ASSESSING THE INFLUENCE OF THE CLIMATIC FACTORS (CF) ON THE SILT CONTENTS OF SOILS (SCS): EFFECTS ON EROSION

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Abstract *– This report assesses the influence of climatic factors on the silt contents of soils and the likely effects such could have on the erosion of the silt particles. The sites are located at the humid tropical South Eastern region of Nigeria with at 17% silt. The climatic factors considered include maximum air temperature (MAT), rainfall amount (RA), solar radiation (SR), and sunshine (S). In the study, the silt contents , as dependable variable were correlated and regressed with the climatic factors, using the IBM SPSS Statistics Software. The silt contents correlated positively with the maximum air temperature and the solar radiation. In the light of these observations, the maximum air temperature and the solar radiation had been unfolded as having played significant roles. Nevertheless, such roles are apparently in-situ at pre-detachment stage of the erosion process. It is however remarkable to note that the silt contents of the soil had not correlated with the rainfall amount. As such the relationship between the silt contents and the rainfall amounts was insignificant and this will hardly enhance the detachment, transport and delivery stages of an erosion process. Solar radiation produced the best single parameter, non linear, exponential, model: Silt content= 1.324-0.197solar radiation. This model had comparatively the least standard error of estimate, SE, of 0.764. Correlation analyses carried out between the climatic factors revealed that the climatic factors work in synergy to effect an erosion process, since the maximum air temperature, the solar radiation and the sunshine hours correlated positively with one another. This notwithstanding, it was apparent the amount of silts in the soil, 17%, was not significant to enhance the erosion of the soil.*

Keywords: climatic factors, influence, silt contents, synergy, erosion.

1. INTRODUCTION

The danger posed by erosion on soils and the environment has continued to cause sleepless nights to researchers. In the light of this, the vulnerability of the Southeastern zone of Nigeria has been stressed [15]. According to the report, gully erosion annually caused environmental problems and damages estimated at over $100million. Most of these gullies were observed to have occurred on bare soils surfaces created by human activities [2]. In the humid tropics, bare soil surfaces usually experienced devastating erosion following exposure to the prevalent harsh climatic factors (CF). These factors include internal or inherent factors as well as external factors that quite often support the internal factors to aggravate erosion processes.

The internal factors are the in-situ soil physical and engineering properties which basically include the soil particle size or soil texture. The texture of the soil tells as much as possible about the soil in one word [5]. Usually various particle sizes are found in soil namely: gravel (2mm – 20mm), sand (0.063mm-2mm), silt (0.002mm – 0.063m), and clay (particles less than 0.002mm) [10]. Silt particles by their nature are usually unstable in water. Water affects the interactions between the minerals grains and this affects their cohesiveness, making them unstable in the presence of water [5]. Sequel to this, soil with silt contents of between 40% to 60% silt contents are usually erodible [9].

The external factors, on the other hand are those factors that are not inherent on the soils but act on it, influencing its behavior, quite often shattering or detaching it into the delivery system of the erosion process. These factors include CF of rainfall, temperature, sunshine, solar radiation, and relative humidity [14]. The damage being posed by these CF on soils demands urgent attention. Heat related damages are steadily being meted out, not only to our soils but also to the environment and ecosystems. The earth is seen getting hotter day by day [1];[6].

The soil has been referred to as the skin of the earth's crust and as such damages to it should not be allowed [8];[12];[13];[16]. It is very expensive to lose the soil. It takes 300years to form just a centimeter of soil [4].

The main objective of the study is to assess the influence of climatic factors on silt contents of soil in a bid to unfold the likely effect this could have on the erosion of the soil.

2. MATERIALS AND METHODS

2.1 The Study Sites

The study sites included Afikpo, Akaeze, Akwete, Bende, Egbema, Isieke-Ibeku, Isuochi, Okposi, Orlu, Owerri, Umuna, Okwele, Aba, Igbere, and Owutu-Edda, all in the former Imo State of Nigeria.

Table 1: The Representative Soil groups and their Locations

S/N	USDA	FAO	Parent Material	Location
1	Aqui Paleudult	Dystric Nitosol	Shale	Akaeze
2	Arenic Paleudult	Dystric Nitosol	Sandy Alluvium	Akwete
3	Eutric Tropofluents	Eutric Fluvisol	Shales and Sandstone	Egbema
4	Orthoxic Tropodult	Dystric Ferralsol	Coastal Plain Sands	Owerri
5	Gross Arenic Paleudult	Dystric Nitosol	Sandstone	Isuochi
6	Orthoxic Tropodult	Rhodic Ferralsol	Sandstone	Igbere
7	Plinthic Tropodult	Plinthic Acrisol	Shales	Okposi
8	Typic Dystropepts	Dystric Cambisol	Sandstone	Afikpo
9	Typic Dystropepts	Dystric Cambisol	Shale	Bende
10	Typic Hapludult	Orthic Acrisol	Shale and Sandstone	Okwele
11	Typic Tropaquepts	Dystric Gleysol	Shale and Sandstone	Isieke Ibeku
12	Typic Tropadquepts	Eutric Gleysol	Shale and Sandstone	Umuna
13	Typic Tropudalfs	Eutric Nitosol	Siltsyone	Orlu
14	Typic Tropudult	Dystric Ferralsol	Coastal Plain Sands	Aba
15	Typic Tropudult	Ferric Acrisol	Shale and Sandstone	Owutu-Edda

[7]

Table 2: The Silt Contents of the Soils

Site	Afikpo	Akaeze	Akwete	Bende	Egbema	Isieke Ibeku	Isuochi	Okposi	Orlu	Owerri	Umuna	Okwele	Aba	Igbere	Owutu Edda
Silt Contents (%)	15	44	38	3	43	14	1	9	8	9	10	19	7	6	29

[7]

Table 3: The Climatic Records of Imo State

Month	Max. Temp (^0C)	Rainfall amounts (mm)	Solar Radiation (W/m^2)	Relative Humidity (%)	Sunshine (hrs)
January	33.2	37.1	13.4	62	5.8
February	35.2	34.3	14.9	72	5.2
March	34.2	45.9	14.1	77	5.8
April	33.3	99.6	13.7	77	5.4
May	32.0	298.8	12.9	79	5.5
June	30.4	185.9	11.5	85	3.7
July	-	-	-	-	-
August	29.9	438.2	8.8	88	2.5
September	29.2	622.2	9.2	86	3.0
October	30.3	284.3	10.2	83	4.7
November	32.1	111.7	11.5	77	6.6
December	32.5	0.0	12.8	45	7.0

[11]

Table: 4 Summary of the CF

CF	Range
Maximum air temperature (^oC)	29.2-35.2
Rainfall amounts (mm)	34.3-622.2
Solar radiation (W/m^2)	8.8-14.9
Sunshine (hours)	2.5-7.0

[11]

2.2 Method of Data Analysis

The analysis was done using the IBM SPSS Statistics software [3]. The silt contents of the soils, as dependable variables were correlated with the each of the CF of maximum air temperature , solar radiation, relative humidity and sunshine hours, as independable variables. The outcomes that were significant at 0.05 (1-tailed) were noted. Also noted were the strength and nature of the relationship. Regression analyses were then conducted on the significant items using both linear and non-linear (curve estimation) methods. The respective model equations were gathered. The model equations were observed to identify the model equation that comparatively predicted the silt contents of the soils, with the least error of estimate (SE).

3. RESULTS AND DISCUSSIONS

3.1 Results

Table 5: Results of Correlation analysis of the Silt contents of the soils with the climatic factors

Factors[a]	Correlation	P-Value*
Silt / Max. Temp	0.602	0.022
Silt/Rainfall amounts	-0.340	0.168
Silt/Solar radiation	0.621	0.021
Silt/Sunshine	0.302	0.184

* Correlation is significant at 0.05 level (1-tailed)
[a]Threshold values of the Max. air temp was 29.2^0C, Rainfall was 34.3mm, Solar radiation was $8.8W/m^2$, and that of Sunshine hours was 2hours.

Table 6: Strength and nature of relationship between the Silt contents of the soil and the climatic factors

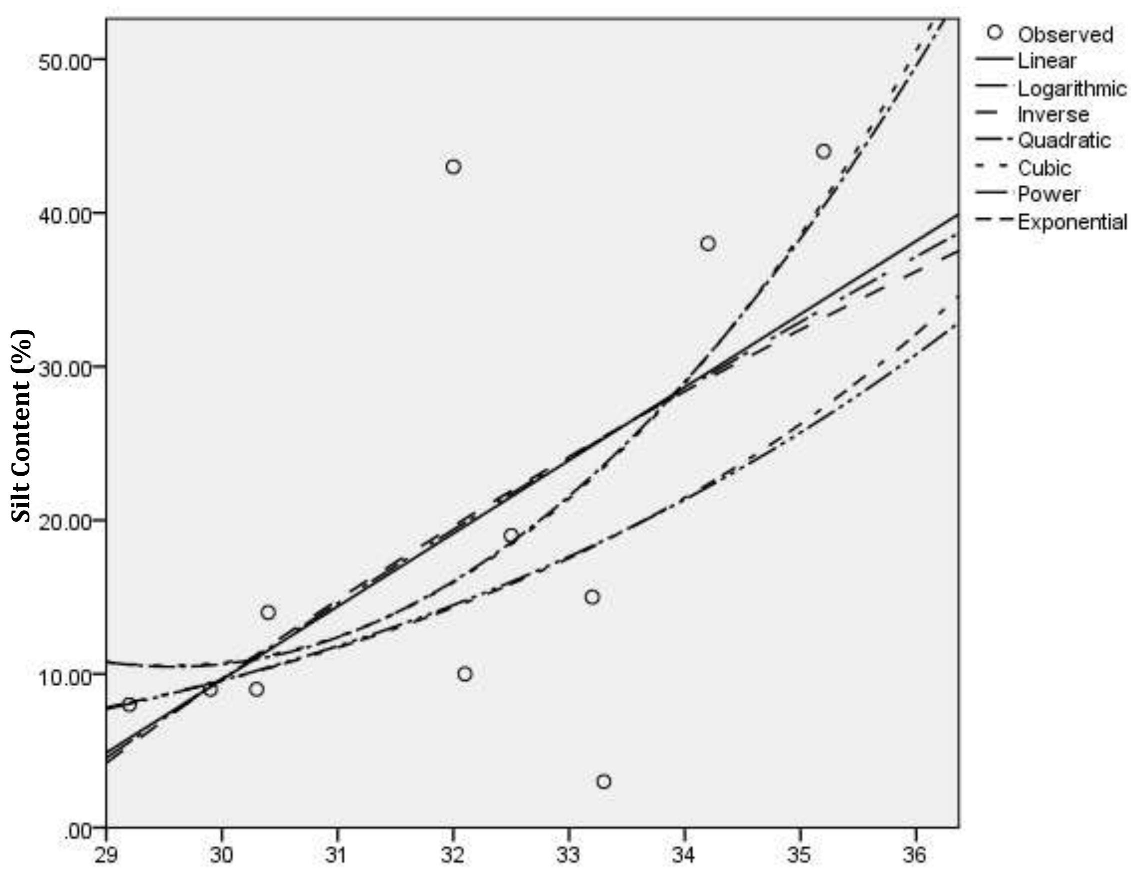
Factors	R	Nature of the Relationship	R^2	Strength of the Relationship
Silt /Max. temp.	0.602	Positive	0.362	Moderate
Silt/Solar radiation	0.621	Positive	0.385	Moderate

Table 7 : Model Gathering (Max .temp on Silt content)

Model Equation	R^2	Standard error of estimation
Linear: Silt content=-133.078+4.757Max.temp	0.362	12.657
Logarithmic: Silt content = -o.503.450+150.859 In(Max.temp)	0.355	12.723

Inverse: Silt content = $168.681\text{-}4769.816\left(\frac{1}{156.667 Sunshine\ hours}\right)$	0.349	12.790
Quadratic: Silt content=839.699+0.948(Max.temp)^2-56.072 Max.temp	0.405	12.961
Cubic: Silt content=251.613+0.019(Max.temp)^3-0.830(Max.temp)^2	0.409	12.925
Power: Silt content=3.327E-009+6.404 In(Max.temp)	0.211	0.775
Exponential: Silt content=0.022-0.202 Max.temp	0.215	0.773*

* Silt content=0.022-0.202 Max.temp is hereby selected.



Maximum air temperature (°C)

Fig. 1: Silt content (observed and predicted values) versus maximum air temperature.

Table 8 : Model Gathering (Solar radiation on Silt content)

Model Equation	R^2	Standard error of estimation
Linear: Silt content=-36.589+4.620Solar radiation	0.386	12.420
Logarithmic: Silt content = -108.630+51.596 In(Solar radiation)	0.363	12645
Inverse: Silt content = 67.023-561.416(1/Solar radiation)	0.339	12.882
Quadratic: Silt content=107.590+1.078(Solar radiation)^2-20.667 Solar radiation	0.445	12.516
Cubic: Silt content=30.039+0.052(Solar radiation)^3-0.725(Solar radiation)^2	0.449	12.476
Power: Silt content=0.058+2.228 In(Solar radiation)	0.224	0.769
Exponential: Silt content=1.324-0.197 Solar radiation	0.233	0.764*

*Silt content= 1.324-0.197 Solar radiation is hereby selected.

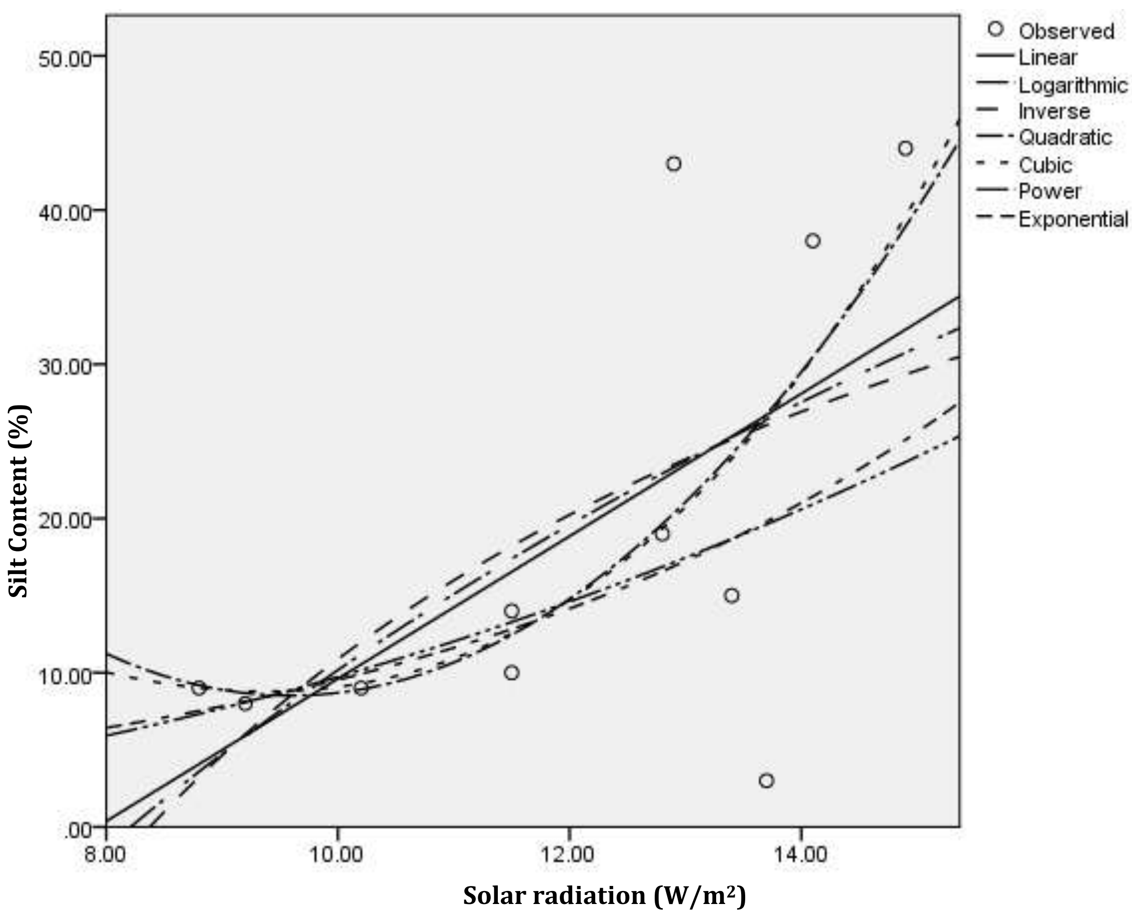


Fig. 2: Silt content (observed and predicted values) versus Solar radiation.

Table 9: Regression analysis of the significantly correlated factors of silt content of the soil and the climatic factor of Solar radiation.

Climatic Factors and Soil Properties	Nature of relationship	R^2	SE	F	Model Equation -Exponential*
Silt content and Solar radiation	Positive	0.233	0.764	2.728	1.324 + 0.197 Solar radiation

***Predicted values of the sand content ranged from 6.5 to 27.0%.**

Table 10: Correlation and Nature of Relationships of the CF.

Factors	R	Nature of the Relationship	P-value	Strength of the Relationship
Max. temp/Rainfall amount	-0.830	Negative	0.001	Good
Max. temp/Solar Radiation	0.951	Positive	0.000	Very good
Max. temp/Sunshine hours	0.682	Positive	0.010	Medium
Rainfall/Solar radiation	-0.833	Negative	0.001	Good
Rainfall/Sunshine hours	-0.807	Negative	0.001	Good
Solar radiation/Sunshine hours	0.697	Positive	0.009	Medium

3.2 Discussions

Tables 3 and 4 showed that the study had been carried out within the following ranges of the climatic factors: Maximum Air Temperature (29^0C to 35.2^0C), Rainfall amounts (34.3mm to 622.2mm), Solar radiation (8.8 to 14.9W/m^2), and Sunshine hours (2.5hours to 7.6 hours).

From Table 5, it was obvious that the silt content of the soil showed no correlation with both the rainfall amounts and the sunshine hours, but correlated positively with the maximum air temperature and the solar radiation. The strength of the correlation as indicated in Table 6 were moderate in all the cases.

Through the regression analysis carried out using both linear and non-linear (curve fit) methods as could be seen in Figure 1, it was noticed that whenever the maximum air temperature increases, the silt content of the soil also increases. In like manner, the silt content of the soil increases whenever the solar radiation increases, as indicated in Figure 2.These activities apparently have occurred in-situ, at the pre-detachment stage of the erosion process, as both the maximum air temperature and the solar radiation do not play roles in the transportation and delivery phases of the erosion process.

Remarkably, it was noted that the rainfall amounts that usually play major role in the transport, delivery and deposition phases of the erosion process had not correlated with the silt content of the soil. This behaviour appeared to have resulted following the amount of the silt content in the soil which is 17%. Based on this amount of silt content of 17%, the soil is not erodible. Judging from the silt content of a soil, erodible soil should contain between 40% to 60% silt content [9]. It is not therefore surprising that rainfall amounts which ought to play roles in the detachment, transportation and delivery stages of an erosion process did not correlate with the silt content of 17% of the soil.

Further investigations carried out by conducting a correlation analysis between the climatic factors unfolded as could be seen in Table 10,that the climatic factors work in synergy. The rainfall amounts correlated negatively with each of the other climatic factors, the maximum air temperatures, the solar radiation, the sunshine hours, while the maximum air temperatures, the solar radiation and the sunshine hours correlated positively with one another. The maximum air temperatures, the solar radiation and the sunshine appeared to have played complementary role in the evaporation of moisture from the land and sea. This evaporated moisture latter fall as rains, which the rainfall amounts portray. Notwithstanding, the extent the climatic factors had worked in synergy, the fact remained that the influence of the climatic factors on the silt content of 17% of the soil had not enhanced the erosion of the soil.

From Tables 7, 8, 9, and 10, the best single parameter, non-linear, Exponential, predictor model for the silt content is given as Silt content= 1.324-0.197solar radiation , which have comparatively the least value for the standard error of estimate, SE, of 0.764.

4. CONCLUSION

The influence of the climatic factors of maximum air temperature, 29.2^{0}C to 35.2^{0}C and Solar radiation of 8.8W/m^2 to 14.9W/m^2 on the silt content of the soil which was 17% could not enhance the erosion of the soil. The extent these climatic factors worked together in synergy was also not able to accelerate the erosion process.

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