

Evaluating the Impact of River Bank Erosion on Environmental Stream Morphology for the Mini Piti Stream, Obio-Akpor, Rivers State, Nigeria

ABSTRACT

This study was designed to assess the impact of river bank erosion on the environmental channel morphology for the Mini-Piti stream in Obio-Akpor local government area of Rivers State, Nigeria. The stream was divided into three stations; upstream 2.5km, midstream 2.5km, and downstream with interval of 1km measured to differentiate each station as 5 samples were obtained per station at intervals of 0.5km apart. The flow velocity and discharge were estimated as the average depth recorded upstream was DS 0.9m, WS 1.4m, Midstream DS 1.3m, WS 1.7m, and Downstream=DS 1.5m WS 1.7m. The field observation and the impacts of precipitation and storm water from the built area of midstream were very intensive whose action increased the water level above its channel capacity and eroded the bank. The collapsed sediments and waste dumped at the bank of the stream were transported downstream due to reduced velocity and more coarse sediments which were trapped at the stream bed causing shallow depth while the suspended fine sediment on the water column reduced the clarity of the stream. The research revealed that bank erosion has significant impact on water quality and geometry of stream by alterations of the channel depth and width, flow rate, scouring and deposition of sediments in the stream. There is need for regulatory agencies to control anthropogenic inputs and enhance bank erosion prevention programmes.

Key Words: Impact, River Bank, Erosion, Channel, Morphology, Mini-Piti stream

1.0 INTRODUCTION

There are many forms of hazard in our environment, directly or indirectly which have impact on man, aquatic organisms and properties, either anthropogenic or naturally occurring. Riverbank erosion has now become a serious threat to man and one of the major environmental hazards that requires urgent attention. Yearly, millions of people are affected by Riverbank erosion, due to pollution of water body, obstruction of inland water transport routes and declined of aquatic population.

The primary causes of River bank erosion are geological and human activities, such as dredging (sand mining), construction, storm water, tidal current, wave and shore deforestation practices along the bank which is one of the most unpredictable and critical type of disaster that accounts for the quantity of rainfall, soil structure, river morphology, topography of the river, and flood, (Tripathy & Mondal, 2020)

According to World Bank, Nigeria Erosion and Water-shed Management Project (NEWMAP) gully erosion and associated processes, such as river bank failure are the major environmental challenges affecting the South-east region of Nigeria, causing estimated damage of over 100 million US Dollars (Okeke & Ede, 2019). However, the constant dredging of rivers, poses a negative impact to the River bank and water-shed, which includes chemical, physical and ecological impacts. The dredging of River channel for the purpose of land reclamations altered the riverbed profile.

River bank erosion can also be caused by house placement, water saturation and load on bank, vegetation and tectonic activities. When structures are built too close to the bank of the river, the weight may exceed the weight which the bank can hold and cause slumping or acceleration slumping that may already be active. Every year, river bank failure and erosion

causes unemployment, landlessness and increases poverty, which contributes to unstable economic conditions of the country (Rahman, 2010). Riverbank has been described as the land besides the river (Rutherford, 2000; Tripathy & Mondal, 2020).

Stream morphology is the study of the physical feature and processes of the flowing water that is limited by the channel. Tide is a periodic regional rise and fall of water levels caused by gravitational effects of the sun and the moon and the centrifugal forces of the earth own rotation (Eze, 2004; Box *et al.*, 2018). Gobo and Abam (2006) analyzed rainfall anomalies and flooding over the world in recent times and stated that dredging is the process of digging, scrapping, gathering, scoping, sucking or pulling out material from the bed or bank of the river and depositing it in another environment or another part of the river. During dredging, waterway sediment, soil, creek banks and vegetation along the right of way (ROW) are removed and because of lack of better ways to manage the concomitant dredged materials, they are deposited as spoils at the bank of the newly dredged canals (Ohimainet *al.*, 2010). Dredging not only causes vertical instability in the channel bed, but also causes lateral instability in the form of accelerated stream bank erosion and channel widening (Kabirulet *al.*, 2019). According to Abam (1993), bank erosion leads to the continuous adjustment of channel geometry, this adjustment affects the utility of rivers by man, and increases the level of risk in the commercial development of the rivers.

Abam and Okagbue (1986), on the construction and performance of riverbank erosion protection structure in the Niger Delta, emphasized the mechanical properties of bank protection structures. Ohaeri *et al.* (2021) studied environmental impact of sand mining in some selected coastal communities and stated that sand mining activity is one of the serious environmental problems when the river are widely exploited for river bed materials resulting in land degradation as well as loss of riparian habitat.

These activities are of great concern to the conservation of the ecosystem and so the impacts are considered for the Mini-Piti stream based on the economic value of this stream to the Obio-Akpor and Rivers State based on the topography and nearness to the capital city of Port Harcourt and its environs.

2.0 METHODOLOGY

2.1 Study Area

Mini Piti stream is located in Obio Akpor Local Government Area of River State, South - South Nigeria and is one of the major hydrographic streams in Port Harcourt Metropolitan. This is located in the tropical belt with an equatorial climate characterized by dry and wet seasons. The Apamini road, Market road, Abrikka road, Ogbogoro Road, , Iwofe road, New road, were the access roads that leads to the study area on land, while New Calabar River served as the means of entrance to the stream.

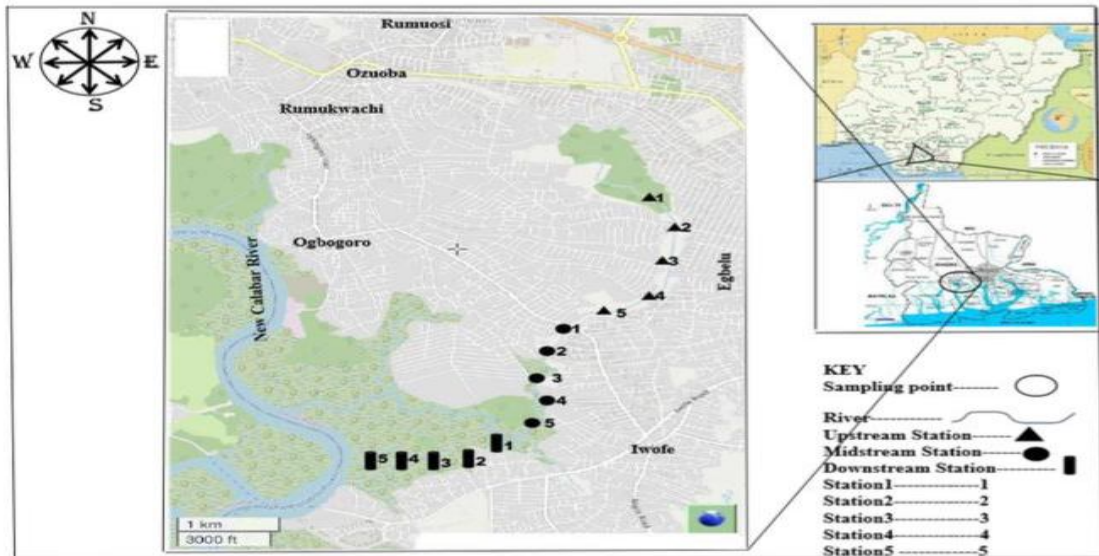


Fig.1: Map of River State showing study Area

2.2 Sample Analysis

2.2.1 Bathymetry Survey

Bathymetry Survey was carried out with the help of Echo sounder and meter rule to measure the depth of the stream, in order to facilitate the river bed profile by dividing the study area into three stations.

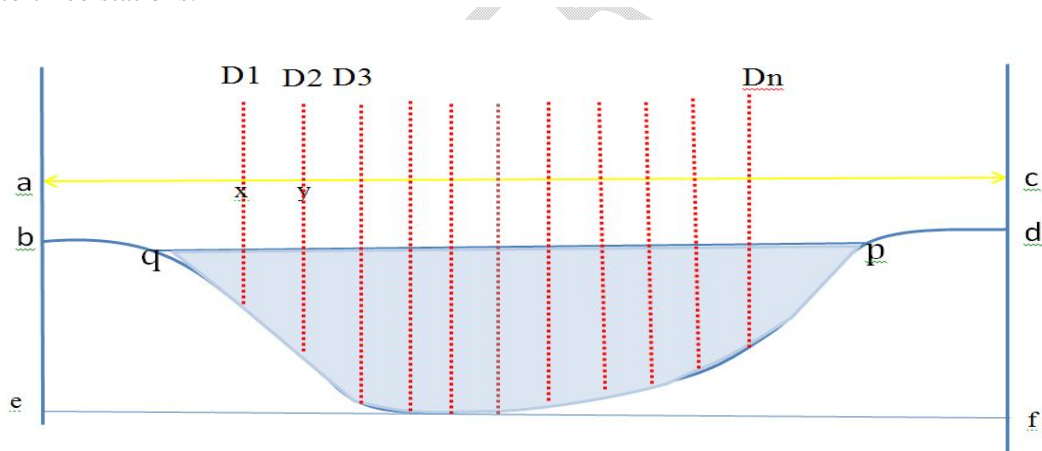


Fig. 2: The Cross Section of the Stream

The upstream extended from upper Egbelu to New road and cuts across Mgaraja. The depth profile was carried out in 5 samplings location at intervals of 500m apart and labeled as location 1 to 5 during dry and wet seasons. The bathymetry data obtained was properly recorded, after the last location at the upstream, a distances of 1000m was measured to begin midstream profiling for 5 sampling at intervals of 500m. The midstream section covered Mgbuakara community at right bank and Egbelu community at left bank. The downstream section covered Elioparanwo, upper Egbelu and Iwofe. The same method for upstream and midstream was used at the downstream for five sample points. Figure 2 above shows the cross section of the stream, a calibrated rope **ab** from right to left bank to measure the width of the stream, **D1** to **Dn** indicate depth sounding at every 0.5m intervals to measure the stream depth, **qp** is the water level, while **bq** and **pd** represent the right and left bank. This

procedure was applied for upstream, midstream and downstream during the dry and wet season to generate bathymetry data as shown in Tables 1 to 7.

2.2.2 Flow Dynamic

The manual approach was employed during the study. A floating object was suspended at a known distance ‘**AB**’ of length 10m along the bank and width measurement was obtained as ‘**CD**’, a horizontal distance from right bank to left bank, with average depth of the stream **D** measured (vertical sounding from a platform). The time taken for the object to flow from point **A** to **B** was carefully recorded, the process was repeated three times and the average time calculated.

AB = length of the stream measured = 10m
CD = width of the stream
D = Average depth of stream
T = Average time $(\frac{t_1 + t_2 + t_3}{3})$

Velocity = $\frac{\text{Float object length}}{\text{average time}} = \frac{\text{AB}}{\text{T}}$ (m/s)

Cross sectional area = average depth × velocity = $D \times \frac{\text{AB}}{\text{T}}$

Discharge = Area × velocity

The results of the study are shown in Figures 3-14 below.

2.3 Results of the Study

Table 1: Bathymetry Data of Upstream (Wet Season)

Location 1		Location 2		Location 3		Location 4		Location 5	
Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
0.50	0.20	0.50	0.10	0.50	0.10	0.50	0.30	0.50	0.40
1.00	0.40	1.00	0.10	1.00	0.30	1.00	0.40	1.00	0.40
1.50	0.70	1.50	0.30	1.50	0.40	1.50	0.50	1.50	0.50
2.00	0.80	2.00	0.50	2.00	0.50	2.00	0.70	2.00	0.70
2.50	0.90	2.50	0.70	2.50	0.50	2.50	0.80	2.50	1.00
3.00	1.00	3.00	0.90	3.00	0.60	3.00	1.10	3.00	1.10
3.50	0.90	3.50	0.70	3.50	0.60	3.50	1.20	3.50	1-10
4.00	0.70	4.00	0.60	4.00	0.70	4.00	1.00	4.00	1.00
4.50	0.60	4.50	0.40	4.50	0.50	4.50	1.40	4.50	0.90
5.00	0.40	5.00	0.20	5.00	0.40	5.00	1.30	5.00	1.00
5.50	0.30	5.50	0.10	5.50	0.40	5.50	1.10	5.50	0.80
6.00	0.20	-	-	6.00	0.20	6.00	1.00	6.00	0.60
6.50	-	-	-	6.50	0.10	-	-	6.50	0.40

Table 2: Bathymetry Data of Mid-stream (Wet Season)

Location 1	Location 2	Location 3	Location 4	Location 5
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Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
0.5	0.20	0.50	0.40	0.50	0.10	0.50	0.10	0.50	0.20
1.0	0.70	1.00	0.70	1.00	0.20	1.00	0.30	1.00	0.60
1.5	0.70	1.50	0.70	1.50	0.30	1.50	0.40	1.50	0.60
2.0	0.90	2.00	1.10	2.00	0.70	2.00	0.60	2.00	0.70
2.5	1.30	2.50	1.10	2.50	1.00	2.50	0.70	2.50	0.80
3.0	1.40	3.00	0.90	3.00	1.30	3.00	0.70	3.00	0.80
3.5	1.60	3.50	0.90	3.50	1.30	3.50	0.50	3.50	1.00
4.0	1.60	4.00	1.30	4.00	1.60	4.00	0.50	4.00	0.70
4.5	1.30	4.50	1.40	4-50	1.60	4.50	0.60	4.50	0.80
5.0	1.30	5.00	1.60	5.00	1.30	5.00	0.90	5.00	1.00
5.5	1.70	5.50	1.50	5.50	1.40	5.50	1.10	5.50	1.30
6.0	1.60	6.00	1.30	6.00	1.50	6.00	1.30	6.00	1.40
6.5	1.40	6.50	0.80	6.50	1.30	6.50	1.40	6.50	1.60
7.0	0.80	7.00	0.60	7.00	1.10	7.00	1.50	7.00	1.60
7.5	0.60	7.50	0.40	7.50	0.90	7.50	1.50	7.50	1.40
8.0	0.40	8.00	0.30	8.00	0.60	8.00	1.50	8-00	1.20
8.5	0.40	8.50	0.40	8.50	0.40	8.50	1.40	8.50	1.00
9.0	-	9.00	0.30	9.00	0.30	9.00	1.40	9.00	0.80
9.5	-	-	-	9.50		9.50	1.20	9.50	0.60
10.0	-	-	-	10.0		10.00	1.00		

Table 3: Bathymetry Data of Downstream (Wet Season)

Location 1		Location 2		Location 3		Location 4		Location 5	
Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
0.50	0.20	0.50	0.40	0.50	0.30	0.50	0.40	0.50	0.30
1.00	0.30	1.00	0.40	1.00	0.40	1.00	0.60	1.00	0.50
1.50	0.50	1.50	0.30	1.50	0.40	1.50	0.90	1.50	0.80
2.00	0.60	2.00	0.30	2.00	0.40	2.00	0.90	2.00	0.90
2.50	0.90	2.50	0.40	2.50	0.60	2.50	0.90	2.50	0.60
3.00	0.90	3.00	0.60	3.00	0.80	3.00	0.70	3.00	0.70
3.50	1.10	3.50	0.70	3.50	0.90	3.50	0.70	3.50	0.80
4.00	1.00	4.00	0.90	4.00	1.00	4.00	0.80	4.00	1.00
4.50	0.90	4.50	1.10	4.50	1.20	4.50	1.00	4.50	1.30
5.00	0.90	5.00	1.20	5.00	1.50	5.00	1.20	5.00	1.50
5.50	1.20	5.10	1.30	5.50	1.80	5.50	1.50	5.50	1.70
6.00	1.50	6.00	1.50	6.00	1.90	6.00	1.60	6.00	1.90
6.50	1.60	6.50	1.80	6.50	1.90	6.50	1.80	6.50	2.10
7.00	1.70	7.00	1.80	7.00	1.90	7.00	2.10	7.00	2.00
7.50	1.50	7.50	1.80	7.50	1.70	7.50	2.10	7.50	1.70
8.00	1.30	8.00	1.70	8.00	1.50	8.00	2.00	8.00	1.50
8.50	1.00	8.50	1.70	8.50	1.30	8.50	1.70	8.50	1.30
9.00	0.80	9.00	1.50	9.00	1.00	9.00	1.50	9.00	1.00
9.50	0.60	9.50	1.30	9.50	1.00	9.50	1.30	9.50	0.70

10.00	0.40	10.00	1.30	10.00	0.80	10.00	1.20	10.00	0.70
10.50		10.50	1.00	10.50	0.80	10.50	1.00	10.50	0.60
11.00		11.00	0.90	11.00	0.70	11.00	0.80	11.00	0.60

Table 4: Bathymetry Data of Upstream (Dry Season)

Location 1		Location 2		Location 3		Location 4		Location 5	
Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.20	0.50	0.20
1.00	0.20	1.00	0.30	1.00	0.20	1.00	0.30	1.00	0.30
1.50	0.30	1.50	0.40	1.50	0.30	1.50	0.50	1.50	0.40
2.00	0.60	2.00	0.70	2.00	0.50	2.00	0.60	2.00	0.60
2.50	0.70	2.50	0.50	2.50	0.50	2.50	0.70	2.50	0.80
3.00	0.50	3.00	0.40	3.00	0.30	3.00	0.90	3.00	0.70
3.50	0.30	3.50	0.30	3.50	0.20	3.50	1.00	3.50	0.50
4.00	0.20	4.00	0.20	4.00	0.20	4.00	0.80	4.00	0.30
4.50	0.10	4.50	0.10	4.50	0.10	4.50	0.60	4.50	0.20
5.00	-	5.00	-	5.00	0.10	5.00	0.40	5.00	0.10

Table 5: Bathymetry Data of Mid-stream (Dry Season)

Location 1		Location 2		Location 3		Location 4		Location 5	
Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
0.50	0.10	0.50	0.30	0.50	0.10	0.50	0.10	0.50	0.10
1.00	0.30	1.00	0.40	1.00	0.20	1.00	0.20	1.00	0.30
1.50	0.50	1.50	0.50	1.50	0.40	1.50	0.40	1.50	0.40
2.00	0.70	2.00	0.60	2.00	0.70	2.00	0.60	2.00	0.70
2.50	0.90	2.50	0.80	2.50	0.90	2.50	0.60	2.50	0.60
3.00	1.00	3.00	0.90	3.00	1.00	3.00	0.70	3.00	0.60
3.50	1.00	3.50	1.00	3.50	1.00	3.50	0.80	3.50	0.90
4.00	1.20	4.00	0.90	4.00	1.20	4.00	1.00	4.00	1.00
4.50	1.00	4.50	1.10	4.50	1.10	4.50	1.20	4.50	1.20
5.00	1.20	5.00	1.00	5.00	0.90	5.00	1.20	5.00	1.20
5.50	1.00	5.50	0.80	5.50	0.70	5.50	1.00	5.50	1.00
6.00	0.80	6.00	0.60	6.00	0.50	6.00	1.20	6.00	0.80
6.50	0.60	6.50	0.40	6.50	0.40	6.50	1.00	6.50	0.60
7.00	0.40	7.00	0.20	7.00	0.30	7.00	0.80	7.00	0.40
7.50	0.20	7.50	0.30	7.50	0.20	7.50	0.70	7.50	0.30
8.00	0.20	8.00	-	8.00	-	8.00	0.6	8.00	0.30

Table 6: Bathymetry Data of Downstream (Dry Season)

Location 1	Location 2	Location 3	Location 4	Location 5
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Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
0.50	0.10	0.50	0.30	0.50	0.20	0.50	0.30	0.50	0.20
1.00	0.20	1.00	0.30	1.00	0.40	1.00	0.50	1.00	0.30
1.50	0.30	1.50	0.30	1.50	0.40	1.50	0.60	1.50	0.50
2.00	0.40	2.00	0.40	2.00	0.50	2.00	0.80	2.00	0.70
2.50	0.70	2.50	0.60	2.50	0.80	2.50	0.80	2.50	0.80
3.00	0.80	3.00	0.80	3.00	1.00	3.00	1.00	3.00	1.10
3.50	1.00	3.50	1.00	3.50	1.10	3.50	1.10	3.50	1.20
4.00	1.20	4.00	1.10	4.00	1.20	4.00	1.20	4.00	1.40
4.50	1.10	4.50	1.30	4.50	1.40	4.50	1.40	4.50	1.60
5.00	1.30	5.00	1.40	5.00	1.60	5.00	1.60	5.00	1.70
5.50	1.50	5.50	1.50	5.50	1.50	5.50	1.80	5.50	1.90
6.00	1.30	6.00	1.40	6.00	1.30	6.00	2.00	6.00	2.00
6.50	1.20	6.50	1.50	6.50	1.20	6.50	2.00	6.50	1.90
7.00	0.90	7.00	1.30	7.00	1.00	7.00	1.70	7.00	1.70
8.00	0.70	8.00	1.10	8.00	1.00	8.00	1.50	8.00	1.60
8.50	0.50	8.50	0.90	8.50	0.70	8.50	1.30	8.50	1.40
9.00	0.40	9.00	0.70	9.00	0.70	9.00	1.00	9.00	1.20
9.50		9.50		9.50	0.60	9.50	0.80	9.50	0.90
10.00		10.00		10.00	0.60	10.00	0.70	10.00	0.80
10.50		10.50		10.50		10.50		10.50	

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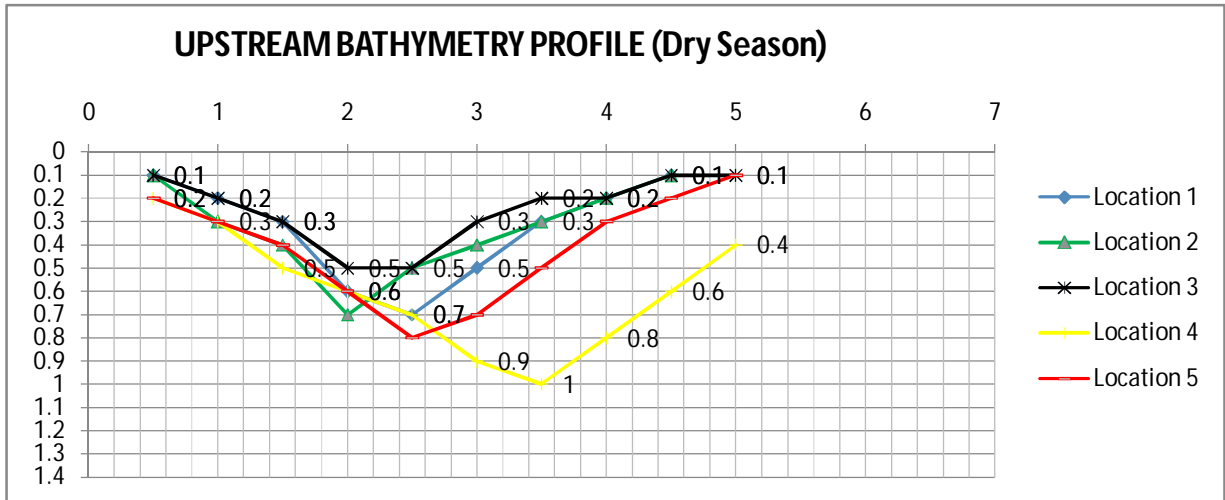


Figure 3: Graphical interpretation of upstream dry season bathymetry profile

The chart in Figure 3 shows the cross sectional depth profile of the upstream of the study area during the dry season where a total of five stations were surveyed across the channel. Maximum depth of 1m was recorded at location 5 indicated in the graph as red line and 0.5m depth observed at location 3. Observation at field indicated an average of 1.4m of water regression from the bank full stage and point bar. No serious bank erosion was recorded at the upstream of the study area, and is highly vegetated with farmland and distance built houses. The profile shows a well-defined, uniform and undisturbed channel basin.

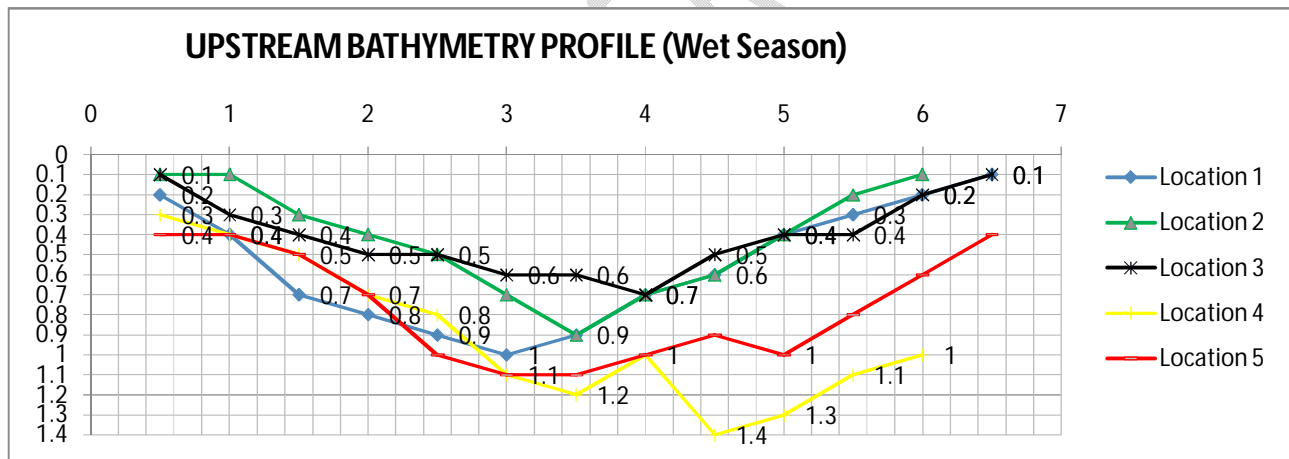


Figure 4: Graphical interpretations of wet season upstream bathymetry profile

There were significant changes in the depth and width of the upstream of the study area during the wet season as shown in Figure 4, the maximum width of the stream was 6.5m at location 5 and maximum depth of 1.4m at location 5. The changes in depth and width of the channel is as the result of input from the rain and runoff from the watershed which is between 1.2m and 1.4m depth. There was deposition of about 0.2m height of sediment in the stream bottom and bed erosion at location 5.

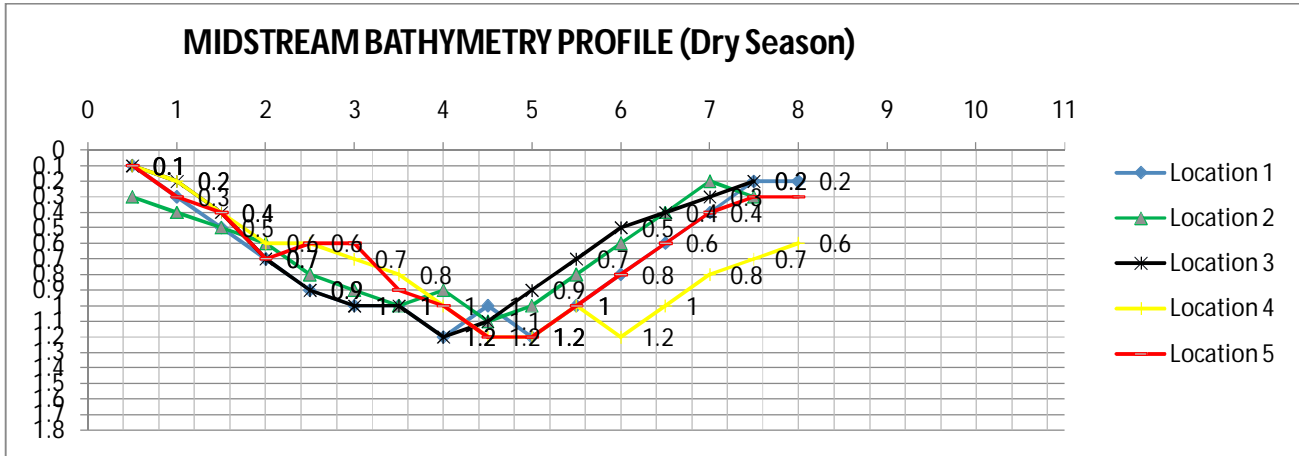


Figure 5: Graphical interpretations of dry season midstream bathymetry profile

The midstream of the study area covered five sample locations. The eroded zone of the bank was well exposed during the dry season as waste and debris dumped along the bank extended about 1.5m into the water channel, scarp, and bank full dimension was observed during the study (Figure 5). The maximum depth of the stream was 1.2m at location 2, 3, 4 and 5 and maximum width of 8.5m during the dry season.

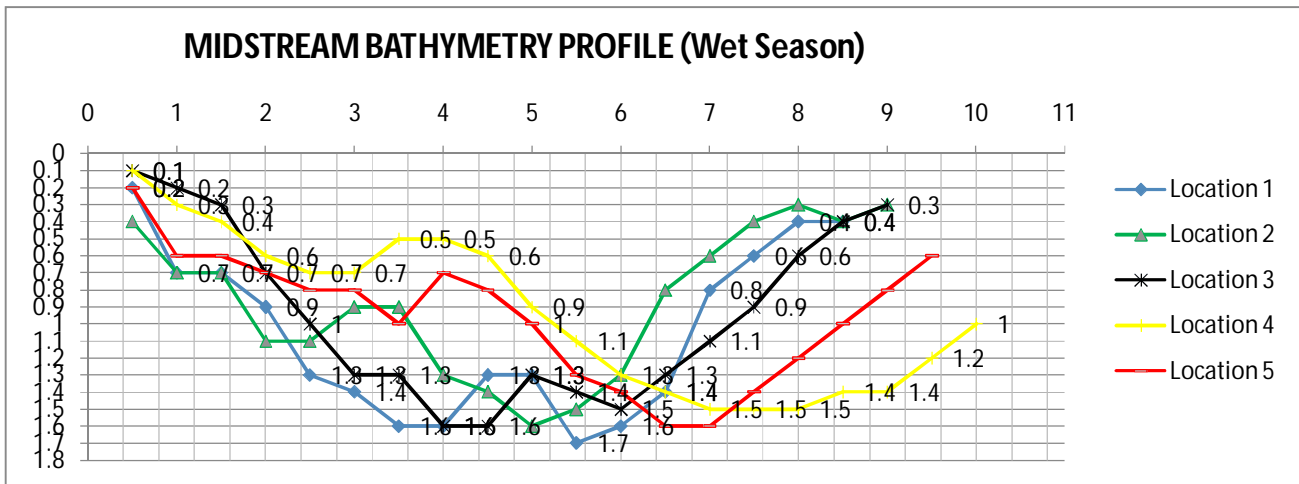


Figure 6: Graphical interpretation of midstream wet season bathymetry profile

The horizontal distance of about 2m from the floodplain which was exposed during the dry season was completely covered at the wet season as shown in Figure 6. The width distance of 0 -2m at 0.2 -0.6m depth shows bank erosion across the five locations of the midstream at the right bank. The scarp that was visible at the dry season was completely submerged during the wet season and for locations 1 and 3 at 1.3m depth, there was sediment accumulation on the bed of the stream and bed erosion at 1.6m depth and at location 1 and 1.7m depth at location 2. The maximum depth of the midstream during the wet season was recorded at location 1 and the width of 10.5m at location 4. From the field observation, the midstream was characterized by sharp sand.

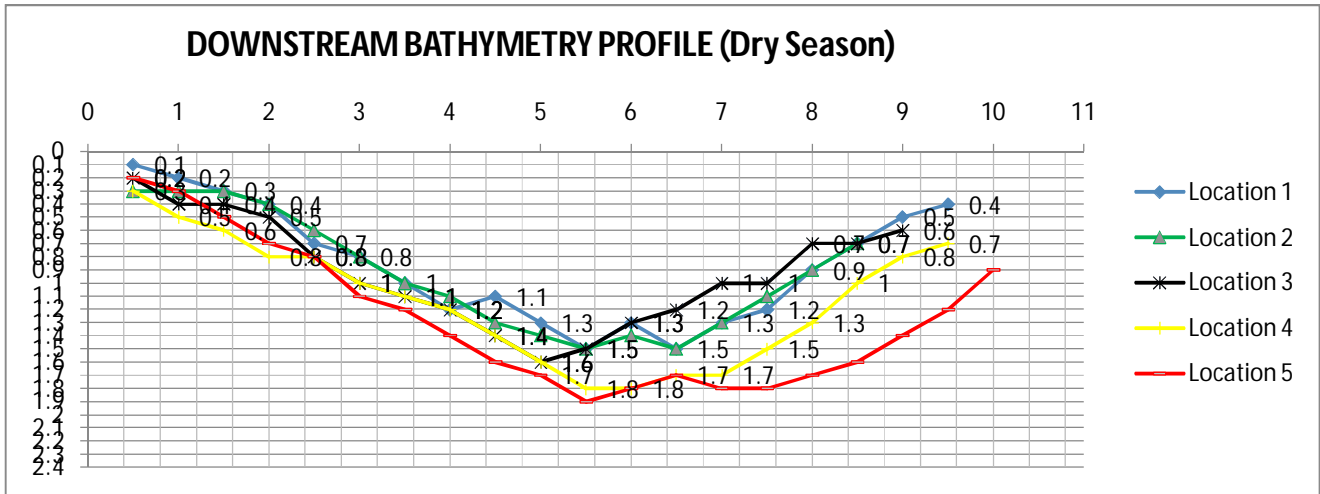


Figure 7: Graphical interpretation of downstream dry season bathymetry profile

The downstream bed characterization is the reflection of the processes that occurred along the upstream and midstream of the study area as shown in Figure 7. Locations 1 and 2 have an average depth of 1.5m and location 3 depth of 1.6m which is relatively shallow due to high rate of sediment deposition compared to the midstream of the study area. There was sand dredging activities along Location 4 and 5 which affected the depth profile at that point. The maximum depth of location 4 and 5 was 1.9m with maximum width of 10m.

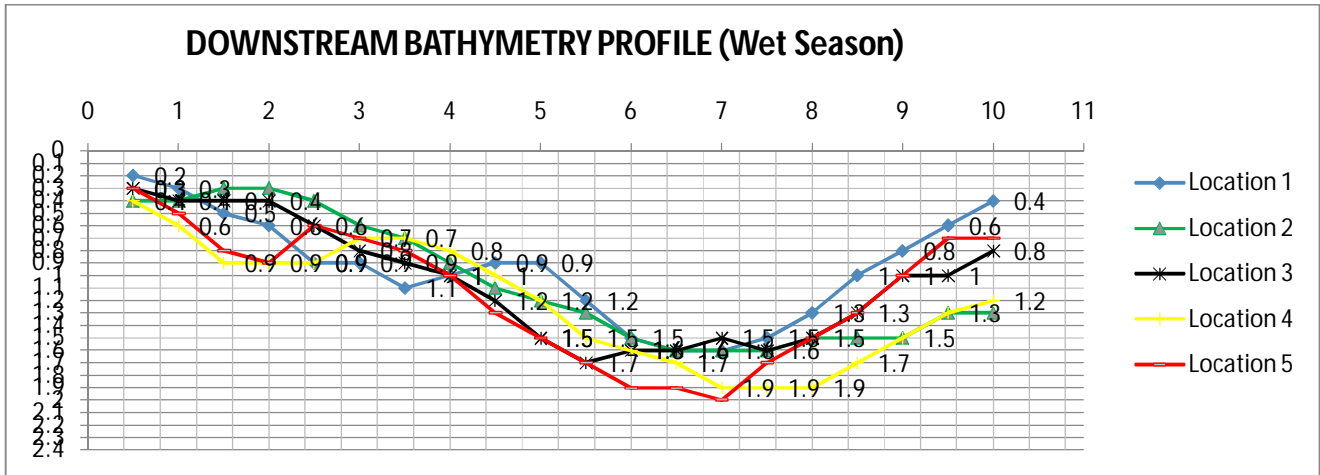


Figure 8: Graphical interpretation of downstream wet season of bathymetry profile

During the wet season, the eroded part of the bank that was exposed at dry season was covered with water as shown in Figures 7 and 8. The width length between 0.1m and 1.1m was covered with water as the result of increased rainfall and storm water impacts from the watershed. Maximum depth of 1.9m was recorded at locations 4 and location 5 of the right bank. The stream showed increase in depth towards the left bank with maximum width of 11m and at locations 4 and location 5 where there were sand minding activities.

2.5 Flow Dynamics of the Stream during Wet and Dry Season

The flow dynamics are shown in Figures 9, 10 and 11 from Table 7 below.

Table 7: Flow Dynamic of Upstream, Midstream and Downstream

Upstream	B.H (m)	SW (m)	A.V depth (m)	Float distance (m)	Time (s)	Vel. (m/s)	Area (m)	Discharge	A.V B.H
Dry	1.00	4.00	0.70	10.00	40.20	0.25	3.15	0.78	1.5
Wet	0.60	6.50	1.10	10.00	18.50	0.54	7.5	3.87	2.3
Midstream									
Dry	1.40	7.00	1.00	10.00	32.70	0.30	7.00	2.10	4.2
Wet	0.80	9.50	1.70	10.00	20.50	0.47	16.15	7.91	3.7
Downstream									
Dry	0.70	10.00	1.50	10.00	39.60	0.25	15.00	3.75	1.0
Wet	0.50	11.00	1.70	10.00	28.00	0.36	18.00	6.735	0.8

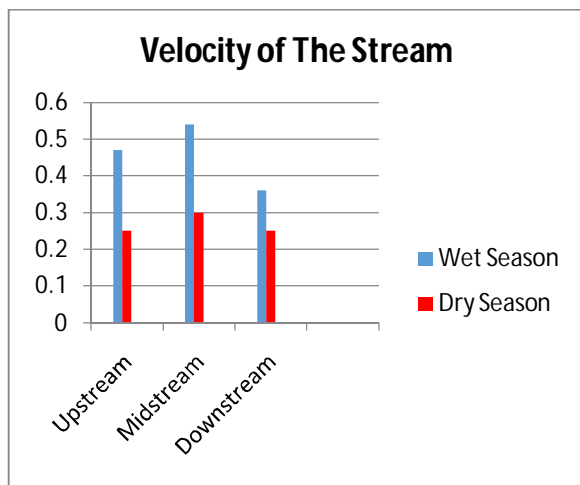


Fig. 9: Wet & dry season velocity

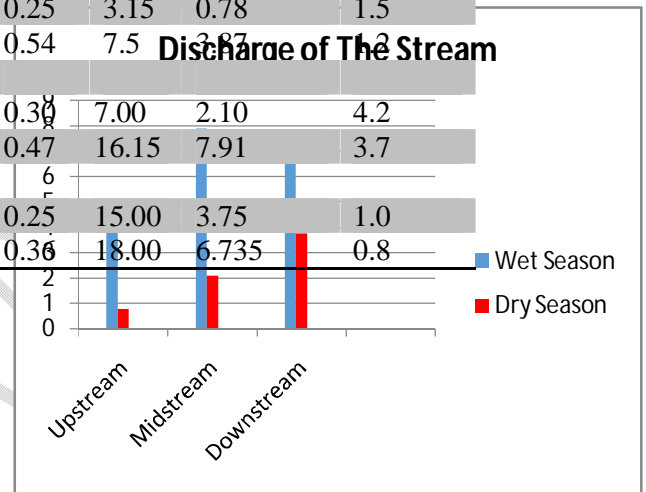
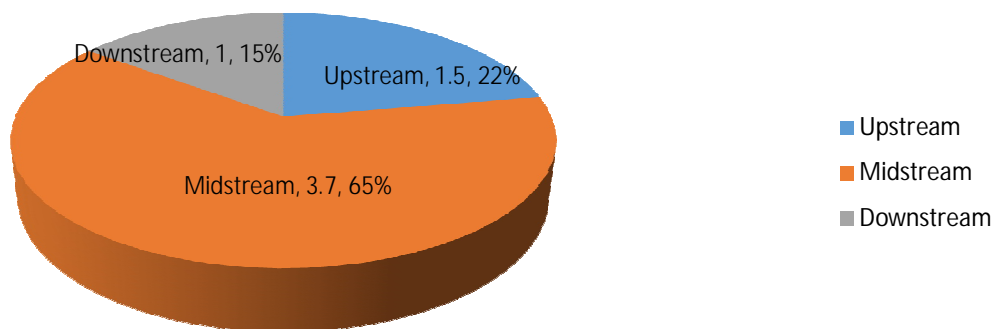


Fig.10: Wet & dry season discharge

Average Bank Height (Dry Season)



Average Bank Height (Wet Season)

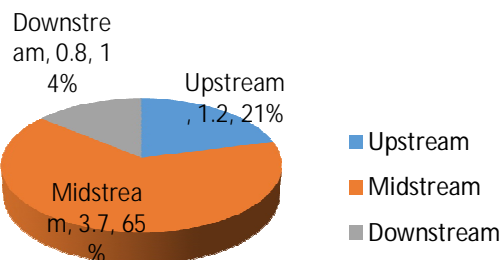


Fig.11: Average Bank Height

High velocity and discharge was recorded at midstream station of the study area during the wet season.

2.5 DISCUSSION OF FINDINGS

2.5.1 Impacts of Bank Erosion on Stream Bathymetry

Bank erosion has significant impacts on Mini-Piti stream bed. The eroded sediments from the bank, transported along the channel were deposited on the stream bed depending on the flow dynamics and channel geometry.

Comparatively, the three sections of the stream (upstream, midstream and downstream) for wet season and dry season were based on the conclusion drawn from analyzed data and indicates that there were changes in bed profile due to bank erosion. The cross section surveyed for the upstream showed a plane bed at across the five lactations of the two seasons with maximum depth 1.4m and width 7m for wet season, 1m depth and 5.0m width for dry season .There were no significant bed and bank erosion at the upstream section. The midstream section of the study area were characterized by bank and bed erosion from the analyzed bed profile data during the dry season as the riparian area was well exposed as a result of water transition, but was covered at the wet season due to increased surface runoff and storm water impact eroding the bank sediment and shaping the channel width .These led to accelerated stream scouring potential and sediment load in the water column and high rate of bed deposition causing shallow depth at the downstream as corroborated by Ohimain (2010) on similar studies. The downstream section of the study area was relatively shallow at locations 1, 2 and 3 with average depth of 1.5m for dry season and 1.7m depth at wet season while the width recorded 10m and 11m for dry and wet seasons (Iyama & Edori, 2014a; Iyama & Edori, 2014b). The eroded sediments, debris and dirt washed from the bank at the midstream is transported downstream by water current and the accumulations of sediment load on the stream bed over time, results in the shallow depth of the downstream section of study area irrespective of sand mining at station 4 and 5 which may cause economic devastation as agreed by Okeke and Ede (2019) previously.

2.5.2 Impacts of Stream Flow Rate on the Bank

The nature of sediment transports and bank erosion were highly affected by the stream flow rate. It was observed that large particles rested on the bottom as bed load and were only moved during rapid flows due to flooding and impacts of storm water entering the stream. Smaller particles were carried on siltation and suspension depending on increased or decreased velocity at certain points along the channel. Increase in the flow rate resulted in rapid erosion of the bank materials. The study area experienced decreased velocity and discharge during the dry season and increase at the wet season. The decrease was due to high evaporation rate and recharge of ground water during the dry season. The stream shows significant increase in water level during the wet season causing increase in velocity and high discharge of stream during the wet season as agreed earlier by Rentier and Cammeraat (2022) during sand mining activities. The highest velocity of 0.54m/s and discharge of 7.9m/s were recorded at the midstream section during wet season while minimum velocity of 0.25m/s was obtained at downstream of the study area. The high rate of velocity at midstream section contributed to bank and bed erosion at the midstream, while reduced velocity at the downstream could lead to deposition of fine grain material on the channel similar to the observations of Abam and Okagbue (1986), Abam and Nwankwoala (2020) on mechanical properties of bank protection structures. From field observation, erosion was high during the wet season as the flow depth and velocity increased, the force of water flowing against the bank eroding sediments and waste dumped at the stream bank. The midstream and part of upstream section of the stream was dredged about ten years ago to help evacuate floods from the residential area of the section but dredged materials were not transported out of the site. The abandoned materials left at the bank increased the bank height and inserted load on it to which impact of rain and stream velocity over time collapsed the bank into the water, causing adjustment of the bank, changes in water quality (Iyama *et al.*, 2017), sediment loads on the water column and bed deposition.

2.5.3 Impacts of Bank Erosion on Water Quality

The impact of river bank erosion on water quality has been examined in the study area by comparing the variation in water quality of the upstream, midstream and downstream and also using seasonal variation in the physicochemical parameters of 15 samples location during the wet season and 15 samples location during the dry season. The concentrations of physicochemical parameters of Midstream and downstream of the study area were generally well above World Health Organization (WHO, 2017) standards for drinking water during wet season indicating that eroded materials could have contaminated the midstream and downstream of the study area.

This is in agreement with previous studies (Abam, 1995 & 1997). Some of the parameters that shows variations at difference location of stream are well-spelled out. The following are considered to be the major factors responsible for bank erosion in Mini Piti stream. The protective cover provided by vegetation to help stabilizes the stream bank were completely removed for the purpose of farming and constructions at the midstream station of the stream, this action exposed the bank to erosion due to intensive rain and run off from the built environment (Abam, 1997). The midstream was dominated with series of human activities due to development of the area as earlier reported in similar reports (Gobo & Ngah, 2021; Garanaik, & Sholtes, 2013). During wet the season from field observation, there were rapid flows of storm water channeled from the built environments into the stream without resistance, weakening and weathering the bank materials by destabilizing and widening the pre-existing crack which eventually results to rapid bank failure and erosion (Andrew *et al.*, 2013). This was similar to water level variation from less than 1.5 m in the estuaries to about 8 m at the apex of the delta, with Nun River having a slightly higher elevation compared to Forcados River, implying that canals connecting both rivers at the same reach would experience water movements from Nun to Forcados River (Abam & Fubara, 2022). The flow rate of the stream was high during the wet season which increased the stream water column as this also has significant impact on the stream bank. This also had an impact on the shear stress exerted by the water volume as velocity increase exceeded the strength of the bank material causing erosion (Hagerty *et al.*, 1981).

The height of the bank and slope are the critical factors responsible for erosion of the bank along the midstream station of the stream with average height of 4.5m and upstream of 0.9m.

2.6 CONCLUSION

The assessment of impacts of bank erosion on the channel morphology of Mini Piti stream was carried out between the months of December 2023 to May 2024. The results revealed that there was a significant difference in some physicochemical parameters of the upstream, midstream and downstream of the study area during wet and dry season. The bathymetric survey carried out also revealed that there was constant bed and bank erosion at the midstream and deposition at the downstream section of the stream. The high rate of bed sediment load makes the downstream to be relatively shallow, with increased depth and width during wet season due to impact of rain and storm water recharge from the watersheds. The stream flow velocity and discharge was higher at the midstream section. The results obtained also showed high velocity and discharge at the midstream section as the increased flow rate also increase the stress on the bank and bed of the stream, thereby increasing erosion rates as flow overcomes the shear stress of the bank sediment. There is ardent need to regularly observe and monitor stream water parameters to avoid bank failures occasioned by anthropogenic activities.

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