

EVALUATION OF ENGINE BOATS' SPEED RANGE, DISTANCE RANGE, AND CLASS INFLUENCE ON BANK EROSION

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Abstract

Measurements and documentations of speed range, distance range and class of engine boats were carried out upon individual boat passes at various turbulent levels in selected waterways for two years time frame. Level of erosion at the shoreline of the river bank was noted following relevant measurements and computations. Prior the results, engine boats speed range, distance range, and class were found to have negative influence on bank erosion.

Keywords: Bank Erosion, Turbulent Flow, Engine Boat Classification, River Niger, Erosion Control.

1.0 INTRODUCTION

1.1 Bank Erosion: Loss of soil or land at the sides of shoreline or coastline result to bank erosion. Bank erosion refers to the wearing or washing away of soil materials from the land along the sides of a water body like lakes, stream, rivers, seas, *e.t.c*. River bank erosion occurs naturally and through human impact (GEI, 2017). An example of bank erosion can be seen in Plate 1.1.



Plate 1.1: Eroding waterbanks/ bank erosion

1.2 Turbulent Flow: Generally in fluid flow, flow of liquids moving in a straight line (about Reynolds number of 10^0) is referred as a Laminar flow. Liquid flow in a non – laminar flow is referred to as a turbulent flow (flow with Reynolds number above 10^4). From figure 1.1, apart from medium sized fishes, the micro invertebrates and small fishes cannot withstand the force exerted in the turbulent environment due to the chaotic nature. These flows categorized using Reynolds number and their shapes are presented in figure 1.1.

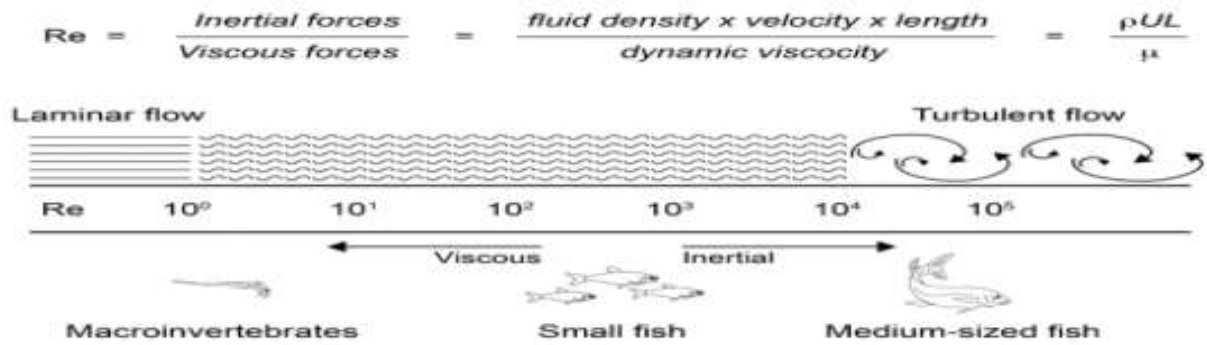


Figure 1.1: Definition of Turbulent flow with respect to Laminar flow and Reynolds (Trinci *et. al.*, 2017)

This flow generated by engine boat can be seen in Plate 1.2.



Plate 1.2: Turbulent flow generated by engine boat

In terms of erosion, they pose higher threat to banks of river, ocean and other flowing water bodies than the normal erosive force from the water current. The force generated (wave) by this flow from the boat direction to the banks of a shore or coast can be seen in Plate 1.3.

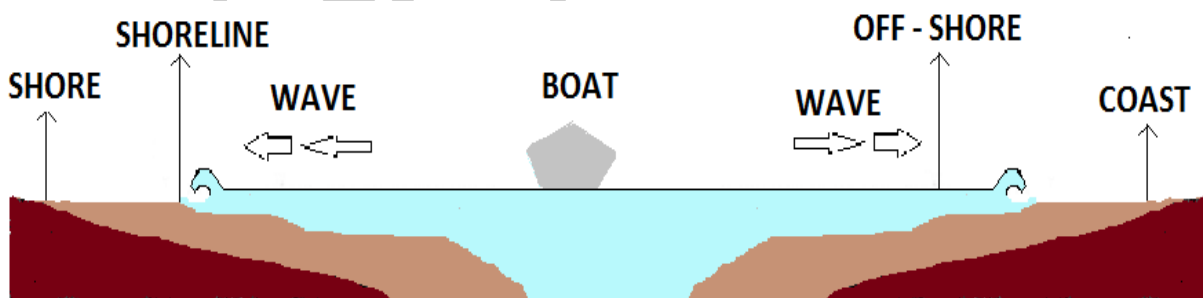


Plate 1.3: Wave impact on bank of a shore/ coast

1.3 Engine Boat Classification: Engine boat classification is divided into boat type classification and boat size classification. Boat type classification is done according to the boat engine types which are divided into outboard engines, inboard engines, and the stern drive engines.

- i. Outboard engine boats are boats with the engine mounted outside the boat, usually behind the boat. The advantage is that the engine can be easily removed for repairs and storage unlike the others.
- ii. Inboard engine boats are automotive engines boats, mostly with four stroke engine attached inside the boat, to power the drive shaft connected to a propeller (blade).

- iii. The stern drive engine boats are boat types with both features of the outboard and inboard engine boat types.
 - iv. Jet drive engine boats are boat types that use water obtained from bottom intake unit of the boat to propel and steer the boat. This is made possible through the use of the jet drive unit of the transom which aid in pushing the boat forward using a thrusting force.
- Boat size classification requires measurement of boat parts for appropriate categorization. A practical example of such measurement is presented in Figure 1.2.

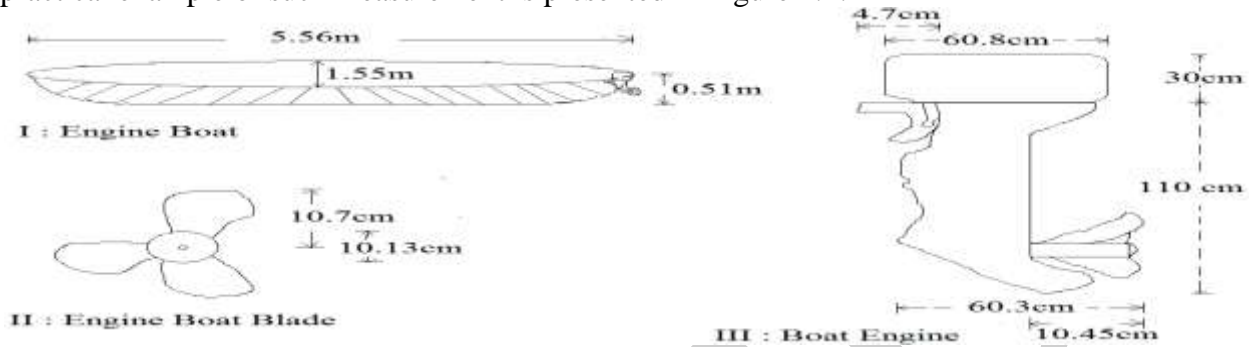


Figure 1.2: Engine boat measurement

Boat length is obtained by measuring along the centre line from the outside bow (boat front) to the outside stern (boat back). Four classes of recreational boats determined by length (classifications as applicably used by the US Coast guard federal regulatory) are:

1. Class A: Less than 16 ft
2. Class 1: Boats measuring more than 16 ft but less than 26ft
3. Class 2: Boats measuring more than 26 ft but less than 40 ft
4. Class 3: Boats measuring more than 40 ft but less than 65 ft

2.0 MATERIALS AND METHODS

2.1 Materials

The study area is Otu Ogwu – Kebul Marine section of the River Niger in Asaba. Asaba (capital city in Delta State of Nigeria) is one of the cities located along the banks of the River Niger. The Niger rises in Guinea at 9°05'N and 10°47'W on the eastern side of the Fouta Djallon (Guinea) highlands, only 150 miles (240 km) inland from the Atlantic Ocean (Britinca, 2021). The West African River from the Atlantic Ocean travels through the Sahara region countries of Africa from Guinea to Mali and Niger before moving down to delta state in Nigeria where it flows back to the Atlantic Ocean. The Niger River, with a total length of about 4100 km, is the third – longest river in Africa, after the Nile and Congo/ Zaire Rivers, and the longest and largest river in West Africa (FAO, 1997). Meseko et. al. (2018) noted that “the basin area is 2,117,700 km.sq and discharge rate (volume of water passing through a point in a given time) at 5589 m.cu/s. The location of the study area (Asaba River Niger) is presented in Plate 2.1.



Plate 2.1: Location of Asaba (Nigeria) section of River Niger in map of Africa

Other materials used include:

- i. **Materials Used for Obtaining Boats Class:** workbook (used to record obtained values for various analysis), one class A engine boat (used for transportation within the aquatic parts of the site to obtain require measurements), hand gloves (used for hand - skin protection while taking measurements) and 7.5 x 25mm PO9A Putero Power Tape (used to measure boat length, that is, from boat front to boat back).
- ii. **Materials Used for Obtaining Boats Sailing Speed:** manual speed meter (use to manually obtain speed of boats), two class A engine boats (used for transportation within the aquatic parts of the site to obtain measurements like on - board boat speed value), and workbook (used to record obtained values for various analysis).
- iii. **Materials Used for Obtaining Boats Sailing Range:** one class A engine boat (used for transportation within the aquatic parts of the site during break water pipe markings, and to obtain measurements like sailing distance value), 7.5 x 25mm Professional Putero Power Tape (used to measure require range lengths while marking the range numbers on the break water pipe), break water pipe (used for attaining boats distance position through the pipe markings), site camera (used for the photograph of boats position near the break water pipe markings) and workbook (used to record obtained values for various analysis).
- iv. **Materials Used for Obtaining Turbulence Level:** Workbook (paper sheet used to record documentation through writing with the pen), swim goggles (used for eye protection and increased vision in the water environment for water condition investigation), 5.0 MP site camera (for capturing water surface condition) and hand gloves (for hand - skin protection in the site).
- v. **Materials Used to Obtain Shoreline Erosion Rate:** Yamaha engine boat (used for transportation within the aquatic parts of the site), Google GIS/ satellite (used for site mapping), 5.0 megapixels (2592 x 1944 resolution) camera (used for bank shoreline position imaging), workbook (used for bank shoreline record documentation), 7.5 x 25mm PO9A Professional Putero Power Tape (used for measuring length of bank shoreline change), and hand gloves (for skin protection while obtaining bank shoreline change measurements).

2.2 Methods

Boat Sailing Speed was obtained by implanting the manual speed meter inside every boat that sought passage along the selected waterway and upon each exit the values were recorded while the meter was detached.

Boat sailing distance range was obtained by measuring boat sailing distance from the bank shoreline upon passage.

Boat sailing range values are: 1 (1m to 15m), 2 (15m to 30m), 3 (30m to 45m), 4 (45m to 60m).

Boats' class values were obtained using boat length (by measuring along the centre line from the boat front to the boat back) categorization.

Boat class values are: class A (Boats measuring less than 16 ft), class 1 (Boats measuring more than 16 ft but less than 26ft), class 2 (Boats measuring more than 26 ft but less than 40ft), class 3 (Boats measuring more than 40 ft but less than 65ft).

Turbulence Level was obtained from observed wave condition using wave characterization technique by Tomkins *et. al.* (2014). Where: turbulence level values are: 0 (very low, VL) for Ripples of 0 > 25% disturbance, 1 (Low, L) for Small waves of 25 > 50% disturbance, 2 (High, H) for Medium waves of 50 > 75% disturbance, 3 (Very high, VH) for Large waves of 75 > 100% disturbance.

Erosion rates were computed using formula by Cox *et. al.* (1994). Where Erosion rating are: 1 = less than 0.0050, 2 = 0.0050 to 0.0099, 3 = 0.0100 and above.

3.0 RESULTS AD DISCUSSIONS

3.1 Results

Speed range, distance range and boat class for various turbulent levels with their erosion levels for the years 2016 and 2017 are presented in Tables 3.1 to 3.26.

Table 3.1: January 2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	336	3
	(15-34)	20	127	44	191		
	(35-49)	15	76	24	115		
	50>	5	20	5	30		
Distance range	1	97	30	16	143	296	3
	2	77	44	20	141		
	3	9	1	2	12		
	4	97	30	16	143		
Boat class	A	21	126	42	189	336	3
	1	14	74	19	107		
	2	5	21	14	40		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 56.8% with 37.8% of turbulent 2 with erosion level 3. Distance range of 1 had highest intensity of 48.3% with 32.8% of turbulent 1 with erosion level 3. Boat class A had highest intensity of 56.3% with 37.5% of turbulent 2 with erosion level 3.

Table 3.2: February 2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	303	3
	(15-34)	16	73	44	133		
	(35-49)	10	74	26	110		
	50>	4	42	14	60		
Distance range	1	1	16	28	45	303	3
	2	10	82	26	118		
	3	12	72	28	112		
	4	6	17	5	28		
Boat class	A	15	75	42	132	303	3
	1	12	99	40	151		
	2	3	11	6	20		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 43.9% with 24.1% of turbulent 2 with erosion level 3. Distance range of 2 had highest intensity of 38.9% with 27.1% of turbulent 2 with erosion level 3. Boat class 1 had highest intensity of 49.8% with 32.7% of turbulent 2 with erosion level 3.

Table 3.3: March2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	297	2
	(15-34)	7	44	113	164		
	(35-49)	12	24	69	105		
	50>	3	6	19	28		
Distance range	1	2	10	77	89	297	2
	2	5	24	66	95		
	3	14	33	61	108		
	4	1	3	1	5		
Boat class	A	20	54	157	231	297	2
	1	1	11	32	44		
	2	-	5	17	22		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 55.2% with 38.0% of turbulent 3 with erosion level 2. Distance range of 3 had highest intensity of 36.4% with 20.5% of turbulent 3 with erosion level 2. Boat class A had highest intensity of 77.8% with 52.9% of turbulent 3 with erosion level 2.

Table 3.4: April2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	365	1
	(15-34)	38	154	56	248		
	(35-49)	21	65	25	111		
	50>	1	5	-	6		
Distance range	1	-	25	15	40	365	1
	2	15	89	31	135		
	3	34	107	32	173		
	4	11	6	-	17		
Boat class	A	47	185	61	293	365	1
	1	7	35	13	55		
	2	2	10	5	17		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 67.9% with 42.2% of turbulent 2 with erosion level 1. Distance range of 3 had highest intensity of 46.4% with 29.3% of turbulent 2 with erosion level 1. Boat class A had highest intensity of 80.3% with 50.7% of turbulent 2 with erosion level 1.

Table 3.5: May2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	350	1
	(15-34)	25	182	42	249		
	(35-49)	8	64	22	94		
	50>	1	3	3	7		
Distance range	1	-	14	10	24	350	1
	2	9	154	47	210		
	3	21	87	5	113		
	4	3	-	-	3		
Boat class	A	30	206	54	290	350	1
	1	2	37	8	47		
	2	1	11	1	13		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 71.1% with 52.0% of turbulent 2 with erosion level 1. Distance range of 2 had highest intensity of 60.0% with 44.0% of turbulent 2 with erosion level 1. Boat class A had highest intensity of 82.9% with 58.9% of turbulent 2 with erosion level 1.

Table 3.6: June2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	296	2
	(15-34)	12	146	54	212		
	(35-49)	3	57	8	68		
	50>	1	12	3	16		
Distance range	1	-	9	11	20	296	2
	2	3	145	47	195		
	3	10	62	6	78		
	4	3	-	-	3		
Boat class	A	12	178	55	245	296	2
	1	3	24	6	33		
	2	1	16	1	18		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 71.6% with 49.3% of turbulent 2 with erosion level 2. Distance range of 2 had highest intensity of 65.9% with 49.0% of turbulent 2 with erosion level 2. Boat class A had highest intensity of 82.8% with 60.1% of turbulent 2 with erosion level 2.

Table 3.7: July2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	397	3
	(15-34)	5	99	161	265		
	(35-49)	2	37	78	117		
	50>	-	2	13	15		
Distance range	1	-	10	47	57	397	3
	2	1	84	187	272		
	3	6	44	18	68		
	4	-	-	-	-		
Boat class	A	6	114	199	319	397	3
	1	-	12	41	53		
	2	-	14	11	25		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 66.8% with 40.6% of turbulent 3 with erosion level 3. Distance range of 2 had highest intensity of 68.5% with 47.1% of turbulent 3 with erosion level 3. Boat class A had highest intensity of 80.4% with 50.1% of turbulent 3 with erosion level 3.

Table 3.8: August2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	386	3
	(15-34)	13	65	229	307		
	(35-49)	2	20	52	74		
	50>	-	2	3	5		
Distance range	1	1	9	102	112	386	3
	2	5	49	174	228		
	3	6	26	10	42		
	4	3	1	-	4		
Boat class	A	12	63	214	289	386	3
	1	2	16	56	74		
	2	1	8	14	23		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 79.5% with 59.3% of turbulent 3 with erosion level 3. Distance range of 2 had highest intensity of 59.1% with 45.1% of turbulent 3 with erosion level 3. Boat class A had highest intensity of 74.9% with 55.4% of turbulent 3 with erosion level 3.

Table 3.9: September 2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	304	2
	(15-34)	3	89	161	253		
	(35-49)	-	19	26	45		
	50>	1	3	2	6		
Distance range	1	2	34	87	123	304	2
	2	-	65	98	163		
	3	-	14	2	16		
	4	2	-	-	2		
Boat class	A	3	84	147	234	304	2
	1	1	27	28	56		
	2	-	2	12	14		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 83.2% with 53.0% of turbulent 3 with erosion level 2. Distance range of 2 had highest intensity of 53.6% with 32.2% of turbulent 3 with erosion level 2. Boat class A had highest intensity of 77.0% with 48.4% of turbulent 3 with erosion level 2.

Table 3.10: October 2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	327	1
	(15-34)	29	136	94	259		
	(35-49)	5	43	12	60		
	50>	-	5	3	8		
Distance range	1	-	16	49	65	327	1
	2	4	58	29	91		
	3	18	136	5	159		
	4	11	1	-	12		
Boat class	A	25	163	61	149	327	1
	1	7	39	20	66		
	2	2	8	2	12		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 79.2% with 41.6% of turbulent 2 with erosion level 1. Distance range of 3 had highest intensity of 48.6% with 41.6% of turbulent 2 with erosion level 1. Boat class A had highest intensity of 45.6% with 49.8% of turbulent 2 with erosion level 1.

Table 3.11: November 2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	193	1
	(15-34)	71	37	8	116		
	(35-49)	36	26	2	64		
	50>	11	2	-	13		
Distance range	1	-	5	5	10	193	1
	2	14	17	6	37		
	3	91	41	-	132		
	4	14	-	-	14		
Boat class	A	92	52	9	153	193	1
	1	16	8	1	25		
	2	10	4	1	15		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 60.1% with 36.8% of turbulent 1 with erosion level 1. Distance range of 3 had highest intensity of 68.4% with 47.1% of turbulent 1 with erosion level 1. Boat class A had highest intensity of 79.3% with 47.7% of turbulent 1 with erosion level 1.

Table 3.12: December 2016 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	222	1
	(15-34)	85	21	22	128		
	(35-49)	61	14	12	87		
	50>	4	1	2	7		
Distance range	1	5	15	22	42	222	1
	2	28	16	11	55		
	3	110	3	2	115		
	4	10	-	-	10		
Boat class	A	126	31	27	184	222	1
	1	24	2	4	30		
	2	6	1	1	8		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 57.7% with 38.3% of turbulent 1 with erosion level 1. Distance range of 3 had highest intensity of 51.8% with 49.5% of turbulent 1 with erosion level 1. Boat class A had highest intensity of 82.9% with 56.8% of turbulent 1 with erosion level 1.

Table 3.13: January 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	249	3
	(15-34)	15	128	22	165		
	(35-49)	4	65	4	73		
	50>	-	9	2	11		
Distance range	1	-	23	12	35	249	3
	2	1	72	15	88		
	3	14	105	3	122		
	4	4	-	-	4		
Boat class	A	17	163	26	206	249	3
	1	2	28	3	33		
	2	-	7	3	10		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 66.3% with 51.4% of turbulent 2 with erosion level 3. Distance range of 3 had highest intensity of 49.0% with 42.2% of turbulent 2 with erosion level 3. Boat class A had highest intensity of 82.7% with 65.5% of turbulent 2 with erosion level 3.

Table 3.14: February 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	251	3
	(15-34)	9	63	28	100		
	(35-49)	13	86	25	124		
	50>	3	15	9	27		
Distance range	1	-	14	47	61	251	3
	2	7	84	16	107		
	3	15	65	-	80		
	4	3	-	-	3		
Boat class	A	24	145	59	228	251	3
	1	1	12	2	15		
	2	-	6	2	8		
	3	-	-	-	-		

Speed range of 35-49 had highest intensity of 49.4% with 34.3% of turbulent 2 with erosion level 3. Distance range of 2 had highest intensity of 42.6% with 33.5% of turbulent 2 with erosion level 3. Boat class A had highest intensity of 90.8% with 57.8% of turbulent 2 with erosion level 3.

Table 3.15: March 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	275	2
	(15-34)	26	72	15	113		
	(35-49)	14	102	26	142		
	50>	2	12	6	20		
Distance range	1	-	7	26	33	275	2
	2	7	70	16	93		
	3	30	112	2	144		
	4	5	-	-	5		
Boat class	A	40	171	42	253	275	2
	1	1	14	-	15		
	2	-	6	1	7		
	3	-	-	-	-		

Speed range of 35-49 had highest intensity of 51.6% with 37.1% of turbulent 2 with erosion level 2. Distance range of 3 had highest intensity of 52.4% with 40.7% of turbulent 2 with erosion level 2. Boat class A had highest intensity of 92.0% with 62.2% of turbulent 2 with erosion level 2.

Table 3.16: April 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	315	1
	(15-34)	22	141	35	198		
	(35-49)	8	81	22	111		
	50>	-	4	2	6		
Distance range	1	-	15	44	59	315	1
	2	7	100	17	124		
	3	21	104	1	126		
	4	4	2	-	6		
Boat class	A	28	189	52	269	315	1
	1	3	23	7	33		
	2	1	9	3	13		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 62.9% with 44.8% of turbulent 2 with erosion level 1. Distance range of 3 had highest intensity of 40.0% with 31.7% of turbulent 2 with erosion level 1. Boat class A had highest intensity of 85.4% with 60.0% of turbulent 2 with erosion level 1.

Table 3.17: May 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	256	1
	(15-34)	26	102	20	148		
	(35-49)	11	72	14	97		
	50>	-	9	2	11		
Distance range	1	-	1	16	17	256	1
	2	5	75	18	98		
	3	25	104	4	133		
	4	7	1	-	8		
Boat class	A	32	155	32	219	256	1
	1	5	23	4	32		
	2	-	3	2	5		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 57.8% with 39.8% of turbulent 2 with erosion level 1. Distance range of 3 had highest intensity of 52.0% with 40.6% of turbulent 2 with erosion level 1. Boat class A had highest intensity of 85.5% with 60.5% of turbulent 2 with erosion level 1.

Table 3.18: June 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	313	2
	(15-34)	7	42	84	133		
	(35-49)	11	39	113	163		
	50>	-	2	15	17		
Distance range	1	-	3	32	35	313	2
	2	2	16	176	194		
	3	12	62	6	80		
	4	4	-	-	4		
Boat class	A	17	71	184	272	313	2
	1	1	8	22	31		
	2	1	3	6	10		
	3	-	-	-	-		

Speed range of 35-49 had highest intensity of 52.1% with 36.1% of turbulent 3 with erosion level 2. Distance range of 2 had highest intensity of 62.0% with 56.2% of turbulent 3 with erosion level 2. Boat class A had highest intensity of 86.9% with 58.8% of turbulent 3 with erosion level 2.

Table 3.19: July 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	343	3
	(15-34)	11	38	197	246		
	(35-49)	2	16	69	87		
	50>	-	3	7	10		
Distance range	1	-	6	66	72	343	3
	2	4	23	187	214		
	3	5	29	20	54		
	4	3	-	-	3		
Boat class	A	11	53	231	295	343	3
	1	1	3	37	41		
	2	-	1	6	7		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 71.7% with 57.4% of turbulent 3 with erosion level 3. Distance range of 2 had highest intensity of 62.4% with 54.5% of turbulent 3 with erosion level 3. Boat class A had highest intensity of 86.0% with 67.3% of turbulent 3 with erosion level 3.

Table 3.20: August 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	290	3
	(15-34)	13	49	150	212		
	(35-49)	3	15	57	75		
	50>	-	-	3	3		
Distance range	1	2	5	36	43	290	3
	2	5	20	69	94		
	3	8	34	108	150		
	4	1	2	-	3		
Boat class	A	14	53	187	254	290	3
	1	1	7	21	29		
	2	-	2	5	7		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 73.1% with 51.7% of turbulent 3 with erosion level 3. Distance range of 3 had highest intensity of 51.74% with 37.2% of turbulent 3 with erosion level 3. Boat class A had highest intensity of 87.6% with 64.5% of turbulent 3 with erosion level 3.

Table 3.21: September 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	292	1
	(15-34)	14	42	118	174		
	(35-49)	4	29	82	115		
	50>	-	-	3	3		
Distance range	1	-	3	22	25	292	1
	2	2	23	148	173		
	3	11	41	29	81		
	4	4	6	3	13		
Boat class	A	13	61	174	248	292	1
	1	4	10	22	36		
	2	1	1	6	8		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 59.6% with 40.4% of turbulent 3 with erosion level 1. Distance range of 2 had highest intensity of 59.2% with 50.7% of turbulent 3 with erosion level 1. Boat class A had highest intensity of 84.9% with 59.6% of turbulent 3 with erosion level 1.

Table 3.22: October 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	304	1
	(15-34)	5	128	27	160		
	(35-49)	1	96	39	136		
	50>	-	7	1	8		
Distance range	1	-	5	5	10	304	1
	2	3	64	38	105		
	3	3	156	20	179		
	4	1	6	3	10		
Boat class	A	5	178	52	235	304	1
	1	1	41	13	55		
	2	-	12	2	14		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 52.6% with 42.1% of turbulent 2 with erosion level 1. Distance range of 3 had highest intensity of 58.9% with 51.3% of turbulent 2 with erosion level 1. Boat class A had highest intensity of 77.3% with 58.6% of turbulent 2 with erosion level 1.

Table 3.23: November 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	296	2
	(15-34)	97	30	16	143		
	(35-49)	77	44	20	141		
	50>	9	1	2	12		
Distance range	1	6	10	3	19	296	2
	2	20	29	33	82		
	3	137	37	2	176		
	4	19	-	-	19		
Boat class	A	154	65	31	250	296	2
	1	25	10	4	39		
	2	3	1	3	7		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 48.3% with 32.8% of turbulent 1 with erosion level 2. Distance range of 3 had highest intensity of 59.5% with 46.3% of turbulent 1 with erosion level 2. Boat class A had highest intensity of 84.5% with 52.0% of turbulent 1 with erosion level 2.

Table 3.24: December 2017 Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	335	1
	(15-34)	128	39	11	178		
	(35-49)	97	35	15	147		
	50>	8	1	1	10		
Distance range	1	5	4	5	14	335	1
	2	95	45	15	155		
	3	124	25	7	156		
	4	8	2	-	10		
Boat class	A	199	66	24	289	335	1
	1	29	8	3	40		
	2	4	2	-	6		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 53.1% with 38.2% of turbulent 1 with erosion level 1. Distance range of 3 had highest intensity of 46.6% with 37.0% of turbulent 1 with erosion level 1. Boat class A had highest intensity of 86.3% with 59.4% of turbulent 1 with erosion level 1.

The annual average speed range, distance range, and boat class for various turbulent levels with their erosion levels for 2016 and 2017 are presented in Tables 3.47 and 3.48.

Table 3.25: Year 2016 Average Annual Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	314.61	2
	(15-34)	27	97.75	85.67	210.42		
	(35-49)	14.58	43.25	29.67	87.5		
	50>	2.53	8.58	5.58	16.69		
Distance range	1	9.00	16.08	39.08	64.16	323.24	2
	2	14.25	68.92	61.83	145		
	3	27.58	52.17	14.25	94		
	4	13.42	4.83	1.83	20.08		
Boat class	A	34.08	110.92	89.00	234.00	314.83	2
	1	7.42	32.00	22.33	61.75		
	2	2.58	9.25	7.25	19.08		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 66.9% with 31.1% of turbulent 2 with erosion level 2. Distance range of 2 had highest intensity of 44.9% with 21.3% of turbulent 2 with erosion level 2. Boat class A had highest intensity of 74.3% with 35.2% of turbulent 2 with erosion level 2.

Table 3.26: Year 2017 Average Annual Speed range, Distance range, and Boat class for various turbulent levels with their erosion level

Factors	Sub-factors	No. of Turb. Level 1	No. of Turb. Level 2	No. of Turb. Level 3	Sub-total	Total	Erosion level
Speed range	<15	-	-	-	-	293.25	2
	(15-34)	31.08	72.83	60.25	164.16		
	(35-49)	20.42	56.67	40.5	117.59		
	50>	1.83	5.25	4.42	11.5		
Distance range	1	1.08	8.00	26.17	35.25	293.24	2
	2	13.17	51.75	62.33	127.25		
	3	33.75	72.83	16.83	123.41		
	4	5.25	1.58	0.5	7.33		
Boat class	A	46.17	114.17	91.17	251.51	291.6	2
	1	6.17	13.92	11.50	31.59		
	2	0.83	4.42	3.25	8.5		
	3	-	-	-	-		

Speed range of 15-34 had highest intensity of 56.0% with 24.8% of turbulent 2 with erosion level 2. Distance range of 2 had highest intensity of 43.4% with 21.3% of turbulent 3 with erosion level 2. Boat class A had highest intensity of 86.3% with 39.2% of turbulent 2 with erosion level 2.

3.2 Discussions

From the results, it was noted that boat speed, distance range and class alter the water wave conditions. Khetchaturst *et. al.* (2014) reported that waves are the main factor inducing coastal erosion. Thus, in the absence of such waves (like in non - moving water bodies) bank erosion (accelerated by engine boat) will be minimal. This is because erosion in coastal banks occurs naturally or by accelerated erosion. FAO – SWALIM (2009) noted that ‘it is called “accelerated” because it speeds up the geologic soil erosion, thus upsetting the balance between soil forming processes and soil losses.

To control bank erosion, soil bioengineering techniques like hard and soft armouring can be used to control bank erosion. Hard armouring method like rip - raps may be built to control wave actions along the banks. Ripraps are rock materials (concretes, lime stones, granites, *etc.*) that are placed at water boundaries (between off – shore and on – shore) along bank shorelines to absorb and deflect wave impacts before they reach their defending erosion prone structures (coasts and properties that exist up - on it). An example is a case of erosion protection (stone rip raps) at the Niger River Head-Bridge at the Asaba Delta area. These stones were placed to prevent or slow down erosion impact of the advancing water waves from reaching the constructed bridge foot at the near coast of Asaba. This is presented in Plate 3.1.



Plate 3.1: Stone rip rap placed to control erosion by the Niger Head-Bridge

For shores with high banks, bonded rip raps may be used. This involves using cement or related material to bond the concrete stones together.

Construction of effective erosion control structures from the study area to the popular Niger Bridge or beyond will be an ideal solution instead of controlling one or two stretches. This will help reduce erosion and flooding activities in residential areas. Such constructions are invariably expensive, and may require the assistance of governmental bodies.

Coastal protection in Denmark works on a “those who benefit must pay principle” (Sorensen *et. al.*, 2016). In this case, groups of individuals and house owners associations pay for such protection. However, other resource revenues may be deployed in building the city coastal protection. Soft armouring method like vegetation can also be used to minimize erosion.

4.0 CONCLUSION

From the obtained results, engine boats’ speed range, distance range and class influences erosion.

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