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Research Paper

Assessing the Form Ratio of the WOJI River, Port Harcourt Metropolis, Nigeria

OKU, H. B.; WEJINYA, O. S. C. and MARK, E. O.
Department of Geography and Environmental Studies
Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt.

ABSTRACT
The study assessing the form ratio of the Woji river in the Port Harcourt metropolis has the sole objective of giving a geomorphic evaluation of the form ratio characterization of the Woji river channel. The study used a stream length of 5.4km at a sampling interval of 60metres giving a sample frame of 90 sampling points. The work adopted 30 sampling size which was randomly selected using the table of random numbers. The result of the hypothesis shows that the form ratio of the Woji river vary significantly across sampling points. The study thus conclude that morphometric parameters should be better understood in managing downstream flood hazards and recommend constant measurement of the urbanizing basin to fully understand the dynamics of channel adjustments.
KEYWORDS: *form ratio, Woji river, channel width, channel depth*

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I. INTRODUCTION

In contemporary fluvial studies, channel geometric parameters are the basic foundation for a proper understanding of the geomorphological activities of stream. Form ratio is one of the terminologies most frequently employed by hydrologists and fluvial geomorphologists in the description of streams and the channel they occupy. (Bagyarag & Gurugnanam, 2011, Wejinya 2018).

According Srahler (1970) in Wejinya (2018), form ratio was identified as an important parameter used in expressing stream channel geometry. Channel geometry encompasses all characteristics that define the channel shade and size as they appear to the eyes at a point. They include width, mean channel depth, cross sectional area, wetted perimeter, hydraulic radius and form ratio for the entire channel reach (Wejinya, 2018). This implies that form ratio is an integral component of stream channel geometry. Form ratio is the ratio of the width of a stream or river to its depth. Similarly, it is defined as the width, divided by the mean depth, d, or w/d. (Andrew, et al, 1997, Susan, 2009, Oku, 2016 and Weijinya, 2018). Various stream properties can be evaluated with the help morphometric studies. The morphometric analysis of drainage basin plays an important role in understanding the geo-hydrological behavior of drainage basin (Hajam et. al 2013).

According to Andrew et. al (1997) a wide range of morphometric measures has been devised for drainage basin and these have usually been defined as either ratio measure such as ratio of channel width, characteristics to the mean channel depth, that is the form ratio. So morphometry which is the quantitative description of forms is necessary to characterize mean depth and channel widths quantitatively so as to allow for easy comparison and to demonstrate how the depth and width characteristics are inter-related. In line with these assertions, Gregory and Walling (1976) noted that the morphometry of drainage basins has focused upon the area, length, shape and relief.

Morphometry is needed as a tool for measuring or assessing the impact of nature and anthropogenic activities within the drainage basin, so as to verify that changes that has taken place overtime by comparing the past with present channel, geometric indices or components of the river basin. To understand the evolution and behavior of drainage patterns, form ration is one of several quantitative parameters that has been developed, even as Hajamas et. al (2013) noted that morpholometry does not only deal with measurement but also deals with the mathematical analysis of the earth's surface configurations. In addition Goudie (2004) opined that morphometric parameters comprise the form and structure characteristics of drainage basin and their associated drainage.

Man's concern about his environment has greatly increased overs centuries now, he has been seeking a better way of controlling his environment (Sunsuwa, et. al 1999) various developmental activities that man has engaged himself in over the past century has brought about considerable distortion in channels geometry(that is shaping, remolding and restructuring the stream channel).

Since the post industrial revolution, urbanization pace has been on a continuous rise, taking up most land uses (Paul & Meyen, 2001). In fact, it has become the leading form of changing land use since the 1950's as affirmed by Onokerhorage (1985). Port Harcourt has already joined the trend of urbanization drive and Woji drainage basin is not an exception even as Booth, (1991) cited that man's activities associated with urbanization cause irreversible damaging effect on the drainage form and its hydrology. Contemporary fluvial studies have revealed deliberate attempt by fluvial geomorphologist to manage water resource within the drainage basin in a manner which optimizes water use throughout the basin and minimizes deleterious effects for water, stream channel geometry (which include width, mean channel depth, cross sectional area, wetted perimeter, hydraulic radius and form ration) and land use.

It has become quite obvious that assisting the recovery of ecological integrity in a degenerated water shed system by re-establishing hydrologic, geomorphic and ecological processes, and replacing lost, damage or compromised biological element are the way forward in drainage basin management

In attempt to flood-proof a river channel which include the straightening, narrowing and shortening of a river course, removing gravel, installing new flood banks and river bank walling, and improving flood plain drainage the application of the concept of hydraulic radius and form ratio must be taken into consideration in other to enhance channel efficiency.

Therefore, it has become necessary to assess and monitor changes and proffer solution on how to solve the problem that nature and man has created within the Woji river basin.

II. RELATED LITERATURE

The entire area that collects the rainwater and contributes it to a particular channel is known as the drainage basin or catchment area (Kale & Gupta 2001). River basins have special relevance to drainage pattern and geomorphology and consist of distinct morphological regions (Gundekar. et al 2011). The assessment of the present condition of water resources in an area can be investigated with the study of drainage basin.

According to Andrew et. al (1997) form ratio is a simple measure of the shape of a river channel cross section usually obtained as w/d where w is the top width of the (r) to be characterized and d is derived as an average value by dividing the cross-sectional area (a) by w in the form: d = a/w.

The form ratio is key to understanding the distribution of available energy within a channel and the ability of various discharge occurring within the channel to move sediment. The width/depth ratio is the most sensitive of trends in channel instability (Hickin 2004, and Das, 2013).

A fundamental index of channel shape is the form ratio (w/d) which is determined by energy-load relation and bank and bed materials. Average river channels tend to develop their channel cross sectional form in a way to produce an approximate equilibrium between the channel and the water and sediment it transport (Hickin, 2004) the controlling influence of discharge upon channel form, flow resistance and flow velocity is explored in the concept of hydraulic geometry (Hugget, 2007). The form ratio of a river increases downstream. Moreover, form ratio is a good reflector of driving variables (discharge, quantity and size of sediment load and boundary conditions (valley confinement, channel substrate, valley slope and riparian vegetation/that controls the form of a channel reach (Chariton, 2008). A river with given slope tries to shape its channel to minimize the flow resistance. It is estimated that 95% of a rivers energy is used in overcoming flow resistance, leaving just 5% to carry out geomorphological work (Chariton, 2008). Flow resistance is determined by channel shape and an ideal channel reach that attain a shape of minimum flow resistance is called most efficient channel. Cross-sectional form of a river channel is primarily adjusted by bed and bank erosion (Charlton, 2008) and lateral channel migration (Simon & Castool, 2003). Width/ depth ratio represents dominant measure of channel response (Simmon 1992, Simmon & Darby, 1997) and w/d alone does not define cross-sectional shape (Hey 1978).

The conventional belief of the V-shaped cross-sectional form of the rivers is far from the reality (Sen 1993). Circular and parabolic forms are also theoretical (Sen 1993, Leopold & Wolman, 1969, Lane, 1955) Rather trapezoidal form represents the reality (Sen 1993). But all these forms, whether theoretical or practical are not obvious for all channels or entire reach of the same channel. Straight course of a river is impossible (Leopold, 1968) which makes another impossibility of uniformity of cross-sectional form of the channel. Width increases faster than depth in downstream and cross-sectional form because, increasingly rectangular (Sen 1993) but sometimes opposite is also the reality (Knighton, 1998, Das, 2013).

The conditions for efficiency of cross-sectional characteristics of the channels are closely related to their capacity of maximum flow. Maximum flow (water and sediment load) is only possible when the cross-sectional form attains the semi-circular or parabolic shape (Kinighton 1998) or equilaterals triangular or rectangular (Hickin 2004).

These shapes generate the minimum turbulence and shear stress hence channel becomes the most efficient. Thus ideal channel form is considered as the best conveyance characteristics' (Crickmay) 1974). Relationship between channel form and processes operating in the channels were studied as hydraulic geometry by Leopold and Maddock (1953), Wolman (1955), Leopold and Miller (1950) and others. They computed cross-sectional variables of mean depth (d) and width (w) in terms of discharge (Q).

Simon and Castro (2003) suggest that flow resistance determines the velocity of a river. Flow resistance in turn is determined by channel form.

Semi-circular form, having best conveyance characteristics with minimum wetted perimeters and maximum hydraulic radius. Hydraulic radius with given cross-sectional area of wide v-shaped and narrow v-shaped triangular channels are smaller than that of an equilateral triangular channels. Therefore, ideal cross-sectional form of a river having maximum wetted perimeters and maximum hydraulic radius with given cross-sectional area of wide v-shaped and narrow v-shaped triangular channels are smaller than that of an equilateral triangular channels. Therefore, ideal cross-sectional form of a river having maximum efficiency is either semi-circular or equilateral triangular and rectangular with w/d ratio 2:1 as well (Hickin 2004) ideal width of triangular channel provides tool to compare natural channel width (w) with ideal width which the channel tries to attain to be most efficient. Significance of width index in triangular channel form is as width index in semi-circular channel form.

Width index (w) is a numerical tool to compare the shape of the river cross-sectional form, whether its width matches the width of most efficient channel or how much deviated from it. If width index (1w) = 1, the width matches perfectly with the width of a most efficient channel. If 1w>1, it indicates wider unconfined channel with negligible slope, no-cohesive substrate and lack of riparian vegetation (Charlton 2008) when 1w<1, then the channel is narrower with confined channel, steeper slope, cohesive substrate and or presence of riparian vegetation. In both cases, where 1w>1 or 1w<1, channels are less efficient than ideal channel. (Hickin, 2004)

Ideal depth provides tool to compare depth of a natural channel with given area to that of the ideal depth which the channel tries to attain to be most efficient.

Depth index (1d) is a numeral tool to compare the shape of the river cross-sectional form, whether its depth matches the depth of most efficient channel or how much deviated from it. If 1d = 1, the depth matches perfectly with the depth of a most efficient channel. If 1d>1, it indicated deeper confined channel (Charlton 2008) with steep valley-side slope, cohesive or bed-rock substrates and presence of riparian vegetation. When 1d<1, then the channel is shallower with non-confined channel, gentle slope, non-cohesive substrate and or absence of riparian vegetation. In both cases, where 1d>1 or 1d<1, channels are less efficient than ideal channel.

If channel form index (cf1) = 1, channel is ideal and semi-circular with maximum efficiency, higher value indicated aggraded and or shallower channels whereas lower value indicated degraded and or deeper channel respectively. In both cases where cf>1 or cf<1, channels are less efficient than ideal channel (Hickin, 2004).

Channel forms and patterns are important determinants of ease of movement of water and sediment and immediate clearance of materials from up slope whereas constriction (bottle neck shape) of the channel (width-depth ratio) hinders free draining or flow of water leading to ponding effect in some part and reduction of velocity and stream energy, to discharge the sediment and initiates sedimentation (Charlton 2008). the ratio of width to depth is the function of channel shape. But mere width: depth ratio (w/d) does not define cross-sectional shape even though it is a widely used index (Hickin, 2004).

III. METHODOLOGY

In this work, the research design adopted was quasi-experimental design as this helps in assessing the form ratio. The primary and secondary data were considered very relevant in this work. The researchers' interest is confined to upper and middle segment of the river. Within the upper and middle segment, sample frame of 90 points at 60 meters internal from the source to the middle segment was considered. That is 5.4km (5400 meters) from the source to the middle segment was adopted so that each cross sectional measurement will include measures of the channel width and depth characteristics. Using the simple random sampling technique with the aid of a table of random numbers which gives an equal and a non-zero chance form all the points being selected, the researcher decided to adopt a sample size of 30 selected along the main stream channel of the upper and middle segment of the river system.

The depth and width characteristics of the channel were measure with the aid of a tape and ranging poles, lap tape on the surface of the ranging pole. and tape tightly. Then pin the pole at right angle to the channel bed at three equal intervals, where, the top water level touches the tape, the reading is taken as the vertical distance that is from the channel bed to the water level and the average is taken as the mean channel depth. The channel width characteristic is measure by stretching the tape across the stream channel from one edge of water to another edge. The data generated from the measurement of width and mean depth, were used to derived the ratio between the width and depth as they serve as the function of the form ratio. It is important to state that it is not possible to measure from ratio directly in the field.

IV. RESULTS AND DISCUSSION

In line with the objectives of this paper, the one sample chi-square (x^2) formula was used to analyze the result obtained in the research at 95% probability level.

H0: Change in form ratio characteristics does not significantly affect the stream channel morphology of the upper and middle segment of the Woji River.

H1: Change in form ratio characteristics significantly affects the stream channel morphology of the upper and middle segment.

Summary table for chi (x^2) data

Probability Level	Degree of Freedom	Calculated Value	Critical Value	Decision
95%	29	437.02	17.71	We do not accept the null hypothesis

Calculated Value = 437.02
Table value = 17.71
At 95% probability level

Obviously, from the table above, we do not accept the null hypothesis (H_0) which states that change in form ratio characteristics does not significantly affect the stream channel morphology of the upper and middle significant of Woji River.

This is because the calculated chi square (x^2) value (473.02) is greater than the critical chi square (x^2) table value (17.71) at the 95% probability level with 29 degrees of freedom. Therefore, we accept the alternative hypothesis which states that change in form ration characteristic significantly affects the stream channel morphology of the upper and middle segment of the Woji River.

V. CONCLUSION

This paper on assessing the form ratio of Woji River, Port Harcourt was done statistically using one null hypothesis. A sample size of 30 different points were collected from a sample frame of 90 points at 60 meters interval from the River source to the middle segment along the main stream channel this was achieved with the use of simple random technique with the aid of table of random numbers. Data generated from the actual measurement of width and depths ratio were tested statistically using one sample chi square (x^2) at 95% probability level. The result led to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1) since the calculate value (473.02) is higher than the critical value of 17.71 at the 95% probability level.

The implication is that the form ratio which has the calculated value of (473.02) has profound effect on the channel morphology of Woji River.

VI. RECOMMENDATIONS

The following recommendations are put forward by the researcher based on the findings of the study.

a) The state ministry of environment and urban development can ensure yearly desilting of the river channel to prevent the risk of flooding especially in areas that are prone to flood.

b) Installation of gauging stations to measure fluvial characteristics for the prediction and management of flood hazards along the entire Woji stream channel.

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