SunKrist Publishing
Accelerate Scientific Knowledge in Open Access

SunKrist Geology and Research Journal

Research Article *Volume: 1, Issue: 1* *Scientific Knowledge*

Sediment Dynamics and Sedimentation Patterns as Veritable Tools for Assessment of Shoreline Erosion on Sandy Beaches

Saviour P Udo-Akuaibit*

[1]Department of Physical Oceanography, University of Calabar, Calabar, Cross River State, Nigeria

1. Abstract

Studies on sediment transport on tropical sandy beaches of the South-East coast of Nigeria were carried out to understand the dynamics and pattern of sedimentation at beaches adjoining Qua-Iboe River Estuary, Ibeno, Akwa Ibom State. The beaches are genetically characterized by very fine grained, well to very well sorted sediments. Results of shoreline mapping and beach profile surveys showed no significant relationship and correlation with the alongshore variations in grain size parameters and the erosion arcs/ areas on the beaches. Moreover, the backshore sedimentary facies were morphologically stable at the beaches due to less tidal inundation and the presence of scanty vegetation. Updrift beach revealed a stable upper foreshore and a trough-like mid-foreshore, starved in sediment and sheltered from direct and intense wave impacts by an elevated lower foreshore which morphologically developed into offshore sand bar. On the other hand, down drift beach depicted erosion at the backshore and upper foreshore while mid- and lower foreshore revealed accretion. However, eastward directed longshore sediment transports energized by oblique incident waves were evident at the updrift beach whereas cross-shore sediment transport systems controlled by shore parallel waves were prevalent at down drift beach. The beach morpho-dynamics correlated strongly with increase in tidal influence during the accelerated phase of neap-spring tidal cycle.

2. Keywords: Beach, Sediment, Cross-Shore and Long-Shore Transport, Accretion and Erosion

3. Introduction

Studies on near-shore sediment transport systems have been carried out by many coastal scientists and engineers in the world. However, outcome of several attempts made by researchers [1-6] to empirically compute, predict, simulate, model, etc., coastal sediment transport at different hydrodynamic settings proven to offer limited solutions to coastal problems. Hence the nearshore sediment transport systems on beaches adjoined to Qua Iboe River estuary, South-East coast of Nigeria were investigated using daily beach profile surveys and beach volume change to determine the temporal and spatial sediment transport and sedimentation patterns on the study area.

Previous work on beach erosion and sediment transport along Nigerian coastline confirmed longshore currents and tidal currents as agents of sediment transports and beach erosion along the coastline [7, 8]. However, the different in the onshore-offshore sediment movement across shore determines

***Corresponding author:** Saviour P Udo-Akuaibit, Department of Physical Oceanography, University of Calabar, Calabar,Cross River State, Nigeria, Email: saviourakuaibit@gmail.com

Received Date: September 21, 2020; **Accepted Date:** September 22, 2020; **Published Date:** September 30, 2020

the seaward migration or landward retreat of the shoreline while alongshore sediment transport depletes sediment input at the source and replenishes at the sink developing shoreline erosion and accretion respectively [9-11]. This work, as part of my Master of Science Degree Dissertation, examines and considers sediment dispersal and sedimentation pattern as veritable tools for assessment of shoreline erosion on beaches in the study area.

4. Study Area

The study area is the sandy beaches located in Ibeno Local Government Area of Akwa Ibom State, South-East coast of Nigeria. The beaches are downdrift and updrift beaches adjoined to Qua Iboe River Estuary, Ibeno, Akwa Ibom State. (Figure 1). The shoreline is meso-tidal and exposed to semi-diurnal tides with tidal range of 2-4m and south westerly waves with amplitude less than 20 cm associated with south-westerly wind. Near-shore modal wave periods ranged 8-12 s and the surf-zone is predominantly characterised by plunging and spilling breakers at the ratio of 60:40 [1, 12]. Long-shore current velocities along the ocean shoreline ranged 50-125 cm/s east with periodic reversals to the west at the downdrift beach contiguous to the estuary mouth due to changes in tidal stage [12] The study area is an exposed section of the abandoned beach ridges laterally bounded by mangrove swamps of the lower Deltaic plain sand of Holocene age. It is underlain by Sombreiro-Warri Deltaic Plain sand of late Pleistocene [13]. The beach is texturally characterized by very well sorted fined grained sand [14].

5. Materials and Methods

The field investigation spanned a period of nine days from September 28, to October 6, 2013. Beach profile stations were established at 200m and 500m away from the estuary mouth at the downdrift and updrift beaches respectively with the aid of Global Positioning System (Figure 1). Daily beach profile measurements were made, along a one-metre wide transect, using graduated staff and measuring tape at the monitoring stations during low tide over a neap-spring tidal phase. Linear beach profile measurements per station were converted to beach sediment volumetric change. Analysis of sedimentation patterns were analysed using Microsoft Excel based on spring tide beach profiles data relative to neap tide counterparts. Hydrodynamic processes were also monitored at the same stations at half-hourly intervals over a tidal cycle [12].

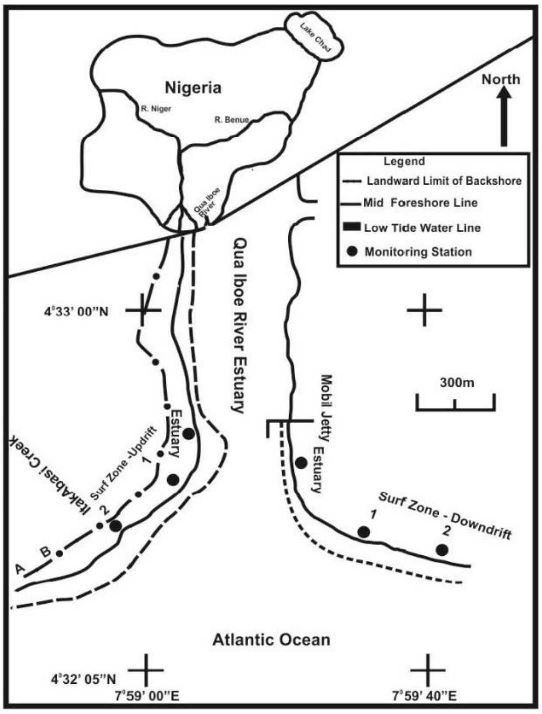

Figure 1: Location map of the study area showing current monitoring /beach profile stations [12].

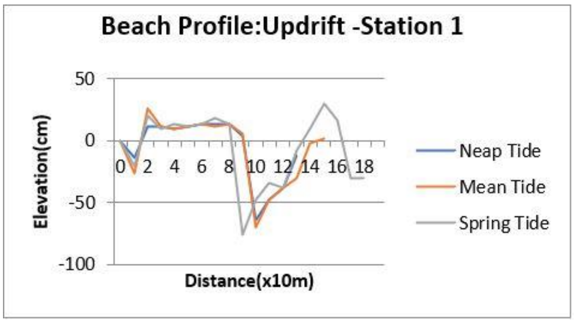

Figure 2a: Beach profiles at updrift station 1[12].

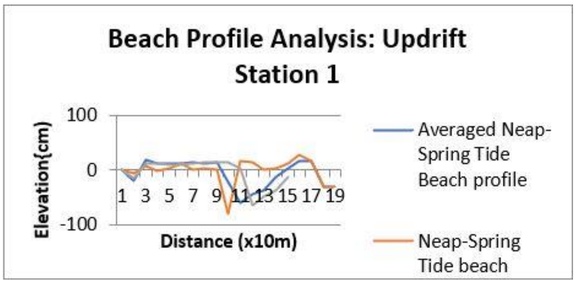

Figure. 2b: Analysis of effect of Spring Tide on beach sedimentation at updrift station 1[12].

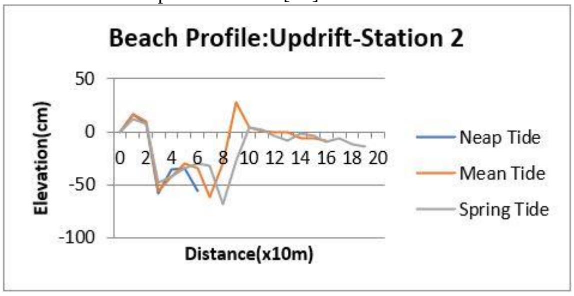

Figure 3a: Beach profiles at updrift station 2[12].

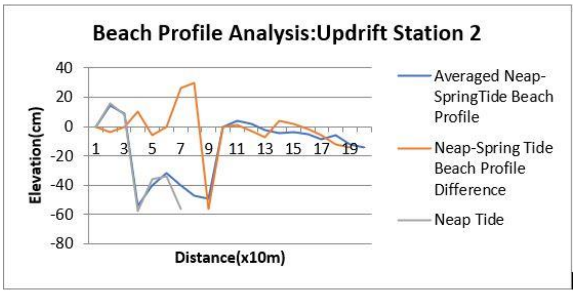

Figure 3b: Analysis of effect of Spring Tide on beach sedimentation at updrift station 1[12].

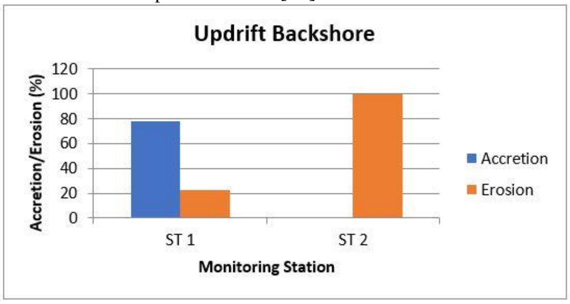

Figure 4: Analysis of beach sedimentation and erosion patterns at updrift backshore [12].

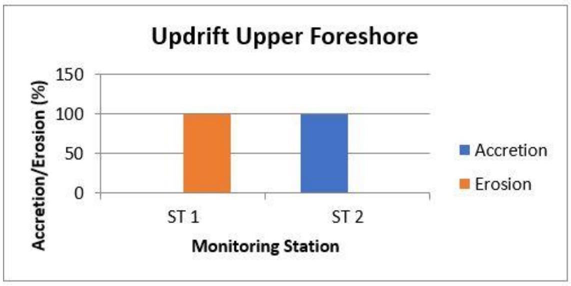

Figure 5: Analysis of beach sedimentation and erosion patterns at updrift upper foreshore [12].

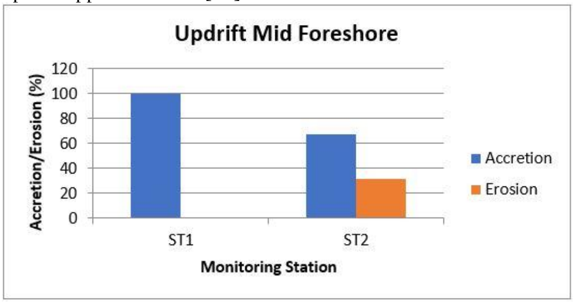

Figure 6: Analysis of beach sedimentation and erosion patterns at updrift mid-foreshore [12].

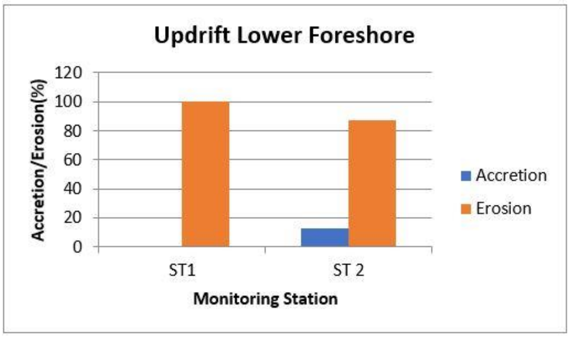

Figure 7: Analysis of beach sedimentation and erosion patterns at updrift lower foreshore [12].

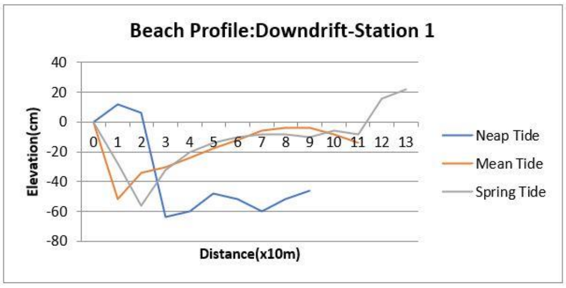

Figure 8a: Beach profiles at down drift station 1[12].

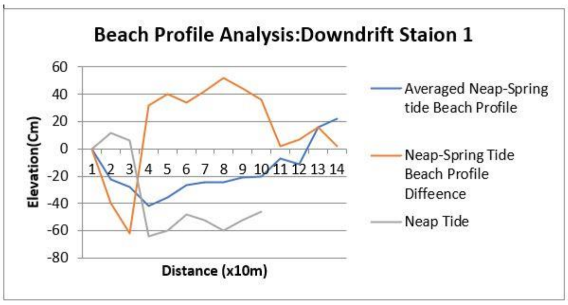

Figure 8b: Analysis of effect of Spring Tide on beach sedimentation at downdrift station 1.

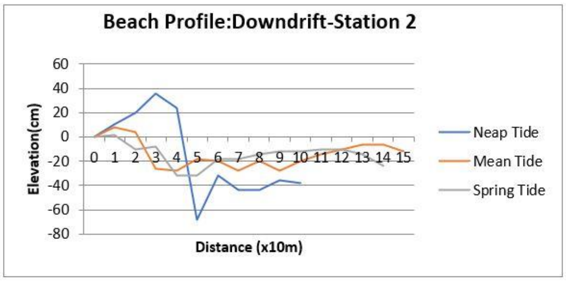

Figure 9a: Beach profiles at down drift station 2 [12].

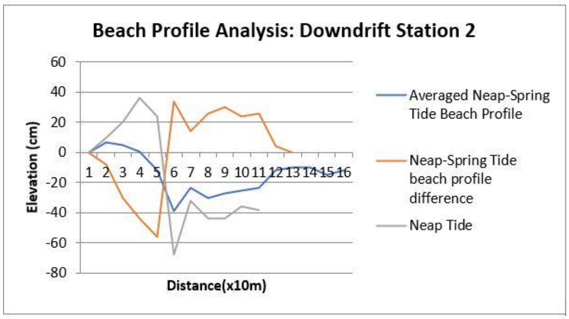

Figure 9b: Analysis of effect of Spring Tide on beach sedimentation at downdrift station 2 [12].

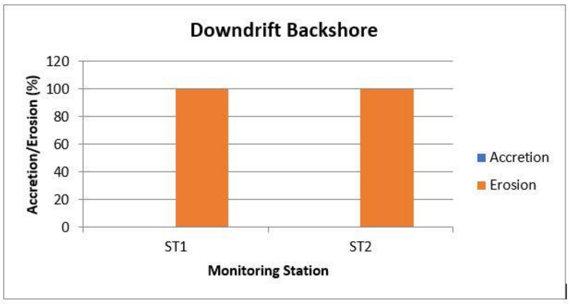

Figure 10: Analysis of beach sedimentation and erosion patterns at downdrift Backshore [12].

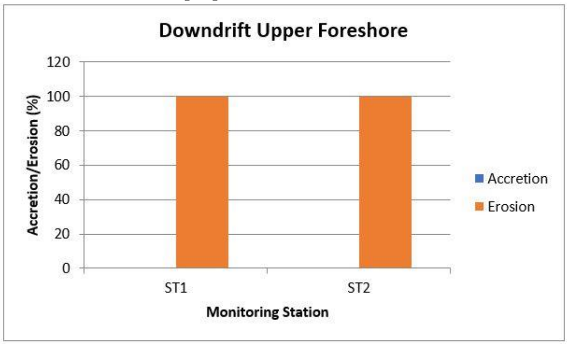

Figure 11: Analysis of beach sedimentation and erosion patterns at downdrift upper foreshore [12].

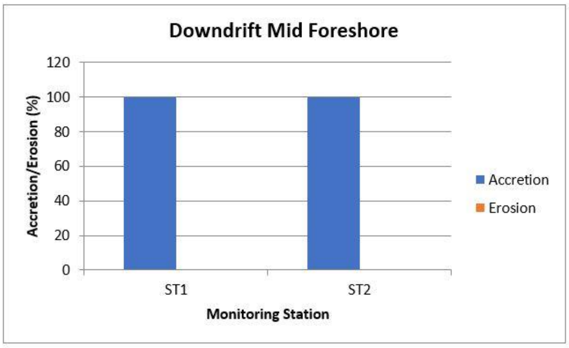

Figure 12: Analysis of beach sedimentation and erosion patterns at downdrift mid- foreshore [12].

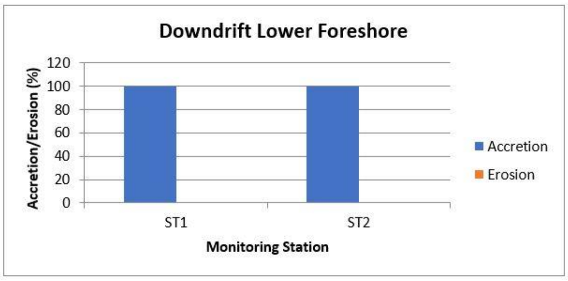

Figure 13: Analysis of beach sedimentation and erosion patterns at downdrift lower foreshore [12].

6. Result and Discussion

6.1 Result

6.1.1 Updrift beach morphology and sedimentation

6.1.2. Downdrift beach morphology and sedimentation

7. Result and Discussion

7.1.1 Updrift sediment dynamics and sedimentation patterns

Alongshore trend

Figure 2,3, and 4 reveals that backshore sediment is transported from station 2 to station 1 towards the estuary in the east. The upper foreshore sediment characterized by erosion at station 1 and accretion at station 2 could suggest a west-east direction of sediment gain and transport with station 1 experiencing almost 100% sediment loss to the estuary (Figure 5). Mid foreshore showed 100% accretion at station 1 with almost 80% accretion at station 2 (Figure 6). The lower foreshore depicted 100% erosion at station 1 and almost 85% erosion at station 2. Sediment transport patterns showed an eastward directed trend toward the estuary from station 2 to station 1 (Figures 7).

Cross-shore trend

Sediment transport at the backshore showed a north-east trend caused by the effect of wind and the action of wave over-wash processes (Figure 4) but figure 5 reveals a possibility in which sediment could be transported from the upper foreshore at station 1 by scouring and winnowing actions of plunging wave breakers during high tide and transported seaward to the mid foreshore by undertow. However, figures 6 and 7 suggest sediment movement from lower foreshore to the upper foreshore as hydrodynamic aftermaths of storm surge in the area which resulted in the closure of Itak Abasi creek entrance at station 2 with sediment from the ebb tidal delta [12, 15.16]. The mid foreshore at the two stations, generally, derived it sediment from the upper foreshore through under current generated by breaking waves, wave swash actions during rising tide and of course long-shore current transport. The lower foreshore is dominantly characterized by more onshore sediment transport during flood tide which indicates accretion than offshore sediment transport which promotes erosion during ebb tide.

However, table 1 summarizes the sedimentation patterns at the updrift in which backshore, upper foreshore and lower foreshore except mid foreshore beach geomorphic facies at station 1 were generally erosional. This could be attributed to the turbulence generated by wave diffractions and interferences with the estuarine currents at the mouth of the estuary and enhanced by the eastward directed long-shore currents. Whereas, at Station 2, which is distant from the wave turbulence at station 1 experienced accretion at the backshore and upper foreshore while erosion was evident at the mid and lower foreshore as a factor of prevalent and dominant eastward directed longshore current. Sediment transport generally depicted west to east trend with longshore current as the dominant agent enhanced by ebb estuarine currents.

Table 1: Analysis of updrift beach Morphodynamics

Beach geomorphic facie	**Beach morphodynamic state**		**Major agent (s) of sediment transport**
	Station 1	Station 2	
Backshore	Accretion	Erosion	Wind/ over wash
Upper foreshore	Accretion	Erosion	Backwash /
Mid-foreshore	Erosion	Accretion	Longshore current
Lower foreshore	Erosion	Accretion	Longshore current

7.1.2 Downdrift sediment dynamics and sedimentation patterns

Cross-shore trend

Downdrift segment of the studied shoreline is characterized by vegetated narrow backshore (Figures 8-11) which indicates low landward sediment transport on the beach geomorphic zone but enhances the seaward transport of sediment through upper foreshore by backwash and undercurrent during high tide to mid foreshore. This sediment is extensively spread by the breaking actions of shore parallel wave along the mid foreshore. More so, the interferences of wave-swash and flood tidal currents from the lower foreshore with seaward undertow entrained with sediment during rising flood tide and the presence of standing waves during high water at the mid foreshore could account for massive sedimentation at the mid foreshore (Figure 12).

Alongshore trend

Due to the presence of shore parallel and standing wave forms in the beach surf zone during flood tide which inhibit the generation of strong eastward directed long-shore current characterized by occasional reversal flow patterns, the alongshore trend of sediment transport is much influenced by the actions and directions of flow of wave backwash and undertow, which often times, are truncated by incoming onshore waves which limit the distance of sediment transport to a short range. It is very instructive that the eastward trend of sedimentation depicted by high level of sediment accumulation at station 1 which is closer to the estuary than at station 2 away from the estuary could be attributed to the influence of the eastward deflected fluvial discharge from the estuary during ebb tide (Figures10-13).

Moreover, from table 2, the downdrift sediment transport depicted erosion at the backshore and upper foreshore while accretion was evident at the mid foreshore and lower foreshore at stations 1 and 2. These sediment transport patterns can be attributed to cross shore current transport due to the actions of shore parallel waves on the beach and anticlockwise circulation patterns of tidal currents at the downdrift [17]. The erosion of the backshore was made by over wash processes which transported sediment to the vegetated segment of the backshore. While accretion at the mid foreshore can be attributed to the action of undercurrent which transport sediment from the upper foreshore and deposited at the mid foreshore. The accretion at the lower foreshore is attributed to the actions of onshore currents generated by breaking onshore parallel waves which transport sediment from the surf zone shoreward.

8. Conclusion

The foregone analysis of sediment transport patterns

Table 2: Analysis of down drift beach morpho-dynamics

Beach morphodynamic state			
Beach geomorphic facie	Station 1	Station 2	**Major agent(s) of sediment transport.**
Backshore	Erosion	Erosion	Over wash/ backwash
Upper foreshore	Erosion	Erosion	Under current/ backwash
Mid-foreshore	Accretion	Accretion	Cross-shore current
Lower foreshore	Accretion	Accretion	Cross-shore current

revealed that at updrift beach, alongshore sediment transport towards the estuary through dominant agent of longshore currents due east was prevalent whereas, cross shore sediment transport due to cross shore currents and anticlockwise circulation patterns of tidal currents were dominant at the down drift beach. Moreover, oblique incident waves energized sediment transport system and caused erosion at the updrift beach while shore-normal incident waves dominated the surf-zone and generated cross-shore sediment transport which favored sedimentation and accretion at the down drift beach.

9. Acknowledgement

Thanks to Professor Effiom Antia, Institute of Oceanography, University of Calabar, Cross Rivers State, and Professors Chidi Ibe and Enuvie Akpokodje, Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt, Rivers State, for their advice. Additional thanks to Charles Odeh, Theresa Udeh and Kinsley Nwogbidi for their field assistance. Also, I wish to acknowledge the support for this study for my Master of Science Degree Dissertation by Mac Arthur Foundation, Chicago USA.

10. References

1. Komar, PD, Inman, DL. Longshore sand transport on beaches. Journal of Geophysical Research.1970; 75: 5514–5527.
2. Dean RG. Measuring longshore sediment transport with traps. Nearshore Sediment Transport. 1989; 313–337.
3. Bodge K, Kraus N. Critical examination of longshore transport rate magnitude. Coastal Sediments. 1991: 139–155.
4. Kraus NC, Larson M, Kriebel DL. Evaluation of Beach Erosion and Accretion Predictors. Paper Presented at Coastal Sediments. Am Soc Civ Eng.1991.
5. Short AD. Handbook of Beach and Shoreface Morpho dynamics. Wiley. 1999; 177.
6. Eversole D, Fletcher CH. Longshore Sediment Transport Rates on a Reef-Fronted Beach: Field Data and Empirical Models Kaanapali Beach, Hawaii: Journal of Coastal Research. 2002; 19: 649-663.
7. Ibe, AC. Coastal Erosion in Nigeria. Ibadan University Press, Ibadan, Nigeria. 1988.
8. Antia EE. A short-term study of the effects of the changing coastal condition on some geomorphic elements on Nigerian beaches. Zeitschrift f. Geomorphologie. 1988; 73:1-16.
9. Wright LD, Nielsen P, Short AD, Green MO. Morphodynamics of A Microtidal Beach. Marine Geology. 1982; 50:97-128.
10. Samsuddin M, Suchindan GK. Beach Erosion and Accretion in Relation to Seasonal Lonshore Current Variation in the Northern Kerela Coast, India. Journal of Coastal Research. 1987; 3: 55-62.
11. Engstrom WN. Beach foreshore sedimentology in the Northern Island of Wisconsin. Journal of Sedimentary Petrology. 1973; 44: 190-206.
12. Udo-Akuaibit SP. Analysis of near-shore flow interactions, sediment budget and offset shoreline development adjoining Qua-Iboe River estuary, south-east coast if Nigeria. Thesis Report, Institute of Natural Resources, Environment and Sustainable

Development, University of Port Harcourt, Nigeria. 2013.
13. Short KC, Stauble AJ. Outline geology of the Niger Delta. Am Assoc Pet Geol Bull. 1967; 51: 761-769.
14. Udo SP. Estuarine Shoreline Erosion Dynamics: Case Study of Qua-Iboe River Estuary. SE Nigeria. PGDCZM. 2002.
15. Udo-Akuaibit SP. Sediment Budget Analysis for Sustainable Shoreline Protection and Management. J Geol Geosci. 2014; 3: 170.
16. Udo-Akuaibit SP. Morpho-Dynamics Shoreline Offset at the Entrance of Qua Iboe River Estuary, South East Coast of Nigeria. J Coast Dev 2014; 17: 391.
17. Udo-Akuaibit SP. Analysis of Nearshore Currents Circulation Patterns at the Entrance of Qua-Iboe River Estuary, South-East Coast of Nigeria. J of Marine Science Research and Oceanography. 2020; 3: 1-6.

Citation: Saviour P Udo-Akuaibit. Sediment Dynamics and Sedimentation Patterns as Veritable Tools for Assessment of Shoreline Erosion on Sandy Beaches. SunKrist Geol Res J. 2020; 1: 1001.