American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-9, Issue-6, pp-10-15
www.ajer.org
Research Paper Open Access

Geometrical Parameters Measurement across River Asa, Ilorin North Central Nigeria

Olatunji Olaniyan S., Adedayo Adegbola A., Taiwo Ayanniyi J., Quadri Ibrahim O., Ayanlola Jeremiah A. & Babatola Ayotunde O.
[1]*Department of Civil Engineering,*
Ladoke Akintola University of Technology, PMB 4000, Ogbomoso (Nigeria)
Corresponding author: Olatunji Olaniyan S

ABSRACT: *Hydraulic geometry deal with the variation in channel characteristics in relation to variation in discharge. Two set of variations are important, which are variation at particular cross-section (at station) and variations along the length of the stream (downstream variations).There is paucity of information on geometrical parameters on River Asa which has a frequently flooding history. In this study, geometrical parameters were measured across the river to generate data for sediment transport modelling on the river. Five measuring points were selected along the river course from upstream to downstream.Geometrical parameters [Cross Sectional Flow Area (CFA), water depth, wetted perimeters, Hydraulic Radius (R_h)] and velocity were measured at measuring points using was achieved by surveying equipment and velocity meter from July to December, 2018.The CFA, water depth, $R_h$and velocity ranged (11.03-30.96)cm^2, (0.96-8.74)m, (1.048-2.156)m and (0.37-0.99)m/s for upstream and downstream, respectively. Variability of water discharges proves to be an important factor influencing natural river geometry.*

KEYWORDS*: hydraulic radius, velocity, river*

Date of Submission: 18-05-2020 Date of acceptance: 03-06-2020

I. INTRODUCTION

The quantity and quality of Nigeria's water resources are affected human factors and climate change. The spatial distribution of rainfall, climate pattern and hydrogeological units from the coastal areas to the Sahel regions of Nigeria provide a framework for the identification of the threats in terms of quantity and quality. Considering the importance of water to a developing nation like Nigeria, and in line with the MDGs number 7, the issues to be addressed are; the ever increasing water demand due to urban population increase vis-à-vis the impairment of the available water resources from both manmade and natural causes. Identification of these threats and their pathways are key to the formulation of mitigation or adaptation measures (Goldface and Irokalibe, 2006 & Olaniyan,2014).

The importance of water and its effective management cannot be overemphasized. Inadequate water supply and poor water quality give rise to health and other societal issues, limit agricultural productivity and economic prosperity, and pose national security risk. In order to effectively harness and manage water, there is need to adopt sustainable measures and one of these measures is cost recovery (Adah and Abok, 2013). The management of water and other natural resources is too often subject to poor governance, which contributes to insufficient and polluted water and threatens the health and livelihood of millions of people. These problems are particularly acute in poorer countries, in which people are mostly dependent on their national resource base. Water management is highly complex and extremely political. Therefore, balancing competing interests over water allocation and managing water scarcity requires strong institutional approach (Kevin, 2015).

Geometrical parameters on rivers are important input needed in any river modelling. The geometrical input and hydrological parameters are both parameter needed to model a river system. The model can be one dimensional, two dimensional and three dimensional models depending on the orientation of measurements. These geometrical values are cross-sectional area, wetted perimeter, slope and hydraulic radius, centroid of a cross-section or subsection, top width of a cross-section or subsection. The selection of representation cross-sections and study reach length in the model may affect the accuracy of simulated or predicted results (Adegbola and Olaniyan, 2012 & Olaniyan, 2014).

1.1 Aim and Objectives

The aim of this project is to compute the geometrical parameters on River Asa.

The objectives include:

i. To compute the cross sectional area.
ii. To compute the wetted perimeter across the river.
iii. To compute the hydraulic radius along River Asa.
iv. To compute the discharge of River Asa.

1.2 Scope of the Project

The measurement is limit to seven points on River Asa. These points are designated by Z_1toZ_5. These points are chosen based on accessibility and easiness of measurement. Point (Z_1-Z_2) represent upstream section, (Z_3) midstream and (Z_4andZ_5) are located within downstream section.

1.3 Significance of Study

River modelling is poorly developed in Nigeria. Insufficient hydrological records on most Nigeria Rivers have discouraged researchers in the field. Simulation of flow and sediment transport is therefore very important to curtail some environmental problems like siltation and channel instability. Numerical model has changed perception and entire world of modelling and simulation. Geometrical value is one of the inputs needed in river modelling. Geometrical computation of the river is one of the input variables in the numerical model. This will ensure modelling the river system to enhance environmental and hydrological decision.

II. LITERATURE REVIEW

Poor catchment management leads to increased flood peaks in streams and rivers. Given that many settlements are located along streams and rivers then this risk presents a potentially high economic cost and the possibility of loss of life. It needs to be recognized that patterns of development, of water use and of settlement are the cause of much of this flooding and that flooding should not be treated as an act of God over which we have no control. Water can be managed and to a greater or lesser extent, flooding is mitigated (Olaniyan, 2009). It requires, in addition to understand the process and the hydrology, management of water storage, it requires drainage and it frequently requires some engineering. If flooding is not prevented then, to the extent possible, it should be forecast and emergency measures should be in place to reduce damage and loss of life. Geometrical parameters is an important input in sediment transportation study as changes in river geometry are defined by cross-section. Characteristics responsive to analysis by hydraulic geometry include width (water-surface width), depth (mean water depth), velocity (mean velocity through the cross section), hydraulic radius and discharge. The cross-section describes available volume in system, slope of the channel bottom and roughness (Olaniyan, 2014)

2.1 Study Area

Ilorin, the state capital of Kwara State is located on latitude 8º30' and 8º50'N and longitude 4º20' and 4º35'E of the equator. Ilorin city occupies an area of about 468sqkm and it is situated in the transitional zone within the forest and the guinea savannah regions of Nigeria. It is about 300 kilometers away from Lagos and 500 kilometers away from Abuja the federal capital of Nigeria. The climate of Ilorin is tropical under the influence of the two trade winds prevailing over the country. Ilorin metropolis experiences two climatic seasons i.e. rainy and dry season. The rainy season is between March and November and the annual rainfall varies from 1000 mm to 1500 mm, with the peak between September and early October. Also, the mean monthly temperature is generally high throughout the year. The daily average temperatures are in January with 25 ºC, May 27.5 ºC and September 22.5 ºC.The vegetation type found here is derived savannah with riparian forest along the river bank. The drainage system of Ilorin is dendritic in pattern due to its characteristics. The most important river is Asa River which flows in south-northern direction. Asa River occupies a fairly wide valley and goes a long way to divide Ilorin into two parts namely the Eastern and the western part.

The major rivers are Asa, Agba, Alalubosa, Okun, Osere and Aluko. Some of these rivers drain into river Niger or river Asa (Oyegun, 1986). The general elevation of land on the western part varies from 273 m to 364 m (i.e. 900 to 1/200 ft) above sea level. To the north of the western part of Ilorin exists an isolated hill known as Sobi hill, which is about 394 m high above sea level (Olaniyan et al, 2017).

2.2 Suspended and Bed load

Suspended load

Suspend sediment load are the material which is held in water flowing in turbulence manner and move in the same rate as water. It can contain some wash load and bed material load. Suspended sediment load is the clastic material, which moves in the channel water column. They are majorly silt and sand that are kept in suspension by the upward flux of turbulence generated at the bed of the channel (Olaniyan, 2009; 2014).

Bed load

Bed load on the other hand is the part of sediment load, which is supported wholly by a solid-transmitted stress. It usually stay on the bed during motion. Bed loads are the clastic particle that moves through the channel that is fully supported by bed itself. They are majorly sand and gravel. Its mode of movement in water include rolling and sliding. Bed load is extremely difficult to measure because the bed load sampler used for its measurement interferes with flowing of water (Adegbola and Olaniyan, 2012).

III. METHODOLOGY

3.1 Field Measurements

3.1.1 Cross-sectional Area

Producing a cross-section of a river channel is a basic river fieldwork skill. Whether you need to find the discharge or examine the profile of a feature such as a meander or riffle, it will be necessary to produce a cross-section of the river. Wetted Area is the cross section of the river channel at the gauging point.

Equipment used are:

a) A long waterproof tape to measure the width of the river.

b) A rigid meter rule and or a long pole, such as a surveying pole, are needed for the actual depth readings.

At first the width of the river was discovered. After which a measuring tape was stretched across the course of the river from one bank to another at an angle of 90^o. For the purpose of clear and accurate measurement, the starting and ending point was closed at the point where dry soil meets the river edge. The measurement was taken from 20cm above the water level to factor in error that might occur due to water flow interfering and stretching the tape into a curve. The measurement was observed directly above the tape at 90^o to the ground to minimize error due to parallax.

3.1.2Water Depth

The depth of the river was measured proportionately to the established width of the river at regular intervals. The number of readings was dependent on the measurement of the width of the river and other required details. For the purpose of this project, the measurements was taken at an interval of 100cm. To ensure a relatively straight line measurement, measuring tape was drawn from one point to another on the river bank at the minimum interval to enclose the river.

A rigid meter rule was immersed in the water, at an interval of 100cm, until it just touches the bed of the river. It is held with its edge facing upstream, thus reducing to a minimum the surface area exposed to the running water. It was necessary to reduce the exposed surface area for two reasons. Firstly, the water may be flowing quite rapidly in places and its force can be sufficient to bend it out of the desired position at 90° to the river bed. The bed measurement was in accordance with method used by Olaniyan, 2014. The measured depths was used to draw a chart of the stream bottom; making sure that the scale is the same on the x-axis and y-axis. It will helpful to invert the y-axis so that the graph has the same orientation as the channel. Having drawn the cross-section by 'joining the dots' on the graph, thus a scale picture of a slice through the river was created. The chart was used to calculate the Cross-sectional Flow Area of the river, which was needed to find discharge and channel efficiency.

3.1.3 Wetted Perimeter

In order to find the wetted perimeter, the wetted area between each interval at which the stream's depth was measured. The perimeter was computed using equation 3.1.

$$P_i = \sum \sqrt{(D_2 - D_1)^2 + W^2} \qquad 3.1$$

3.1.4 Hydraulic Radius

The hydraulic radius of the river was derived from the cross-sectional area and wetted perimeter using equation 3.2

$$R_h = \frac{A}{P} \qquad 3.2$$

Where:
$R_h =$ Hydraulic Radius (m)
A = Cross-sectional Area (m^2)
P = Wetted Perimeter (m)

4.2 Wetted Area and Wetted Perimeter
The wetted area between each measurement depth is calculated using equation 3.3

$$A_w = \sqrt{(D_2 - D_1)^2 + W^2} \qquad 3.3$$

Where:
A_w = wetted area between two points
D_1 = depth at first point (m)
D_2 = depth at second point (m)
W = distance between measured points (m)
In this study, “W" is constant value 100cm. This is because the depth of the channel at intervals of 100cm was used at all stations.

IV. RESULT AND DISCUSSION

4.1 Results
The result of the water depth measurement in July and September are presented in Table I and II

The calculated wetted areas from in September, 2018 is shown in Table III. The monthly average of CFA in September is presented in Table IV. The hydraulic radius is a measure of channel flow efficiency.

The hydraulic radius is a term used to describe the shape of the channel. The higher the hydraulic radius the lower the amount of water in contact with the bed and banks which means there is less friction and water can move with a higher velocity. The hydraulic radius in July, 2018 at the downstream was 0.125m which was high compare to that of September which was 0.110m. This shows higher efficiency of the river channel at July to convey average monthly discharge of 6.178(m^3/s) to flood the situation in September (which have discharge of 8.694 (m^3/s) and lower hydraulic radius of 1.0986m)

Flow speed along channel depends on its cross-sectional shape (among other factors), and the hydraulic radius is a characterization of the channel that intends to capture such efficiency. Discharge is the rate of flow of the river. It is the function of the cross-sectional area of the river and the velocity along the river.

The cross-sectional area obtained shows that the area decreases down the stream which was due to anthropogenic factor. The upstream area of the river is an isolated area where houses and human activities except fishing are minimal. Towards the downstream, human habitat, institutions, companies, factories etc., are located close to the river bank and narrow the river channel along the station.

Table I: Depth Computation at Measuring Stations (July, 2018)

Distance (cm)	Depth (cm)				
	Z_1	Z_2	Z_3	Z_4	Z_5
0	0	0	0	0	0
100	300	130	225	147	065
200	305	175	220	121	098
300	325	206	260	199	134
400	350	182	305	247	185
500	386	213	382	326	173
600	380	200	270	318	168
700	357	206	244	331	170
800	305	211	290	294	171
900	268	187	220	261	134
1000	0	0	0	0	0

Table II: Depth Computation at Measuring Stations (September, 2018)

Distance (cm)	Depth (cm)				
	Z_1	Z_2	Z_3	Z_4	Z_5
0	0	0	0	0	0
100	185	120	195	182	096
200	254	128	152	176	122
300	260	215	245	145	134
400	324	360	271	264	121
500	403	350	414	373	211
600	370	292	304	340	203
700	335	260	274	335	176
800	367	170	310	305	171
900	265	165	280	292	134
1000	0	0	0	0	0

Table III: Wetted Area Computation at the Measuring Stations (September, 2018)

Distance (cm)	Wetted Area (A_w)(cm^2)				
	Z_1	Z_2	Z_3	Z_4	Z_5
0	0	0	0	0	0
100	316.23	164.04	246.22	177.79	119.27
200	100.12	109.66	100.12	103.32	105.30
300	101.98	104.69	107.70	126.82	106.28
400	103.08	102.84	109.66	110.92	112.25
500	106.28	104.69	126.21	127.44	100.72
600	100.18	100.84	150.15	100.32	100.12
700	102.61	100.17	103.32	100.84	100.02
800	112.71	100.12	110.07	106.63	100.00
900	106.63	102.84	122.07	105.30	106.63
1000	286.05	212.06	241.66	279.50	167.20
$\sum A_w$	1435.87	1201.92	1417.18	1338.88	1117.79

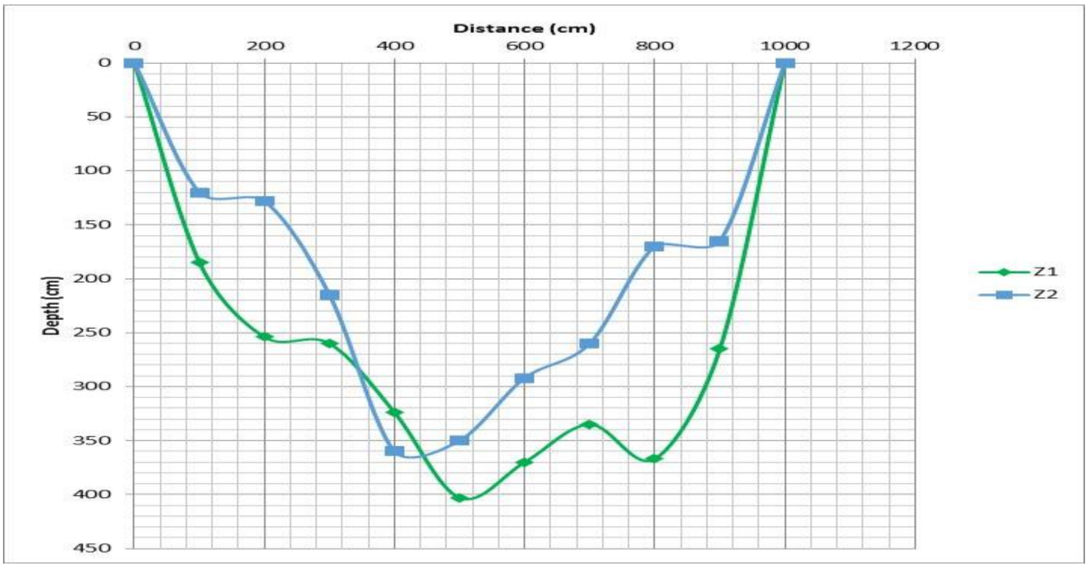

Figure1: Scale Picture of a Slice through River Asa at Z_1 and Z_2 in September, 2018

Table IV: Average Cross-sectional Flow Area at the Measuring Stations in September 2018

Stations	Z_1	Z_2	Z_3	Z_4	Z_5

R_h (cm)	194.87	159.22	167.22	164.31	109.82

The average geometrical parameters in at the critical months (September and October) is shown in Table V. The highest rainfall intensity were recorded within these two months in the year 2018.The velocity at mid-stream is the highest along due to the effect of Asa dam which can release water when the floodgate is full. Higher velocity of the river transport suspended sediment which are deposited at downstream where the velocity is lower.The value tends to reduces due to urbanization effects within Ilorin metropolis. The discharge trends follows as the velocity trend across River Asa.

Table V: Average geometrical/hydrological parameters in September and October 2018

Region	Station	R_h(m)	V(m/s)	A (m^2)	Q (m^3/s)
Upstream	Z_1	1.949	1.490	27.680	41.243
	Z_2	1.592	1.230	20.920	25.732
Mid-stream	Z_3	1.672	1.620	25.200	40.824
Downstream	Z_4	1.643	1.400	23.720	33.208
	Z_5	1.098	0.630	13.8000	8.694

V. CONCLUSION AND RECOMMENDATION

The CFA, water depth, R_h and velocity across River Asa varied from (11.03-30.96)cm^2, (0.96-8.74)m, (1.048-2.156)m and (0.37-0.99)m/s, respectively from July- December, 2018The channel efficiency of River Asa decreases from upstream to downstream. The river will mostly be flooded at the downstream and sparsely at the mid-stream. Wash load will be more prominent at the upstream due to the dominance of farming activities.

Recommendations from the Study

(i) Channelization of River Asa is strongly recommended at the Upstream and downstream to reduce the possibility of incessant flooding.

ACKNOWLEDGEMENT

The authors acknowledge Tertiary Education Trust Fund TETFund and Authorities of Ladoke Akintola University of Technology, Ogbomoso for the Institution Based Research (IBR) grant (PV No: 00082805) to carry out this research.

REFERENCES

[1]. Ada, P. D. and Adok G. (2013) Challenges of Urban Water Management in Nigeria: The way Forward, Journal of Environmental Sciences and Resources Management, Vol 5. No.1, 111-121.

[2]. Adegbola, A.A. and Olaniyan O.S. (2012). Temporal variation of Sediment Transport in River Omi, South-Western Nigeria. International Journal of Applied Engineering Research 4(7), 421-431.

[3]. Goldface, I.J and Irokalibe, 2006. Water Management in Federal and Federal – Type Countries: Nigeria Perspectives. Ahmadu Bello University, Zaria Nigeria.

[4]. Kevin Ejike Chukwu, (2015) Water Supply Management Policy In Nigeria.European Scientific Journal vol.11, No.26 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.

[5]. Olaniyan, O.S. (2009). Hydrological Analysis of Sediment Transport in a Turbulent Flow. Master’s Dissertation, VrijeUniversiteit Brussels, Belgium, 97 pp.

[6]. Olaniyan O.S. (2014). Numerical Modeling of Sediment Transport in River Omi, South-Western Nigeria, Unpublished Doctoral Dissertation, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

[7]. Olaniyan, O.S.,Olaniyan, O.M., Azeez, I.A., & Akolade, A.S (2017). Inudation and Hazard Mapping on River Asa, using GIS. Arid Zone Journal of Engineering,Technology and Environment, 13(6), 868-877.

Olatunji Olaniyan S, et. al. "Geometrical Parameters Measurement across River Asa, Ilorin North Central Nigeria.” *American Journal of Engineering Research (AJER)*, vol. 9(06), 2020, pp. 10-15.