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Flow Pattern of River Ogbese in Akure, Ondo State, Nigeria

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Abstract: *As the world is at the beginning of the new millennium, the rapid increase in the population, especially in the third world, is becoming alarming and the corresponding demand for all types of user is far out-stripping the available water supply, for this reason adequate water supply is one of the Millennium Development Goals (MDGs) of the United Nations. Hence, the need for adequate planning, management and control of water resources in such that any water resources development strategy to be undertaken for any beneficial use whatsoever must rely on data collected over a relatively long period of time. The present area of study falls within Latitude 7° 16' N and Longitude 5° 23' E. The two seasons observed in this area are dry season (November to March) and wet season (April to October. Annual precipitation over the area ranges from 1600mm to 2100mm. The months of August to October recorded the highest value of rainfall which is associated with peak discharge, water stage and runoff of the river. Stepwise regression analysis was used in place of meteorological model ALADIN due to insufficient input parameters required by the model.*

Keywords: *Population, water supply, resources development strategy, seasons and precipitation*

1. Introduction

In the last decades, an increasing demand for water resources has been posing a serious threat to environment and sustainable development in some countries of the world and the competition for the use of such limited resources is growing dramatically among different sector. Water scarcity is more and more becoming one of the main restrictive factors of economic growth and social cohesion and a timely implementation of water policies and strategies that incorporate criteria of sustainability has become essential. In view of this, interest in flow forecasting of streamflow has developed a pace since the formation of regional water authorities in some countries of the world in the last four decades. This is to optimally allocate increasingly limited water supplies for various demands that include irrigation for agriculture, habitat for endangered fishes, hydropower production and other users.

Studies of flow forecasting methods have been carried out in many research institutes. Examples are the U.S. Geological Survey and River Basin Authorities in Nigeria. In 1988, WMO Commission for hydrology accorded high priority to the monitoring of developments in forecasting of streamflow and to the preparation of relevant guidance materials for the benefit of all concerned. Likewise in 2003, the U.S. Geological Survey, the Natural Resources Conservation Service, and the Bureau of Reclamation began a collaborative study to reduce uncertainty and error in seasonal flow forecasting in the upper Klamath Basin. The main objectives of their work is to find and evaluate potential model variables that better described long-term climate-trend conditions and to analyze the efficacy of upper Klamath Basin snow-water equivalent and precipitation data in forecast models.

In 2005, John et al carried out an analysis to determine the ability and extent to which current snow-water

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equivalent and precipitation conditions can be used to forecast future flow conditions. The analyses were made by decomposing the flow time series into annual periodic, long-term climatic and chaotic component time series. Their result showed that after 120 days (approximately 4 months); all of the snow-water equivalent and precipitation correlation coefficients were less than 0.4.

The main objectives of this paper is to applying statistical analysis to the existing hydrological data collected at the monitoring site of the river as input, with a view to establish a model for the prediction of the flow. The study will also looks at the water stage, discharge and runoff volume hydrograph of river Ogbese. It will also studies flow frequency analysis, the return period of the event and the percentage probability.

2.Materials And Methods

2.1. Study Site

River Ogbese (7° 16^{l} N, 5° 23^{1} E) is located at Ogbese village (near Akure) South western Nigeria (Figures 1 and 2). It has an annual rainfall of about 1600mm to 2100mm, which covers the month of April to October and drainage area of 2039km². The mean daily maximum temperatures range from 30°C to 35°C, while the mean daily minimum temperatures range from 21°C to 26°C (Ayoade, 1983, Philips, 1996, BORB, 2004-2013).

2.2. Data Collection and Analysis

This study is limited to some extent and this is due to non-availability of continuous real-time hydrological (discharge, runoff volume and stage) data. Therefore, the years of interest had to be limited within those years of available hydrological data (2004–2013). The above mentioned data plus rainfall data which will be used for this study were collected from the Benin-Owena river basin development authority, Akure Area office.

3. Data Processing

3.1. Discharge

Mean discharge (Qa) was computed from the expression:

$$Qa = \left(\sum_{j=1}^{k} Qj\right)/k \qquad 1.$$

Where Qj is the daily discharge, subscript j refers to the day, k is the number of days in the period considered.

Monthly total discharge (Qtm) was computed from the expression.

$$Qtm = \sum_{j=1}^{k} Qj \qquad 2.$$

Coefficient of variation (Cvd) of mean daily flow

$$Cvd = 1/Qa\left\{\left(\sum_{j=1}^{k} Qj - Qa\right)^2\right\}^{1/2}/(k-1) \qquad 3.$$

Mean precipitation (Pa) was computed from the expression.

$$Pa = \left(\sum_{j=1}^{k} Pj\right)/k \qquad 4.$$

Where Pj is the daily precipitation, subscript j refers to the day, k is the number of days in the period under consideration

Monthly total precipitation (Ptm) was computed from the expression.

$$Ptm = \sum_{j=1}^{k} Pj \qquad 5.$$

3.2 Water Stage

Mean water stage (Ha) was computed from the expression

$$Ha = \left(\sum_{j=1}^{k} Hj \right) / k \qquad 6.$$

Where Hj is the daily water stage, subscript j refers to the day, k is the number of days in the period under consideration

3.3 Streamflow Frequency Analyses

The daily streamflow of the river for the study period were ranked in descending order of magnitudes.

The return period of each of the ranked flow was computed from the expression:

$$Tr = (N+1)/m \text{ (in days) (Wilson, 1974)} \qquad 7.$$

Where Tr is the return period (days), N is the number of events on record and m is the rank (order) of each entry.

From the concept of return period Tr, where P is the probability of the occurrence of the array equal to or greater than a given value y, then the return period Tr will be:

$$Tr = 1/\Pr(Wilson, 1974) \qquad 8.$$

Therefore, percentage probability Pr will be computed from the expression:

$$Pr\% = 100/\mathrm{Tr}(Wilson, 1974) \qquad 9.$$

3.4 Mass Curve

The mass curve was constructed by using the cumulative catchment mean monthly runoff values for the four water years.

4.Flow Forecasting Modeling of the River Flow for the River Ogbese

4.1 Preparation of the Input Data

Noilhan, 2002 and Artinyan, et al. 2003 stated that meteorological model ALADIN, used by the National Institute of Meteorology and Hydrology (NIMH) for meteorological prognosis could as well be used for hydrological modeling. But due to the non-availability of the necessary input parameters such as temperature, air humidity, wind velocity and radiation for the study river, the model could not be used. In view of this, stepwise regression analysis which was used by Omonijo and Ojomo (2004) was applied to rainfall, stage and discharge data that were available for the study river in order to establish a model that will predict the flow of the river.

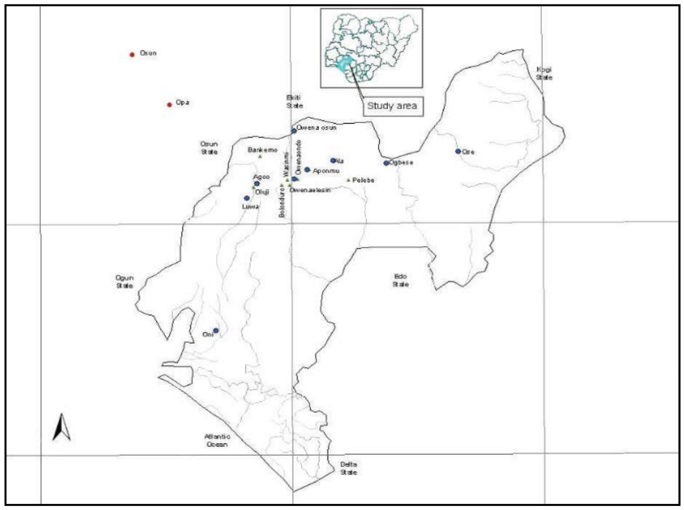

Fig. 1: Map of Ondo State Showing Location of River Ogbese

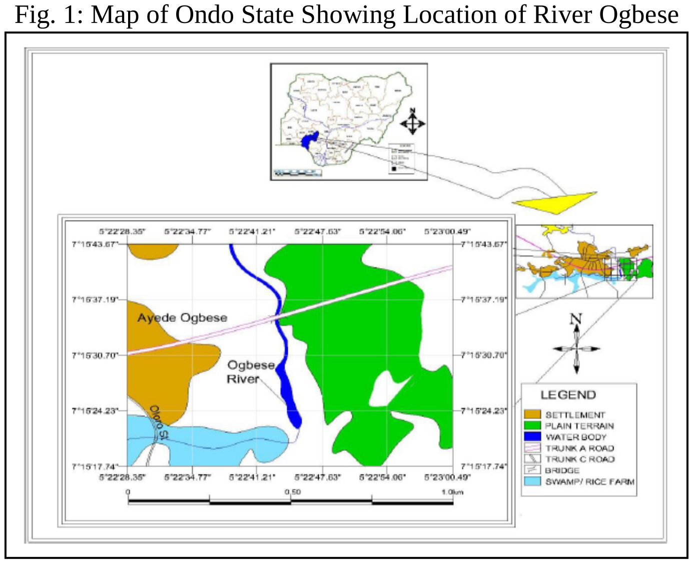

Fig. 2: The Map of River Ogbese (Source: Olawusi-Peters et al. 2014)

5.Results and Discussions

The result in Figure 3 showed a progressive change in discharge and water stage character. **VW** on the graph represents the overland flow due to rains and is called the **RISING LIMB**. The fall in the discharge value at **W** on the hydrograph may likely be attributed to the complex interplay of the local factors that affect discharge in this area. In September, the rainfall value increases, therefore the discharge value ascends again until reaching the peak at **Y** which is the highest discharge attained. **YZ** is the **RECESSION CURVE** whose shape is controlled by the rate of water withdrawal from the ground storage. VWXY marked out by joining V and Z represents total surface runoff principally and groundwater runoff in part. Below line VZ is the groundwater condition for the various months.

The mean daily discharge (Qa) of the river was 2.678m^3/s, while the standard deviation and standard error were 2.585m^3/s and 0.068m^3/s respectively and coefficient of variation is 0.965. Also from the analysis, the mean daily water stage is 122.71cm while the standard deviation and standard error were 67.525cm and 1.768cm respectively and the coefficient of variation is

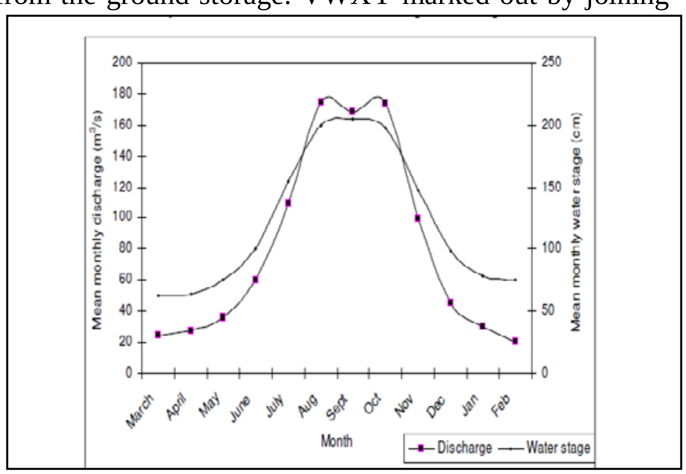

Fig. 3: Discharge and Water stage hydrograph of river Ogbese

0.550. The mean daily precipitation was 3.73mm while the standard deviation and standard error were 10.205mm/day and 0.296mm/day respectively and coefficient of variation is 2.736.

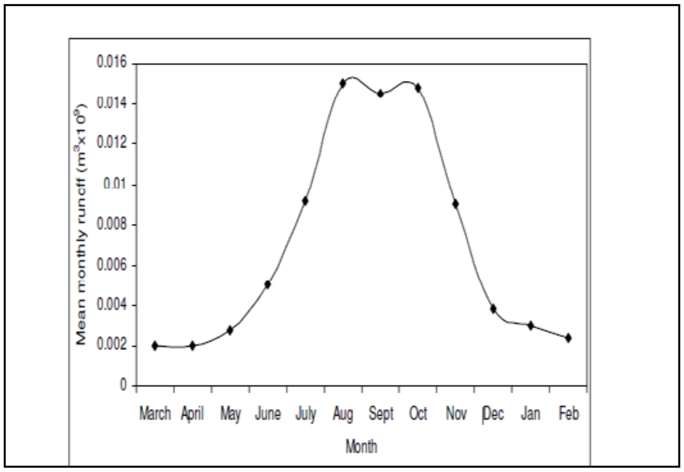

Fig. 4: Runoff Hydrograph of River Ogbese

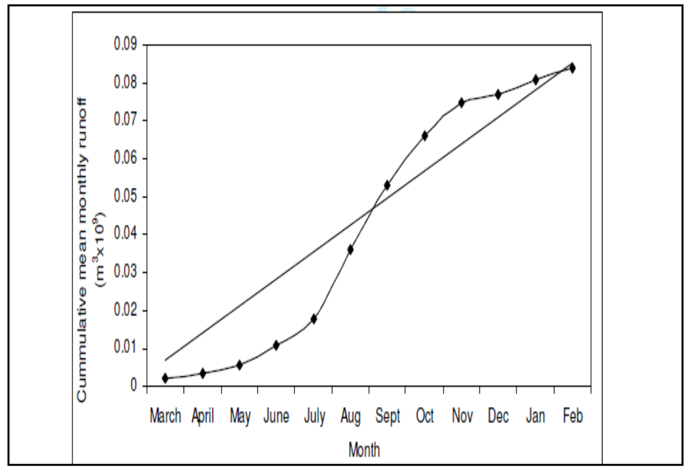

Fig. 5:Cumulative Mean Monthly Runoff of River Ogbese

Figure 4 and 5 is the runoff hydrograph and cumulative mean monthly runoff of river Ogbese. Figure 5 has four sections separated by A, B, C on the curve. From March, stream flow increases till May, when due to decrease of stream flow in June; a nipple develops at A to mark this rate of change. From July, it increases steadily to September where a major nipple develops at B denoting commencement of stream flow decrease again and from there it decreases till December, and it increases gradually again from January.

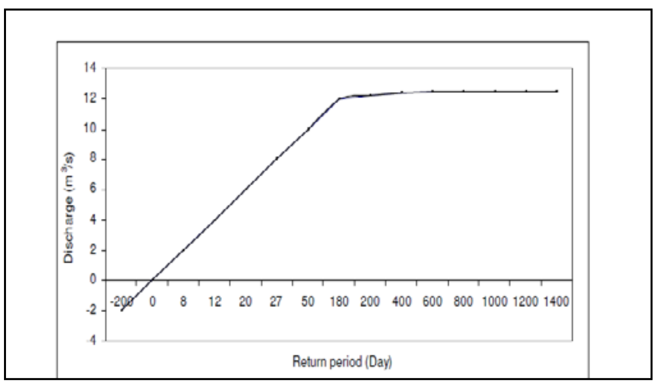

Fig. 6: Relationship between return period and discharge at River Ogbese

Figure 6 shows the relationship between return period and discharge of river Ogbese. It could be seen from Figure 1 that we can extrapolate and then infer the return periods of the stream flow.

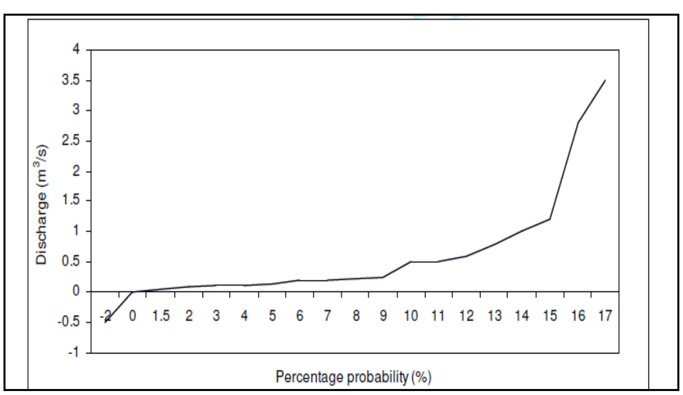

Fig. 7: Relationship between Percentage Probability and Discharge at River Ogbese

Figure 7 is the normal probability graph that shows the relationship between percentage probability and discharge. The points on the graph do not lie along a straight line, but follow a shallow curve path. The Figure showed the probability of the corresponding value of discharge that will be equaled or exceeded in any one year.

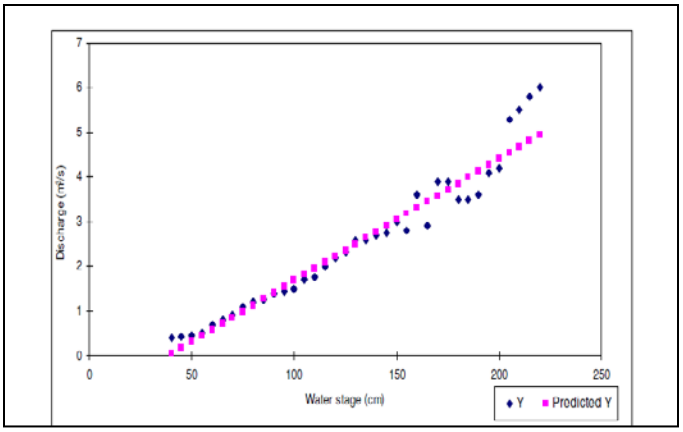

Fig. 8: Flow Rating Curve of River Ogbese showing Observed and Predicted Trend Lines

Figure 8 describe the relationship between the water stage and discharge which is the flow rating curve of the river. The equations of the trend lines that connecting observed and predicted discharge with water stage as well as the coefficient of correlation were calculated.

The observed and predicted equations with their coefficient of correlation are shown below:

A.Observed equation

$Q = 0.0273H – 1.0457; R^2 = 0.9517$

B.Predicted equation

$Q = 0.0273H – 1.0457; R^2 = 0.9842$

Where Q is the water discharge and H is the water stage.

All the variables (rainfall and water stage) explained 99.0% (0.99) of the variation in the water discharge at both 0.01 and 0.05 probability levels which confirmed the findings of Omonijo and Ojomo (2004) that rainfall and water stage contributed significantly to water discharge. In this study water stage contributed 98.3% (0.98) and rainfall contributed 0.7%.

The predictive equation involving all hydrological data used in this study to establish a model for flow forecasting of river Ogbese is given below:

$$Q = 47.73 + 0.78H + 0.09P$$

Where Q represents water discharge in m^3/s, H represents water stage in cm and P represents rainfall in mm

6. Conclusion

The results presented and discussed above show that water stage is prominently depend on underground water and is critical for effective planning, management and control of water resources. The study of rainfall showed that highest rainfall occurred in the months of August, September and October which associated with peak discharge, water stage and runoff volume of river Ogbese. This result implies that water storage could be done in the months of August, September and October for use when there is scarcity of water for different user.

7. References

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