Journal of Engineering and Applied Sciences 2 (4): 659-663, 2007

Rainfall Pattern and its Effect on Seasonal Variability of Owena River in Ondo State of Nigeria

[1]Akinro O. Akinola and [2]Olawale Olanrewaju
[1]Department of Civil Engineering Technology, Rufus Giwa Polytechnic,
Owo, P.M.B 1019 Owo, Nigeria
[2]Department of Agricultural Engineering, Federal University of Technology,
P.M.B. 704, Akure Nigeria

Abstract: Data on monthly rainfall depths in Owena catchment area were collected and analyzed. The mean monthly rainfall depths were found and these values were plotted against the months of occurrence. Periods of high and low rainfall were found from the graph. The streamflow hydrograph of River Owena was also obtained. A comparison was then made between the graphs. From the study, it was found that seven months experienced intense rainfall while five months of the year experienced rainfall deficit. Similarly, from the hydrograph, it was found that River Owena experienced high flows in seven months and low flows in five months, the months perfectly correlating with the onset and cessation of rainfall in the catchment area. This clearly shows that rainfall is a major contributor to the reservoir build up of River Owena and the major cause for its seasonal stage and discharge variability.

Key words: Rainfall pattern, seasonal variability, River Owena

INTRODUCTION

For a surface reservoir to be developed, the sources of water must be identified. According to Wanielista, (1990) the average annual rainfall is a first indicator of possible water availability. The existence of perennial rivers is a significant indication of the magnitude of surface sources. Before a supply can be relied on for the design life of a project, the availability and reliability of the major source of replenishment to the river needs to be investigated vis-à-vis its variability. Once a suitable source has been identified and the reliability established, some form of storage could then be made to guarantee continuous supply and reservoir build-up. Frequently, rivers are replenished through rainfall from storms and base flows. However, the magnitude of the contribution of each source differs in time and space. Precipitation is a general term used to describe the processes by which water falls to the land surface in the form of rainfall, snowfall, hail and sleet.

According to Chow *et al*. (1988) precipitation varies in space and time according to the general pattern of atmospheric circulation and according to local factors. In Nigeria, the most common precipitation occurrence is in the form of rainfall. Rainstorms vary greatly in time and space.A knowledge of the maximum rainfall depth and intensity is crucial and enables the hydrologist and the water engineer make reliable prediction that could form a basis for the design of flow control structures.

An important fact to be determined from historical rainfall records is the average depth of rainfall over a watershed. This is essential in order to determine the contribution of the storm to the river within the catchment area and its effect on the seasonal variability of the river flow. This, to a large extent, has effects on the performance of the surface water system in a region. Planning of water resources development works such as impoundment of water through construction of dams for water supply, sanitation, irrigation and agriculture, hydroelectric power generation, flood mitigation, soil erosion and pollution control works are better done when information about river flow regimes and its variability are known. This can only be established when the pattern of the storm contributing to the reservoir build-up is known.

This study attempts to evaluate the variability of rainfall within the catchment area of River Owena and relate it to the streamflow characteristics of the river in order to establish its seasonal variability.

BACKGROUND THEORY

Climatic characteristics of Nigeria: Nigeria lies within the tropics along the Gulf of Guinea on the Western Coast of Africa. Its climate varies from tropical at the coast to

Corresponding Author: Akinro O Akinola, Department of Civil Engineering Technology, Rufus Giwa Polytechnic, Owo, P.M.B 1019 Owo, Nigeria

sub-tropical further inland. Temperature is generally very high (about 28°C) and increases as one moves Northward from the Coast resulting in a wide geographical variety in physical features (FOS, 1996).

The diversified geographical regions provide the country with an almost inexhaustible variety. There are two well-defined seasons, namely: The dry season and the rainy season. Temperature at the coast seldom rises above 32°C but humidity can be as high as 95% (FOS, 1996).

The climate is drier further North where high temperatures are common. The climate of Nigeria is controlled by the dynamics of the South-Westerlies wind, which emanates from the Atlantic Ocean and moves from the South to North and the North Easterlies wind from North East moving from the North down South. These major winds are responsible for the two main seasons in Nigeria.

However, large-scale atmospheric circulation over the South Western Nigeria had resulted in a positive gradient of annual rainfall of 2mm km^{-1} in the vicinity of Ondo State (Omotayo, 2001). Reported in Omotayo (2001) that, penetration of moisture from the Gulf of Guinea initiates the rainy season where 80% fall between periods of July and September. As we move towards upland from the Gulf of Guinea, annual rainfall is the composite of convective storms of three main types identified by Desbois reported in Okoli (2000) namely: Local convective systems, moving organized convective systems and squall limes which move in the opposite directions of the tropical North Easterlies. As we move from the regional area of South Western Nigeria, where annual rainfall gradients are well defined, to the spatial and temporal variability of the North, rainfall pattern is more pronounced. At the catchment points of major rivers in Southwestern Nigeria, the annual rainfall depends largely on the chance of a storm passing over its location. This had made it possible for some catchments to have slight hydrological extremes of drought and flood.

Le Barbe and Label (1997) in Akinro (2005) suggested that the rainy season length and mean event are relatively constant over the region which indicate that the spatial distribution of rainfall may be due to decrease in the mean number of rainfall events between the peak seasons. There are indications that show that there are fewer rainfall days with high intensities resulting into flooding and other drainage problems. It is therefore noted, that, in Ondo State, located within the South Western Nigeria, the effect of climatic variability will equally have an effect on the performance of the surface water system of the region. The assessment of the surface water resources in the basin for planning and development of water projects is therefore linked with the contribution of rainfall-a vital climatic parameter. This study therefore attempts to evaluate the variability of rainfall within the catchment area of River Owena and relate it to the streamflow characteristics of the river in order to establish the seasonal variability of the river.

MATERIALS AND METHODS

General description of the study area: River Owena is perhaps the most popular river in Ondo State. Owena River is under the control of Benin-Owena River Basin Development Authority (2001) It flows within an area bounded by Longitude 5° 01` E and Latitude 7° 17` N and Longitude 5° 45` E and Latitude 8°15` N as shown in Fig. 1. The drainage area of Owena River is 790 sq. kilometres (FMWR and RD, 1997).

The river has its source in the hills in the Northwest of the catchment area around Effon Alaaye in Ekiti State and flows directly Southwards to be joined by the Ofosu and Aden Rivers north of the Siluko Village in Ondo State and then, as the Siluko River, flows into the estuarine creek area. The tributaries and the location of the gauging stations on River Owena are shown in Fig. 1.

Statistical analysis of the model used: The mean monthly rainfall depths expressed as a function of the annual rainfall over a period of data generation can be derived for each month as follows:

For January: $Mr_j = \Sigma(r_{j1}, r_{j2,} r_{j....} r_{jn}) / n$ (1)

For February: $MR_{f\,and} = \Sigma(r_{f1,} r_{f2,} r_{f3,...} r_{fn})/n$ (2)

For any month, $Mr_m = \Sigma(r_{m1,\, m2,\, m3..}\, r_{mn}) / n$ (3)

where

Mr_j = Mean rainfall depth for the initial month (January), mm

$MR_{f\,and}$ = Mean rainfall depth for the month of February, mm.

Mr_m = Mean rainfall depth for any month m , mm

r_j = rainfall for January in mm

Subscript 1,2,3, ………n denote 1st year, 2nd year, 3rd year to the last year, n.

Computational and statistical methods: Rainfall data of the basin for 25 years (1980-2004) were collected from the Federal Ministry of Aviation, Akure, Nigeria for the purpose of showing the pattern of rainfall in Owena catchment area. Equation 3 was applied to obtain the mean rainfall depth for each month.

The rainfall depths in millimeters for January in each year of the 25years of record were taken and added

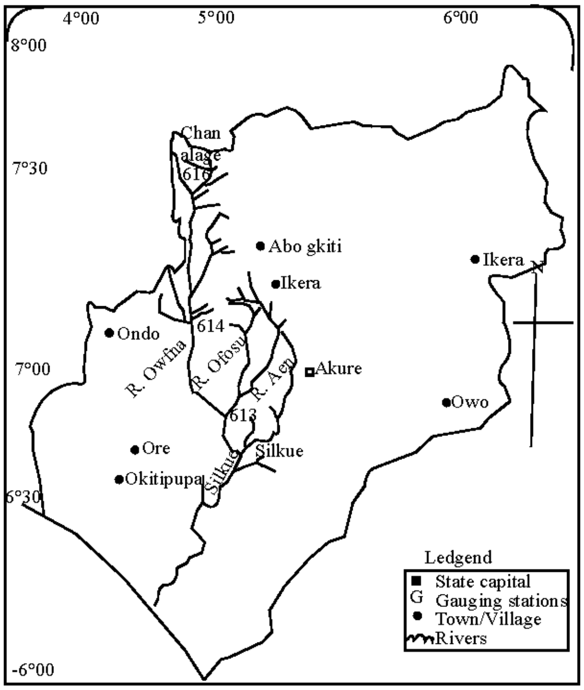

Fig. 1: Location of river Owena, its tributaries and gauging station

together. This addition of rainfall depths was then divided by 25 to obtain the mean rainfall depths for January. The same approach was applied to other months of the year and the mean monthly rainfall depths so obtained were then plotted against the corresponding months. The monthly discharges for a period of ten years (1990-1999) for River Owena was also obtained from the Benin Owena River Basin Development Authority, Akure, Nigeria. The mean monthly discharges were found and plotted against the corresponding months.

RESULTS AND DISCUSSION

Rainfall variability of the study area: The monthly rainfall depths of the study area are as shown in Appendix A. Table 1 gives the results of the analysis. The mean monthly rainfall depths were plotted against the corresponding months as shown in Fig. 2. From Fig. 2, it can be seen that there is little or no rainfall experienced in the months of January and February. Rainfall begins in the month of March and continues to increase appreciably up till June when it reaches its first peak; it declines in July and then rises again in August until it then reaches its second peak in September.

The months of September experiences heavy rainfall throughout, thereafter, the rain begins to reduce both in frequency, duration and intensity until it

Table 1: Mean monthly rainfall depths in owena catchment area (1980-2004)

Month	Total (mm) Rainfall	Mean rainfall depth (mm)	Standard deviation
January	207.2	8.29	16.39
February	991.5	39.66	35.61
March	1938.4	77.54	56.79
April	3854.6	154.18	59.44
May	4022.8	160.91	58.63
June	4911.7	196.47	54.85
July	4602.4	184.21	85.25
August	4605.3	194.21	99.43
September	5843.7	233.75	51.62
October	3616.9	144.68	66.14
November	717.0	28.68	24.39
December	206.7	8.27	17.1

Table 2: Mean monthly discharges of owena river in ondo state. (1990-1999)

Month	Total discharge	Mean monthly discharge	Standard deviation
January	19.9	1.99	2.26
February	13.933	1.390	0.96
March	11.775	1.18	0.54
April	15.038	1.5	0.61
May	31.124	3.11	1.65
June	56.99	5.7	3.07
July	129.21	12.92	11.69
August	197.21	19.72	14.04
September	273.83	27.38	12.47
October	227.99	22.8	8.92
November	116.706	11.67	8.89
December	47.544	4.75	3.53

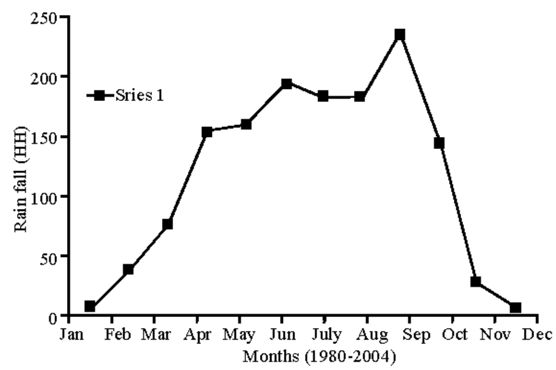

Fig. 2: Rain fall variability in Owena catchment area

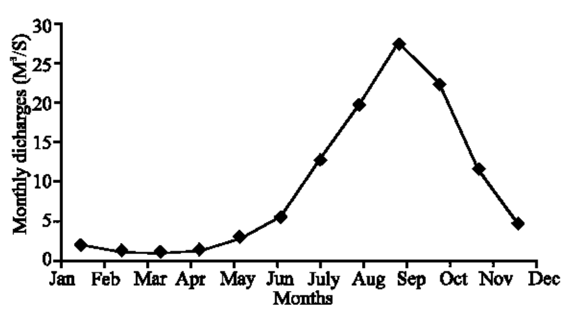

Fig. 3: Streamflow hydrograph of river Owena (1990-1999)

eventually diminishes at the latter part of November. The month of December is almost generally free of rainfall.

Streamflow characteristics of River Owena: Appendix B gives the mean monthly discharges for a period of ten years (1990-1999) for River Owena while Fig. 3 shows the streamflow hydrograph of the same river obtained by plotting the mean monthly discharges against the corresponding months (Table 2). It can be seen from Fig. 3 that the river experiences low flow in January up till April. Beyond April, the flow begins to increase until it gets to its peak in September; thereafter, the flow reduces appreciably throughout the month of December. Figure 3 shows that there is low flow between November and April and high flow between May and October; the situation that perfectly agrees with the onset and cessation periods of rainfall in the study area.

This clearly shows that rainfall is the major contribution to the reservoir build-up of River Owena. Though, base flow is equally important and undoubtedly contributes to the reservoir build-up, its contribution is obviously not significant.

The seasonal variability of the river flow regimes could therefore be directly linked to the pattern of rainfall within the catchment.

Appendix A: Monthly rainfall depths (mm) in owena catchment area (1980-2004)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	ANN. Total
1980	0.00	41.80	64.60	129.80	28.30	298.00	104.00	227.60	242.50	179.90	13.60	0.00	33.101
1981	0.00	22.40	34.10	253.30	223.30	258.60	148.20	152.70	210.60	5.90	10.10	0.00	3300.2
1982	8.20	68.10	73.00	211.30	211.80	170.70	180.90	25.20	131.00	269.60	11.00	0.00	3342.8
1983	0.00	26.20	7.90	161.90	254.50	194.80	89.40	59.90	343.60	142.90	6.00	52.90	3270.1
1984	0.00	0.00	174.90	188.60	203.00	218.30	154.30	206.60	202.10	166.10	21.90	0.00	3519.8
1985	2.40	0.00	155.70	146.50	220.90	186.70	231.30	326.60	252.60	99.50	24.30	0.00	3631.5
1986	12.70	150.30	130.80	41.80	157.50	142.20	106.60	77.50	217.90	82.20	46.60	0.00	3152.1
1987	7.70	42.70	107.10	94.30	93.10	116.70	158.10	384.40	276.40	113.70	0.00	0.80	3381.2
1988	18.40	74.70	74.10	182.90	156.90	203.50	193.10	82.60	278.10	229.90	44.70	17.60	3526.9
1989	0.00	0.00	123.30	59.10	183.70	226.80	199.60	357.80	175.50	111.50	19.10	0.00	3445.4
1990	4.40	15.50	0.00	199.10	113.60	90.70	320.20	245.80	220.90	213.30	72.40	62.50	3485.9
1991	1.20	98.60	136.00	223.10	201.20	160.90	463.00	203.60	200.90	152.60	0.00	10.40	3832.1
1992	0.00	0.00	40.80	107.80	151.10	237.00	265.30	101.70	248.10	194.60	25.60	0.00	3364.0
1993	0.00	57.00	18.80	84.60	95.10	141.00	131.80	274.10	303.70	95.60	72.30	21.40	3267.0
1994	11.20	39.40	44.40	97.80	109.90	225.80	147.60	218.20	181.30	157.30	28.00	0.00	3254.9
1995	0.00	28.40	128.00	196.30	181.40	214.20	268.60	279.60	290.60	87.30	14.20	0.00	3683.6
1996	0.00	68.00	82.60	218.30	220.00	154.00	106.20	116.20	279.40	103.90	17.60	0.00	3362.2
1997	4.50	53.20	204.40	173.00	146.70	218.30	209.30	187.00	191.90	95.50	0.00	33.30	3480.8
1998	0.00	23.70	10.90	122.30	231.10	243.50	155.30	90.40	256.30	273.30	46.80	0.00	3451.6
1999	20.30	35.40	57.00	117.30	183.50	169.30	98.00	223.70	187.20	258.60	58.70	0.00	3408.0
2000	44.70	0.00	34.90	207.20	118.90	299.30	215.30	215.90	232.60	137.00	19.60	5.40	3525.4
2001	0	0	70.7	255	106.6	125.9	155.1	52	185.4	74.5	1.2	0	3027.4
2002	0	40.7	121.3	130.1	80.6	272.8	255.6	214.7	236.9	125.5	78.3	2.4	3558.5
2003	1.10	44.50	30.50	87.30	115.30	158.90	77.40	58.70	320.80	114.00	60.00	0.00	3071.5
2004	70.4	60.9	12.6	165.9	234.8	183.8	168.2	222.8	177.4	132.7	25	0	3458.5
SUM	207.2	991.5	1938.4	3854.6	4022.8	4911.7	4602.4	4605.3	5843.7	3616.9	717	206.7	35311.5
MEAN	8.29	39.66	77.54	154.18	160.91	196.47	184.21	184.21	233.75	144.68	28.68	8.27	1412.58
STD	16.39	35.61	56.79	59.44	58.63	54.85	85.25	99.43	51.62	66.14	24.39	17.10	

Appendix B: Monthly dicharge records of river owena in m^3/s (1990-1999)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	0.95	1.2	1.6	1.5	2.6	7.025	9.461	10.451	15.545	14.032	3.059	1.537
1991	1.014	0.915	0.652	1.539	2.736	5.686	9.136	20.23	23.21	13.06	3.01	1.61
1992	0.981	1.51	1.323	1.687	7.263	6.08	43.984	41.239	30.33	13.648	4.253	3.394
1993	2.14	1.5	1.365	2.341	3.736	7.213	10.5	12.606	45.795	15.533	7.643	3.601
1994	1.65	1.21	1.01	1.69	2.68	2.89	3.904	3.602	16.957	21.33	5.198	2.205
1995	1.207	0.996	0.934	0.855	1.188	1.968	5.512	6.248	5.218	33.225	20.458	5.23
1996	1.531	0.825	0.8	0.732	1.61	2.531	6.341	6.432	30.432	35.021	25.331	11.12
1997	8.32	4.025	2.451	2.551	3.461	6.3	5.421	38.211	42.231	20.003	12.241	4.621
1998	0.879	0.725	0.7	1.253	3.12	12.57	14.331	33.421	35.337	30.21	10.303	3.225
1999	1.21	1	0.94	0.89	2.73	4.73	10.62	24.77	28.77	31.93	25.21	11.01
Total	19.88	13.91	11.78	15.04	31.12	56.99	119.21	197.21	273.83	227.99	116.71	47.55
Average	1.99	1.39	1.18	1.50	3.11	5.70	11.92	19.72	27.38	22.80	11.67	4.76
STD	2.26	0.96	0.54	0.61	1.65	3.07	11.69	14.04	12.47	8.91	8.89	3.53

CONCLUSION

Evaluation of rainfall within the catchment area of River Owena was carried out using the rainfall data of Akure for 25 years. Seven months out of the twelve months in the year experienced varying degree of high rainfall intensities while the remaining five months experienced rainfall deficit. Similarly, the hydrograph of the river was obtained. From the hydrograph, it was found that River Owena experienced high flows in seven months and low flows in five months, the months perfectly correlating with the onset and cessation of rainfall in the catchment area.

This phenomenon has affected the activities of the farmers in the region as they could only plant during the rainy period. Lack of adequate water has also limited domestic water supply in the study area. In order that the farmers may plant both in the rainy as well as in the dry season periods, there is need to develop the water resources potentials within the Owena catchment area. This will make the farmers increase their production. Similarly the development will also provide water for irrigation and hydroelectric power generation. Information about river flow regimes and its variability will surely help in planning for storage during periods of peak flow for use during periods of low flows through the construction of water storage facilities.

REFERENCES

Akinro, A.O., 2005. Estimation of the Reservoir Capacity and Flow Frequency of River Owena in Ondo State. M. Eng. Thesis. Federal University of Technology, Akure, Nigeria, pp: 79.

Benin-Owena, 2001. River Basin Development Authority. Hydrology Year Book, pp: 11-14

Chow Ven Te, R.M. David and Larry W. Mays, 1988. Applied Hydrology. McGraw-Hill Book Company. New York, pp: 71.

Federal Ministry of Water Resources and Rural Development, 1997. Report on Baseline study in the South-West Zone of Nigeria.

Federal Office of Statistics, 1996. FOS Publication on Agricultural activities in Nigeria FOS, Abuja, Nigeria.

Omotayo, K.F., 2001. Variability of Flow regimes of Ogbese and Owena Rivers in South Western. Nigeria: M. Eng. Thesis. Federal Univ. Tech., Akure, Nigeria, pp: 34.

Okoli, C.S., 2000. Modelling of Sediment transport capacities of Ogbese and Owena Rivers in South Western Nigeria: PhD Thesis, Federal Uni. Tech., Akure, Nigeria, pp: 21.

Wanielista, P.M., 1990. Hydrology and Water Control. John Wiley and Sons Inc; Canada, pp: 107.