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Boundary Influence and Flow Characteristics of Orisa and Ala Rivers in Kwara and Ondo States, Nigeria

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Abstract

In this study, the effects of boundary influence on flow characteristics of Rivers Ala and Orisa were investigated. Soil samples were collected from three points each from both rivers namely Glory Parish Area (GPA), Olusola Oke Area (OOA) and Fiwasaye; Aran-Orin Area (AOA), Rore and Omu-Aran on Rivers Ala and Orisa Respectively. A MGG/KL-DCB Portable Electromagnetic Velocity Meter was used to measure the in-situ readings of discharge and velocity at the various points. The sediments collected from the sampling points were placed in the Flume in the Hydraulic Laboratory of Civil Engineering Department, Landmark University. The Flume was then set with the measured parameter (Discharge) for each sampling point to apply the Flume to determine the Velocity for both Rivers at slopes of 0.008 to 0.056 respectively. The velocities obtained at the different slopes were inserted into Manning's Coefficient equation to obtain the flow characteristics. The relationship between the velocity and Manning's Coefficient was determined using the Spearman's rank correlation coefficient. All analyses were done at P-value less than 0.05 level of significance. The velocity varied between 0.0237± 0.0004 and 0.0587± 0.0004 m/s; 0.0542± 0.0004 and 0.0701± 0.0003m/s and 0.0789± 0.0005 and 0.0172± 0.1323m/s for GPA, OOA and Fiwasaye for Ala River and between 0.0751± 0.0007 and 0.1008± 0.0006m/s; 0.0628± 0.0007 and 0.0839± 0.0004m/s and 0.0421± 0.0005 and 0.1076± 0.0004m/s for AOA, Rore and Omu-Aran for Orisa River. The results of the effects of soil boundary influence showed that the velocity was inversely proportional with the Mannings' coefficient at all sampling points of both rivers if the geometry of the river channel is kept constant. This indicates that areas with high velocities are prone to flooding. Further studies should be carried out on more sampling points on the rivers to confirm flow characteristics of the rivers.

Keywords: Flooding, Boundary Influence, Flow Characteristics, Ala River, Orisa River

Introduction

Rivers represent one of mankind's most important environmental assets. River flows are often affected by man's activities and therefore require careful management for water supply, waste disposal, flood alleviation and power generation as well as amenity uses. River engineering design and management has tended to be dominated by engineering concerns there is now an increasing recognition that the conflicting pressures of engineering and ecological objectives must be rationalized and harmonized to ensure optimum use of a valuable resource. Thus, river design is becoming more environmentally sensitive seeking solutions which are sustainable, and which enhance the ecological environment as well as ensuring flood protection. The impact of the sediment supply mechanism for mobile-bed flumes, i.e., upstream feed or sediment recirculation, on observed sediment discharges and bed morphology has been studied to clarify their suitability relative to the conducted sediment transport experiment (Mendoza *et al*., 2017; Parker, 2003). Mendoza *et al*., (2017) showed that the sediment-feed mechanism should be used for analyzing a river's response to an imposed sediment discharge, whereas sediment recirculation is more suitable when analyzing the sediment transport response to a certain imposed hydraulic condition. Further, Mendoza *et al*., (2017) demonstrated that in the case of uniform sediment, both boundary conditions yield the same equilibrium bed morphology. Incidence of flooding has been on the increase recently in Ondo State and this exemplifies the problem operating in most urban centers in Nigeria. There have been a lot of problems connected with flood occurrences in some parts of Nigeria like Ibadan, Delta, Ilorin, Lokoja, Bayelsa and Benue, Ilaje (Nwigwe and Emberga, 2014). These problems don't only happen or occur in Nigeria but also in most developing countries of the world (Olaniyan and Adegbola, 2018). Flooding along the Ala river in Akure metropolis is an annual occurrence. The unsafe condition of lives and properties along the rivers has over the years become an issue of serious concern to individuals, Local, State and Federal Governmentt. Properties worth billions of Naira are damaged yearly (Olatona *et al*., 2017). Rainy season as usual is worse for the people living close to Ala river in Akure, as residential buildings and business premises are submerged, making life unbearable for the residents and patrons of business located in these areas located there (Olatona *et al.,2017).* Therefore, there is need to know the morphological characteristics of the river to avoid flooding in the nearest future and also make plans to construct hydraulic structures for flood control. The aim of this study is to investigate the boundary influence and effects on flow characteristics of Rivers Ala and Orisa.

Materials and Methods

Description of the Study Area

River Orisa

River Orisa is a major perennial river in the north central part of Nigeria. The source of the river is Ora in Osun State which serves as a boundary with Aran-Orin Hills in Irepodun Local Government Area in Kwara State. The River flows through many little towns such as Aran Orin, Rore and Landmark University and through Omu-Aran town and other parts of Omu-aran before discharging into the River Niger. River Orisa is an alluvial river with channels and floodplains that are self-formed in unconsolidated or weakly-consolidated sediments. The River provides not only potable and irrigation water to the community but also deposits fertilizing matter suitable for farming on its banks particularly during the rainy season and floods (Osemwegie *et al*, 2014). The river flows approximately 300 km from its source before flowing into the River Niger.

River Ala

River Ala is one of the main tributaries of River Ogbese, Southwestern, Nigeria. River Ala with total length of about 57 km and has a length of about 14.8 km within Akure Township. It took its source from northwestern part of Akure town and flow towards Southeastern part of the town. Akure Township dominated the upstream of River Ala while rural towns such as Ilado, Ehinala, Ajegunle, Owode, Aiyetoro and Araromi are located in the downstream where the water is being used for drinking and other domestic purposes (Ijaware, 2020). The River was a source of potable water as a water supply scheme was built but the scheme has been abandoned by the State Government due to heavy siltation of the river. The Sampling points on the two Rivers are shown in Figure 1.

Measurement of in-situ Parameters

The equipment used for the measurement of the parameters (Discharge and Velocity) is the MGG/KL-DCB series of electromagnetic velocity meter. The meter is a portable instrument designed for the flow velocity/rate measurement. It is used for agricultural irrigation, hydrologic monitoring, and river flow monitoring. The MGG/KL-DCB portable electromagnetic velocity/flow meter depends on the Faraday's law of electromagnetic induction.

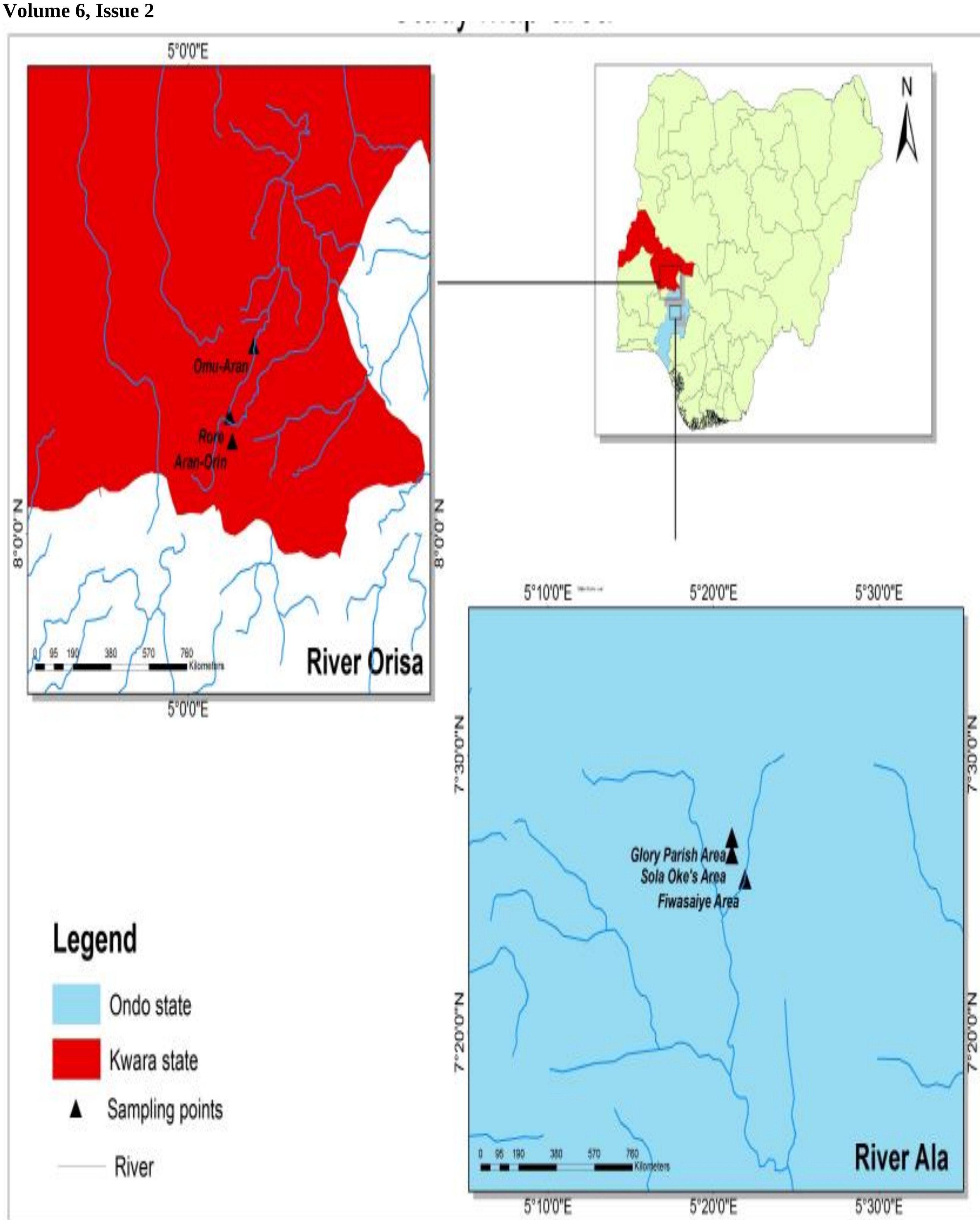

Figure 1. The Sampling Points in the Study Areas

The MGG/KL-DCB Portable Electromagnetic Velocity Meter comprises of display interface and velocity sensor. The display interface and the velocity senor were connected to each other. To take measurement of the parameters, the device was first calibrated. The calibration of the device is dependent on the channel measuring parameters which were inputted into the device. The parameters were 7.00 and 3.00m; 0.50 and 0.85; 4.0 and 2.5m; 1.50 and 0.90m for height, side slope, channel bottom width and water depth for Rivers Ala and Orisa respectively. A velocity measuring margin of 20.00m was added for the river. After the calibration of the device the velocity sensor was suspended for 30 seconds in each river for the sensor to be active in the river. The display interface displayed the flow rate, velocity and time in which it was recorded for each of the rivers at each sampling point. These parameters were measured at the points where the sediment samples were collected. The parameters were obtained with an MGG/KL-DCB Potable Electromagnetic Velocity/Flow meter as shown in Figure 2, while the measurement of in-situ parameters is shown in Figure 3. The Parameters were measured before the collection of the sediment samples. The sediments collected from the sampling points were placed in the Flume in the Hydraulic Laboratory of Civil Engineering Department, Landmark University. The Flume was then set with the measured parameter (Discharge) for each sampling point to utilize the Flume to determine the Velocity and Manning's Coefficient.

Figure 2. MGG/KL-DCB Potable Electromagnetic Velocity/Flow meter

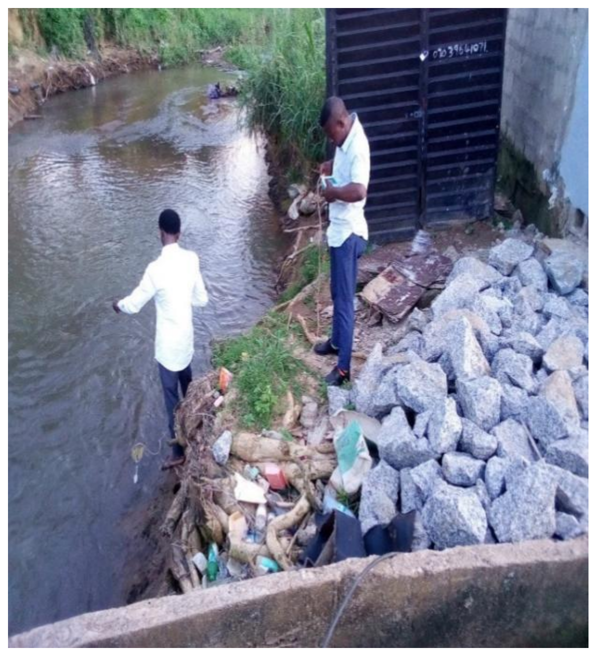

Figure 3. Measuring of In-situ Velocity Parameters using the MGG/KL-DCB Potable Electromagnetic Velocity/Flow meter

Soil Sample collection

Table 1 shows the description of the various points where soil samples were collected with respect to the elevation and geo-referencing. The points are at elevations of 359, 330 and 314m for Glory Parish, Sola Oke's and Fiwasaye for River Ala respectively. Figure 4 shows the collection of water samples at Glory Parish Area (Ala River) and Omu-Aran (River Orisa) respectively.

Table 1. Location of sampling points on the Rivers with elevation and its coordinates

Sampling Points	Elevation (m)	Location (Latitude and Longitude)
Glory Parish	359	07' 27.0" N, 05' 21.1"E
Sola Oke	330	07' 26.4" N, 05' 21.2"E
Fiwasaiye	314	07' 25.5" N, 05' 21.9"E

Figure 4. Collection of water samples at Glory Parish (River Ala)

Application of Flume to determine Velocity, Manning's Coefficient and Friction Factors

The main apparatus used in the laboratory for determination of effect of boundary conditions on the flow characteristics at various points of Rivers Orisa and Ala is the sedimentation transport demonstration channel as shown in Figure 5. The Flume is a straight channel which is 2.5m long and 0.075m wide. The soil particle is placed within the channel to idealize the river bed. The flume has a manometer for measuring pressure differences in the channel with a meter wheel to control the gradient to get slope, sediment reservoir which comprises of pebbles to sieve sand from the pump, water reservoir/basic hydraulic feed system where the water is stored for pumping, pumping machine from where the water flows, control valve used in controlling the flow/discharge of water and stand which helps in raising the channel to a gradient. Among many functions the apparatus is used for, the focus would be more on the application of the apparatus to determine the Manning's resistance coefficient values for the river bed, conveyance capacity, friction factor of the sediments at the specific points where the samples were collected along Rivers Orisa and Ala.

Determination of Velocity for the Rivers

After particle size analysis and distribution, the soil samples from the various locations were distributed evenly on the flume channel bed, one after the other to idealize the original bed roughness. The soil sample was placed at the left side inside the flume at a height of 150 mm and distance of 200 mm and the flume was adjusted to a slope of 0.008. The channel discharge was regulated to 0.83, 2.43, 3.99, 3.60, 3.86, and 2.88 m^3/s for soil samples which were the discharge values obtained in-situ from the various locations and the pump is switched on. The stopwatch was switched as soon as the water touched the soil and stopped when the sediment is first observed to reach the end of the flume. The time taken is recorded and velocity obtained by dividing the length of the flume with the time recorded. The procedure is repeated for slopes 0.016, 0.024, 0.032, 0.040 and 0.056

Figure 5. Sedimentation transport demonstration channel (Flume)

Determination of Manning's Coefficient

The Manning equation was used to determine the Manning's coefficient for Rivers Ala and Orisa. Equation (1) was used to obtain the wetted perimeter of the channel, the area of the channel and the hydraulic radius.

$$Q=\frac{A}{n}(R_H)^{\frac{2}{3}}S^{\frac{1}{2}} \quad (1)$$

$$R_H=\frac{A}{P}$$

$$n=\frac{A}{Q}(R_H)^{\frac{2}{3}}S^{\frac{1}{2}} \quad (2)$$

Where:

A = transverse section of the current (B x D)

R_H= hydraulic radius

P= wet channel perimeter

n=manning's coefficient

S= slope of the channel

$$R_H=\frac{A}{2D+B} \quad (3)$$

B= width of the channel

D= depth of Water

Determination of the Friction Factors using Darcy-Weisbach's Equation

For the proper estimation of velocity in an open channel section, the selection of a suitable value of roughness coefficient f is an important aspect that needs to be addressed properly. Under steady and uniform flow conditions, the section mean velocity carried by a channel section was calculated by the aid of Darcy-Weisbach's equation, as stated in equation (4)

$$U^2 = \sqrt{\frac{8g\,R_H S}{f}} \quad (4)$$

$$f = \frac{8gR_H S}{U^2} \quad (5)$$

Where, S = slope of the channel, g = gravitational acceleration, R = the hydraulic mean radius of the channel section, f = the friction factor.

Determination of influence of soil boundary conditions on the resistance of flow in the various points of rivers Orisa and Ala

The determination of the influence of boundary conditions on the resistance of flow in the various sampling points of Rivers Orisa and Ala was achieved by placing soil samples collected from the various sampling points on both rivers in the Hydraulic Channel (Flume) for various slopes. The relationship was obtained by plotting of the velocities of flow through the soil samples against the Manning's Coefficient of the same soil samples. The influence of the soil boundary on flow characteristics for both rivers was evaluated using the Pearson correlation coefficient (R^2)

Results and Discussion

In-Situ Readings of the Sampling Points on Both Rivers

The readings were taken for eight days between 05.55pm on Friday, the 8th of November 2019 and 04.25 pm on Saturday, the 18th of November 2019. Table 2 shows the in-situ readings of the following parameters (discharge and velocity) of the sampling points for both rivers. The parameters of the sampling points for Glory Parish Area, Sola Oke Area and Fiwasaye were 0.83±0.03, 2.43±0.15, 3.99±0.07 m^3/s and 0.29±0.01, 0.03±0.00, 0.57±0.01m/s for discharge and velocities respectively for River Ala while the parameters of the sampling points of Aran-Orin, Rore and Omu-Aran were 2.88±0.15, 3.60±0.03 and 3.86±0.12 m^3/s and 0.44±0.03, 0.36±0.01, 0.48±0.01m/s for discharge and velocities respectively for River Orisa.

Table 2. In-situ Readings of the Sampling points on both Rivers

Parameters	Location					
	Ala River			Orisa River		
	Glory Parish Area	Sola Oke's Area	Fiwasaiye Area	Aran-Orin	Rore	Omu-Aran
$Q(m^3/s)$	0.83	2.43	3.99	3.60	3.86	2.88
V(m/s)	0.29	0.03	0.57	0.44	0.36	0.48
Time	05.55.35pm	06.36.39pm	10.16.42am	3.19.34pm	03.58.34pm	04.25.28pm

Velocity of flow through the soil samples collected at the different locations

Table 3 shows the velocity of flow through the soil samples collected at the different locations at different slopes of 0.008, 0.016, 0.024, 0.032, 0.040, 0.048 and 0.056. For Ala River, the velocity varied between 0.0237± 0.0004 and 0.0587± 0.0004 m/s with the highest value at Slope of 0.056 for the Glory parish reach; for the Olusola Oke reach, the velocity of flow varied between 0.0542± 0.0004 and 0.0701± 0.0003m/s with the highest value also at Slope 0.056, while for the Fiwasaye area, the velocity varied between 0.0789± 0.0005 and 0.0172± 0.1323m/s with the highest value also at Slope of 0.056. For River Orisa, the velocity varied between 0.0751± 0.0007 and 0.1008± 0.0006m/s with the highest value at Slope of 0.056 for the Aran-Orin reach; for the Rore area, the velocity varied between 0.0628± 0.0007 and 0.0839± 0.0004m/s with the highest value also at Slope of 0.056, while for the Omu-Aran Area, the velocity varied between 0.0421± 0.0005 and 0.1076± 0.0004m/s with the highest value also at Slope of 0.056. It could be seen that the value of the velocity increased with increase in slope for all locations. This agrees with Sun *et al*., (2019) who proposed a velocity - discharge slope relationship that shows that the flow velocity increases as a function of slope gradient. It could also be seen that there were significant differences between the values of the velocity at different locations but on the same slope.

Table 3. Velocity of flow through the soil samples collected at the different locations and different slopes

Slope	Location					
	Orisa River			Ala River		
	Aran-orin	Rore	Omu-aran	Fiwasaye	Sola Oke	Glory parish
0.008	0.0751±0.0007[b]	0.0628±0.0004[c]	0.0421±0.0005[c]	0.0789±0.0005[a]	0.0542±0.0004[d]	0.0237±0.0004[e]
0.016	0.0797±0.0006[b]	0.0656±0.0005[d]	0. 0668±0.0006[c]	0.0862±0.0003[a]	0.0549±0.0006[e]	0.0446±0.0006[f]
0.024	0.0890±0.0006[b]	0.0693±0.0003[d]	0. 0775±0.0005[c]	0.0983±0.0003[a]	0.0577±0.0005[e]	0.0456±0.0004[f]
0.032	0.0899±0.0058[a]	0.0703±0.0005[c]	0.0839±0.0004[c]	0.0990±0.0003[b]	0.0665±0.0007[d]	0.0476 ±0.0006[e]
0.040	0.0921±0.0006[b]	0.0779±0.0005[c]	0.1013±0.0044[e]	0.1047±0.0004[a]	0.0698±0.0004[d]	0.0482±0.0005[f]
0.048	0.0995±0.0004[b]	0.0818±0.0004[c]	0.1055±0.0004[c]	0.1193±0.0006[a]	0.0699±0.0002[d]	0.0522±0.0005[e]
0.056	0.1008 ±0.0006[a]	0.0839±0.0004[a]	0.1076±0.0004[a]	0.1323±0.0006[a]	0.0701±0.0003[b]	0.0587±0.0004[c]

*For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test

Manning's coefficient of the soil samples at different slopes collected from both rivers

Table 4 shows the Manning's coefficient of the soil samples collected from different locations at different slopes of 0.008, 0.016, 0.024, 0.032, 0.040, 0.048 and 0.056. For Ala River, the Manning's coefficients varied between 0.0114± 0.0004 and 0.0400± 0.0004 with the highest value at Slope of 0.008 for the Glory parish reach, for the Olusola Oke reach, the Manning's coefficients varied between 0.0081± 0.0003 and 0.0285± 0.0004 with the highest value also at Slope 0.008, while for the Fiwasaye area, the Manning's coefficients varied between 0.0049± 0.0006 and 0.0172± 0.0005 with the highest value also at Slope of 0.008. For River Orisa, the Manning's coefficients varied between 0.0054± 0.0006 and 0.0189± 0.0007 with the highest value at Slope of 0.056 for the Aran-Orin reach, for the Rore area, the Manning's coefficients varied between 0.0069± 0.0004 and 0.0239± 0.0004 with the highest value also at Slope of 0.008, while for the Omu-Aran Area, the Manning's coefficients varied between 0.0069± 0.0004 and 0.0240± 0.0005 with the highest value also at Slope of 0.008. It could be seen that the value of the Manning's coefficient decreased according to increase in slope for all locations. It could also be seen that there were significant differences between the values of the Manning's coefficient at different locations but on the same slope. The values of the Manning's coefficient all fall into the values for Manning's coefficient for channels for clean, straight full stage with no rift or deep pools (0.025, 0.030 and 0.033) for (minimum, normal and maximum respectively (Chow, 1959). According to Chow, 1959, fine grain results have a relatively low value of n and coarse grains have a high value of n. This is agreement with the Manning coefficient values at Fiwasaye and Omu-Aran. The grains at Fiwasaye and Omu-Aran are finer than those from the other sampling points with values of 0.6 and 1.6% respectively.

Table 3: Manning's Coefficient of the soil samples collected at the different locations a different slope

Slope	**Location**					
	Orisa River			**Ala River**		
	Aran-Orin	**Rore**	**Omu-Aran**	**Fiwasaye**	**Sola Oke**	**Glory parish**
0.008	0.0189±0.0007[b]	0.0239±0.0004[c]	0.0240±0.0005[c]	0.0172±0.0005[a]	0.0285±0.0004[d]	0.0400±0.0004[e]
0.016	0.0157±0.0006[b]	0.0202±0.0005[d]	0.0199±0.0006[c]	0.0143±0.0003[a]	0.0234±0.0006[e]	0.0333±0.0006[f]
0.024	0.0137±0.0006[b]	0.0175±0.0003[d]	0.0172±0.0005[c]	0.0126±0.0003[a]	0.0204±0.0005[e]	0.0291±0.0004[f]
0.032	0.0109±0.0058[a]	0.0148±0.0005[c]	0.0142±0.0004[c]	0.0102±0.0003[b]	0.0165±0.0007[d]	0.0238±0.0006[e]
0.040	0.0094±0.0006[b]	0.0123±0.0005[c]	0.0148±0.0044[e]	0.0087±0.0004[a]	0.0145±0.0004[d]	0.0205±0.0005[f]
0.048	0.0077±0.0004 [b]	0.0096±0.0004[c]	0.0097±0.0004[c]	0.0070±0.0006 [a]	0.0116±0.0002[d]	0.0166±0.0005[e]
0.056	0.0054 ±0.0006[a]	0.0069±0.0004 [a]	0.0069±0.0004 [a]	0.0049±0.0006[a]	0.0081±0.0003[b]	0.0114±0.0004[c]

*For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test

Friction factor coefficient of the soil samples at different slopes collected from both rivers

Table 5 shows the Friction Factor coefficient of the soil samples collected from different locations at different slopes of 0.008, 0.016, 0.024, 0.032, 0.040, 0.048 and 0.056. For Ala River, the Friction Factor coefficients varied between 0.049± 0.0083 and 0.257± 0.0077 with the highest value at Slope of 0.008 for the Glory parish reach, for the Olusola Oke reach, the Friction Factor coefficients varied between 0.036± 0.0013 and 0.160± 0.0082 with the highest value also at Slope of 0.008, while for the Fiwasaye area, the Friction factor coefficients varied between 0.016± 0.0015 and 0.049± 0.0132 with the highest value also at Slope of 0.008.

Table 5. Friction Factor Coefficient of the soil samples collected at the different locations at different slopes

Slope	Location					
	Orisa River			Ala River		
	Aran-Orin	Rore	Omu-Aran	Fiwasaye	Sola Oke	Glory parish
0.008	0.074±0.0017	0.100±0.0516	0.067±0.0035	0.049±0.0132	0.160±0.0082	0.257±0.0077
0.016	0.065±0.0045	0.097±0.0422	0.067±0.0018	0.046±0.0092	0.134±0.0058	0.245±0.0060
0.024	0.061±0.0016	0.089±0.0590	0.058±0.0041	0.043±0.0190	0.119±0.0096	0.232±0.0025
0.032	0.055±0.0042	0.084±0.0254	0.055±0.0032	0.041±0.0110	0.094±0.0027	0.213±0.0105
0.040	0.053±0.0042	0.065±0.0405	0.042±0.0035	0.037±0.0045	0.092±0.0087	0.178±0.0104
0.048	0.053±0.0071	0.049±0.0209	0.034±0.0013	0.027±0.0035	0.069±0.0017	0.134±0.0043
0.056	0.035±0.0097	0.025±0.0014	0.018±0.0007	0.016±0.0015	0.036±0.0013	0.049±0.0083

*For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test

For River Orisa, the Friction factor coefficients varied between 0.018± 0.0007 and 0.074± 0.0017 with the highest value at Slope of 0.008 for the Aran-Orin reach, for the Rore area, the Friction factor coefficients varied between 0.025± 0.0014 and 0.100± 0.0052 with the highest value also at Slope of 0.008, while for the Omu-Aran Area, the Friction factor coefficients varied between 0.035± 0.0097 and 0.067± 0.0035 with the highest value also at Slope of 0.008. It could be seen that the value of the Friction factor decreased according to increase in slope for all locations. It could also be seen that there were significant differences between the values of the Friction factor at different locations but on the same slope

Effects of the soil boundary influence on the velocity of flow for both rivers

The results of the effects of soil boundary influence on flow are presented in Figures 6-11 showed the relation between the velocity and the Manning roughness coefficient, friction factor for the various bed materials under a fixed boundary in the Rivers. The Mannings coefficient has been identified as the most appropriate factor to represent open channel flow (Gualtieri *et al*., 2018). The relationship between the velocity and the Manning roughness coefficient, showed that the velocity was inversely proportional with the Mannings' coefficient. This agrees with (Lau and Afshar, 2013; Gualtieri *et al*., 2018) from their work which showed that flow rate decreased as the Manning's coefficient increased. This is because smoother surfaces have lower roughness coefficient and less retarding effect on the water flow, hence a higher rate is produced and it can be concluded that flow rate and roughness coefficient were influenced by bed roughness and slope. Also, an increase of flow resistance involves smaller flow velocities and greater water depths (Roca *et al.*, 2016). The experiment was performed in a flume with a fixed boundary where the area is constant. Therefore, it is the velocity which is changing. It showed that the correlation coefficients R^2 varied between 0.8226 and 0.9598 with the highest value at the Rore location for River Orisa and Fiwasaye location for River Ala. From the correlation coefficients, it can be seen that the offstage-discharge curves for the experimental channels follow the standard form for open channel flow and is consistent with the works of (Ibrahim and Abdel-Mageed, 2014). It can also be seen that there were no significant differences for the correlation coefficients of all locations with all values of all points above 0.80 for the six location and the data are well fitted with high degree of coefficient of determination (R^2). This shows that there is a great relationship between the Velocity and Mannings' Coefficient at all sampling points of both rivers if the geometry of the river channel is kept constant. Manning's coefficient represents the resistance to flood flows in channels and flood plains (Lau and Afshar, 2013). This means the higher the manning's coefficient, the greater the resistance to flooding indicating that the tendency of flooding is highest at Fiwasaye point and Omu-Aran because of the lowest values of Manning's coefficient on the aforementioned points on both rivers. The deposition of sediments due to low elevations can also account for the area to be prone to flooding. The relationship between the velocity and the friction factor, showed that the velocity was inversely proportional with the friction factor. This agrees with (Di Stefano, 2018) which revealed from their work that velocity decreases as the Darcy Weisbach's Friction coefficient increases. It showed that the correlation coefficients R_{cc} varied between 0.5953 and 0.9351 with the highest value at the Rore location for River Orisa and Fiwasaye location for River Ala.

It could also be seen that there were no significant differences for the correlation coefficients of all locations with all values of all points above 0.80 for the locations except that of the Glory parish location on the Ala River. This shows that there is a relationship between the velocity and friction factor at all sampling points of both rivers if the geometry of the river channel is kept constant. From the foregoing it is shown that the roughness which is represented by the Manning's coefficient and the Darcy-Weisbach friction factor are inversely proportional to the velocity of flow.

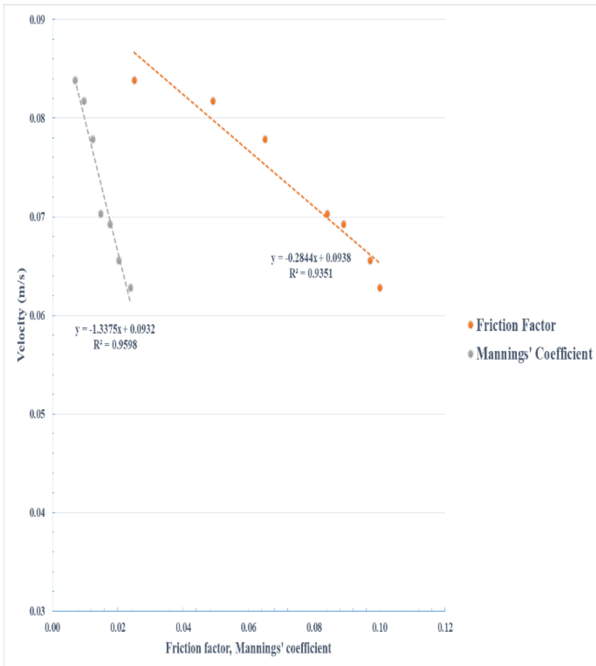

Figure 6: Effect of Boundary Resistance Factors on Flow at Aran-Orin

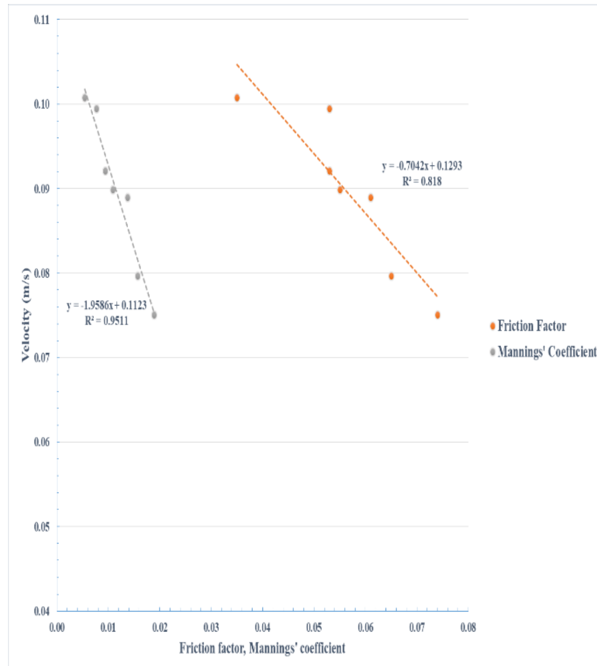

Figure 7: Effect of Boundary Resistance Factors on Flow at Rore

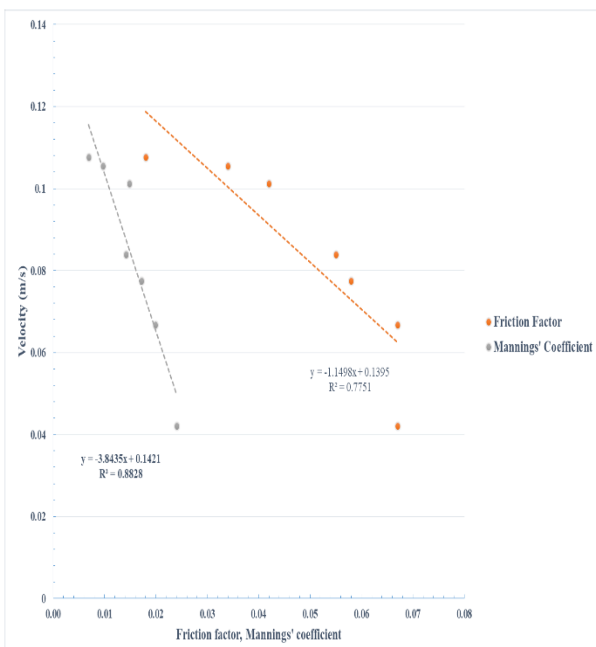

Figure 8: Effect of Boundary Resistance Factors on Flow at Omu-Aran

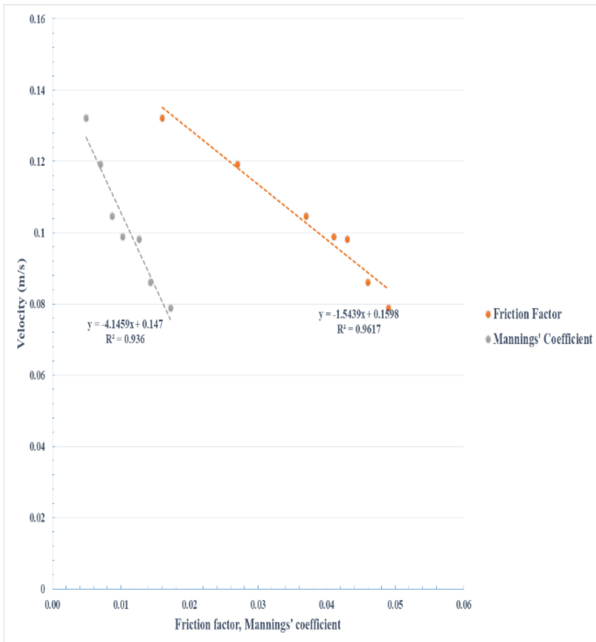

Figure 9: Effect of Boundary Resistance Factors on Flow at Fiwasaye

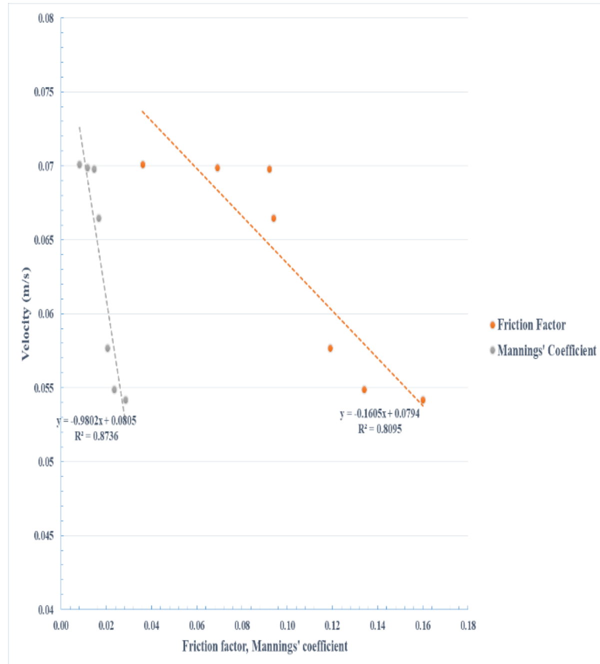

Figure 10: Effect of Boundary Resistance Factors on Flow at Sola Oke Area

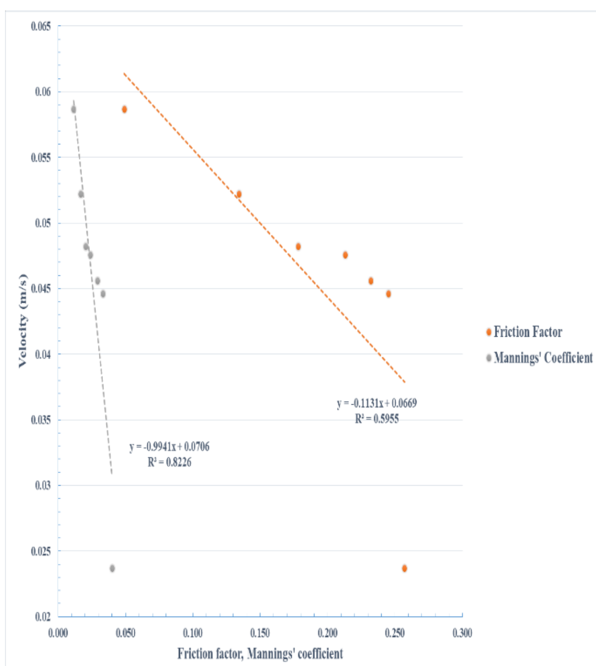

Figure 11: Effect of Boundary Resistance Factors on Flow at Glory Parish Area

Conclusions

The study was carried out with the intent of examining the effect of boundary influence on flow characteristics of identified rivers in Ondo and Kwara States. It was observed during the study that not much work had been done on the examination of boundary influence on flow characteristics and the determination of flow parameters of rivers using the hydraulic channel (Flume). Most studies were on the determination of the flow parameters and hydraulic relationships in-situ, which is the actual collection of data on the Rivers. At the end of the study, it was concluded that the velocity of flow increased with increase in slope for all locations; the value of the Manning's coefficient decreased according to increase in slope for all locations and there is a relationship between the Velocity and Mannings' Coefficient at all sampling points of both rivers if the geometry of the river channel is kept constant. Further studies should be conducted on more sampling points on the rivers to confirm the effects of boundary influence flow characteristics of the rivers.

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