COMPARATIVE ANALYSIS OF STREAM DISCHARGE MEASUREMENT UPSTREAM OF RIVER KUBANNI, ZARIA, NIGERIA

BY

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ABSTRACT

The requisite for planning of water resources development is the availability of accurate data of stream flow for a considerable period of time to determine the extent and pattern of available supply of water. The aim of this study was to carry out a comparative analysis of discharge measurement upstream of River Kubanni in Zaria in order to know the extent and pattern of available supply of water. Stream discharge data were obtained from the gauging stations at Malmo, Tukurwa, Maigamo and Goruba tributaries using the weir technique for the 2017 hydrological year and tables, charts and Analysis of Variance were used for the analyses. It was observed that the flow periods of the tributaries ranged from 206 to 239 days with Malmo having the least and Goruba the highest. The regime diagrams revealed a single peak discharge periods of August for Goruba and Maigamo and September for Tukurwa and Malmo. The study shows a significant difference in the stream discharges with Goruba tributary having the highest discharge value of 2,344,896 m^3/yr., followed by Maigamo and Tukurwa with discharge values of 1,215,648 m^3/yr. and 1,127,520 m^3/yr. respectively, while Malmo tributary has the lowest stream discharge of 508,896 m^3/yr. The study therefore recommends that there should be continuous monitoring of stream discharge in order to determine the pattern of available supply of water and measures to prevent or control flooding should be established since there was an increment in the flow periods of each tributary, as water may be forced into the land destroying farmlands and properties if they exceed their carrying capacity.

Key words: River Kubanni, Stream discharge, Tributaries, Weir method.

INTRODUCTION

Almost every day, water makes the headlines somewhere in the world. Drought, Flood and Pollution are all big News, as water becomes the most precious and most contested essential resources. Man requires water for cooking, drinking, sanitation, agriculture and manufacturing processes. However, because water is freely available through rainfall, man has, until fairly recently, taken this unique resource for granted. Although more than 70 percent of the earth's surface is water, water has become a scarce commodity in many parts of the world. The threat of a world water crisis is becoming increasingly real in the face of increasing demand, relative static supply and deteriorating quality due to pollution (Ayoade and Oyebande, 1978, as cited in Yusuf 2013).

The scarcity of water and threats of flash floods in Nigeria require further understanding of the natural processes of water resources in order to manage and sustain current and future water resources. Rainfall fluctuation and climate change are expected to increase water scarcity in Nigeria. These combined factors will drive Nigeria to severe water stress. Hence, hydrological measurement become more essential in order to interpret water quality data and for water resource management (Ibrahim, 2011).

When a dam is constructed across a river, the resultant reservoir receives water and sediments from the catchment areas of the river network (Yusuf, 2013). However, sediments yield in any reservoir or river has a relationship with the river discharge. Hence, the need for stream discharge measurement becomes a paramount importance in water resources evaluation. Stream discharge is quite important on both concentration of substance dissolved in the stream and on the distribution of habitat and organism throughout the stream, Discharge is also a major factor influencing water chemistry (Zubairu, 2009).

Stream flow or discharge is defined as the volumetric rate of flow of water in an open channel including any sediments or other solids that may dissolved or mixed with it that adhere to the Newtonian physics of open channel hydraulics of water. Stream flow cannot be measured directly but must be computed from variables that can be measured directly such as stream width, stream depth and stream flow velocity. Even though stream flow is computed from measurement of other variables the term “Discharge measurement” is generally applied to the final result of the calculations (Whiting, 2003).

Several studies have been carried out on tributaries of the Kubanni drainage basin. For example, Iguisi (1997), in trying to assess the level of siltation in the Kubanni reservoir observed that the degradation of the biological environment around the basin results in instantaneous overland flow during rainfall. This consequently results to high overland flow, which meant high sediment yields. Hence, contributing immensely to the siltation of the Kubanni reservoir.

Several methods are available for the measurement of river discharge and the choice will depend upon the magnitude and character of the channel and associated flow, cost and the accuracy required (Gregory and Walling, 1973). These include velocity area techniques, dilution gauging, volumetric gauging, slope area technique, weirs and flumes methods. However the weir method was used for this study because of its consistency (Yusuf, Iguisi and Bello, 2007). The type of structure used and details of its design will depend upon the purpose of measurement, the nature of the stream channel, the sizes of the channel and the resources available (Gregory and Walling 1973). Weirs may be classified into sharp-crested or thin plate weirs, and broad crested weirs. In the sharp-crested weirs, the notch and crest is formed by a sharpened metal plate, while in the broad crested weirs a thicker construction usually made of concrete is used.

Sharp-crested weirs are commonly used in small catchments and the triangular form is especially suited to the accurate measurement of flow as low as 0.1 m/s. The 90° V notch is the commonly triangular weir form, although 120° notch are also employed depending on the sizes of the channel.

To this end, this research will analyze the stream discharges of all the four major tributaries of River Kubanni upstream using the Weir method in order to see whether there is significant difference between the stream discharges. The aim will be achieved through the following objectives to; determine the stream discharges of the study area, examine the stream discharge regimes and compare the stream discharges of the study area.

THE STUDY AREA

The study area is located in Zaria, Kaduna State, Nigeria between Latitudes 11°05'50" to 11°10'25"North and Longitudes 7°35'40"to 7°38'50" East. Zaria is one of the province that make up the Central high plains of Northern Nigeria and it is approximately 670m above mean sea level. It is located about 950km away from the coast. Zaria is the second largest city in Kaduna State, covering a total land s of about 61km^2 making it a nodal point in terms of road and rail transport because of locational factors (Jatau, 1999; Arowolo, 2000). The Kubanni River takes its source from the Kampagi Hill, in Shika, near Zaria and flows in a southeast direction through Ahmadu Bello University main campus, Samaru. It has four major tributaries upstream of the Kubanni Reservoir.

The study area belongs to the tropical continental type of climate corresponding to Koppen's tropical wet and dry climate zone (Aw), characterized by strong seasonality in rainfall and temperature distributions (Oladipo, 1985). It has two distinct seasons: the dry or harmattan season (October to March) and wet season (April to September). The seasons generally coincide with the southward and northward movement of the surface transition known as Inter-Tropical Discontinuity (ITD) between the hot, moist tropical maritime air-mass (mTs) of Atlantic ocean origin to the south and the cold, drier tropical continental air-mass (cTs) blown by the northeast trades from the Sahara Desert.

Zaria is drained by three major rivers, the largest of which is River Galma that originates from Jos plateau and is a tributary of River Kaduna. It is a perennial river. The second river in Zaria is River Kubanni which have many tributaries including Malmo, Tukurwa, Maigamo and Goruba. The northernmost tributary, Malmo has its major source from Kampagi hill in Shika near Zaria. It flows in south east direction through Ahmadu Bello University. The third major river is River Saye which drains through the south western section of Zaria. These rivers are very important to the economic development and survival of Zaria as they provide most of the useful water for domestic, industrial and irrigational purposes (Yusuf, 2013).

MATERIALS AND METHODS

In order to achieve the aim and objectives of this study, both Primary and Secondary data were used. The primary data is the stream discharge data that was obtained from the gauging stations using the weir method during the flow periods of the four tributaries; Malmo, Tukurwa, Maigamo and Goruba from May 2017 to January, 2018. The topographic map sheet of Zaria SW 102 served as secondary data and was utilized to present the gauging stations in Figure 1.

A calibrated 120° V-Notch sharp-crested weir was used for the Malmo tributary. The 120° V-Notch was already installed for the Malmo tributary by Yusuf (2006) with discharge formula of:

$Q = 2.47H^{2.5}$ --- (1)

While the 90° V-Notch sharp-crested weir was used for Tukurwa which was also installed by Yusuf (2013). Two new 90° V-Notch sharp-crested weirs were constructed and installed at Maigamo and Goruba tributaries. The 90° V- Notch has a discharge formula of:

$Q = 1.38H^{2.5}$ -- (2)

Where Q = Discharge in m^3/s H = Head of water in metres (stage).

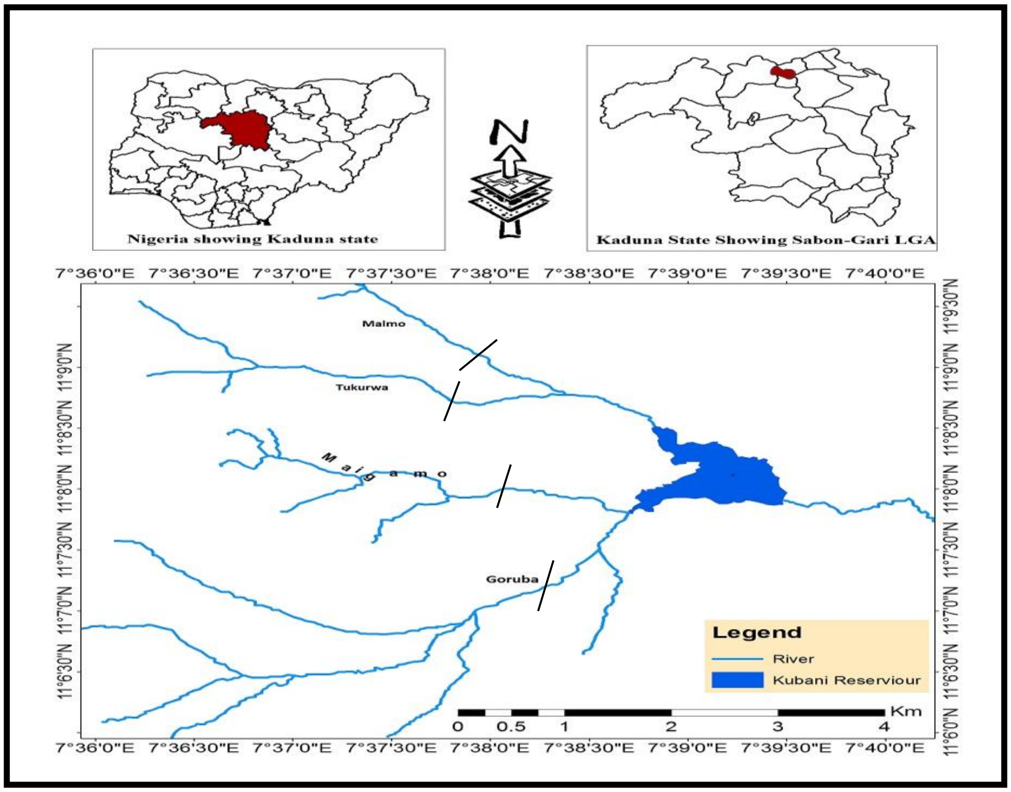

Figure 1: Map showing the Sampling Points along the Tributaries
Source: Adapted from Topographic Map of Zaria sheet SW 102

Measurements were observed after rainfall events and twice a day; in the morning (7.00am) and in the evening (6.00pm) everyday, which represent instantaneous and regular interval monitoring from May 2017 to January 2018. Subsequently, the daily average readings were inserted into the discharge formula in order to obtain the stream discharges. The instantaneous stream discharges data which were obtained from the gauging stations using the weir method were presented in a tabular form for all the tributaries. These were converted from cubic metres per second (m^3/s) to cubic metres per month (m^3/m) by multiplying the monthly sum totals by 60 seconds, 60 minutes and by 24 hours respectively to present the stream discharge regimes in charts.

Finally, Analysis of Variance (ANOVA) was used to compare the Stream Discharges of the tributaries upstream of River Kubanni.

RESULTS AND DISCUSSION

Stream Discharges of the Tributaries Upstream of River Kubanni

Tables 1 to 4 present the instantaneous stream discharges of the tributaries upstream of River Kubanni using the weir method.

Table 1: Mean Instantaneous Discharge Values in m^3/s for Malmo Stream

Day	May	June	July	August	September	October	November	December	January
1		.0442	.0060	**.0936**	.0078	.0014	.0008	.0008	
2		.0151	.0032	.0022	.0078	.0014	.0008	.0008	
3	**.0772**	.0045	.0013	.0014	**.2057**	.0014	.0008	.0008	
4	.1025	**.2199**	.0013	**.0627**	**.1665**	.0014	.0008	.0008	
5	.0151	.0627	.0007	.0022	.0442	**.0060**	.0008	.0008	
6	.0014	.0151	**.2659**	.0014	.0078	.0014	.0008	.0008	
7	-	.0014	.0561	**.1322**	.0045	.0014	.0008	.0008	
8	-	.0004	.0151	.0099	**.1025**	.0014	.0008	.0008	
9	-	.0004	**.2346**	.0060	.0215	.0014	.0008	.0008	
10	-	.0001	.0151	.0032	.0014	.0014	.0008	.0008	
11	-	.0001	.0032	.0022	**.1790**	.0014	.0008	.0008	
12	-	-	.0021	**.1119**	.0442	.0014	.0008	.0008	
13	-	-	.0013	.0060	**.1545**	.0014	.0008	.0008	
14	-	-	.0013	**.1431**	.0253	.0014	.0008	.0008	
15	-	-	**.1218**	.0078	.0078	.0014	.0008	.0008	
16	-	-	.0215	.0014	**.0936**	.0014	.0008	.0008	
17	-	-	**.1430**	**.1665**	.0060	.0014	.0008	.0008	
18	-	-	.0215	.0151	**.1119**	.0014	.0008	.0004	
19	**.0772**	-	**.1430**	.0022	.0078	.0014	.0008	.0004	
20	.1321	-	.0123	.0022	**.0561**	.0014	.0008	.0004	
21	.0151	-	.0078	.0014	**.0851**	.0014	.0008	.0004	
22	.0014	-	.0013	**.1119**	.0389	.0014	.0008	.0004	
23	-	-	.0013	.0099	.0078	.0014	.0008	.0002	
24	-	**.0772**	.0013	.0078	**.0499**	.0014	.0008	.0002	
25	-	**.1545**	.0013	.0060	.0215	.0014	.0008		
26	-	**.2057**	.0013	**.1025**	.0014	.0014	.0008		
27	-	.0340	.0013	.0078	.0014	.0014	.0008		
28	-	**.1186**	.0013	.0078	.0014	.0014	.0008		
29	-	.0078	.0013	.0078	.0014	.0014	.0008		
30	**.0772**	**.1025**	.0013	**.1431**	**.1322**	.0014	.0008		
31	**.1218**		**.2346**	.0151		.0014	.0008		
Total	**0.6210**	**1.0641**	**1.3244**	**1.1943**	**1.5969**	**0.0480**	**0.0248**	**0.0160**	

Sum = 5.89 m^3/s

Source: Fieldwork, 2017

Table 2: Mean Instantaneous Discharge Values in m^3/s for Tukurwa Stream

Day	May	June	July	August	September	October	November	December	January
1		.1396	.0930	**.1000**	.0476	.0431	.0247	.0055	.0008
2		.0431	.0572	.0350	.0389	.0350	.0247	.0055	.0008
3	**.1875**	.0247	.0278	.0279	**.3385**	.0350	.0247	.0055	.0008
4	.1000	**.0625**	.0189	**.1073**	**.2563**	.0279	.0247	.0055	.0008
5	.0389	.0247	.0164	.0523	.0799	**.0625**	.0190	.0055	.0004
6	.0120	.0120	**.1772**	.0389	.0431	.0389	.0190	.0055	.0004
7	.0044	.0084	.0431	**.2822**	.0431	.0389	.0190	.0055	.0004
8	.0001	.0055	.0278	.0431	**.1311**	.0350	.0190	.0055	.0004
9	-	.0044	**.2202**	.0431	.0476	.0247	.0190	.0055	.0004
10	-	.0025	.0313	.0389	.0431	.0247	.0190	.0044	.0004
11	-	.0007	.0246	.0389	**.1311**	.0247	.0190	.0044	.0004
12	-	.0002	.0246	**.1578**	.0389	.0247	.0190	.0044	
13	-	.0002	.0246	.0431	**.1980**	.0247	.0164	.0044	
14	-	.0002	.0246	**.2090**	.0431	.0247	.0164	.0044	
15	-	.0002	**.1149**	.0476	.0431	.0247	.0164	.0044	
16	-	.0002	.0799	.0389	**.2319**	.0247	.0164	.0044	
17	-	.0002	**.1772**	**.1874**	.0523	.0247	.0120	.0044	
18	-	.0002	.0738	.0625	**.3848**	.0247	.0120	.0044	
19	**.1875**	.0002	**.3239**	.0431	.0431	.0247	.0120	.0044	
20	.1311	.0002	.0680	.0431	**.2691**	.0247	.0101	.0044	
21	.0572	.0002	.0475	.0389	**.2202**	.0247	.0101	.0044	
22	.0247	.0002	.0475	**.3535**	.0476	.0247	.0101	.0044	
23	.0120	.0002	.0431	.0680	.0431	.0247	.0084	.0044	
24	.0025	**.2090**	.0350	.0431	**.1485**	.0247	.0084	.0044	
25	-	**.3096**	.0350	.0389	.0431	.0247	.0084	.0018	
26	-	**.3096**	.0313	**.3838**	.0431	.0247	.0055	.0018	
27	-	.1980	.0313	.0476	.0389	.0247	.0055	.0018	
28	-	**.2319**	.0313	.0431	.0350	.0247	.0055	.0018	
29	-	.0738	.0313	.0431	.0313	.0247	.0055	.0018	
30	**.0120**	**.3699**	.0278	**.1673**	**.1980**	.0247	.0055	.0018	
31	**.1875**		**.2957**	.0799		.0247		.0018	
Total	**.9574**	**2.0323**	**2.3058**	**2.9473**	**3.3534**	**0.8844**	**0.4354**	**0.1281**	**0.0060**

Sum = 13.05 m^3/s

Source: Fieldwork, 2017-2018

Table 3: Mean instantaneous Discharge Values in m^3/s for Maigamo Stream

Day	May	June	July	August	September	October	November	December	January
1		.0190	.0930	**.1578**	.0247	.0217	.0055	.0008	.00008
2		.0044	.0313	.1000	.0247	.0120	.0055	.0008	.00008
3	**.1875**	.0044	.0043	.0625	**.1485**	.0084	.0055	.0008	.00008
4	.1228	**.2822**	.0033	**.1578**	**.1396**	.0044	.0055	.0008	.00008
5	.0389	.0084	.0024	.0431	.0476	**.0217**	.0055	.0008	.00008
6	.0084	.0044	**.1149**	.0044	.0247	.0247	.0044	.0008	.00008
7	.0024	.0044	.0278	**.2700**	.0190	.0247	.0044	.0008	.00008
8	.0004	.0044	.0190	.1149	**.1000**	.0247	.0044	.0008	.00008
9	.00008	.0024	**.3385**	.0247	.0247	.0101	.0044	.0008	.00008
10	-	.0008	.0164	.0247	.0247	.0084	.0044	.0008	.00008
11	-	.0008	.0033	.0247	**.1228**	.0084	.0044	.0008	.00008
12	-	.0008	.0017	**.1311**	.0247	.0084	.0044	.0008	
13	-	.0002	.0007	.0247	**.1308**	.0084	.0025	.0008	
14	-	.00008	.0007	.0930	.0247	.0084	.0025	.0008	
15	-	.00008	**.1875**	.0247	.0247	.0084	.0025	.0004	
16	**.1875**	.00008	.1485	.0247	**.1396**	.0084	.0025	.0004	
17	.2203	-	**.2563**	**.2203**	.0247	.0084	.0008	.0004	
18	**.4701**	-	.1673	.0389	**.1673**	.0084	.0008	.0004	
19	.2439	-	**.1980**	.0247	.0680	.0084	.0008	.0004	
20	.0930	-	.1673	.0247	**.2563**	.0084	.0008	.0004	
21	.0572	-	**.3689**	.0247	**.3096**	.0084	.0008	.0004	
22	.0190	-	.0799	**.8149**	.2440	.0084	.0008	.0004	
23	.0084	-	.0572	.2440	.1073	.0084	.0008	.0004	
24	.0002	**.1875**	.0522	.0863	**.0799**	.0084	.0008	.0004	
25	-	**.8924**	.0799	.0431	.0431	.0084	.0008	.0002	
26	-	.0930	.0384	**.3848**	.0247	.0084	.0008	.0002	
27	-	.0738	.0384	.1396	.0247	.0084	.0008	.0002	
28	-	**.5862**	.0313	.0431	.0247	.0084	.0008	.0002	
29	-	.0431	.0278	.0247	.0247	.0084	.0008	.0002	
30	**.0044**	**.2822**	.0278	**.5862**	**.1073**	.0055	.0008	.0002	
31	**.2203**		**.1149**	.0279		.0055		.0002	
Total	**1.8848**	**2.4950**	**2.6989**	**4.0107**	**2.5518**	**0.3314**	**0.0795**	**0.0166**	**0.0008**

Sum = 14.07 m^3/s

Source: Fieldwork, 2017-2018

Table 4: Mean Instantaneous Discharge Values in m^3/s for Goruba Stream

Day	May	June	July	August	September	October	November	December	January
1		.1000	.1951	**.6283**	.0680	.0625	.0120	.0044	.0004
2		.0313	.0930	.4177	.0680	.0523	.0120	.0044	.0004
3	**.1875**	.0247	.0431	.2563	**.1228**	.0523	.0120	.0044	.0004
4	.1673	**.1228**	.0350	**.3239**	**.2440**	.0523	.0101	.0025	.0004
5	.0680	.0247	.0278	.1673	.1396	**.0738**	.0101	.0025	.0004
6	.0350	.0247	**.0624**	.1149	.0680	.0476	.0084	.0025	.0004
7	.0084	.0247	.0930	**.8149**	.0625	.0431	.0084	.0025	.0004
8	.0008	.0247	.2439	.3848	**.3690**	.0431	.0084	.0025	.0004
9	.0004	.0247	**.4521**	.2957	.0680	.0431	.0055	.0025	.0004
10	-	.0247	.0624	.1772	.0625	.0431	.0055	.0025	.0004
11	-	.0247	.0572	.1073	**.2691**	.0431	.0055	.0025	.0004
12	-	.0247	.0572	**.6949**	.0523	.0431	.0044	.0025	
13	-	.0247	.0522	.4347	**.1396**	.0431	.0044	.0025	
14	-	.0120	.0522	**.7900**	.0680	.0431	.0044	.0025	
15	-	.0044	**.2439**	.4522	.0523	.0313	.0044	.0025	
16	**.1875**	.0044	.1396	.3848	**.4177**	.0313	.0044	.0018	
17	.1578	.0044	**.3535**	**.9465**	.0738	.0247	.0044	.0018	
18	**.4347**	.0008	.1396	.5071	**.1149**	.0247	.0044	.0018	
19	.2203	-	**.4883**	.2822	.0572	.0247	.0044	.0018	
20	.0799	-	.1149	.1772	**.3385**	.0247	.0044	.0018	
21	.0431	-	**.4347**	.1311	**.1578**	.0247	.0044	.0018	
22	.0247	-	.1396	**.9192**	.0738	.0217	.0044	.0018	
23	.0055	-	.1396	.4701	.0625	.0217	.0044	.0018	
24	.0002	**.1673**	.1396	.4177	**.3096**	.0217	.0044	.0018	
25	-	**.4347**	.1149	.3848	.0680	.0190	.0044	.0008	
26	-	.2439	.0930	**.6501**	.0572	.0190	.0044	.0008	
27	-	.1980	.0930	.4011	.0523	.0190	.0044	.0008	
28	-	**.3385**	.0799	.3848	.0523	.0141	.0044	.0008	
29	-	.0738	.0680	.2957	.0431	.0141	.0044	.0008	
30	**.0863**	**.3848**	.0624	**.5458**	**.1308**	.0120	.0044	.0008	
31	**.3096**		**.1673**	.0930		.0120		.0008	
Total	**2.0171**	**2.3681**	**4.5384**	**13.0513**	**3.8632**	**1.0460**	**0.1815**	**0.065**	**0.0044**

Sum = 27.14 m^3/s

Source: Fieldwork, 2017-2018

Table 1 shows Malmo stream which has a flow period of 206 days. The daily mean instantaneous discharge values for the weir in m^3/s throughout the study period for the Malmo tributary recorded the lowest value of 0.00002 on 25th December 2017 while the highest value of 0.2659 m^3/s was recorded on 6th July 2017. A careful observation of the discharge using the weir shows that there are days of dry spell in the month of May and June. This means that rainfall is not well established unlike the other months whereby there is flow in the river channel throughout.

Table 2 shows that Tukurwa stream has a longer flow period of 239 days compared to Malmo stream which has a flow period of 206 days. It is therefore obvious that the flow period for this hydrological year has increased as compared to the work of Yusuf (2013) where it flowed for 192 days. The factors that affect stream flow of a basin from a storm are broadly classified into three major groups. These include climatic factor which include rainfall intensity, duration, aerial distribution and evaporation, basin characteristics which include the basin size, shape, relief and stream density and land use and basin infiltration characteristics. The measured daily mean instantaneous discharge values using the weir method in m^3/s throughout the study period for the Tukurwa tributary recorded the lowest value of 0.0004 m^3/s on 11th January 2018 outside the rainy season while the highest value of 0.3848 m^3/s was recorded on 18th September 2017 close to the peak of rainfall.

The results in Table 3 shows that Maigamo stream has a flow period of 236 days. The flow period has increased compared to the work of Yusuf (2013) where it only flowed for 172 days. The likely reasons for this is the increase in rainfall amount and the use of the weir method which is different from the velocity cross-sectional area method used by Yusuf that allows for stream discharge monitoring at low flow periods. The measured daily mean instantaneous discharge values using the weir method in m^3/s throughout the study period for the Maigamo tributary recorded the lowest value of 0.00008 m^3/s on 11th January 2018 while the highest value of 0.8149 m^3/s was recorded on 22nd August 2017.

Table 4 shows that Goruba stream has a flow period of 238 days (from May 2017 to January 2018) compared to the other three streams. When compared with the work of Yusuf (2013), it can be observed that the flow period of Goruba stream has increased from 175 days to 238 days. The reasons for this is similar to that given in the Maigamo stream. The measured daily mean instantaneous discharge values using the weir method in m^3/s throughout the study period recorded the lowest value of 0.0004 m^3/s on 11th January 2018 while the highest value of 0.9465 m^3/s was recorded on 17th August 2017. The results in Table 4 shows that the discharge measured by the weir method shows some days of dry spell in the months of May and June when rainfall is not well established.

The findings from above confirm the contribution to surface flow by subsurface flow during the dry season as a result of the subsurface flow contributing to the surface flow as discussed by Yusuf (2013) because of factors such as rainfall intensity and duration, soil type, geology, shape and size of the channels.

Stream Discharge Regimes of the Tributaries Upstream of River Kubanni

Figures 2a to 2d present the discharge regime diagram for the four tributaries which are upstream of River Kubanni.

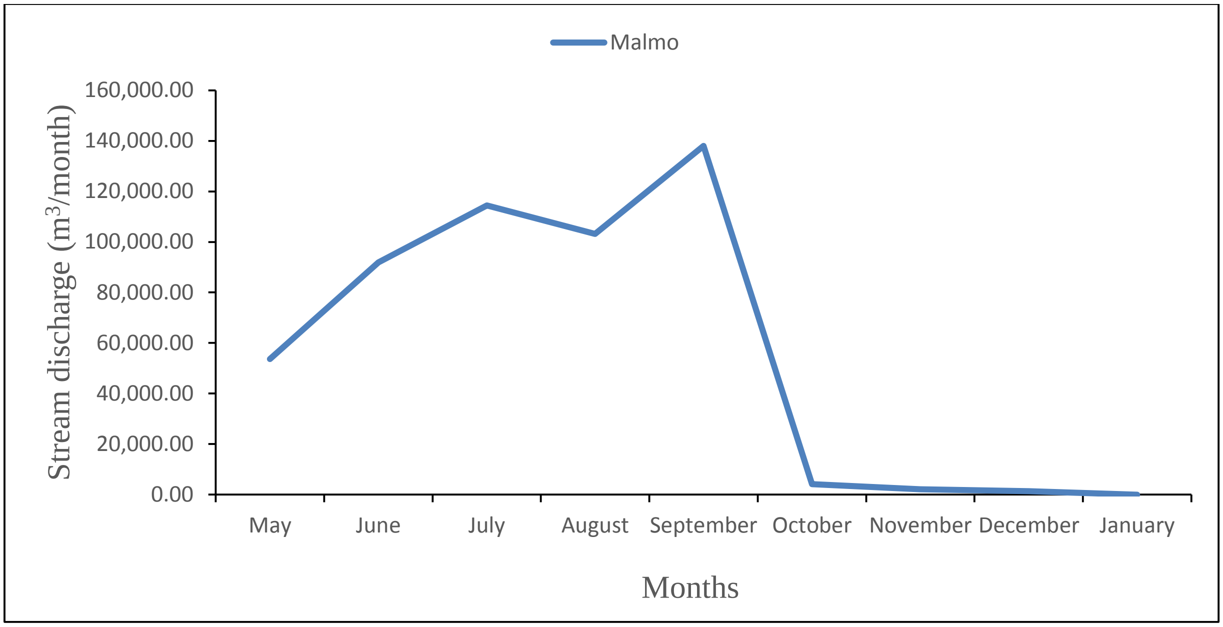

Figure 2a: Stream Discharge Regime for Malmo River
Source: Authors' Computation, 2017.

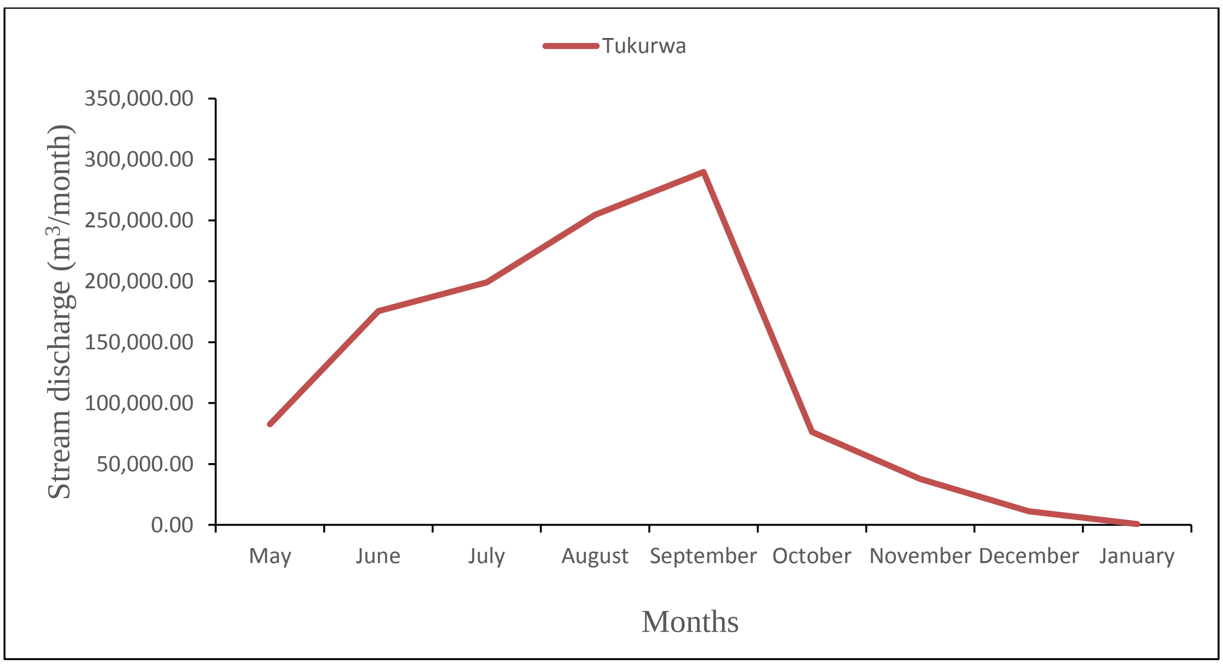

Figure 2b: Stream Discharge Regime for Tukurwa River
Source: Authors Computation, 2017.

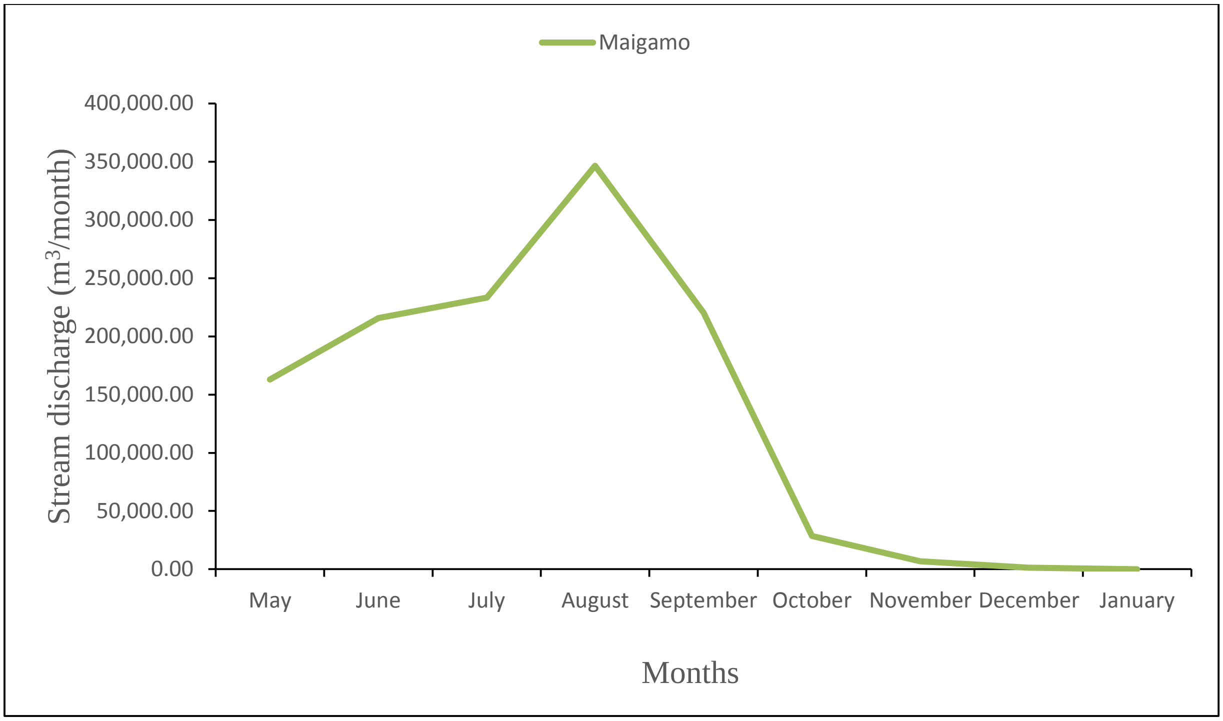

Figure 2c: Stream Discharge Regime for Maigamo River
Source: Authors' Computation, 2017.

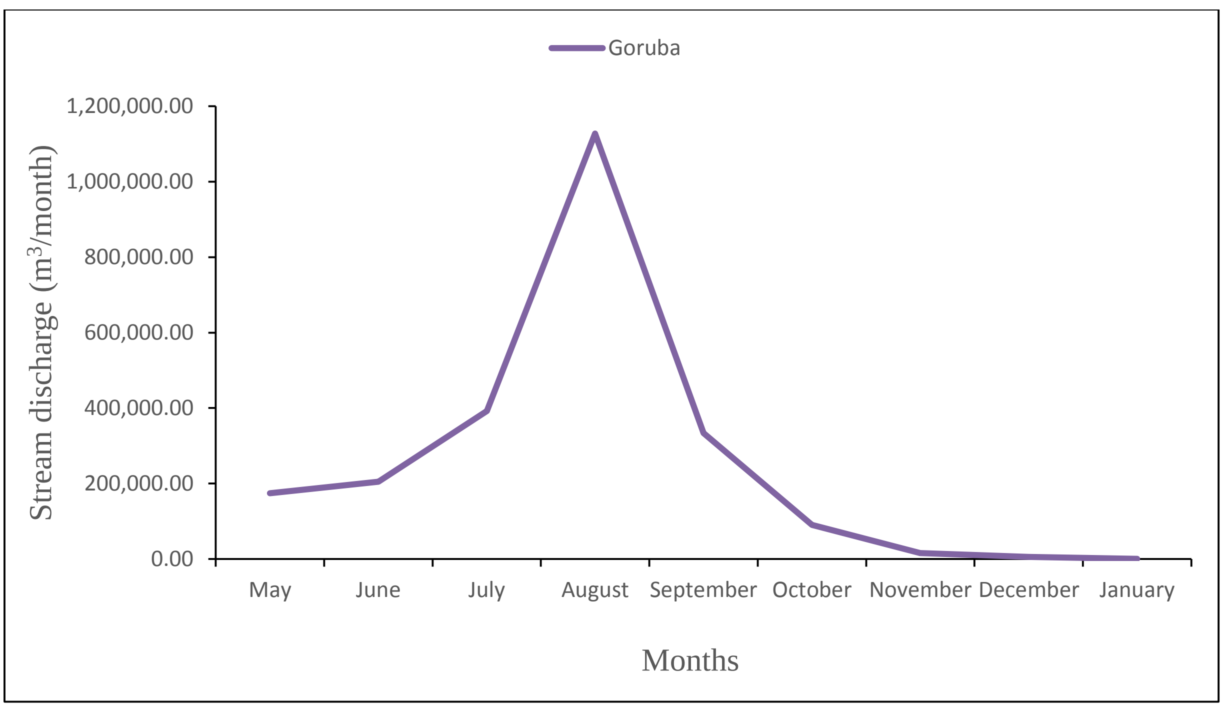

Figure 2d: Stream Discharge Regime for Goruba River
Source: Authors Computation, 2017.

From Figures 2a to 2d, it was observed that the highest discharge values of 137,972.16 m^3/m and 289,733.76 m^3/m using the weir method for Malmo and Tukurwa tributaries were obtained in September, while the highest discharge values of 346,524.48 m^3/m and 1,127,632.32 m^3/m using the weir method for Maigamo and Goruba tributaries were obtained in August. This justifies Horton model of 1965 and Kirby of 1967 which explain that when rainfalls on a hill slope a little infiltrate and travel deep into the ground. The remaining water flows fast as overland flow into the stream channels. However, in a vegetated environment, the precipitation is fully infiltrated into the soil. Infiltrated water subsequently travel laterally along the slope towards the stream and continue to flow even when precipitation is over. In this study, the soil, the topography, vegetation and other climatic factors play vital roles in determining the stream discharge upstream of River Kubanni.

Comparison of the Stream Discharges of the Tributaries Upstream of River Kubanni

The comparison of the stream discharges using the weir method is presented in Table 5.

Table 5: Comparison of Stream Discharges using the Weir Method

Streams		Sig	Remark
Malmo	Tukurwa	0.091	No Significant difference
	Maigamo	0.029	Significant difference
	Goruba	0.001	Significant difference
Tukurwa	Maigamo	0.967	No significant difference
	Goruba	0.001	Significant difference
Maigamo	Goruba	0.001	Significant difference

Variables	Sum of Square	Df	Mean Square	F- cal	F- critical	Remark
Between Groups	0.872	3	0.391	20.868	2.60	Significant difference
Within Group	12.774	917	0.014			
Total	13.646	920				

Source: Authors Computation, 2017

The Table shows that between Malmo and Tukurwa tributaries, there is no significant difference in discharge. However, between Malmo, Maigamo and Goruba it shows that there is a significant difference in discharge. It therefore implies that Malmo and Tukurwa tributaries may be smaller in sizes and in basin characteristics compare to Maigamo and Goruba. Also, comparing the stream discharges between Tukurwa with Maigamo, it shows that there is no significant difference in their stream discharges. However, between Tukurwa and Goruba, there is a significant difference. There is also a significant difference in the stream discharges between

Maigamo and Goruba tributaries. This may be attributed to variation in area, soil infiltration capacity and other intervening factors.

Table 5 also shows the stream discharge values between and within groups with their total values for the four tributaries with the F-calculated (20.86) greater than the F- critical (2.60) at 0.05 level of significance. Since the F-calculated is greater than the F-critical, we conclude that there is a significant difference between the stream discharges upstream of River Kubanni using the weir technique. The Goruba stream has the highest discharge values of 2,344,896 m^3/yr., followed by Maigamo stream with discharge value of 1,215,648 m^3/yr., Tukurwa stream has a discharge value of 1,127,520 m^3/yr., and Malmo stream which is the smallest in size has the least discharge value of 508,896 m^3/yr. respectively. Consequently, these implies that Goruba, Maigamo and Tukurwa streams contribute immensely to Kubanni reservoir in terms of availability of water because of their sizes.

CONCLUSION

This study attempted a comparative analysis of discharge measurement upstream of River Kubanni in Zaria in order to know the extent and pattern of available supply of water. Data on stream discharges were obtained from the four gauging stations by the use of a 120° and 90° V-notch control structures (weirs). Based on the study findings, there is a significant difference in the stream discharges with Goruba tributary having the highest discharge value while Malmo tributary has the least. Thus, the Goruba, Maigamo and Tukurwa supply more water to the reservoir than the Malmo tributary. Factors such as precipitation intensity and duration, sizes and shapes of the channels, the soil infiltration capacity, the geology and topography may be responsible for the differences in the stream discharges.

Based on the results obtained from the research, it is recommended that there should be a continuous monitoring of stream discharge upstream of the Kubanni, since the first and foremost requisite for planning of water resource development is the availability of accurate data of stream flow for a considerable period of time to determine the extent and pattern of available water supply. Measures to minimize siltation of the reservoir should be put in re-enforced since sediment yield in any reservoir has a relationship with the stream discharge. Also, measures to prevent or control flooding should be established since there was an increment in the flow periods of each tributary, as water may be forced into the land destroying farmlands and properties if they exceed their carrying capacity.

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