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Rainfall and Runoff Relationship for Determination of Water Abstraction Potential of River Osun, Southwestern, Nigeria

Adeyokunnu, A.T.
Department of Civil Engineering, Ajayi Crowther University, Oyo, Oyo State, Nigeria.

ABSTRACT: The hydrological regime is characterized by high variability of rainfall and runoff distribution. The hydrologist finds it difficult to make accurate prediction of water abstraction by various dams. Inspite that Osun is blessed with abundant water resources being one of the states that supplier water to resident in Osun state, water supply is made inadequate due to lack of schedule of water by facilities abstracting water from the river. In this study, the Rainfall-Runoff Relationship for Determination of Water Abstraction Potential of River Osun was investigated. The model developed was a linear regression approach considering effects of past rainfall on the runoff of the effluent streams. Forty (40) years rainfall data collected from 1974 – 2012 were used to estimate corresponding runoff using empirical approach. The rainfall were repressed against runoff and the corresponding runoff arrived at regression coefficient of 0.912 and 0.896 respectively. Generated runoff for River Osun were determined. The data could serve as a veritable hydrological input in the allocation of water for the dams abstracting water on the river. It is recommended that to find a lasting solution to the menacing frequent lack of water by dams abstracting water on River Osun.

KEYWORDS: Rainfall-runoff model, Generated runoff, Potential, River Osun, Nigeria

1.0 INTRODUCTION

The main socio-economic activities of people living around the Osun River are farming and fishing with little population into sand dredging. Basher et al. (2006) observed that people use the water from the river for domestic purpose, fishing, recreation, and washing. Sand dredging activities also take place along the river water course in these areas.

There are many dams on Osun River such as Asejire dam, Erinle dam, Ede dam, Esa-Odo dam, Apara, Aponje, and Owalla dam. The five functioning dam out of those dams are Ede, Erinle, Aponje, Apaara, and Esa-Odo dam in Osun State, Nigeria. In which they supply potable water abstracted to Osun State. While EsaOdo supplied water to international breweries. Otin River was impounded in EkoEnde Area, which is about 370 sq. km in Odo Otin Local Government Area in the north-east (Adeboye and Alatise, 2007).

River Osun has five major dams in which one of the dam abstract water for the industrial uses, while the other four dams abstract water for domestic uses.

River Osun is located in an area whose boundaries are approximately longitudes and t t Easthing and latitudes th Northing with population of slightly over three million spread over an area of about ¸of the catchment area. Olajire (2006) reported that River Osun takes its source from Imesi Ile where it takes it's upstream, and takes it's downstream at Asejire Dam. It flows through Ogbere (Ijebu-ode /Benin Road), lagoon in Epe (Lagos State). River Osun is a river that flows southwards through central Yoruba land in south western Nigeria. It is one of the several rivers ascribed in local mythology who become an important tourist attraction drawing people from various parts of Nigeria and countries. River Osun is very useful to the inhabitants for domestic, agricultural and recreational purposes.

A dam built across the River Osun created the lake for storage purposes to augment water supply and eradicate inadequacy in water allocation to those dams.

Figure 1 shows the facilities abstracting water from river Osun.

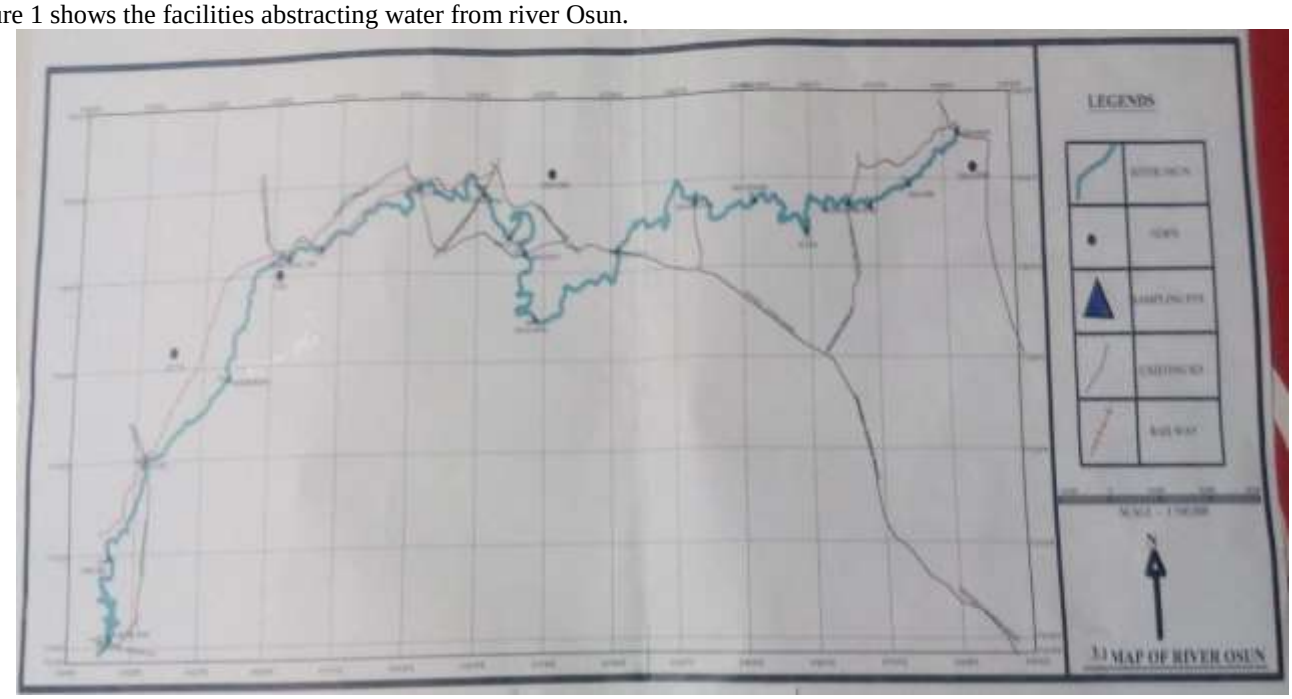


Figure 1: Map of River Osun

2.0 MATERIAL AND METHODS

2.1 Description of the Study

River Osun bears its origin from Igede Ekiti, flows through Ilesha forest and enter Osogbo at the west. River Osun has a number of tributaries that join it at Osogbo. These include Ajibu River, Okoko River, Ogbaagba River, Asaba River and Elekunkun River. Apart from the use of the Osun River for miraculous deeds as believed by the Osun worshippers, it also constitutes a water source for the people residing in the state. It is a city in Africa, lies within longitude $5^0\,10^{'}\,3^{'}$ and $5^0\,26^{'}\,47^{''}$ easting and latitudes $8^0\,20^{'}\,3^{''}$ and $5^0\,10^{'}\,35^{''}$ northing with population of slightly over three million spread over an area of about 9,251 km^2 of the catching area. River Osun has five functioning dams; one of these dams withdraw water for industrial use, while the four dams abstract water for domestic use.

2.2 Computation of Runoff

Forty (40) years monthly data records were collected from Nigeria meteorological (NIMET), Oshodi, Lagos state. The rainfall were converted to runoff using equation 1 and table 1 for various runoff co-efficient.

$$Q = C\,I\,A$$

where: Q = Runoff in (m^3),
I = Rainfall intensity in (mm)
A = Catchment area in (m^2),
C= Runoff coefficient

Table 1: Simplified Table of Rational Method for Runoff Coefficients.

Ground cover	Runoff coefficient, C
Lawns	0.05 - 0.35
Forest	0.05 - 0.25
Meadow	0.1 - 0.5
Parts, cementeres	0.1 - 0.25
Unimproved areas	0.1 - 0.3
Pasture	0.12-0.62
Industrial areas.	0.5 - 0.9
Asphalt streets	0.7 - 0.95
Concrete street	0.7 - 0.95
Urban area	0.3 - 0.5

(**Source:** Ragunath, 2006).

In this study, the runoff coefficient that fall between 0.3 and 0.5 was therefore adopted because Osun state where River Osun is located belongs to an urban area in simplified rational table.

2.3 Rainfall / Runoff Modeling of River Osun.

The rainfall/runoff relationship for generated runoff on River Osun was obtained by regressing collected rainfall against computed runoff using Excel software. A rainfall-runoff model based on transfer function to translate rainfall into river flow has be developed for River Osun using equation 2

$y = mx + C$

Where: Y = general runoff,

X = Rainfall data,

C = regression coefficient.

2.4 Generated Runoff on River Osun

The runoff value was estimated for River Osun in order to know the potential of River Osun source. This was achieved by substituting rainfall (x) into rainfall/runoff modeled equation.

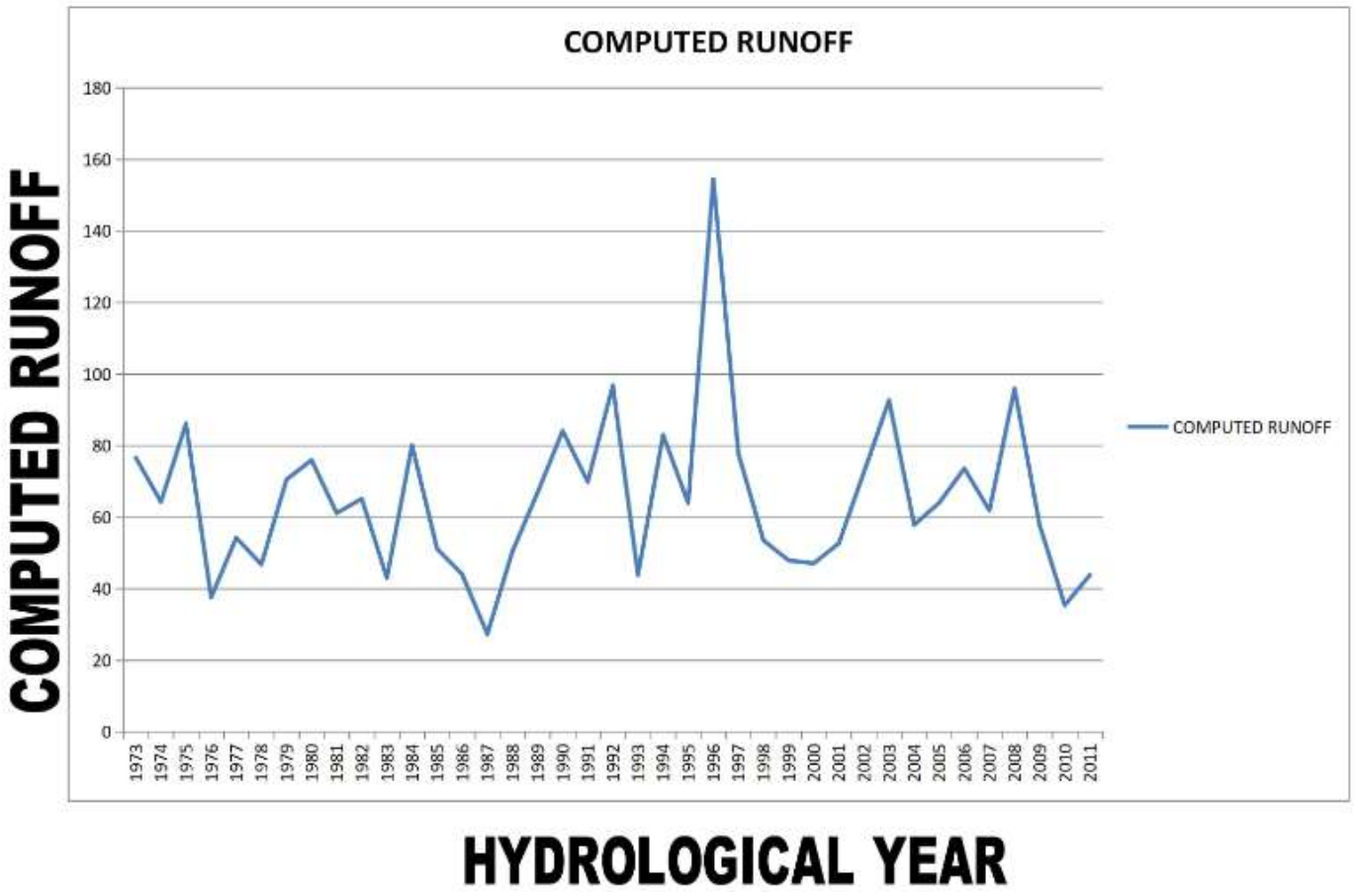
2.5 Quantity of water abstracted by the Dams across River Osun

The total consumption domestic facilities demand generally amount to 55% of the total water generated. The quantities of water required for industrial purposes as per (IS: 1172-1962) Indian standard code of basic requirements for water-supply is 25% of the total demand for industrial purposes.

3.0 RESULTS AND DISCUSSION

3.1 Computed Runoff of River Osun

The runoff was estimated based on rational formulae and the result of runoff computed is presented in figure 3. It was observed that runoff was at its peak in July, August, September and October with no runoff in January and February but lowest runoff in March and April. The lowest runoff based on computed runoff is $37.56 \times 10^3 mm^4$ and highest runoff was $155.49 \times 10^3 mm^4$ in the year 1976 and 1996 respectively.



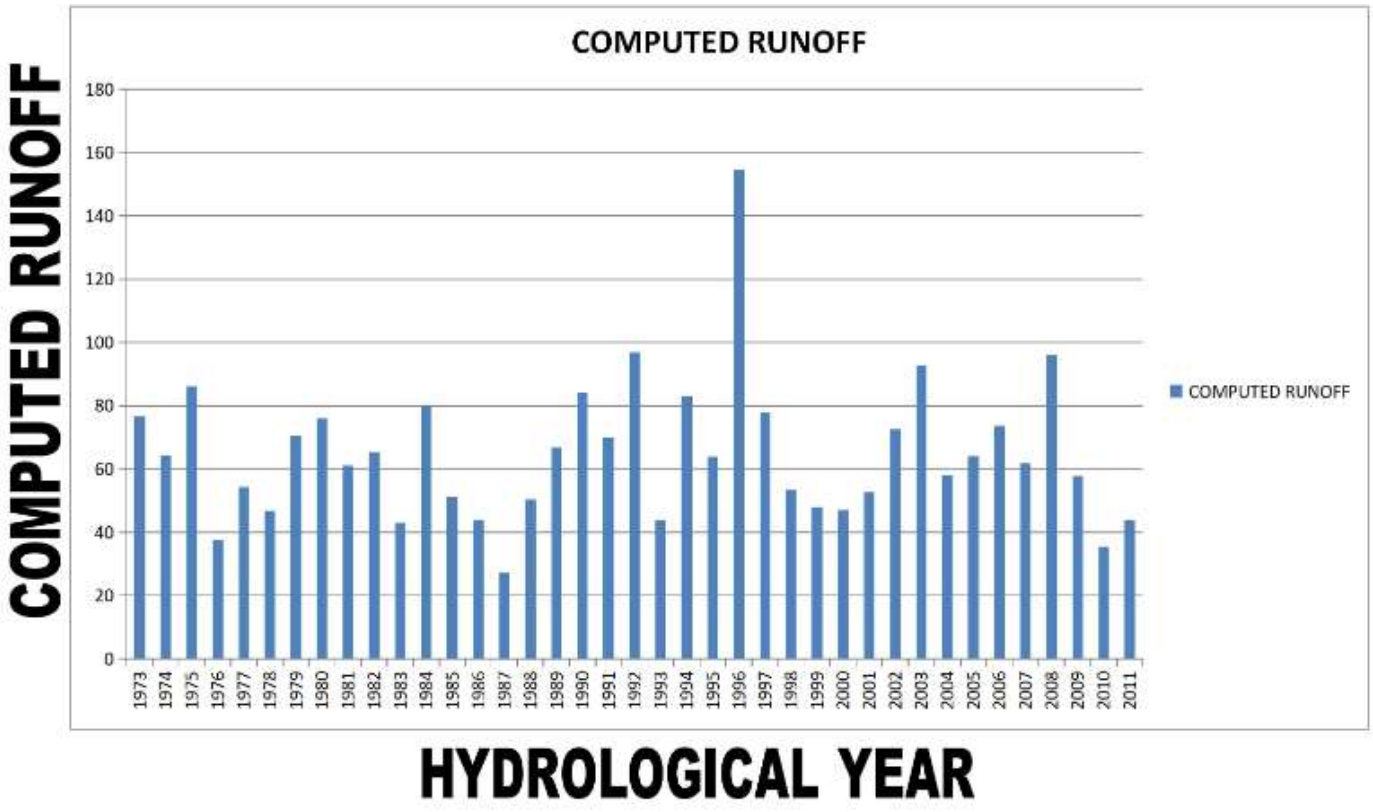


Table 2: Regression Equation with their Regression Coefficients

Year	Repression Equation	Repression Coefficient
1992	y = 69971x-69782	0.779
1993	y=49231x-49098	0.812
1994	y=55209x-55060	0.767
1995	y=82186x-81964	0.762
1996	y=44544x-44424	0.719
1997	y=70377x-70187	0.880
1998	y=72406x-72210	0.910
1999	y=73441x-73242	0.819
2000	y=73808x-73608	0.900
2001	y=46463x-46338	0.912
2002	y=54694x-54548	0.776
2003	y=98293x-98266	0.777
2004	y=10787x- 10784	0.810
2005	y=44034x-43811	0.886
2006	y=51224x-51086	0.788

2007	y=80794x-80576	0.754
2008	y=42883x-42767	0.798
2009	y=46426x-46301	0.862
2010	y=49820x-49685	0.855
2011	y=11274x-11243	0.896
2012	y=9964x-9937	0.909

3.2 Rainfall/Runoff Modeling

The rainfall runoff relationship for estimation of runoff on River Osun was obtained by regression analysis. The developed rainfall-runoff relationship was of the form y = 10961x-10956 in October, 1996. The generated runoff on River Osun from 1973-2012 varied from 37.56 – 154.49 x 10^3 m^3 as the year increases. The generated runoff across the hydrologic year of study increase based on the year the rainfall intensity is high.

3.3 Quantity of Water Abstracted by the Facilities

River Osun is the main river source in Osun state. The quantity of water abstracted by those facilities abstracting water from River Osun increases from April to October and later decreases from November to March, this follows similar trend for all the years for both domestic and industrial facilities abstracting water from the River. Adamec (2008) have reported similar high value of water demand in the month of April to October and later reduces in the month of November to March. The water demand by for domestic purpose is 682 x 10^3/day while for industrial purpose is 4820/32 x 10^3/day. The water abstraction by domestic and industrial purposes does not exceed the amount of water generated on River Osun.

4.0 CONCLUSIONS

The following conclusion can be drawn from the study:

(i) The runoff was at its peak between July to October

(ii) The quantities of water abstracted for industrial and domestic purpose does not exceed total amount of runoff generated

(iii) Rainfall and runoff data are very crucial to ascertain the potential of River Osun.

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