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Riverbed Classification and Evaluation of Woji Creek Portharcourt, Rivers State Nigeria Using Side Scan Sonar Technology

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Abstract- The aim of this study is to classify and evaluate the riverbed in Woji Creek, Port Harcourt, Nigeria using side scan sonar technology. Its objectives are to; classify and evaluate the riverbed of Woji Creek using side-scan sonar technology, analyse and quantify the variations in water depth throughout Woji Creek, evaluate the water volume of Woji Creek for navigational suitability purposes and determine the turbidity levels of Woji Creek. The methodology involved the acquisition of Side-Scan Sonar (SSS) and Sub-bottom profile Data. The acquired data acquired underwent backscatter processing to obtain a geocoded back scatter image from which feature points were extracted and matched. The matched images were used to derive a riverbed classification, depth classification, water volume analysis and river turbidity analysis. The riverbed classification identified three predominant sediment types: Clayey Silty Sand, Silty Clay, and Silty Sand, each with distinct implications for navigation. Clayey Silty Sand, covering 43.11% of the riverbed, poses challenges due to its cohesive nature and sand content, potentially leading to increased frictional resistance and the formation of sandbars. Silty Clay (30.33%) influences sediment transport and water clarity, while Silty Sand (26.55%) is relatively mobile, potentially affecting channel migration. The depth classification analysis revealed the presence of Shallow, Moderate, Deep, and Very Deep areas within Woji Creek. Shallow areas (24.22% of the total area) may pose challenges for vessels with deeper drafts, while Moderate areas (30.54%) offer improved navigability. Deep areas (41.25%) provide favorable conditions for navigation, and Very Deep areas (3.98%) accommodate vessels with extreme drafts. The water volume distribution analysis is crucial for assessing depth limitations and planning routes. Shallow areas (11.15%) present smaller volumes, potentially posing navigational challenges. Moderate (25.65%) and deep (31.72%) areas offer larger volumes, facilitating navigation for vessels with moderate and deeper drafts, while Very Deep areas (31.49%) provide substantial volumes that require careful navigation. The assessment of river turbidity identified low (70.43%), moderate (23.67%), and high (5.91%) turbidity zones. Low turbidity indicates clear water with minimal suspended particles, while moderate and high turbidity suggest increased particle concentration and reduced visibility. It is recommended that the findings of this study be utilized as a decision support tool for navigation planning and management in Woji Creek. The comprehensive analysis of the riverbed classification, depth ranges, volume distribution, and turbidity provides valuable information that can inform strategic decision-making processes. It is recommended that the findings of this study be utilized as a decision support tool for navigation planning and management in Woji Creek.

Keywords- Depth; Navigation; Riverbed; Side Scan Sonar

I.INTRODUCTION

Rivers and creeks constitute vital components of ecosystems, economies, and transportation networks worldwide. In Nigeria, the intricate network of rivers and creeks serves as a lifeline for communities and industries, playing a central role in transportation, fisheries, and freshwater supply. Woji Creek, located in Port Harcourt, Rivers State, Nigeria, exemplifies this significance, making it an ideal subject for comprehensive investigation. This research seeks to provide an extensive assessment of Woji Creek's riverbed characteristics and substrate composition through the application of state-of-the-art Side Scan Sonar Technology. Riverbed morphology and substrate composition are critical parameters that influence a watercourse's ecological health, navigability, and suitability for diverse uses. Accurate data on riverbed characteristics is essential for sustainable river management, including sediment transport, erosion control, and the preservation of aquatic habitats. Furthermore, in coastal regions like Port Harcourt, an in-depth understanding of the riverbed is indispensable for infrastructure development and maintenance.

Traditional methods of riverbed classification 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 disturbance. By emitting sound waves and analyzing the reflected signals, Side Scan Sonar delivers invaluable data on riverbed topography, sediment distribution, and the presence of submerged objects. These insights contribute to a holistic understanding of river systems.

This study builds upon the work of several esteemed researchers who have successfully applied Side Scan Sonar Technology in diverse geographical contexts (Smith et al., 2019; Johnson and Brown, 2021; Wang and Zhang, 2018; Zheng et al., 2016; Li and Wu, 2020). We aim to customize this technology for Woji Creek, a region of unique significance within Nigeria's riverine landscape. Our research will not only advance knowledge of Woji Creek's riverbed composition but also contribute to the broader understanding of riverine ecosystems and their management.

Furthermore, we will explore the potential impact of riverbed composition on sediment dynamics, water quality, and aquatic habitats (Jones and Baker, 2017; Liu et al., 2015; Anderson and Smith, 2020; Chen et al., 2018). We will also investigate how riverbed data can inform sustainable resource management and environmental conservation strategies, in line with international best practices and guidelines (UNEP, 2018; EU Water Framework Directive, 2000; EPA Sediment Assessment Framework, 2012).

In the following sections of this paper, we will delve into the methodology used, data collection processes, and findings obtained through Side Scan Sonar Technology application in Woji Creek. The insights garnered from this study 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.

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 4°48'36"N and 4°49'48"N and longitudes 7°1'48"E and 7°3'36"E

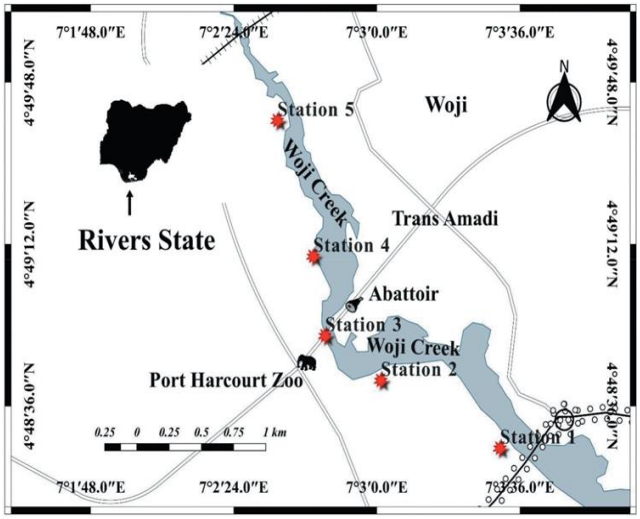

Figure 1: Map of Woji Creek (Study area)

II.MATERIAL AND METHODS

Methodology

The methodology adopted in achieving the desired goal included:

- Data Acquisition
- Survey Procedures / Field Operations
- Processing Techniques

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:

Administrative boundary maps obtained from Nnamdi Azikiwe University, aiding spatial analysis and study contextualization. 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.

Survey Procedures / Field Operations

The survey procedures and field operations carried out were:

i. Mobilization / Installation of Equipment.
ii. Vessel offset Measurement.
iii. Navigation and data acquisition.
iv. Deploying the Side Scan Sonar.
v. Deploying the Sub-Bottom Profiler.

Processing Techniques

The study employed processing techniques to analyze the riverbed of Woji Creek, ensuring accurate and comprehensive results. The Techniques used were:

i. Backscatter Processing
ii. Geocoded Backscatter Image
iii. Feature Extraction
iv. Point Matching Results
v. Finer Matching Results
vi. Riverbed Classification
vii. River Depth Analysis
viii. River Turbidity Analysis

III.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.

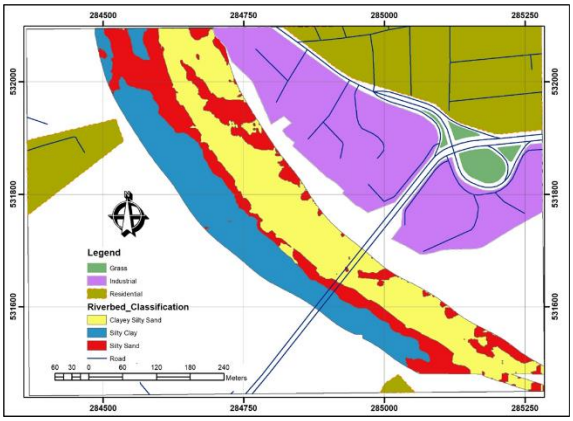

Figure.1: Woji Creek Riverbed Classification

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.

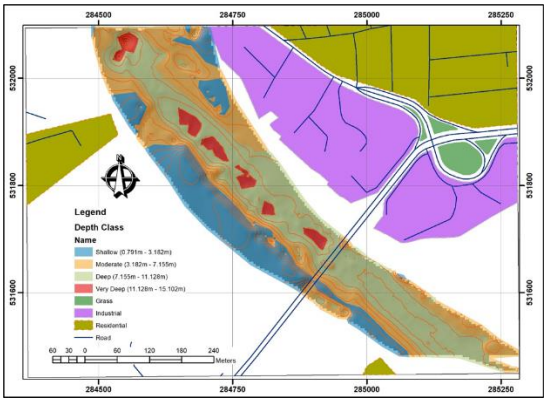

Figure 2: Woji Creek Depth class and range

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.

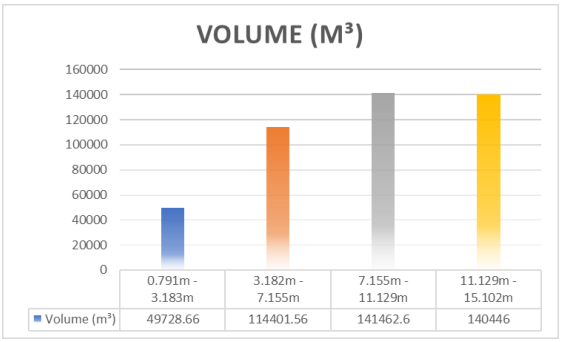

Figure 3 Woji Creek Water Volume Distribution

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.

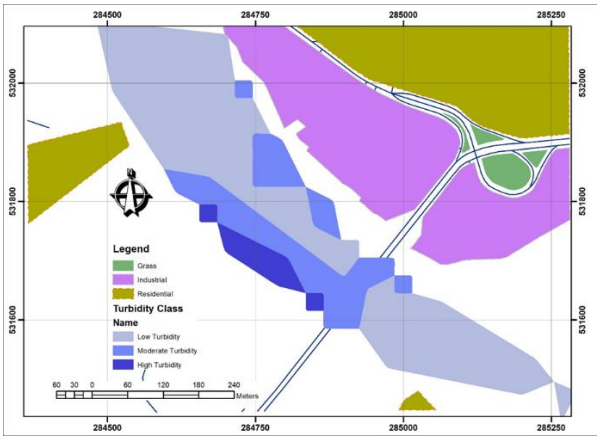

Figure 4. Map showing Woji Creek Turbidity Levels

IV.CONCLUSION

The comprehensive analysis of Woji Creek's riverbed classification, depth range, volume, and turbidity emphasize 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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