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Analysis of River Benue Discharge at Jimeta Bridge

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ABSTRACT

Water is a sustaining element which is vital for all living being ,the discharge is a major concept in hydrography that presents information on the availability of water for human use and resource management. The aim of the research is to analyze the volume of discharge of River Benue at Jimeta with a view to provide early warning changes for flood. The primary data used were sounding, planimetric points and the velocity while the secondary data includes the discharge of previous years of 1999, 2002, and 2012 and the topographic map of the study area. The statistical analysis carried out using ANOVA to ascertain the assessment of the discharge; the result shows that there was decrease in the volume of discharge in the preceding years. The average velocity of water obtained was 1.03 m/s; it is as a result of the channel platform with 1.42% slope within the study area .In conclusion, the volume of discharge is decreasing with increase in sedimentation within the study area. Based on the findings of the research, it is recommended that there should be restoration measures such as dredging and buffer zone so as to create more space for adequate flow of water and to reduce the risk of flooding.

Keywords: Discharge, Analysis, Soundings, Dredging, Velocity

I. INTRODUCTION

Marine environment covers more than two-third of the Earth's surface. River discharge is the volume flow rate through a river cross section and perhaps the most important aspect of hydrographic surveyors operation. It is a major link in the global hydrology that represents the rate at which nature makes water available for human use and management. Inform of flood, It constitute one of the most destructive natural hazard. (Acreman, 2001).Most of the rivers in the world have been dammed to serve as water storage facilities for hydropower generation, drinking water supply and irrigation purposes. Reservoirs are indispensable storage facilities in arid and semi-arid regions of the world where there is irregular rainfall. Extreme drought and floods characterize by these areas resulting in insecure livelihood (Clark, 2002).
Brath et al. (2006) assessed the effect of land use changes on discharge frequency in Kenya; they found

that the sensitivity of the discharge decreases with increase return of vegetation along the river channel. Ibrahim (2014) carried out an assessment of siltation and its effect on river Benue at Jimeta and states that the increase level of sediment reduces the quality of water and the amount of habitat in fresh water ecosystem. He further states that sediments that are suspended in water increases turbidity and have significant impact on the fauna and flora in the river.

Dakin et al (2011) reviewed the use of volunteer monitors in the Huron river to provide an early warning of changes in the stream discharge and cross sectional channel shape. The goal is to provide early warning for flood. Tilley et al (2009) demonstrated the inadequacy of current stream guage height measuring averaging techniques combined with a rating curve to estimate flow at a site during flash flooding in Sydney urban areas. They recommended that the monitored guage height be used for each sub areas for each time increment in order to calculate the volume of discharge during storm event.

The poor control of the Lagdo reservoir, surface runoff and urbanization have in recent pass caused untold havoc to the immediate communities that reside by the banks of the river Benue. As a result, there is the need for proper planning to manage the reservoir on the river Benue for the benefit of downstream communities for proper planning and sustainable development.

The aim of the research is to analyze volume of discharge at River Benue in Jimeta, Adamawa State, Nigeria. While the objective is to compute the volume of discharge of River Benue along its cross sectional area and examine whether there is increase or decrease in the volume of discharge with respect to the preceeding years. The study on the volume of discharge measurement would serve as vital tool for assessing the rate of siltation. The result can be used as a guide for forecasting flood events that would provide security for life and properties against water related hazard. The paper would also help the policy and decision makers to provide information for planning, operation of water project and other related facilities. In addition, it can serve as a basis for further research in the study area.

II. STUDY AREA

Jimeta is situated along the bank of river Benue and is also the Administrative Headquarter of the State. It is between latitudes 09° 15'N and 09° 20'N and longitudes 12° 25'E and 12° 29'E with an elevation of 135 meters above sea level. It covers a land area of about 1009km^2 (Adebayo and Tukur 1999). It is situated at a point where the Benue river carves its valley through the eastern highlands. The rainy season runs from May through October with insignificant rains in March, April and November. The dry season commence in November and ends in April to May. The average annual rainfall in the study area ranges between 850mm-1000mm with over 41% of rain falling in August and September. Temperature also has a significant temporal variation in the study area; April is the hottest month with an average maximum temperature of 42℃entigrates. December and January are the coldest months with a temperature of 25°Centigrates.Upper Benue River Basin Development Authority Yola. (U.B.R.B.D.A. Yola, 2012).

The study area falls within the Benue trough which is generally a low lying flat terrain of 183.30-200.00 meters above the sea level with gentle undulation and hill ranges punctuating the extension flat flood plain at various locations notably across the river Benue from Jimeta eastward. The land rises steeply to attain a maximum height of 240 meter above mean sea level (U.B.R.B.D.A. Yola, 2012).The flat terrain boarding the river Benue is a favourable locale for wide range of socio-economic activities such as farming, grazing and settlement etc. River Benue is approximately

1,400 kilometers long and is almost entirely navigable during the summer months. The Benue is the largest and most important affinent of the river Niger which joins at Lokoja after a course of over 800 miles in a general east to west direction from its source in the mountains of Adamawa in Cameroun.

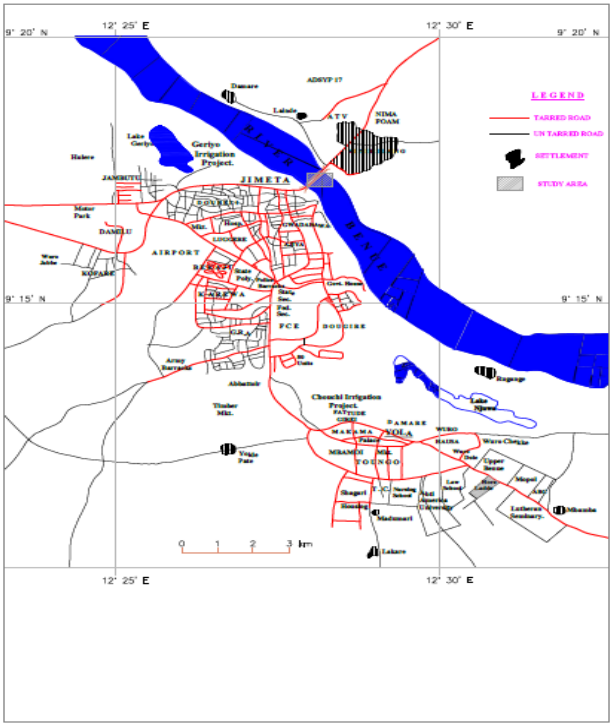

Figure 1. Map of jimeta showing the studyarea

III. MATERIALS AND METHOD

This paper focused on the study of discharge at river Benue. At the time of the actual survey, the water level was recorded. The sounding was carried out at ten meters interval and velocity was also measured at the same point. The primary data was then processed and the discharge and velocity along the cross sections were obtained. The general outlines of the river features were then identified.

The primary data used for the field observation was current meter; sinker weight and other bathymetric survey equipment, such as GPS, gauge Staff, gauging reel, suspension derrick, fish tail, battery and bray stoke flow meter, the data that was obtained were the depth, velocity, and discharge of the river. while the Secondary data was obtained from the upper Benue river basin development authority Yola; this includes the discharge of previous years, map of Nigeria, map of Adamawa state, and topographic map of river Benue showing the study area of such site. The determination of the initial point was done by measuring the distance from the embankment of the river to the edge of the water. The suspension derrick was assembled and suspended from the boat. The sounding was done by releasing the gauging reel down to the river bed with the aid of a sinker weight; the weigh sinker was released by turning the handle of the gauging reel in a clock wise direction. As the weigh sinker touches the water surface, the gauge meter reel was set at 0.00 .The weigh sinker was further released until it reaches the river bed. Then the digital reading on the meter was displayed and recorded.

The velocity was determined using the current meter; the bray stoke flow meter was attached to the current meter via a cable for digital display of revolution in 60 seconds. The handle of the gauging reel was turned in a clock wise direction and the fish tail was suspended on the surface of the water. When the Bray stoke metal touches the surface of the water and revolves once, the metal was set on the gauging reel at 0.00. The suspension cable was then released gently until it touches the river bed then the actual depth was displayed on the digital meter and further multiplied by 0.6 i.e. the one point method. When the result was obtained, the handle was further moved in anti-clock wise direction .As a result, the bray stoke flow meter was suspended between the surface of the water and the river bed. The current meter was switched on to count the number of revolution in 60 seconds.

IV. DATA PROCESSING

In data processing, the computation of depth and velocity measurement was obtained in the process of

field observation. Raw data collected by a receiver was processed to determine the differential relationship between the points occupied during data collection. In order to get the velocity and discharge, the mean of revolutions were obtained and divide by two to get the actual mean ,the mean was further divided by sixty to obtain the mean revolution per second .the velocity at point was obtained under the bray stoke flow meter chart 001 to obtained the velocity.

V. RESULT PRESENTATION AND DISCUSSION

This paper deals with the presentation and analysis of the data obtained from Field as well as the data for the volume of discharge for the year (1999, 2002, 2012 and 2015) in order to analyze the decrease or increase of discharge with respect to previous data.

Table1. Discharge volume of river Benue for the months of (June, July and August) for the year 1999, 2002, 2012 and 2015.

Months/Years	1999	2002	2012	2015	Total discharge(m^3)	mean discharge(m^3)
June	2160.759	442.938	1661.950	285.083	4550.730	1137.683
July	4136.171	918.550	1922.220	712.807	7689.748	1922.437
August	5436.461	3549.082	2160.759	1083.096	12229.398	3057.349
TOTAL discharge(m^3)	11733.391	4910.570s	5744.929	2080.986	24469.876	
Mean discharge(m^3)	5866.696	1636.857	1914.976	693.662		

The objective of the statistical analysis is to investigate whether the result of the discharge is affected by the different months of the observation. (row effect) as well as the different years of the observation (Column effect).

The two Hypotheses for the statistical test are:

H_{o1}: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$

(I.e. there is no row effect or the mean of rows are equal).

H_1: at least one of the means is not equal to zero (i.e. row effect).

H_{o2}: $\beta_1 = \beta_2 = \beta_3 = 0$

(I.e. there is no column effect or column means are equal).

H_2: at least one of the means is not equal to zero. (i.e. column effect).

The significance level $\alpha = 0.05$

A Computation for the estimates of column population variance σ^2 from the sum of squares for the row means (SSRM).

$$SSRM = \frac{\sum_{i=1}^{r} T_i^2}{c} - \frac{T^2}{rc}$$

$$= \left(\frac{4550.730^2 + 7689.748^2 + 12229.398^2}{4}\right) - \frac{24469.876^2}{3*4}$$

$= (\frac{229399543.3}{4}) - \frac{598774831.5}{12}$

$=57349885.82 - 49897902.62 = 7451983.198$

$S_1^2 = \frac{SSRM}{r-1}$

$= \frac{7451983.198}{3-1} = \frac{7451983.198}{2} = 3725991.599$

Computations for another estimate of variance σ^2 from the sum of squares as for the columns means (SSCM)

SSCM = $\frac{\sum_{j=1}^{c} T_i^2}{r} - \frac{T^2}{rc}$

$= (\frac{11733.391^2+4910.57^2+5744.929^2+2080.986^2}{3}) - 49897902.62$

$= (\frac{199120874.00}{3}) - 49897902.62$

$= 66373624.68 - 49897902.62 = 16475722.06$

$S_2^2 = \frac{SSCM}{c-1}$

$= \frac{6632372.678}{4-1} = \frac{6632372.678}{3} = 22107908.93$

Computations of yet another estimate of variance σ^2 from the Error sum of squares (ESS)

ESS = TSS – SSRM – SSCM

Therefore, TSS =$\sum \sum_{j=1}^{c} X_{ij}^2 - \frac{T^2}{rc}$

TSS=(2160.759^2+442.938^2+1661.950^2+285.083^2+4136.171^2+918.550^2+1922.220^2+712.807^2+5436.461^2+3549.082^2+2160.759^2+1083.096^2) – 49897902.62

TSS = 77856159.490 – 49897902.62 = 27958256.87

ESS = 27958256.87 – 7451983.198 – 6632372.678 = 13873900.99

$S_3^2 = \frac{ESS}{(r-1)(c-1)}$

$= \frac{13873900.99}{(3-1)(4-1)} = \frac{13873900.99}{2*3} = \frac{13873900.99}{6} = 2312316.832$

The statistics for testing the Null Hypothesis, H_{o1}: there is no row effect

$F_1 = \frac{S_1^2}{S_3^2} = \frac{3725991.599}{2312316.832} = 1.611$, with degree of freedom $v_1 = 2$; $v_2 = 6$

$F_{0.95}(2, 6) = 5.14$

Since $F_1 < F_{0.95}(2, 6)$, we accept the Null Hypothesis,

Test for the Null Hypothesis, H_{o2}: there are no row effects. The statistics for testing this Null Hypothesis is the ratio

$F_2 = \frac{S_2^2}{S_3^2} = \frac{22107908.93}{2312316.832} = 9.561$, with degree of freedom $v_1 = 3$; $v_2 = 6$

$F_{0.95}(3, 6) = 4.76$

Since $F_2 > F_{0.95}(3, 6)$, we reject the Null Hypothesis, H_{o2}: that there are column effects.

Based on the statistical analysis we accept the Null Hypothesis at 95% significance level which shows that there is decrease in the volume of discharge with respect to the previous years.. Other factors such as bush clearance for farming activities and urbanization within the vicinity of the river contribute to surface runoff which in turn leads to increase the rate of siltation and decrease in the volume of discharge of the river. In conclusion

we,accept the Null Hypothesis, H_{o2}: since there is decrease in volume of discharge from 1999, 2002, 2010 and 2015 at 95% significance level.

Table 2 shows the discharge measurement in June

RIVER:- Benue **Gauge Height:- 1.89m** **Method:- Boat**

Station:-Jimeta bridge **Date:- 18/June/2015** **Meter No:- BFM 001**

No.	Dist. From I.P (m)	Width (m)	Depth (m)	Depth of obs. (m)	Revolutions per---60---sec Rev.	Mean	Mean rev/sec.	Vel. (m/sec) At point	Mean in sect.	Area of sect. (m^2)	Discharge (m^3/sec)
1	20		0.0	0.0	00/00	0.0		water edge left bank			
		10						0.226	5.00		1.130
2	30.0		1.0	0.6	102/96	99.0	1.65	0.452			
		10						0.615	13.50		8.3
3	40.0		1.7	1	160/183	171.5	2.86	0.778			
		10						0.886	18.70		16.570
4	50.0		2.2	1.3	224/215	219.5	3.66	0.994			
		10						1.017	26.00		26.44
5	60.0		3.0	1.8	230/229	229.5	3.83	1.040			
		10						0.993	31.00		30.780
6	70.0		3.2	1.9	209/208	208.5	3.48	0.945			
		10						0.913	34.00		31.04
7	80.0		3.6	2.2	191/198	194.5	3.24	0.881			
		10						0.904	38.00		34.35
8	90.0		4.0	2.4	198/211	204.5	3.41	0.927			
		10						0.842	41.00		34.52
9	100.0		4.2	2.5	167/167	167.0	2.78	0.757			
		10						0.685	38.50		26.37
10	110.0		3.5	2.1	140/130	135	2.25	0.613			
		10						0.597	31.50		18.8
11	120.0		2.8	1.7	131/125	128.0	2.13	0.581			
		10						0.573	27.50		15.76
12	130.0		2.7	1.6	126/122	124	2.07	0.565			
		10						0.542	25.50		13.820
13	140.0		2.4	1.4	119/114	116.5	1.9	0.519			
		10						0.519	22.00		11.420
14	150.0		2.0	1.2	114/115	114.5	1.9	0.519			
		10						0.463	18.00		8.330
15	160.0		1.6	1.0	90/87	88.5	1.48	0.406			
		10						0.368	13.00		4.780
16	170.0		1.0	0.6	78/68	73	1.2	0.33			
		10						0.271	7.50		2.033
17	180.0		0.5	0.3	50/41	45.5	0.76	0.211			
		10						0.175	3.50		0.613
18	190.0		0.2	0.1	30/29	29.5	0.49	0.138			
		4.36						0.069	0.40		0.030
19	194.4		0.0	0.0	00/00	0.0					

Total Discharge=285.083m^3/sec

Total Area=308.40m^2; Mean Velocity = 0.627m/s

Table 3 shows the discharge measurement in July.

Discharge measurement notes on river Benue at Jimeta bridge

RIVER:- Benue **Gauge Height:- 3.08m** **Method:- Boat**

Station:-Jimeta Bridge **Date:- 23/July/2015** **Meter No:- BFM 001**

Vert. No.	Dist. From I.P (m)	Width (m)	Depth (m)	Depth of obs. (m)	Revolutions per---60---sec Rev.	Mean	Mean rev/sec.	Vel. (m/sec) At point	Mean in sect.	Area of sect. (m^2)	Discharge (m3/sec)
1	14.5		0.0	0.0	00/00	0.0		water edge left bank			
		10							0.101	4.50	0.455
2	24.5		0.9	0.5	47/38	43.0	0.72	0.201			
		10							0.493	14.00	6.902
3	34.5		1.9	1.1	171/174	173	2.88	0.784			
		10							0.924	19.50	18.020
4	44.5		2	1.2	237/232	235.0	3.92	1.064			
		10							1.248	21.00	26.21
5	54.5		2.2	1.3	320/313	317.0	5.28	1.431			
		10							1.481	24.50	36.280
6	64.5		2.7	1.6	341/336	339.0	5.65	1.531			
		10							1.5	33.00	49.5

7	74.5	10	3.9	2.3	302/348	325	5.42	1.469	1.531	43.00	65.83
8	84.5	10	4.7	2.8	349/356	353.0	5.88	1.592	1.619	48.50	78.52
9	94.4	10	5.0	3	332/398	365.0	6.08	1.645	1.582	48.50	76.73
10	104.5	10	4.7	2.8	334/338	336	5.6	1.518	1.46	48.50	70.81
11	114.5	10	5.0	3.0	322/298	310.0	5.17	1.402	1.457	40.00	58.28
12	124.5	10	3	1.8	310/360	335	5.58	1.512	1.438	32.00	46.020
13	134.5	10	3.4	2	304/300	302	5.03	1.364	1.293	37	47.84
14	144.5	10	4	2.4	272/268	270	4.5	1.221	1.191	39.5	47.04
15	154.5	10	3.9	2.3	255/258	256.5	4.28	1.161	1.075	33.50	36.01
16	164.5	10	2.8	1.7	223/214	218.5	3.64	0.989	0.907	26.5	24.04
17	174.5	10	2.4	1.4	182/181	181.5	3.03	0.824	0.683	21.5	14.68
18	184.5	10	1.9	1.1	119/118	118.5	1.98	0.541	0.492	14.5	7.13
19	194.5	10	1.0	0.6	99/95	97.0	1.62	0.443	0.34	7	2.38
20	204.5	5.31	0.4	0.2	55/47	51.0	0.85	0.236	0.118	1.1	0.13
21	209.8		0.0	0.0	00/00	0.0					

Total Discharge =712.807m^3/sec ,
TotalArea =557.60m^2 ,
Mean Velocity = 1.102m/s

Table 4, showing the discharge measurement in August

Discharge Measurement Notes on River Benue at Jimeta Bridge

RIVER:- Benue | Gauge Height:-3.57 m | Method:-Speed Boat

Station:-Jimeta Bridge | Date:- 27/Aug/2015 | Meter No:- BFM 001

Vert. No.	Dist. From I.P (m)	Width (m)	Depth (m)	Depth of obs. (m)	Revolutions per---60---sec Rev.	Mean	Vel. (m/sec) Mean rev/sec	At point	Mean in sect.	Area of sect. (m^2)	Discharge (m3/sec)
1	9.1	10	0.0 s	0.0	00/00	0.0	water edge left bank		0.283	3.00	0.849
2	19.1	10	0.6	0.36	124/124	124.0	2.07	0.565	0.762	7.50	5.72
3	29.1	10	0.9	0.54	209/214	211.5	3.53	0.959	1.074	11.50	12.350
4	39.1	10	1.4	0.84	259/266	262.5	4.38	1.188	1.304	12.00	14.5
5	49.1	10	2.0	1.2	313/316	314.5	5.24	1.420	1.4995	23.00	34.490
6	59.1	10	2.6	1.56	350/350	350.0	5.83	1.579	1.583	32.00	50.66
7	69.1	10	3.8	2.28	351/352	351.5	5.86	1.587	1.554	40.00	62.16
8	79.1	10	4.2	2.52	343/330	336.5	5.61	1.52	1.578	45.00	71.01
9	89.1	10	4.8	2.88	366/359	362.5	6.04	1.635	1.651	52.00	85.85
10	99.1	10	5.6	3.36	367/372	369.5	6.16	1.667	1.662	58.00	96.4
11	109.1	10	6.0	3.6	370/364	367.0	6.12	1.656	1.608	49.50	79.59
12	119.1	10	3.9	2.34	348/343	345.5	5.76	1.56	1.524	37.00	56.390
13	129.1	10	3.5	2.1	335/324	329.5	5.49	1.488	1.55	44.50	68.98
14	139.1		5.4	3.24	350/364	357	5.95	1.611			

15	149.1	10	5	3	373/384	378.5	6.31	1.706	1.659	52.0	86.27
16	159.1	10	4.7	2.82	319/317	318	5.3	1.437	1.572	48.5	76.24
17	169.1	10	4.3	2.58	361/365	363	6.05	1.637	1.537	45.0	69.17
18	179.1	10	4.2	2.52	299/296	297.5	4.96	1.345	1.491	42.5	63.37
19	189.1	10	3.7	2.2	304/300	302.0	5.03	1.364	1.355	39.5	53.53
20	199.1	10	3.6	2.16	272/268	270	4.5	1.22	1.292	36.5	47.16
21	209.1	10	2.2	1.32	255/258	256.5	4.28	1.161	1.191	29.0	34.54
22	219.1	10	1.0	0.6	101/98	99.5	1.66	0.454	0.808	16.0	12.93
23	229.1	8.3	0	0	00/00	0	0		0.227	4.15	0.94

Total Discharge=1083.096m^3/sec
Total Area= 728.15m^2

Mean Velocity = 1.369 m/s

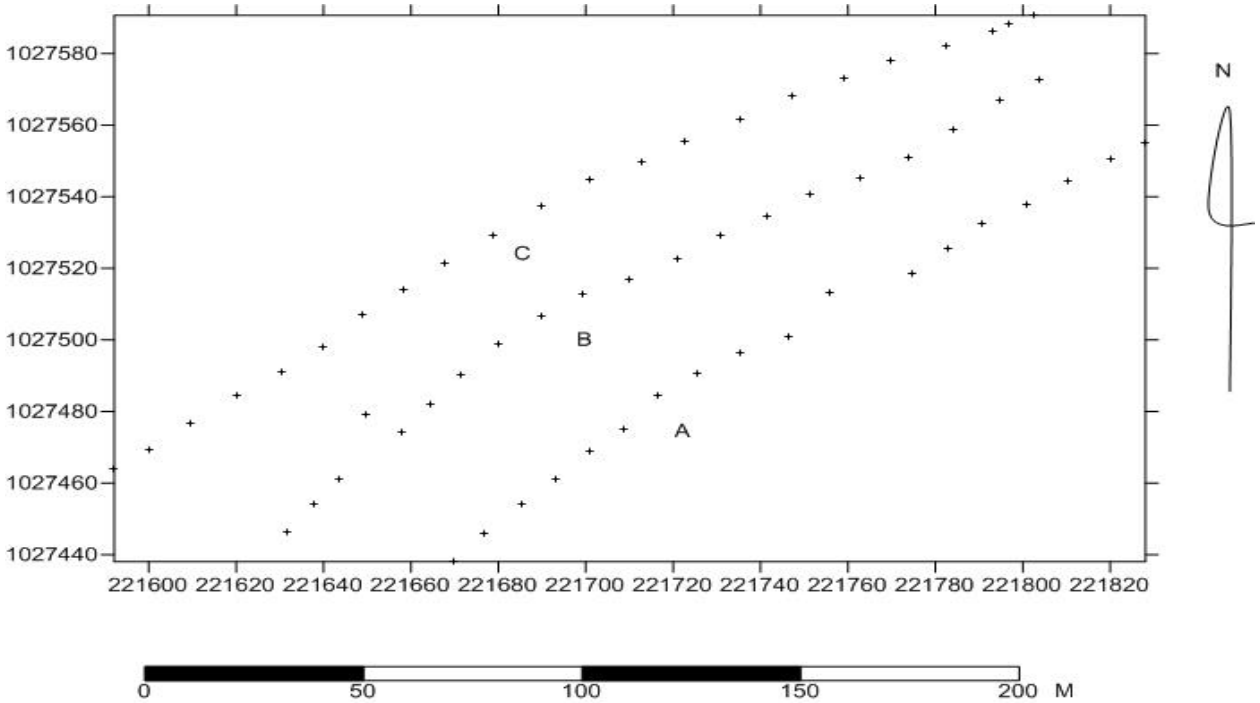

Figure 2. Shows points taken along the cross section of part of river Benue.

V. SUMMARY

In summary, the cross sectional depth of the river was obtained and the digital elevation model of part of the river Benue was produced. The volume of discharge is decreasing and these could be as a result of increase in sedimentation, these factors affect the ecosystem, irrigation project and increase the risk of flooding. Sounding and the velocity were obtained at ten meters interval along the cross section which gives the result of the discharge. The discharge was compared with that of the previous years and it was observed that there is decreased in the volume of discharge. These were as a result of surface runoff, urbanization and deforestation within the vicinity of the river which eventually leads to increase in siltation along the channel of the river. The pattern of flows shows that it is a laminar flow because of the

slope and width of the river as well as the fluid particles moving in a straight path at low velocity.

VI. CONCLUSION

There is decrease in discharge of river Benue and the siltation is mostly due to impact of human and natural activities such as surface run off and the occasional release of water from Lag do Dam in Cameroon. From the studies, it was found that the effects of discharge were siltation of the river channel which leads to reduction in flow. Consequently, these factors have constrained irrigation and fishing activities which were formally undertaken along the river.

VII.RECOMMENDATION

Based on the recommendation, dredging should be executed in the river Benue so as to increase the rate of discharge. The government should be construction of filter fence at the embankments in order to protect channel from sediment in storm water runoff. A buffer zone should be created around the river so that the encroachment of human activities such as farming would be monitored.

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