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Analysis of Fluvial Properties of Egbelu and Mgbuduohia Rivers in Obio/Akpor Area of Rivers State

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Abstract
The study examined the fluvial properties of Egbelu and Mgbuduohia Rivers in Obio/Akpor Area of Rivers State, Nigeria. The study was anchored on system theory of minimum stream power and theory of maximum flow efficiency. Data were collected on fluvial properties such as river flow velocity, channel width, channel depth, wetted perimeter and form ratio, using such instruments as stop watch, marine rope, global positioning system (GPS), measuring tape, floater, etc. Data were analyzed using mean, range and two sample student t-test. Furthermore, the mean values of the fluvial properties of Egbelu River were channel depth 1.52m; wetted perimeter 31.07 m; and form ratio 2.92. The mean values of the fluvial properties of Mgbuduohia River were channel depth 8.93m; wetted perimeter 59.57m; and form ratio 4.47. The results also showed that there is significant difference in channel depth, wetted perimeter and form ratio between the two rivers among the three parameters. Based on the results, the study concluded that the observed differences could be a function of differences in the input factors as well as process modification along the river channel and its basin area. The study therefore recommends periodic studies for monitoring of fluvial properties of the rivers.

I. Introduction

The geomorphic explanation of the underlying fluvial processes influencing the form ratio, hydraulic radius, flow velocity, discharge, and suspended sediments in any river channel varies across the river system globally today. These processes vary across climatic regions and affect channel capacity efficiency in conveying flood water and suspended sediments. Every point on earth supplies water and sediment to a drainage basin (Nwaturuogu, 2021; Oku, 2016). These provide the necessary energy input and slope quality (Adeleke & Ogungbeni, 2016; Babatola & Babatola, 2013). They noted that rivers are characterized by their dynamic nature and spatial geomorphic agent in surface water bodies, attracting attention due to their importance in which fluvial systems transport excess surface moisture from precipitation to interior basins or the sea, resulting in predictable landforms. Ashmore (2013) suggests solar energy and gravity power the hydrological cycle, making fluvial systems a natural system. The river's variations in tributaries and discharge characteristics vary globally, with only 10% of the earth's land surface covered by ice being affected.

Urbanization also leads to increased impervious surfaces, altering the flow properties and suspended sediment index. Water saturates the ground, excavates channels, and deepens channels, eroding soil from construction sites (Anton & Stokes, 2015). Geological and geomorphic processes shape landscape design, shaping earth's surface and form. Landscape architecture, climate, vegetation, soil, land-use, and impervious surface patterns moderate global flow properties, including surface run-off and surface water index (Wali, 2015). However, Climate affects precipitation patterns, affecting river discharge, velocity, and sediment transport.

Sediment yields and its total amount of soil particles generated within a river catchment system that reached the outlet during any given time, have been considered as a decisive factor in designing drainage system planning, soil conservation techniques and sustainable development of natural resources (Owhnegh & Nohtani 2004; Borah, 2010). There is evidence that water basins in watershed catchment areas were one of the major sources of suspended sediments. The reasons for this include their lack of vegetation cover, high surface run-off, unconsolidated materials, fine materials over laying an impermeable compact layer (Grey, 2014). Controlling of sediment and runoff from catchment areas is the major priority for sustainable management of watershed environment. The preferred method for controlling sediment movement from water drained system is to spread runoff water by expanding the drainage and avoid channelization.

Sediments are supplied to the stream from surface erosion either by slope, mass wasting, stream bank and tributaries. In a stream where the channel is not bordered by a valley whether flat nor well developed flood plain, the supply of sediment will be seen through rapid mass wasting and through bank erosion (Church & Ryder, 2001). There are some sediment which can enter into a stream through adjacent slopes or upstream tributaries (Surtherland et al., 2002). The rate at which a stream response to its external sediment depends on the history of flood and sediment supply. The temporal and spatial difference in the amount of stream sediment storage depends mostly on the supply from external sources. Consequently, the activities of sediment flow rate can also create different types of stream morphologies and sediment movement (Yanda, 2001).

However, it has been observed that suspended sediment can serve as a transport medium for pollutants like phosphorus and bacteria sobbed to sediment surfaces (Miao et al., 2017; Badgley & Thomas, 2011). Heavy metals such as aluminum, lead, mercury, iron, manganese and zinc have been significantly correlated to suspended solids with increased concentrations observed during precipitation events (Wang et al., 2021). According to Chen et al. (2020) when sediment particles are suspended in the water, they make t le water turbid (cloudy), which in turn decrease the distance that light can penetrate. Thus, the base of the food web in an aquatic ecosystem consists of photosynthetic algae and plants that require light for photosynthesis turbid water lessen the ability of producer to photosynthesis. Extreme turbidity also reduces the number of photosynthesizing organism, which in turn cause a decrease in the number of aquatic organisms that feed on the primary producers. When sediments build up to the point where they envelop coral reefs and shellfish beds, they can clog the gills and feeding structure of many aquatic organisms. Fine fractions of sediment are known to result in biomass declines in benthic micro invertebrates and fish and lead to over declines in holistic ecosystem health (Chen et al., 2020).

In Nigeria, sediment losses in different drainage channels have been evaluated overtime, but there is limited knowledge of the effect of the watershed management system on the sediment control from the drainage system within the study area. Hence, it becomes pertinent to ensure sediment run-off reduction and spread runoff water, an efficient and effective filter strips should be designed to provide an additional barrier to the movement of sediment into waterways as well as management of soil erosion (Omireh, 2019). Discharge and sediment yield vary across geographic space and time, with factors like land-use, climate, soil properties, and vegetation influencing temporal variations. Understanding fluvial characteristics of major rivers is crucial for downstream water discharge, sediment transport, channel width, depth, velocity, and slope roughness. Oku and Wejinya that discharge and channel geometry vary significantly between upper and middle Woji basin in Port Harcourt area of Rivers State, Nigeria.

The Egbelu and Mgbuduohia river basins which two decades ago were purely a rural drainage system is now traversed by series of urban structures which in some areas are at the river bank. Similarly, the basins have enhanced vegetal depletion process due to emerging urban development. The changing land-use activities is increasing the index of impervious and sediment generation and transport. However, increased impervious surfaces contribute immensely to overland flow and discharge properties of the Egbelu and Mgbuduohia basins. Hence with the geometrical increase in urban structures and land-use pattern due to urbanization, their flow or discharge properties as well as suspended sediment index have been altered. Hence, the study analyzed suspended sediment yield and fluvial properties of Egbelu and Mgbuduohia rivers in Obio/Akpor Area of Rivers state.

Aim and Objectives of the Study

Analyze the difference on the observed flow velocity of the two rivers.

Determine the channel width characteristics of the two rivers in the study area.

Hypotheses

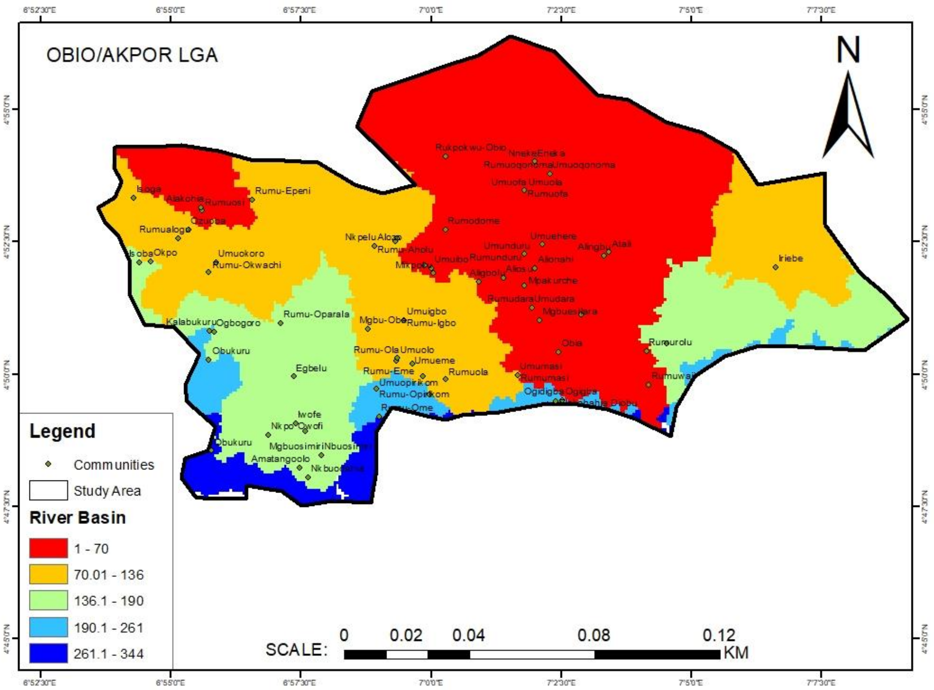
H01 There is no significant difference in river velocity between the two rivers.

H02 There is no significant difference in channel width between the two rivers.

The Study Area: Egbelu and Mgbuduohia Rivers Basin in Obio-Akpor Area of Rivers State

This work is centered on Egbelu and Mgbuduohia river basin in Obio/Akpor Area of Rivers State. The Egbelu basin as shown in Figure 1.1 is located in Obio/Akpor area of Rivers State, situated between latitudes 40 41 and 40 491 North of the equator and longitudes 6071 and 7051 East of the Greenwich Meridian (GM). Similarly, Mgbuduohia basin is located between latitude 40 491 3811 and 40 5111 0711 N and longitudes 60 571 4111 and 60 591 1511 E. The Egbelu and Mgbuduohia basins (river) drains the Rumuolumeni, Egbelu, Elioparanwo, parts of Mgbouba, Rumuokwachi, and Ozuoba in Obio/Akpor. Their first order streams drains from the Mgbuodohia, Azumini canal and Ozuoba landscape moving eastward and later turns southward and westward flowing into the New Calabar River at Rumuolumeni. Obio/Akpor Local Government Area is bounded in the north by Ikwerre and Etche, in the south by Port Harcourt, in the East by Oyigbo and Eleme and in the west by Emohua (See Figure 1.1 below)

Figure 1.2: Obio/Akpor Showing the Basins in the Study Area



Source: Rivers State Ministry of Land and Survey, Port Harcourt (2024)

The climate condition of the basin is dominated by the North-south trade wind of a zone of discontinuity between the dry tropical continental (CT) air mass, (North-East trade wind) and the humid tropical maritime air-masses (mT) (Oku, 2016). The relative humidity is about 85.20% for most part of the wet season. The basin experiences a double regime. These two air masses give rise to the two main climatic conditions of dry and wet seasons. The dry season runs from November through March while the wet or rainy seasons, runs from April and terminates in October. The two types of rainfall experience are the convectional and frontal rainfall. The annual rainfall varies between 2600mm to

5()()()mm a year (Oku, 2016). There is however, a break in rainfall, as August break separating the double maxima rainfall region. The annual temperature ranges from 28oc to 31Oc. The highest temperature is usually around March during the brief heat season. But the combined effects of the amount and the equitable temperature result in high relative humidity. However, Obio/Akpor Local Government Area where the Rumuolumeni and Egbelu basin is located generally has an average relative humidity of about 90.25% with a range of (Oku, 2016).

The Egbelu and Mgbuduohia basins drain into the New Calabar River at the Rumuolumeni area. It drains parts of Mgbuodohia, Azumini, Ozuoba, Mgbouba, Rumuokwachi, Egbelu and Elioparanwo. The Egbelu first order streams are in the Ozuoba-Mgbuoba axis. While Rumuolumeni first order streams are in the Mgbuodohia-Azumini axis. However other first order stream category exists in the Elioparanwo and Rumuolumeni tributary strealfis. It is an all-season stream during the wet and dry season all the year round. The drainage pattern especially surface runoff is westwards or south-westwards and emptying into the primary rivers. Found within these major drainage systems which are either local tributaries or flows directly into the sea like Calabar River (Oku, 2016).

The Egbelu and Mgbuduohia basin located in the Obio/Akpor Area of Rivers state has various human and physical properties. The basin is daily increasing its level of built-up areas due to housing needs for residential and commercial use. Similarly, vegetation is being depleted as it gives way to new homes and other urban structures. Since farming is done by several local communities residing in parts of the basin, secondary vegetation is found. Few pockets of natural vegetation are found at river banks and sacred grooves. However fresh water swamp vegetation is mostly found on the wetlands which include raffia palm, climbers, and other tropical species of plants. Due to significant human activities of the Egbelu basin, the soil is exposed or vulnerable to sediment loss due to impact of splash erosion from precipitation. Human activities in Egbelu basin expose soil to sediment loss, while transportation and agriculture occupy the landscape.

II. Methodology

The sampling frame of the present work consists of two (2) kilometer each of the two rivers of the Egbelu and Mgbuduohia basins. The researcher used two (2) kilometers of each river before the daily tidal mark to eliminate the impact of the salt water on variables measured. Thus, these constitute four (4) kilometres of river as the area of study. The researcher generated a sampling frame of all points at 50 metres interval of all river length which gives a sampling frame of 80 sampling points. According to Oku and Wejinya (2021) a sample size of 30 points is ideal for drainage basin studies hence the researcher made use of sample size of 30 for the present study using random table numbers.

The 30 sampling points were derived using the simple random sampling technique. The simple random sampling procedure ensured that all points had equal and non-zero chance of being selected. This was achieved using the table of random numbers. The table of random numbers is an unpredictable manner from which the introduction of the bias is reduced or completely eliminated. The researcher went to the field with the necessary instruments and took observations and possible measurement on discharge and river velocity of the lower segment of river catchment area.

The discharge of the river basin was measured with the aid of measuring tape and poles. The depth as well as bank full widths were measured to calculate the discharges which were expressed in cubic meter (m3)/second. This constituted the data set for discharge of the lower segments of rivers in the various basins. The float method was used to determine the river velocity by using a stop watch to determine the time lag between two points. A floating bottle or cork was used to enable the researcher explain or generate the data set on water flow velocity. The researcher used descriptive statistics for preliminary tables to display possible pattern of sediment yield and discharge velocity. The descriptive statistics include mean, range, minimum and maximum values. The hypotheses were analyzed using two samples t-test at 5% level of significance for the acceptable or otherwise of the conjectural statements earlier proposed for the study.

III. Results and Discussion

Table 4.1: Geomorphological Characteristics of Mgbuduohia River Across Fifteen (15) Sampling Points

S/n	Location	Geographical coordinates	River Velocity Ratio (M/s)	Channel Width (m)
1	Sampling point 1	Latitudes: 40- 501 3511 Longitude: 70 051 0011	3.50	91.44
2	Sampling point 2	Latitudes: 40- 501 3611 Longitude: 70 051 011	5.10	112.5
3	Sampling point 3	Latitudes: 40 501 3611 Longitude: 7` 051 0211	3.20	120
4	Sampling point 4	Latitudes: 40 501 3711 Longitude: 70 051 0311	2.50	97.1
5	Sampling point 5	Latitudes: 40 501 3811 Longitude: 70 051 0811	3.30	111.1
6	Sampling point 6	Latitudes: 40 501 3411 Longitude: 70 051 0911	4.20	130
7	Sampling point 7	Latitudes: 40 501 5511 Longitude: 70 051 4911	3.60	125.5
8	Sampling point 8	Latitudes: 40 501 5811 Longitude: 70 051 5511	4.40	110.4
9	Sampling point 9	Latitudes: 40 501 5111 Longitude: 70 051 5311	3.80	115
10	Sampling point10	Latitudes: 40 501 4911 Longitude: 70 051 5611	5.50	100
11	Sampling point 11	Latitudes: 40 501 5111 Longitude: 70 051 5711	6.60	127.3
12	Sampling point 12	Latitudes: 40 501 5011 Longitude: 70 051 5011	5.6m	126.5
13	Sampling point 13	Latitudes: 40 501 5911 Longitude: 70 051 4811	4.90	124.8

14	Sampling point 14	Latitudes: 40 501 4611 Longitude: 70 051 4411	4.60	98.7
15	Sampling point 15	Latitudes: 40 501 4211 Longitude: 70 051 0311	4.30	96.4

Source: Omireh (2024)

The result in table 4.1 shows that the river channel width recorded a mean of 112.46m and a range of 63.6m; the channel depth recorded a mean of 8.93m with a range 7.3m; the form ratio recorded a mean of 4.4 with a range of 2.38 and lastly, the wetted perimeter recorded a mean of 59.57m and a range of 26.9m.

Table 4.2: Geomorphological Characteristics and Geographical Coordinates of Egbelu River Across Fifteen (15) Sampling Points

S/n	Location	Geographical Coordinates	River Velocity Ratio (M/s)	Channel Width (m)
1	Sampling point 1	Latitude: 40 511 0111 Longitude: 70 051 1011	3.10	25.2
2	Sampling point 2	Latitude: 40 511 0211 Longitude: 70 051 1111	1.50	15.02
3	Sampling point 3	Latitude: 40 511 0211 Longitude: 7` 511 1111	1.50	15.02
4	Sampling point 4	Latitude: 40 501 0211 Longitude: 70 051 1111	1.65	15.40
5	Sampling point 5	Latitude: 40 511 0311 Longitude: 70 051 1511	1.75	45.5
6	Sampling point 6	Latitude: 40 501 0811 Longitude: 70 051 1211	1.53	23.40
7	Sampling point 7	Latitude: 40 501 0511 Longitude: 70 051 1011	1.65	15.4
8	Sampling point 8	Latitude: 40 501 1211 Longitude: 70 051 1511	1.70	21.20
9	Sampling point 9	Latitude: 40 511 0311 Longitude: 70 051 2011	1.48	2.2
10	Sampling point 10	Latitude: 40 511 0511 Longitude: 70 051 3311	2.15	38.40
11	Sampling point 11	Latitude: 40 511 0711 Longitude: 70 051 2511	1.53	23.4
12	Sampling point 12	Latitude: 40 511 3011 Longitude: 70 051 4011	1.87	29.80
13	Sampling point 13	Latitude: 40 511 3511 Longitude: 70 051 6011	1.61	20.5
14	Sampling point 14	Latitude: 40 511 3711 Longitude: 70 051 8211	1.82	24.60

15	Sampling point 15	Latitude: 40 511 4811 Longitude: 70 051 7311	1.70	21.2

Source: Omireh (2024)

The result in table 4.2 shows that the channel width recorded a mean of 26.33m with a range of 43.4m.

Descriptive Statistical Analysis for Mgbuduohia River Characteristics

The result of the descriptive statistics of Mgbuduohia river is presented in table 4.3

Table 4.3 Descriptive Statistical Analysis for Mgbuduohia River Characteristics

S/n	Descriptive Statistics	River Flow Velocity	Channel Width
1	Mean	4.34	112.46
2	St. Dev	1.08	13.09
3	Range	4.10	38.56
4	Minimum	2.50	91.44
5	Maximum	6.60	130.00
6	Sum	65.10	1686.84

Source: Omireh (2024)

As displayed in table 4.3, the central tendency analysis revealed a sum of 394.97m across the fifteen (15) sampling points with a mean of 26.33m, a minimum value of 15.02m and a maximum value of 120.10m. The mean value of 15.02m indicates that each sampling point is expected to have a value of 15.02m and a range of 30.13m.

Table 4.4 Descriptive Statistical Analysis for Egbelu River Characteristics

S/n	Descriptive Statistics	River Flow Velocity	Channel Width	Channel Depth	Form Ratio	Wetted Perimeter
1	Mean	2.31	26.33	1.52	2.92	31.07
2	St. Dev	0.57	8.04	0.34	0.51	4.36
3	Range	1.95	30.13	1.15	1.85	15.10
4	Minimum	1.10	15.02	0.75	2.15	23.30
5	Maximum	3.05	45.15	1.90	4.00	38.40
6	Sum	34.63	394.97	22.75	43.76	466.00

Source: Omireh (2024)

The result revealed that the sum of the river flow velocity across the fifteen (15) sampling points recorded a total of 34.63m/s; with a mean of 2.31m/s, a minimum value of 1.10m/s and a maximum value of 3.05 m/s. The mean value of 2.31m/s implies that each of the four sampling points is expected to record a value of 2.31m/s and a range of 1.95m/s.

As displayed in the table, the central tendency analysis revealed a sum of 394.97m across the fifteen (15) sampling points with a mean of 26.33m, a minimum value of 15.02m and a maximum value of 45.15m. The mean value of 26.33m indicates that each sampling point is expected to have a value of 26.33m and a range of 30.13m.

Testing of Hypotheses

Table 4.6 A Summary of Two-sample t-test on the difference between Suspended

Sediments for Mgbuduohia and Egbelu Rivers

Variable	N	Mean	SD	Df	Calculated t-	Table t	Decision
Mgbuduohia River	15	13062.00	5406.44				
				28	9.203	1.701	H01 Rejected
Egbelu River	15	215.47	36.21				

Source: Omireh's Computation (2024)

The result showed that Mgbuduohia River recorded a mean value of 4.34 with a standard deviation of 1.08 while Egbelu River indicated a mean value of 2.31 with a standard deviation of 0.57. Furthermore, the result of the two-sample t-test on the differences between the river flow velocity of Mgbuduohia River and Egbelu River reveals a t-value of 6.438 with 28 degrees of freedom. Based on the decision rule, since the calculated t of 6.436 is longer than the calculated t value of 1.701, the null hypothesis is rejected while the alternate hypothesis is accepted. Therefore, the study concludes that there is significant difference between river flow velocity of Egbelu River and Mgbuduohia River in Obio/Akpor Local Government Area of Rivers State.

Table 4.8 A Summary of Two-sample t-test on the difference of River Flow Velocity Between Mgbuduohia and Egbelu Rivers

Variable	N	Mean	SD	Df	Calculated t-	Table t	Decision
Mgbuduohia River	15	4.34	1.08				
				28	6.438	1.701	H02 Rejected
Egbelu River	15	2.31	0.57				

Source: Omireh's Computation 2024

The result showed that Mgbuduohia River recorded a mean value of 4.34 with a standard deviation of 1.08 while Egbelu River indicated a mean value of 2.31 with a standard deviation of 0.57. Furthermore, the result of the two-sample t-test on the differences between the river flow velocity of Mgbuduohia River and Egbelu River reveals a t-value of 6.438 with 28 degrees of freedom. Based on the decision rule, since the calculated t of 6.436 is longer than the calculated t value of 1.701, the null hypothesis is rejected while the alternate hypothesis is accepted. Therefore, the study concludes that there is significant difference between river flow velocity of Egbelu River and Mgbuduohia River in Obio/Akpor Local Government Area of Rivers State.

Table 4.10 A Summary of Two-sample t-test on the difference of Channel Width between Mgbuduohia and Egbelu Rivers.

Variable	N	Mean	SD	df	Calculated t-	Table t	Decision
Mgbuduohia River	15	112.46	13.09				
				28	21.715	1.701	H03 Rejected

Egbelu River	15	26.33	8.04

Source: Researcher's Computation (2024)

The result showed that Mgbuduohia River recorded a mean value of 112.46 with a standard deviation of 13.09 while Egbelu River indicated a mean value of 26.33 with a standard deviation of 8.04. Furthermore, the result of the two-sample t-test on the differences between the channel width of Mgbuduohia River and Egbelu River reveals a t-value of 21.75. Based on the decision rule, since the calculated t value of 21.75 is greater than the table value of 1.701, the null hypothesis is rejected while the alternate hypothesis is accepted. Therefore, the study concludes that there is significant difference between channel width of Egbelu River and Mgbuduohia River in Rumuolumeni, Port Harcourt.

Flow Velocity

The hypothesis result reveals that (here is significant difference in the stream velocity of the two rivers. This result implies that the two rivers vary in their flow velocity which emanate from various variables. This finding is consistent with the finding of Nwaturuogu (2021) which observed that there is significant variation in the flow velocity of the observed tributaries of Otamiri Rixer basin in Etche local government area of Rivers state. According to Nwaturuogu (2021) the variation observed in the flow velocity of rivers which emanate from water discharged by the tributaries at different points. On the contrary, the findings of this study differ with that of Hyginus-Oku (2021) that states that the stream velocity does not significantly vary across selected streams in Port Harcourt metropolis. Across the globe, different studies have shown that velocity of streams could vary depending on gradient seasonality, discharge as well as channel size in relation to discharge volume as reported by Bhattachargee (2016), Fryers and Bierley (2013) and Haiam et al. (2013) in Hyginus-Oku (2021) this means that despite the variations of intra-basinal streams, such variation may likely not be stable and significant over time. Geomorphologists have explained that temporal as well as the spatial nature of velocity in river basin.

Channel Width Characteristics

The result of the study from the hypothesis state that there is significant difference in the channel width of Egbelu River and Mgbuduohia River. This result agrees with the findings ofNwaturuogu (2021) that there is a variation in the channel with characteristics of measured tributaries of Otamiri river basin in Rivers state. According to Soni (2017) channel width depicts observable changes by increasing wideness due to influences of some factors ranging from lateral erosion which has replaced vertical erosion. Nwaturuogu (2021) stated that bankful discharge of a river determine to a great extent how river channel width will be.

This finding is in contrast with the finding of Hyginus-Oku (2021) which observed that channel width does not significantly vary across selected streams in Port Harcourt metropolis which includes these two rivers studied. According to Oto (2010), Okon and Ikebude (2015) in HvginusOku (2021), channel configuration of drainage basins is unique in space both within and among different stream channel. The submissions of these scholars support the findings of the study of Hyginus-Oku (2021). The means that channel of streams width is modified naturally by its geology, gradient, nature of material basin vegetation as well as discharge hydraulic capacity.

IV. Conclusion

The study made analysis of suspended sediment yield and fluvial properties of two rivers in Obio/Akpor Local Government Area in order to underscore their geomorphic characteristics for sustainable river basin management in the area. The study indeed observed that the two rivers differ significantly in their fluvial properties and suspended sediments yield, thus I believe has advanced the field of fluvial geomorphology in the study area and will significantly help the different stakeholders in the area in drainage management and dealing with environmental challenges associated with river basin, especially flooding and erosion.

V. Recommendations

Based on the findings of the study, the following recommendations are made as a remediation to observed challenge.

There should be regular studies to ensure that geomorphic parameters of river basins in the urban areas are adequately monitored in line with increasing urbanization and industrialization taking place along river basins.

The state government, through its Ministry of Environment should embark on regular environmental campaign, education and sensitization of urban dwellers on the implication of their various activities on river fluvial properties so as to reduce or minimize harm done to them by human beings.

There is also a very crucial need to have a regular monitoring or assessment of river and stream basins in the urban areas through space-based platforms such as environmental satellites. This will give timely, information on the river basins of Port Harcourt. This can be achieved by the state government through the Nigerian based environmental satellite in space.

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