Sub-Sahara African Academic
Research Publications
September, 2020, Editions

JPAS
Journal of Pure and Applied Science
Vol..16, No.9, ISSN 2318-9315

SOIL PERMEABILITY AND MOISTURE CONTENT EFFECT ON FLASH FLOOD IN PORT HARCOURT, NIGERIA

JOHNSON, DUMKA VALIANT
Institute of Geosciences and Space Technology, Rivers State University, Nkpolu -Oroworokwu, Port Harcourt. Nigeria.

Abstract
Flash flood is the most devastating of all floods caused by extreme rainfall and other environmental and hydrologic factors. Soil moisture and permeability contribute to level of severity of flash flood in the city of Port Harcourt. 48 samples of soil were taken at (0-30cm) at different flash flood prone areas of Port Harcourt and geo-referenced in-situ using GPS. The samples were analyzed in the Laboratory for particle size distribution (PSD), moisture content, and permeability. Results show that the texture of the soil were; loamy sand, sandy loam, sandy soil, and sandy clay loam. The particle size were distributed into sand, silt and clay. The soil moisture in percentage ranged from 1.95 – 38.65 while the permeability ranged from 0.7 - 3.7 (cm/sec) x 10^{-3}. The result clearly show that while the moisture content is between low and average, the permeability is very low. This is an indication that when there is heavy or intense rainfall, the moisture of the soil is quickly increased and fills up within few hours and more rain water could no longer infiltrate because the soil has reached its maximum filling capacity. The rain water becomes runoff as flash flood if not quickly discharged. The higher the moisture content of the soil, the more the likely severity of flash flood. At low permeability of the soil, rain water from heavy precipitation could not easily infiltrate the soil as pores of the soil are almost closed. Soils with low permeability are responsible for high flash flood severity in the city. Provision of good and efficient drainage systems, desilting of receiving creeks and rivers, proper waste disposal

ssaapublications@gmail.com

habit and other flood mitigation measures could assist in protecting the populace and properties against flash flood.

Keywords: *Rainfall, permeability, soil moisture, flash flood, soil*

Introduction

Floods are in different forms and types and depending on your locality, one or more types of flood may affect you. Generally in which ever form they come, they are capable of destruction, devastation, displacement, alteration, inconveniences on man and livelihoods and on properties the world over. When a normally dry land is covered by water to a level of inconvenience and distortion in socio-economic activities, flood is said to have occurred (Collier, 2007).

One of the most devastating type of flood is flash flood mainly due to excessive rainfall in a short period of time (NWS, 1995). In a period of 6 hours, water released from rain could no longer be infiltrated into the soil within the short period and also due to the intensity of the rain. This runoff could not be discharged by the channels and basin depending on the condition and size of the basin and so become flood with tendency to destroy (Grunfest, 1998; Messner and Meyer, 2015).

The destructive nature of flash flood is because during a storm event which takes place within a very short time, the quantity of water released from the extreme rainfall fills the soil so quickly so much so that the channels and basin become too small to handle such volume of water within the short period. It may also raise the level of the stream so much so that water will start to rush back to the hinterland as flood with devastating consequences (Creutin and Borga, 2003; Collier, 2007).

In assessing the risk of flash flood, there are three critical soil properties to consider, namely:

1. Moisture of the Soil, with particular interest in the degree of saturation.
2. Permeability of the soil, including alterations of the soil surface (e.g, compaction, paving and fire).
3. Profile of the soil (Antil *et al*., 2003; Beven, 1984).

ssaarpublications@gmail.com

The ability of dry soil to absorb rainfall water at specific rate is called infiltration capacity. With the rainfall rate exceeding the infiltration capacity runoff is bound to occur in any form may be rapid and efficient subject to the intensity of the rain. Soil permeability also affect rainfall infiltration. Soil texture is a commonly used indicator for soil permeability because as a soil property it is used in describing the relative proportion of different grain sizes and particles. There are other soil properties that could determine the soil permeability rate like crust formation, soil compaction, soil expansion, microbial activity, soil hydraulic conductivity (Beven, 1984).

In the particle distribution of soil, clay, silt and sand are identified in different proportions in percentages. Low infiltration rate can result from clay and to some extent silk when rain water passes through. This results in serious runoff under intense rainfall. The sandy soil component has wider spaces between particles and so allow for rainfall infiltration and thereby reducing runoff and flood as a consequence. As a universal rule, there will be more rapid runoff with soils more of clay than with one more of sand (Beven, 1984; Bankoff, 2003).

A knowledge of the soil moisture content and permeability in areas will assist in city planning for provision of adequate drainages in flash flood prone areas and in establishing a comprehensive flood mitigation plan for the city of Port Harcourt. This study will analyze the effect of soil moisture and permeability on flash flood in Port Harcourt.

Study Area

Location

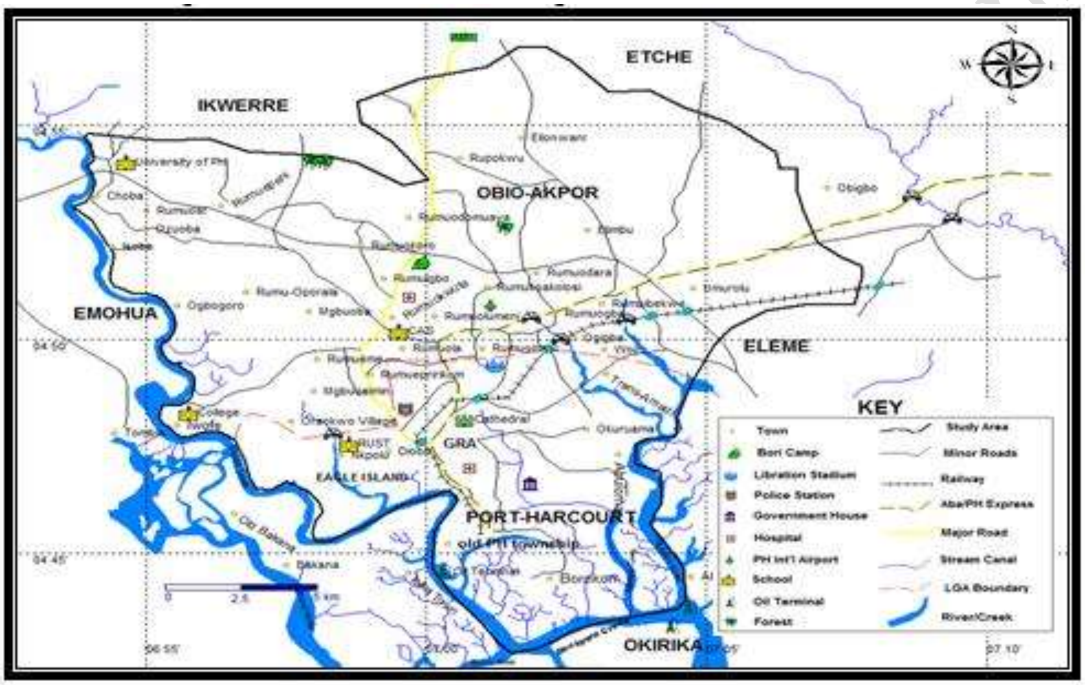
Port Harcourt metropolis is located between Latitude 4045'N and Latitude 4055'N, and Longitude 6055'E and Longitude 7005'E. The city lies at the mouth of River Bonny in Rivers State. It is located at about 25km from the Atlantic Ocean and it is situated between the Dockyard creek/Bonny River and the Amadi creek. It lies at an average altitude of about 15m above mean sea level. Port Harcourt Metropolis as study area spans over two Local Government Areas of; Port Harcourt and Obio/Akpor (Fig. 1).

ssaapublications@gmail.com

Population

The 1991 National Population Census results showed that Port Harcourt metropolis comprising Port Harcourt and Obio/Akpor LGAs had a population of 703,416 persons.[7] In 2006, the population of Port Harcourt Metropolis grew to 1,000,908 persons (Bankoff, 2003).

FIG.1: Map of Port Harcourt Metropolis



Source: Adapted from Google Earth

Climate

Port Harcourt features a tropical wet climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualifies as dry season months in the city. Port Harcourt's heaviest precipitation occurs during the months of July and September with an average of 367 mm of rain. December on average is the driest month of the year, with an average rainfall of 20 mm. Temperatures throughout the year in the city are relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25 °C -28 °C in the city.

Materials and Methods

Soil Sampling

Areas normally affected by Flash flood and flood generally were considered in carrying out the sampling, Table 1. Minimum of 2 Soil samples each were be collected in designated Areas. The soils of the area were examined by choosing sampling stations randomly so as to cover the entire area. Each soil sampling station or point was properly marked and geo- located using Global positioning system (Garmin 76 GPS). Soil samples were collected from the surface (0 – 15cm) for top and subsurface (15 – 30cm) for bottom with Dutch man hand auger (Smith and Atkinson, 1975). At each point two auger borings (of top and subsurface) were composited to give a representative soil sample of the area.

In some highly flooded areas, additional sampling points were examined at a distance of about 500m away from the major flood zones. Each composite sample were placed in a well- labeled polythene bag for laboratory analysis for; particle size distribution, moisture content, and permeability.

In Situ Measurements of Sampling Points Coordinates

The coordinates of points of sampling were taken in-situ with GPS and as shown in Table 1.0

Table 1: Coordinates of Sampling Points in Port Harcourt Metropolis (Obio /Akpor & Port Harcourt City L.G.As)

S/N	SAMPLE LOCATION	COORDINATES (DMS)		COORDINATES (DD)	
		NORTHING	EASTING	LATITU.	LONGI.UDE
1.	Rumuodara by Adamac	040 511 49.0311	0070 021 35.0511	4.8636155	7.0430681
2.	Rumuokwurushi by pipeline	040 511 48.5411	0070 031 40.6311	4.8635019	7.0430681
3.	Elelenwo by Ihunwo Aghari Rd	040 501 19.8911	0070 041 13.1911	4.8387052	7.0703349
4.	Eneka	040 531 26.7111	0070 021 43.0511	4.8908058	7.0452471
5.	Igwuruta , by Dr Okerekuga Street	040 571 25.5511	0070 001 56.3811	4.9570290	7.0158618
6.	Rukpokwu	040 551 20.5511	0060 591 51.3111	4.9224014	6.9975604
7.	SARS Road	040 531 37.8111	0060 571 52.6111	4.8934746	6.9644322
8.	Rumuopara Comm. Sec. Sch	040 521 14.2011	0060 581 31.1511	4.8714861	6.9748831
9.	Nkpolu Junction, East/West Road	040 521 09.7211	0060 581 52.7411	4.8693194	6.9812570
10.	Nkpolu Junction (2), East/West Road	040 521 11.9711	0060 581 52.7811	4.8697597	6.9810924
11.	Control for Rumuopara Sec, Sch	040 521 14.3411	0060 581 19.9211	4.8706306	6.972169

12.	Rumuosi	040 521 41.2811	0060 571 07.5111	4.8783602	6.9507948
13.	Rumuekini, off East/West Road	040 531 25.4511	0060 561 20.6411	4.8904641	6.9390139
14.	Rumualogu, Choba Road	040 521 38.2311	0060 541 44.1411	4.8772046	6.9122481
15.	Mbuogba, NTA Road	040 511 14.0411	0060 581 25.5611	4.8538079	6.9737498
16.	Nwanwuna Str, Mbuogba	040 511 08.4111	0060 581 52.3611	4.8503201	6.9812587
17.	Rumuokwuta by YKC filling station	040 511 45.1811	0060 581 53.2311	4.8458295	6.9814330
18.	Rumuigbo, Civic Centre	040 511 05.3411	0060 591 26.8611	4.8501978	6.990827
19.	Rumuomasi (1)	040 491 34.1911	0070 011 19.3711	4.82619	7.02201
20.	Rumuomasi (2)	040 491 36.1511	0070 011 13.8411	4.82668	7.020515
21.	Rumuomasi (3)	040 491 27.7211	0070 011 13.5811	4.82444	7.020435
22.	Stadium Rd/Ken Sarowiwa Road	040 491 14.1211	0060 011 05.1011	4.820749	7.021509
23.	Daniel Amadi Avenue, Ken Sarowiwa	040 491 11.3211	0070 011 07.9011	4.8198794	7.018779
24.	Uyo Str, Rumuomasi	040 491 46.5811	0070 011 51.1711	4.829567	7.018779
25.	Market Junction, PH/Aba Road	040 501 13.0911	0070 011 23.0711	4.83651	7.022305
26.	Rumuola Link Road	040 491 50.7011	0070 001 36.7011	4.83076	7.101033
27.	Ohiamini Road, Elekahia	040 481 53.7811	0070 011 10.6711	4.815064	7.019451
28.	Amadi Kalagbor str, Rumuokalagbor	040 481 56.9511	0070 001 53.3711	4.816184	7.016477
29.	Dammy Str, Rumuokalagbor	040 491 11.0711	0070 001 42.7611	4.820096	7.011447
30.	Grace Land Rd by Tombia Str, GRA	040 491 20.8611	0060 591 23.9211	4.82258	6.989784
31.	Rotimi Amaechi rd, GRA	040 491 11.2611	0060 591 27.2611	4.819935	6.990763
32.	Bayelsa Rd, GRA	040 481 43.9411	0060 591 30.2711	4.81248	6.99133
33.	Prefab close, Olu Obasanjo Rd, GRA	040 481 33.6311	0060 591 47.0911	4.809297	6.996498
34.	Money Gram by Olu Obasanjo Rd	040 481 23.7711	0060 591 56.2011	4.8067126	6.998562
35.	Wogu Str, D/Line	040 481 23.7711	0060 591 56.2011	4.807652	6998288
36.	Emekuku str, D/Line	040 481 23.7611	0060 591 55.2011	4.806439	7.001653
37.	Greg Ogbeifun Avenue, Woji	040 491 19.4511	0060 591 42.0911	4.822005	6.99496
38.	Rumuekpirikom, Spring Hospital	040 501 05.3911	0070 591 12.1711	4.834659	6.986044
39.	Timber, Mile 3	040 481 22.4411	0070 591 32.7311	4.80622	6.991676
40.	Mile 1 flyover	040 471 11.9111	0070 001 14.5711	4.786416	7.00309
41.	CBN/Post NIPOST	040 461 21.6711	0070 001 48.5711	4.772644	7.013222
42.	Sokoto/Victoria Street, Town	040 451 39.4011	0070 011 22.1211	4.760937	7.022753
43.	Garri Market, Church rd, Town	040 451 23.1611	0070 021 10.2411	4.771104	7.0336891
44.	IB Johnson str/Bundu, Town	040 451 23.1611	0070 021 10.2411	4.771104	7.036891
45.	Industry Rd/Harbour Rd,Town	040 451 51.7311	0070 001 47.1611	4.764614	7.012307
46.	Eastern Bypass, Marine Base	040 461 37.3911	0070 011 16.2911	4.777029	7.021066
47.	Peter Odili Rd, NOSDRA Zonal Office	040 481 45.8311	0070 021 28.0211	4.796068	7.041002
48.	Akpajo Rd, West Sea Auto repairs	040 481 41.5211	0070 041 11.8911	4.816917	7.073007

NOTE: DMS = Degrees, Minutes, Seconds
DD = Decimal Degrees

Laboratory Procedure for Samples

Soil samples were analyzed in the laboratory using BS or ASTM laboratory standards. The particle size distribution was determined using wet sieve analysis for coarse soil particles and sedimentation for fine grain fractions. Moisture content of particles as well as permeability were also determined using various Laboratory procedures.

Moisture Content by Oven Drying Method

The Moisture content of a soil sample is the mass of water in the sample expressed as a percentage of the dry mass, normally heated at 105^0C.
Naturally occurring soils have water and this water has a remarkable effect on the soil characteristics. The knowledge of the moisture content usually acts as a guide to the soil classification and for all analysis and tests in laboratory or field work. The commonly used method for measuring Moisture content of soil expressed as a percentage of its oven- dried weight is the Oven-drying method. The method applies to different sizes of soil including fine, medium and coarse grained soils for particle sizes ranging from 2 mm to >10 mm.
The oven drying method as the name implies is based on removing soil moisture from a soil sample by oven-drying it until the weight remains constant. The moisture content in percentage (%) is calculated from the sample weight before and after drying the sample (SAA, 1977).

Procedure

1. Clean and dry the silica crucibles and weigh to 0.01g as W1
2. Weigh 30g of moist soil and put into sample crucible and weigh it as W2
3. Oven-dry the sample to constant weight at 105^0C for 18 hours
4. Cool sample for 1 hour in a desiccator containing anhydrous self-indicating silica gel.
5. Both container and content was weighed to 0.1g as W3

ssaapublications@gmail.com

Calculations

Calculate the moisture content of the soil (using equation 3.1) as a percentage of the dry soil weight (SAA, 1977).

$$MC\ (\%) = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \qquad (1.0)$$

Where:

MC (%) = moisture content in percentage

W_1 = weight of crucible (g)

W_2 = weight of moist soil + crucible (g)

W_3 = weight of dried soil + crucible (g)

Particle Size Distribution (PSD) by Hydrometer Method

The standard laboratory procedure for determination of the particle size distribution of soil is called Particle size analysis. It is based on the principle that soil consists of an assembly of ultimate soil particles (discrete particles) of various shapes and sizes. The aim of a particle size analysis is to essentially group these particles into separate ranges of sizes and also to determine the relative proportion by weight of each size range. The hydrometer method uses sieving and sedimentation of a soil / water / dispersant suspension for particles separation. This technique on sedimentation is based on Stoke's law applied to a soil / water suspension and periodically measuring the density of the suspension.

This method uses settling rates in an aqueous solution with hydrometer to determine quantitatively the physical amounts of three sizes of primary soil particles. This method used to estimate particle size analysis of sand, silt and clay content is based soil aggregates dispersion using a sodium hexametaphosphate solution and the subsequent measurement based on changes in the density of the suspension (Sheldrick and Way, 1993).

Procedure

1. Measure 50ml of 5.0% Sodium hexametaphosphate and 100ml of distilled water, from the air-dried soil, sieved through 2-mm mesh, also measure 50g.

ssaapublications@gmail.com

2. Sample was homogenized by mixing with stirring rod before leaving it to stand for 30minutes.
3. Transfer the Soil suspension into a 1000ml glass measuring cylinder.
4. Put the Hydrometer in the suspension and add distilled water to the lower blue line of hydrometer making the suspension to get to the 1130ml mark before removing the Hydrometer (ASTM, 2007).
5. Cover the top of cylinder and invert it many times until the soil is in suspension.
6. Place the hydrometer in the suspension and read off the first hydrometer reading 40 seconds after setting down the cylinder.
7. Take the initial temperature in ^{0}F of the suspension thereafter.
8. After 3 hours of leaving the soil suspension to stand and settle, a second reading is taken, and it is immediately followed by a final temperature reading (IITA, 1979).

Calculations

1. Sand = $100.0 - (H_1 + 0.2\,(T_1 - 68) - 2.0)\,2$ (3.2)
2. Clay = $(H_2 + 0.2\,(T_2 - 68) - 2.0)\,2$ (3.3)
3. Silt = 100 – (% Sand + % Clay) (3.4)

Results obtained are expressed as percentages by weight of sand, silt and clay for the soils tested.

Where:

H_1 = Initial hydrometer reading

T_1 = Initial Temperature

H_2 = Final hydrometer reading

T_2 = Final temperature reading

Estimation of Permeability using Index Sand Properties

Soil permeability determination in the laboratory is a lengthy and difficult procedure, however it is now possible to use simple correlations in expressing permeability in relation to and as a function of soil index properties, especially the grain size (Arora, 1987).

ssaarpublications@gmail.com

Soil permeability depends on the particle size, structure of soil mass, shape of soil particles, void ratio and properties of the Permeate. The two main factors that determine permeability are particle size and void ratio (Shepherd, 1989).

Procedure

1. Sieve oven-dried soil through sieve mesh of sizes 4.75mm and higher sizes by agitation
2. Mass of soil retained on each sieve size should be recorded.
3. The portion of the soil passing through 4.75mm sieve was oven-dried at 105^{0}C and weighed.
4. Oven dry the portion of soil retained on 75micron sieve and sieve it through a mesh of 2mm, 425micron and 75micron sieves.
5. Weigh separately the fractions retained on each of the sieves in (4) above and record their masses.
6. Results are recorded and tabulated as shown in Table 2

Table 2: Estimation of Permeability using Index Sand Properties

LS Sieve No./ Size (mm)	Weight retained in each sieve	Percentage (%) retained in each sieve	Cumulative % retained in each sieve	% finer
100				
75				
19				
4.75				
2.00				
0.425				
0.075				
PAN				

Calculations

1. Calculate percentage of soil retained in each sieve on the basis of total weight of soil sample taken. The cumulative percentage of soil retained (equivalent to % finer) was obtained by deducting from 100.

2. Plot a graph was plotted on log scale with "particle size (diameter)" on X-axis and "Percentage finer" on Y-axis. The plot (also called grading curve) corresponding to 10%, 30% and 60% finer was used to obtain diameters from graph, which are designated as D_{10}, D_{30} and D_{60} (Elhakim, 2016).
3. To calculate the coefficient of uniformity (C_u) and the coefficient of curvature (C_c) the equations 3.5 and 3.6 were used.

$$C_u = D_{60} / D_{10} \quad (3.5)$$

$$C_u = D_{30}^2 / (D_{60} \times D_{10}) \quad (3.6)$$

1. Permeability was further estimated using Hazem equation:

$$K\ (m/s) = CD_{10}^2 \quad (3.7)$$

Where: C = constant and typically taken as 1

For granular soils, their permeability are affected by their grain size distribution, which is mainly explained by the equivalent particle diameters of $D10$, $D30$ and $D60$ corresponding to 10%, 30% and 60% passing by weight.

Where; D is the effective particle diameter.

Results

The results of analysis and calculations are as shown in Table 3 and 4, Figs. 1, 2 and 3.

Table 3: Soil Samples Analysis Result for Samples 1 – 24.

S/N	SAMPLE ID	SAND %	SILT %	CLAY %	TEXTURE CLASS	MOISTURE %	PERMEABILITY (cm/sec.) x 10^{-3}
1	S1	82.24	5.28	12.48	LS	11.64	2.3
2	S 2	83.32	3.32	13.36	LS	16.99	3.2
3	S 3	85.24	3.36	11.40	LS	20.44	3.0
4	S 4	79.40	2.12	18.48	SL	14.04	1.8
5	S 5	76.52	4.0	19.48	SL	11.55	1.5
6	S 6	82.64	2.04	12.32	LS	23.14	2.1
7	S 7	83.72	3.84	12.44	LS	17.12	2.4
8	S 8	83.64	3.00	13.36	LS	24.85	3.5

sapublications@gmail.com

9	S 9	74.00	5.56	20.44	SL	14.93	2.4
10	S 10	78.96	9.60	11.44	LS	23.22	2.8
11	S 11	80.88	9.36	9.76	SS	26.60	3.4
12	S 12	74.08	4.60	21.32	SCL	24.69	3.0
13	S 13	84.00	2.52	13.48	LS	4.10	1.3
14	S 14	81.96	6.28	11.76	LS	26.69	2.8
15	S 15	83.96	6.28	9.76	SS	28.69	3.0
16	S 16	78.88	7.28	13.84	LS	26.92	3.4
17	S 17	86.88	2.28	10.84	SS	28.04	1.6
18	S 18	85.88	4.28	9.84	SS	26.45	1.9
19	S 19	80.32	10.44	9.24	SS	38.65	3.4
20	S 20	87.84	2.88	9.28	SS	14.78	1.2
21	S 21	81.32	6.44	12.24	LS	9.55	1.5
22	S 22	80.96	6.80	12.24	LS	17.70	1.8
23	S2 3	78.32	7.44	14.24	LS	14.19	1.0
24	S 24	85.04	5.24	9.27	SS	16.23	1.2

Where: LS = Loamy Sand, SL = Sandy Loam, SS = Sandy Soil, SCL = Sandy Clay Loam

Table 4: Soil Samples Analysis Result for Samples 25 – 48.

S/N	SAMPLE ID	SAND %	SILT %	CLAY %	TEXTURE CLASS	MOISTURE %	PERMEABILITY (cm/sec.) x 10^{-3}
25	S 25	79.32	5.44	15.24	LS	9.65	1.1
26	S 26	87.32	4.56	8.12	SS	7.57	2.2
27	S 27	87.32	2.84	9.84	SS	9.45	1.0
28	S 28	87.12	3.64	9.24	SS	30.87	2.9
29	S 29	84.32	5.72	9.96	SS	30.91	3.4
30	S 30	86.00	0.76	13.24	LS	6.60	1.8
31	S 31	85.24	5.64	9.12	SS	31.82	3.7
32	S 32	87.00	4.76	8.24	SS	20.72	2.4
33	S 33	80.32	8.84	10.84	SS	30.54	3.1
34	S 34	80.32	6.80	12.88	LS	14.20	2.1

35	S 35	82.32	2.56	15.12	LS	6.89	1.8
36	S 36	88.32	1.72	9.96	SS	5.28	0.7
37	S 37	83.32	4.64	12.04	LS	12.81	1.3
38	S 38	81.88	6.00	12.12	LS	17.94	2.3
39	S 39	88.84	3.20	7.96	SS	6.85	1.6
40	S 40	62.04	7.84	30.12	SCL	16.05	2.3
41	S 41	83.88	4.36	11.76	LS	11.66	2.1
42	S 42	87.88	4.28	7.84	SS	8.74	1.5
43	S 43	83.88	5.00	11.12	LS	8.01	2.2
44	S 44	85.88	6.16	7.96	SS	37.91	3.5
45	S 45	89.88	2.20	7.92	SS	14.65	1.7
46	S 46	89.84	2.08	8.08	SS	1.95	0.9
47	S 47	88.88	1.28	9.84	SS	5.70	1.6
48	S 48	81.76	6.63	11.61	LS	5.13	1.9

Where: LS = Loamy Sand, SL = Sandy Loam, SS = Sandy Soil, SCL = Sandy Clay Loam

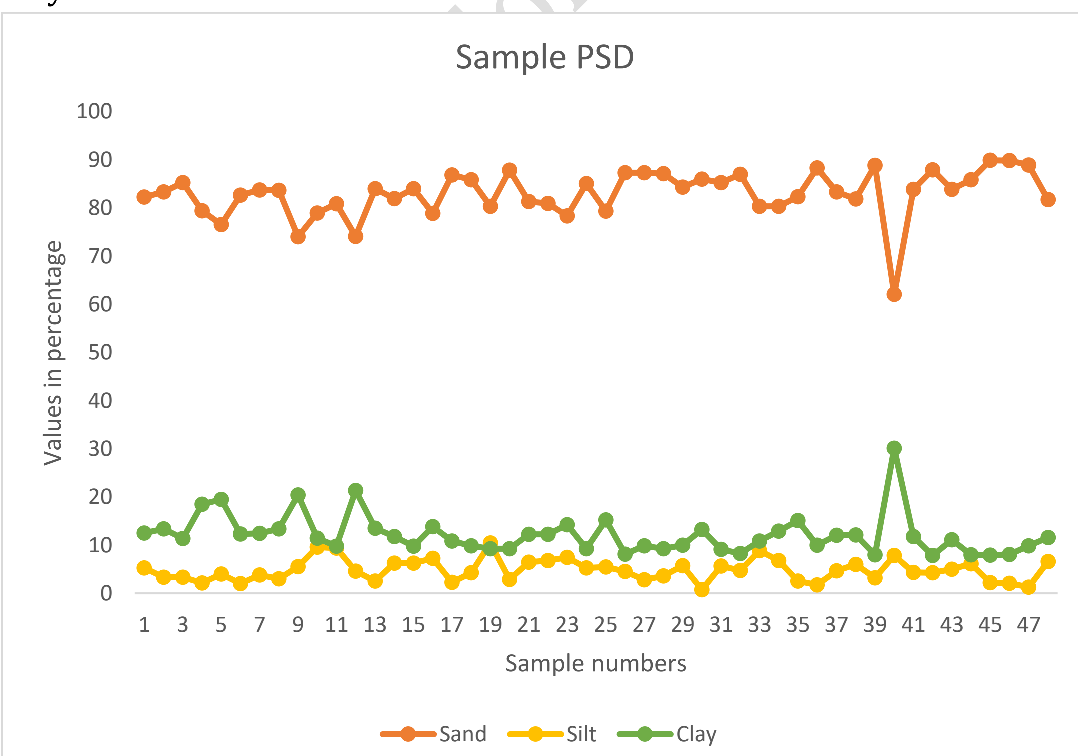


Fig. 1: PSD of Samples

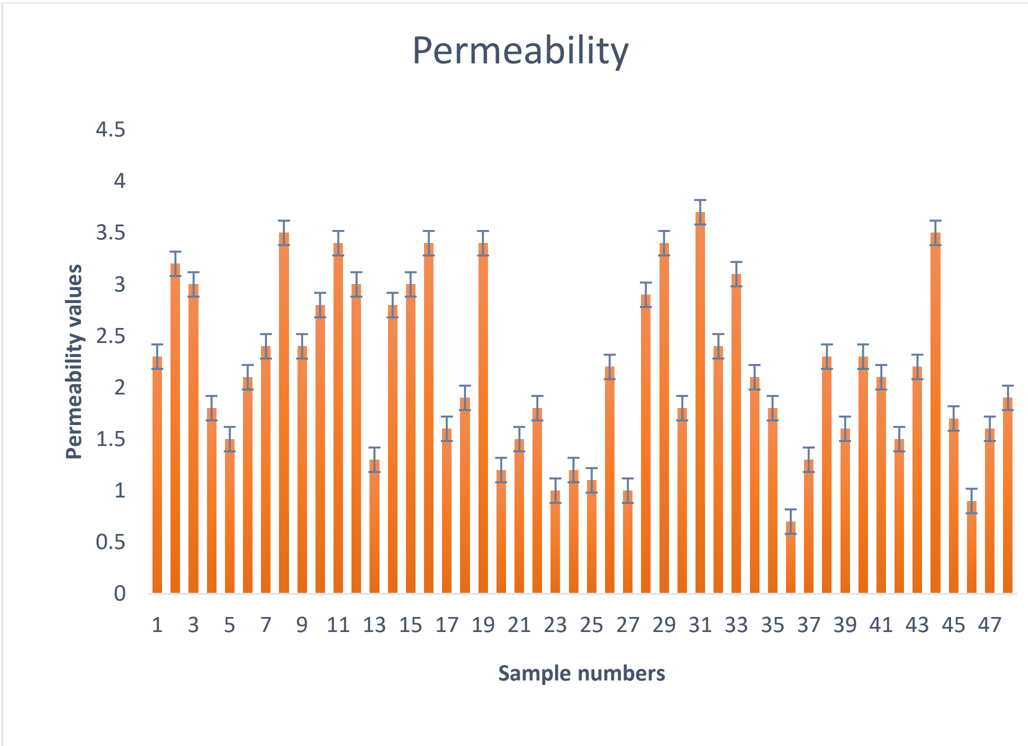


Fig. 2: Permeability of Samples

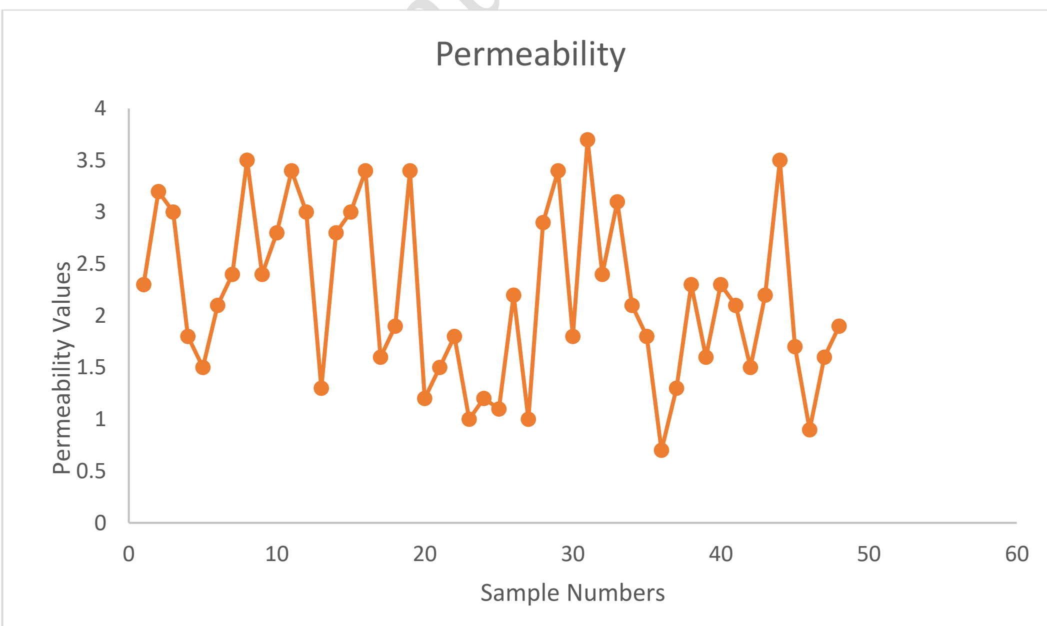


Fig. 3: Permeability of Samples graphically

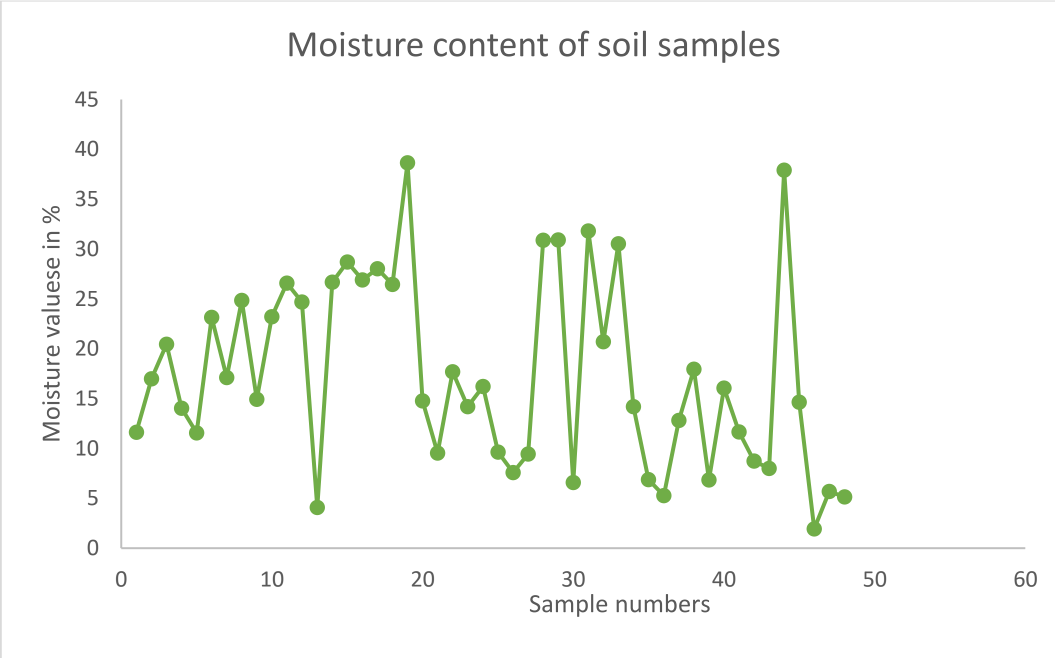


Fig. 4: Moisture content of Samples

Discussion

48 samples of soil collected for analysis at different parts of Port Harcourt showed generally the soil type, composition, moisture content and permeability as in Table 3 and 4.

Analysis of the 48 samples showed that 22 of them were largely Loamy Sand (LS), 21 samples were Sandy soil (SS),3 Samples were Sandy loam (SL) while the remaining 2 samples were of Sandy clay loam (SCL).

Loamy Sand (LS) has high sand percentage averaging over 80%, silt component with an average of 6% and clay component averaging over 13%. The Loamy sand in most cases have moderate moisture content averaging over 15% and permeability of about 2.0 cm/sec x 10^{-3} in average. The Loamy soil allows water to go through for sometimes until the moisture level is full and could not take more thereby giving rise to Flash flood.

Sandy Soil (SS) has higher sand percentage than the LS averaging over 85%, with silt component having an average of 5% and clay component averaging over 9%. Most sandy soil samples in the study have high moisture content averaging over 25% and a generally low permeability in average. The SS allows water to go through for sometimes until the moisture level is full and could not take more thereby giving rise to Flash flood.

Sandy Loam (SL) Soil was sampled in three places during the sampling stage. The soil has sand percentage averaging between 74 to 79%, silt component with an average of 4% and clay component averaging over 19%. The Sandy loam soil in most cases has moisture content averaging over 12% and permeability of about 1.7 cm/sec x 10^{-3} in average. The Sandy loam soil does not allow much water to go through and fills quickly, thereby allowing for flood.

Sandy Clay Loam (SCL) has sand percentage averaging between 64 – 74%, with silt component having an average of 6% and clay component averaging between 20 – 30%. Sandy clay loam samples in the study have high moisture content averaging over 20% and a generally low permeability in average of 2.5 cm/sec x 10^{-3} .The SCL allows water to go through for sometimes until the moisture level is full and could not take more thereby giving rise to Flash flood.

The soil analysis shows that all sand fractions were fine and medium in size, the values of permeability for the samples were generally very low in most cases and too low in others, the moisture content was on the average low and medium. These properties contribute to the flash flood observed in the rainy season. This agrees with the study of (Chiadikobi *et al.*, 2011), which states that soils with the above attributes contribute to flooding.

Conclusion.

Preventing flash flood is almost impossible due to speed and suddenness with which it comes, the short duration of time involved coupled with the interplay of natural factors involved, but we must adopt measures to assist in reducing its impact on life and property. Concrete efforts are now being made to increase knowledge and awareness of flash flood through the collection of reliable data using improved technology and advance forecasting methods from knowledge of modelling and Risk assessment.

ssaapublications@gmail.com

After each flash flood event, there is always the need for evaluation to know what went wrong and what could be improved upon. Accurate knowledge of data on areas of vulnerability can assist in taming the danger the same way a good knowledge of factors that contribute to flash flood as studied about Port Harcourt will assist in mitigating the impact.

Recommendation

Flash flood have devastating consequences on the populace; in their socio-economic activities and general well-being. Flash flood destroys life and properties in a flash so concerted effort must be made by individuals, Government at all levels and Non- governmental organizations (NGO), to prevent, reduce, mitigate its impact in consonance with United Nations goal of Disaster Risk reduction (DRR) and sustainable development.

Structural and Non- structural measures could be employed in reducing impact of flash flood and flood in general.

1. Building of dams and dykes that will impound water in the rivers and prevent them from running ashore as flash flood.
2. Building of suitable drainages to quickly and adequately discharge flood water within limited time to the receiving rivers. Drainages must properly discharge into receiving basin.
3. Desilting of receiving rivers and creeks on regular basis to allow them take in more flood water from occupied areas.
4. Proper education of the populace on waste disposal methods in order to prevent them from blocking the drainages with their wastes.
5. Control and proper legislation against building and construction of houses in flood plains and flood water routes.
6. Informing the public of impending flood and measures to take to avoid same and assistance to flood victims.

Acknowledgements

I acknowledge the assistance of Prof. A. E. Gobo, Dr. O.D. Ngerebara and Prof. E.N. Ekaka-a

ssaapublications@gmail.com

Conflict of Interest

I declare there is no conflict of interest

REFERENCES

Anctil, F., Michael, C., Perrin, C., & Andreassian, V. (2003). A soil mixture index as an auxiliary ANN input for stream flow forecasting. *Journal of Hydrology*, 286, 155 – 167.

Arora, K.R. (1987). Soil Mechanics and Foundation Engineering. *Standard Publishers Distributors,* 205 – 247.

ASTM, (2007). *American Society for Testing and Materials*. 1988 standard test method for particle-size analysis of soil. D 422 -63.

Bankoff, G. (2003). Constructing Vulnerability: The historical, natural and social generation of flooding in metropolitan. *Manila Journal*, 27 (3): 224-238.

Beven, K.J. (1984). Infiltration into a class of vertically non- uniform soils. *Hydrological Sciences Journal,* 29(4), 425 – 435.

Chiadikobi, K.C., Omoboriowo, A.O., Chiaghanam, O.I., Opatola, A.O. & Oyebanji, O. (2011). Flood Risk Assessment of Port Harcourt, Rivers State, Nigeria. *Journal of Advances in Applied Science Research* 2(6), 287 – 298.

Collier, C. (2007). Flash Flood Forecasting: What are the limits of predictability? *Quarterly Journal of the Royal Meteorological Society*. 133(622A), 3 – 23.

Creutin, J.D. & Borga, M. (2003). Radar Hydrology modifies the monitoring of flash flood hazards. *Hydrological Processes*, 17 (7), 1453 – 1456.

Elhakim, A.F. (2016). Estimation of Soil Permeability. *Alexandria Engineering journal*, 55: 2631 – 2638.

Gruntfest, E. (1998). Flash floods in the United States. In: Pielke Jr., R., Pielke, R. (Eds.) *Storms*. Routledge, New York, 377 – 391.

IITA, (1979). *International Institute of Tropical Agriculture. Selected Methods for soil and plant analysis*. Manual series 1: 4 -5, Ibadan, Nigeria.

Messner, F. & Meyer, V. (2015). Flood Damage, Vulnerability and Risk perception. Challenges for flood damage research. Discussion paper UFZ Centre for Environmental Research.

NWS. (1995). National Weather Service. United States of America, National disaster survey report. Maryland, USA.

SAA. (1977). Standard Association of Australia. AS 1289B1. 1-1977. Determination of the moisture content of soil: Oven drying method (Standard method).

Sheldrick, B.H. & Way, C. (1993). Particle-Size Distribution. 499 – 511. In: Carter, M.R. (ed), Soil Sampling and Methods of Analysis, Canadian Society of soil science, Lewis Publishers, Ann Arbor, MI.

Shepherd, R.G. (1989). Correlations of Permeability and Grain Size. *Ground water*, 27 (5), 633 – 638.

ssaapublications@gmail.com