Academic Scholars Publishing League (ASPL)
International Journal of Natural Resources and Environmental Studies
ISSN: 2360-915X | Volume 11, Issue 10 | June, 2024| pages 88 – 96
DOI: 277-513-69-0-11107
arcnjournals@gmail.com
https://arcnjournals.org

Comparative Analysis of River Channel Response to Differential Settlements in Rivers State, Nigeria

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Abstract: *Physical development on drainage basins often causes changes on stream channels. This study investigates the process-form differences in channel response to urban and rural land uses. The urbanized Amadi Creek in Port-Harcourt and the rural Lubara Creek in Bori (Khana) were studied. The geomorphic parameters of channel morphology, sediment yield, infiltration capacity, channel velocity and discharge were studied in the two river catchments. To achieve comparative objectives in these studied basins, primary and secondary data were collected. The students't test parametric statistics was used to test and validate the hypothesis that land use whether in the rural or urban settings influences channel response. The result reveals that urbanization of basins triggers changes in channel processes much more than it does in a rural setting. The study maintains that sustainable land use and forest resources management on Creek basins should be enhanced through legislations.*

Key Words: *Urbanization, rural, discharge, infiltration capacity, channel morphology, velocity, sediment yield.*

INTRODUCTION

In urban areas, a stream represents potential wildlife corridors, wetland multipliers of ecosystem integrity, scenic resources, recreational facilities close to homes and green-way links among neighbourhood and parts (Ferguson, 1991). Understanding the response of a watershed to urbanization and rural landuse is important. River basin has intrinsic properties which facilitates their being used as development units, some of which are geomorphic, others hydrological, transportation, landscaping and ecological balance.

Urbanization tends to disrupt stream equilibrium in many ways. Strahler and Strahler (1992), examined the hydrological effects of urbanization. According to them, an increase in the proportion of impervious surface reduces infiltration and increases the rate of runoff from urbanized area. An important result is that, the discharge of a stream increases in response to a period of heavy rainfall or snowmelt. The concentration of runoff in gutters and sewers which act as transmission channels to the man-made drains augments stream flow and sediment discharge (Odemerho, 1984). He further emphasized that, in response to this increased volume of water, the stream channel develops morphological characteristics and hydraulic geometry which approximates a form of stability or quasi-equilibrium that adjust to the prevailing conditions. The sediments and runoff from these concrete surfaces reaching the river channel are large enough base on per capita human discharge, size of urban or rural settlements and the rate of flow. Thus, the stream may not be able to make internal adjustments to maintain its previous equilibrium state. What obtains is that, these additional discharges introduce some imbalances into the stream channel system, sufficient to initiate significant adjustments in both the channel capacity and hydraulic geometry until a new equilibrium state is re-established.

Starkel (2002) in their study of rainfall, runoff and soil erosion around Cherrapiji, India, noticed that the conversion of the natural vegetation of different urban landuses is causing the stream channel to adjust to additional runoff and sediments production. Such that over years, enlargement of stream channel size occurs which creates alterations in hydraulic exponential relation.

It is understandable that the effects of runoff along stream are numerous. Umeuduji (2000) note that, human activities within a drainage basin can trigger off changes in processes that occur in stream channels. Development in the drainage basin can take different forms and can be located on different parts of the basin. It can be direct land phase development (Knighton 1984), such includes removal of vegetation by logging, deforestation, forestation, and even changes in landuse etc. While, on the other hand, it can be through channel phase development which takes place for a considerable distance along the river channel like river regulation and channel changes. Due to addition to the volume of water in the stream channel, there is the probability of increased sediment yield. Normally, such sediments may lead to areas down valley being covered with sand and silt deposits. Therefore, channels capacity is reduced as a result of siltation thereby resulting into flood hazards.

Studies in Nigeria generally have focused on urbanization and storm generation but neglecting how stream channels respond to the huge quantity of urban storm runoff. However, Oyegun (1984) was able to establish a relationship between percentage built-up area as the current operational process of urbanization and basin response through variation in sediment yield, discharge and channel capacity of the basin in Ibadan North-East.

Similarly, Odemerho (1984) examines the effect of Agricultural landuse practice on rural basins. It is significant to note that the size of the various land uses such as residential, commercial, industrial, recreation, institutional and agriculture and the quality of management [environmental management] or extent of physical planning may constitute serious effects on the available natural drains.

This study however focuses on some of the geomorphic consequences of stream/creeks on channel morphology, infiltration capacity and sediment yield as well hydraulic consequences of discharge and velocity resulting from physical development within the urban and rural areas..

AIM AND OBJECTIVES

This study attempts to know how the increased volume of runoff generated in the urbanized Amadi Creek in Port-Harcourt affects the morphology of the channel. This is in comparison with a rural third order Lubara Creek in Khana, Rivers State which is in its natural settting. There is a reason for this concern, Amadi Creek; a third order channel occupies a prominent position in Port-Harcourt. As a result, it offers waterways for both fishing and transportation purposes among others. Besides, the lower valley of the Creek accommodates huge proportion of the population of Port-Harcourt whose activities constitute serious changes in the creek. The study attempts to achieve the following objectives;

1. to examine the effect of urbanization and Agricultural land uses on stream channel velocity of Amadi Creek and Lubara Creek channels.
2. to make a comparative analysis of channel discharge, infiltration capacity, sediment yield and channel morphology of an urban catchment (Amadi Creek) and a rural catchment (Lubara Creek).
3. to recommend some alternative policy approach on the use of River basins for resource production and sustainability by government and individual.

STUDY AREA

The study areas are located in Port-Harcourt and Khana (Bori) Rivers State. It is an area, located within Latitude $4^0$30 and $5^0$30 North and Longitude $6^0$30 and $7^0$30 East. The Amadi Creek passed through the built-up area of Ogbunabali extending to the East and North-East of Rainbow town and Trans-Amadi. The Creek is joined at the Western flank by the Ntawogba Creek crossing Eastern by-pass road into Amadi Creek. Also, the Elekohia Creek into Amadi Creek. The Lubara Creek drains Bori Town with its source from Kaani through the rural communities of Kor and Kpong through other communities of Ken Khana (East of Bori) down to Imo River separating Rivers and Akwa Ibom States [see fig. 1 and 2].

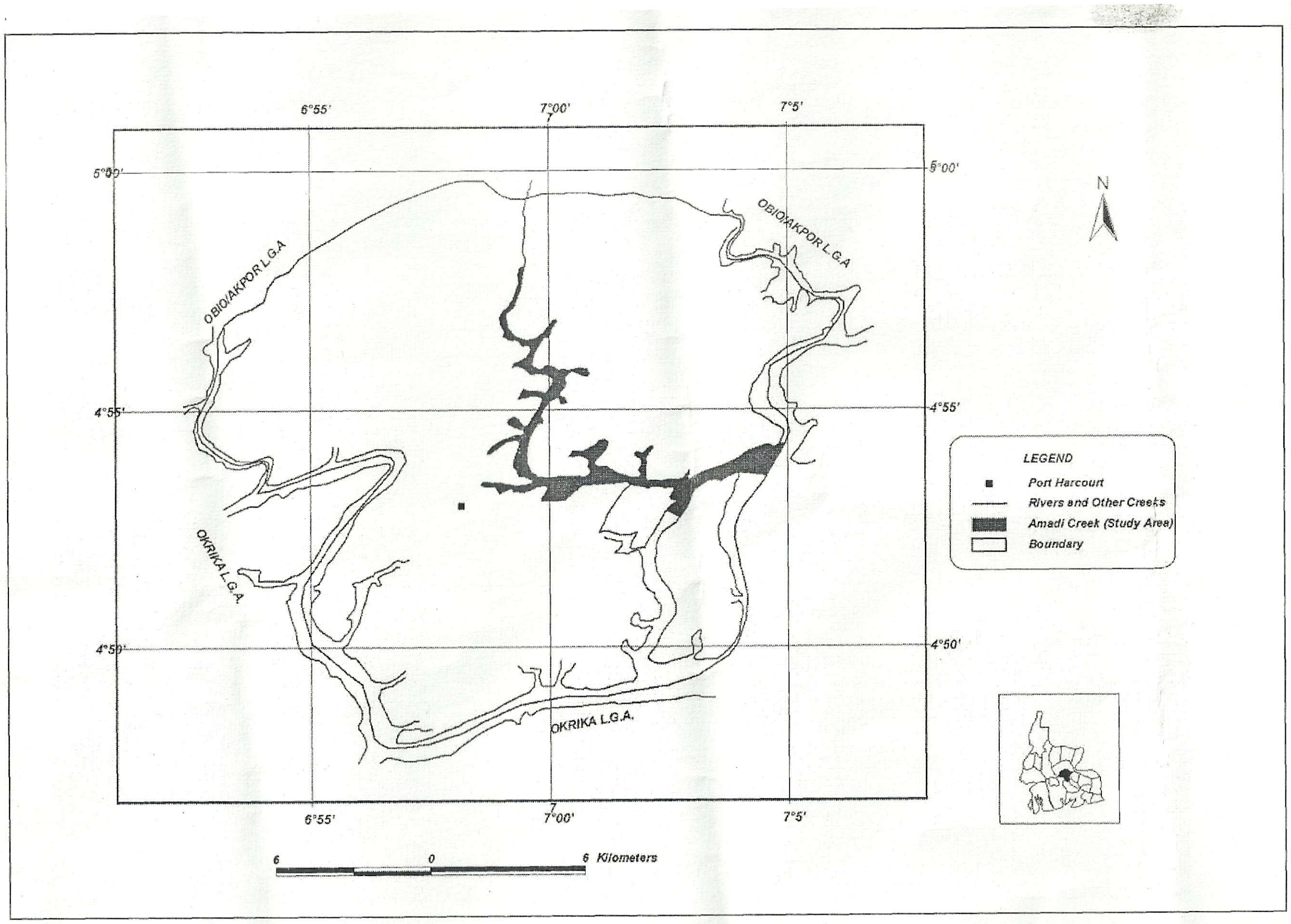

Fig 1: Map of Port Harcourt Local Govt Area showing Amadi Creek (Study Area)

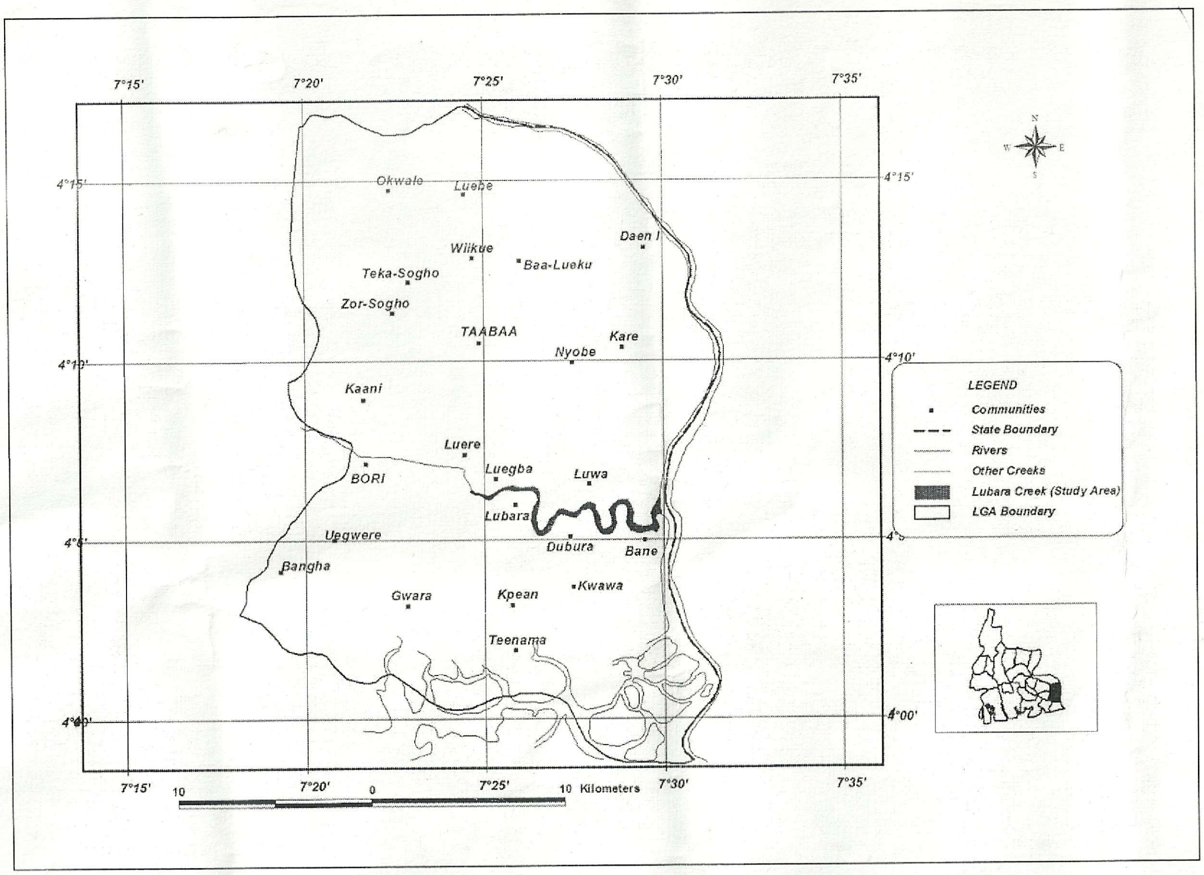

Fig. 2 : Map of Khana Local Govt. Area showing Lubara Creek (Study Area)

MATERIALS AND METHODS

Choice of sampling points was based on careful site and point location. A total of 30 sampled points each were selected for Amadi Creek and Lubara Creek. All the 30 sampled points each were chosen base on an interval of 333.3 meters for Amadi Creek and 733.3 meters for Lubara Creek. Parameters of interest measured include; Discharge stream velocity, infiltration capacity, sediment yield, and channel morphology. Equally observations were made on the extent of built up areas along and within the catchments of the River plains. These were conducted to assess areas of building coverage and proper determination of the extent of flow into the drains.

DISCHARGE

The width and average depth of sample site across the channel were obtained as well as the channel velocity.

$$Q = W \quad [d_1+d_2[v^{-}_1+v_2] \ldots\ldots\ldots\ldots\ldots (1)$$

Where; q = total discharge

W = Total width

$D_1\ d_2$ = Marginal depth

$v_1\ v_2$ = Marginal velocity

VELOCITY

Surface float method with the use of cork was used and dropped on the channel water surface and allowed to float for a distance of 10meters and the time recorded.

SEDIMENT YIELD

A 250ml beaker, funnel, 25ml pipette, filter papers and a stirrer were used.

An over and desicator used in the drying of the resulting filtrate and weighing balance.

INFILTRATION CAPACITY

A flooding infitrometer was used to keep a constant head of water intake. The plots of water intake into the soil and time to show a leveling off as the infiltration capacity is reached.

CHANNEL MORPHOLOGY

This was collected with the aid of a measuring tape and calibrated sticks. The mean channel depth and its corresponding width and its product stated in meters (m^2).

DATA ANALYSIS

The parametric statistical tool of student's t' test was used in data analysis. In testing and analysis of the two-sampled areas, the students't test was used in comparing the values from the two creek channels.

$$t = \frac{\dot{x}_1 - \dot{x}_2}{\sqrt{\frac{sx_1 + sx_2}{nx_1 nx_2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where;

t = Students' t test

$\dot{x}_1$ = mean of sample (Amadi Creek)

$\dot{x}_2$ = mean of sample (Lubara Creek)

sx_1 = standard deviation (Amadi Creek)

sx_2 = standard deviation (Lubara Creek)

nx_1 = sample size (Amadi Creek)

nx_2 = sample size (Lubara Creek)

RESULTS AND DISCUSSION

The students' t' test alongside with their degrees of freedom was employed to compare the means of the various parameters for the data set of interest in this study. Table 1 and 2 below are the summary statistics of data collected for the various parameters for Amadi Creek and Lubara Creek.

Table 1: Summary statistics of data for Amadi Creek

Parameter	Mean	Standard dev.	No. of Cases
Discharge (cumees)	0.98	0.78	30
Velocity (m/s)	0.26	0.08	30
Sediment Yield (ppm)	0.65	0.24	30
Infiltration Capacity (m/s^{-1})	0.64	2.17	30
Channel Morphology (m^2)	7.29	3.35	30

Source: Field Work, 2009

Table 2: Summary statistics of data for Lubara Creek

Parameter	Mean	Standard dev.	No. of Cases
Discharge (cumees)	0.49	0.24	30
Velocity (m/s)	0.12	0.06	30
Sediment Yield (ppm)	0.39	0.07	30
Infiltration Capacity (m/s^{-1})	4.0	0.10	30
Channel Morphology (m^2)	3.21	1.41	30

Source: Field Work, 2009

The calculated value for velocity was found to be 2.05 slightly greater than the 2.10 probability confidence level at 95% (0.05) critical value and 58 degrees of freedom resulting from the rejection of null (H_o) hypothesis, therefore revealing that there is a significant difference in channel velocity of urbanized Amadi Creek and rural Lubara Creek. This is because Amadi Creek is purely a low-land and the high pressure of sewage in storm and sanitary sewers run directly into the channel from highly paved surfaces of urban land uses. Therefore, velocity is influenced by runoff intensity of the basin (Amadi Creek) which is quicker, greater and shorter lag time compared to rural Lubara Creek process and flow velocity is brought about by man's alteration of river basin (Bird, 1980).

On discharge, the calculated value is 2.67 which is greater than the critical table value of 2.01 at 95% (0.05) confidence level and 58 degrees of freedom. We therefore reject the null (h_o) hypothesis and accept the alternate (h_1) that, there is a significant difference in channel discharge of urban landuses as experienced in Amadi Creek channels. Discharge and runoff volumes increases as water quickly runoff paved surfaces with relatively very low infiltration (Pizzuto, 2002).

The parameter of infiltration which is the calculated value of 12.4 is greater than the critical table value of 2.01 at 95% (0.05) probability confidence level and 58 degrees of freedom. We therefore reject the null (ho) of no significant difference and accept the alternate hypothesis that, there is a significant difference in infiltration on rural and agricultural as well as natural landuse basin of Lubara Creek compared to urbanized Amadi Creek.

Therefore, urbanization reduces the level of infiltration capacity of soil as a result of the high level of reduced vegetal covers and subsequent increase in runoff (Rogowski, 1972; Thornes 1976; and Dunin 1976).

On sediment yield, the calculate value of 2.60 which is greater than the critical table value of 2.01 at 95% (0.05) probability confidence level at 58 degrees of freedom (df). Here also, we reject the null hypothesis (H_o) of no significant different in sediment yield and accept the alternate hypothesis (H_i) that there is a significant difference in sediment yield under different landuses (urban and rural). There is high sediment yield of the urbanized Amadi Creek compared to Lubara Creek. This is due to the high level of both solid and liquid wastes which are disposed indiscriminately on the Amadi Creek channel. Also, debris from vegetation, construction and land reclamation materials contribute in the increment of sediments in the channel (Amadi Creek).

Finally, the channel morphology; the calculated value of 10.25 is greater than the critical table value of 2.01 at 95% (0.05) probability confidence level and 58 degrees of freedom. We therefore reject the null hypothesis (H_o) of no significant difference and accept the alternate hypothesis (H_i) that there is a significant difference in channel morphology of Creek channel under different land uses (urban and rural).

The channel morphology of the urbanized Amadi Creek is generally higher than that of Lubara Creek that is under rural landuse. Therefore, urbanization influences channel morphology of Creek channels. It is also found that urban channels are wider, straighter and smother than their rural counter parts (Pizzuto, 2002).

CONCLUSION

Sequel to the results and findings resulting from disparities in the quantity of discharge of sewage through both sanitary and storm sewers, response to land use dynamics, importance attached to creeks as well as changes in quantity of built up areas in urban and rural areas, it becomes acceptable fact that significant difference occur in creek channel response to both urban and rural landuses. Velocity, discharge, infiltration capacity, sediment yield and channel morphology used as parameters in the study indicate that, urban channel response is higher than the rural channel.

RECOMMENDATIONS

Both the Federal and State laws on the environment should be encouraged at all levels.

The sections of the Nigerian Urban and Regional Planning Laws on the percentage of built-up within the residential and other land uses should be followed.

Building permits and approval of building documents should be obtained and approved by the relevant government authorities before building.

Water channels should be protected through enforcement of relevant laws for ecological balances especially environmental laws.

Environmental impact assessment should be carried out on proposed developmental projects which may constitute environmental and physical planning challenges to the environment.

Educational trainings, orientations and awareness on the importance of flood plain should be conducted in all sectors of the society.

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