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Analysis of Suspended Sediments and Channel Morphometry of Igbogene and Swali Streams in Bayelsa State, Nigeria

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ABSTRACT: This study investigated suspended sediment dynamics and channel morphometry of Igbogene and Swali streams in Yenagoa Local Government Area, Bayelsa State, Nigeria. Sediment production and transport in streams are influenced by a range of natural and anthropogenic factors, including flow characteristics, channel geometry, and surrounding land use. The objectives of the study were to assess and compare the depth and width of the two streams. Data analysis was performed using chi-square contingency tests at a 0.05 level of significance. Results revealed that the calculated chi-square value for depth (8.654) exceeded the critical table value (3.841), leading to the rejection of the null hypothesis, indicating a significant difference in the depth of the streams. Similarly, the calculated chi-square value for width (162) was greater than the table value (3.841), also resulting in rejection of the null hypothesis and demonstrating a significant difference in the width of the streams. Based on these findings, the study recommends the restoration and conservation of wetlands within floodplains, which can act as natural filters to reduce suspended sediment loads, enhance water quality, and support the ecological integrity of the streams. The results provide useful insights for sustainable water resource management and environmental planning in the Niger Delta region.

KEYWORDS: Suspended Sediments, Stream, Morphometry, Stream Sedimentation.

INTRODUCTION

Streams are dynamic bodies of water that exhibit continuous movement, commonly referred to as a current. Geologists classify streams into various categories based on attributes such as size, depth, velocity, and geographical location. Terms like creeks, brooks, tributaries, bayous, and rivers are often collectively termed as streams. The primary characteristic that defines a stream is its flowing nature, driven by gravitational forces, which propels water downhill. However, the specific path and behavior of this downhill movement are influenced by factors like rock type, topography, and other environmental conditions (Roering, 2007). The distinction between streams and rivers is nuanced and often context-dependent. In geological terms, a stream encompasses any flowing body of water, regardless of size, while a river is typically considered a larger stream. This classification is based on the stream order system, where streams are ranked from first-order (smallest) to higher orders as they merge with other streams. For instance, the Mississippi River is a tenth-order stream, indicating its large size and extensive network of tributaries Christopherson (2002). Understanding the classification and behavior of streams is crucial for comprehending their role in the hydrological cycle, sediment transport, and landscape evolution. In regions like Bayelsa State, Nigeria, where streams such as Igbogene and Swali are prevalent, these water bodies significantly influence local ecosystems, agriculture, and human settlements. Therefore, a detailed analysis of their suspended sediment dynamics and channel morphometry is essential for effective environmental management and planning (Oku, 2005).

Stream morphometry refers to the quantitative analysis of a stream's shape, size, and spatial configuration. This field of study is integral to geomorphology, as it provides insights into the structural characteristics of river systems and their evolution over time. Key morphometric parameters include drainage density, stream frequency, bifurcation ratio, and elongation ratio, among others (Achite, 2007). These indices help in understanding the hydrological behavior of a watershed, its susceptibility to flooding, and its capacity for sediment transport and deposition. Recent advancements in Geographic Information Systems (GIS) and remote sensing technologies have significantly enhanced the precision and efficiency of morphometric analyses allowing for detailed assessments of river basins and their dynamic processes (Twidala, 2002). The study of suspended sediments within streams is crucial for assessing water quality and understanding sediment transport mechanisms.

Suspended sediment concentration (SSC) is influenced by various factors, including precipitation, land use, and stream-flow dynamics. Recent studies have employed advanced statistical and modeling techniques to analyze trends in SSC, providing valuable insights into sediment dynamics and their implications for water quality management (Rai, et al 2017). Integrating morphometric analysis with sediment dynamics offers a comprehensive approach to understanding river systems. Such integrated studies facilitate the development of predictive models that can inform river management strategies, particularly in regions experiencing rapid environmental changes. For instance, research has highlighted the importance of incorporating sediment transport dynamics into river basin management to mitigate the impacts of erosion and sedimentation (Pere, 2017). In the context of Bayelsa State, Nigeria, where streams like Igbogene and Swali are prevalent, understanding the interplay between stream morphometry and suspended sediment dynamics is essential. These water bodies significantly influence local ecosystems, agriculture, and human settlements.

Stream sedimentation is the process by which particles suspended in water settle and accumulate at specific locations within a channel (Dunne, 2000). This phenomenon involves the deposition of sediments across various aquatic environments and can also describe the obstruction of water flow caused by sediment accumulation (Slaymaker, 2000). Essentially, sedimentation occurs when gravity causes suspended particles in a stream to descend and deposit along the bed or banks. The materials that settle from the flowing water are collectively referred to as sediments (Gregory, 2010). Sediments enter streams primarily through surface erosion, which can occur via slope processes, mass wasting, stream-bank erosion, and contributions from tributaries. In streams whose channels are not confined by valleys whether flat or lacking well-developed floodplains sediment input is often dominated by rapid mass wasting and pronounced bank erosion (Church & Ryder, 2001). In order words, it is necessary for an individual to understand the balancing, in relation to the policies and socio-economic factors leading to sediments load, which is critical to the sustainable management of the basin (Zapata, 2002). Therefore, a detailed analysis of their suspended sediment concentrations and morphometric attributes is crucial for effective environmental management and planning.

Purpose of the study

The purpose of the study was the Analysis of Suspended Sediments and Channel Morphometry of Igbogene and Swali Streams in Bayelsa State, Nigeria and the specific objectives were to:

1. Examine the depth level of both streams.
2. Examine the nature of width in both streams

Research Hypotheses

1. There is no significant difference of depth level between the two streams.
2. There is no significant difference of velocity between the two streams.

Literature Review

Several studies have examined suspended sediments and stream morphometry in tropical river systems, providing valuable insights that are relevant to the investigation of Igbogene and Swali streams in Bayelsa State.

Sylla, Servat, Gaye, and Dacosta (2013) conducted an extensive nine-year monitoring program on the Niger River, analyzing the relationship between suspended sediment concentration and river discharge. Their findings revealed distinct seasonal patterns, including hysteresis during flood events, emphasizing how sediment dynamics are closely tied to hydrological variability in tropical rivers. Building on this, Sylla, Gaye, Dacosta, and Servat (2013) developed predictive models for the Upper Niger River Basin at Banankoro to simulate the temporal evolution of suspended sediment concentrations during floods. Their models highlighted that sediment transport is not only influenced by the amount of water flow but also by the availability and mobilization of sediment within the watershed, demonstrating the interplay between hydrological forces and sediment supply in shaping river channel characteristics.

In a complementary study, Emmanuel, Ouyang, and Gessesse (2021) developed regression models to estimate sediment transport specifically in tropical rivers. They pointed out that sediment characteristics and hydrological responses in tropical regions differ significantly from those in temperate climates, necessitating the use of region-specific models to accurately predict sediment behavior. Their findings underscored the importance of tailoring sediment management and river analysis approaches to the local environmental context, which is particularly pertinent to Bayelsa State's Niger Delta streams. Similarly, Vercruysse, Poesen, and Vanmaercke (2017) explored the multi-scale drivers of suspended sediment transport, emphasizing the combined influence of hydro-meteorological conditions, catchment characteristics, channel morphology, and human activities. Their review highlighted that sediment transport is a complex process, shaped by both natural and anthropogenic factors, and that understanding these drivers is essential for effective watershed management and floodplain conservation.

Further insight into the modeling of sediment transport in small tropical catchments was provided by Fritz, Vincent, and Le Cozannet (2023), who developed a phenomenological model for the Capesterre River in Guadeloupe. Their work illustrated how flood events, sediment properties, and channel morphology jointly influence the concentration and movement of suspended sediments, reinforcing the concept that both geomorphological and hydrodynamic factors must be considered when analyzing river systems.

Syvitski and Milliman (2007) investigated sediment fluxes in tropical deltaic rivers, emphasizing the role of both natural and anthropogenic factors in controlling sediment delivery to downstream channels. Their findings showed that human activities such as deforestation, urbanization, and agriculture can significantly accelerate sediment mobilization, altering channel forms and increasing sediment loads. Likewise, Dutta, Sinha, and DeFries (2020) examined the morphometric characteristics and sediment transport patterns of smaller tropical rivers in South and Southeast Asia. They demonstrated that stream geometry, including width, depth, and slope, strongly influences sediment deposition patterns and channel evolution. Their study further revealed that extreme rainfall events could drastically increase sediment loads, leading to rapid changes in channel morphology over relatively short time scales. Such findings highlight the dynamic nature of tropical streams and underscore the need for continuous monitoring and morphometric analysis to anticipate sedimentation impacts on aquatic ecosystems and local communities.

METHODOLGY

Research Design

The study used both experimental design and field survey. It has to do with, defining the problem, the objective of the problem will be stated, identifying of variable to be controlled, the variable will be specified.

Source of Data

The source of data was based on primary and secondary data. Primary data is the type of data in which the researchers get information directly from the field in order to claim the stated hypothesis. Primary data is the first-hand data collected by the researcher. The data is being collected through direct field observation or physical measurement.

Sample Frame

A linear distance of each stream under study is 16.7km for Swali stream and 11.4km for Igbogene stream, the sampling interval is 200m which gives a sampling frame of 83 for Swali stream and 57 for Igbogene stream respectively. The sample that is being taken is seen as a representative of the wider stream, so as the conclusions drawn from the study can be reasonable extrapolated to the areas that were not included.

Sample Size/Sampling Techniques

The study employed a simple random sampling technique to select the designated sample points. Simple random sampling is a probabilistic sampling method in which every member of the study population has an equal chance of being selected (Oku et al., 2004). This ensures that each element of the population has the same probability of inclusion, thereby providing an unbiased and representative subset of the larger population. Based on this sampling approach, a total of 83 sampling points were selected for Swali stream, while 57 points were chosen for Igbogene stream.

Instrument for Data Collection

Measuring instruments were two flags (to mark the start and end of the stream monitoring section), measuring tape, any colour of float device, stop watch, handheld GPS and calculator

Method of Data Collection

The depth of the streams were measured with the aid of tape and ranging pole, the tape was lap to the ranging pole and the pole was pin at right angle of the channel bed at two interval in order to be sure is at the equal interval, the level where the top water touches the tape the reading is then taken from the vertical distance from the channel bed direct to the water level and the average of it is being taken as the depth of the stream.

The width of the stream channel was measured by stretching the tape across the stream channel from one edge to the other; the data got from the measurement is then recorded as the width of the stream.

The dataset is analyzed based on the results got from the laboratory. However, Chi-Square technique is used in testing the records of the field work. The observed information was in the form of contingency table.

Method of Data Analysis

The data is analyzed based on the result gotten from the laboratory. However, Chi-Square is used in testing the records of the field work. The observed information will come in form of contingency table

$x^2{}_{test} = \sum \frac{(0-E)^2}{E}$ where O = observed frequency, and E = expected frequency

$x^2{}_{critical} = x^2{}_{a(df)}$

Where $a = level\ of$

$df = degree\ of\ freedom$

Data Presentation

Table 4.1: Depth level of Igbogene and Swali Streams

Stream	Meters
Igbogene	1.2192
Swali	11.85672

Source: Researcher's field work 2022

Table 4.2: Width of Igbogene and Swali Streams

Stream	Meters
Igbogene	22
Swali	220

Source: Researcher's Field work 2022

Hypothesis 1

The null hypothesis, there is no significant difference in depth level of the both streams. It was analyzed with one sample chi-square contingency table (table 4.3) which reveals that the calculated value (8.6538) is greater than the table value (3.841) at 0.05 level of significant, reject null hypothesis which states there is no significant difference in the depth level of the both streams.

Table 4.3: One sample Chi-Square of depths of the Streams

χ2 cal.	χ2 critical	Alpha level	Result	Decision
8.6538	3.841	0.05	Significant	Reject null hypothesis

Source: Researcher's Field Work 2022

4.2.3: Hypothesis 2

The second null hypothesis, there is no significant difference in the velocity of Igbogene and Swali streams. It was analyzed with one sample chi-square contingency table (Table 4.4) which reveals that, the calculated value (7.15) is greater than the table value (3.841) at 0.05 level of significant, the null hypothesis was rejected, which state that, there is no significant difference in the level of velocity of the two streams.

Table 4.4: One Sample Chi-Square of velocity of the streams

$\chi 2$ cal.	$\chi 2$ critical	Alpha level	Result	Decision
7.156	3.841	0.05	Significant	Reject null hypothesis

Source: Researcher's Field Work 2022

DISCUSSION OF FINDINGS

The study, which analyzed suspended sediments and channel morphometry of Igbogene and Swali streams in Yenagoa Local Government Area, revealed significant differences in the depth and width of the two streams, which have implications for sediment transport and channel dynamics. The depth of the streams was measured in meters, with Igbogene stream recording an average depth of 1.22 m, while Swali stream had a significantly greater depth of 11.86 m. This substantial difference indicates that Swali stream is considerably deeper, which corresponds with a higher hydraulic gradient. A steeper gradient facilitates faster water flow, enhancing the stream's capacity to erode its bed and banks and transport sediments over longer distances. Faster flow velocities also contribute to the formation of pits and scour marks on the streambed, indicating active erosional processes. These findings align with the observations of Christopherson (2002), who noted that the volume and nature of materials transported by a stream are largely influenced by flow velocity and stream gradient. Similarly, Zuecco et al. (2016) highlighted that the intensity of erosion is strongly dependent on water flow, while particle size and the cohesiveness of materials also regulate sediment mobilization and deposition (Christopherson, 2002).

The width measurements further illustrate significant differences between the streams. Igbogene stream has an average width of 22 meters, whereas Swali stream spans approximately 220 meters, making it ten times wider. A wider stream provides a larger surface area for interaction with the surrounding landscape, increasing its susceptibility to soil erosion and sediment deposition from adjacent land use activities. Wider channels generally carry greater volumes of suspended sediments, as more debris is entrained into the flow. The combination of depth and width in Swali stream not only increases its sediment transport capacity but also affects the spatial distribution of sediments, with finer particles remaining in suspension for longer distances, influencing water turbidity and quality.

Overall, the differences in depth and width between Igbogene and Swali streams underscore the influence of morphometric characteristics on sediment dynamics. Swali stream's greater depth and width facilitate higher flow velocities and sediment transport capacity, making it a more dynamic system compared to the relatively shallow and narrow Igbogene stream. These findings are consistent with prior research, which emphasizes that channel geometry specifically depth, width, and gradient is a critical determinant of erosion intensity, sediment load, and fluvial processes (Rai et al., 2017; Christopherson, 2002; Zuecco et al., 2016).

The study highlights the importance of understanding stream morphometry in relation to suspended sediment transport, as these characteristics not only affect the physical structure of the channel but also influence ecological health and water quality. The results suggest that management strategies aimed at reducing sedimentation impacts in these streams should consider both the depth and width variations, as these directly affect the capacity of each stream to erode, transport, and deposit sediments across the watershed.

CONCLUSION AND RECOMMENDATION

Suspended sediments in a stream is seen as one of the major problems facing the study areas. When sediments is deposited in excess it will lead to bed aggradation, in a way of raising the flood water level in the area. In a stream where the sediments level I reduced it will improve the water quality, aquatic habitats and also the issue concerning flooding will be reduced drastically. The issue of sediments in a stream is due to weathering factors, and man induced activities in the areas. The research work is based on the analysis of suspended sediments and channel morphometry
Morphometry parameters such as depth and width of the streams were measured in meters. The channel morphometry of Swali stream is much deeper, wider, flatter and the water move faster than the Igbogene Stream.

Based on the above findings, the following recommendations were made;

- ❖ The state ministry of environment and urban development has to ensure yearly desisting of the river channel to prevent the risk at which flooding occur in the areas.
- ❖ Ensure proper measurement of channel characteristics for the prediction and management of flood hazards among the two-stream channels.
- ❖ Sediments management actions must be reasonable and justified.
- ❖ Government should take note of the sediments related problem and identify its cause.

SUGGESTIONS FOR FURTHER STUDIES

1. **Longitudinal Monitoring of Sediment Transport:** Future research could involve long-term monitoring of suspended sediment concentration and transport dynamics in Igbogene and Swali streams across different seasons. This would allow for the assessment of temporal variability in sediment loads in response to rainfall patterns, storm events, and anthropogenic activities.
2. **Impact of Land Use and Human Activities:** Further studies could investigate the influence of surrounding land use, including agriculture, urbanization, and construction activities, on sediment load and stream morphometry. Understanding how these factors alter erosion rates and sediment deposition could inform watershed management and mitigation strategies.

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3. **Hydrodynamic and Hydraulic Modeling:** Subsequent research could develop detailed hydrodynamic models to simulate flow velocity, sediment transport, and deposition patterns under varying flow conditions. Such models would help predict the behavior of sediments under extreme rainfall events or flood conditions, improving flood risk assessment and sediment management.
4. **Ecological Implications of Sediment Load:** Additional studies could focus on the ecological consequences of high suspended sediment concentrations, including impacts on water quality, aquatic biodiversity, and fish habitats. Linking sediment characteristics to biological health could provide a more holistic understanding of stream ecosystem sustainability.
5. **Comparative Studies across Streams of Different Orders:** Future research could expand to include multiple streams of varying orders within the Niger Delta or similar tropical regions. Comparative analyses would enhance the understanding of how stream order, gradient, and morphometric characteristics influence sediment transport and deposition dynamics.
6. **Impact of Climate Change on Sediment Dynamics:** Research could also explore how changing rainfall patterns and extreme weather events related to climate change affect suspended sediment transport and stream morphology in the region, providing insights for adaptive water resource management.

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