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ARTICLE

Use of Soil Physicochemical Properties in Assessment of Soil Erosion: A Case Study of Agbor, South-South Nigeria

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ABSTRACT

The study area is one of the areas in the South-South region of Nigeria that has been ravaged by erosion. This has led to loss of infrastructures and impact on the livelihood of the inhabitants of the study area. In this study, the physio-chemical of soil in Agbor and its neighboring communities were assessed in eleven different locations. A total of eleven soil samples, consisting of 5 samples each at a depth of 0 – 200 cm were taken in accordance with the clarification of different horizons. The samples were air-dried, crushed and sieved in 2mm mesh sieve then subjected to analysis for both physical and chemical properties in the laboratory. The physio-chemical analysis results showed that pH value ranges from 5.0 to 6.3 indicating very strongly acidic to strongly acidic. Bulk density ranged from 1.29 to1.35 indicating a slight increase due to the presence of sand fraction. And low level of porosity which ranged from 49.4 to 50.9. The low level obtained from Total Organic Matter (TOM) indicates intense rainfall and constant leaching. The low Ca, Mg, K^+ and Na^+ values indicate intense rainfall and leaching problems. The values obtained from $Al3^+$, H^+, EA and P revealed a slight increase and cause of acidity nature across eleven soil test sites. The properties showed by all soils revealed that they are vulnerable to weathering, leaching, easy removal by runoff and low resistivity.

1. Introduction

Soil is considered as one of the most important resources for sustainable development and need to be managed wisely and protected timely.It covers most lands on earth, but as per their service for humans they are limited and largely non-renewable resource [1]. According to [2] the development and survival of civilizations has been based on the performance of soils on land to provide food and further essential goods for humans. Although soil erosion problem is now on the increase and its impact has caused decline in water resources, agricultural and loss of infra-

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structure[3], stated that soil erosion is amongst the world's largest form of soil degradation that threatens sustainability and totality of plants and animals across the world. The degradation of soils caused by erosion is a source of concern, it takes place where surface water concentrated in small streams flows and begins to erode channels in the ground surface, making it deeper and wider. Thereby resulting in the removal of soil particles from surface of the earth, transportation and deposition of the particles by the action of wind, heat, and water [4].As a type of soil degradation it encompasses all activities by water in all forms (rain, flood, ice, and sea) resulting in soil erosion [3]. Several factors trigger soil erosion, trigger, topographical features, rainfall characteristics, soil properties and vegetation. On the other hand, erosion has caused serious damage to lives and properties in Southern part of Nigeria. This damage has attracted the interest of professionals (environmental scientists, geographers, cartographers, geomorphologists, geoscientist, chemists, engineers etc.) who are interested in its studies (causes and effects) and has been of great concern to researchers and communities who are interested in its solution (control and minimization) [5]; [3]. The Orogodo river is the major river in Agbor, it has a lot of tributaries surrounded, on both sides are the sloppy terrain of the Agbor metropolis. The river serves as the drainage point for all run off of waste water produced industrially or domestically within Agbor metropolis and beyond, as majority of the drainage channels constructed by the state and local government within the Agbor metropolis and its neighborhoods', aimed at controlling erosion is channeled into the river at various points along the river length, thereby making it not been able to withstand the current erosion problem. That is to say, different types of erosion, such as sheet, rill and gully, are pervasive in Agbor metropolis. Although studies showed that gully erosion constitutes the most significant threat to the survival of individuals and communities. Human activities, such as bush burning, deforestation, improper farm practices and more importantly construction activities (building of roads, houses, industries) that undermine natural landscape or drainage systems account for much of the erosion menace plaguing the area. In this study, we presented the recent findings on the negative impact of erosion to the totality of the environment as well as the physio-chemical assessment of soils in Agbor and its neighbouring communities. Our report suggested control measures and ways this menace can be mitigated. This study is aimed at evaluation of soil erosion around Agbor and its adjoining communities using physio-chemical analysis.

2. Climate, Topography and Geology of the Study Area

Agbor is located in southwestern Nigeria within latitudes 6^o06^1 and 6^o21^1N and longitude 6^o 04^1 and 6^o 21^1E, and covers an area of about 650 km^2 (Figure. 1). It has a population in excess of 240,000 people and is located along a major route connecting southeastern and northwestern Nigeria. Consequently, it is a flourishing center of trade and agriculture. The physiography of the area shows two topographic highs separated by a valley. Within the valley is River Asimiri, which flows in a southwest-northeast direction. The area lies within the subequatorial climate, with annual rainfall over 2000mm, long wet season (about 8 months), high humidity and atmospheric temperature of between 24 - 27^0C [6], which supports the rainforest-type vegetation. The study area is underlain by the Miocene – Recent Benin Formation. This formation previously recognized as the Coastal Plain Sands [7]; [8] stretches over a considerable portion of the coastal region of Nigeria, adjacent to the Deltaic Plain Sediments. Within the area, the Benin Formation is capped by lateritic soil in the first few metres for more followed by fine grained sand that varies in thickness from 9 to 58 m. underlying these, is a sequence of medium to coarse grained sand with several horizons of intercalated discontinuous lenses of clay. The medium to coarse grained sandy beds constitute the main aquifer tapped in the area. Groundwater occurs at a depth generally greater than 60 m, predominantly under unconfined conditions.

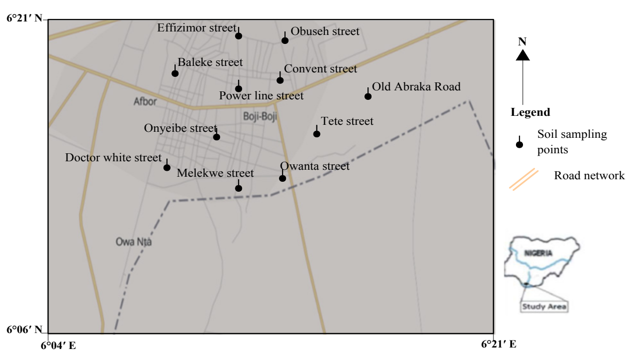

Figure 1. Map of the Study Showing soil sampling Points.

2.1 Erosion Activities in Agbor

Eleven erosion sites were identified within Agbor and its neighbouring communities namely- Old Abraka, road, Power line road, Baleke street, Doctor white street, Melekwe street, Convent street, Obuseh street, Owanta road, Tete street, Effizomor street and Onyeibe street. The most spectacular is the one along old Abraka Road Boji Boji

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Owa-Ika North-East which has destroyed several buildings and farmlands (Figure 1). As most of these erosion also occurs along residential buildings. Soil characteristics, nature of soils and rainfall are other factors responsible for the various types of erosion that occur within the study area.

3. Methods

Field surveys covering Agbor and its environs were considered for this study.A total number of eleven (11) soil samples were collected within Agbor, and its neighbouring communities from September 13th to September 28th 2019. These areas include- the Old Abraka, road, Power line road, Baleke street, Doctor white street, Melekwe street, Convent street, Obuseh street, Owanta road, Tete street, Effizomor street and Onyeibe street. These places were all chosen to reflect the magnitude of erosional activities and soil physiochemical properties. Profile pits were dug each on different locations to a depth of 0 to 200cm. Soil samples were collected according to clear differentiation horizon and soil surface was measured at a depth of 0- 200cm. The measurement was taken with the use of a tabular sampling auger, as each representative soil samples were taken and bulked for each depth and location. The samples were further air-dried at room temperature for two weeks, crushed to pass through 2 mm mesh sieve. The Sub-samples of soil from different location were also grounded to pass through a 100-mesh sieve for determination of organic matter. As the remaining samples were then subjected to both physiochemical analyses in the laboratory.

4. Laboratory Procedure

4.1 Determination of Physio-chemical Properties of Soil

Soil samples were analyzed for physio-chemical properties as follows:

Bulk Density: It was determined using the core sample and calculated from:

$$b = \frac{Ms}{Vt} \quad \text{(i)}$$

b=Ms/Vt

Where;

b =Bulk Density (g/cm^3)

Ms=Mass of oven- dried sample (g)

Vt = Total Soil Volume (same as v of core) cm^3.

Clay Ratio

This was calculated as follows:

$$\frac{Sand(\%)}{Silt(\%)+Clay(\%)} \quad \text{(ii)}$$

Porosity (F)

It was calculated using density values, thus

$$F = \frac{1-Bd}{Ps} \quad \text{(iii)}$$

Where;

F = Porosity

Bd= Bulk Density

Ps = Particle Density (2.56 cm^3).

The analysis for particle size distribution was determined using the hydrometer method as proposed by [9]

Soil pH was measured using a glass electrode pH meter in soil: water at ratio 1:1 as proposed by [10]

Organic Matter: This was carried out through the use of wet dichromate acid oxidation method

Exchangeable Bases: This was determined from NH4OAc leachate of the soil sample. Exchangeable Ca and Mg were determined by EDTA versante titration method while K and Na were determined by flame photometric methods.

Exchangeable Acidity (Al^{3+}, H^+): This was extracted with 1 N KLC and determined using titration method, by leaching the soil with KCl and titrating with 0.05N NaOH using phenolphthalein indicator.

Effective Cation Exchange Capacity (ECEC): This was calculated by summing exchangeable bases (Ca, Mg, K and Na) and exchangeable acid (Al^{3+}, H^+) expressed in Mcq/100g of soil as proposed by [11]

4.2 Data Presentation and Analysis

The results data are presented in Tables 1 and 2, Figure 3 to 4. Statistical analyses were summarized using; mean and range. The measurements used in summarizing the data are expressed as follows;

Mean

$$(x) = \frac{\Sigma x}{N} \quad \text{(iv)}$$

Where:

X = Arithmetic Mean, Σx =Total Measurement and N = Total measurement.

Range = Maximum- Minimum

5. Results and Discussion

Where SL is silt

Table 1. Physical Properties of Selected Soils in Agbor, Delta State.

Soil Samples Location	Depth		Soil Properties					
	(cm)	Horizon Description	Sand(%)	Silt(%)	Clay(%)	Bulk Density (gcm)	Total Porosity (%)	Textural Classes
Old Abraka Road	0 – 20	A_A	90	2.2	6	1.27	50.2	SL
	19 – 45	A_B	87.3	2.2	10.2	1.23	48.3	SL
	45 – 75	Bt_1	83.55	2	12	1.30	49.4	SL
	75 – 115	Bt_2	82.1	2	12	1.29	53.5	SL
	115- 200	Bt_3	82.20	2	14.4	1.36	52.7	SL
Max			90	2.2	14.4	1.36	53.5	
Min			82.1	2	6	1,23	48.3	
Range			7.9	0.2	8.4	0.13	5.2	
Mean			85.03	2.08	10.9	1.29	50.8	
Power Line Road	0 – 20	A_A	91	3	8.20	1.33	47.4	SL
	19 – 45	A_B	88.4	2.82	11.45	1.26	49.0	SL
	45 – 75	Bt_1	85.72	2.64	13.23	1.24	52.1	SL
	75 – 115	Bt_2	83.4	2.33	14	1.31	48.5	SL
	115- 200	Bt_3	80	2	15.30	1.28	51.9	SL
Max			91	3	15.30	1.33	52.1	
Min			80	2	8.20	1.24	47.4	
Range			11	1	7.1	0.09	4.7	
Mean			85.7	2.6	12.4	1.28	49.8	
Baleke Street	0 – 20	A_A	89.0	3	6.2	1.25	49.6	SL
	19 – 45	A_B	84.2	3	9	1.29	51.4	SL
	45 – 75	Bt_1	84	2	10.8	1.30	50.7	SL
	75 – 115	Bt_2	82.2	2	13	1.36	49.2	SL
	115- 200	Bt_3	81	2	15.1	1.29	47.8	SL
Max			89.0	3	15.1	1.36	51.4	
Min			81	2	9	1.25	47.8	
Range			8	1	6.1	0.11	3.6	
Mean			84.1	2.4	10.8	1.30	49.7	
Doctor White Street	0 – 20	AA	90	2.6	6.2	1.35	52.9	SL
	19 – 45	AB	88.4	2.55	8	1.32	50.2	SL
	45 – 75	Bt1	86.1	2.3	10.2	1.25	47.4	SL
	75 – 115	Bt2	83	2	12.6	1.28	48.0	SL
	115 – 200	Bt3	82	2	16	1.31	50.5	SL
Max			90	2.6	12.6	1.35	52.9	
Min			82	2	8	1.25	47.4	
Range			8	0.6	4.6	0.1	5.5	
Mean			85.9	2.3	10.6	1.30	49.8	
Melekwe Street	0 – 20	AA	89.6	3	6	1.30	49.4	SL
	19 – 45	AB	88.3	3	12	1.34	47.9	SL
	45 – 75	Bt1	86	2.6	12	1.27	48.6	SL
	75 – 115	Bt2	84.5	2.3	14	1.23	48.6	SL
	115 – 200	Bt3	80	2	16	1.29	52.7	SL
Max			89.6	3	16	1.34	52.7	
Min			80	2	6	1.23	47.9	
Range			9.6	1	10	0.11	4.8	
Mean			85.7	2.6	12	1.3	49.4	
Convent Street	0 – 20	AA	91	3	8	1.26	51.4	SL
	19 – 45	AB	87	3	9.2	1.32	49.9	SL
	45 – 75	Bt1	84	2	12.6	1.30	52.2	SL
	75 – 115	Bt2	82.1	2	14	1.26	48.2	SL
	115 – 200	Bt3	82	2	16	1.28	47.4	SL

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Max			91	3	16	1.30	52.2	
Min			82	2	8	1.26	47.4	
Range			9	1	8	0.04	4.8	
Mean			85.2	2.4	12.0	1.28	49.8	
Obuseh Street	0 – 20 19 – 45 45 – 75 75 – 115 115 – 200	AA AB Bt1 Bt2 Bt3	90 88 85.1 83 81.9	2.8 2.6 2.2 2.2 2	6 10 12.4 14 14.9	1.24 1.31 1.27 1.36 1.25	50.0 52.1 49.1 48.3 50.2	SL SL SL SL SL
Max			90	2.8	14.9	1.36	50.2	
Min			81.9	2	6	1.24	48.3	
Range			8.1	0.8	8.9	0.12	1.9	
Mean			85.6	2.4	11.5	`1.29	50.0	
Owanta Road	0 – 20 19 – 45 45 – 75 75 – 115 115 – 200	A_A A_B Bt_1 Bt_2 Bt_3	91 87.4 86 84 82.2	3 2.7 2.5 2.4 2	8 12 12 14 16	1.35 1.23 1.36 1.24 1.30	49.2 50.8 52.5 49.6 52.2	SL SL SL SL SL
Max			91	3	16	1.35	52.2	
Min			82.2	2	8	1.23	49.2	
Range			8.8	1	8	0.12	3	
Mean			86.1	2.5	12.4	1.30	50.9	
Tete Street	0 – 20 19 – 45 45 – 75 75 – 115 115 – 200	A_A A_B Bt_1 Bt_2 Bt_3	91 86 84.3 82 80	3 2.8 2.6 2.2 2	6.8 8.8 10 12.6 14	1.31 1.27 1.30 1.30 1.36	51.3 50.5 48.8 52.7 47.3	SL SL SL SL SL
Max			91	3	14	1.36	52.7	
Min			80	2	6.8	1.27	47.3	
Range			11	1	7.2	0.09	5.4	
Mean			84.7	2.5	10.4	1.31	50.1	
Effizimor Street	0 – 20 19 – 45 45 – 75 75 – 115 115 – 200	A_A A_B Bt_1 Bt_2 Bt_3	89 87.6 85 85 82	3 3 2.4 2.3 2	6 9.0 10.5 12 16	1.23 1.23 1.33 1.29 1.26	51.8 52.6 50.0 48.4 49.1	SL SL SL SL SL
Max			89	3	16	1.33	52.6	
Min			82	2	6	1.23	48.4	
Range			7	1	10	0.1	4.2	
Mean			85.7	2.5	10.7	1.27	50.4	
Onyeibe Street	0 – 20 19 – 45 45 – 75 75 – 115 115 – 200	A_A A_B Bt_1 Bt_2 Bt_3	90 88 86.5 84 80	3 3 2.3 2 2	6 8.9 11 13.1 15.9	1.31 1.36 1.23 1.27 1.24	52.9 47.4 49.1 51.8 48.7	SL SL SL SL SL
Max			90	3	15.9	1.36	52.9	
Min			80	2	6	1.23	47.4	
Range			10	1	9.9	0.13	5.5	
Mean			85.7	2.5	10.1	1.28	50.0	

Table 2. Chemical Properties of Selected Soils in Agbor, Delta State.

Soil Samples Location	Depth	pH		Organic Matter (%)			Total Exchangeable Bases (mol/kg)					Total Exchangeable Acids (mol/kg)			
	(cm)	KCl	H_2O	C	O.M	N	Ca^{2+}	Mg	K+	Na^+	ECEC	Al^{3+} (mol/kh)	H^+	EA	P (PPM)
Old Abraka Road	0 – 20	5.1	5.4	0.30	0.50	0.020	0.40	0.09	0.03	0.05	3.0	1.5	0.4	2.0	2.0
	19 – 45	5.3	5.7	0.24	0.47	0.018	0.50	0.07	0.03	0.04	3.4	1.3	0.3	1.6	2.3
	45 – 75	5.0	6.0	0.34	0.38	0.023	0.30	0.08	0.07	0.02	2.9	1.1	0.3	1.8	1.5
	75 – 115	5.0	5.5	0.29	0.40	0.021	0.30	0.08	0.06	0.02	3.2	1.6	0.5	2.2	1.3
	115 – 200	5.1	6.1	0.18	0.41	0.021	0.40	0.10	0.03	0.05	2.5	1.6	0.6	1.7	1.7
Max		5.3	6.1	0.34	0.54	0.023	0.50	0.10	0.07	0.05	3.4	1.6	0.6	2.2	2.3
Min		5.0	5.4	0.18	0.38	0.018	0.30	0.07	0.03	0.02	2.5	1.1	0.3	1.6	1.3
Range		0.3	0.7	0.16	0.16	0.005	0.20	0.17	0.04	0.03	0.9	0.5	0.3	0.6	1.8
Mean		5.1	5.74	0.27	0.43	0.021	0.38	0.09	0.03	0.18	3.0	1.42	0.42	1.9	1.8
Power Line	0 – 20	5.2	5.6	0.27	0.49	0.024	0.50	0.20	0.05	0.08	3.5	1.7	0.4	1.5	2.3
	19 – 45	5.1	5.6	0.31	0.53	0.022	0.30	0.07	0.04	0.06	3.7	1.5	0.3	2.1	1.9
	45 – 75	5.0	6.3	0.19	0.36	0.018	0.40	0.10	0.07	0.02	2.8	1.3	0.5	2.4	2.4
	75 – 115	5.0	5.8	0.32	0.44	0.023	0.70	0.09	0.03	0.06	3.3	1.6	0.7	1.9	2.0
	115 – 200	5.3	6.2	0.32	0.44	0.015	0.60	0.09	0.05	0.06	2.6	1.4	0.4	2.0	1.7
Max		5.3	6.3	0.32	0.53	0.024	0.70	0.20	0.07	0.08	3.7	1.7	0.7	2.4	2.4
Min		5.0	5.6	0.19	0.36	0.015	0.30	0.07	0.03	0.02	2.6	1.3	0.3	1.5	1.7
Range		0.3	0.7	0.13	0.17	0.009	0.40	0.13	0.04	0.06	1.1	0.4	0.4	0.9	0.7
Mean		5.1	5.9	0.28	0.45	0.020	0.50	0.11	0.05	0.06	3.2	1.5	0.5	2.0	2.1
Baleke Street	0 – 20	5.2	5.7	0.34	0.56	0.019	0.30	0.08	0.06	0.03	3.1	1.2	0.8	1.6	1.4
	19 – 45	5.2	5.5	0.28	0.49	0.020	0.50	0.08	0.04	0.05	3.0	1.1	0.4	2.2	1.4
	45 – 75	5.0	5.5	0.26	0.42	0.027	0.50	0.20	0.04	0.05	3.6	1.1	0.3	2.6	2.5
	75 – 115	5.1	6.1	0.30	0.37	0.024	0.40	0.07	0.06	0.03	2.5	1.5	0.6	1.5	2.6
	115 – 200	5.2	6.3	0.34	0.36	0.020	0.60	0.10	0.07	0.09	2.3	1.4	0.6	2.3	1.8
Max		5.2	6.3	0.34	0.56	0.027	0.60	0.20	0.07	0.09	3.6	1.5	0.8	2.6	2.6
Min		5.0	5.5	0.26	0.36	0.019	0.30	0.07	0.04	0.03	2.3	1.1	0.3	1.5	1.4
Range		0.2	0.8	0.08	0.20	0.008	0.90	0.13	0.03	0.06	1.3	0.4	0.5	1.1	1.2
Mean		5.1	5.9	0.30	0.44	0.022	0.46	0.11	0.05	0.05	2.9	1.3	0.5	2.0	2.0
Doctor White Street	0 – 20	5.1	5.5	0.10	0.38	0.015	0.33	0.09	0.04	0.08	3.0	1.6	0.4	1.7	1.8
	19 – 45	5.2	6.0	0.22	0.50	0.017	0.40	0.19	0.06	0.03	2.2	1.2	0.6	1.5	2.2
	45 – 75	5.1	5.8	0.19	0.24	0.020	0.39	0.10	0.04	0.05	2.9	1.7	0.3	1.9	1.7
	75 – 115	5.3	5.8	0.20	0.39	0.020	0.37	0.08	0.07	0.08	3.4	1.1	0.8	2.6	2.5
	115 – 200	5.1	6.1	0.33	0.48	0.024	0.66	0.08	0.03	0.04	2.5	1.5	0.6	2.4	2.1
Max		5.3	6.1	0.33	0.50	0.024	0.66	0.19	0.07	0.08	3.4	1.7	0.8	2.6	2.5
Min		5.2	5.5	0.19	0.24	0.015	0.33	0.08	0.03	0.03	2.2	1.1	0.3	1.5	1.7
Range		0.1	0.6	0.14	0.26	0.009	0.33	0.11	0.04	0.05	1.2	0.6	0.5	1.1	0.8
Mean		5.2	5.8	0.21	0.40	0.019	0.43	0.11	0.05	0.06	2.8	1.4	0.5	2.0	2.1
Melekwe Street	0 – 20	5.0	5.4	0.19	0.55	0.028	0.50	0.10	0.03	0.04	3.5	1.8	0.5	2.7	1.7
	19 – 45	5.3	5.9	0.26	0.49	0.014	0.70	0.10	0.05	0.06	3.2	1.4	0.3	2.3	2.5
	45 – 75	5.3	5.7	0.31	0.47	0.022	0.30	0.09	0.05	0.04	2.9	1.7	0.6	1.9	1.9
	75 – 115	5.1	6.0	0.31	0.50	0.026	0.40	0.20	0.07	0.08	3.0	1.3	0.9	2.2	2.0
	115 – 200	5.2	5.9	0.30	0.43	0.022	0.40	0.20	0.03	0.06	3.2	1.5	0.7	2.2	1.4
Max		5.3	6.0	0.31	0.55	0.028	0.70	0.20	0.07	0.08	3.5	1.8	0.9	2.7	2.5
Min		5.0	5.4	0.19	0.43	0.014	0.30	0.09	0.03	0.04	2.9	1.3	0.3	1.9	1.4
Range		0.3	0.6	0.12	0.12	0.014	0.40	0.11	0.04	0.04	0.6	0.5	0.6	0.8	1.1
Mean		5.2	5.8	0.27	0.49	0.022	0.46	0.12	0.05	0.06	3.2	1.5	0.6	2.3	1.9
Convent Street	0 – 20	5.1	5.5	0.22	0.45	0.021	0.60	0.20	0.04	0.02	2.7	1.4	0.6	1.4	2.5
	19 – 45	5.1	6.1	0.32	0.36	0.026	0.40	0.07	0.06	0.06	2.5	1.6	0.4	2.0	2.1
	45 – 75	5.3	6.1	0.19	0.49	0.016	0.40	0.10	0.03	0.07	3.3	1.1	0.3	1.9	1.6
	75 – 115	5.0	5.8	0.28	0.49	0.016	0.30	0.08	0.03	0.05	3.6	1.3	0.5	2.2	1.2
	115 – 200	5.1	6.0	0.27	0.57	0.025	0.50	0.09	0.05	0.02	2.8	1.4	0.5	2.2	2.3

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Max		5.3	6.1	0.32	0.49	0.026	0.60	0.20	0.06	0.07	3.6	1.6	0.6	2.2	2.5
Min		5.0	5.5	0.19	0.36	0.016	0.30	0.07	0.03	0.02	2.5	1.1	0.3	1.4	1.2
Range		0.3	0.6	0.13	0.13	0.01	0.30	0.13	0.03	0.05	1.1	0.5	0.3	0.8	1.3
Mean		5.1	5.9	0.26	0.47	0.021	0.44	0.11	0.04	0.04	3.0	1.4	0.5	2.0	2.0
Obuseh Street	0 – 20	5.0	5.4	0.34	0.56	0.023	0.70	0.07	0.05	0.03	3.0	1.9	0.8	2.5	1.9
	19 – 45	5.2	5.8	0.29	0.47	0.028	0.50	0.07	0.05	0.03	3.4	1.7	0.5	1.6	2.1
	45 – 75	5.1	5.8	0.24	0.35	0.019	0.60	0.20	0.07	0.06	2.6	1.5	0.3	2.3	1.4
	75 – 115	5.3	6.2	0.18	0.44	0.014	0.60	0.20	0.04	0.05	3.8	1.3	0.7	2.3	1.2
	115 – 200	5.3	5.9	0.30	0.48	0.027	0.40	0.10	0.04	0.09	3.2	1.5	0.6	1.7	2.0
Max		5.3	6.2	0.34	0.56	0.028	0.70	0.20	0.07	0.09	3.8	1.9	0.8	2.5	2.1
Min		5.0	5.4	0.18	0.35	0.014	0.40	0.07	0.04	0.03	2.6	1.3	0.3	1.6	1.2
Range		0.3	0.8	0.16	0.21	0.014	0.30	0.13	0.03	0.06	1.2	0.6	0.5	0.9	0.9
Mean		5.2	5.8	0.27	0.46	0.022	0.56	0.13	0.05	0.05	3.2	1.6	0.6	2.1	1.7
Owanta Street	0 – 20	5.2	5.8	0.20	0.45	0.025	0.30	0.08	0.07	0.06	2.4	1.4	0.7	1.5	2.3
	19 – 45	5.2	6.0	0.26	0.50	0.022	0.50	0.10	0.04	0.03	2.4	1.4	0.7	2.4	2.3
	45 – 75	5.1	6.0	0.26	0.50	0.017	0.40	0.07	0.06	0.05	3.0	1.8	0.5	2.0	1.8
	75 – 115	5.0	5.9	0.32	0.43	0.026	0.30	0.09	0.07	0.05	3.2	1.3	0.3	2.6	2.4
	115 – 200	5.2	6.3	0.28	0.53	0.021	0.60	0.20	0.05	0.08	3.5	1.6	0.8	2.5	2.7
Max		5.2	6.3	0.32	0.53	0.026	0.60	0.20	0.07	0.08	3.5	1.8	0.8	2.6	2.7
Min		5.0	5.8	0.20	0.43	0.017	0.30	0.07	0.04	0.03	2.4	1.3	0.3	1.5	1.8
Range		0.2	0.5	0.12	0.10	0.009	0.30	0.13	0.03	0.05	1.1	0.5	0.5	1.1	0.9
Mean		5.14	6.0	0.26	0.48	0.022	0.42	0.11	0.06	0.05	2.9	1.5	0.6	2.2	2.3
Tete Street	0 – 20	5.1	5.5	0.30	0.57	0.015	0.40	0.09	0.03	0.05	3.8	1.3	0.4	2.5	2.3
	19 – 45	5.3	6.3	0.19	0.49	0.020	0.40	0.10	0.05	0.07	3.6	1.2	0.6	2.1	2.6
	45 – 75	5.0	6.0	0.29	0.37	0.018	0.30	0.08	0.05	0.09	3.6	1.4	0.8	2.7	2.2
	75 – 115	5.1	6.2	0.34	0.41	0.018	0.50	0.20	0.03	0.04	2.7	1.2	0.5	1.9	1.7
	115 – 200	5.1	5.8	0.33	0.40	0.024	0.30	0.10	0.04	0.04	2.4	1.5	0.4	2.1	1.7
Max		5.3	6.3	0.34	0.57	0.024	0..50	0.20	0.05	0.09	3.8	1.5	0.8	2.7	2.6
Min		5.0	5.5	0.19	0.37	0.015	0.30	0.08	0.03	0.04	2.4	1.2	0.4	1.9	1.7
Range		0.3	0.8	0.15	0.20	0.009	0.20	0.12	0.02	0.05	1.4	0.3	0.4	0.6	0.9
Mean		5.1	6.0	0.29	0.45	0.019	0.38	0.11	0.04	0.06	3.2	1.3	0.5	2.3	2.1
Effiziomor Street	0 – 20	5.3	5.7	0.22	0.55	0.022	0.60	0.20	0.06	0.07	2.5	1.6	0.8	1.9	1.2
	19 – 45	5.2	5.4	0.22	0.43	0.026	0.40	0.10	0.03	0.04	3.0	1.8	0.5	2.3	2.4
	45 – 75	5.2	5.9	0.33	0.57	0.019	0.70	0.09	0.05	0.02	2.7	1.5	0.4	2.6	1.5
	75 – 115	5.1	6.1	0.27	0.38	0.020	0.40	0.09	0.04	0.02	2.7	1.5	0.4	2.0	1.7
	115 – 200	5.0	6.1	0.25	0.38	0.027	0.50	0.07	0.05	0.08	3.6	1.4	0.9	2.3	1.8
Max		5.3	6.1	0.33	0.57	0.027	0.70	0.20	0.06	0.08	3.6	1.8	0.9	2.3	2.4
Min		5.0	5.4	0.22	0.38	0.019	0.40	0.03	0.03	0.02	2.5	1.4	0.4	1.9	1.2
Range		0.3	0.7	0.11	0.19	0.008	0.30	0.17	0.03	0.06	1.1	0.4	0.5	0.4	0.9
Mean		5.2	5.8	0.26	0.46	0.023	0.52	0.11	0.05	0.05	2.9	1.6	0.6	2.2	1.7
Onyeibe Street	0 – 20	5.0	6.0	0.31	0.35	0.027	0.70	0.09	0.07	0.02	3.3	1.6	0.4	1.6	2.6
	19 – 45	5.3	5.8	0.23	0.40	0.024	0.50	0.20	0.04	0.02	2.8	1.9	0.4	2.2	2.1
	45 – 75	5.1	5.7	0.34	0.51	0.020	0.50	0.08	0.05	0.06	3.0	1.7	0.6	1.8	2.3
	75 – 115	5.2	6.2	0.19	0.46	0.028	0.30	0.09	0.03	0.04	2.6	1.5	0.7	2.6	1.9
	115 – 200	5.2	6.2	0.33	0.50	0.018	0.60	0.20	0.04	0.07	2.9	1.6	0.7	2.0	2.2
Max		5.3	6.2	0.33	0.51	0.027	0.70	0.20	0.07	0.07	3.3	1.9	0.7	2.6	2.6
Min		5.0	5.7	0.19	0.35	0.018	0.30	0.08	0.03	0.02	2.6	1.5	0.4	1.6	1.9
Range		0.3	0.5	0.14	0.16	0.009	0.40	0.12	0.04	0.05	0.7	0.4	0.3	1.0	0.7
Mean		5.2	6.0	0.28	0.4	0.023	0.52	0.13	0.05	0.04	2.9	1.7	0.6	2.0	2.2

Source: Researcher's Field Survey, 2019.

Figure 2a, b, c and d: Shows erosion sites at Old Abraka road-Boji Boji Owa-Ika North-East, Power Line road–Boji Boji Owa-Ika North East, Baleke street Boji-Boji Owa- Ika South and Doctor White Boji-Boji Owa-Ika South respectively.

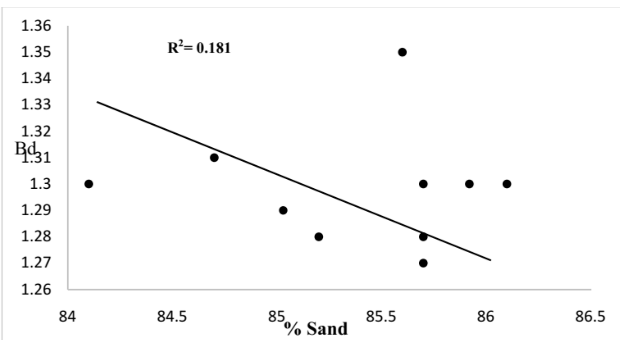

Figure 3a. Plot of Bulk Density (Bd) against %Sand

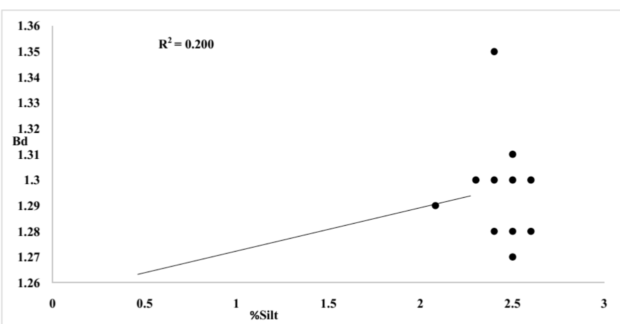

Figure 3b. Plot of bulb density (Bd) against %Silt

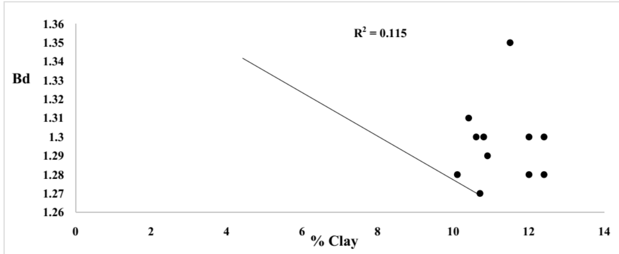

Figure 3c. Plot of Bulk Density(Bd) against %Clay

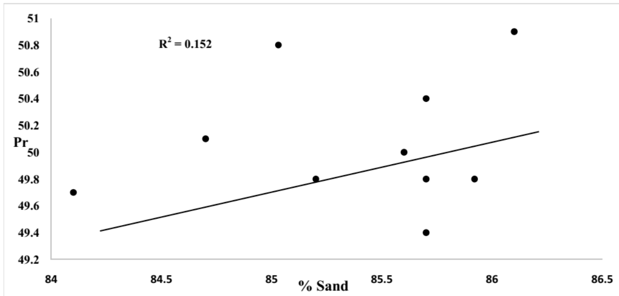

Figure 3d. Plot of Porosity against %Sand

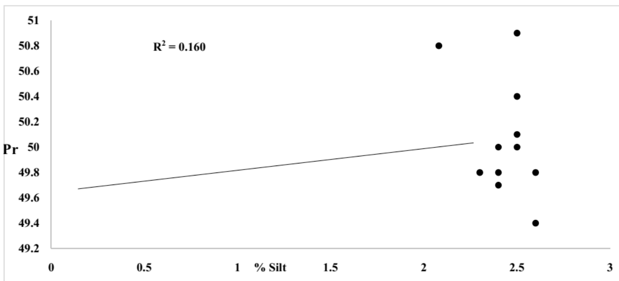

Figure 3e. Plot of Porosity against %Sand

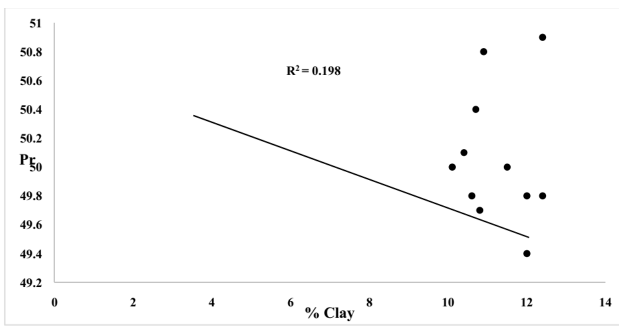

Figure 3f. Plot Porosity against % Clay

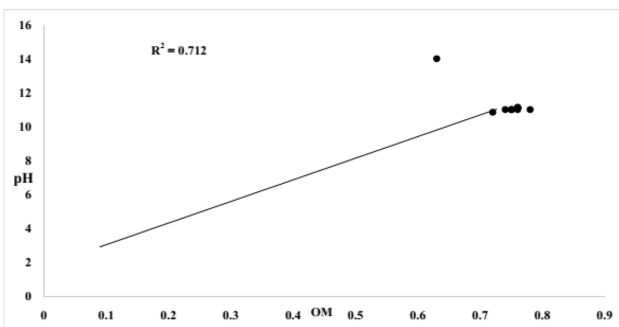

Figure 3g. Plot of pH against Organic matter (OM)

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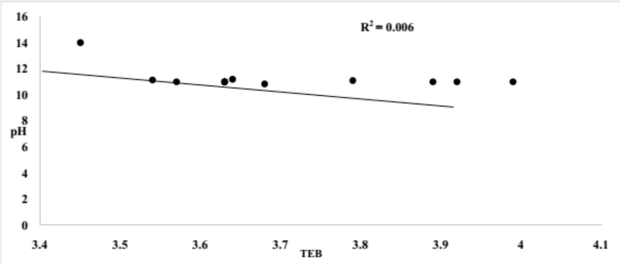

Figure 3h. Plot of pH against Total Exchangeable Bases (TEB)

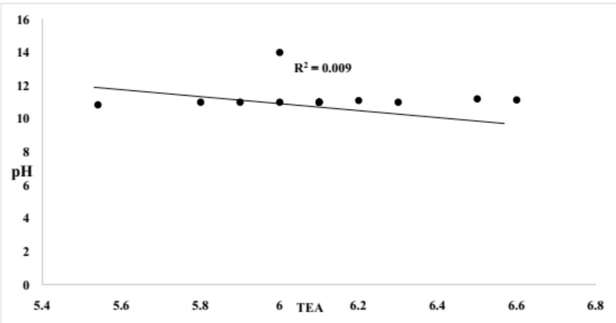

Figure 3i. Plot of pH against Total exchanges acids (TEA)

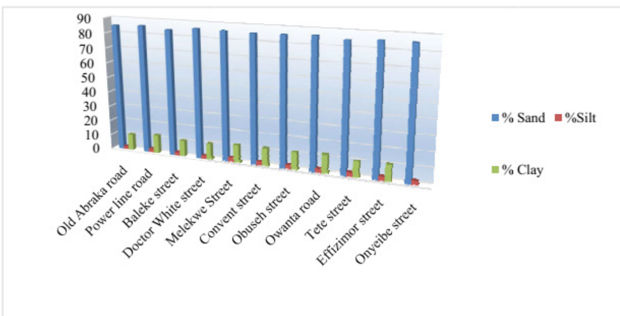

Figure 4a. Distribution of Textural Classes of Profile Pits of Soil Samples

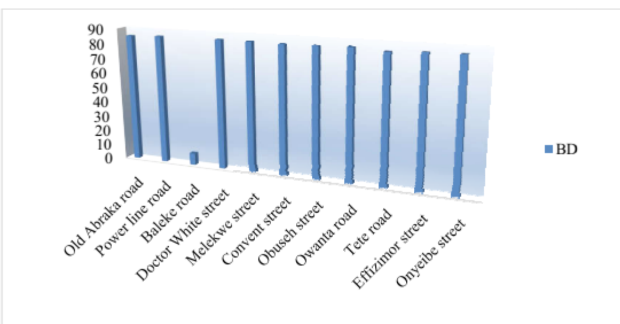

Figure 4b. Distribution of Bulk Density of Profile Pits of Soil Samples

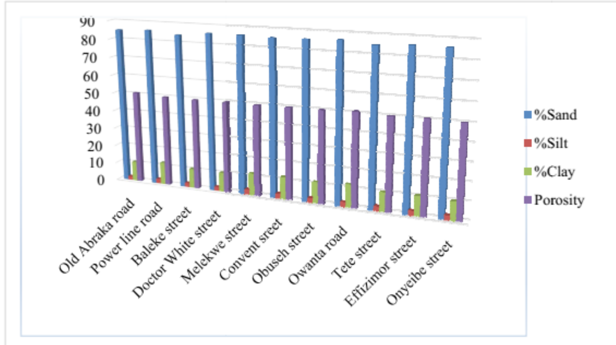

Figure 4c. Distribution of Physical Characteristics Profile Pits of Soil Samples

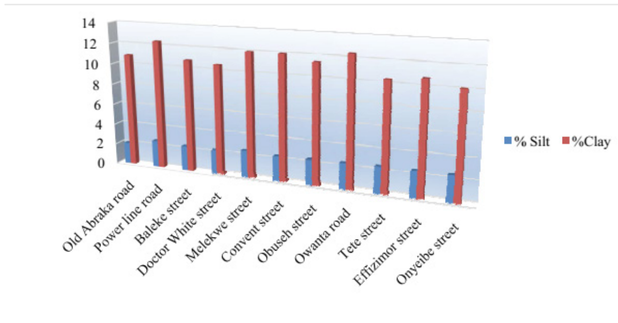

Figure 4d. Distribution of Physical Characteristics of Profile Pits of Soil Samples

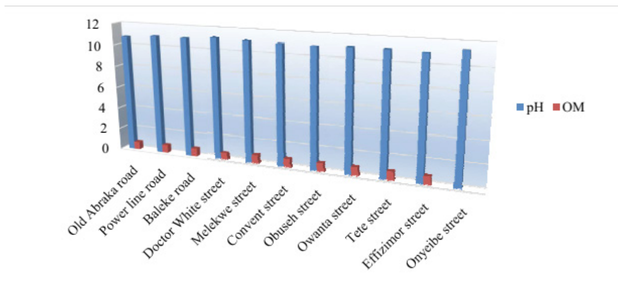

Figure 4e. Distribution of chemical characteristics of profile pits of soil samples

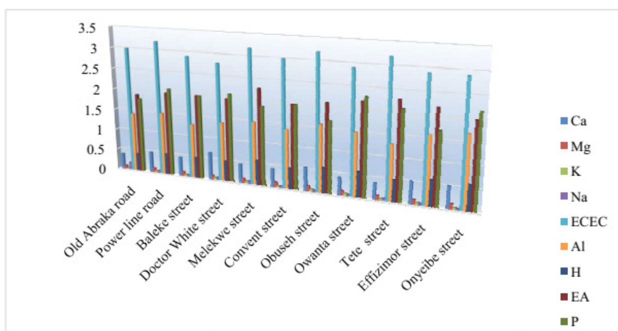

Figure 4f. Distribution of chemical characteristics of profile pits of soil samples

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6. Discussion

Results from Table 1, showed that Doctor White street had the highest sand content at (21.48%), while Baleke street recorded the lowest value at (21%). It was observed that the sand fractions in all eleven locations were similar at same ranges and were not significantly different. The top soil in all sampled soils was also higher than sub soils in all eleven locations. Clay content results in sampled soils in all eleven locations was also significantly different, ashighest value was recorded for two sampled soils in three locations (Power line road and Owanta road) at (3.1%) respectively. While low value (2.61%) was recorded at Tete street. However, there was also no significant difference between the clay contents of soil depths in two sampled locations. Silt content indicates that Power line road and Effizimor street has the highest value at (0.64 %) while Doctor white has the lowest value at (0.57 %). The silt content between the three soil depths also revealed no significant difference. The bulk density value shows that all sampled soils are same value at (0.32%), while soil porosity shows that Ownata road has the highest value at (12.7%) while lowest value was recorded for two sampled soils (Power line road and Doctor white) at (12.4%). This also shows no significant difference in soils sampled results in all eleven locations. Findings from Table 2 below revealed that pH level pHKcl (pH of soil matrix) and pHH_20 (pH of water) for all sampled soils results in all eleven locations were significantly different. With the highest pHKcl value recorded at two sampled location Melekwe street and Obuseh street at (1.30%), while the lowest value was at four sampled soils such as; Old Abraka road, Powerline road, Convent street and Tete street at (1.28%) respectively. Highest value for pHH_20 was recorded at two soil sampled location Tete street and Onyeibe street at (1.49%), while the lowest value was observed at Old Abraka road at (1.42%).In terms of organic carbon Baleke street had the highest content at (0.08%) than Doctor white street which recorded the lowest value at (0.05%). In terms of organic matter content in five sampled soils in all eleven locations Melekwe street, Convent street, Obuseh street, Owanta road and Effiizimor street recorded the highest value at (0.12 %). Thus, were said to be not significantly different. While Doctor White street recorded a low value at (0.10%) respectively. However, the highest value for nitrogen content were recorded in Baleke street, Melekwe street, Obuseh street, Owanta road, Effizimor street and Onyeibe street at (0.006%), while lowest value was recorded at Old Abraka road, Power line road, Doctor White street and Tete street at (0.005%). Hence, from the result it was observed that organic carbon, organic matter and nitrogen content of all sampled soils in all eleven locations were not significantly different in all sites. Results from Table 2 showed that there was no significant difference in Calcium (Ca) content of the sampled soils in all eleven sites, as the calcium content either increases or decreases from (0.08% - 0.14%) with soil depth (topsoil – subsoil) simultaneously. It was also observed that there was no significant difference in the mean of Magnesium (Mg). It showed that all value of sampled soils in all eleven locations was at (0.03%). The potassium (K^+) content at Owanta road recorded the highest value at (0.015%) while Old Abraka road recorded the lowest value at (0.02%) respectively. However, there was no significant difference in their mean value. The sodium (Na^+) content in Power line road, Doctor white street, Melekwe street, Owanta road; Covent street and Onyeibe street were at same value at (0.014%) and (0.011%). Sodium contents also increases and decreases at different soil depth; while old Abraka road had the lowest value at (0.009%). Table 2 also shows that the exchangeable cation exchange capacity (ECEC) of sampled soils in all eleven locations were not significantly different with Tete street having the highest value at (0.82%) while Doctor white street had the lowest value at (0.7%). However, the mean values of ECEC in all sample locations were equally similar. Table 2 further shows a slight significant difference in the aluminum (Al^{3+}) content in all soil sampled in all eleven locations. The highest values were recorded in Onyeibe street at (0.40%) while the lowest value was in Baleke street at (0.32%) respectively. There was also a slight increase as well as decrease in soil depth of Al^{3+} content in all sites. Results for hydrogen content revealed that four sampled soils; Melekwe street, Obuseh street, Owanta road and Effizimor street had similar value (highest value) at (0.15%); thus, there was no significant difference in their mean value, as old Abraka road, Power line road and Convent street had the lowest value at (0.12%). The mean value for Exchangeable acidity (EA) content are same for all soil sampled locations, there was also an increase as well as a decrease in soil depth in all sites. Highest value was recorded by Melekwe street and Tete street at (0.57%) while Old Abraka road had the lowest value at (0.47%). The phosphorous content at Owanta road recorded the highest value at (0.58%). It was observed that the lowest value was recorded in two sampled soils Obuseh street and Effizimor street at (0.43%) respectively. As there were also similar values in the increase and decrease in soil depths in all sampled locations in the study area.

7. Conclusions

The physio-chemical properties of soils in Agbor and

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its neighbouring communities were assessed. A field procedure that involved the collection of soil samples and laboratory analysis was employed in the study. A total of 11 erosional sites were recorded in the area and they were majorly rill, sheet to gully with 0 – 200cm. The laboratory results from the physio-chemical properties of soil results showed that all soils in 11 locations are susceptible to erosion. Consequently, soils in the study area were mainly sandy silt. There is an increase in pH of soils, slight increase in bulk density and low level of porosity due to annual heavy rainfall with resultant leaching problems. Ca, Mg, K^+, Na^+ and ECEC has a low value range. However, these low values were due to low level of organic matter. While the slight increase in Al^{3+} H^+, EA and P was as a result of acidity nature of soils in the study area. With this results it is therefore recommended that measures that will drastically reduce the negative effect of soil erosion such as; mulching, crop rotation, planting of vegetative cover, cover cropping on soil surface to reduce the rate of surface runoff, flow force and transport capacity of flow should be encouraged due to the presence of high fraction of sand and heavy rain drops on soil surface in the study area. Mechanical structures that will boost proper construction of drainage facilities and silt trapping should also be instigated. Finally, we recommended that information regarding soil erosion within the study area should be fused into long-term plans of Agbor and other erosion vulnerable areas, as the public should also be conscious of the menace and preventive measures.

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