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Research Paper

Assessment of the nature of the sediment loading in the channel of Mubi Section of River Yedzeram at Lokuwa Bridge, Northeastern Nigeria.

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Assessment of the nature of the sediment loading in the channel of Mubi Section of River Yedzeram at Lokuwa Bridge, Northeastern Nigeria was the main objective of the reseatch. Equipment required for field measurements of suspended load sediment and bed load sediment included improvised suspended load sampler, Helley-Smith bed load sampler, inventory checklist, Sample ID forms (sampling information and identification) and labels, G. P.S, Camera, Protective clothing, tape, and Personnel. The sampling procedure used was area sampling technique through equal increment of width (IIL), using the same transit rate for all verticals and the same bill along the same cross-section. The cross-section of the river was divided in to thirteen (13) sections (3m) each with their distinct boundaries, after which the use of systematic sampling technique was adopted and drew one sample from each section so that the total samples were thirteen (13) for the whole cross-section. The result obtained indicated that the mean volume of sediments that passed through Lokuwa Bridge station was 2164g within 20 second. The major nature of the channel bed was medium sand, consisting of 28.60%, followed by coarse sand 27.73%, then fine sand 17.38%, gravel 15.11%, pebbles 6.47%, cobbles 1.99%, boulders 1.76%, silt 0.97%, and 0% clay contents (table 2). This implies that channel bed of Yedzeram majorly consisted of medium sand without clay. The Cu was 0.145 which was less than 4-6, while Cc was 4.768 above the range 1-3, which indicated that the sediment sizes were not well graded. In a year, the volume of 2,883,604.1472g of suspended load passed through River Yedzeram at Lokuwa Bridge. This result indicated that the volume of water that passed through Lokuwa Bride was averagely turbid. It was recommended that; Awareness on the turbid nature of water that pass through Yedzeram channel around Alaokuwa Bridge should be done, so as to reduce the level of negative effects of contaminated water on human and properties, secondly, there is a serious lack of hydrologic and morphometric records and data in the area. Therefore, much data gathering by appropriate agencies in areas like Geomorphology, Hydrology, Geology, Soil science and Soil engineering required from relevant related fields is required. Dredging of the river channel should be done so as to remove the accumulated bed load particles that are presently cemented in the river. This will result to smooth flow of the water in the river.

Keywords: *Bed Load, Bed-Load Sampler, Channel, Fine Material, Particle Diameter, Sediment, suspended load sediment and Total Sediment Discharge.*

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I. INTRODUCTION

Sedimentation of water bodies is a global geomorphic phenomenon that possesses threat to the morphological structure of the waters and concern on the sustainable functions of the bodies as vital water resources (Oliver 2016). When sedimentation occurs in excess, it directly affects the health of a waterway, decreasing its life-supporting capacity.

Sedimentation is the tendency for particles in suspension to settle out of the fluid in which they are entrained and come to rest against a barrier. This is due to their motion through the fluid in response to the forces acting on them: these forces can be due to gravity, centrifugal acceleration, or electromagnetism (Joanne *et al* 2011).

During normal flow conditions, suspended sediment is dominated by particles less than 0.0625 mm and can include colloids, clay, mud and silt. These smallest particles also form part of the deposited sediment, and can be collectively referred to as 'suspendible sediments'. Larger particles deposited on the streambed are collectively referred to as 'bed load' (Joanne *et al* 2011). The movement of sediment is dependent on channel morphology and flow. For example, higher water velocities are able to transport larger particles. Consequently, sediments are a sink as well as a source of contaminants in the aquatic environment. Stronger flows will increase the lift and drag on the particles, causing them to rise, while larger or denser particles will be more likely to fall through the flow (Da *et al* 2005). When soils erode, sediments are washed into streams and rivers. Sediments in waterways are often high in areas where river banks are grazed by livestock, on farms with steep slopes cleared of trees, and where there is a lack of riparian vegetation. Grazing along river banks removes or damages existing vegetation, increases compaction of the soil, and damages the banks of a waterway (Taihoro 2013).

One cause of high sediment loads from slash and burn and shifting cultivation of tropical forests. When the ground surface is stripped of vegetation and then seared of all living organisms, the upper soils are vulnerable to both wind and water erosion. In a number of regions of the earth, entire sectors of a country have become erodible (Ongley 1996). Sedimentation is characterized by particles that settle discretely at a constant settling velocity down to the point source. They settle as individual particles and do not flocculate or stick to other during settling. For instance this is common to sand and silt materials which are characterized by particles that flocculate during sedimentation and because of this their sizes are constantly changing and so also their settling velocities (Joanne *et al* 2011).

Natural processes responsible for the formation of bed sediments can be altered by anthropogenic activities. Many man-made materials have entered bodies of water through atmospheric deposition, runoff from land, or direct discharge into the water (Roger *et al* 2006). Human activities, including urban development, overgrazing of land, deforestation, quarrying, forestry, excavation, agriculture, can accelerate the delivery of sediment to in-stream, downpour of sediment particles on rivers, or disrupt the natural downstream progression. These activities accelerate the delivery of sediment to streams, thereby increasing the quantity of smaller particle size in the channel or disrupt the natural downstream progression (Joanne 2006). Sedimentation is very important, without it we wouldn't have any dinosaur fossils. It is the building up of layers of small particles like sand or mud. The easiest place to see this is the beach. A beach is made up of lots of sand which have been deposited, or left behind, by the sea. Sand and mud come from inland. Rivers erode them from the land and bring them towards the sea. As the water slows, it can't carry as much and so sand and mud are dropped. The bigger the grain of sand, the sooner it is dropped. If you look at a cliff, you will often see layers which make the cliff look like a layer cake. These layers are caused by sedimentation. Over a long period of time, the grains of sand and mud build up and up, forming the layers (Aaronfaunch 2013).

In particular, sediment alters the physical habitat by clogging interstitial spaces used as refuge by benthic invertebrates and fish, by altering food resources and by removing sites used for egg laying. As such, sediment can affect the diversity and composition of biotic communities. Furthermore, sedimentation and soil erosion causes substantial (large) waterway damages and water quality degradation, and remains as one of the main environmental concerns and very costly in sediment removal or dredging (Russell, 2011). Hence, the need for river sedimentation studies towards providing solution to aforementioned alterations of the fluvial rivers in the world is evitable.

II. THE STUDY AREA

Location and Extent:

River Yedzeram is one the rivers that flow its water into Lake Chad. It has a total length of about 330 km (Uba topographical sheet 156, Edition 1., 1974). It takes its source from the Hudu Hills south-east of Mubi and flows northwards into the Chad, (Adebayo, and Dayya, 2004, extracted from Yonanna, 2007). The study area is located between longitudes 13° 11' 12"E, and 13° 30' 00"E of Equator, and between latitudes 10^0 06' 30"N, and 10^0 26' 54"N Greenwich Meridian Time (GMT). The study area lies within the tropical zone, comprising of both wet and dry climate symbolized as Aw in the Coppin's climate classification (Jones, and Bartlett, 2012).

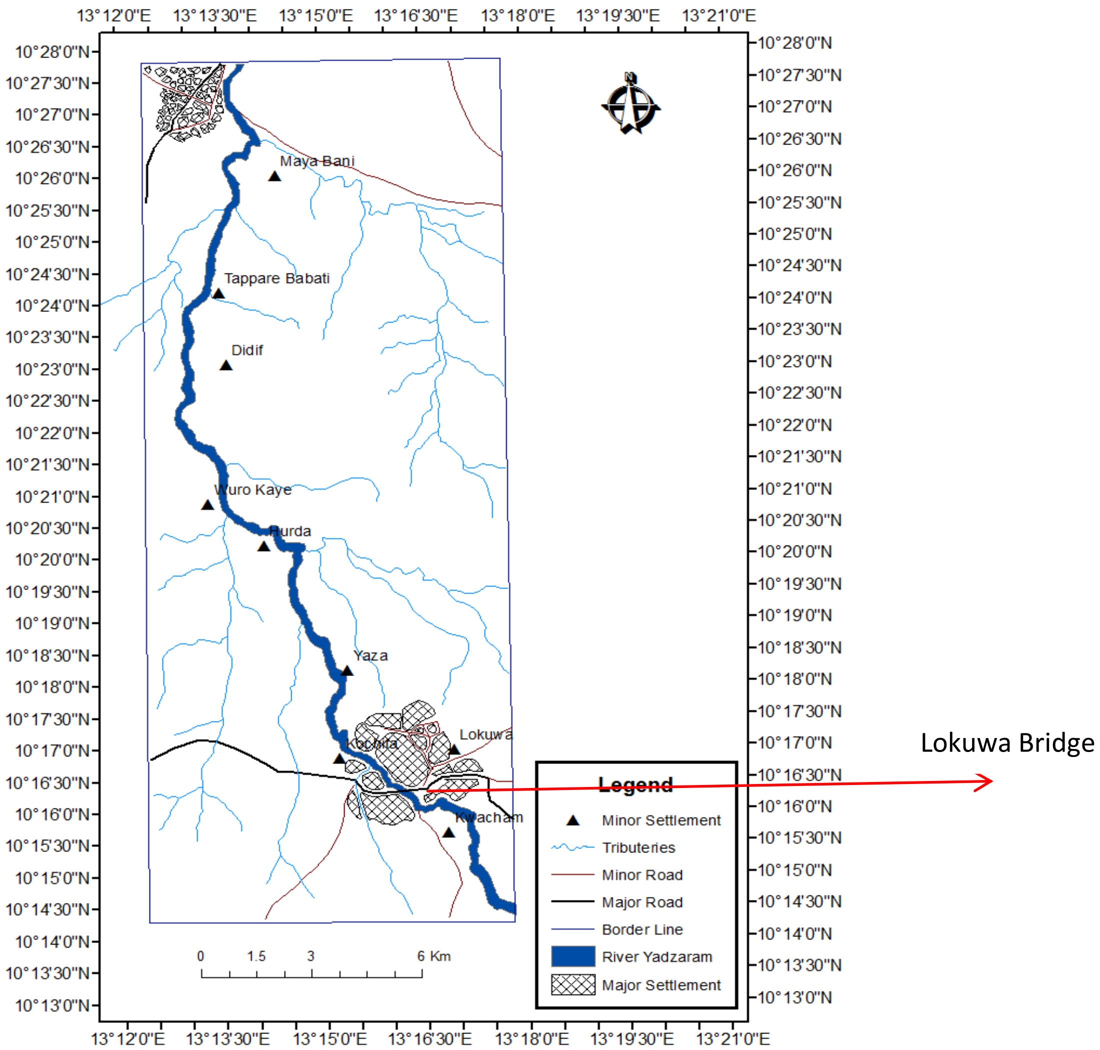

Figure 1: The studied area.

Source: Researchers work 2019

The radiation of the study area is high in that the temperature is warm as from May to October, while hottest months are the months of Match, and April. Basement complex rock is the dominant rock in the North Eastern part of Nigeria particularly the Hard Crystalline rock within the study Area. The hard crystalline rock form series of orogenic cycles within the mobile belts of Central Africa (Opeloye, and Dio, 1999). The origin of the rocks were Gneisses, migmatites and quarzites, but later on wiped out by the late proterozoic and pan-Africa period, and replaced by older Biotite granite, Biotite, porphyroid-granite, and alkaline granite (Yonanna, 2007). The study area is dominated by upland and lowland landscapes (of heights up to 305m and 152m above sea level, respectively) with some few outcrops of hills around Vimtim in Mubi (Yonanna 2007). The soils of the entire study area fall under the class of ferruginous tropical soils of granitic parent material (Adebayo, and Dayya, 2004).

III. MATERIALS AND METHODS

Equipment required for field measurements of suspended load sediment and bed load sediment included improvised suspended load sampler, Helley-Smith bed load sampler, inventory checklist, Sample ID forms (sampling information and identification) and labels, G. P.S., Camera, Protective clothing, tape, solar tape, First aid kit, and Personnel (plate 1&2).

plate 1 and 2 materials and instrument

Sampling procedure for suspended and bed load sediments

The sampling procedure used was area sampling technique through equal increment of width (IIL), using the same transit rate for all verticals and the same bill along the same cross-section. The cross-section of the river was divided in to thirteen (13) sections (3m) each with their distinct boundaries. After dividing the cross-section into thirteen (13) sections or units, the use of systematic sampling technique was adopted and drew one sample from each section so that the total samples were twelve (13) for the whole cross-section.

Method of suspended load sediment collection

The sample was collected every week for the complete rainy season starting from May to October. All the samples were kept separately; analysis was done on each, providing the concentration curve for each of the samples. In practice, the improvised depth integrating sampler was lowered to the river bottom, then immediately raised to the surface. Lowering and rising was done at the same rate to fill the sampler to about ninety (90) percent capacity. When the sampler was completely full, it was poured in the field blank container. The sampler was biased because it stopped sampling at the point at which it filled up. Therefore, proper monitoring was done to maintain at most ten (10) percent error.

Method of Bed Load Sediment Collection

In practice, the bed load sampler was sank into the bed of the river, and allow it to settle for about twenty (20) seconds, after the bed load sampler has been oriented to the flow of the river (plate 3). Then the bed load materials entered the sampler through the inlet and the divergent flows within the sampler reduced the flow velocity allowing the sediment to accumulate. Affine mesh at the rear of the sampler allowed water to pass through, but not the bed load sediments. After the appropriate measured time-interval (20s), the sampler was removed and the trapped sediment was removed for weighing in the laboratory (plate 4).

Plate 3 and 4: bed load sediment collection Source: Fieldwork 2019

Transportation and Storage of Sample

After collection of the sediment samples using the sampler at the field, the samples were transported to the laboratory under conditions that could not compromise the subsequent planned analysis. This was done by using vehicle as transportation means with the sampler under strict protection condition respectively. Since the samples were mainly for physical analysis, and concentration, plastic bags made of polyethylene were used for transportation and storage. During the transportation, care was taken to; minimize the interaction between samples, and containers/implements, minimize the interaction between sample, and external environment, treat the sample containers with the same precaution as that of samples, wash the containers and implement with appropriate cleaning agents, and ran appropriate analytical blanks which was referred to every sample.

Quality Assurance and Quality Control for Sample Preparation

Quality assurance and quality control for samples during the sample preparation was ensured that the sample identity and the element distribution in the original sample were maintained until the time of analytical determination (plate 5&6). Appropriate and unambiguous labeling system was designed, implemented, and strictly followed in the analytical laboratory. The transformation applied to the samples was documented in a laboratory logbook with careful registration of date, identity, label, operator, and the type of transformation and any observation of relevance to the interpretation of the final result. Parameters affecting the analytical result were monitored by calibrated instruments and equipment.


Plate 5 and 6: Quality control for sample preparation Source: Fieldwork 2019

Laboratory Test

Bed load sediment Analysis procedure

It was started with the drying of sample. Since the sample was moist, it was placed in an open space where air dried it (plate 7). The mortar and the pestle were used to gently break up any big clumps of the sediment. Any individual pebbles or pieces of gravel were noted. Weigh each empty sieve and record the result (plate 8).The samples were weighed out to the nearest gram on an analytical balance (plate 9). Record the weight of the given dry sediment sample.

Plate 6

Plate 7

Plate 9

All the sieves were assembled in the ascending order of sieve numbers. The sediment samples were carefully poured into the top sieve, and place the cap over it. Sediment sample was poured into the sieve. The sets of sieves with the sediment were placed on the shaker to shake them very well (Plate 10). The stack was removed from the shaker and carefully weighed and recorded the weight of each sieve with its retained sediment (plate 11). In addition, the weight of the bottom pan with its retained fine sediment were weighed, and recorded. The Amount of Material Retained on the Sieve was determined.

Plate 10

Plate 11

The mass of sediment retained on each sieve was obtained by subtracting the weight of the empty sieve from the mass of the sieve + retained sediment, the weight retained on the data sheet was recorded as the mass. The sum of these retained masses should be approximately equals the initial mass of the soil sample. The percentage retained on each sieve was determined. The percent retained on each sieve was calculated by dividing the weight retained on each sieve by the original sample mass. The total weight of each size fraction present in the sediment sample was determined. The total weight of each size fraction present in the sediment sample was determined by subtracting each corrected sieve weight from the previous weight of container plus sediment. Gram size analysis was conducted to determine the sand, silt and clay contents of the channel bank material. The analysis involved the use of 10mm, 4. 75mm, 2.36 mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm and 0.075mm stack sieves.

Calculation of coefficient of Uniformity (C_u) and Coefficient of Curvature (C_c)

The percent passing (or percent finer) was calculated by starting with 100 percent and subtracting the percent retained on each sieve as a cumulative procedure. Quantity passing = Total mass - Mass retained. The percent retained was calculated as; % retained = Mass retained/Total mass. Quantity passing = Mass arriving - Mass retained.

The coefficient of uniformity (C_u) and coefficient of curvature (C_c) using the following equations. $C_u = \frac{D_{60}}{D_{10}}$

While $C_c = \frac{D_{30}^{2}}{(D_{60} \times D_{10})}$ (equation 1) as postulated by (Elizabeth, Melissa, and Scott, 2007)

Coefficient of uniformity here we said is C_u which is equal to D_{60} by D_{10} and Coefficient of curvature as (D_{30} square) by (D_{60} into D_{10}). Effective particle size is indicated as D_{10} which indicates that 10 percent of the particles are finer and 90 percent of the particles are coarser than this size. C_u shows whether the sediment is well graded or poorly graded. C_c complements C_u to evaluate whether the sediment was well graded or poorly graded, or gap graded (Elizabeth, Melissa, and Scott, 2007).

Suspended Load Sediment Sample Analysis

The volume of the filter paper was weighed on electronic weighing machine (plate 12). Filtration method was used by removing fifteen percent (15%) (Plate 13) of the suspended load sample out of the 250 millimeter and filtered it on filtration paper (plate 14).

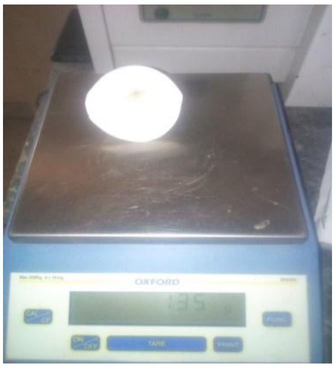

Plate 11

Plate 12

Plate 13

The filtered sampled sediments were dried in oven and weighed (plate 14). After drying, the sediment on the filtering paper was weighed (plate 15).

Plate 14 and 15: drying of retained sediments in oven and weighing

The volume of the filtering paper was subtracted from the filtered sediment load sample. The remaining volume of the suspended load sample was related to the one liter of the suspended load sediment sample and recorded.

Computation of Suspended Load Sediment Discharge

From the indirect vertical integrated measurement method for suspended load sediment discharge, the computation of the obtained concentration value was performed through:-

1. Total suspended load (ml) =250
2. Percentage filtered =15
3. Mass of suspended load in (g) = [Mass of Filter Paper + Suspended load Retained (g)] – [Mass of Empty Filter Paper (g)]
4. Total mass of suspended load (g) = Mass of suspended load ×100
5. Percent retained = Suspended load Retained (g) ×100
6. Total percent retained = total suspended load- Percentage filtered
7. Percent passing = Percentage filtered- Percent retained
8. Total percent passing = Percent passing ×100

When the suspended sediment load discharge for a day was calculated, the result was multiplied by seven (7) to obtain seven (7) days suspended load sediment discharge. For the month, the result of seven (7) days was multiplied by four (4). For the year, the result of one month was multiplied by twelve (12) months.

Plotting of Logarithmic Curve of the Size Distribution:

The information was used to plot logarithmic curves of the size distribution of the silt, clay, Coarse sand, Medium sand, Find sand, gravel, pebble, cobble and boulder fraction of the sample as described previously, through that the grain distribution was determined. D_{10}, D_{30}, and D_{60} from the graph, which corresponded to the particle size for 10% finer, 30% finer and 60% finer (Pramanik, and Hasan, 2017).

Table 1: Sieve Size and Grain Type

S/N	Sieve Size	Sediment Type
1	10mm	Boulder
2	4.75mm	Cobble

3	2.36mm	Pebble
4	1.18mm	Gravel
5	0.600mm	Coarse sand
6	0.300mm	Medium sand
7	0.150mm	Find sand
8	0.075mm	Silts
9	Pan	Clay

Source: Adopted from Horiba 2019

IV. RESULTS AND DISCUSSION

The nature of bed particles (grain size) of Yedzeram channel at Lokuwa Bridge sample station analysis of the channel particle samples revealed that, the mean volume of sediments that passed through Lokuwa Bridge station was 2164g within 20 second, The major nature of the channel bed was medium sand, consisting of 28.60%, followed by coarse sand 27.73%, then fine sand 17.38%, gravel 15.11%, pebbles 6.47%, cobbles 1.99%, boulders 1.76%, silt 0.97%, and 0% clay contents (table 2). This implies that channel bed of Yedzeram majorly consist of medium sand without clay. The results obtained from textural and data analysis revealed that the bed of the channel is mainly sand deposit derived from the erosion processes operating in the drainage basin.

Table 2: The Samples of Grain Size Characteristics of Yedzeram at Lokuwa Bridge Channel Bed

Sieve Type	Wight Retain (gm)	% Wight Retain (gm)	Cum. % Wight Retain (gm)	% Passing (%)
10mm	38	1.76	1.76	98.24
4.75mm	43	1.99	3.74	96.26
2.36mm	140	6.47	10.21	89.79
1.18mm	327	15.11	25.32	74.68
600µ	600	27.73	53.05	46.95
300µ	619	28.60	81.65	18.35
150µ	376	17.38	99.03	0.97
75µ	21	0.97	100.00	0.00
Pan	0	0.00	100.00	
Total	2164			

Source: Fieldwork 2019

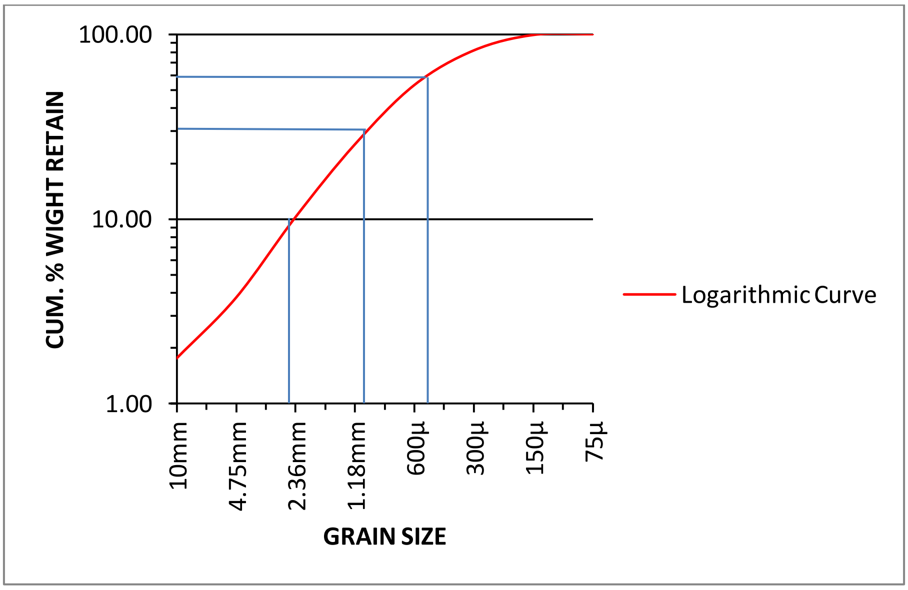

Figure 2: Logarithmic curve of Grain Size of Lokuwa Channel

Source: Fieldwork, 2019

The coefficient of uniformity (C_u) and coefficient of curvature (C_c) using the following equations. $C_u = \frac{D_{60}}{D_{10}}$

While $C_c = \frac{D_{30}^2}{(D_{60} \times D_{10})}$ (equation 1), revealed from the Grain Size Distribution Curve that:

% Pebbles= 10.25_ D_{10}= 3.360 mm
% Gravel = 25.32_ D_{30}= 0.045 mm
% Coarse Sand = 60.2_ D_{60}= 0.525 mm

$$C_u = \frac{0.525}{3.360} \qquad C_C = \frac{(0.045)^2}{(0.525 \times 3.360)}$$

$$= 0.146 \qquad = \frac{0.000841}{1.764} = 4.768$$

Since the C_u = 0.145 is less than 4-6, C_c = 4.768 is above the range 1-3, then the sediment sizes were not well graded. This means that the sediments in the reach were not uniformly graded. In this case, the sediments were not good enough for construction because pebbles, coarse sand and gravels partially dominated the section of the river.

The Nature of Suspended Particles of Yedzeram Channel at Lokuwa Bridge Sample Station

Table 3: The Samples of suspended load Characteristics of Yedzeram Channel Bank at Lokuwa Bridge

weight of cylinder (250 cm^3)	Weight of Cylinder + water (cm^3)	weight of water (cm^3)	% of water filtered (cm^3)	Volume of water Filtered (cm^3)	weight of filter paper	weight of Filter Paper + Sediment	mass of sediment load retained (g)	% weight of sediment
189.41	437.8	248.43	25% = 10	24.843	1.37	1.38	0.01	1.25
189.41	436.5	247.13	25% = 10	24.713	1.36	1.38	0.02	2.5
189.41	440	250.63	25% = 10	25.063	1.35	1.36	0.01	1.25
189.41	437.4	247.94	25% = 10	24.794	1.35	1.36	0.01	1.25
189.41	437.9	248.45	25% = 10	24.845	1.34	1.37	0.03	3.75

Source: Fieldwork 2019

From table 3, total suspended load obtained was 1242.58cm^3, Percentage filtered was 124.258 cm^3, and total Mass of suspended load retained by filter paper was 1.98661g. This indicates that in every 20 second, 2189.63cm^3 volume of water that pass through Lokuwa channel contain an approximate of 1.98661g of suspended load. In a minute, volume of 5.95983g can pass through the channel. In an hour the volume of 357.5898g can pass through the channel. In a day, the volume of 8,582.1552g can passes through the channel, in a week the volume of 60,075.0864g can pass through the channel, in a month the volume of 240,300.3456g. In a year, the volume of 2,883,604.1472g of suspended load can pass through River Yedzeram around Lokuwa Bridge. This result indicated that the volume of water that passes through Lokuwa Bride is averagely turbid. It could not be used directly for washing clothes and bathing.

V. CONCLUSION

This study revealed that the major grain size particle characteristics of Yedzeram channel at Lokuwa Bridbe are coarse sand, pebble and cobble. The suspended load sediments that occurred within the channel and the influence of the suspended load on the land use activities around the river Yedzaram at its middle course are immense.

VI. RECOMMENDATIONS

i. Awareness on the turbid nature of water that pass through Yedzeram channel around Alaokuwa Bridge should be done, so as to reduce the level of negative effects of contaminated water on human and properties.

ii. There is a serious lack of hydrologic and morphometric records and data in the area. Therefore, much data gathering by appropriate agencies in areas like Geomorphology, Hydrology, Geology, Soil science and Soil engineering required from relevant related fields is required.

iii. Dredging of the river channel should be done so as to remove the accumulated bed load particles that are presently cemented in the river. This will result to smooth flow of the water in the river.

REFERENCE

[1]. Aaronfaunch N. (2013). Sediment and agriculture Retrievedon14/02/2016 From https://www.niwa.co.nz/ourscience/freshwater/tools/kaitiaki_tools/impacts/sedimet/cause sediment
[2]. Adebayo A. (2004). Climate in Adebayo A.A (ed). Mubi region: A Geographical Synthesis. Yola: Paraclete Publishers.
[3]. Da O. Jon B. James S. (2005). Assessing Sediment Loading from Agricultural Croplands in the Great Lakes Basin. The Journal of American Science, 1(2). Assessing Sediment Loading from Croplands.
[4]. Elizabeth G., Melissa B., and Scott M., (2007), hydraulic geometry in river channel networks a method for the assessment of river condition.
[5]. Jones G., and Bertlett T., (2012). Process-based principles for restoring river ecosystems. Bioscience 60(3):209–222
[6]. Joanne c. Roger Y. Jon H. Christopher M. John Q. and Ruslle D. (2006).Sediment Assessment Methods: New Zealand, Cawthron Istitude.
[7]. Joanne c. Roger Y. Jon H. Christopher M. John Q. and Ruslle D. (2011).Sediment Assessment Methods: New Zealand, Cawthron Istitude.
[8]. Oliver K. (2016) Assessment of Channel Sedimentation of Selected Reach of River Benue in Yola. An undergraduate project submitted to the Department of Geography, Adamawa State University Mubi, Adamawa State Nigeria.
[9]. Ongley E. (1996). Sediment Measurements: Stockholm, United Nations Environmental programme and World Health Organization
[10]. Opeloye, S.A. and Dio, C.J. (1999). Geology and Minerral Resources: In Adebayo, A.A. and Tukur, A.L. (eds). Adamawa State In Maps. Yola: Paraclete publishers.
[11]. Pramanik M. and Hasan M. (2017), Dhonagoda River: Threats Investigation of River and Biodiversity for Policy Implementation. Received date: November 23, 2017; Accepted date: December 13, 2017; Published date: December 20, 2017.
[12]. Roger Y. (2006).Sediment Assessment Methods: New Zealand, Cawthron Institute.
[13]. Taihoro N. (2013). Sediment and agriculture Retrieved on 14/02/2016 from https://www.niwa.co.nz/ourscience/freshwater/tools/kaitiaki_tools/impacts/sediment/causes/sediment
[14]. Yonnana, E. (2007). Assessment of Channel Morphologic Characteristics of the Middle Course of River Yedzeram, Mubi Northeastern Nigeria. An MSc Geomorphology Thesis submitted to the Department of Geography, Federal University of Technology Yola, Adamawa State Nigeria.