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The Trend in Bed Sediment Characteristic in Sand-mined River Kagara, Katsina State, Nigeria

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Abstract

Sand mining activities is increasing at an alarming rate in Nigeria because of its utilization as cheap material for housing and infrastructural construction. People seem to be exploiting these natural resources extensively without considering the impact posed on the environment. What then are the characteristics of the bed load sediments as a consequence, along the river Kagara chosen for this Study? The study focused on comparing the active mining site as an experimental site, and two other sites free of the mining activities at locations above and below the active mining site along the river channel. Within the stretch of 2000 metres, 100 sample points at an interval of 20 meters were selected in each of the three sites for collection of sediment samples. The bed-load sediment was then taken to the lab for particle size analysis. On this basis, sediment particles size classes grouped by the Hydrologic Cycle, FISRWG, (1998) was used to classify the soil particle size distribution. Analysis reveals that the greater percentage of sand that is moving along the channel was concentrated at the reference site with 91% and the lesser percentage of sand was clearly at the river stretch along the disturbed site with 88%. The information obtained was then analyzed using ANOVA which that there are significant differences in at least one of the three study sites (reference, disturbed or undisturbed) at 95% level of significance. Particle size distribution were significantly difference between the treatments (p=0.0002). The sand was being moves less in the active site, more silt in the undisturbed site and more clay in the active mining site. The bed sediment characteristics vary significantly at a greater rate. It is therefore, recommended that the activity should be strictly limited so that sand recruitment (the rates at which bed load is supplied from upstream to replace the extracted materials) and accumulation rates which are sufficient to avoid prolonged impacts on channel morphology.

Key words: Kagara, Sand Mining, Sediment Characteristics, Active Mining Site

Introduction

Rivers are indispensable fresh water systems that are necessary for the continuation of life. They are resources of great importance across the globe. The benefits of these systems to all living organism cannot be over emphasized as the quality of any body of surface water is a function of either or both natural influence and human activities (Pasquini, 2006).

The effects of sand mining include extraction of bed material in excess of replenishment by transport from upstream which causes the degradation of the stream bed, upstream and downstream of the site of removal. Bed degradation can undermine bridge supports pipe lines or other structures. Degradation may change the morphology of the river bed and degradation can deplete the entire depth of gravely bed material, exposing other substrates that may underlie the gravel. If a floodplain aquifer drains to the stream, ground water levels can be lowered as a result of bed degradation. Flooding is reduced as bed elevations and flood heights decrease reducing hazard for human occupancy of floodplains and the possibility of damage to engineering works, Collins et al. (1990).

Dacker et al (1999) observed that, sand dredging operations can produce large quantities of suspended sediment; elevating turbidity levels and creating deposits in streams. There are several effects on stream caused by dredging activities: such as change in channel morphology, locally increase water velocity and scour, head cutting, streambed modification, enhanced fine particle deposits, remobilization of contaminants in the sediments, and increased turbidity.

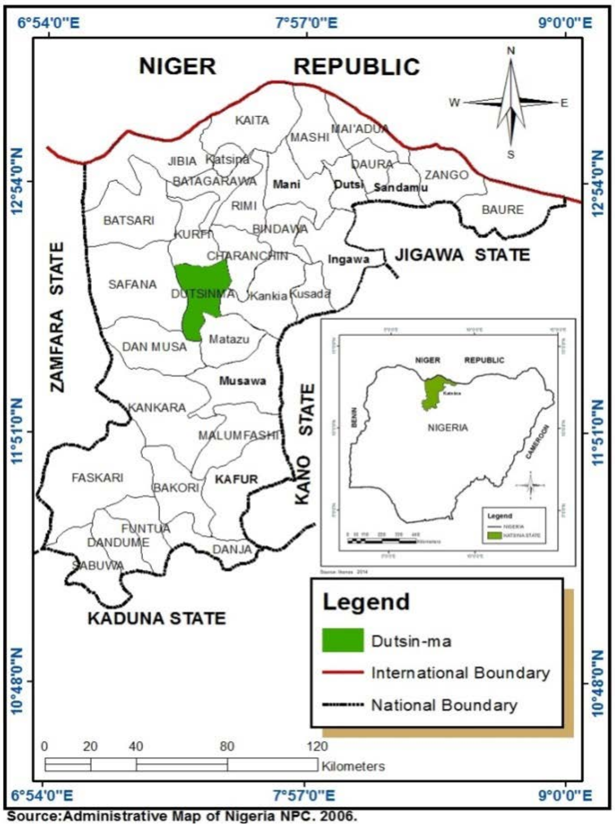
Most of the rivers in the world are overexploited for living and non-living resources and today the challenge posed to the society is to restore its natural ecology. Nabegu (2014b) observed that, in Nigeria sand mining activities is increasing at an alarming rate as a result of its utilization as cheap material for housing and infrastructure construction. As the transportation and construction infrastructure expanded since the mid-twentieth century, the demand for construction grade sand also increased exponentially. The market demand of river sand is high throughout the world.

River Kagara in Dutsin-ma local government of Katsina state is not an exception. The sand mining, which was only in limited levels before 1990s, spreads out in a large scale due to state`s economic development resulted from the stabilization of democratic system of government in the country from 1999 to date. People seem to be exploiting these natural resources extensively without considering the impact posed on the environment. It has become a daily activity where Tipper trucks are carrying river sand on daily bases and labourers are engaged in daily extraction of the sand along the river channel. The sand is for housing and industrial constructions. What then are the characteristics of the bed load sediments as a consequence, along the river Kagara both at the active mining sites and the control sites?

The Study Area

The study area here is the Kagara River channel in Dutsin-ma local Government in Katsina state in the Northern Nigeria (Figure 1.2). It lies within latitude 12^{0} 28` 52$''$to $12^{0}$ 26`15$''$North of the equator and between longitude 7^{0} 30`00$''$ E to $7^{0}$ 31` 30$''$ E of the Greenwich meridian. The area covers a distance of 6000 metres.

The geology of the study area is found to have linked with the southern margin of the Mesozoic and tertiary lullamedan basin of the south sahara. The crystalline base portion of this area predominantly consists of granite-magmatite and gneiss rock jones, (1975).



Source:Administrative Map of Nigeria NPC. 2006.

Figure 2: Map showing the location of the Study Area

Kogbe, (1976) reported that, in Katsina area the geology consists of two of the four groups Paleozoic and Precambrian crystalline which are the older granite of the pre-cambrian and basement complex of the Dahomeyan.

The climate of the area is chracterised as tropical wet and dry type (tropical continental climate) classified by Koppen as Aw climate. Duration of rainfall receive is four month which fallsbetween May and September with its peak in August. The average annual rainfall is about 700mm. pattern of rainfall in the area is highly variable. The mean annual temperature ranges from 29^oc-31^oc. the highest air temperature normally occur in April/May and the lowest in December.

The humidity in the study area changes abruptly with the movement of hamattan or mosoon air. After wet season, Northern air moves faster towards the south, resulting in a steeper decrease of relative humidity (Ibrahim, 2013).Evapotranspiration is generally high throughout the year. The highest amount of evaporation occur during the dry season. (Abaje, et. al 2014).

The soil type of the area is Ferruginous tropical brown and reddish brown soil derieved from basement complex rock. The parent material underlying the area are composed of unconsolidated sands, the nature of which makes part of the area very porous and susceptible to erosion, Scott (1985). Top soils are largely influenced by the drift material and are thus similar in properties except on eroded and some alluvial soils. FAO (1989) reported that, the soil are generally sandy which have little humus and are easily cultivated.

The vegetation of the study area is Sudan Savanna type which combines the characteristics and species of both the Guinea and Sahel Savanna (Abaje et al, 2014). Trees and short grasses (usually less than 1metre) predominate. Although it is difficult to define exactly where the boundary of the vegetation should be positioned

The drainage is formed by the main Kagara river and its tributaries. It was also a tributary to River Karadua which is now dammed at Makera along Dutsin-ma to Kankara road. As a result of the damming, the Kagara river is no longer a tributary to Karadua river but instead emptyits water directly into Zobe dam. However, the river is stil part of the major Karadua river Basin which is the largest in Katsina state.

The Kagara river forms a basin of its own covering a considerable area south of Dutsin-ma. The river stretched from northwest around Farar Kasa village to the south where it enters the Zobe dam reservoir.

Methodology

Sampling

The focus of the study is on comparing the active mining site as an experimental site, and two other sites free of the mining activities at locations above and below the active mining site along the river channel. As a result of this, the channel was divided into three sites based on the method used by Brown et al. (1998) and Nabegu (2014) which consisted of:

- Site before the active mining area
- Active mining area
- Site after the active mining area

These sites and their spatial extent are shown in Figure 1.

The site before the sand mining site was assumed to be undisturbed by the sand mining activity and considered as reference site; the site after the sand mining is the segment with no active mining activity but, with consequent impact of mining activity; whereas the active mining site is the stretch with current active sand mining. Within the stretch of 2000 metres, 100 sample points at an interval of 20 meters were selected in each of the three sites for collection of sediment samples.

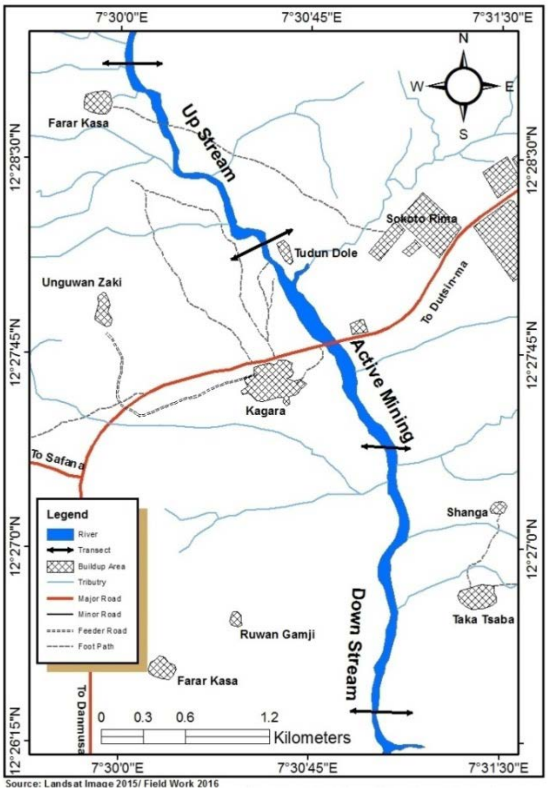


Figure 1: Map of River Kagara Showing the three sites investigated

Data Collection

To meets up with the requirement of the objective set in assessing the changes in bed sediment characteristics within the three study sites, the bed-load sediments data were generated with the aid of hand trowel machine. Each transect was randomly selected at equidistant of 200 meters at three parallel points; the left bank, the center and the right bank of each sample point. The sediments were then mixed up to ensure a reliable sample with good representation of each of the study sites.

Method of data analysis

The bed-load sediment was then taken to the lab for particle size analysis. On this basis, table 1 was used to classify the soil particle size distribution.

Table 1: Sediment size classes grouped

Size Class	Size range(mm)
Bedrock	>2,048
Boulder	256-2,048
Cobble	64-256
Gravel	2-64
Sand	0.062-2
Silt/clay	<0.062

Source; - The Hydrologic Cycle, *FISRWG (1998)*

Results and Discussion

Table 2: shows the particle size distribution of the sediments along the three study sites. It is clear to see in the table that the greater percentage of sand that is moving along the channel was concentrated at the reference site with 91% and the lesser percentage of sand was clearly at the river stretch along the disturbed site with 88%. This is as a result of the obvious conception that, greater percentage of sand is being removed by sand mining activities. The rate of silt is also very low in

the stretch before the mining site having only 4%; the stretch after the mining site almost doubled that amount found at the stretch before the mining site; whereas, active mining site is having only 6%. The stretch after the Active mining site has greater percentages of silt; this is as a result of the bulk sand removed along the Active mining site thereby leaving behind finer particles. Moreover clay particle was found greater in the active mining site. This also revealed that, the top sand was removed, thereby exposing deep down the bed of which superficial part was carried in suspension to the region after mining site. Low clay content was determined along the stretch after mining site. For obvious reasons greater percentage of clay in the middle stretch was attributed to the bank collapse which adds to the percentage of clay in the stretch of the active mining site. This correspond with the findings of Brown et al (1998), who concludes that sand mining results in fine particle dynamics.

Table 2: Particle size distribution

Sample ID	%Sand	%Silt	%Clay	Textural Class
Up stream	91	4	5	Sand
Down stream	90	7	3	Sand
Active mining site	88	6	6	Sand

Source: Author`s field work

The analysis of variance (ANOVA) conducted for this study provides sufficient bases for logical conclusion that, there are significant differences in at least one of the three study sites (reference, disturbed or undisturbed) at 95% level of significance. Particle size distribution were significantly difference between the treatments (p=0.0002) the sand were being moves less in the active site, more silt in the undisturbed site and more clay in the active mining site (table 3).

Table 3: Analysis of Variance (ANOVA) on Channel particle size distribution

SOURCE	SS	Df	MS	F	P-Value
Between Group	14,281.99	2	7141	3051.71	5.14
Within Group	14.01	6	2.34		
Total	14,296	8			

The study therefore, resolves that there are significant spatial variations of the bed sediment loads along the three studied sites.

Conclusion

This study examines the spatial variation of bed sediment characteristics imposed by the activities of sand mines by assessing the changes at the three identified study sites. It is obvious to conclude that sand mining changes the original state of the texture of bed sediment to a considerable level. Though other factor may lead to certain change along the river, yet the mining activity has beyond any reasonable doubt that the bulk sand removed along the Active mining site thereby leaving behind finer particles in the River. Moreover clay particle was found in high concentration in the active mining site which revealed that, the top sand was removed, thereby exposing deep down the bed of which superficial part was carried in suspension to the region after mining site. At the region beyond, low clay content was determined which for obvious reason was attributed to the bank collapse which adds to the percentage of clay in the stretch of the active mining site.

It is also logical to conclude that sand mining resulted changes in sediment characteristics with clear evidence of deterioration of the soil texture, hence degradations of the immediate as well as the larger environment.

Recommendations

River sand provide physical setting for river ecosystems and changes in hydro morphology have impacts on ecosystem functioning. For that therefore, there is the need to control such sand mining activities by implementing strict rules and regulations to govern the activity.

The activity should be strictly limited so that sand recruitment (the rates at which bed load is supplied from upstream to replace the extracted materials) and accumulation rates which are sufficient to avoid prolonged impacts on channel morphology.

An integrated environmental assessment, management, and monitoring program should be a part of the extraction operation, so as to encourage the Federal, state, and local governments in the assessment and prediction of possible environmental impacts. Further studies should be promoted in order to generate information on the various impacts of sand mining on the rate of bank erosion and sedimentation.

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