Annual Changes in Erosion and Accretion atSeme and Yovoyan Beaches, Badagry, Lagos, South West, Nigeria

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Abstract
Seme and Yovoyan beaches are bounded by the Atlantic Ocean and are regularly inundated by ocean water as a result of breaking wave generated nearshore. This project aims to monitor the rate of erosion and accretion on the beaches of Seme and Yovoyan, Badagry, located at Badagry, Lagos State, Nigeria. This paper emphasises the aspect of annuality in erosion/accretion study using the profile data time series derived from the theodolite leveling of beach. Thus, the analysis of the profiles generated the data used for the calculation of accretion and erosion rate based on the berm movement over the period of 2013 to 2019. The overall results from the profiles of the two beaches show episodes of accretion and erosion which is an indication of differential ocean water inundation and littoral transport. Yovoyan beach which is closer to the west-mole side of the Lagos coast is more stable at the backstake to the frontstake. The approximate magnitude of the accretion and erosion on the beaches which were estimated from the foreshore berm movement shows that the net sediment movement on both beaches could be said to be accreting in nature. The results of the average gradient from the two beaches show that they are gently sloping. In general, the results of the average erosion and accretion over all the stations monitored at Seme and Yovoyan beaches shows that there is a cyclic systematic change uniform over these beaches. The trend shows two years dominance of one event (accretion or erosion) that changes.

Keywords**:** Erosion/accretion; beaches; Theodolite; berm; Badagry, Lagos.

INTRODUCTION

Coastal zone vulnerability to erosion is an issue of global concern due to the increase and influx of human population in those areas (Panagos *et al*., 2011). Shoreline as part of a coast is the boundary connecting the continent with the sea, and directly behind it is the swash zone, which is defined as the section of the beach/coastline that is intermittently submerged and sub aerial as a result of wave run-up and run-down actions (Elfrink and Baldock, 2002). Shoreline changes pose a problem for the artisanal fisheries which supply about 50% of the fisheries resources in Nigeria. Similarly, the beach areas which were active for recreation and tourism are fast becoming a destination for high rise buildings and sky scrapers. The persistence of these problems will result to complete annihilation of the beaches and coastal settlements. Previous efforts taken to

addressing those problems include the construction of west/east moles in the early 1990's, beach nourishments and the construction of break waters along the coastline, still the problem is still persistent.

Breaking waves drive a number of interrelated surf zone processes such as the creation of turbulent bores, wave set-up, near shore currents and low frequency motions, which force the entrainment and transport of sediments, thereby giving rise to morphological changes (Komar, 1998; Masselink *et al.,* 2011). The barrier lagoon coastal system has been experiencing erosion and accretion along its beaches and water front. Although the beaches in the western part of the barrier coast have been relatively stable while those on the eastern part especially the Lekki beach is fast eroding. An annual erosion rate of about 25-30m has been reported along beaches in the western axis (Ibe *et al.,* 1985). Shoreline erosion has become very serious ecological problem affecting the eastern part of the barrier coast. The area has been degraded by erosion and flooding leading to destruction of coastal settlements, infrastructures and decimation of vegetation. The major causes of erosion in the barrier lagoon coastal area includes; low-lying topography, vulnerable sediment characteristics and anthropogenic activities such as decimation of coastal vegetation and indiscriminate construction along water front as discussed by Ibe at al., 1985.

Beach sediments show wide variation in textural characteristics rendering the particles size vulnerable to agents of erosion such as waves, tide and long shore current. Sediment accretion/deposition or erosion is thus a function of the hydrodynamic conditions. The state of sediment erosion and accretion pursued in this study is therefore directed towards an understanding of the fundamental principles of shoreline dynamics and reconstruction of sedimentary history in the western part of the barrier coast. The status of erosion and accretion along the Seme and Yovoyan beaches were monitored from 2013 to 2019. This was done by utilizing beach profiling using levelling technique. Beach profile using levelling is a useful tool for determining the physical characteristics of the beach in order to monitor the changes in the morphology and in determining the sediment transport over time.The rate of erosion and accretion in this study were determined via monitoring the berm movement annually.

STUDY AREA

The Beaches lie between longitudes 3°0′ and 3°45′ E and between latitudes 6°25′ and 6°30′ N (Figure 1). It covers three local governments administrative boundary (i.e. Badagry LGA, Eti-Osa and Ibeju-lekki LGA) respectively. They are part of a continuous system barrier bar complex along the coast of Nigeria from the border with the Republic of Benin to the Niger delta.

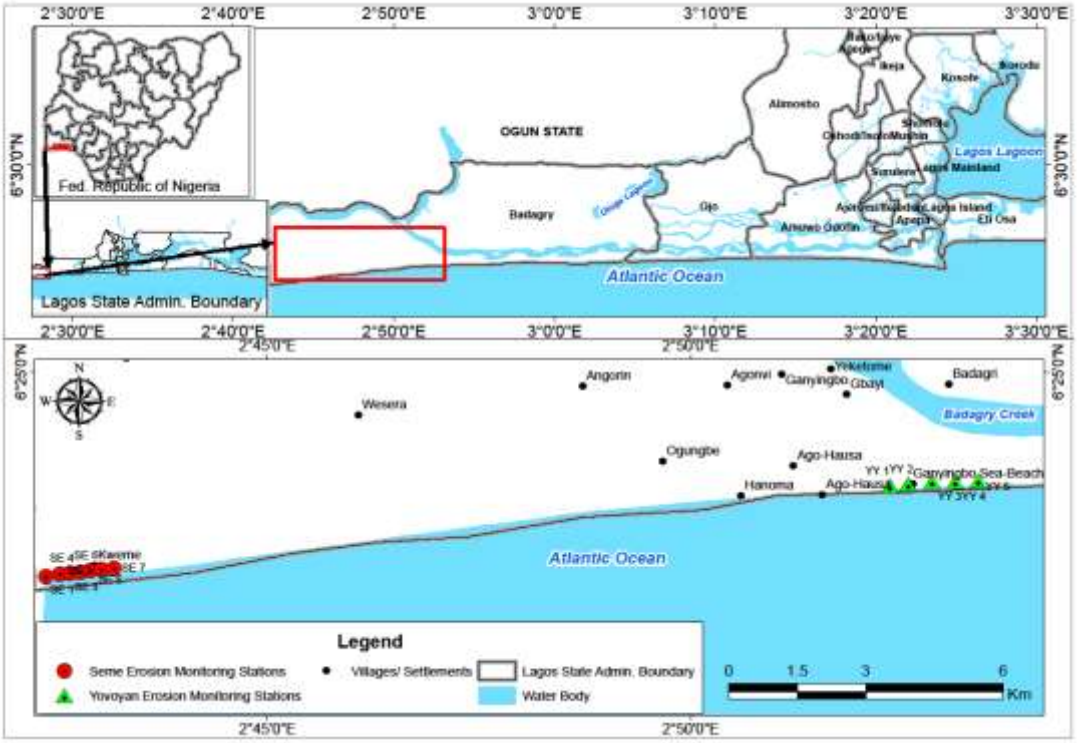

Figure 1: Erosion Monitoring Stations at Seme and Yovoyan beaches in Badagry

MATERIALS AND METHOD

The Beach Profiling was carried out using leveling instrument (theodolite), leveling staff,100 m steel measuring tape and Garmin 76S GPS. At Seme, five erosion monitoring stations were established, the first three (SE1, SE2 and SE3) at intervals of 250 m and the last two stations (SE4 and SE5) at intervals of 500 m. At Yovoyan, five erosion monitoring stations (YY1, YY2, YY3,YY4 and YY5) were established at intervals of 500 m. Beach profiling was accomplished by establishing transect lines placed at specific intervals to cover the stretch of the beach. Each transect line was referenced to an assumed height, subsequent leveling of the station was tied to the height. The transect line was then leveled from the back bench as far as possible into the water line at low tide. The beach profiling was done using the Emery method (Tortell and Awosika, 1996).

RESULT

Beach-Profile Changes in Annual Scale

The beach profiles of the study period (2013-2019) for Seme and Yovoyan beaches are presented in Figures 2 and 3. Data derived from the profiles and used for the calculation of erosion and accretion rates in the study areas are presented in tables 1 and 2.

The length of profiles for SE1 monitored over study period ranges between 30 and 53.8 m and the average gradient ranges between 0.08 and 0.12 m (Figure 2). Based on the changes in the position of the berm monitored over the study period, we were able to determine the accretion and erosion rate. At SE1, accretion occurred twice (2014 and 2018) at the rates of 19 and 5.35 m per

annum respectively within the study period. The years 2015, 2016 and 2019 were period of erosion with rates of 12.6, 1.55 and 6.8m per annum respectively (Figure 2 and table 1).

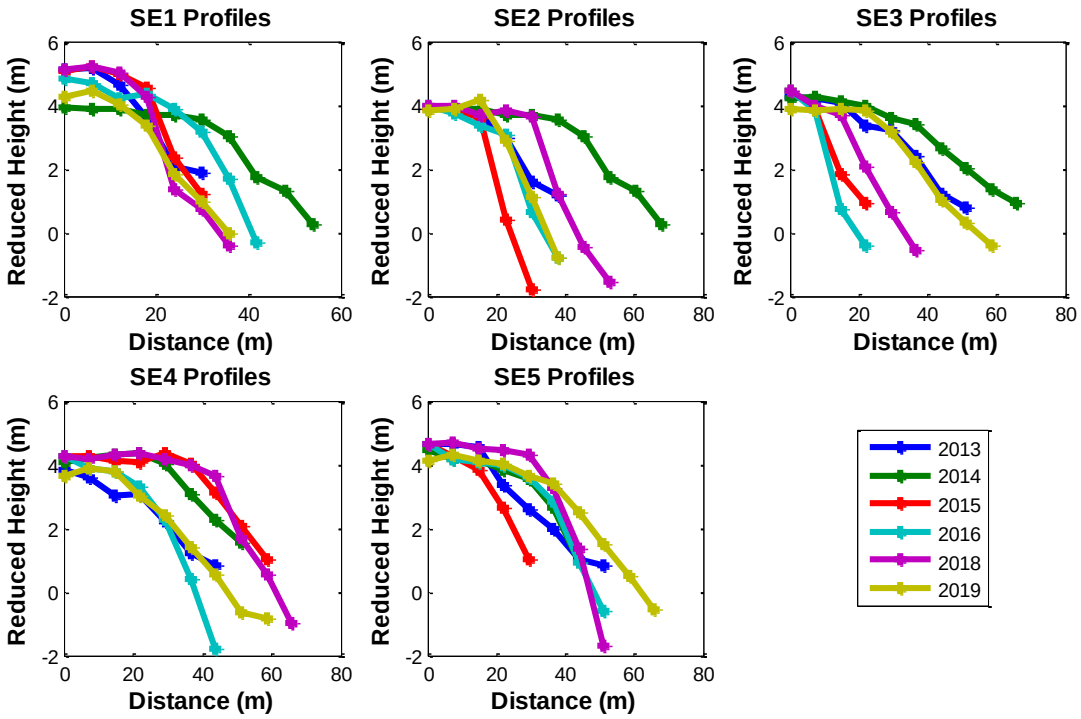

Figure 2: Seme Stations Beach Profiling Plots

The length of profiles for Seme station 2 (SE2) ranges between 37.3 and 67.52 m while the average gradient ranges between 0.06 and 0.13 m (Figure 2). At SE2, accretion occurred twice (2014 and 2016) at the rates of 9 and 2 m per annum respectively within the periods of observation, while the years 2018 and 2019 were period of erosion (Figure 2 and Table 1). The erosion rates are 0.06 and 14.34 m per annum respectively.

The length of profiles for Seme station 3 (SE3) ranges between 40 and 60 m and the average gradient ranges between 0.057 and 0.87 m (Figure 2). At this station, accretion occurred in four consecutive years (2015, 2016, 2018 and 2019) at the rates of 3, 1.22, 0.41 and 0.37 m per annum respectively within the periods of observation, and year 2014 was a period of erosion. The erosion over these period was at a rate of 5 m per annum (Figure 2 and Table 1).

The length of profiles for Seme station 4 (SE4) ranges between 30 and 43.15 m and the average gradient ranges between 0.07 and 0.15 m (Figure 2).At SE4, accretion occurred twice (2015 and 2019) at the rates of 1.65 and 4.53 m per annum respectively within the periods of observation. The years 2014, 2016 and 2018 were periods of erosion (Figure 2 and Table 1). The erosion rates during these periods are 3, 5.25 and 0.93 m per annum respectively.

The length of profiles for Seme station 5 (SE5) ranges between 27 and 59.2 m and the average gradient ranges between 0.10 and 0.13 m (Figure 2). At SE5, accretion occurred three time (2014, 2016 and 2018) at the rates of 7, 4.9, 11.5 m per annum respectively within the periods of observation. The years 2015 and 2019 were period of erosion.The erosion rates are 5.6 and 1.8 m per annum respectively (Figure 2 and Table 1).

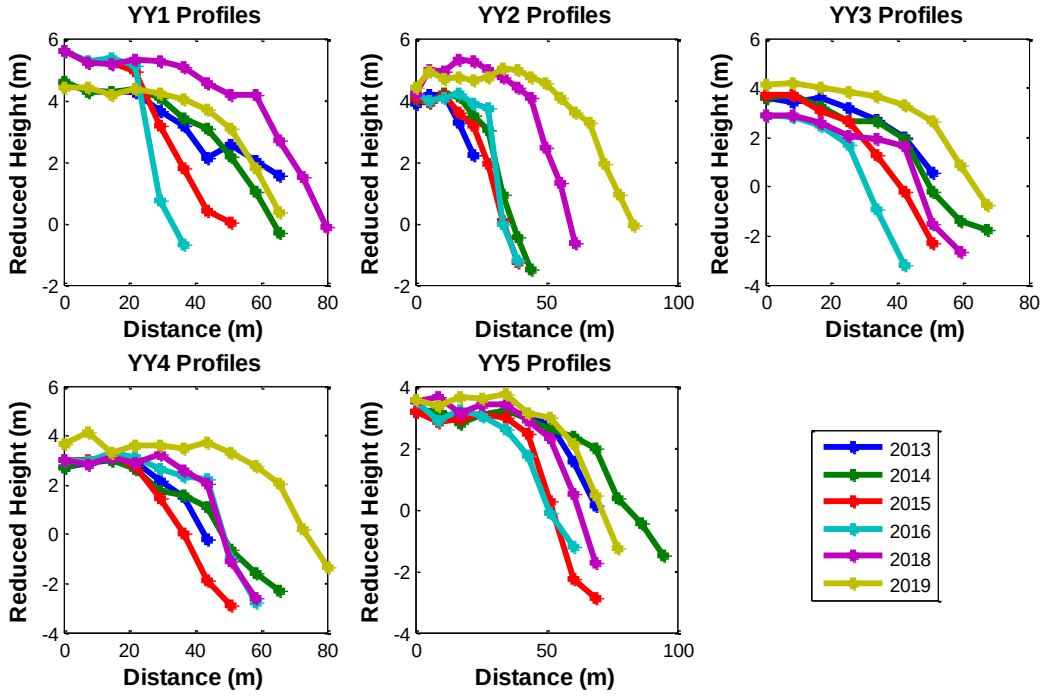

Figure 3: Yovoyan Stations Beach Profiling Plots

The length of profiles for Yovoyan station 1 (YY1) ranges between 54 and 79.95 m and the average gradient ranges between 0.06 and 0.08 m (Figure 3). At YY1, accretion occurred twice (2016 and 2019) at the rates of 6 and 6.79 m per annum respectively within the periods of observation. Erosion was observed in the years 2014, 2015 and 2018 at the rates of 2, 4 and 1.8 m per annum (Figure 3 and table 2).

The length of profiles for Yovoyan station 2 (YY2) ranges between 36 and 83.18 m and the average gradient range between 0.06 and 0.14 m (Figure 3). At YY2, accretion occurred three times (2014, 2016 and 2018) at the rates of 1.5, 7.2 and 11.21 m per annum respectively within the periods of observation. The years 2015 and 2019 were period of erosion that occurred at the rates of 0.7 and 9.21 m per annum (Figure 3 and table 2).

The length of profiles for Yovoyan station 3 (YY3) ranges between 43 and 67.44 m and the average gradient ranges between 0.06 and 0.12 m (Figure 3). At YY3, accretion occurred two times (2016 and 2019) at the rates of 11 and 11.28 per annum within the periods of observation. Erosion occurred during the years 2014, 2015 and 2018 at the rates of 2, 5 and 2.28 m per annum (Figure 3 and Table 2).

The length of profiles for Yovoyan station 4 (YY4) ranges between 40 and 80 m and the average gradient ranges between 0.07 and 0.12 m (Figure 3). At YY4, accretion occurred three times (2014, 2018 and 2019) at the rates of 8, 2.32, and 9.68 m per annum within the periods of observation. Erosion of 4 m per annum occurred in the year 2015 and their was balance in sediment transport during the year 2016, so during this period there was equilibrium in sediment transport (Figure 3 and Table 2).The length of profiles for Yovoyan station 5 (YY5) ranges between 69 and 94.56 m and the average gradient range between 0.04 and 0.08 m (Figure 3). At YY5, accretion occurred two times. (2015 and 2019) at the rates of 2 and 6.18 m per annum respectively within the periods of observation. The years 2014 and 2018 were period of erosion that have calculated rates of 10 and 4.18 m per annum (Figure 3 and Table 2).

Table 1: Net erosion/accretion rates during the study period (2013-2019) at each station within Seme, Badagry

Date	Station	Length of profile (m)	Average Gradient	Berm Position (m)	Berm Movement (m)		Comment
					Accretion +	Erosion -	
2013	SE 1	30	0.11	6			
2014		45	0.08	25	19		Accretion
2015		31.5	0.12	12.4		12.6	Erosion
2016		49.39	0.10	10.85		1.55	Erosion
2018		53.8	0.10	16.2	5.35		Accretion
2019		35.8	0.11	9.4		6.8	Erosion
2013	SE 2	45	0.06	16			
2014		45	0.08	25	9		Accretion
2015		46	0.125	25	-	-	Equilibrium
2016		57	0.08	27	2		Accretion
2018		67.52	0.08	26.94		0.06	Erosion
2019		37.3	0.13	12.6		14.34	Erosion
2013	SE 3	60	0.057	20			
2014		40	0.08	15		5	Erosion
2015		41	0.87	18	3		Accretion
2016		46.3	0.11	19.22	1.22		Accretion
2018		54.3	0.09	19.63	0.41		Accretion
2019		47.8	0.089	20	0.37		Accretion
2013	SE 4	42	0.07	18			
2014		30	0.09	15		3	Erosion
2015		42	0.08	16.65	1.65		Accretion
2016		41	0.15	11.4		5.25	Erosion
2018		43.15	0.12	10.47		0.93	Erosion
2019		43	0.11	15	4.53		Accretion
2013	SE 5	32	0.12	6			
2014		27	0.13	13	7		Accretion
2015		38	0.10	7.4		5.6	Erosion
2016		40.5	0.13	12.3	4.9		Accretion
2018		59.2	0.11	23.8	11.5		Accretion
2019		44	0.11	22		1.8	Erosion

Table 2: Net erosion/accretion rates during the study period (2013-2019) at each station within Yovoyan, Badagry

Date	Station	Length of profile (m)	Average Gradient	Berm Position (m)	Berm Movement (m)		Comment
					Accretion +	Erosion -	
2013	YY 1	54	0.06	40			
2014		63	0.08	38		2	Erosion
2015		72	0.08	34		4	Erosion
2016		79.95	0.08	40	6		Accretion
2018		72.14	0.08	38.21		1.8	Erosion
2019		55	0.07	45	6.79		Accretion
2013	YY 2	36	0.06	20			
2014		40	0.14	21.5	1.5		Accretion
2015		54	0.10	20.8		0.7	Erosion
2016		64	0.09	28	7.2		Accretion
2018		83.18	0.07	39.21	11.21		Accretion
2019		67	0.08	30		9.21	Erosion
2013	YY3	48	0.06	20			
2014		43	0.12	18		2	Erosion
2015		56	0.11	13		5	Erosion
2016		56.5	0.11	24	11		Accretion
2018		67.44	0.08	21.72		2.28	Erosion
2019		59	0.08	33	11.28		Accretion
2013	YY 4	40	0.08	20			
2014		60	0.09	28	8		Accretion
2015		49	0.12	24		4	Erosion
2016		68	0.09	24	-	-	Equilibrium
2018		79.5	0.07	26.32	2.32		Accretion
2019		80	0.07	36	9.68		Accretion
2013	YY 5	72	0.04	60			
2014		81	0.06	50		10	Erosion
2015		80	0.08	52	2		Accretion
2016		83	0.06	52	-	-	Equilibrium
2018		94.56	0.06	47.82		4.18	Erosion
2019		69	0.07	54	6.18		Accretion

DISCUSSION

The Nigerian coast forms the social and economic nerve centre for the whole country where over 70 percent of the national income is generated. Environmental issues such as coastal erosion have become very serious and recognized as growing problem in the coastal areas of Nigeria. The Nigeria coastal zone has been degraded by coastal erosion and flooding leading to destruction of coastal settlements, infrastructures and decimation of coastal vegetation. It is also a problem for the artisanal fisheries which supply about 50% of the fisheries resources in Nigeria.

Several works have been done on the downdrift side of the Lagos coast (Ibe at al., 1985, Awosika and Ibe, 1993 and Van Bentum, 2012), but this work provides information on the erosion and accretion

trends on the updrift side which can be used to draw comparison with the downdrift side.

The result of our study at the updrift side carried out at Seme and Yovoyan, Badagry, Lagos to monitor the recent trend in the rates of erosion and accretion shows that in the year 2014, accretion was dominant at Seme and Yovoyan with an average of 11.7 and 4.75m respectively and an average of 4 and 4.67 m respectively for erosion. In 2015, erosion was dominant in both Seme and Yovoyan but more at Seme having average values of 9.1 m and 3.425 m at Yovoyan. Accretion at Seme and Yovoyan recorded average values of 2.3 m and 2 m respectively. In 2016, Seme and Yovoyan experienced variation, while Seme was dominated by erosion of an average value of 3.4 m and having accretion of average value of 2.7 m. Yovoyan only experienced accretion during this said year of 8.1 m. In 2018, accretion was dominant at Seme and Yovoyan which recorded average values of 5.75 m and 6.77 m respectively. Erosion was minimal at Seme with an average value of 0.495 m while Yovoyan recorded 2.75 m. In 2019, erosion was dominant over accretion in both Seme and Yovoyan. The average values for erosion at both sites are 7.65 m and 9.21 m respectively while accretion values are 2.47 and 8.48 m respectively. It could be seen that the slopes of the profile lines on Seme beach is undulating in nature and extend to different positions on the profile lines as one traverses from the west to the eastern part of the beach. They also show episodes of accretion and erosion along the profile lines which is an indication of differential ocean water inundation and littoral transport along the profile lines. In Yovoyan beach, double berm was discovered on line YY5, with the foreshore slopes dipping gently from the swash zone to the surf zone. Comparison of the profile lines shows that the beach is mostly stable from the backstake to the frontstake. However, from the active part of the beach, there is visible sediment movement. The approximate magnitude of the accretion and erosion on the beaches which were estimated from the foreshore berm movement shows that the net sediment movement on both beaches could be said to be accreting in nature. The results of the average gradient from the two beaches show that they are gently sloping.

CONCLUSION

Beach-profile surveys have been conducted along the beaches of Seme and Yovoyan, Badagry, Lagos over a period of 2013 to 2019.

At Seme, maximum accretion of 19 m occurred in the year 2014 at SE1 and the minimum accretion of 0.41 m occurred in the year 2018 at SE3. Maximum erosion of 14.34 m occurred in the year 2019 at SE2 and the least value of 0.06 m was recorded for the year 2018 at SE2.

At Yovoyan, maximum accretion of 11.28 m was recorded in the year 2019 at YY3 and the minimum value 1.5 m was recorded in the year 2014 at YY2. Maximum erosion of 10 m was recorded in the year 2014 at YY5 and in the year 2016, Yovoyan beach attained equilibrium state in terms of sediment transport in two (YY4 and YY5) out of five stations monitored in 2016.

The results of the average erosion and accretion over all the stations monitored at Seme and Yovoyan beaches shows that there is a cyclic systematic change over these beaches. Even though there was no observation in the year 2017, the trend shows two years' dominance of one event (accretion or erosion) that changes. The approximate magnitude of the accretion and erosion on the beaches which were estimated from the foreshore berm movement shows that the net sediment movement on both beaches could be said to be accreting in nature.

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