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Assessment of the Total Annual Water Loss and Its Effect in Akpoha, And Ebonyi Rivers South Eastern Nigeria

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Abstract **Original Research Article**

This work assessed the annual water loss in Akpoha, and Ebonyi rivers. It adopted flood metrics of the three rivers for three years to determine the amount of water lost to the ocean within the period of study. This assessment tried to characterize the water yield and the volume of water lost by the respective rivers within the period of study. The evaluation also provided information on the flooding pattern in the affected floodplains given the volume of flood water available at each point. Akpoha, and Ebonyi Rivers were sampled at different points. The design of 4x4 factorial was applied to determine the relationship between sample points and parameters for control, 2014 and 2015 using analysis of variance for Completely Randomized Design. Mean values evaluated for significant differences using Fisher's Least Significant Differences at $P < 0.01$.T-test was used for confirmation. The rivers sampled at four points, a1, a2, a3, a4 Akpoha. b1, b2, b3, b4. Ebonyi. The main factors determined were discharge, flow velocity, width and depth. Results showed that the factors were highly statistically significant at 1% level and the confirmatory test via FLSD also agreed to that. Results of evaluation of water loss showed that the highest value of 743.01 m3/s was recorded in Akpoha in 2015 as against 26.63 m3/s in the control and 62.85 m3/s recorded in 2014. The discharge result showed that the control < 2014 < 2015 at a1.The discharge reflected the amount of water discharged by the water body at that point in the control, 2014 and 2015. The control indicated that a very low amount 23.22 m3/s was observed initially and that large amount of 743.01 m3/s was observed in 2015 while medium amount of 62.85 m3/s was recorded in 2014. The results were recommended to individuals living in floodplains to enable them exploit water benefits from the areas.

Keywords: Floodplain, Annual water loss in a river, Water yield, Flood and its relationship water loss.

INTRODUCTION

Flood is excess water that overflows stream bank and covers adjacent land. Flood is also defined as a very large amount of water that over flooded from a source such as a river to cover a previously dry area, (Powel, 2009). The excess water when passing through a stream, over flows it normal channel and spills into the adjacent area called floodplain, (Padaria, *et al*, 2009). The large volume of flood waters usually receded within a short Period of about an hour, hours and days after its occurrence. The international flood initiative (IFI, 2009) flood water inundates large areas of land by the rise and overflow of a body of water as result of heavy downpour, continuous or incessant rainfall. The excess water generated during flood also temporarily covered lands not

previously covered by water, European Union Flood Directive (EUFD, 2009). Floodplain refers to a flat region of a valley floor located on either side of a river that flows through it and is covered by water during floods especially when the river overflows its banks. Flood occurs in low lying areas of drainage basins and generates massive flood waters. The floodplains around the water bodies usually receive water from the tributaries and this can exceed carrying capacities of such channels. According to Akintola and Ikwuyatum (2006) flood calamities resulted in the destruction of human settlements and inflicted great sufferings on humans, great losses on plants and affect the economic improvement of people due to large volume of water in the stream channels. The study of floodplain characteristics and the clear understanding of it would help to determine the amount of water loss through the river channels within a period. Floods have previously affected the regional, continental and worldwide economies by the increase in the volume of water available within the floodplain. The flood effects on the amount of water loss were made possible by the annual flooding of the stream channels and creates ecological water imbalance within the flooded zones (Osasogie *et al*, 2015). The regime of a river depends on the elevation of an area, width and the depth of the stream channel. It is also stated that about one third of the land in Nigeria is at an elevation of less than eight meters above sea level, (Ivbijaro, 1999). Flood occurrences usually make available excess water that devastates the economy of the affected zones and make the inhabitants depended on the unaffected zones and the various world governments for their survival. Often this development could lead to the displacement of the inhabitants of the affected floodplain. Annually the inhabitants of the areas of study kept on counting their losses due to the availability of excess water. It is also necessary to determine the causes of flood water and their consequences with a view to establish its actual effect on the ecological water balance of Ebonyi state (Rock et al, 2016). Considering the effect of climate change on the world rainfall distribution, it is then deemed necessary to study the floodplain characteristics where great mass of water is harbored annually and allowed to drain into the bigger water bodies. There is always this annual scarcity of water along the river channels around the world. The scarcity of water in Nigeria particularly led to organizing a workshop to proffer solution on prevailing water Scarcity tagged “Workshop to Proffer Solution to the Shortage of Water Supply in Nigeria”. Agarwal and Narain, (1999), had lent their support to the views on water harvesting to facilitate all year round agricultural activities. A close look at the rivers, during rainy seasons showed that discharge from these water bodies could be harvested to boost agricultural production during the dry spells. Flood disaster resulting from large volume of excess water during its occurrences usually devastated the world economy, (Onwe *et al* 2016). Ezeh and Eze (2015) reported that flood in 2010 racked havocs in parts of Ebonyi state due to the unprecedented volume of flood water generated in the area. It was also revealed that many states like Anambra, Delta, Benue and Ebonyi were heavily flooded leading to the loss of properties as a result of high volume of flood water. Real effects of flooding on ecological water balance can only be expressed through the affected inhabitant responses, especially those that are confined in the floodplains as their choice for area of habitations. The assessment of their population and the effects of flooding on their agricultural inputs and the damages caused to their properties can serve as clues to the amount of water lost the reality of existence of excess water along the rivers annually. According to Onwe *et al*, (2016), Assessment of flood effect on ecological water balance in the floodplains can only be effective when the inhabitants directly affected are given the opportunity to get involved in the estimation of the losses to the annual flood disasters.

MATERIALS AND METHOD

Study Area: The study area is part of Ebonyi State. Three rivers were selected viz. Akpoha,and Ebonyi rivers. The rivers were located generally by latitude 06º 19’N and longitude 08º 061E, in the derived savannah zone of the Southeast agro ecological area of Nigeria. The three rivers individually were located at different co-ordinates. Akpoha river in the southern part at distance of 39.3km (24.4 mile) from Abakaliki and 17.9km (11.1miles) from

Afikpo lies in latitude 05° 59¹N and longitude 08o 00¹ E; Ebonyi river in the Northern part at a distance of 6.6km (4.1 mile) from Abakaliki lies in latitude 06° 20¹N and 08° 10¹E and and Ebonyi river in the Central part at a distance of 29.3km (18. 2 miles) from Abakaliki lies by latitude 06° 21'N and 07° 49¹E. Rainfall pattern of Ebonyi State was bimodal, April-July and September – November with a short dry spell in August normally referred to as "August Break." (Mbah, 2006). The total annual rainfall in the area ranges from 1500mm to 2000mm with a mean of 1800mm (Echiegu 2007). At the onset of rainfall, it is torrential and violent, sometimes lasting for to two hours,(Okonkwo and Ogu, 2002 prediction, the time of start and cessation of rain were both late and early respectively. Ebonyi State, the area of study is characterized by high temperature of 27°C and maximum mean daily temperature of 32°C throughout the year. Humidity was high (80%) within the rainy season and with lowest (60%) levels occurring during the dry season from December to April, before the rainy season began. According to the Federal Development of Agricultural and Land Resources, (FDALR, 1987) the zone of study, Abakaliki agricultural zone lies within "Asu River group" and consists of Olive brown sandy shale fine grain sandstones and mud stones. The soil within the area of study is shallow with consolidated 1M of the soil surface. It belongs to the order ultisol and it is classified as types Hapulstult.

Materials for sampling

The materials used for sampling include:- Ranging Poles, Meter tape, Oranges, Hand gloves, Santana bags, Swan water bottles, Cooler of ice blocks and Stop Watch, Masking tapes, Permanent Markets, Bic, Exercise books, Ropes, Thermometer, Weights, Boats, and Questionnaires.

Research Design

The experiment was a 4x4 factorial in Complete Randomized Design (CRD), the factors were the four sample points (4) in each rivers namely; Akpoha a1, a2, a3 and a_4; Ebonyi b1, b2, b3 and b4. Whereas the second factors are the five (4) observed factors that affected the rivers namely, width, depth, flow velocity, and the discharge,$w_{1....}w_4$, $dp_{1....}dp_4$,$v_{1....}v_4$,$r_{1....}r_4$, $dc_{1....}dc_4$. The rivers were denoted by A, B, C and the sample points were

Denoted by $a_1 \ldots a_4$, and $b_{1....}$ b_4.

Sampling Procedure

In- situ sample analysis was conducted in the three sample points, A, and B. the in situ analysis was run to determine the following parameters:-

(i) To determine the velocity of flow of the three rivers.

(ii) To Determine the cross sectional areas of the rivers.

(iii To Determine the discharge (volume) of water produced by the rivers for the period of time.

(iv) To determine the depth of the body waters.

(i) Determination of the velocity of flow of the rivers.

The velocity of the river was determined by running a float and taking note of the time the float; oranges take to cross the channel section. A straight section of each channel (rivers at a distance of 14.44m with fairly uniform cross section was measured out for this purpose. The time taken by the float to reach the end point of the straight section was recorded in seconds (s). A number of the readings on a stop watch were recorded and the mean taken for calculation. Flow velocity equation V= distance/ time (d/t) where v = velocity, d = distance (in meter) and t = time (in seconds). V = m/s

(ii) Determination of Cross Sectional Area.

The cross sectional areas were determined by selecting a straight section of river bank. 14.44m length were measured out and the varying width of the river measured at the water surface level and at the bottom level and the mean width of the channels in cm or m i.e a+b /2 gotten. The mean width of the River was determined by the aid of a Boat operators. The meter tape or a rope was held across the river and the edge where the water reached pegged and the measurement taken from the other side. Equation for cross

sectional areas = L x W. Where L is length or distance and W, width of the rivers.

(iii) Determination of River Discharge

According to Suresh, (2005), Method of measuring the discharge is by determining the velocity of flow of the rivers, the cross sectional area of the river and the depth of the rivers. Discharge Q= AV where A is the cross sectional area and V, the velocity of flow. River and stream gauging is also known as stream flow measurement which is the measurement of discharge-stream flow passing through the stream section in a unit time. However to compensate for the variation in the width a and b, a general equation for discharge was used. Discharge equation, Q = 0.85 (a+b/2)H, where Q was the discharge, "a", the width of the channel at flow surface level in cm/m "b", was the bottom width of the channel in cm or m, H, the flow depth of the rivers in m and v, the flow velocity in m.

(iv) Determination of the water depth.

Water depth was determined using method. The method to determining the water depth was sounding method. The sounding method used include the application of a lead weight at the end of a long rope. The rope was marked at appropriate intervals so that when it dropped into the water body, the depth would be determined as soon as the lead strikes the bottom. Then the weight was detached and a meter tape used to measure the length that went into the water. The length measured gave the actual length or depth of the water body.

Laboratory Analysis

The discharge, velocity of flow and cross sectional area of the rivers were determined in-situ in the affected rivers; Akpoha, Ebonyi and Inyaba.

RESULTS

Effect of water loss on discharge.

The effect of water loss on discharge in Akpoha River is presented in Table 1. The length of each sample point is constant at 14.44m and the discharge in the Table 1 showed that control < 2014 <2015 in a1. Control < 2014 < 2015 at, a2. Control < 2014 < 2015 at, a3. Control < 2014 < 2015 at a4. Comparing the control and 2014 result showed that volume of water generated in 2014 was higher than the control which signify that more than half of the volume in the control was lost at a1 in 2014.similarly the result in 2014 and 2015 indicated that the volume generated in 2014 was much lesser than that generated in 2015 showing that a large volume of flood water was lost subsequently at a1, a2, a3 and a4 in 2015.

Table 1; **Effect of water loss on Discharge, Width, Depth, and Flow velocity in Akpoha, River for control, 2014 and 2015.**

Discharge(m^3/s)			Width(m)			Depth (m)			Flow velocity(m/s)		
AK1	AK2	AK3	AK1	AK2	AK3	AK1	AK2	AK3	AK1	AK2	AK3
26.63	62.85	743.01	73.04	94.56	184.02	3.20	4.60	8.19	0.13	0.17	0.58
23.63	42.28	390.33	71.82	94.21	182.95	2.91	4.40	8.09	0.13	0.12	0.54
23.92	47.86	381.16	70.53	104.47	177.24	2.85	4.90	7.89	0.14	0.11	0.56
23.22	49.87	584.10	67.46	104.02	176.19	2.70	4.70	7.80	0.15	0.12	0.59
170.24	170. 24	170.24	72.09	72. 09	72.09	3.22	3. 22	3.22	0.15	0. 15	0.15
FLSD tα = 0.01											

Source; Field Survey, Ak1 = control, AK2 = year 2014, AK3 = year 2015.

Effect of water loss on width; The effect of water loss on width in Akpoh river is presented in Table 1 indicated that control, 73.04m, 2014, 94.56m and 2015, 184.02m at a1 and the result indicated the spreading of flood water within the sample point in the control, 2014 and in 2015. **Effect of water loss in depth;** The effect of water loss on depth as presented in the Table showed that control recorded 3.20m, 2014,4.60m 2015, 8.19m at a1, and this indicated the various depth of the sample points. **Effect of water loss on the flow velocity of the river;** The observation here showed that control recorded 0.13 m/s, 2014,0.17 m/s 2015,0.58 m/s at a1 and it revealed the flow rate of the sample points. **Effect of water loss on discharge;** The effect of water loss on discharge in the river presented in the table showed that the control recorded 26.63 m^3/s, 2014, 62.85 m^3/s 2015,743.01 m^3/s. Other records in b2, b3 and b4 were also presented in the table1 above.

Table 2; 2014 Effect of water loss on Discharge, Width, Depth, and Flow velocity in Ebonyi Rivers for control, 2014 and 2015.

Discharge(m^3/s)			Width(m)			Depth (m)			Flow velocity(m/s)		
EB1	EB2	EB3	EB1	EB2	EB3	EB1	EB2	EB3	EB1	EB2	EB3
8.14	33.80	748.87	12.21	19.22	184.70	1.52	2.65	8.22	0.52	0.78	0.58
7.40	33.00	673.91	11.54	18.87	184.30	1.45	2.45	8.13	0.52	0.84	0.54
6.99	56.35	320.39	10.15	29.28	122.70	1.33	2.94	5.48	0.61	0.77	0.56
6.12	51.44	322.82	9.60	28.68	121.70	1.30	2.74	5.29	0.58	0.77	0.59
134.70	134.70	134. 70	45.57	45. 57	45.57	1.92	1.92	1. 92	0.33	0.33	0.33

FLSD tα = 0.01

Source; Field Survey: EB1= control, EB2 = year 2014, EB3 = year 2015.

Effect of water loss on width; The effect of water loss on width in Ebonyi river is presented in Table 2 indicated that control, 12.2m,2014, 19.22m and 2015, 184.70m at b1 and the result indicated that spreading of flood water within the sample point in the control, 2014 and in 2015. **Effect of water loss in depth;** The effect of water loss on depth as presented in the Table showed that control recorded 1.52m, 2014, 2.65m and 2015 8.22m at b1, and this indicated the various depth of the sample points. **Effect of water loss on the flow velocity of the river;** The observation here showed that control recorded 0.52m/s, 2014, 0.78m/s and 2015, 0.58m/s at b1 and it revealed the flow rate of the sample points. **Effect of water loss on discharge;** The effect of water loss on discharge in the river presented in the table showed that the control recorded 8.14 m^3/s, 2014,33.80 m^3/s and 2015,748.87 m^3/s. Other records in b2, b3 and b4 were also presented in the table 2 above.

Source; Field Survey; INY1= control, INY2 = year 2014, INY3 = year 2015.

Effect of water loss on width; The effect of water loss on width in Inyaba river is presented in Table 1 indicated that control, 33.37m, 2014,40.70m and 2015,65.95m at c1 and the result indicated the spreading of flood water within the sample point in the control, 2014 and in 2015. **Effect of water loss in depth;** The effect of water loss on depth as presented in the Table showed that control recorded 1.80m, 2014,2.16m and 2015, 3.50m at c1, and this

indicated the various depth of the sample points. **Effect of water loss on the flow velocity of the river;** The observation here showed that control recorded 0.85 m/s,2014,0.69 m/s and 2015, 0.10 m/s at c1 and it revealed the flow rate of the sample points. **Effect of water loss on discharge;** The effect of water loss on discharge in the river presented in the table showed that the control recorded 44.51 m^3 /s, 2014, 36.60 m^3 /s and 2015,37.28 m^3 /s. Other results in b2, b3 and b4 were also presented in the table 3 above.

Discussion

The effect of water loss on width in Akpoha river presented in Table 1 indicated that control < 2014 < 2015 at a1 and subsequently at a2, a3 and a4. Relating the control and 2014, the result indicated that spreading of flood water was higher in 2014 than the control and was highest in 2015.the effect of flood on the width of water bodies was stressed on by IFI, (2009). The international flood initiative stated that flood water inundates large areas of land by the rise and overflow of a body of water as result of heavy downpour, continuous or incessant rainfall. The excess water generated during flood also temporarily covered lands not previously covered by water, European Union Flood Directive (EUFD, 2009), there by taken over the water body surroundings. The international Flood Initiative (IFI), gave information on the effects as flood water spreads which also inundate the adjacent lands and cause damages. **Effect of water loss in depth.** The effect of water loss on depth as presented in the Table showed that control < 2014 < 2015 at a1 and subsequently in a2, a3 and a4. However it was observed that at a1 the control was highest compare to control at, a2, a3 and a4. The variations on the volme of water at the sample points depends on the range of rainfall. According to Mbah, (2006) the range of rainfall within the study area is 1500mm- 2000mm with a mean of 1800mm annually. The observation at the point probably resulted from the dry season evaporation from the river. **Effect of water loss on the flow velocity of the river;** The observation here showed that control > 2014 > 2015 at a1. However there was fluctuation in the results. 2014 > control > 2015 at a3, a2 and a4. The result in the effect on flow velocity showed that the fastest flow was in 2014 while flow in control was faster than in 2015. The outcome in the flow velocity showed that the rate of water loss was very high in 2014 at a2, a3 and a4, where as the highest was observed in a4.The faster the flow, the easier the draining of the available flood water. The need to harvest water for other purposes was stressed on by Agarwal (1999) who lent their support to the views on water harvesting to facilitate all year round agricultural activities. The information by FDALR, (1987) showed that the zone of study, Abakaliki agricultural zone lies within "Asu River group" in which the soil is prone to erosion. Mbah (2006), stated that Ebonyi State, the area of study is characterized by high temperature of 27^{o}C and maximum mean daily temperature of 32^{o}C throughout the year. Humidity was high (80%) within the rainy season and with lowest (60%) levels occurring during the dry season from December to April, before the rainy season began. All the factors mentioned by Mbah favours the chances of heavy rainfall with high volume of runoff. Heavy runoff introduces much volume of flood water into the rivers. The flow velocity is central to erosion and other damages caused by flood. The results showed that the factors were highly statistically significant at 1% level.

Effect of water loss on discharge; The effect of water loss on discharge in Ebonyi river is presented in Table 2. The length of each sample point is constant at 14.44m and the discharge in the Table 2 showed that control < 2014 <2015 in b1. Control < 2014 < 2015 at,b2. Control < 2014 < 2015 at, b3. Control < 2014 < 2015 at b4. The discharge pattern of the river is expressed in Mbah, (2006) and it is linked to the flow velocity. Comparing the control and 2014 result showed that volume of water generated in 2014 was higher than the control which signify that more than half of the volume in the control was lost at b1 in 2014.similarly the result in 2014 and 2015 indicated that the volume generated in 2014 was much lesser than that generated in 2015 showing that a large volume of flood water was lost subsequently at b1, b2, b3 and b4 in 2015.

Table 2; 2014 Effect of water loss on Discharge, Width, Depth, and Flow velocity in Ebonyi Rivers for control, 2014 and 2015.

Effect of water loss on width; The effect of water loss on width in Ebonyi river is presented in Table 2 indicated that control < 2014 < 2015 at b1 and subsequently at b2, b3 and b4. It is in line with IFI, (2009) assertion on the effect of water loss on the width of rivers and water bodies. Relating the control and 2014 the result indicated that spreading of flood water was higher in 2014 than the control and was highest in 2015. **Effect of water loss in depth;** The effect of water loss on depth as presented in the Table showed that control < 2014 < 2015 at b1 and subsequently in b2, b3 and b4 and it is expressed in Mbah, (2006). **Effect of water loss on the flow velocity of the river;** The observation here showed that control > 2014 < 2015 at b1, b2, b3 and b4. The result in the effect on flow velocity showed that the fastest flow was in control while flow in 2015 was faster than in 2014 in all the sample points. The flow velocity behavour of the river is relted to Mbah, (2006) opinion a stated above. The outcome in the flow velocity showed that the rate of was very high in control at b1 and b2, where as the highest was observed in both b1 and b2. The results showed that the factors are highly statistically significant at 1% level of water loss.

Effect of water loss on discharge; The effect of water loss on discharge in Inyaba river is presented in Table 3. The length of each sample point is constant at 14.44m and the discharge in the Table 3 showed that control < 2014 >2015 in c1. Control < 2014 < 2015 at,c2. Control < 2014 < 2015 at, c3. Control < 2014 < 2015 at c4. The volume of water as obtained here is connected to the amount of rainfall and the flow velocity, Mbah, (2006). Comparing the control and 2014 result showed that volume of water generated in 2014 was higher than the control which signify a little difference in the volume of water in the control was lost at c1 in 2014.similarly the result in 2014 and 2015 indicated that the volume generated in 2014 was much lesser than that generated in 2015 showing that the volume of flood water was lower in 2015 than in 2014 at c1. However the volume was very high in 2015 at c2 and c3 and a remarkable decrease in c4 in the same 2015.

The general results for discharge in the two rivers within the three years indicated that Ebonyi > Akpoha > Inyaba at b3 in 2015. It was observed that Ebonyi recorded the two highest values of 748m^3/ s and 673.91m^3/ s in 2015. The observation in the width results showed that two highest records of 184.70 m and 184.30 m were observed in Ebonyi in 2015 at b1 and b2. This results indicated that Ebonyi > Akpoha at b1 and b2 in 2015. Subsequently the depth results showed that Ebonyi > Akpoha at b1 with the depth value of 8.22 m. The general results in the flow velocity showed that Akpoha was the highest in 2014 with a value of 0.11m / s at a3 in 2014.

Conclusion

The findings of the research and the discussion revealed that the highest values of 743.01m^3/s, 748.87m^3/s and 187.24m^3/s discharge recorded in Akpoha, and Ebonyi were high enough to cause environmental damages. It was also clear that the amount of discharge obtained in the area if converted to determine the volume per hour and per day could aid in tackling water supply related problems in agricultural activities within Ebonyi state if properly harvested. The effect of the discharge indicated that Ebonyi discharged more volume of water within the period of study. The results also established that more spilling was observed in Ebonyi than the two other rivers studied.

Recommendations

1. It is here recommended that the three rivers can sever as sources for water supply

Planning Projects.

2. Since the observed results showed that the flow rate at Ebonyi is relatively

High, more flood control measures should be put in place to control, flood related

damages around the rivers.

3. Insitu water project is recommended in Akpoha considering the high values of flood

water observed in the sample points.

4 Feature review of this research is recommended to create room for effective flood control

Measures within these sample points.

Disclosure of conflict of interest

The authors declare that they do not have any conflict of interest to disclose.

Statement of informed consent

Not applicable

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