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EFFECT OF FLOAT-WEIGHTS ON DISCHARGE MEASUREMENT

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ABSTRACT

The use of float method of discharge measurement information in rivers is vital for hydrological analysis, though; there is no specific information on the choice of float material to be used for the measurement. A comparison of four float materials having different weight for estimation of stream discharge was carried out on Apakula stream in Ogun State, Southwestern Nigeria. Depth and width measurements were carried out by means of a canoe, ropes and graduated metal rod. Velocity measurement was carried out by means of Table tennis egg, Orange, 0.5 and 1 liter plastic bottle partially filled with water and a stop clock. Ten different measurements were carried out at various locations along the river. Data were subjected to one – way ANOVA using the Genstat statistical package discovery edition 3 to determine the weekly mean and standard deviation of estimated discharge records for the stream. Results show significant difference ($p < 0.05$) in discharge measured with varying weight of floats. It was observed that though the pattern of discharge measured values were similar in all the selected float weight, the discharge increases with decreasing weight of float.

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1.0 INTRODUCTION

Stream flow is the only confined component of the hydrologic cycle in a well defined channel which permits accurate measurement of all the components of the water cycle (Wang, *et al*., 2013). The other components are point measurement for which uncertainties on an areal basin are difficult if not impossible to estimate (Fenton and Keller, 2002). Stream-flow measurement is important for making accurate assessment of the available water resources, for planning of irrigation and flood control works (Callade *et al*., 2000). Several methods of measurement of stream flow have been adopted. This varies in complexity depending on design, accuracy of measurement and cost (Wang, *et al*., 2013). Among such methods are velocity-area method (using current meter), float method, slope area method, stage-fall-discharge method, structural method (Weirs and flumes), dilution ganging/method, ultrasonic method and electromagnetic method among others (Fulton and Ostrowski, 2008). Of all these methods, float method is the most widely used in developing countries particularly in Africa because of its affordability and availability (Otuagoma *et al*., 2015). However, float method has been acclaimed to be in-accuracy in its use for

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discharge measurement. It is often used where excessive velocity is not required, and when depth and float drift prohibit the use of a current meter (Oberg and Mueller, 2007). The problem of in-accuracy of float in the measurement of discharge as compared to other methods may not be unconnected with weight of the object used for the float. According to Archimedes principle which state that, "When an object is fully or partially submerged in a fluid, the upthrust on it is equal to the weight of the liquid displaced" (Biran and López-Pulido, 2014). Hence, it can be deduced that the weight of the object use in measuring discharge by float method would influence the velocity of float material and would subsequently affect the discharge measurement. The present work was therefore carried out to determine the effect of weight of float materials used in estimation of discharge in stream on the flow measurement.

2.0 MATERIALS AND METHODS

Suitable section of cross section of more than 50 m long for gauging was selected on a straight reach along the stream channel free of eddies and aquatic weeds to allow for velocity of flow at all point to be streamlined. This cross section was divided into 10 m segments marked with pegs at the upstream and downstream section of the stream to demarcate the float measurement section. The width of stream was measured with measuring tape and the depth with graduated metal rod. Four objects were selected as floats as described in Table 1. The choice of selection was based on the size, shape and floatation tendency of the object. The discharge of the stream was measured with the four floats objects on the stream with cross section of more than 50 m long and at the section having fairly consistent width and depth. The floating objects were placed at the point in the river where the velocity is required. The time't' taken for the float to cover a known distance'd' was recorded. The floating objects which were slightly submerged were used. The surface velocity V of the water was computed by the relation:

$$V = \frac{d}{t} \text{ (m/s)} \tag{1}$$

This method is not always accurate especially for large streams, since velocity varies from point to point with depth and width over the cross-section of the river. The discharge was determined from the cross-sectional area and the mean velocity. The area of cross-section of the river was determined from the profile of the river bed obtained by lead lines. The lead line consists of a heavy weight attached to the lower end of a rope. The depth of water was measured when the lead touches the river bed. By means of a canoe, the water depth was measured at 10 m increment was achieved by wading through the by river holding the lead line vertically across the river. The total discharge in the river was computed as the sum of the discharges in various segments. The discharge in each segment is equal to the area of the segment multiplied by the mean velocity of flow (Arora, 2009). The principle of all Area-Velocity methods is that flow, Q is as presented in equals 2.

$$Q = V_{mean} \text{ x } A \text{ } (M^3/S) \tag{2}$$

The exercise was repeated for a period of 20weeks (3days/ week). In this study, both surface and sub-surface floats were used. A

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simple and convenient method was use as the velocity coefficient α defined as the depth-average velocity to surface velocity ratio. A default value of α= 0.85 is commonly chosen for river flow (Rantz, 1982; Muste *et al.*, 2008), assuming a logarithmic vertical velocity distribution and typical bed roughness. The depth of flow of float materials were 0.1cm, 8cm, 5cm and 10cm for tennis egg, orange, 0.5 liter plastic bottle and 1 liter plastic bottle, respectively, filled with water.

Data were subjected to one – way ANOVA using the GenStat statistical package (Discovery Edition 3, 2008) to determine the weekly mean and standard deviation of estimated discharge of the stream using the 4 float materials over the period of 20 weeks record for the stream.

Table 1: Description of float materials

Float materials	Code	Float type	Shape	Weight(g)
Table Tennis Egg	F_1	Surface	Circular	2.06
Orange	F_{II}	Surface	Circular	137.78
0.5-liter bottle filled with water	F_{III}	Sub- Surface	Cylindrical	520.00
1-liter bottle filled with water	F_{1V}	Sub- Surface	Cylindrical	1100.00

2.1 Study Area

The Apakula stream is located at Odeda (7° 15'N, 3°25'E), Ogun State, Southwest Nigeria. The stream is a tributary of River Ogun, taking its source from a hill upstream of Apakula village. The area is located within a region characterized by bimodal rainfall pattern (commences in March and increases in magnitude in July and September, with a short dry spell in August). The long dry period extends from November to March. The annual rainfall of the area ranges from 1250 mm and 1400 mm. The Apakula stream takes its name from flow path with settlements along it bank which contributed to their continuous flow all year round (Figure 1). The stream at the cross section of the measuring site is about 1.1 m and the width is about 6.0 m.

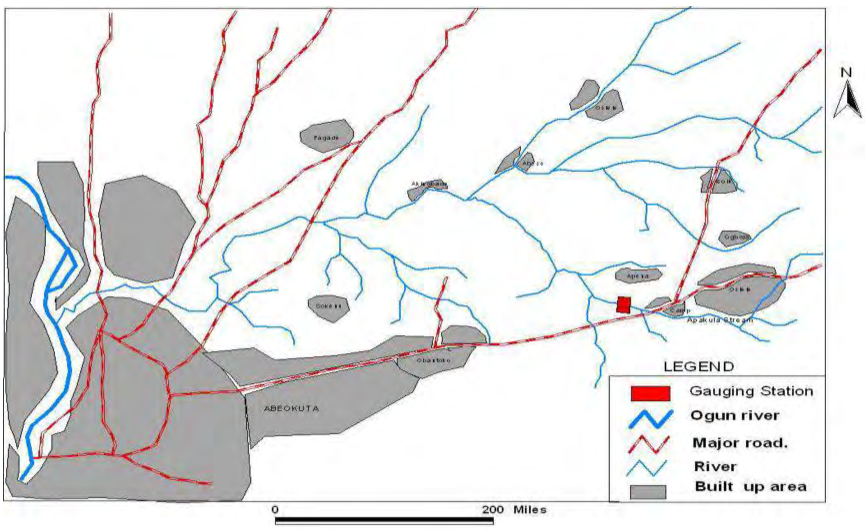

Figure 1: Hydrographic Map of the study area

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Table 2: Multiple comparison of discharge at variable float materials

	(I) FLOAT METHODS	(J) FLOAT METHODS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	FI	FII	.02700*	.00959	.006	.0079	.0461
		FIII	.04850*	.00959	.000	.0294	.0676
		FIV	.06000*	.00959	.000	.0409	.0791
	FII	FI	-.02700*	.00959	.006	-.0461	-.0079
		FIII	.02150*	.00959	.028	.0024	.0406
		FIV	.03300*	.00959	.001	.0139	.0521
	FIII	FI	-.04850*	.00959	.000	-.0676	-.0294
		FII	-.02150*	.00959	.028	-.0406	-.0024
		FIV	.01150	.00959	.234	-.0076	.0306
	FIV	FI	-.06000*	.00959	.000	-.0791	-.0409
		FII	-.03300*	.00959	.001	-.0521	-.0139
		FIII	-.01150	.00959	.234	-.0306	.0076

*. The mean difference is significant at the 0.05 level.

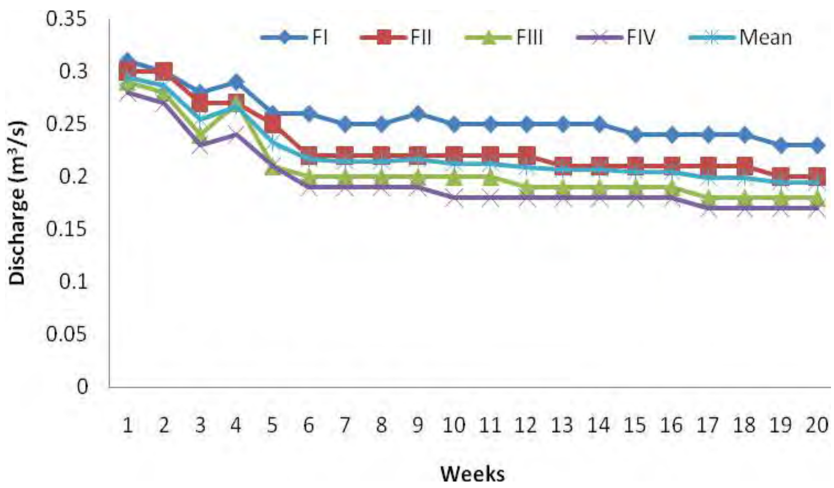

Figure 2: Discharge pattern of stream at different float materials.

3.0 RESULTS AND DISCUSSION

Weight of float has been shown to have significant effect ($p < 0.05$) on the discharge measurement of a stream as observed in Table 2 and Figure 2 showed. The discharge varied weight of floats from 0.20 to 0.33 m^3/s.

It was observed from Figure 2 that though the pattern of discharge measured values were similar in all the selected float materials of varying weight, the discharge increases with decrease in the weight of float as observed in Figure 3.

Table 3 showed that the least deviation in estimated discharge was with the lowest weighted float (F_I) at 0.02207, followed by F_{II} of 0.03103, then F_{III} of 0.03397 and lastly the float with the highest weight (F_{IV}) of 0.3821. This implies therefore that heavy weight of float tends to under estimate the discharge of a stream. This may be due to the fact that the material used as float submerged in the stream, indicating that it weight was equal to the weight of the liquid displaced. This could have resulted in the reduction of the velocity as it floated. Hence, since velocity is a function of discharge, the consequence is the low discharge as observed in the result.

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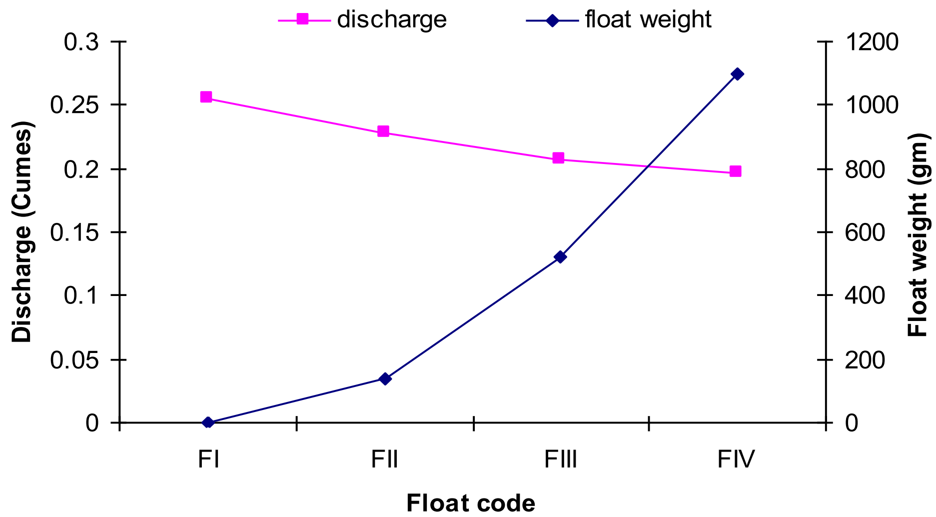

Figure 3: Relationship between the mean discharge and the float weight of stream

Table 3: Deviation in discharge estimated using different float materials of varying weights

Floats	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
FI	20	.2565	.02207	.00494	.2462	.2668	.23	.31
FII	20	.2295	.03103	.00694	.2150	.2440	.20	.30
FIII	20	.2080	.03397	.00760	.1921	.2239	.18	.29
FIV	20	.1965	.03821	.00734	.1811	.2119	.17	.28
Total	80	.2226	.03761	.00420	.2143	.2310	.17	.31

4.0 CONCLUSION

It can be concluded from the results that the reliability of accurate measured discharge using float method will depend on choice of object to be used as float. Where the heavy float material is used in obtaining discharge and bulk of the results are obtained without consideration of turbulence wave action on the stream, then a less reliable result is expected. Thus, determination of stability of the floating object is necessary to arrive at a reliable float object required for estimation of velocity of a stream vis-à-vis reliable prediction of discharge record.

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