NIGERIAN JOURNAL OF ENGINEERING RESEARCH UNICROSS (NJERU)

Volume 1, Issue 2, 1st June, 2024

Effect Of Storm Water Drainage Systems Modelling for Owakadi Community of Obubra L.G.A Of Cross River State Nigeria.

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Received: 17th June, 2024 Reviewed: 14th July, 2024 Accepted: 22nd July, 2024

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Abstract:

The modeling of storm water drainage systems of Obura catchment area of Cross River State, Nigeria to address problem of local flooding. A current metre was used alongside a speed boat to carry out measurement of discharge as a dependable variable while cross sectional area, velocity, width and depth of channel was also determined as independent variables. The data so measured were subjected to developed a model whose result was Q = -2417.75 +11.68D + 0.33W + 1772.15V + 1.24A. The model gave a correlation r value of 0.994. Verification of the model was carried out and an r value of 0.995 was obtained all indicating a strong correlation. Rainfall records for the period of thirty—six years 91979 – 2014) and 24 months were used to developed regression analysis of the study area. Furthermore, a validation test was conducted using velocity-area method for water flow measurement having a relationship as Q = AV, a correlation value of 1.0 was obtained. The model when applied will enhance the prediction of the adequate of the density of the drains to accommodate the storm runoff generated in the area. The study recommends that, proper design, computations, adequate constitutions and routine maintenance of drainage channels be made ensuring that the velocity satisfied the minimum requirement.

Keywords: storm water. Drainage, urbanization, discharge, flooding

Introduction:

Drainage systems are needed in urban areas because of the interaction between human activity and the natural water cycle. This interaction has two main forms: the abstraction of water from water bodies to provide water supply for human life, and the covering of land with impermeable materials to divert rainwater away from the local natural system of drainage. These two types of interaction give rise to two types of water that requires drainage (Butler and Davies, 2004). Waste water is water that has been supplied to maintain standard of living and satisfy the needs of industry after use, if not drained properly, it could cause pollution and create health risks. Wastewater contains, fine solids and large solids originating from water closet (WCs), from washing of various sorts, from industry and other water uses.

The second type of water requiring drainage, storm water, is rain water (or water resulting from any form of precipitation) that has fallen on a built –up area. If storm water is not drained properly, it will cause inconveniences, flooding and further health risks. It contains some pollutants, originating from rain, the air or the catchment surface.

Urban drainage system handles these two types of water with the aim of minimizing the problems caused to human life and the environment.

Urban drainage has two major interface with the public and the environment.

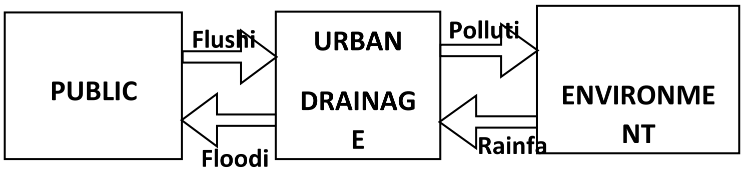

Fig 1.1 Interfaces with the public and the environment

Urban drainage defines the systems which have been designed to drain wastewater and storm water out of populated areas. However, drainage is necessary to handle wastewater generated by populations and storm water generated by rain events.

Thus, Urban drainage is at the interface between populations (public) and their environment as presented in figure 1.1. It shows already how complex it can be to keep a certain balance between the different processes. The population and industry consume water and flush wastewater to the system which in the same time might receive stormwater. Part of the wastewater and of the storm water is treated depending on the System capacity. The rest of it overflows to the receiving waters. Flooding can be generated at different steps of the process.

It is striking to realize that many innovation in the domain of stormwater management have been already presented and discussed for several decades. However, on the field, their implementation is not straightforward and in practice to the issues and local constraints make the policy changes complicated. There is an urgent need to “do more with less” in the domain of water management, especially in urban areas. One way to achieve this challenge is for a better understanding of the interconnected issues in the domain of stormwater management and urban drainage in general

The increase in population density and building exert the most obvious influence on hydrological process in an urban area. Modification of the land surface during urbanization alters the storm water runoff characteristics. The major modifications which alter the runoff processes is the impervious surface of the catchment such as roofs, sidewalks, roadways and parking lots, which were previously pervious.

Natural channels which were in existence before urbanization is yet another factor, channel drains and storm drainage pipes are laid in the urbanized area to convey runoff rapidly to stream channels. Urban drainage systems should be designed to handle storm water and waste water with the aim of minimizing the problems caused to humans and the environment. (Butler and Davis, 2004).

Traditionally, wet-weather collection systems have been designed to move storm water from the urban areas as quickly as possible providing safe drainage and thus avoiding problems of local flooding. This traditional conveyance approach leads to problem of local flooding. This traditional conveyance approach leads to problems with decreasing ground water levels, high downstream discharges and release of pollutants to receiving waters.

The combined effect of all these changes is to reduce the lag time of runoff. Since a larger volume of runoff (due to urbanization) is discharged within a shorter time interval, the peak discharge inevitably increases.

Stormwater management plays a critical role in the maintenance of healthy streams, lakes, and aquatic life as well as supports human uses by maintaining the natural hydrologic cycle.

Without proper stormwater management, infiltration can decrease reducing soil replenishment and groundwater recharge. It helps government and engineers as well as in the construction of roads and recreational centres. It can as well aid in the forecasting and prediction of flood over time. The work advances the frontier of knowledge about the prediction of the storm water drainage of the catchment area.

This work was mapped out to cover a period of two years between 2018 – 2019 and to explore the sub-catchment within the Obubra area with the view of carrying out modeling of storm water drainage system of the area to prevent the event of flooding on the surface of the land cause by high precipitation and over laying of the catchment area.

Two Phenomena, storm water and drainage are involved, amongst others in any given watershed. Urban storm runoff is controlled by various factors namely, human, morphological, meteorological, ecological, topographical and hydraulic, the action of which is not always easy to identify and quantify. Rainfall is however not directly controlled by man but grossly influenced by him as he embarks on certain ecological programs in the environment. In order to derive a functional relationship which reflects a specific situation, a great amount of basic documentation is needed as well as long experimentation.

Storm water drainage system, requires good quality hydrological data. Resources for the hiring of all the field equipment required for this work limited the volume of data obtained for the model development. The researcher relied on data from nearby meteorological stations, and the use of up-to-date literature/internet materials was employed.

Floods are natural hazards that have a significant impact on human settlements and infrastructure. They account for two thirds of natural disaster related to deaths of an average of 84 people per annum in the Republic of South Africa (Kahu 2003). According to the intergovernmental panel of climate change (IPCC 2014), extreme events such as floods will become more common because of global warming. Knoesen et al., 2009.

The characteristics of a catchment and its

response to accumulated precipitation are often reflected as a line marked out by the elevation of the flood, which offers a basic zonation of statistical threat posed by flood waters for a particular system.

Although both long-rain and flash floods are caused by the inability of drainage systems to effectively remove excess run-off from a catchment when flooding occurs within six hours of a storm event, it is considered a flash flood (Kobiyama and Goerl 2007).

Catchment shape is controlled by factors such as the mean annual rainfall, topography and underlying geology, all of which result in different drainage pattern and density (Bridge 2003). Lastly, land cover and topography can influence run-off (Mark and Marek 2011).

Storm drainage problems have not just posed threat but have caused serious damages to lives and properties in Obubra for several years now (CRBC 2007).

MATERIALS AND METHODS

The major equipment used for the river discharge measurement was a current meter, it is used in conjunction with a speedboat and was deployed to a laptop with a direct cable. The unit was set up, configured and operated using the laptop and win-river I software. A summary of installations is as follows;

- Deployment Equipment (Boats)
- Ocean-Science River Boat
- Bluetooth Radio Modems
- 12 Volt Lead Acid Re-Chargeable Batteries
- Ropes and Pulleys
- Laptops
- Hand Held GPS

An Acoustic Doppler Velocity Meter (ADVM), was now installed and configured. Configuration of the ADVM involves the selection of an appropriate measurement volume for the index velocity measurements, selection of the measurement interval and averaging interval and configuration of the ADVM to store internal quality – assurance (QA) data and velocity.

Plate 3.1 A current meter

Plate 3.2. Conf

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state is bounde
West by Ebony
Ibom State and
Obubra is a Lo
State, Nigeria. It's headquarters are in the town of Obubra which is home to the National Youth Service Corps Orientation Camp. It has an area of 1115km^2 and lies between latitude 6^0 5^1N of the equator and longitude 8^0 18^1 E within the rainforest zone of south-south Nigeria. It has a population of 172,549 based on the 2006 census.

The mean annual rainfall of the study area is 2250-3000mm per annum and a mean annual temperature of between 21^0c-29^0c (CRADP, 1992). The soil type of the area is predominantly sandy loam with an undulating topography with a slight slope. The area receives about 90% of the total annual rainfall during the period. It is however usually disrupted by a short dry season in August (August Break).

The area consists of the rainforest belt of Nigeria whose primary vegetation has however been replaced by the secondary forest. In some of the parts of the area, the savannah type grassland emerges during the hamarttan season after the seasonal fires. The forests have therefore been continuously given way farms residential and infrastructural developments. The people of the area are mostly farmers and traders. They main crops cultivated are yam, maize, melon, cassava, sweet potatoes, cocoyam and Vegetables. The land is being Use for residential and industrial purposes. It is expected that there will be an increasing need for industrial use of the rivers based on the development programs that are being put in place by state government and others.

The geology of Cross River State is characterized by the underlying Eze Aku Shale group of black shale and silt stone. The soils are generally shallow, well drained and stony.

Obubra has low ground elevation which submerges under water even with few hours of intense precipitation. Most part of the city suffered from long term urban flooding during extreme weather events such as rainfall. The situation is likely to worsen in the future due to climate change, which may lead to more frequent and intense precipitation. Storm water modeling has a major role in preventing issues such as flash floods and urban water quality problems.

The result of rapid creation of large impervious areas give rise to serious problems such as regular flooding, inadequate drainage facilities, erosion, sedimentation and deterioration of water supply quality in receiving water bodies. Urbanization of a rural catchment can cause a dramatic change to the hydrology and in particular to the peak flow.

The urban water system is a complex structure consisting of drinking water production from a new water source (surface or underground) distribution of water to consumers in a pipe system, urban drainage (i.e conveyance of wastewater and storm water) and in the end treatment of the wastewater and discharge to receiving waters.

Storm water drainage has become a central issue in urban planning and management particularly in developed countries with substantial urban infrastructure in place. The magnitude of investment required to construct, operate and maintain urban storm drainage acidities and the potential for significant adverse social and environmental impacts mandate the use of the best possible methods of planning, analysis and design.

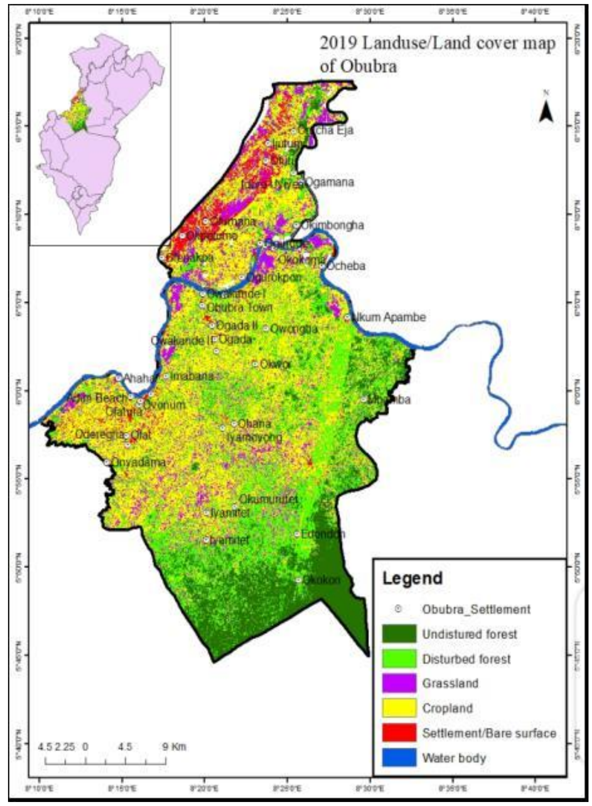


Figure 3.1 Map of study area.

The most effective statistical methods for analyzing linear models (GLMs) for Poisson distribution, the modified Fournier method and the seasonal auto regressive moving average model (SARIMA). The most commonly used methods are for spatial averaging of precipitation Data:

a. Arithmetic average
b. Normal ratio method,
c. Distance power method
d. Thiessen polygon method, and
e. Isohytial method

The average rainfall of a week is by adding up all the rain water of all 7 days in a week, then dividing it by 7, it will give the average rainfall of that week. The capability to measure rainfall is important to many industries, so its no surprise that rain gauges were one of the first weather related instruments our ancestors invented. They're believed to have been used in India 2000 ago. The measurement help farmers make decisions about planting, harvesting, and irrigating crops, they also enable engineers to design effective storm drains, bridges, and other structures.

A clear, cylindrical can be either glass or plastic, and should be at least 12 inches tall, the shape is important. If the top is wider than the bottom (or narrower) it will require much more calculation and measurement. As the volume of the container gets bigger, a coke can to a mop bucket so as the area which collects the rain because of this one inch of rainfall will be recorded. Consistently between cylinders of varying size since rain will often be accompanied by wind, you'll went to steady your gauge so that it can stay upright through a storm. Fill the container with water, to provide a level starting point for your scale. Your weights will be taking up volume and so we don't want them included in the measurable area. If you recorded data for a month, you can analyze your data and see overall rainfall trends. Adding up the rainwater for all 7 days in a week, then dividing it by 7, will give you the average rainfall of that week. Over a longer period of time, you could do this for months (or even years if you're particularly dedicated).

Model Formulation

The model formulation was a rigorous process of which different models were created and tested, among which the model (Q = - 2417.75 + 11.68d + 0.33W + 1772.15V + 1.24A) stand out to be the best in all aspect. The model developed is a multiple regression model, a model with Q as the dependable variable while other cross sectional area, velocity, depth and width are independable variables.

Mahalanobis distance (Manalanobis, 1936), is measured of the distance between a point P and a distribution D. it is a multi-dimensional generalization of the idea of measuring how many standard deviations away P is from the mean of D. It weights the distance calculation according to the statistical variation of each component using the covariance matrix of the observed sample. It measures distance relative to the centroid of the data, which can be thought of as an overall mean in multivariate data. The centroid is a point in multivariate space where value of Mahalanobis distance, the more unusual the data point (i.e., the more likely it is to be a multivariate outlier).

Rainfall Measurements

Rainfall measurements for the data at the Cross River Basin Development Authority (CRBDA) and Cross River University of Technology, Obubra Campus, Cross River State. Two sets of rainfall data were obtained for the study. The first was a twenty-four (24) months daily rainfall data, while the second was a thirty-six (36) yearly / monthly rainfall data from 1979 to 2014.

Land use data.

This was obtained from the most recent use topo map (2011) of the study area obtained from the state ministry of Land and Survey, Calabar. The Land Development Software was engaged with the application of the poly-line approach in discretizing both the total basin area and the area that has become built-up (Okon, 2012)

Slope of the catchment.

The topographical map with the aid of the Land Development Software was used to generate the Sub-Catchment of the area the profiling approach was equally employed for confirmation. The study area was divided into regular grids of 25m by 25m square. Stakes where driven at the corners of the grids and a dumpy level is used to determine the elevation of the corners. Points with equal elevation were joined to produce a contour map. With the contour map, the slope was computed from the expression:

$$G = \frac{\Delta y}{\Delta x}$$

Where Δy = change in height between the first and the last contour.

Δx = corresponding horizontal distance.

A Global Positioning System (G.P.S.) instrument was used; mapping was carried out by marking of 25m interval on ground. The entire length of the flow was covered within the sub-drainage basins. The plot of the inlet and outlet elevations was obtained to the overland flow length. The tangent of the angle formed gave the value of the slope (Uyanah 2006, Okon. 2012).

Model Development

Mulligan and Wainwright (2004) identified three (3) purpose among others to which a general model is usually put. They include;

i. An aid to research
ii. As a tool for simulation and prediction
iii. As a research product

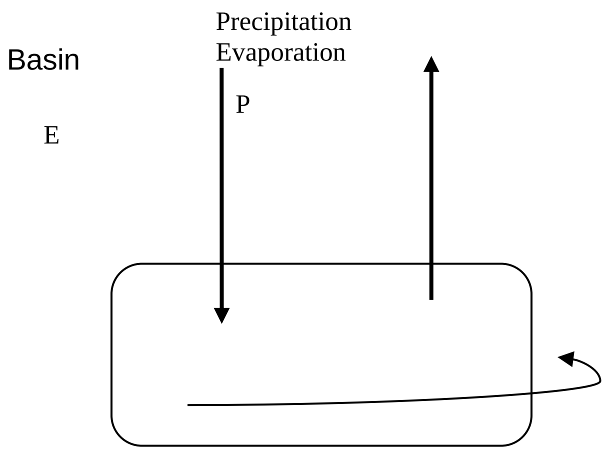
However, to effectively execute the objectives of this study, different approaches were employed to develop a model with the right result to serve as a tool for the analysis of storm water drainage of Obubra catchment. The approaches were the multiple Regression approach and the Marko chain approach.

Brezonik and Staidelmann (2002) observed that storm water models are usually based on regression analysis between water quantity, quality and relevant explanatory variables. Empirical models describe the observed behaviour between variables using the observations alone and do not include any process.

In terms of storm water modelling, an empirical approach would be a model that relates runoff quantity to a number of factors such as rainfall or other characteristics of the catchment as discussed.

Plate 3.3 movement of the current meter along the transit.

The water balance is a method by which we can account for the hydrologic cycle of a specific area with emphasis on plants and soil moisture. In its simplest form, the equation reads inflow = outflow + recharge in storage Ø.



Storage value

Fig 3.2 Illustration of water balance diagram

However, the hydrological processes in a catchment of area (A) in m^2 are represented by the simple water balance equation given as

$$P = Q + AET + GW + \Delta S \quad 3.21$$

Where:

P = Precipitation

Q = Runoff

AET = Actual evapotranspiration

GW = Exchange with groundwater aquifer and

DS = change in soil storage

RESULT AND DISCUSSION:

Rainfall is one of the principal controlling elements in agriculture in the tropics. The success of crop establishment and growth depend largely on the availability of adequate rainfall. The amount of rainfall that is received determines the type of agriculture that can be carried out and the crop that can be cultivated. Various aspects of rainfall pattern in peninsular Malaysia have been studied by Dale. Specific investigation of the occurrence and pattern of rainfall within a specific area have been carried out by various sectors. For agriculture, important aspects which relate to rainfall include the days of the start and the end of the rainy season, and hence its length, plus the rainfall amounts and the risk of day spells within the seasons.

The daily rainfall data from Obubra were supplied by the Cross River Basin Development Authority (CRBD) as shown in Appendix III and University of Cross River State, Obubra Campus, two sets of rainfall data were obtained, the first was a twenty-four (24) months daily rainfall data, while the second was thirty-six (36) yearly data from 1979 to 2014. The mean annual rainfall for the period was 2250 – 3000mm per annum a mean annual temperature of between 21℃ – 29℃ (CRADP, 1992). Rainfall data are often analysed by calculating totals on an annual, monthly, and daily bases and using these totals a the “raw” data for subsequent summaries. Methods by which such totals could be processed. These methods are equally applicable to the other characteristics, such as the start and the end of the rains.

Table 4.1 Relationship between depth, width, velocity, area and discharges.

	Depth (m)	Width	Velocity	Area	Measured Discharge (Q)	*Predicted Discharge (Q)*
1	4.5	362.33	1.992	1630.485	3247.926	3306.303
2	3.7	501.12	1.676	1854.144	3107.545	3060.098

3	5.3	467.61	1.050	2478.333	2602.250	2732.356
4	4.1	352.06	1.652	1443.446	2384.573	2463.783
5	5.7	272.47	1.454	1553.079	2258.177	2241.265
6	5.7	356.50	1.023	2032.050	2078.787	2099.122
7	5.7	356.50	1.020	2032.050	2072.691	2093.806
8	5.7	356.50	1.008	2032.050	2048.306	2072.540
9	3.3	578.10	1.045	1907.730	1993.578	2029.049
10	3.7	501.12	1.050	1854.144	1946.851	1950.732
11	5.3	325.72	1.104	1726.316	1905.853	1848.727
12	2.9	523.23	1.231	1517.367	1867.879	1851.840
13	3.7	501.12	1.900	1854.144	3522.874	3457.059
14	2.9	362.33	1.565	1050.757	1644.435	1812.044
15	3.3	585.05	1.800	1930.665	3475.197	3397.755
16	4.5	347.24	1.020	1562.580	1593.832	1494.591
17	3.7	346.72	1.211	1282.864	1553.548	1476.709
18	4.1	494.24	1.600	2026.384	3242.214	3141.393
19	3.7	342.06	1.104	1265.622	1397.247	1264.171
20	1.7	578.10	1.331	982.770	1308.067	1370.245

Table 4.1 shows the relationship which exist between the variables with the measured and predicted discharges, the highest value in the measured discharge was 3522.874 at a depth of 37m. while the lowest value of measured discharge was 1397.247 at the same depth of 37m at point 20.

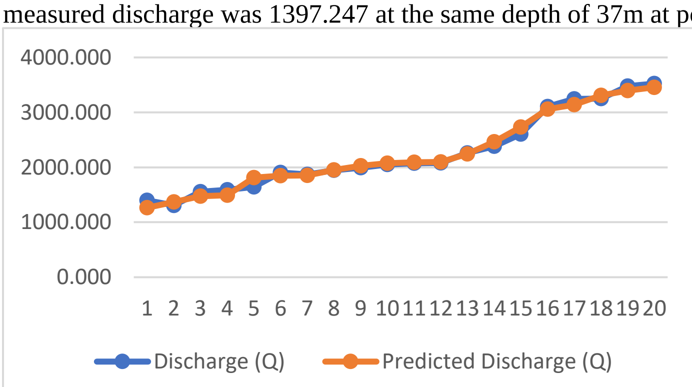


Fig 4.1 Measured and predicted plot of the mode

Figure 4.1 illustrate the 20 values data of measured and predicted discharges, showing a high value of 3522.874 with a lower value of 1397.247 for measured and a higher value of 3457.059 with a lower value of 1264.171 at a depth of 37m for the predicted discharge.

Table 4.2 below shows the Pearson correlation for measured and predicted discharges represented by x and y respectively. It indicates the product of x and y, the square of x and y.

Table 4.2 The Pearson correlation between measured and predicted discharges.

X	**Y**	**xy**	**x^2**	**y^2**
3247.93	3306.30	10738628.2	10549024.08	10931640.19
3107.55	3060.10	9509391.925	9656838.07	9364197.08
2602.25	2732.36	7110271.716	6771703.24	7465767.78
2384.57	2463.78	5875069.049	5686187.40	6070224.90
2258.18	2241.27	5061173.135	5099362.76	5023269.52
2078.79	2099.12	4363628.775	4321356.02	4406315.06
2072.69	2093.81	4339812.852	4296047.98	4384023.57
2048.31	2072.54	4245197.356	4195559.11	4295422.88
1993.58	2029.05	4045067.043	3974352.64	4117039.64
1946.85	1950.73	3797784.273	3790229.59	3805354.01
1905.85	1848.73	3523401.724	3632275.14	3417791.67
1867.88	1851.84	3459011.943	3488971.13	3429310.02
3522.87	3457.06	12178782.45	12410638.40	11951258.04
1644.43	1812.04	2979788.583	2704165.50	3283504.65
3475.20	3397.76	11807868.33	12076994.19	11544739.72
1593.83	1494.59	2382127.002	2540299.17	2233803.45
1553.55	1476.71	2294138.157	2413512.33	2180668.32
3242.21	3141.39	10185070.79	10511954.22	9868352.24
1397.25	1264.17	1766358.296	1952298.31	1598127.51
1308.07	1370.25	1792372.677	1711038.94	1877572.59
45251.83	**45163.59**	**111454944.3**	**111782808.20**	**111248382.83**

Table 4.2 showing the Pearson correlation between the measured and the predicted discharges indicate the product of measured and predicted discharges which also show the square of each discharges.

The cross sectional area of the channel shows the most positive value of 1.835 as an independent variables to the discharge during the Multicollinearity test table as agreed with Uyanah, 2006 whose value was 1.912, with a difference of 0.077 compared to my work.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum x)^2}}$$

$$r = \frac{20(111454944.3) - (45251.83)(45163.59)}{\sqrt{[20x111782808.20 - 2047728044)x(20x111248382.83 - 2039749699}}$$

$$r = \frac{2229098885 - 2043734978}{\sqrt{1879288120x185217957.4}}$$

$$r = \frac{185363907.1}{186568117.64}$$

$$r = 0.993545464491829$$

$$r = 0.994$$

The Pearson correlation of r=0.994 agreed with (Gobo, 1998) showing a high correlation that exist between measured and predicted dischrages.

Table 4.3 Relationship between measured and predicted discharges for calibration of the model.

X	Y	xy	x^2	y^2
3247.93	3306.30	10738628.2	10549024.08	10931640.19
3107.55	3060.10	9509391.925	9656838.07	9364197.08
2602.25	2732.36	7110271.716	6771703.24	7465767.78
2384.57	2463.78	5875069.049	5686187.40	6070224.90
2258.18	2241.27	5061173.135	5099362.76	5023269.52
2078.79	2099.12	4363628.775	4321356.02	4406315.06
2072.69	2093.81	4339812.852	4296047.98	4384023.57
2048.31	2072.54	4245197.356	4195559.11	4295422.88
1993.58	2029.05	4045067.043	3974352.64	4117039.64
1946.85	1950.73	3797784.273	3790229.59	3805354.01
23740.68	**24049.05**	**59086024.32**	**58340660.89**	**59863254.62**

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum x)^2}}$$

$$\boldsymbol{r = \frac{10(59086024.32) - (23740.68)(24049.05)}{\sqrt{[10x58340660.89 - 563620094)x(10x59863254.62 - 578}}}$$

$$\boldsymbol{r = \frac{590860243.2 - 570940800.4}{\sqrt{40118296377723}}}$$

$$\boldsymbol{r = \frac{19919442.8}{20029552.26}} \qquad \boldsymbol{r = 0.994502649955891}$$

$$\boldsymbol{r = 0.995}$$

Table 4.4. Relationship between measured and predicted discharges for verification of the model.

X	Y	xy	x^2	y^2
1905.85	1848.72704	3523401.724	3632275.14	3417791.67
1867.88	1851.83963	3459011.943	3488971.13	3429310.02
3522.87	3457.05916	12178782.45	12410638.40	11951258.04
1644.43	1812.04433	2979788.583	2704165.50	3283504.65
3475.2	3397.7551	11807868.33	12076994.19	11544739.72
1593.83	1494.5914	2382127.002	2540299.17	2233803.45
1553.55	1476.70861	2294138.157	2413512.33	2180668.32
3242.21	3141.39336	10185070.79	10511954.22	9868352.24
1397.25	1264.17068	1766358.296	1952298.31	1598127.51

1308.07	1370.24545	1792372.677	1711038.94	1877572.59
21511.14	**21114.53**	**52368919.95**	**53442147.32**	**51385128.21**

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum x)^2}}$$

$$r = \frac{10(52368919.65) - (21511.14)(21114.53)}{\sqrt{[10x53442147.32 - 462729350.95)x(10x51385128.21 - 445823578.13)}}$$

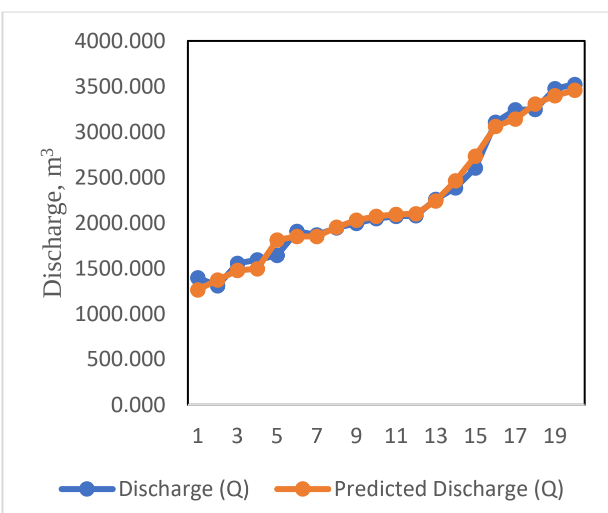
$$r = \frac{523689196.5 - 454197610.9}{\sqrt{4877050469404050}}$$

$$r = \frac{69491585.64}{69835882.39}$$

$$r = 0.995069916234791$$

$$r = 0.995$$

The selected values used for verification of the developed model was in line with the work of Antigha, 2007 and that of Brenzonik, 2002 for the average velocity of water flow passing through an open chanel.



The Model Validation:

The model so developed was used to validate with the velocity-area method for water flow measurement having the relation as Q = AV

Where Q = Discharge rate cm^3/s

A = Cross-Sectional Area, Cm^2

V = Velocity of Flow, Cm/s

The method involves the flow of velocity of water passing a point in an open channels cross-sectional area of the flow at right angle to the direction of flow by the average velocity of water, since the float method and current meter are used to measure the velocity of water the discharge is determined by the equation Q = AV.

CONCLUSION AND RECOMMEDNATION

Urbanization has been shown to increase surface runoff by creating more impervious surface such as pavement and structures that impede percolation thereby resulting to perennial flooding in some parts of the Obubra drainage basin which has been a thing of great concern to all residents in recent times.

The volume of storm water runoff presents in any given point in time in an Urban watershed cannot be diminished or compressed. Runoff itself is a product of rainfall whose intensity exceeds the infiltration capacity of the soil.

Rainfall frequency analyze are used extensively in the design of systems to handle storm runoff, including roads, culverts and drainage systems. Drainage coefficient is the design capacity of the drainage system expressed as a depth of water removed in 24 hours. It should be chosen to economically remove excess water from the top part of the root zone within 24 to 48 hours.

The choice of drainage coefficient can be influence by climate, soils and crops grown and it is based on local conditions, experience and judgment. The result coefficient (c) is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received. It is a large value for areas with low infiltration and high runoff (pavement, steep gradient) and lower for permeable, well vegetated areas (forest, flat land).

Legislation against construction along the right-of-way of storm runoff and the provision of adequate drainage outlets is recommended in curbing the menace of flooding within the Obubra catchment. In addition, the use of empirical approach instead of the rule-of-thumb is also recommended in the design of the storm drainage systems in the area.

The stochastic model developed will enhance the forecasting of flood events in the area, this will in no small measure, help the government spent less on flood victim resettlement programmes and to avoid the era of 'trial and error' for managers of the hydrologic setting is over.

Stakeholders and Governments should as well increase their attempts in the construction of culverts, drainage channels and others water conveying or diversion structures to curb these flooded areas.

A redesign of inadequate drainage channels of basin is recommended to ensure that the drains are adequate enough to safely discharge the runoff generated.

The study also recommends that; proper design, computations (analysis), adequate constitution and routine maintenance of drainage channels be made ensuring that the velocity satisfies the minimum requirement.

REFERENCES

Abam, T. K. S. (2004). Geohydrology with Applications to

Environmental Management. Published in Nigeria by Charisma Graphics Aba Pp 39 – 60

Adams, B. J. and Papa, F. (2000). Urban Storm Water

Management Planning with analytical probabilistic

Agunwamba, J. C. (2011). Water and waste management tools.

Immaculate printers, Nigeria 24- 26

Ahmad, N. B. (2008). Peak flow Attenuation using Dry Pond for

existing Housing Scheme, Master Theses, University of Malaysia

Antigha E. E. (2015). Development of Rainfall Runoff Model for

the Calabar Metropolis catchment using Differential Equation Approach.

Antigha R, E.E., Akor, A.J. Ayotamuno, M.J. Ologhodien I, and

Ogarekpe, N. M (2014). Rainfall – runoff Model for Calabar Metropolis using multiple regression, Nigeria *Journal of Technology, 33(4), 566-573.*

Antigha R. E. E and Ogarekpe N. M (2013). Development of

Intensity Duration Frequency curve for Calabar Metropolis, South-South Nigeria. International

Antigha R. E. E. Ayotamuno, M. J. Fubara-Manual, I and Akor,

A. J. (2015). Morphological studies of the Calabar Metropolis catchment, South-South Nigeria. *Journal of Environment Science Toxicology and Food Technology. 9(6), 15-22*

Antigha, N. R. B. (2007). Infiltration characteristics of selected

soils in Cross River State, Nigeria and their implication for sustainable crop production. Published Ph.D. Thesis in water Management and Soil conservation, University of Calabar, 3032.

Antigha, R. E. E. Ayotamuni M. J. Fubara- Manual, I, and Akor

A. J (2015). Development using the Differential Equation Approach. Global *Journal of Science and Technology, 2(5). 327-338.*

water management in Agriculture D. molden (ed.) London, Earthscan and Colombo, International Water Management Institute.

Cai, W; Borlace, S, Lengaigne, M; et al , 2014 increasing frequency of extreme El. Nino events due to green house warming. Nature climate change, 5(1), PP.1-6

Carey, S. K, Tetzlaff, D, Buttle, J, (2013) US of color maps and wavelet coherence to discern seasonal and inter-annual variation in northern catchments. Water resources Research 49, PP.1-14

CEPA (Common Wealth Environmental Protection Agency) (1993).

"Urban Storm Water" Australia

CRBC (2007): Cross River Broadcasting Cooperation, Calabar.

CSIRO (2007). Climate change: Australia CSIRO and Bureau of meteorology.

137P ISBN 9781921232947. Canberra. Australia.

David, B. (2004). Performance Indicator for urban storm

drainages in developing countries. Elsevier vol. 4 issue 2 Pp 137-144.

Dayaratne S. T., Perera, B. J. C. (2006). "Parameter optimization of

urban storm water Drainages models. Proceedings of the 8th International Conference on urban storm Drainage, Sydney, Australia, 1768 – 1775.

Dayaratne S.T. (2000). Modeling of urban storm water Drainage

System, using Design and Analysis Programme (ILSA). Ph.D. Thesis Victoria University, Australia. Pp 21-23, 34.

Gobo, A.E. (1998). Relationship between Rainfall Trends and

Flooding in the Niger-Benue River Basin. The *Journal of Meteorology, 13 (132), Pp 34-37*

Goyburo, A, Rau, P, ; Lavado-Casimiro, et a.. (2023) Assessmentt of present aand future water

security under Anthrropogenic and climate changes using WEEAP model in the Vilcanoota -Urubamba Catchment, Cusco Peru water 2023, 15, 1439.

Hansingo, K. ∝ Reasons, C.JC. 2009. Modeling the atmospheric response over southern Africa to SS1 forcing in the southeast tropical Alantic and south west. International journal of clinatogy, 1012 (April). PP 1001 – 1012.

Hatt, B. E, Fletcher, T. D, Walsh, C. J and Taylor, S. L. (2004). The influence of urban density and drainage infrastructure on the concentrations and loads of pollutants in small streams. Environmental Management, 34(1), 112 – 124.

Hortons, R.E (1930) Perceptual model of infiltration process. Hydrological

process: 18 (17); 3447 – 3460.

Hossain, S. J. (2015). Hydrological Modeling of Storm Water

Drainage System due to frequent and intense precipitation of Dhaka City using storm water management Model (SWMM) American Geophysical Union, Full Meeting 2015 Abstract id H431-1667.

Mulligan, M. and wainwright, J. (2004). Environmental Modeling.

Finding simplicity in complexity. John Wiley& Sons, 2nd Edition 78-79.

Ugbong, I.A (2000): An analysis of Runoff flow, channel characteristics and

flood and erosion menace in the Calabar Drainage Basin. An Msc Research, Department of Geography and Regional Planning University of Calabar.

UN – Water. 2007. Farms, Rivers and Markets: A whole – of – system.

Approach to doing more with less water. Business case to the National Water Commission, Australia.

Uyanah, M.E (2006). Functional correlates of the Reliability of Affective and

Cognitive measures. Unpublished Msc. Dissertation in Research and statistics, Department of mathematics and statistics. University of Calabar: 45

Valtanen, M., Sillanpaa, N. Setaia, H. (2014). Effects of hand use

intensity of storm water runoff and its temporal occurrence in cold climates.