IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Investigating the Hydrological Characteristics of Kaduna River Basin

A Saminu[*1], I Abdullahi[2], U Tsoho[3], I Nasiru[4], A I Ayinla[5]
Department of civil Engineering, Nigerian Defence Academy, Kaduna, Department of Agric Engineering Kaduna polytechnics
saminuahmed4real@yahoo.com

Abstract

The water resource potential of the Kaduna River for use in irrigation development and water resource management has been studied. The water conveyance efficiencies of the river channels are very low that development of upstream reservoirs and downstream irrigation schemes will result in much water conveyance losses as the water flows downstream from these reservoirs. also, the runoff coefficient of the basin decreases from upstream to downstream catchments while the basin river have been observed to behave as gaining river and loosing river in their upstream and downstream ends respectively .Excessive loss of water by percolation below the root zones should be avoided by proper selection of irrigation water application method because of the low runoff coefficient of the lowland catchment areas. It is thus recommended that the development of the downstream of the basin for agriculture should be carried out with caution as a result of the great water –conveyance losses and the semi-aridity shown by stream flow analysis.

Keywords:

Introduction

Water Resources Management is a set of well co-ordinated technical intervention in the hydrological cycle under – taken, to augment and regulate the existing water supplies for meeting human needs more effectively. The need for water balance studies arises from the mismatch between the spatial and seasonal distribution of water as demonstrated by the hydrological cycle and the spatial and seasonal dimensions of the human need structures.

Many of the World's greatest civilizations have had close association with rivers. The Hindu – India, Egytian, Chinese and Sumerian civilizations emerged and flourished in the major river valleys of the India, Nile, HwangHo and Tigris – Euphrates respectively. These hydraulic civilizations rose to great height of splendor because they were each successful in evolving an economic and political system which enabled them to harness the water resources at their disposal. They flourished over long periods of history because they learnt to manage their land and water resources in a way that harmonized the pursuit of economic objectives with the integrity of their environment.

The water resource in this country, varies markedly in time and space that, it is necessary to find its distribution pattern in order to assess quantitatively its availability at any time and place and thus, enable its use to be planned more effectively. The run-off coeffient, which is an indication of conversion of precipitation to runoff, is very low in this country while the seasonal distribution ofrainfall is skewed. This makes it more imperative the need for the application of scientific method and management practices to assess and manage the available water resource.

Rainfall and stream flow records provide the basic data for most water resource investigations. They provide the inputs for the evaluation of the quantity of water that can be utilized and of the discharge that should be controlled. Delivering a presidential Address, Saha (1938), made a plea to the National Institute of Sciences of India for a systematic study of all the river basins of India so that a scientific foundation could be laid for future integrated programs of flood control, irrigation, navigation and generation of hydro-electricity. In the speech, he saw these programs as instrument of revitalizing agriculture and initiating industrialization – pieces of a jig-saw which all fit together into a comprehensive plan of regional development. into a comprehensive plan of development.

The foregoing study aimed at quantifying the water resource of the country according to the hydrological areas into which the country has been divided. The hydrological area No. 2 out of eight hydrological areas has been chosen for the initial study because of the serious water shortage being experienced

ISSN: 2277-9655
Impact Factor: 1.852

by Lake Chad River Basin Development Authority. It is hoped the studies when completed could help in laying a scientific foundation for future integrated programs in the basin.

Location for Study Area

The country is divided into eight hydrological areas, as shown in (fig1), the area of study in this report is the hydrological area no.2 . This study area covers the area of operation kangimi, Romi, Ruza ,and Rigacikun River Basin, it has an area of about 189,942 square kilometers. it is located between the latitude latitude 10^0 -31^1 and longitude 7^{0} $^{-}27^1$.

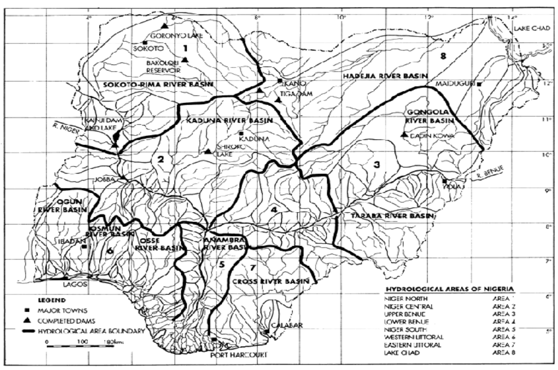

Figure 1: Hydrological Map of Nigeria

Climate

The climate of Nigerian is strongly influenced by the Equatorial Maritime and Tropical Continental air masses. The boundary between these two is known as the inter-Tropical Convergence Zone (ITCZ). The Equatorial Maritime air mass is characterized by south – westerly winds which approaches the land off the Gulf of Guinea. The rainfall in the study area is derived from this moisture – laden air mass with a long history of movement over the Atlantic Ocean. The Tropical Continental air mass is that of the dry north easterly wind known as the Harmattan. The climate of the study area is very much affected by then movement of the ITCZ. The rainy season is normally in the period of mid-April to late September or early October, when the Inter-Tropical Convergence Zone has reached the northern part of the Country. The dry season is from October to early April when the North Easterly wind cover the whole of the northern part of Nigeria. The surface position of ITCZ is often considerably to the North of the equatorial low-pressure belt. The inter-tropical Convergence Zone decreases in altitude towards the North. It lies approximately in the east-west direction. At Kano, record show that the passing of the ITCZ across the city occurs northward in April and southward in October throughout the year, the greater majority of the winds are either north east or southwest or close to these directions. The mean annual rainfall in Kano, the western part of the area over the period 1905 to 1988 is 817.33mm.At the southern fringes of the basin on high Plateau in Jos, the mean annual rainfall total over the period is 1364, 58mm. At Bauchi and Maiduguri representing the central and Northern areas of the hydrological area the mean annual rainfalls are 1054.82mm and 626.56mm respectively.

The Folws Regime

In addition to climatic factors, the flow regime of a river system depend upon the topography, surficial geology, soil and vegetation cover of the drainage area. The study area is made up of rock outcrops in the plateau and sand bed, thus the drainage system of the area is very complex. The Kaduna River and its major tributaries, the kangimi, Romi, Ruza, and Rigacikun River drain the major part of the area.The kangimi (SL2) enter intoKadunaRiver through the eastern end of the upper catchment, while Romi, Ruza enters the river through the western end of the lower catchment,and Rigacikun river (SL3) enters the river through the southern part.As shown in the figure (2) below:

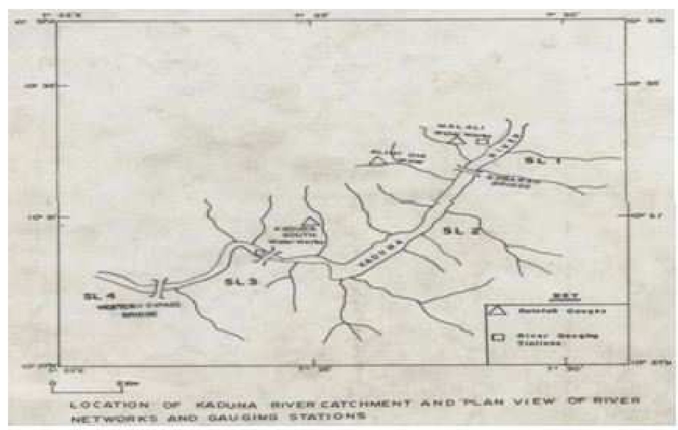

Figure 2; The Flow regime and River networks of Kaduna River

Analysis

Water balance is a problem of catchment yield. Catchment yield refers to the volume of water available from a stream at a given location over a specified period of time. The yield depends on meteorological event mainly rainfall, evaporation, relative humidity, geology, vegetal cover and land use practices within the catchment. The yield from a given hydrological catchment area may be given by the equation.

$$Y = Qdt \quad (1)$$

Which can be changed in term of water depth as

$$Y = V + Idt - ET \quad (2)$$

where

Y = yield (m^3)
y = yield (mm)
Q = discharge in the stream at a given location (m^3/sec)
I = rainfall Intensity (mm/sec)
V = previous volume of water in storage (mm)
ET = actual evapotranspiration from the catchment (mm)
dt = t2 – t1 while t1, t2= Times at beginning and end of period (sec)

An accurate evaluation of all the term in the water balance relationship is not possible. In particular, change in the groundwater storage are difficult to estimate because the boundaries of the ground water reservoir are frequently quite different from those of the hydrological area and the fluctuations in groundwater storage may depend on supply from a larger hydrological area. The above equation can then be expressed as:

$P = E_T + R + G + S$ (3)

Where P is the mean annual rainfall for the period (mm), ET is the mean annual evapotranspiration (mm), R is the mean annual runoff (mm). For a real natural catchment, measurements of rainfall and river discharge may be carried with a high degree of accuracy but groundwater movement into and out of any hydrological area cannot be measured satisfactorily. in this water balance studies it is assumed that hydrological area is 'tight' with respect to groundwater flow such that no substantial subsurface movement of aofwater occurs across the defined hydrological boundry.Since the evaluation of change in storage depend on the time period over which the water balance is made, it is assumed also that the water stored in the ground and in the surface storage are approximately the same each year and thus in the equation should be assumed to be negligible and equal to zero. Nevertheless, it has been observed that significant differences in the amount stored may occur from one year to another. (shaw, 1983). Based on the assumption of Zero change in groundwater storage equation (3) was adopted without the groundwater term.

The term S is used here to account for both groundwater discharge and change in storage and also errors due to measurements. The groundwater discharge and change in storage have been lumped together because they were not measure directly for this study. Thus S is considered as a residual that is.

$S = P – R\ E_T$ (4)

The value of S could be positive or negative. A negative value is an indication that potential evapotranspiration could be higher than rainfall for the period being studied.

In this study, the basic data used are rainfall, river discharged, air temperature, relative humidity, sunshine hours and wind run. Most of these Data were compiled from the data held in storage in the National water Resources institute, Kaduna (NWRI) Data Bank. They do not therefore represent the entire data available within the catchment area.

Runoff Coefficient

The runoff coefficient is the ratio of that portion of the total precipitation which flows on the surface that reaches the stream channel to the catchment total precipitation. The higher the value the higher the runoff expected at a gauge location and the less the infiltration and other losses. The runoff coefficient has been estimated by using the equation.

$C = R/P$ (5)

Where:
C = runoff coefficient
R = total runoff (mm)
P = total precipitation (mm)

Results

Analysis of the surface water balance of the area has shown the existence of two different flow characteristics. The mean annual runoff of the Kangimi riveris estimated to be $1220 * 10^6\ m^3$ 1954 to 1972. At Romi in theRomi Riverjust above the confluence with the KangimiRiver the men annual runoff of the Romi River is estimated to be $674.36 * 10^6\ m^3$. Downstream at Rigachikun which is near the lower boundary of the upland area, the river has an annual runoff of $1982.15 * 10^6\ m^3$. This was the combined flow from the Kangimi and Romi rivers.From the upstream to this station the Kangimi River behaves like ariver in the humid region with increase in the runoff as the drainage area increase downstream. Thus the Kangimi River became a losing stream, a typical behavior of a river in an arid region. The same trend in the mean annual runoff volume of a river was also found in the ZariaRiver. Between Shikaand Zaria rail bridge stations the river is a gaining river thus exhibiting humid region behavior but downstream of Kaurabetween Kauraand Karami, The runoff coefficient in the study areavaried.

The relative humidity of the study area has the lowest value at katsina except in the months of October to February. The relative humidity has an inverse ratio with evaporation and thus evaporation tends to increase from the upstream to downstream areas.

The terrain in the upper catchment area is generally hilly with frequent out crops op bed rocks ranging in elevation from about 450m to about 1200m above mean sea level. The land from the lower catchment basin is extremely flat interrupted occasionally by sand dunes deposited by drifting sand from the Sahara Desert to the north. Most of the reservoirs in the basin are on the upper catchment area. The study showed that the water-conveyance efficiency of the river channel in the basin is very low that the development of the upper catchment for reservoir and the lower hand for irrigation will result in serious water management problem in the basin in relation to irrigation water requirements. The water conveyance efficiency is given by

Ec=100xWd/Wi (6)

Where

Wd=water delivered by a distribution system

Wi = water introduce into the distribution system

any release of water from these reservoir (e.g. Karami dam) for irrigation purpose downstream will result in serious water – conveyance loss that more water would be required than necessary if water deficiency cannot be tolerated downstream The infiltration rate should by low enough, however to avoid excessive loss of water by percolation below the root zone. The lower land catchment with very low runoff coefficient and therefore high infiltration rate will have excessive loss of water by percolation below the root zone. This means that more irrigation water will be required to maintain adequate soil moisture condition for optimum crop yield.

Discussion

Runoff characteristic vary considerably over the hydrological area. Most of the inflows toRomi from the hydrological area originated from two areas namely the Jos plateau and the SaminakaMountains. The upstream of the study area which is made up of rock outcrops has a very high relief and therefore high relief ratio. this area has low infiltration rate and thus relief ratio, the percentage of runoff from a given rainfall amount the high relief ratio, the low infiltration rate, low temperature, high relative humidity and higher rainfall of the upstream areas are the cause of the humid behavior of the upstream in that part of the catchment. The downstream portion of the study area has very low relief and is made up of sandy dunes. Thus, the lower relative humidity and higher temperature also encourage evaporation. The loss of water through evaporation as the rivers move downstream is also caused by high infiltration rates of the sandy formation.

Conclusion

The water-conveyance efficiency of the basin river channels have been found to be low, therefore it is being recommended that the development of the irrigation be concentrated on the upper catchment area to minimize the water conveyance losses. If the lower land has to be developed, measures should be taken to reduce the water conveyance losses otherwise water deficiency will result on the downstream irrigation schemes. The consequences of this is low crop yield which will have great consequences on the farmer's ability to pay for the irrigation water. Table 1: runoff coefficient at selected stations.

River	Area (km2)	Station	Runoff coefficients
Zaria	848.10	Zaria rail bridge	9.52
Galma	585.50	Ribako	8.06
Kaura	629.20	Along Zaria road	9.87
Shika	761.10	Kano to Zaria bridge	9.77
Karami	660.60	Saminaka	8.70
Kangimi	974.90	Rehogi	7.10
Romi	723.90	Ruza	6.08
Rigachikun	767.20	R/Chikun bridge	6.52

Table 1: Runoff Coefficients At selected Stations

References

[1] Shaw E M (1983) Hydrology in practice. First edition,van Nostrand Rainhold (UK) co .ltd.
[2] Subramaya .K (1994), Engineering Hydrology (Second edition).
[3] Everson. W (1973). The hope we have in environmental Quality and water Development
[4] Saha.M (1983). Problem of Indian Rivers, presidential address to the National Institute of sciences of India. Proceeding of the institute, Calcutta.
[5] Garg S.K (1977) A book of Water resources engineering.
[6] Mustapha .S and Yusuf M.I (1997): A textbook of hydrology and water resoueces first edition.
[7] Saha, S.K. (1981). River Basin planning as a field of study; Design of a course structure for practioners in River Basin planning Theory and practice.