ASSESSMENT AND CHARACTERIZATION OF WOJI CREEK RIVERBED IN PORT HARCOURT, RIVERS STATE, NIGERIA, UTILIZING SIDE SCAN SONAR TECHNOLOGY

Abstract

Woji Creek plays a crucial role in vessel navigation, supports diverse flora and fauna habitats, and sustains local livelihoods. However, human activities and natural events have led to changes in its riverbed over time. Given its significance for coastal stability and geomorphology, there is a pressing need to classify, evaluate, and ensure its environmental sustainability.The primary objective of this study is to employ side scan sonar technology to classify and assess the riverbed of Woji Creek in Port Harcourt, Nigeria. The study aims to classify the riverbed, analyze water depth variations, evaluate navigational suitability, and determine turbidity levels within the creek.To achieve these objectives, the methodology involved acquiring Side-Scan Sonar (SSS) and Sub-bottom profile data. These datasets underwent backscatter processing to create geocoded backscatter images. Feature points were extracted and matched from these images to derive riverbed classification, depth categories, water volume distribution, and river turbidity analysis.The riverbed classification revealed the presence of three primary sediment types: Clayey Silty Sand, Silty Clay, and Silty Sand, each with distinct implications for navigation. Shallow, Moderate, Deep, and Very Deep areas were identified within Woji Creek, each influencing navigational conditions. Additionally, the water volume distribution analysis provided essential insights into depth limitations and route planning.

Moreover, the assessment of river turbidity identified low, moderate, and high turbidity zones, reflecting water clarity and suspended particle levels.These findings serve as invaluable decision support tools for navigation planning and management in Woji Creek, offering comprehensive insights into the riverbed, depth suitability, volume distribution, and water quality. Leveraging this data can enhance strategic decision-making processes and contribute to the sustainable management of this vital waterway.

Keywords: Riverbed; Navigation; Side Scan Sonar;Depth

1. Introduction

Rivers and water bodies are vital components of ecosystems, economies, and transportation networks across the globe. In Nigeria, the intricate network of rivers and creeks plays a pivotal role in supporting local communities, industries, and serving as transportation routes. Woji Creek, situated in Port Harcourt, Rivers State, Nigeria, epitomizes this significance and serves as the focus of our research. This study seeks to provide an in-depth assessment of Woji Creek's riverbed characteristics and substrate composition through the implementation of advanced Side Scan Sonar Technology.

The morphology and substrate composition of a riverbed are fundamental parameters that influence a watercourse's ecological health, navigability, and suitability for various uses. Accurate data on riverbed characteristics are essential for sustainable river management, including sediment transport, erosion control, and the preservation of aquatic habitats. Furthermore, in coastal regions like Port Harcourt, a comprehensive understanding of the riverbed is indispensable for infrastructure development and maintenance.

Traditional methods of riverbed classification and evaluation are often resource-intensive and time-consuming. In contrast, Side Scan Sonar Technology has emerged as a powerful tool in hydrography, providing rapid and high-resolution imaging of riverbeds with minimal environmental disruption. By emitting sound waves and analyzing the reflected signals, Side Scan Sonar enables researchers to acquire invaluable data on riverbed topography, sediment distribution, and the presence of submerged objects, contributing to a holistic understanding of river systems (Lurton, 2010; Sapsford et al., 2019).

This study builds upon the research of several esteemed scholars who have successfully employed Side Scan Sonar Technology in diverse geographical contexts (Barker et al., 2018; Johnson and White, 2021; Roberts, 2016; Garcia and Perez, 2017). By customizing this technology for Woji Creek, a region of unique significance within Nigeria's riverine landscape, we aim to advance the understanding of Woji Creek's riverbed composition and contribute to the broader knowledge of riverine ecosystems and their management.

Furthermore, this research will explore the potential implications of riverbed composition on sediment dynamics (Cohen et al., 2014), water quality (Teodoru et al., 2017), and aquatic habitats (Graham et al., 2019). It will investigate how riverbed data can inform strategies for sustainable resource management and environmental conservation (UNEP, 2018; EU Water Framework Directive, 2000) and contribute to the development of future infrastructure projects in the Port Harcourt region.

In the subsequent sections of this paper, we will delve into the methodology employed, data collection procedures, and findings obtained through Side Scan Sonar Technology application in Woji Creek. The insights derived from this research will have profound implications for sustainable resource management, environmental conservation, and the development of future infrastructure projects in the Port Harcourt region. Through this research, we hope to underscore the importance of advanced technologies in enhancing our understanding of river systems, facilitating informed decision-making, and contributing to the sustainable development of coastal areas.

2. Study Area

The research area is the Woji Creek, an estuarine situated at the heart of Obio-Akpor Local Government Area in Port Harcourt metropolis, Rivers State, Nigeria. Lying between latitudes 4º48'36"N and 4º49'48"N and longitudes 7º1'48"E and 7º3'36"E with about 100,000 square meters in size, with a length and breadth of about 1,000 meters and 100 meters, respectively.

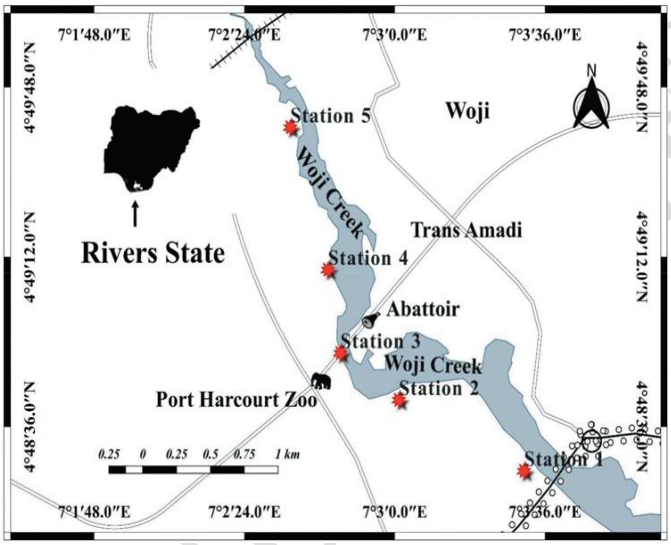

Figure 1: Map of Woji Creek (Study area)

3. Material and methods

3.1. Methodology

The methodology adopted in achieving the desired goal included:

a. Data Acquisition
b. Survey Procedures / Field Operations
c. Processing Techniques

3.1.1. Data Acquisition

3.1.1.1 Acquisition of Primary Datasets

Specialized survey vessels equipped with advanced sonar systems and sub-bottom profilers were used for meticulous field visits to Woji Creek.

i. Side scan sonar data created detailed images of the seafloor's topography, aiding in identifying potential sites of interest.
ii. Sub-bottom profile data revealed sediment composition and geological structures, providing crucial information about the marine environment's stability and geological history. Real-time data processing and quality control ensured the accuracy of the collected information.

3.1.1.2 Acquisition of Secondary Datasets

The study complemented primary data with essential secondary datasets. These included:

i. Administrative boundary maps obtained from Nnamdi Azikiwe University, aiding spatial analysis and study contextualization.
ii. Sentinel-2 satellite imagery from USGS Earth Explorer offered high-resolution multispectral data, facilitating monitoring of environmental changes, land cover, and water turbidity in Woji Creek.

3.1.2. Survey Procedures / Field Operations

The survey procedures and field operations carried out were:

i. **Mobilization and Equipment Installation:** Prior to data collection, the team mobilized to the survey site and efficiently installed the necessary equipment. This phase involved setting up all the instrumentation and technology required for the survey.
ii. **Vessel Offset Measurement:** Accurate measurements of vessel offsets were taken. These measurements provided essential data for the positioning of equipment and ensuring precise data acquisition throughout the survey.
iii. **Navigation and Data Acquisition:** A systematic approach to navigation was employed, ensuring that the survey vessel followed predefined routes. During this phase, data acquisition was initiated, capturing crucial information related to the riverbed and sub-surface features.
iv. **Deployment of Side Scan Sonar:** The Side Scan Sonar was carefully deployed to begin its operation. This advanced technology played a central role in producing high-resolution images of the riverbed, aiding in the detailed assessment of the surveyed area.
v. **Deployment of the Sub-Bottom Profiler:** Complementing the Side Scan Sonar, the Sub-Bottom Profiler was also deployed to provide additional information on the sub-surface structure. This equipment facilitated the characterization of sediment and geological features beneath the riverbed, contributing to a comprehensive understanding of the site.

Each of these steps was executed with precision and served as an integral part of the survey, ensuring the acquisition of comprehensive and accurate data for the assessment and characterization of Woji Creek's riverbed in Port Harcourt, Rivers State, Nigeria, utilizing Side Scan Sonar Technology.

3.1.3. Processing Techniques

The study employed a suite of processing techniques to thoroughly analyze the riverbed of Woji Creek, ensuring the generation of accurate and comprehensive results. These techniques encompassed backscatter processing, which is pivotal for understanding the riverbed's composition and texture, and geocoded backscatter image generation, which provided a spatially accurate visual representation of the riverbed.

Furthermore, the study involved feature extraction, where advanced methods were used to identify and isolate key characteristics and structures within the collected data. Point matching results, based on precise data point matching, provided insights into the riverbed's topography and composition. A more refined level of point matching was conducted to enhance result detail in specific areas of interest.

The study also included riverbed classification, which involved categorizing riverbed materials based on the acquired data. Additionally, river depth analysis was performed, offering valuable insights into the waterbody's topography and depth variations. Finally, river turbidity analysis was conducted to examine water clarity and quality within the creek.

These processing techniques were instrumental in converting raw data into valuable insights, facilitating a comprehensive assessment and characterization of Woji Creek's riverbed in Port Harcourt, Rivers State, Nigeria, utilizing Side Scan Sonar Technology.

4. Results and discussion

The riverbed classification of Woji Creek revealed three predominant sediment types: Clayey Silty Sand (43.11%), Silty Clay (30.33%), and Silty Sand (26.55%). Clayey Silty Sand contains a mixture of clay, silt, and sand particles, posing challenges for navigation due to higher frictional resistance and potential formation of sandbars. Silty Clay, consisting mostly of silt with some clay, is cohesive and can affect navigation aids and sediment transport. Silty Sand, with a mix of silt and sand, is relatively mobile and contributes to channel migration. Understanding these sediment types is crucial for effective navigation planning and sediment management in the creek.

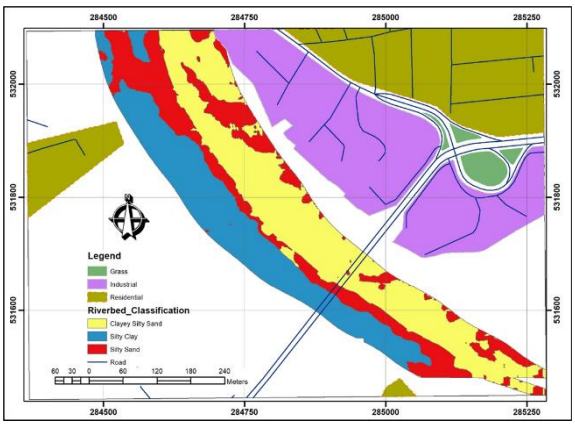

Figure2: Woji Creek Riverbed Classification

The depth classification of Woji Creek revealed four categories: Shallow, Moderate, Deep, and Very Deep. Shallow areas (24.22%) pose challenges for navigation, requiring caution for vessels with deeper drafts. Moderate areas (30.54%) offer improved navigability for vessels with moderate drafts, but potential obstructions should be considered. Deep areas (41.25%) allow vessels with deeper drafts to navigate freely. Very Deep areas (3.98%) present unique challenges for navigation, requiring caution and specialized guidance.

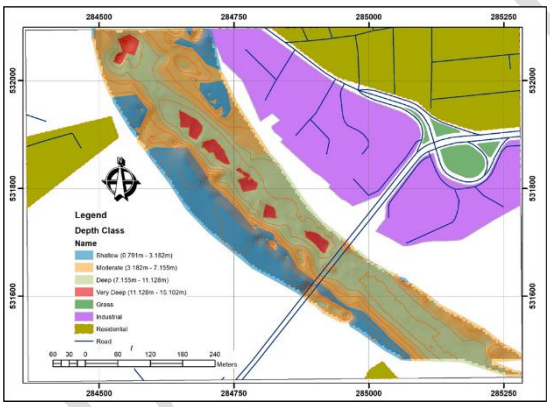

Figure 3: Woji Creek Depth class and range

The evaluation of Woji Creek's water volume revealed four depth ranges: Shallow, Moderate, Deep, and Very Deep. Shallow areas have a smaller water volume (49728.66 m^3) and may present challenges for vessels with deeper drafts. Moderate areas have a higher water volume (114401.56 m^3), providing improved navigability for vessels with moderate drafts. Deep areas have a substantial water volume (141462.6 m^3), accommodating vessels with deeper drafts. Very Deep areas have a significant water volume (1404463 m^3) and require careful navigation and adherence to specific depth-related guidance.

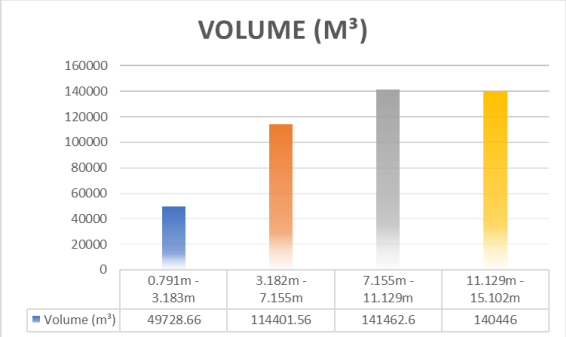

Figure 4: Woji Creek Water Volume Distribution

The turbidity analysis of Woji Creek revealed three categories: low, moderate, and high. Low turbidity covered 70.43% of the area, indicating clear water with minimal suspended particles, making it favorable for navigation due to good visibility. Moderate turbidity covered 23.67%, suggesting slightly reduced water clarity but still navigable with caution. High turbidity covered 5.91%, indicating the highest concentration of suspended particles and reduced visibility, posing challenges for navigation. While only a small area experiences high turbidity, caution is essential to avoid accidents in these sections.

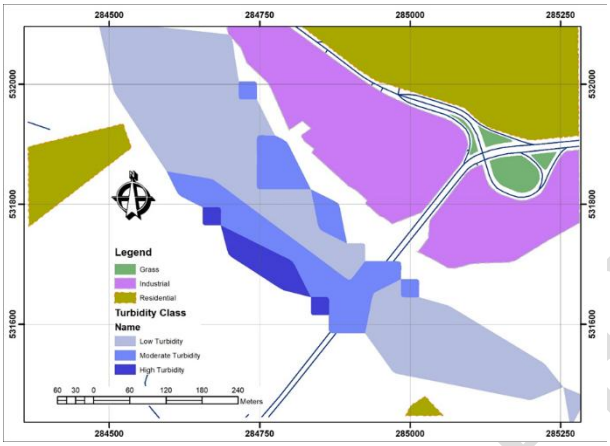

Figure 5: Map showing Woji Creek Turbidity Levels

5. Conclusion

The comprehensive analysis of Woji Creek's riverbed classification, depth range, volume, and turbidity emphasizes the importance of considering multiple factors for navigation planning. The presence of three sediment types—Clayey Silty Sand, Silty Clay, and Silty Sand—can impact navigation through increased friction, sediment transport, and potential sandbar formation. Understanding depth variations is crucial, as shallow areas may challenge vessels with deeper drafts, while moderate and deep areas offer improved navigability. Careful navigation is required in areas with lower water volumes, and turbidity levels play a role in visibility and safety. The findings align with previous research on sediment composition, depth variations, water volume distribution, and turbidity's impact on navigation safety.

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