www.ijramr.com

ISSN : 2350-0743

International Journal of Recent Advances in Multidisciplinary Research

Vol. 06, Issue 01, pp.4373-4377, January, 2019

RESEARCH ARTICLE

A COMPARATIVE ANALYSIS OF DISCHARGEMEASUREMENT TECHNIQUES ON A SECOND ORDER TRIBUTARY IN ZARIAUSING THE VELOCITY AREA METHODS

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ARTICLE INFO

Article History:
Received 20th October, 2018
Received in revised form
18th November, 2018
Accepted 24th December, 2018
Published online 30th January, 2019

Keywords:
Stream discharge,Current metre,
Float method, Kubanni River.

ABSTRACT

A comparison has been made between stream discharge values using the Current metre method and the Float method for a small river in Zaria. This was made in order to establish the most effective method for measuring stream discharge in a small river. Result observed from this study shows that the river discharges from the two techniques are similar and there is no statistical difference between the two. This means that both the current metreand the float method were both suitable for the stream discharge measurement on the stream channel. Although, the field observation shows that the float is of greater applicability and more advantageous for continuous discharge measurements since it can be used on either shallow or deep channel; the factor responsible for the less applicability is the major hindrance caused to the float by the vegetal growth which obstructs the float from reaching the gauging station from where the stream velocities were noted.

INTRODUCTION

The Greek philosopher Pindar described water as the “best of all things”. This view is not surprising since the need for water, throughout human history, has always been appreciated. Water is present everywhere without which life will simply cease to exist. It is constantly in motion, passing from one state to another and from one location to another. Irrespective of its movement as rivers or streams or stationary as it is in lakes (Biswas, 2008). . 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 increasingly demand, relatively static supply and deteriorating quality due to pollution. (Ayoade and Oyebande, 1978). The river basin bounded by its drainage divide and subject to surface and sub-surface drainage, under gravity to the ocean or to interior lakes, forms the logical area units for hydrological studies with this, one can conveniently for instance draw up water balance and assess water resource. Estimate the probability of the occurrence of extreme event such as flood and drought, particularly as they affect reservoir storage and water use by man, and mobilized hydrological information to enable man manage his water resource more efficiently by when and in what ways it is to his advantage to intervene locally in the hydrological cycle (Chorley, 1964). 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.

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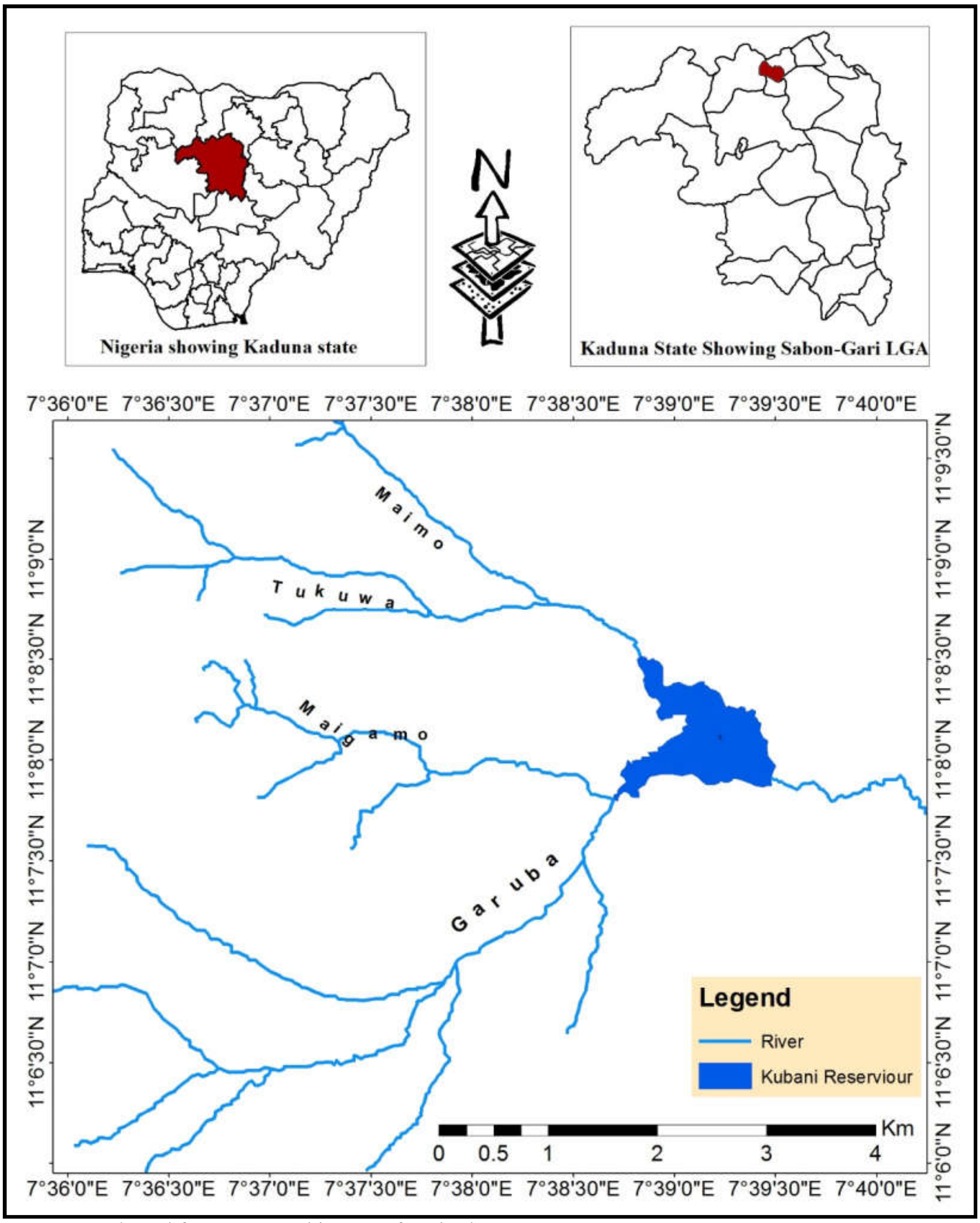
Stream flow cannot be measured directly but must be computed from variables that can be measured directly such as stream width, stream depth and stream flow velocity. Even though stream flow is computed from measurement of other variables the term “Discharge measurement” is generally applied to the final result of the calculations. 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. Methods such as Velocity area techniques, Dilution gauging, volumetric gauging, slope area technique, Weirs and flumes methods. However, it is crucial that the correct technique and instrumentation are used depending on the environmental and flows conditions encountered. This will ensure that discharge estimations are as reliable as possible. The most accurate technique for river discharge measurement through the use of stream gauge recorder (Ogunkoya, 2000). This equipment automatically records all stream flow event continuously. To this end, this study will analyze the various techniques used in measuring river discharge and at the end adopt which method best suits measuring discharge of small rivers in which Maigamo tributary is no exception.

MATERIALS AND METHODS

The study area is in Zaria, Kaduna state Nigeria located on latitude $11^{0}03^{|}$ N and longitude $7^{0}\ 42^{|}$ E while the study site is located in the southernmost part of Kubanni drainage basin with latitude $11^{0}\ 08^{'}01^{''}$N and longitude $7^{0}\ 37^{'}49^{''}$ E which is the Maigamo tributary. The Kubanni has its source from Kampagi Hill in shika near zaria. It flows in the southeast direction through the premises of Ahmadu Bello University. It has four major tributaries namely; Malmo and Tukurwa which are found in the northernmost part and the Maigamo and Goruba which form the southernmost tributaries of Kubanni reservoir. Zaria experiences the typical seasonal climate of northern Nigeria. It belongs to the AW climate of the Koppen's classification that has two distinct seasons; the dry or the harmattan season lasting between October to May, while the other season is the rainy season and lasts from May to October. The temperature of Zaria varies throughout the year. The minimum daily temperature rises gradually from its lowest 15°C December and January to its highest 26°C in April and May. The maximum daily temperature rises from its lowest 30.1°C in December/January to its highest 39.5°C in April/May. Mean monthly minimum temperature rises gradually from its lowest 9.4°C in December to its highest 26.0°C in April. Mean monthly maximum temperature rises gradually from its lowest 29.7°C in January to highest 40.60°C in April (Oladipo, 1985).

The soil of Zaria is termed "the Zaria soil group" and usually has material covering up to 14 feet (4.27m) in depth and consists of deposited silt and overlying sedimentary decomposed rocks. Alluvial soils are expensive in Zaria and in low land areas they are easily drained to produce what is known as the Hydromorphic soil/fadama. These are found around the Kubanni and Galma river basins and are mainly for sugarcane cultivation. It also supports vegetables like onions, spinach, pepper, tomatoes; hence contributing to market gardening (Ologe, 1973). Although the Zaria environment belongs to the northern guinea savannah which is moist woodland undergrown with thick bushes and shrubs, the vegetation is gradually becoming artificial. Some of these vegetation include elephant grass, *Isoberlinadoka, Isoberlinatomentosa*, *Tamarindus*spp, locust beans, silk cotton trees, and baobab tree are commonly seen. Human activities such as cultivation, construction, bush burning and grazing have greatly modified the natural vegetal cover and composition (Jaiyeoba, 1995).



Source: Adapted from topographic map of Zaria sheet S.W 102

Fig. 1. Kubanni Reservoir and its Tributaries

MATERIALS AND METHODS

This research work involves an extensive field activity, which provided the main data that was used although some secondary data were also involved. The primary data involved field and stage observation that was carried out on Maigamo tributary stream where the two methods of discharge measurements were used. The secondary sources include the data gotten from related and relevant project works on the Kubanni River, textbooks etc. Since stream flow and discharge on the Kubanni drainage basin is dependent on rainfall, hence the field observation on the stream channel began when rainfall began in the year 2017. At first the readings were taken after great storm events, as the rainfall became more established and fall almost on daily basis the readings became almost a daily exercise. This was witnessed from late June and almost throughout the month of July and August. The purpose of using the current metreand the float method is to make a comparative analysis between the two to know whether there is significant difference in discharge value using one method from the other. The stream discharge is dependent on the stream velocity and the cross sectional area of the channel. Hence, the stream discharge was obtained from the product of the stream velocity and the cross sectional area for each method i.e.

$$Q = AV \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

RESULTS AND DISCUSSION

The current metre is a digital device used in the determination of the stream velocity. The stream discharge was obtained from the product of the stream velocity and the cross sectional area. The field observation lasted from the 3rd day of May to the 5th day of October in 2017 rainy season. During this period the current metre and the float method were applicable for 37days within the period of study. The instantaneous stream discharges obtained are presented in Table 1a and 1b. The result obtained shows that the instantaneous discharge varied from 0.0255m^3/s on the 30th day of May to 1.0756m^3/s on 22nd August when the highest value was recorded. The mean value was 1.2946m^3/s and the standard deviation was 1.3050m^3/s. Table 1b shows the result obtained using the float method. It can be observed from the study that the instantaneous discharges from the Maigamo tributary varied from as low as 0.0200m^3/s to 1.1180m^3/s. The lowest value was obtained on 30th of May 2017 and the highest on 22nd August, 2017. The mean of the instantaneous discharge was 1.2337m^3/s and the standard deviation was 1.2634m^3/s.

Comparison between instantaneous discharge values obtained using the current metre and the float Methods

In order to determine the level of similarity between the float method and the current metre method instantaneous discharges, the sum of the instantaneous discharge obtained

Table 1a. Mean instantaneous discharge values in m^3/s for 2017 – 2018 using current metre

MAIGAMO RIVER

Date	May	June	July	August	September	October	November
1				.1462			
2							
3					.2419		
4	.3267	.2940		.1344	.3446		
5						.0261	
6			.1430				
7				.2957			
8					.1755		
9			.5324				
10							
11					.3397		
12				.1457			
13					.1237		
14				.1271			
15			.1963				
16	.3772				.1693		
17			.2329	.2665			
18	.4788				.1397		
19			.2117				
20					.1478		
21			.4484		.4010		
22				1.0756			
23							
24		.4851			.1344		
25		.8532					
26				.4170			
27							
28		.6055					
29							
30	.0255	.5428		.5070	.1073		
31	.3078		.1241				
Total	1.5160	2.7806	1.8888	3.1152	2.3249	0.0261	

Sum total = 11.6516

Source: Fieldwork, 2017.

Table 1b. Mean instantaneous discharge values in m^3/s for 2017 – 2018 using Float Method

Maigamo River

Date	May	June	July	August	September	October	November
1				.1301			
2							
3					.2342		
4	.3259	.2570		.1267	.3330		
5						0.0732	
6			.1048				
7				.2770			
8					.1411		
9			.4364				
10							
11					.2614		
12				.1834			
13					.1414		
14				.1383			
15			.1773				
16	.4393				.1475		
17			.2024	.2715			
18	.4774				.1205		
19			.1667				
20					.1560		
21			.3725		.2992		
22				1.1180			
23							
24		.4900			.1005		
25		.8813					
26				.3852			
27							
28		.6299					
29							
30	.0200	.5576		.4792	.1089		
31	.2364		.1022				
Total	1.4990	2.8158	1.5623	3.1094	2.0437	0.0732	

Sum total = 11.1034
Source: Fieldwork, 2017.

from the two methods were compared using the formula below:

$$\frac{\text{Sum Total Instantaneous discharge using the float method}}{\text{Sum Total Instantaneous discharge using the current metre}} \times 100\% \text{ ------------- } 2$$

Comparison between the sum total instantaneous discharges obtained from the float method with that derived from the current metre technique showed that there is little or no difference as the percentage over-estimation using equation (2) was only 4.9% which indicates that there is no significant difference between them.

$$\frac{11.6516}{11.1034} \times 100\% = 104.9$$

The current metre method was most applicable from late June to September during which the rainfall have become established and thus instantaneous discharge values were highest at this period. On the other hand the lowest values were in May while in June and July fairly better results were obtained. There are some reasons accountable for this; a major reason is the fact that the use of current metre is dependent on the depth of the stream, good for deep water and not applicable for very shallow streams.

Conclusion

From the study carried out on the Maigamo tributary, it was observed that there is no statistical difference between the two methods. This means that both the current metreand the float method were both suitable for the stream discharge measurement on the stream channel.

Although, the float method is of greater applicability and more advantageous for continuous discharge measurement since it can be used on either shallow or deep stream channel; the factor responsible for the less applicability is the major hindrance caused to the float by the vegetal growth which obstructs the float from reaching the gauging station from where the stream velocities were noted. In fact, in the course of study, it became necessary to clear the vegetal growth off the stream channel as continuous measurement using the float method became impeded. This allowed for continuous flow and absence of any obstacle on the channel.

Recommedation

Based on the result obtained from the research some recommendations become necessary to assist interested researchers on similar studies especially for hydrogeologists.

a.The University authority should sponsor a continuous monitoring of stream discharge on the Maigamo stream so as to be able to do a good hydrological planning and development for its community. The department should encourage more students in the field of hydrology by providing necessary instruments and making the study interesting. This will give more relevant findings year-in-year-out on various aspects of hydrology; the runoff, evapotranspiration, sediment discharge and yield etc. on the stream channel.

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