Spatial Dimension Of Ginzo River Response To Urbanization In Katsina Metropolis, Nigeria.

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Abstract: Morphological studies in semi-arid urbanizing watersheds reveal varying responses that describe rapid channel adjustment often with adverse economic and environmental consequences. This study assessed spatial dimension of Ginzo catchment response to urbanization in Katsina Metropolis, Nigeria. Morphometric parameters were obtained through direct field measurements while degree of urbanization in each of the three segments of the river channel was computed from satellite imagery of Katsina metropolis. Descriptive statistics like mean, standard deviation, coefficient of variation, percentages and line graphs were then used in the analysis of data generated from the field. The study revealed that channel width were lowest at the upstream (11.2m) and highest at the downstream section (28.9m). Moreover, mean channel depth were lowest at the midstream (0.34m), and highest at the downstream section (1.45m) while channel cross-sectional area were lowest at upstream (15.40m^2) and highest at the midstream (61.55m^2). The results indicate that channel segments respond differently to different level of urbanization. The study therefore, recommends integration of geomorphic knowledge in urban and water resources policy of Nigeria. These include the use of bio-engineering approach in channel management and review of environmental policies to control channel encroachment.

Keywords: Ginzo River, Urbanization, Channel Morphology, Katsina, Metropolis.

1 INTRODUCTION

Streams and rivers are integral parts of the landscape. These streams carry water and sediment from high elevations to downstream water bodies like lakes, estuaries and oceans. The land area draining to a stream is called watershed. When rain falls in a watershed, it runs off the land surface, infiltrates the soils, evaporates, or accumulates in low areas and forms small pond and stream channels. A naturally stable channel maintains its dimension, pattern and profile such that the stream does not degrade or aggrade (FISRWG, 1998). However, Cooke (1976) revealed that landuse changes resulting from human activities often alter the stability of the river channels. The actions of such activities like urbanization, sand mining, deforestation, channelization, and livestock rearing can produce tremendous changes in the hydrogeomorphic stability of the channel (Brookes and Shields, 2006; Iroye and Ajibade, 2010; Nabegu, 2012; Iroye, 2015). The most noticeable human activity according to Brookes and Shields (2006) is urbanization and has the most detrimental effects on river channels as it reduces soil permeability and increases peak flood magnitude, leading to lateral and vertical degradation and thus, changes in channel size. In Katsina metropolis, Ginzo catchment is predisposed to urban induced problems. Such problems include the strengthening and concretization of bed and bank of some channel reaches. These activities hindered channel widening, but however, results in flood episodes generation (Ibrahim, 2008). Building construction along the stream is increasing soil erodibility and silting up the river channel (Hollis, 1988).

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These affects river flow and sediment supply. Changes in flow and sediment supply can produce tremendous adjustments in stream channel morphology, often with adverse economic or environmental consequences (Gaeuman et.al, 2004). Though the degenerating impacts of urbanization on River Ginzo have been explored and documented (Ibrahim, 2008; Kabir, 2015; Aliyu and Lugard, 2015). However, most of these studies have generically evaluated the impact of environmental abuse on the catchment and thus information on the geomorphic characteristics of the channel is anecdotal (Nabegu 2012). In view of the aforementioned, this paper aimed at investigating spatial pattern of catchment responses to urbanization in Katsina metropolis. This study offers important insight in understanding the relationship between urban induced changes in flow and responsiveness of an intermittent and alluvial stream like that of Ginzo.

2 STUDY AREA

The study area located in Katsina urban area (Figure 1) lies on the geographical coordinates of 11^{0}08'N to 13^{0}22'N latitude and 6^{0}52'E- 9^{0}20'E longitudes with a total land area of about 3, 370km^2 (Danjuma, 2012). The climate of the area has a single mode of rainfall pattern which is received between the months of May and September, with annual average of 700mm (Abaje et al., 2014; Maiwada, 2017). Ruma and Sheikh (2010) reported high temperature in most part of the year, with maximum day temperature of about 38°C or higher in the months of March, April and May and the minimum day temperature of about 22°C or a bit lower in the months of December and January. The relative humidity is 20-25% usually in the months of February and March, and higher with 70-80% in August when the highest amount of rainfall received during the year (Maiwada, 2017). Suleiman (2011) disclosed that the study area is generally underlain by granitic rocks of the basement complex which are covered by either the weathered rocks or the Aeolian drift. The soils are sandy ferruginous type, highly weathered and markedly lateritic and slightly acidic due to low organic matter content and phosphorous, with total nitrogen content rarely exceeds 2.0% (Abubakar, 2006). However, soil colour generally ranges from dark grey or greyish brown in the top soil to yellowish red or yellowish brown in the subsoil

(SDKTS, 2008). Even though, the stream flow in the area is intermittent flow with continues recharge only from the neighboring houses, Ginzo River drains the northern part of the city, while Tille River with its dendritic drainage pattern drains through the town in southern part direction (Ibrahim, 2008; Zayyana, 2010). The area also lies within the Sudan Savannah zone but its vegetation has been to a large extent modified as a result of several centuries of bush clearing for construction activities, bush burning, cultivation, animal grazing as well as fuel wood exploitation (SDKTS, 2008). These activities have however greatly contributed to the modification of the environment which leads to excess release of sediments into the Ginzo Catchment (Ibrahim, 2008). Although, in areas very close to the urban centre the natural vegetation is almost absent, several exotic species of trees like Neem (Azadiracta indica) replaced the indigenous species (Ruma, 2009). The land around the study area (Ginzo catchment) is dominated by several activities such as residential, industrial and commercial (Danbuzu et al., 2014). Undeveloped agricultural activities are practiced in the outskirt of the residential vicinities as well as other small plots along the river catchment and other extensive areas just outside the city (Isah, 2011). Katsina being an urban centre accommodates people from different works of life but the predominant ethnic groups are the Hausa and Fulani. Other ethnic groups such as Igbo, Yoruba, Nupe, Kanuri,Tiv, Idoma, Igala among others have also formed part of the composition of today's Katsina and participate in the political, social and economic development of the area (Wyciff, 2012). It is also important to note that there are citizens of Niger Republic who reside in all wards and local governments of the state. Majority of the people living in the study area Muslims, living with other Christians who are either indigenes or immigrants. More so, these people formed the close knit economic, political, administrative, cultural and institutional interrelationship in the area. Based on the 2006 census, Katsina local government Area has a population of 318,132 persons (NPC, 2006). The population of the Katsina urban area has been increasing since then due to the migration of people from all over the country especially the troubled north eastern part because of insecurity and the neighboring nations especially Niger republic (Ladan, 2014). This increased the magnitude of channel modification of the study river.

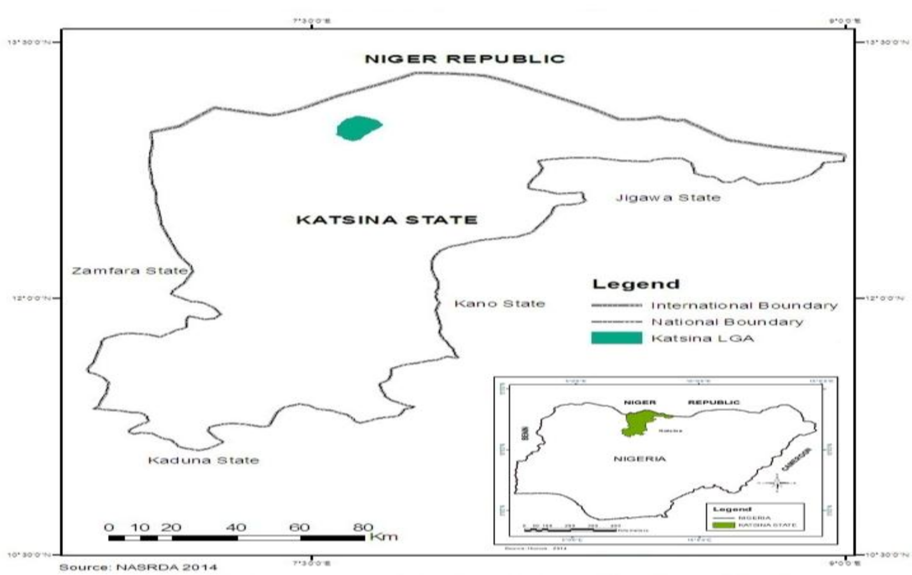

Figure 1: *Map of Katsina state showing the location of Katsina Urban area.*

3 MATERIALS AND METHOD

Ginzo catchment is drain by five streams, three of which are first order streams, one is a second order stream and the other which is the main stream is a third order stream and the stream being investigated in this study. Direct field measurements of stream morphometric properties were carried out using spatial interpolation technique. Based on this technique, the stream which measures a total length of 8.2km was divided into three segments (upper, middle, and lower section). The upper part falls under the rural fringes from Tudun Matawalle to Sabuwar Unguwa while the middle section falls under urban dominated landscape from Kofar Marusa to Filin Samji residential areas. The lower catchment region situated at the area of urban renewal beginning from Yandadi to Modoji quarters. The technique employed is in accordance with (Ajewole, 2010; Nabegu, 2012; Nabegu, 2014). From these three sites, two sampling reaches were selected at a distance of 1.2km apart. These were chosen for detailed measurement and analysis as can be seen in Figure 3. Channel Morphometric parameters of width, mean channel depth and cross sectional area were measured using measuring tape, pegs, measuring staff and recording book. The measurement of channel width was taken by extending taut measuring tape horizontally across the river course from one bank to another. To obtain data on channel depth, a measuring tape was stretched taut across the stream length to serve as a guide to ensure that measurements had been taken in a straight line. Measurements were then taken by immersing measuring staff at 50cm intervals. Channel cross sectional area of each selected reaches were computed by dividing the channel width by mean channel depth. Data generated from the field work were subsequently analyzed using descriptive statistics.

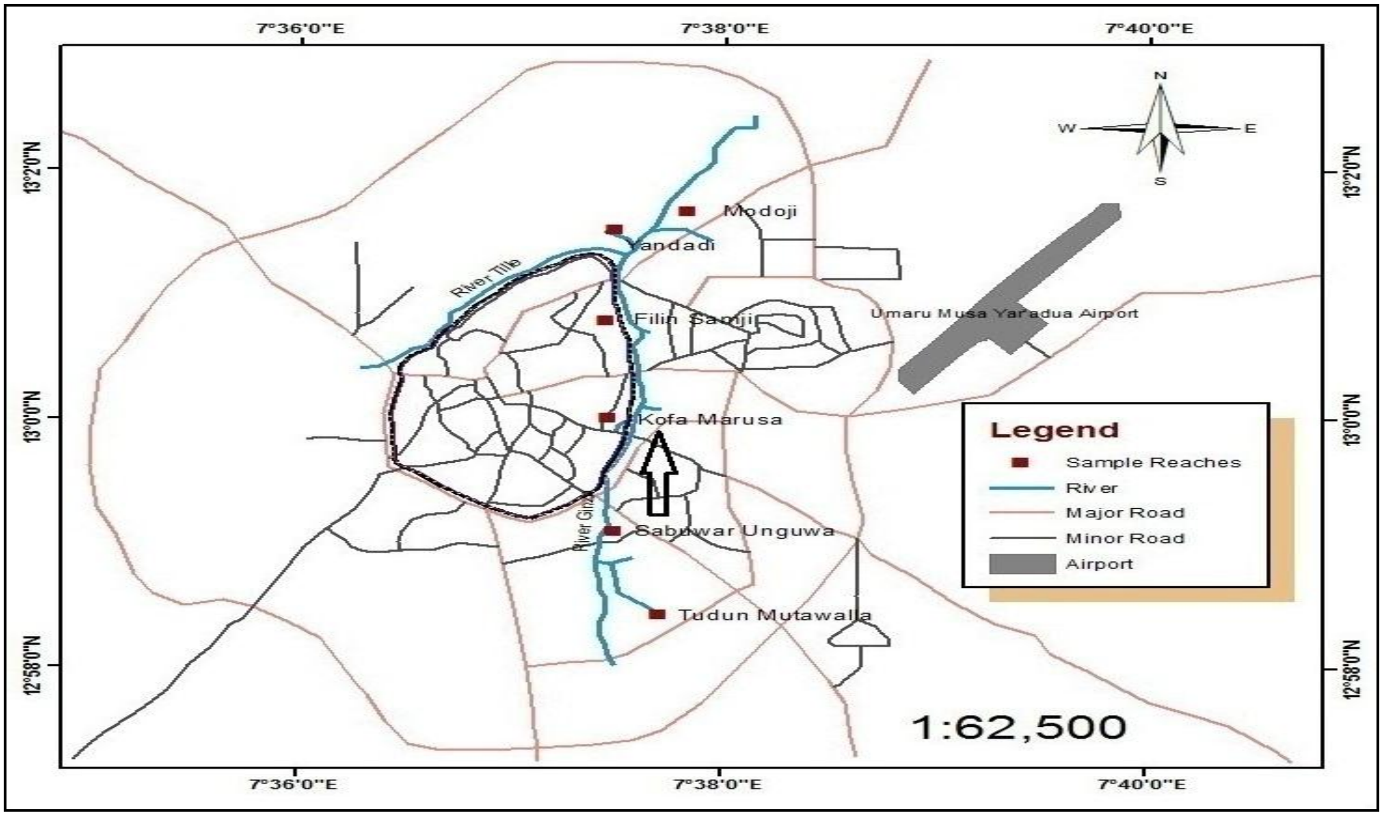

Figure 2: *Ginzo Catchment and Selected Sampling Reaches*

4 RESULTS AND DISCUSSION

Table 1 revealed that channel width ranged between 3.2m at 600m away from the river source to 47m at the 7.4km away from river source. Though the channel width increased from 3.2m at the first sampling point to 25.5m at the third sampling point, the value dropped to 10.8m over a distance of 6.2km away from the river source before rising to its largest value of 47.0m at a distance of 7.4km away from the Upstream as can be seen in Figure 1.The mean channel width is lowest at the upstream section (11.2m) and highest and downstream section (28.9m) while coefficient of variation (75%) shows that the study river exhibits high variability in width. The mean channel depth also shows a high coefficient of variability (77%). It ranges between 0.23m measured over a distance of 4.4km away from river source to 2.2m observed at the fifth sampling point situated at 6.2km away from the river source. The mean channel depth of the study river were highest (1.45m) at the downstream segment, when compared with the lowest observed values at the midstream section (0.34m) as depicted in Figure 2. The mean cross sectional area of the study river is highest (61.55m^2) at the midstream-segment while the value of this parameter is lowest (15.40m^2) at the upstream segment (Figure 3). Likewise, the cross sectional area of the study river exhibits high (79%) variability.

Table 1: *Channel Morphometric Parameters*

Sampled Reaches	Segment of River Channel	Distance from River Source (m)	Width (m)	Mean Channel Width (m)	Depth(m)	Mean Channel Depth (m)	Cross sectional Area (m^2)	Mean Cross sectional Area (m^2)
A(T.Mawale)	Upstream	600	3.2	11.2	1.2	0.95	2.7	27.2
B(S.Ungwa)		1800	19.2		0.7		27.4	
C(K.Marusa)	Midstream	3200	25.5	20.3	0.44	0.34	57.9	61.6
D(F. Samji)		4400	15.0		0.23		65.2	
E(Yandadi)	Downstream	5200	10.8	28.9	2.2	1.5	4.9	32.10
F(K.Tama)		7400	47.0		0.77		61.0	
S.D			15.2		0.71		28.7	
C.V			75%		77%		79%	

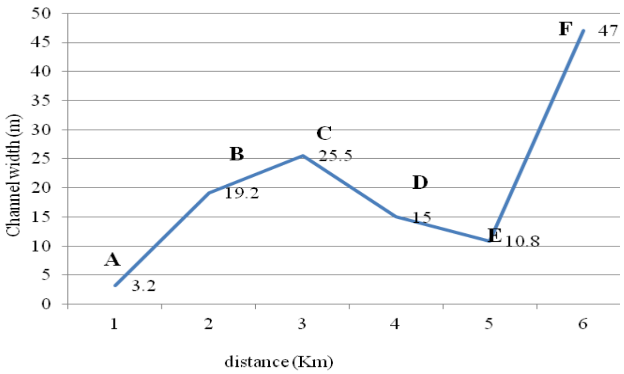

Figure 3: Trend of Channel Width.

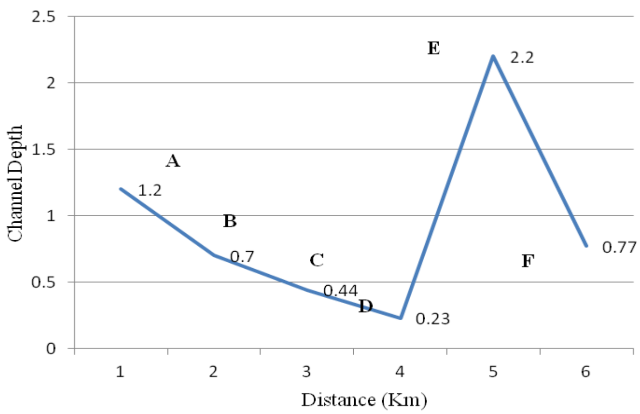

Figure 4: Trend of Channel Depth.

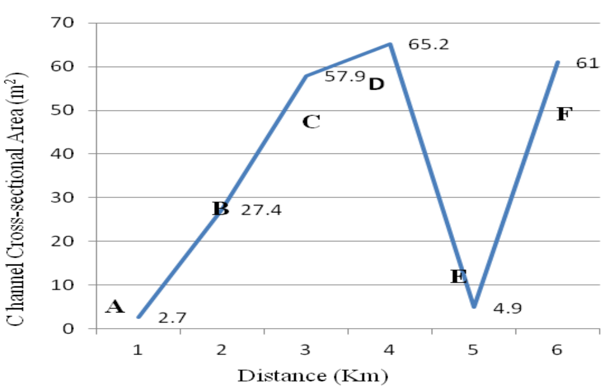

Figure 5: Trend of Channel Cross sectional Area.

The measured low values in channel width at the upstream section around Tudun Matawalle and Sabuwar (Points A and B) is due to the structural reinforcement of the channel banks carried out to prevent lateral and vertical erosion. The reason for the observed low value at Yandadi (Point D) is attributed to the presence of riparian vegetation along the channel corridor. Vegetation provides stabilising force against bank erosion and lateral expansion of the channel. The measured high values at the downstream section at Kwarin Tama (Point F) may not be unconnected with the fact that channel width increases with increasing distance downstream section based on the theory of hydraulic geometry. The recorded low values in channel depth at the mid-stream segment around Kofar Marusa and Filin Samji quarters (Points C and D) is as a result of the improper refuse disposal within the channel corridors. This results in silting up the channel and thus, decreases in channel depth. The observed low values in channel cross sectional area at the upstream segment may be as a result of the concretization of both channel bank and bed to prevent lateral and vertical degradation, while the recorded high values at the midstream segment is basically due to the fact that all the transport elements that form the flow paths like gutters, pipes, and other sewers debouch their flows into the channel. River channel always adjust to accommodate increase in flows. This corroborates the earlier findings of Nabegu (2012) that urban channels adjust their cross sectional area to maintain increasing velocity of higher flow. The observed value first showed an increase trend from 3.2m at 1km distance from the source through 19.2m at 2km distance, to 25.5m at 3km from the source. Thereafter, it showed a downward trend to 10.8m at 5km distance from the source, and subsequently again, an increase trend to 47m at the 6km distance from the source. The measured values of channel depth indicated a decrease trend from 1.2m at a distance of 1km from the first sampling reach through 0.44m at 3.2km distance to 0.23m at a 4km distance from the source. It however, showed an increase trend to 2.2m at a distance of 5km before plunging to 0.77m at a distance of 6km from the source. The recorded values of channel cross sectional area revealed a rising trend from 2.7m at 1km distance from the source through 27.4m at a distance of 2km away from the source to 57.9m at a distance of 3.2km from the source. The trend further ascend to 65.2m at 4.4km distance from the source, and later dropped to 4.9m at 5.2km distance before rising to 61m at a 6km distance from the source.

5 CONCLUSION AND RECOMMENDATIONS

Urbanization remains one of the anthropogenic distortions of the theoretical operation of the hydrological cycle, and its greatest consequences on catchment runoff pattern is as a result of paved surfaces. Paved surfaces reduce infiltration capacity and increase surface runoff, hence increase in channel size. The study revealed that urbanization has upset hydrogeomorphic balance of the catchment through artificial straightening of the substantial part of upstream segment, installation of artificial transport elements like gutters, pipes, and other sewers, construction activities within the catchment and improper waste disposal within the channel corridors. Such modifications cause remarkable changes in channel width, depth and channel cross sectional area. Additionally, altering the stability of the aforementioned parameters is an invitation to flooding, channel widening among others. However, integrating geomorphic knowledge in urban and water resource policies will assist in improving the fluvial and geomorphic conditions of the study river. This is critical especially now that the whole world is facing increase in the rate and intensity of environmental degradation induced by climate change.

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