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Original Research Article

Variation in Depth along the Main Channel of Otamiri River, In Rivers State: A Study in Hydraulic Parameters

Nwaturuogu Christian C[1*]

[1]Department of Geography & Environmental Studies, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Nigeria

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***Corresponding author:** Nwaturuogu Christian C
Department of Geography & Environmental Studies, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Nigeria

Abstract

The study assesses the variation in depth along the main channel of Otamiri River, in Rivers state, Nigeria. Quasi-experimental (field survey) research design was adopted for the study, as it involves observation on the morphometry parameters of the tributaries of Otamiri river. Primary data were collected through tape, ranging pole, float, and Stopwatch, while drainage maps and topographic map become secondary sources of data. The sample frame for this study is total length of all tributaries of Otamiri-river basin, in the study area. The total length of the tributary streams is 320 kilometers, the data were collected at interval 1 kilometre since total length is 320 kilometres, then 320 divide by 1, therefore the sample frame is 320 Sampling Station. Analysis of variance (ANOVA) was used in testing the various conjectural statements at 5% level of significance for acceptance or otherwise. Findings revealed that, there is variation in a significant variation in the depth along the main channel of the Otamiri river basin in the Southern Nigeria. From the findings, it was inferred that geomorphic and morphometric variations exist both with the main trunk of the Otamiri river as well as the major tributaries. These variations could be a function of temporal variation in the input factors as well as process modifications along the river channel and its basin area. Thus, the researcher recommends, adequate and periodic channelization through dredging of the downstream River channel as to improve channel capacity in order to reduce the menace of flooding that causes displacement of settlement and other human meaningful activities within the area concerned.

Keywords: Channel, Channel Depth, Hydraulic Parameter, River, Tributaries.

INTRODUCTION

Rivers are one of the geomorphic agents that constitute an important focus of the attention in the surface water studies because of their dynamic nature and spatial linkage. As opine by Dubey *et al*., (2017), hydraulic parameters of major tributaries of a larger rivers exert profound influence on the downstream channel morphology. Notably, channel morphology studies the structure and form of river channel, as it plays important role in various fields like transportation, settlement planning, land use management, flood control as well as flood management. Thus, understanding various components of channel morphology such as channel shape, bed and bank characteristics, sediment transport, and meander patterns, enables professionals in diverse domains to make informed decisions. Geomorphologists have used drainage basin morphometry to offer explanations in fluid analysis of streams (Federico & Spangnolo, 2004, cited in Susan, 2011). Morphometry is essentially quantitative, involving numerical variables whose values may be recovered from topographic maps.

Morphometric analysis is a quantitative measurement and mathematical analysis of land forms (Clark, 1996 cited in Kaur, 2016; Bailey's cited in Chang, 2018). Morphometric study of a basin provides valuable information about the drainage characteristics of a basin (Apama, 2015; Strahler, cited in Dubey, 2016). As Horton cited in Soni (2017) described, morphometry analysis is an important indicator of landform structure and hydro-geologic processes. Conventionally river basin is the portion of land drained by a river and its tributaries. It encompasses the entire land surface dissected and drained by many streams and creeks that flow into ocean, (Gordon, 2016).

However, one of the basic impacts of some selected channel hydraulic parameters (width, depth, channel bed, channel slope, velocity and discharge) lies on the volume of water discharge, gradient of the channel bed of these various tributaries (river/stream) which is easily felt on the channel width, depth, volume of water discharge, flow velocity, wetted perimeter and bank-full properties of the larger river downstream reach. Secondly the morphometry variables, such as slope (gradient) sinuosity, cross-sectional and longitudinal channel form and flow patter (Adebayo, 2017). Apparently, it is noticed that the drainage basin occur at a variety of scales, in terms of comparison using morphometric variables, as these drainage basins have different lithological compositions, structures and characteristics, coupled with varying number of tributaries and other factors such as, climate, vegetation and land use and the general land elevation among others (Gizachew and Berhan, 2018).

Fluvial processes are one of the most important geomorphic system operating on the earth surface, as river studies are multidisciplinary but the most prominent areas are hydrology and hydraulics. Hydrology treats the occurrence, distribution, movement, and properties of the waters of the earth and their relationship with the environment within each phase of the water cycle (USGA, 2012). Hydraulics applies engineering science to the practical problems of collecting, storing, measuring, transporting, controlling and using of water and other fluids (Salterfield cited in Sahu *et al.*, 2017). However, one of the basic challenges confronting the drainage basin studies lies much on the dearth of data, relating to the hydraulic parameters of major tributaries of rivers in question. Similarly, the inadequate literature on river studies in this part of the world has proved to be a barrier, poor interest and commitment also attributed to low interest on this area of research. Poor funding and its associated problems also cause a limitation on the people to carry out research on this area. Technology also stands as a factor limiting the extent to which people of this part of the world pay attention to river basin studies (Moses and Bhole, 2015).

Notably, in some parts of the world where rivers, and river drainage basins are studied, such as U.S.A., Canada including Western Europe, scholars like Horton (1947), Strahler (1964), Thronbury (1969), Leopold (1962), Huggett (2012), Leopold (1992), Selby (1995), Ashley (1998), Wende (2010) among others have carried out extensive studies on drainage basins at one point in time or the other. However, in Africa very few scholars like Oyegun and Oku cited in Oku (2016), Adebayo (2015), Ogunchi (2014), Okon and Ikebude (2015), among others are seen to have carried out studies of drainage basin among others. Scholars like Horton cited in Owamah *et al*., (2020) worked on river ordering, morphology of watershed; hydraulic geometry was studied by Leopold and Maddock cited in Whipple (2018); river meander by Stahler cited in Fashae (2017); quantitative geomorphology by Schum cited in Ibisate (2017) and his evolution of drainage pattern and slope in badlands (Miller cited in Olutoyia and Adetoye, 2017) and his quantitative, geomorphic study of drainage basin characteristics in the Clinch mountain area; Oyegun and Oku cited in Oku (2016) worked on urbanization and stream processes. In spite these studies, paucity of literature still exists on some rivers in Africa most especially the hydraulic parameters of major tributaries and the changing channel characteristics (Hydraulic parameters) have not been studied by many scholars.

At local level, mostly Africa and Nigeria in particular, Arohunsoro and Adebayo, (2015) studied morphometric parameters as a correlate of flooding in River Ajilosun in Ado- kiti, Nigeria. Oguchi (2014), studied the drainage density and relative relied in humid steep mountains with frequent slope failure. Girema and Bhole (2016) carried out a study on morphometric characteristics and relation of stream orders to hydraulic parameters of river Goro: an ephemeral river in Dive-dawa, Ethiopia. Okon and Ikebude (2015) came up with a study of hydraulic characteristics of Ikpa river in the south eastern Nigeria. There are few researches on the hydraulic parameters of major tributaries in general and no study so far have been done on hydraulic parameters of major tributaries of Otamiri river in Southern Nigeria in particular.

Leopold and John cited in Oku (2016) used descriptive statistics as their statistical tool to analyzed their finding. While Laurent, Stephen, and Tom (2015) adopted large-eddy simulations as a tool for investigation. They used experimental research method to analyze their work Vijuya cited in Gizachew and Berhan (2018) made used of field-survey research method where GPS was to generate data. Adebayo & Ardunsoro (2015) made use of descriptive research method. Schumn cited in Guth (2017) made use of both field -survey and descriptive statistics in analyzing his data. One major point of difference lies on the followings: their works were mainly based on Eastern Europe, USA. Asia whilst few were carried in Africa, besides, they overlook the importance of tributaries (rivers), and their influences on larger drainage basin. Hydraulic parameters of major tributaries to larger watershed has not been given attention in Southern Nigeria, particular the Otamiri river-basin. More scholars have overlooked the contribution of smaller river-basins to the wetted perimeter of larger drainage basins. They also paid less attention to hydraulic geometry of tributary streams to the river channel etc. Hence, a significant geomorphic gap exists in the local geomorphic literature on the input of tributary streams to the geomorphic development of the downstream channel. This study examined the variation in the depth along the main channel of Otamiri river.

Otamiri watershed (river basin) and its major tributaries in the southern Nigeria, happens to be located in about four degree, thirty minutes, North, five degree ten minutes North of equator (4°30′-5°10'N) and about five degree fifty minutes to six degree fifty minutes East of Greenwich meridian (5° 50'E-6° 50′E). It is one of the major rivers basins in the southern Nigeria that empty into the in Atlantic Ocean. It is the fourth largest watershed (drainage basin), in the area. It has four major tributaries joining at one point or the other. These four tributaries are Nworie river at Nekede, Okatankwo joining Uramuriukwa, at Emeabiam, Uramiriukwa joining Otamiri river very close to Orwu in Etche. Ogeochie joined Otamiri river at Opiro, closed to Nihi Etche and Otamiri river other tributaries joined Otamiri river at Opoku, before crossing Bori- Uyo bridge, at East-West road, after which Otamiri river flows into Atlantic Ocean through Opopo estuary. Otamiri river basin or watershed cuts across four states within the Southern Nigeria, the states are, Imo, Rivers, Abia and Akwa-Ibom States.

LITERATURE REVIEW

Theoretical Framework

Theory of Minimum Stream Power

Chang cited in Oku (2016), hypothesized the concept of minimum stream power which states that “for an alluvial channel, the necessary and sufficient condition of equilibrium occurs when the stream power per unit channel length is a minimum subject to given constraints. Hence, an alluvial channel with water discharge and sediment load, the independent variables tend to establish its width, depth and slope such that the stream power is a minimum. Since the water discharge is a given parameter, the minimum stream power means minimum channel slope “for a stream in equilibrium, the channel geometry. Slope and velocity are governed by the water discharge and sediment load, for three unknown namely width, depth and slope, three independent relations are needed which included (1) a resistance relation (2) sediment transport formula and (3) stream power relation.

Employing the flow resistance equation developed by Engelund and Hansen cited in Mohd *et al*., (2017), the bed load formula of Duboys cited in Graf cited in Whipple (2018) and Einstein and Brown cited in Simons and Senturk cited in Chang (2018), Chang (2018) derived hydraulic geometry relations and channel patterns. The author, showed that a stable channel configuration corresponds to a minimum stream power per unit channel length and for a small value of water discharge and segment load, there exists a unique minimum, indicating a unique stable channel configuration when the slope of this unique stable channel equals the valley slope, the channel pattern is straight. Above a certain threshold valley slope, the stream power has two minima, indicating two possible channel configurations and slopes, whenever multiple channel slopes exist on a unique valley slope, the river becomes sinuous.

Highly sinuous rivers which have small width/depth ratio occur on flatter slopes. As the valley slope increase, rivers become more braided and less sinuous for design of stable channels, a unique solution of slope, width and flow depth is needed with reasonable reliable methods available for prediction of form and grain roughness, it is possible to predict flow velocity and depth with sufficient accuracy for a specified bed width. The bed slope for uniform flow in alluvial channels depends on the quantity and quality (in essence, size) of sediment transport and friction equation are sufficient to predict the slope and flow depth for a specified water discharge, sediment load and bed width.

To bring a closure to the problem of determining a unique solution, another equation is needed for determining the channel width. To that end, by analogy with the theory of least work, Chang cited in Fashae (2017) hypothesized that the dependent variables width, depth and slope, must have such values that the total rate at which work is done upon the water and sediment mixture by external forces must be minimum in this way, with an assumed width, the depth and slope are computed for a given water discharge, sediment discharge and sediment size. The channel dimensions leading to minimum slope are supported to be the regime dimension.

Geomorphic Implications of Hydraulic Radius of Several Channels on the River Basin

The term hydraulic parameters is used in describing the shape of channel. It is the ratio between the length of the wetted perimeter and cross-section area, on the other hand, it is wetted perimeter, it is a measure, of efficiency, a high hydraulic ratio means that the river is more efficient, (Knighton, 2012). Based on this perspective, Susan, cited in Ibisate (2017) viewed hydraulic radius as the cross-sectional length of a river or stream to the length of wetted perimeter (cross-sectional length of a river bed). Susan further explained that hydraulic radius is a measure of the efficiency of the river to conveying water. Also, Susan, also stressed that if the hydraulic radius is large there is little friction.

Sparks cited in Merritt (2018) stated that the efficiency of the cross-sectional area form of the channel is often measured by a quantity known as the hydraulic radius, which is defined as the ratio between the cross-sectional area and the length of the wetted perimeter. The author further stressed, that the higher the ratio the efficiency of the stream (river), the smaller the loss of energy due to external friction. In this same vein, Sparks stated that ideal shape of stream/river varies considerably, there is a tendency for the cross-section to be a rectangle. Pierre cited in Ayele and Yasuda (2017) stated that in wide shallow-channels, the hydraulic radius is approximately equal to the flow depth, and the channel ‘width can often be approximated by their wetted perimeter.

Geomorphic Implications of Hydraulic Parameters of Channel Depth

Channel depth (d), is one of the channel variables or hydraulic parameters which denote the degree of deepness of water volume from the surface point to the river/stream bed (bottom) point. It is apparently known that the maximum channel depth is an important parameter in the estimation of stream energy; it is observable that in upland region the cross-section is less than ten (10m) meters deep. It is a vertical difference between surface water and that of channel (bottom) bed for a long distance. The maximum depth (max-d) goes on increasing in the down-stream direction reflecting the convergence of different flow discharges from major tributaries that form the catchment area of such drainage basin.

Majority of shallow streams (tributaries) that formed first and second order streams always flow through shallow channel depicting shallow water volume, and their average channel depth (d) is usually about four to six (4 to 6m), whilst the third, fourth (3d, 4) to higher order streams/rivers have their average channel depth (d) of about fifty to eighty (50m-to-80m) meters; source of these higher order rivers flow from their source Through deep channel. (Kale, 1990) maximum channel depth (d mass) at low water stage is usually measured with help of dumpy level and meter scale staff; it is unit of measurement that depicts the degree of deepness, is usually expressed in fathom level. Strahler and Strahler cited in Oku (2016), put it that channel depth (d) is one of the terms used by hydraulic engineers to describe channel geometry, which is usually measured in meters, to them, depth (d) in meters, is measured at any specified point in the stream as the vertical distance from surface to stream bed.

METHODOLOGY

Kpolovie as stated in Selvan *et al.,* (2017) noted that research design depicts the entire procedure for successfully carrying out the enquiry in order to arrive at new knowledge which is meticulously and logically planned. The author went further to state that, it is a very crucial and central phase that maps out in unmistakable terms everything that will be done to ensure that all the hypotheses or research questions formulated in the first step are objectively tested to answer the questions posed and achieve the purpose of the study. Based on this, the study entails a field- survey (field-observation) of the hydraulic variable of channel depth in the study area. Quasi-experimental (field survey) research design was adopted for the study because the study itself is a field-based, involving observation on these morphometry parameters of the tributaries of Otamiri river, as they influence its channel depth mainly toward the downstream reach.

The nature of data used in this study is non-discrete (continuous) data, as they relate to hydraulic parameters of tributaries of Otamiri river in the southern Nigeria. The sources of data for this study, are primary and secondary sources. The primary source of data includes the field observations such as, channel depth, which was collected by using tape, ranging pole, float, and Stopwatch. The secondary source of data includes all the data obtained from the drainage maps and topographic map. Satellite imagery of the drainage basins of the Southern Nigeria, the Nigeria Inland Waterways (N1W) from Federal Secretariat Port Harcourt. Providing the necessary information (data) on these rivers and their tributaries. However, the sample frame for this study is total length of all tributaries of Otamiri-river basin, in the study area. The total length of the tributary streams is 320 kilometers, the data were collected at interval 1 kilometre since total length is 320 kilometres, then 320 divide by 1, therefore the sample frame is 320 Sampling Station. The study used analysis of variance (ANOVA) to test the various conjectural statements at 5% level of significance for acceptance or otherwise of the stated hypothesis of the study. The reasons for using analysis of variance (ANOVA) is that the data involves variation.

RESULTS AND DISCUSSION

Presentation of Data

Table 4.1 (a): Channel depth of first segment of Otamiri River

S/No	Coordinates Latitude and Longitude	Channel depth
1.	04” 59’ 38” N 07º 03’ 25” E	6.10 meters
2.	04” 59’ 30” N 07º 03’ 27” E	10.20 meters
3.	04” 59’ 25” N 07º 03’ 31” E	10.70 meters
4.	04” 59’ 18” N 07º 03’ 35” E	11.10 meters
5.	04” 59’ 6” N 07º 03’ 50” E	13.05 meters
6.	04” 58’ 05” N 07º 04’ 00” E	12.35 meters
7.	04” 58’ 49” N	12.80 meters

	07º 04' 07" E	
8.	04" 58' 44" N 07º 04' 21" E	11.60 meters

Table 4:1(a) channel depth of first (t ^ p) segments of Otamiri river basin in southern Nigeria. The table 4:1(a) above depicts the field observation taken from sample point one (1) to sample point eight (8), showing channel parameter of depth from sample point one to sample point eight along Otamiri river basin, depicting the nature of channel depth at this first segments; as this table 4:1 (a) revealed the degree of channel depth, as it shows from sample point one to sample point eight. Sample point one is 6.10 meters, sample point two was 10.20 meters, sample point three is 10.70 meters, sample point four was 11.10 meters, sample point five was 13.05 metres, then sample point six was 12.35 meters and sampling point seven was 12.80meters and sample point eight was 11.60meters.

The above table revealed that sample point five is the deepest of all sample points. It also revealed the lithological compositions of channel bed and the volume of water discharge from these major tributaries, also erosive power at that point, finally sediments deposition along the channel bed.

Table 4.2 (b): Channel depth of second segment of the Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
9.	04" 58' 26" N 07º 04' 36" E	10.10 meters
10.	04" 58' 05" N 07º 05' 05" E	13.28 meters
11.	04" 58' 01" N 07º 05' 05" E	11.21 meters
12.	04" 57' 12" N 07º 05' 45" E	11.28 meters
13.	04" 57' 45" N 07º 05' 21" E	7.52 meters
14.	04" 57' 38" N 07º 05' 35" E	12.14 meters
15.	04" 57' 31" N 07º 05' 45" E	12.80 meters
16.	04" 57' 23" N 07º 05' 55" E	12.20 meters

Table 4.2 (b) Channel depth of second (2 ^ (md)) segments of Otamiri river basin in the Southern Nigeria. The table 4.2 (b) above depicts the field observation taken from sample point nine (9) to sample point sixteen (16), revealing channel parameter of depth along Otamiri river basin from sample point nine to sample point sixteen (16) which shows the channel depth as it relates to channel bed topography at that segment. At this sample point nine to sample point sixteen, it reveals the degree of channel deepness and volume of water from the river bed to river surface, the vertical extent of this channel depth is shown in this manner, sample point nine is 10.10 meters, sample point ten was 13.28 meters, sample point eleven is 11.21 meters, sample point twelve is 11.28 meters, at sample point thirteen is 7.52 meters, sample point fourteen is 12.14 meters, sample point fifteen is 12.80 meters, and sample point sixteen is 12.20 meters. This situation of channel depth at these segments reveals the overall channel depth which depicts degree of channel deepness, resulting from various water discharges from the four major tributaries of Otaniri river basin, also the lithological composition of the channel bed, and the erosive power and sediments deposition, etc. along the main river basin.

Table 4.3 (c): Channel depth of third segment of the Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
17.	04" 57' 13" N 07º 05' 58" E	12.35 meters
18.	04" 57' 06" N 07º 06' 00" E	11.75 meters
19.	04" 56' 53" N 07º 06' 05" E	12.20 meters
20.	04" 56' 48" N 07º 06' 13" E	11.17 meters

21.	04" 56' 41" N 07° 06' 19" E	12.70 meters
22.	04" 56' 36" N 07° 06' 25" E	12.30 meters
23.	04" 56' 30" N 07° 06' 31" E	10.63 meters
24.	04" 56' 24" N 07° 06' 39" E	10.32 meters

Source: Researcher's field observation 2020

Table 4.3 (c) channel depth of third (3 ^ prime d) segments of Otamiri river basin in the Southern Nigeria. The table 4.3 (c) above shows the nature of channel parameter depth at this segments of Otamiri river basin in the Southern Nigeria. This table revealed the field observation taken from this third segment of Otamiri river basin which depicts the overall channel parameter of depth, from sample point seventeen to sample point twenty-four. At this sample point of seventeen (17) to sample point twenty-four (24) which depicts the overall channel parameter of depth, from sample point seventeen to sample point twenty- four. At this sample point of seventeen (17) to sample point twenty four, it shows the degree of channel depth characteristics, and it appears in this manner: from sample point seventeen was 12:35 meters, sample point eighteen was 11.75 meters, at sample point nineteen was 12.20 meters, sample point twenty was 11.17 meters, sample point twenty one was 12.70 meters, sample point twenty two was 12.30 meters, sample point twenty three was 10.63 meters, sample point twenty four, it was 10.32 meters respectively, from the above table, it shows the role of the hydraulic radius of major tributaries at channel depth of the downstream reach of the main trunk of larger river basin being Otamiri river. The observations at various sampled points revealed that sample point seventeen was the deepest of all other sampled points of the same segments.

Table 4.4 (d): second channel depth of fourth segment of the Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
25.	04" 56' 17" N 07° 06' 45" E	10.9 meters
26.	04" 56' 10" N 07° 06' 55" E	11.60 meters
27.	04" 55' 58" N 07° 07' 51" E	13.20 meters
28.	04" 59' 08" N 07° 03' 18" E	10.52 meters
29.	04" 55' 44" N 07° 07' 30" E	15.39 meters
30.	04" 07' 42" N 07° 07' 42" E	13.15 meters
31.	04" 55' 28" N 07° 07' 50" E	14.20 meters
32.	04" 55' 18" N 07° 07' 54" E	14.70 meters

Source: Researcher's Fieldwork 2020

Table 4:4 (d) channel parameter of depth for fourth segments of Otamiri river basin in the Southern Nigeria. The above table 4:4 (d) depicts the field observation at the fourth seginents taken from sample points twenty five to sample point thirty two along Otamiri river basin, from twenty five to sample thirty-two shows the channel parameter of depth as it relates to the role of hydraulic radius of four major tributaries of Otamiri river basin, the sample points show as follows: sample point twenty-five, was 10.9 meters, sample point twenty-six, was 11.60 meters, sample point twenty-seven, was 13.20 meters, sample point twenty eight, was 10.52 meters, sample point twenty nine, was 15.39 meters, sample point thirty, was 13.15meters, then the sample point from thirty one was 14.20meters, the sample point thirty two was 14.70meters respectively.

The overview of this fourth segment of channel parameter of depth revealed the degree of channel depth at these points. It also revealed that at segment, the deepest point was observed here, at sample point twenty-nine which was 15.29meters, followed by sample point thirty-two which was also 14.70meters. This situation will be attributed to the effects of mechanical dredging at this downstream reach of Otamiri river basin.

Table 4.5 (a): Channel depth of first tributary (Nworie river) to Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
1.	5^0 25' 32" N 6^0 37' 41" E	4.20 meters
2.	5^0 25' 40" N 6^0 37' 47" E	4.50 meters
3.	5^0 25' 48" N 6^0 37' 55" E	5.11 meters
4.	5^0 25' 56" N 6^0 38' 03" E	5.32 meters
5.	5^0 26' 12" N 6^0 38' 19" E	5.40 meters
6.	5^0 26' 20" N 6^0 38' 27" E	5.38 meters
7.	5^0 26' 20" N 6^0 38' 27" E	5.16 meters
8.	5^0 26' 29" N 6^0 38' 35" E	5.29 meters

Source: Researcher's field work 2020

The table 4 5 (a) above revealed the field observation taken from sample point one to sample point eight along Nworie river course, on the channel depth; these field observations which were taken at different sample points is within Nworie river channel. The sample points was 4.20meters, sample point two was 4.50meters, sample point three was 5.11meters and the sample point four was 5.32meters, sample point five was 5.40meters, sample point six was 5.38meters, sample point seven was 5.16meters and sample point eight was 5.29meters.

This table 4:5 (a) above depicts the rate of human economic activities going on along Nworie river. Such activity like; in-stream dredging, of sand gravel which helped to deepen the channel depth of Nworie river, mostly about hundred meters away from Owerri control-post down to Nnekede where Nworie joined Otamiri river.

Table 4.6 (a): Channel depth of second tributary (Oeraminikwa river) to Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
1.	6^0 37' 41" N 5^0 25' 32" E	5.90 meters
2.	6^0 37' 49" N 5^0 25' 40" E	6.20 meters
3.	6^0 37' 57" N 5^0 25' 48" E	6.30 meters
4.	6^0 38' 05" N 5^0 26' 56" E	6.50 meters
5.	6^0 38' 13" N 5^0 26' 04" E	7.10 meters
6.	6^0 38' 21" N 5^0 26' 12" E	7.20 meters
7.	6^0 38' 29" N 5^0 26' 20" E	7.60 meters
8.	6^0 38' 37" N 5^0 26' 28" E	7.90 meters

Source: researcher's field work 2020

The table 4:6 (a) above depicts the field observation taken from different sample points along Oeramirikwa river. The second tributary is Otamiri river basin in Southern Nigeria on the channel depth, from these various sample point along Oeramirikwa river course, and they are, sample point one was 590meters, sample point two was 6.20meters, sample point three was 6.30meters, sample point four was 6.50meters, sample point five was 7.10meters, sample point six was 7.20meters and sample point seven was 7.60meters, then sample point eight was 7.90meters. This table 4:6 (a) above depicts the extent of the channel depth of the Oeramirikwa river, though channel depth is the interplay of lithological composition of the channel bed rock, the extent of flow velocity and volume of water discharge, etc. Also, the human activities along the Oeramirikwa river affects the channel depth, such activity is the in-stream dredging of sand and gravel due help in deepening the channel bed which indirectly depicts on the channel depth.

Table 4.7 (a): Channel depth of the third tributary (Okatankwo river) to Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
1.	6^0 56’ 25” N 5^0 53’ 52” E	3.41 meters
2.	6^0 56’ 33” N 5^0 54’ 01” E	3.70 meters
3.	6^0 56’ 41” N 5^0 54’ 9” E	4.10 meters
4.	6^0 56’ 49” N 5^0 54’ 17” E	4.50 meters
5.	6^0 56’ 57” N 5^0 54’ 25” E	4.51 meters
6.	6^0 57’ 05” N 5^0 54’ 33” E	3.97 meters
7.	6^0 57’ 13” N 5^0 54’ 41” E	3.88 meters
8.	6^0 57’ 21” N 5^0 54’ 49” E	4.00 meters

Source: Researcher’s field work 2020

Table 4:7 (a) revealed the field observation taken from eight sample points along Okitankwo river course: these points depict channel depth variation. These sample points are; sample point one was 3.41 meters, sample point two was 3.70meters, sample three was 4.10meters, sample point four was 4.50meters, then sample point six was 3.97meters, sample point seven was 3.88meters, sample point eight was 4.0meters. These various sample points depict channel depth characteristics, which is a product of volume of water discharge and flow-velocity, also the lithological nature of the channel bed-rock upon which the river water flows along. This is one of the major tributaries of Otamiri river basin in Southern Nigeria, with shallow depth.

Table 4.8 (a): Channel depth of the fourth tributary (Ogechie river) to Otamiri river basin

S/No	Coordinates Latitude and Longitude	Channel depth
1.	6^0 58’ 41” N 5^0 20’ 32” E	9.30 meter
2.	6^0 58’ 40” N 5^0 20’ 29” E	9.80 meter
3.	6^0 58’ 48” N 5^0 20’ 37” E	10.20 meter
4.	6^0 58’ 56” N 5^0 20’ 45” E	10.90 meter
5.	6^0 59’ 04” N 5^0 20’ 53” E	8.93 meter
6.	6^0 59’ 12” N 5^0 21’ 01” E	9.50 meter
7.	6^0 59’ 20” N 5^0 21’ 09” E	10.70 meter
8.	6^0 59’ 28” N 5^0 21’ 17” E	11.10 meter

Source: researcher’s field work 2020

Table 4:8 (a) depicts the field observation taken from eight sample points along Ogechie river, being the fourth tributary of the major tributaries to Otamiri river basin in Southern Nigeria. This table reveals the channel depth variations among these eight sample points, sample point one was 9.30meters, sample point two was 9.80meters. sample point three was 10.20meters, sample point four was 10.90meters, then sample point five was 893meters, sample point six was 9.50meters, sample point seven was 10.70meters and sample point eight was 11.10meters.

Hypothesis Testing

H_0: states that there is no variation in the depth along the main channel of the Otamiri River.

Table 4.9: Depth characteristics of the main channel of the Otamiri river channel

Channel Depth (m)			
1st Segment	2nd Segment	3rd Segment	4th Segment
6.10	10.10	12.35	10.90
10.20	13.28	11.75	11.60
10.70	11.21	12.20	13.20
11.10	11.28	11.17	10.52
13.05	7.52	12.70	15.39
12.35	12.14	12.30	13.15
12.80	12.80	10.63	14.20
11.60	12.20	10.32	14.70

Table 4.10: ANOVA Summary

Sources	DF	Sum of squares	Mean squares	F-ratio	F-critical	Decision
Between groups	3	17.8554	5.9518	1.9431	1456	Variation
Within groups	18	85.7662	3.0631			
Total	**21**	**103.6216**				

Source: Computer SPSS

From the table 4.10, the calculated F-value of 1.9431 is much greater than the F-critical of 1.456 at 0.5 confident level.

We therefore reject the null hypothesis which stated that there is no variation in the depth along the main channel of the Otamiri River.

We therefor accept the alternative hypothesis which says that there is a variation in the depth along the main channel of the Otamiri river basin.

DISCUSSION OF FINDINGS

Research question: determines the variation in the depth along the main channel of the Otamiri river basin in the southern Nigeria. Hypothesis which stated that there is no variation in the channel depth along the main channel of Otamiri river basin. The finding of the study revealed that the objective of determining the variation in the channel depth along the main channel of the Otamiri river basin. From the table 4.10 ANOVA summary relating to the research hypothesis above, depicted the calculated F-ratio of 1.9431 which is greater than-critical of 1456 at 0.05 significance level. Based on this, the finding revealed that there is variation in the depth along the main channel of the Otamiri river basin in the Southern Nigeria.

SUMMARY, CONCLUSION AND RECOMMENDATION

There is a significant variation in the measured channel depth characteristics along the main stream of Otamiri river.

These variation in depth characteristics along the main stream channel of Otamiri river, is chiefly a product of an increased volume of water discharged by these major tributaries of Otamiri river at different points of convergence, also the amount of rainfall within the catchment area coverage of the Otamiri river basin, Secondly the Lithological backgrounds of the bedrock upon which the river basin cut-across Thirdly the human activities over the years along the main stream of Otamiri river basin, such as instream dredging of sand and gravel along the water course. Lastly the turbulent flow along the stream channel at certain points also gives room for variation channel depth characteristics along Otamiri river basin.

CONCLUSION

From the finding of the study, the researcher concluded that the Otamiri river basin is one of the river basins in Nigeria. From the study, geomorphic and morphometric variations exist both with the main trunk of the Otamiri river as well as the major tributaries. These variations could be a function of temporal variation in the input factors as well as process modifications along the river channel and its basin area.

From the study the anthropogenic dependence on river for survival over time account for such noticeable modification on both the main channel and the tributaries.

Based on the findings of the study, the researcher recommends, Adequate and Periodic channelization through dredging of the downstream River channel as to improve channel capacity in order to reduce the menace of flooding that causes displacement of settlement and other human meaningful activities within the area concerned.

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