being recorded at station 2 which is 2km from the fence of the flow station. The pH values were observed to be the same station 2 and 3. Lowest value of pH was recorded at ststion1. Station 3 recorded the highest value of organic matter, followed by value determined for station 2. The pH of the soil is relatively low in station 2 compared with control. This is unexpected. The flow station emissions seem to have no effects on the pH of the soil as at station 2. Value of clay content was observed to be the same for stations 1 and 3and at the same time being the highest value observed. At station 3, value of silt content was generally higher than values obtained in other stations. Sand content was generally high in all the stations sampled, however, highest sand content was recorded in station 1 followed by value obtained at station 2. Soil organic content and clay content decreased as distance away from the flow station the flare site. The results also revealed that the organic matter around the Flow-Station was lower when compared with the control. Organic matter from the soil is derived from residual plant and animal materials synthesized by microorganisms and decomposed under the influence of temperature, moisture and optimum soil conditions (Ezeigbo *et al.* 2013). These prevailing conditions in this study will deprive the soil of the necessary fertility for effective agriculture. The acidity of the soil at the experimental points is within the range earlier reported by Nwaugo*et al* (2005) and Goselle (2015).

Table 1: Descriptive Statistics for Physical characteristics of soil within the vicinity of the Ologbo flow station (0-15cm)

Parameter	Mean	Standard Error	Standard Deviation	Sample Variance	Range	Min.	Max.	Sum	CV (%)
pH	5.6	0.17	0.34	0.12	0.6	5.3	5.9	22.4	3.04
EC	292.5	28.39	56.8	3225	120	210	330	1170	19.42
Org.C	1.49	0.6	1.2	1.44	2.6	0.62	3.22	5.95	80.54
Clay	4.5	0.28	0.57	0.33	1.0	4	5	18	12.67
Silt	2.85	0.63	1.25	1.58	3	1.6	4.6	11.4	43.86
Sand	92.65	0.85	1.71	2.92	4	90.4	94.4	370.6	1.85

Range value was highest for electrical conductivity, followed by value obtained for sand distribution. Other soil quality parameters recorded varying range values of 0.6 for pH, 2.6 for organic content, 1.0% for clay distribution, 3.0% for silt distribution and 4.0% for sand distribution. Minimum and maximum pH varied between

Table 2: Analysis of variance for difference in soil physical qualities within flare site and control point at different (0-15cm).

Source of Variation	*SS*	*MS*	*F*	*P-value*	*F crit*
Between Groups	772.6238	772.6238	0.188175	0.66718	4.130018
Within Groups	139599.7	4105.874			
Total	140372.4				

5.3 and 5.9; 210µs/cm and 330 µs/cm for electrical conductivity, 0.62% and 3.22% for organic content, 4.0% and 5.0% for clay, 4.6% and 11.4% for silt distribution, 90.4% and 94.4% for clay distribution. Judging from the works of Aweto (1982), coefficient of variability (CV) of soil quality parameters at 0-15cm shows that organic content of soil varied most (CV = 80.54%), followed by silt distribution (CV = 43.86%) and electrical conductivity (CV = 19.42%). sand recorded the least coefficient variability value (CV = 1.85%). It follows therefore that Organic matter was highly variable while silt was moderately variable. Sand, pH, Clay and Electric conductivity were little variable in that order. Ahukaemere *et al* (2017) also reported high coefficient variability of Organic matter and this could be a reflection of Organic matter deposit, rate of mineralization and soil forming processes taking place in the soils. Other researchers have made similar findings on soils of southern Nigeria (Kamalu *et al*, 2018; Osujieke *et al*, 2018; Egbon, 2024).History of the area. The low variability of clay (CV = 12.67%) did not tally with the works of Awuyou *et al* (2013) in southern Nigeria nor with the research of Ugwa *et al* (2023) in the Benin region of Nigeria. The little clay variation; the low variation may be associated with homogeneity of the soils. The electric conductivity recorded low variation (CV = 19.42%). The soil texture of the area is sandy and the rate of variation may also be associated with the soil texture. Soil pH ranged between 5.3 and 5.9 and is moderately acidic. This is not surprising as soils underlain by coastal plain sands have acidic nature (Ahukaemere *et al* 2017; Osujieke *et al* 2018). Soil properties as reported by Kamelu *et al* (2018), which are closely calibrated to a standard such as texture and pH are less variable. This agrees with the findings of Upchurch *et al* (1998) which upheld that soil properties like texture and colour are less variable, while more dynamic properties as Available P and Organic matter are highly variable. The high variable silt fraction in the experimental site might be due ti intense rainfall and leaching that facilitated sorting of particles. Ugwa *et al* (2017) reported that soil texture is a reflection of the parent material and that silt and sand particles are primarily of partial weathered primary mineral. The silt high variability might be attributed to the Results of ANOVA to determine the extent of variation between the observed soil physical properties at stations 1, 2 and 3 and soil quality from the control point at 0-15cm depth did not show significant variations.

Gas flaring has not altered the physical properties of soil at Ologbo Flow station is hereby accepted. It can therefore be said that the environment of Ologbo shows no significant change as a result of gas flaring.

OBSERVED IMPACT OF AIR EMISSIONS ON SOIL PHYSICAL PROPERTIES (15-30cm)

From figure 6, values of physical quality of soil within flare vicinity were generally observed to be higher in station 1 than values obtained at the control site, except for pH, silt and sand distribution. Highest impact of air emission on soil at 15-30cm depth was on electrical conductivity of soil, followed by impact on sand content distribution. The pH at station 1 was recorded as 5.4 against 5.5 recorded for the control site, while electrical conductivity EC was recorded as 460µs/cm which is higher than 240 µs/cm recorded for the control site. Values of organic content, percentage of clay distribution, silt and clay were recorded as 1.03% against 0.5% at control site, 7% against 5% at the control site, 2.6% which is less than 3.6% at control site and 90.4% against 91.4% at the control site respectively. The variation values in stations 1 and 2 may be due to the observed slope gradients between them, geomorphological processes in the experimental area or/and landuse type. Land use systems entail the modification of soil properties (Amuyou *et al*, 2013; Ezeigbo *et al*, 2013; Ugwa *et al*, 2017). Erosion processes are known to influence particle size distribution over time. In station 2, there was a rise in pH to 5.8 while value obtained for control site is 5.3. Values of physical parameters were generally higher that values obtained at control point. Electrical conductivity of soil EC recorded a value of 250µs/cm against 240 µs/cm obtained at control site. Organic content of soil, clay, silt and sand distributions were recorded as 0.72% against 0.5% recorded at control site, 7.0% against 5% recorded at control site, 2.6% against 3.6% recorded at control site and 94.4% which is higher than 91.4% recorded at the control site respectively. In station 3, pH was calculated as 5.1. Electrical conductivity of soil EC at this station was recorded as 220 µs/cm. Values of organic content of soil, clay, silt and sand distributions were recorded as 2.17%, 8.0%, 3.6% and 88.4% respectively. The impact of air emission on percentage of organic content and silt

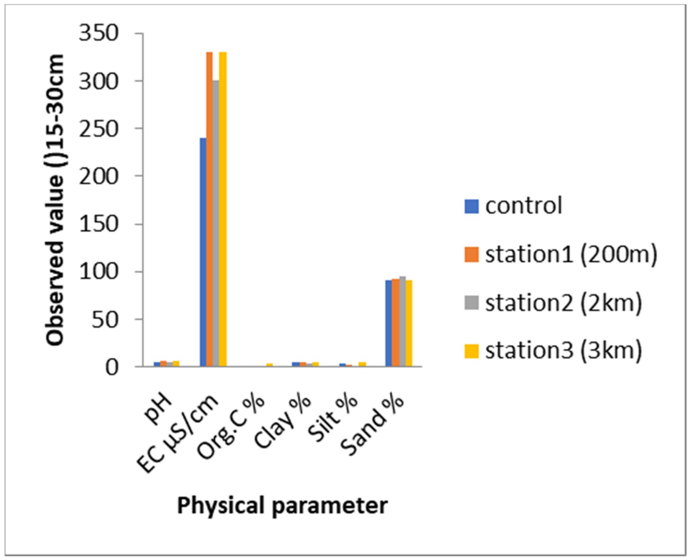

Figure 6: Impact of air emission soil physical properties at different sampling points away from flow station.

Table 3: Descriptive statistics for physical characteristics of soil from Ologbo flow station (15-30cm)

Parameter	Mean	Standard Error	Standard Deviation	Sample Variance	Range	Minimum	Maximum	Sum	CV
PH	5.45	0.14	0.28	0.08	0.7	5.1	5.8	21.8	5.14
EC	292.5	56.18	112.4	12625	240	220	460	1170	38.43
Org.C	1.11	0.37	0.74	0.55	1.67	0.5	2.17	4.42	66.7
Clay	6.75	0.63	1.25	1.58	3	5	8	27	18.66
Silt	3.1	0.28	0.57	0.33	1	2.6	3.6	12.4	18.4
Sand	90.15	0.63	1.25	1.58	3	88.4	91.4	360.6	1.39

Table 4: Analysis of variance for difference in soil physic-chemical qualities within flare site and control point at different (15-30cm)

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	165.0939	1	165.0939	0.048167	0.827596	4.130018
Within Groups	116536.1	34	3427.533			
Total	116701.2	35				

distribution at 15-30cm was noticed to be less when compared to values recorded at stations 1 and 2 (Figure 6). Reduced Organic content affect soil properties. This is the reflection of the influence of Organic matter on the soil characteristics.

Generally, it can be seen that electrical conductivity of soil was highest at station 1, followed by EC value determined for station2 which is 2km from the fence of the flow station, with the lowest EC value being recorded at station 3. The pH values were observed to be the same station 2 and 3. Lowest value of pH was recorded at ststion1. Station 1 recorded the highest value of pH, followed by value determined for station 3. Lowest pH value was recorded in station3. Value of sand distribution was observed to be the same for stations 1 and 2 and at the same time being the highest value observed. At station 3 recorded the lowest value of sand distribution. Value of silt content was generally higher in station3 than values obtained in other stations. Silt distribution was observed to be the same in stations 1 and 2. Organic content was observed to highest at station 3. Sand content was generally high in all the stations sampled; however, highest sand content was recorded in stations 1 and 2. The results also revealed that the organic matter, sand and silt around the Flow-Station were lower when compared with the control.

In Table 3, the descriptive statistics of soil physical characteristics at 15-30cm within the vicinity of flare facility are presented. Within the vicinity of the flow station, pH recorded an average value of 5.45. Electrical conductivity was recorded as 292.5%. Average values of organic content, clay, silt and sand distributions were recorded as 1.11%, 6.75%, 3.1% and 90.15% respectively. Standard deviation varied from 0.28 for pH, 112.4 for electrical conductivity, 0.74 for soil organic content, 1.25 for clay distribution, 0.57 for silt distribution, and 1.25 for percentage of sand distribution. As regards to soil depth, sand and silt decreases down the depth (Ekpenhio, 2022). Distance from the control area has some higher values of soil properties. This phenomenon is observed to have low pH. Lal (1980) reported that deforested area undergo significant changes in the physical and chemical properties. Similarly, soils of the area being derived from sedimentary rocks are generally, low in fertility and are subjected to high temperature and rainfall, both lead to leaching. Removal of vegetative cover contributes to high clay content and leaching of clay materials over depth.

Range value was highest for electrical conductivity, followed by value obtained for sand and clay distribution. Other soil quality parameters recorded varying range values of 0.7 for pH, 0.5 for organic content, 3.0% for clay distribution, 1.0% for silt distribution and 3.0% for sand distribution. Minimum and maximum pH varied between 5.1 and 5.9; 220μs/cm and 460μs/cm for electrical conductivity, 0.5% and 2.17% for organic content, 5.0% and 8.0% for clay 2.6% and 3.6% for silt distribution, 88.4% and 91.4% for clay distribution. Coefficient of variability of soil quality parameters at 15-30cm show that organic content of soil varied most a pattern that is similar to character observed at 0-15 depth. This is followed by electrical conductivity. Sand distribution recorded the least coefficient variability value. Results of ANOVA to determine the extent of variation between the observed soil physic-chemical at stations 1, 2 and 3 and soil quality from the control point at 15-30cmm depth did not show significant variations. Gas flaring has not altered the physico-chemical properties of soil at Ologbo Flow station. This is in consonance with Goselle (2015).

CONCLUSION

The result of ANOVA testing the physical characteristics of soil at the flare vicinity and control at both 0-15km and 15-30km depths revealed that gas flaring has not tampered the physical properties of soil at Ologbo flow station**.** It be concluded therefore that the physical properties of soil at the Ologbo Flow station has not been significantly altered. More so, the flare vicinity and control at both 0-15km and 15-30km depths revealed that gas flaring did not show significant variation at different sampling points on the physical properties of soil at Ologbo flow station.

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