IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 2 Ser. III (Mar - Apr 2020), PP 01-05
www.iosrjournals.org

Estimationofbed Load Transportusing Grain Size Distribution Data in River Ogunpa, Southwestern Nigeria

Olaniyan, O.S., Adegbola, A.A., Adeleke, W.S, Ayanlola, J.A&Ayinde, R.B
Department of Civil Engineering, LadokeAkintola University of Technology, Ogbomoso, Oyo State Nigeria

Abstract
The Ogunpa River disaster in 1980 claimed over 200 lives and resulted in millions of dollars' worth of property damage within Ibadan. There exist paucity of information in the area of sediment transport modelling on the river. In this study, sediment yield parameters were determined to enable sediment transport modelling on the river.
The river was divided into 12 different horizontal sections and the corresponding (water surface/bed) elevation against the different horizontal distances were measured in December 2015 using surveying equipment. The cross sectional depth at regular intervals was measured throughout the cross section of the river to compute the highest and the lowest stages using leveling instrument (dumpy level). High and low stages readings were taken at a stable and accessible reach across the sampling positions. The slope was estimated from hydrographical surveying of River Ogunpa using leveling instrument. The depth of the river was taken at regular distance interval along the path of flow. The water temperature were measured using thermometer. Bed materials were collected using bed material sampler. The materials were taken to the laboratory for grain size analysis. The d_{50} sediment size was obtained from sieve analysis of sediment sample across River Ogunpa using the graph of percentage passing on sieve size against sieve size.
The low and high stages across the width of the River Ogunparanged from 0.1-1.24 m. The slope of the river varied from 0.00275-0.0032. The water temperature ranged from 28-32Oc. The percentage of bed material retained in 0.125-0.075µm sieve was 63%.
The effective mean size of bed load across river ogunpa was 1.8mm. The estimated value will be useful for estimating sediment yield,

Keywords*: stage, sediment yield, temperature, bed load*

Date of Submission: 14-03-2020 Date of Acceptance: 30-03-2020

I. Introduction

Water flowing in a channel has the ability to remove materials from the channel bed and sides and transport them downstream. This action is called sediment transport and is of considerable economic importance. The removal of materials or scour around structures such as bridge piers may cause collapse of the structure. Also, deposition of sediments can block navigable channels and water control gates and weirs requiring dredging and if not, flooding can result, since the water channel capacity can be reduced drastically (Ilaboya*et al.,* 2014 &Chang *et al* (2002).

Sediment transport studies are gradually becoming a very important aspect of fluid flow hydrodynamics coupled with gully head studies and erodibility. The major focus of this research work is to understand the concept and dynamics of sediment transport through simulated river channel which can find application in a real life situation. One of the most obvious problems in sediment transport analysis and modelling is the danger posed by data collection especially when it involves very deep river channel. For a shallow River, data collection can be a lot easier compared to a deep river. Sediment transport studies involving the use of laboratory apparatus will help overcome such limitations (Ilaboya*et al.,* 2014, Chang, 2006&Adegbola and Olaniyan, 2012).

The Ogunpa River system is a third-order stream with a channel length of 21.5 km (13.4 mi) and a drainage basin covering 73.3 square kilometers (28.3 sq mi) draining the densely populated eastern part of Ibadan Nigeria. Household waste is known to be dumped along the path of "ogunpa", these sometimes result in disastrous consequences (Oyo State Government, 2011). In 1960, more than 1,000 residents were rendered homeless when the Ogunpa River again exceeded its banks. More than 500 houses were damaged in 1963 when the river again flooded.

In 1999, the Nigerian Government took over the Channelization Project of Ogunpa. To this end, A 10 billion Naira contract was awarded to complete the Channelization project. Although the entire project was scheduled for completion in February 2003, some of the contractors working on the Channelization reportedly abandoned the site unfinished (Oyo State Government, 2011). Sediment transport dynamics encompasses the way and manner sediment materials are moved along the channel. For bed load, materials are moved along a bed by drag force between the fluid and individual material particles. These materials (load) normally move on or near the stream bed by rolling, sliding and sometimes making brief excursions into the flow a few diameters above the bed i.e. jumping. The term "saltation" is sometime used in place of "jumping" (Adewale*et al.*, 2010).

According to Seminara*et al.* (2002), bed load is generally thought to constitute 5-10% of the total sediment load in a stream, making it less important in terms of mass balance. However, the bed material load (the bed load plus the portion of the suspended load, which comprises material, derived from the bed) is often constituted by bed load, especially in gravel-bed rivers. This bed material load is the only part of the sediment load that actively interacts with the bed, thus making the bed load an important component in river channel studies, more also, the bed load plays a major role in controlling the morphology of the channel. For suspended load, materials are held in the main water stream by turbulence. In times of flood, the materials can be boulders, weighing several tonnes, with the capacity of tremendous destruction. Dissolved load is not sediment: it is composed of disassociated ions moving along with the flow. It may, however, constitute a significant proportion (often several percent, but occasionally greater than half) of the total amount of material being transported by the streamAdegbola and Olaniyan (2012).

Brief Description of Study Area

Ibadan (Oyo state, Nigeria) is the largest city in West Africa and the second largest in Africa, with land area size covering of 240 km. It is located at an average height of 200m above sea level, drained by three major river basins Ogunpa, Ona and Ogbere, and covered by secondary rainforest as well as a savannah. Spatially, it spread out over a radius of 1215 Km and experiences a mainly tropical climate with an estimated annual rainfall of about 1250 mm (Adegbola and Olaniyan, 2013).

The Ogunpa River is situated in Ibadan at a latitude of $3^{\circ}35$‟and $4^{\circ}10$‟N and a longitude of $7^{\circ}2$‟ and $7^{\circ}4$‟E. Ibadan is the capital of Oyo State, Nigeria, in West Africa. Ibadan is 128 Km North of Lagos and 345 km South West of Abuja, the Federal Capital Territory. The city is metropolitan region covers about 4200 km^2 with boundaries varying from 17 km in the southeast to 44 km in the North East. The Ogunpa River takes its source from the Ashi village in the OritaBasorun area of Ibadan. The Ogunpa continues to channel through this highly populated area of the city, despite the industrial, commercial, and residential development that surrounds it. Ogunpa river flooding occurs in the flat or low-lying terrain of Ibadan city where little or no provision has been made for surface drainage. Municipal waste and eroded soil sediments impart to the lower course stagnation of the river, resulting in poor drainage and a propensity for flooding. Figure 1 shows the map of River Ogunpa and the sampling points (Olaniyan and Akolade, 2015 &Adewale*et al.,* 2010).

II. Methodology

The cross sectional depth at regular intervals was measured using surveying equipments. The readings were taken throughout the cross section of the river to compute the highest and the lowest stages using leveling instrument (dumpy level). High and low stages readings were taken at a stable and accessible reach across the sampling positions. The slope was estimated from hydrographical surveying of ogunpa river using leveling instrument. The depth of the river was taken at regular distance interval along the path of flow. The difference in height of the river as taken from the surveying staffs divided by the difference in horizontal distance give the slope of flow of the river. Bed materials were collected using bed material sampler. The materials were taken to the laboratory for grain size analysis.

Grain size Analysis

According to the U.S. Standard Sieve grain size distribution, grain size analysis were performed to determine the percentage grain sizes contained in sediment. Each of the sieve and bottom pan was weighed. The measured weight and dry sample soil were recorded. The clean sieves were stacked in ascending order of sieve number and dry sample was poured on top sieve and shacked electronically for 15 minutes. The weight of each sieve with its retained soil were measured and the percentage retained on each sieve was estimated.

Mean Sediment Size (d_{50})

The d_{50} sediment size was obtained from sieve analysis of sediment sample across River Ogunpa using the graph of percentage passing on sieve size against sieve size. The mid of the graph of weight percentage on sieve against sieve diameter (in phi scale) represents mean sediment d50. According to the U.S. Standard Sieve grain size distribution, the following sediment particle sizes were used: gravel (5.0 to 50), coarse sand (2.0 to 5.0), medium sand (0.4 to 2.0), and fine sand (0.07 to 0.4). The study employed the following grain size distributions:

(i)grain size diameters (D) of particles greater than medium sand that is, grain sizes that are wholly coarse sand and gravel (fine and coarse) (that is, D > 2.000)
(ii) D of particles that are wholly medium sand (that is, 2.000 > D > 0.600)
(iii) D of particles that are mixture of medium sand and fine sand (that is, 0.600 > D > 0.200)(iv) D of particles that are wholly fine sand and silt/clay (that is, 0.200 > D) (Adegbola and Olaniyan, 2012).

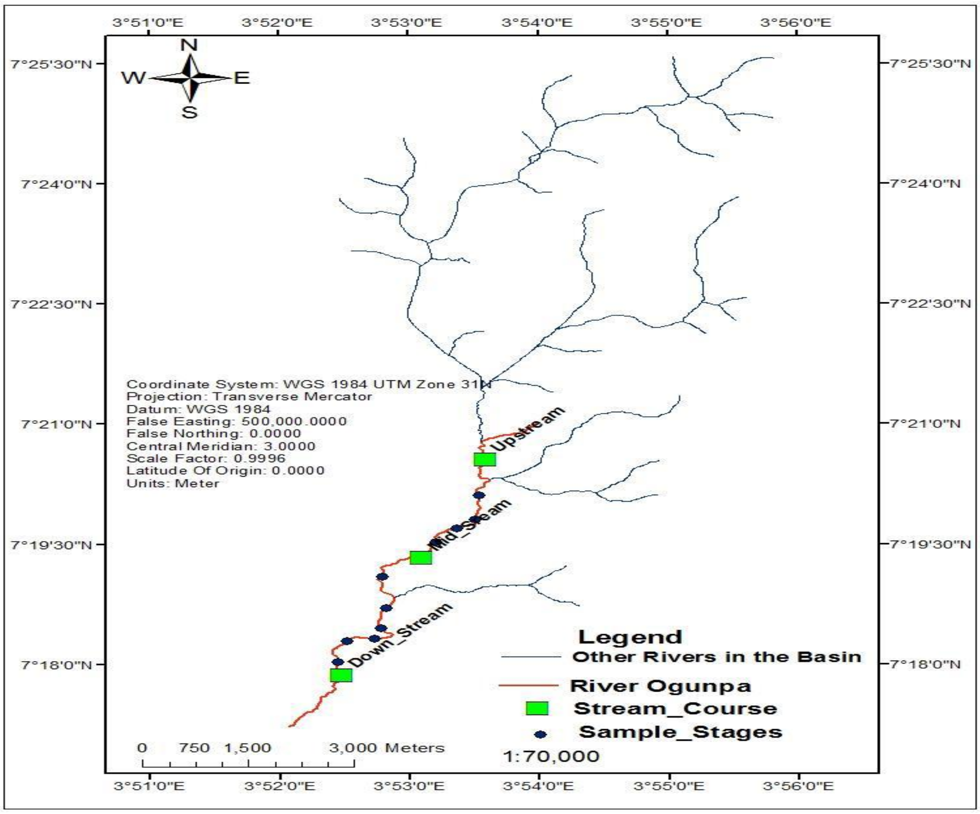

Figure 1: Map of River Ogunpa Showing the Sampling Points

III. Results and Discussion

Field Data Result

(a) Position (stage) -elevation

The River Ogunpa cross section was established perpendicular to the main body of the flow with 10.8m width on the upstream sampling point of at Labaowo market. The points across the section are surveyed relative to a known or arbitrarily established benchmark elevation. The distance-elevation paired data associated with each point on the section was obtained by rod-and level survey as presented in Table 1. The river was divided into 12 equal sections to compute depth/ bed- water surface. The result of position and elevation shows the shape of the cross sectional bed and the elevation of each points as measured from the calibrated rope and measuring tape. Errors were avoided during the marking of points along the cross section.

(b) High and low stages

The cross sectional depth at regular intervals were used to compute the highest and the lowest stages. The low and high stages were taken across the width of the Ogunpa river at the upstream, midstream and downstream which ranged from 0.1-1.23, 0.1-1.23 and 0.1-1.24 m, respectively.

(c) River Channel Slope

The slope were estimated from hydrographical surveying of River ogunpa using leveling instrument. The slope of the river is 0.0032 downstream, 0.0030 midstream and 0.00275 upstream. The average slope was estimated as 0.003 from the steepest point. The river channel slope recorded in the upstream, midstream and downstream shows there is steady flow in the river from the upstream, through the midstream to the downstream.

Table 1: Position-Elevation across River Ogunpa

Position	Elevation(Stage) m
0	0.39
0.9	0.47
1.8	0.55
2.7	0.36
3.6	0.71
4.5	0.78
5.4	0.79
6.3	0.77
7.2	0.71
8.1	0.62
9	0.54
9.9	0.46
10.8	0.38

Grain size analysis was performed to determine the percentage grain sizes contained in sediment. The percentage passing of the sediment on each sieve are presented in Table 2**.** The d50 sediment size was obtained as 1.8mm from sieve analysis of across River Ogunpa when percentage passing on sieve size was plotted against sieve size. The mid of the graph of weight percentage on sieve against sieve diameter (in phi scale) represents mean sediment d50.

Table 2: Particle Size Analysis of Bed Materials from River Ogunpa

Sieve Size (mm)	**% Retained**
0>20.00	100.01
20>0>8.00	87.35
8.00>0>74.00	75.80
4.00>0>2.00	56.90
2.00>0>4.00	25.20
1.00>0>0.425	9.74
0.425>0>0.250	4.98
0.250>0>0.125	2.33
0.125>0>0.075	0.63
0.075 below	0.33

IV. Conclusions

The following conclusions were made based on the results obtained from this study:
(i) From the field study, the river elevation is higher downstream, the river is steepest downstream and the temperature is lower downstream due to the land use pattern.
(ii) The effective mean sediment size (d50) varied across the river from 0.18-2.0mm.

Recommendations from the Study

(i) Channelization of River Ogunpais strongly recommended to reduce the possibility of incessant flooding.

Acknowledgement

The authors acknowledge Tertiary Education Trust Fund TETFund and Authorities of LadokeAkintola University of Technology, Ogbomoso for the Institution Based Research (IBR) grant (PV No: 00082805) to carry out this research.

References

[1]. Adewale, P. O., A. Y. Sangodoyin, and Adamowski, J(2010). Flood Routing in the Ogunpa River in Nigeria Using Hec-Ras. Journal of Environmental Hydrology, 25 (18): 1-3
[2]. Adegbola, A. A and Olaniyan, O.S. (2012). Temporal Variation of Sediment Transport in River Omi, SouthWesternNigeria. International Journal of Applied Engineering Research, 4(7): 421-431pp.
[3]. Adegbola, A. A and Olaniyan, O.S. (2012). Estimation of Bed Load Transport in River-Omi, South-Western Nigeria Using Grain Size Distribution Data. International Journal of Engineering ,2(9):1587-1592pp.
[4]. Adegbola, A. A and Olaniyan, O.S. (2013). Spatial Variation of Suspended Sediment Transport on River-Omi, South-Western Nigeria. International Journal of Engineering Trends and Technology, (4):58-62 pp.
[5]. Chang, H.H., Pearson, D., Tanious, S. (2002). Lagoon Restoration near Ephemeral River mouth. Journal of Waterway, Port, Coastal, and Ocean Engineering 128 (2): 79-87pp.
[6]. Chang, H. H. (2006). Generalized Computer Program: Fluvial -12 Mathematical Models for Erodible Channel User's Manual. San Deigo State University, San Deigo, California
[7]. Ilaboya, I. R., Oti E.O.,Ekoh, G.O.,Umukoro, L.O. (2014). Sediment Transport Analysis and Modelling using Winxspro: A case study of the Sediment Transport Apparatus. Industrial Engineering Letters 4, (1): 1-3pp.

[8]. Olaniyan, O.S. &Akolade, A.S. (2015). Flood Plain Determination using Geographical Information System (GIS) (A Case Study of Ogunpa River in Ibadan, Oyo State.

[9]. International Journal of Energy and Environmental Research. European Center for Research Training and Development UK, 3(6): 22-36pp.

[10]. Oyo State Government (20110. Government of Oyo State Report on the Assessment of the 26th August 2011 Flood Disaster in Ibadan Metropolis. Oyo State Task Force on Flood Prevention and Manage- ment. Ibadan: Oyo State. (B**):** B1–B10.

[11]. Seminara, G., Solari, L., and Parker, G. (2002). Bed Load at Low Shields Stress on Arbitrarily Sloping Beds: Failure of the Bagnold Hypothesis.‖ Water Resources Research, 38(11): 1249-1264pp.

Olaniyan, O.S. “Estimationofbed Load Transportusing Grain Size Distribution Data in River Ogunpa, Southwestern Nigeria.” *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 17(2), 2020, pp. 01-05.