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Small Hydropower Development: Key for Sustainable Rural Electric Power Generation in Imo State of Nigeria

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ABSTRACT: Since hydropower has become a leading source of renewable energy and Imo state with her myriad of perennial rivers, is strategically and naturally empowered to generate reliable electricity from these rivers that are located in hercommunities. The two major rivers that were used for this research included the Njaba and Otamiri rivers. The rivers were subjected to some gauging processes using the area – velocity method which was targeted at determining the discharges of these rivers. The monthly discharge values were used to plot a graph of discharge as abscissa and the monthly duration as the ordinate and the resulting graph is called hydrograph. The graph was divided into two parts by the use of tangents which connected the rising and recession limbs of the graph. The analyses revealed that the Otamiri River had a total volume of $2.28x10^8m^3$ quantity of water while the Njaba River had an abundance of $8.63x10^7m^3$ volume of water. With these available quantities of water, it was established that the Otamiri and the Njaba rivers could comfortably produce 1.89MW and 666.30KW of electricity respectively. This research has become necessary because of prevalent inadequacy of generated power in Imo State. The implementation of the results of the research will stimulate economic development and also precipitate industrial and infrastructural transformation of the rural areas.

KEYWORDS: Electricity, Hydrograph, Generation, Power and discharge.

I. INTRODUCTION

The importance and the need for rural electrification cannot be overstated as it has been identified as the bedrock for global transformation in terms of industrialization. The rural energy situation in all states in Nigeria is in a sordid state and this has been explained to be the reason for the low rate of economic development witnessed in the entire country. The electrical energy generation in Imo State is the crux of this research because of the numerous benefits accruable from a sustainable power generation which has been postulated to be achievable through the development of small hydro power plants.

Currently, two billion people in the world have no access to modern commercial energy. Rural electrification is recognized as a necessary condition for alleviating poverty, satisfying basic human needs, stimulating productive employment and income generation. In Nigeria, we have rural and isolated communities with high population densities necessitating high electric power demands. The total energy requirements show that no single energy generation type can adequately meet enormous electric power consumption of this vast country with over 140 million populations.

Insufficient power being generated to meet the power demand in Imo State as an integral component state of Nigeria and the need of introducing off-grid mini generating systems to cater for rural electrification makes the development of small hydro power stations in Imo State worthwhile and inevitable. The research is limited to the applications of the abundant water resources within the state in generating electric power and minimize the high cost associated with long distance transmission.

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A. Small Hydro Power Plant Development

The development of small hydro power plants is conceived to make electric power available to rural areas because most states are abundantly blessed with rivers and streams with the appropriate capacities and potentialities for electric power generation. The provision of electricity to rural areas through extension schemes of the grid transmissions heavily laddened by the very expensive equipment and the overhead costs associated with such schemes makes it less reliable as a source of power. It is cheaper to invest in a decentralized renewable energy system like mini and micro hydro schemes commonly called small hydropower plants (shp) than to pay for connecting local communities to existing national electricity grids, which can cost up to USD 50,000 / km (Kuale et al, 2001).
Hydroelectric power plants convert energy from flowing water (hydro potential) in rivers and streams into electricity through the use of turbines. Small hydro potential site abound in twelve states of the country in the nation's seven river basins. Nigeria has 278 unexploited sites with SHP potential and Imo State have good number of the hydro potential sites as shown on Table 1.1.

Table 1: Small Hydro Potential Site in Some States of Nigeria

S/N	STATE	RIVER BASIN	TOTLA SITES	POTENTIAL CAPACITY (MW)
1	Sokoto	Sokoto – Rima	22	30.6
2	Katsina	Sokoto-Rima	11	8.0
3	Niger	Niger	30	117.6
4	Kaduna	Niger	19	59.8
5	Kwara	Niger	12	38.8
6	Kano	Hadeja – Jamaare	28	46.2
7	Borno	Chad	29	20.8
`8	Bauchi	Upper Benue	20	42.6
9	Gongola	Upper Benue	38	162.7
10	Plateau	Laver Benue	32	110.4
11	Benue	Lower Benue	19	69.2
12	Cross River	Cross River	18	28.1
13	Imo	Anambra-Imo	20	67.8

(Esan, 2002)

Small hydropower is recognized as a renewable source of energy, which is economical, non-polluting and environmentally sustainable and ideal for rural electrification. Exploiting water resources has many advantages and energy generation is one of them. SHP can therefore maximize the value of water, not only by contributing to more security of power supply, but also to water management such as flood control irrigation, water storage and supply.

SHP is more ideal for decentralized power generation and grass roots participation and thus can also contribute to improve the social opportunities and welfare of the communities. Small hydropower is characterized by its reduced scale which proves to be environmentally friendly. It has negligible impacts on the surrounding natural environment and the noxious greenhouse gas emission is near zero.

B. Economics/Technology of SHP.

Small hydropower station design and construction is highly economical owning to its size and the absence of the transmission grid system in making the power available to the final consumer. Unit cost of owning a typical small low head hydro site in the United Kingdom is typically put at 5 pence/kwh during the first ten years while the capital investment is being repaid but consequently because of the low running costs, the unit costs should fall to around one tenth of this level that is about 0.5 peace /kwh (Esan, 2002).

Decisions to use a technology are generally driven primarily by economic trends and analysis. Naturally, small hydro power is generally high and therefore possesses high head since the higher the head, the less water is required for a given amount of electric power. Consequently the equipment and technology employed are inexpensive to attain the designed amount of power. The structures put in place for the SHP can also be used as a multipurpose project to serve

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such other purpose as water supply, irrigation and flood control in such a case the benefits derivable transcends power generation.

Turbine is important component of the SHP and it is a machine consisting of rotary units mounted on a shaft and this is employed in converting the hydro-energy to electrical energy. The two types of turbines in common use are the impulse and reaction turbines. The impulse turbines consist of the Pelton and Cross Flow turbines. The Pelton turbines are commonly used in the SHP as it tends to be move adaptable to high heads.

C. Power Generation in Imo State

Imo State has no generating station but it has transmission sub-station at Egbu. The substation receives power from the National Grid through the Alaoji transmission sub-station on a double circuit system. Afam generating station and the National Integrated Power Project (NIPP) at Alaoji are the nearest major power generating station to Owerri sub-station and they are major contributors to the National Grid.

The sub-station at Egbu has three power transmission system with two of the systems possessing an installation capacities of 60 MVA each while the third system possesses 40 MVA, the sizes of these operating systems constituted the capacity of the substation which amounted to 160 MVA apparent power. With the influence of the power and equipment factors the capacity of the Egbu sub-station is put at 128 MW. This is grossly inadequate for the state as the projected energy demand of the state stands at 200Mw (PHCN, 2013).

The sub-station is facing a number of problems which range from lack of feeder pillars to transformer problems and this situation has led to suppressed local demand as electric power taken out from the station by the consumer amounted to only 116MW as against the 128Mw power which the sub-station can conveniently supply. This problem has subjected the Orlu area to acute shortage of electric power supply as the area has only one 33KVA feeder which cannot supply more than 24 MW (PHCN 2013). With the development of small hydropower stations these challenges will be overcome and these areas will be supplied with adequate power.

D. Hydro-Potentials of Imo State

Imo State is a well drained area with a lot of rivers lakes, streams, waterfalls, etc and it situates within the main basin of Anambra –Imo River system. The state lies within latitudes 40.45^1N and longitude 50.50^1E and 70.25^1E and it occupies the area between the lower River Niger and the upper and middle Imo River, with an area of about 5100km^2.

The state drew its name from an important river called Imo River which rises from the vicinity of Okigwe and it is joined by the following main tributaries – Otamiri, Oramiriukwu, Ibu and Eme. Excessive rainfall characterizes this area and this helps in the high volume of her rivers. Rivers within Imo State area apart from the ones mentioned above includes Orashi, Iyingodo, Njaba etc while the major lakes includes Abadaba, Oguta, Iyinwoba, etc while her springs and waterfalls include Iyiokwu, Ogidi, etc. It should be mentioned that the number of rivers streams, lakes and waterfalls as mentioned above are not exhaustive as there are more to that.

Njaba river is a notable river in the Anambra – Imo River Basin Development Authority's area of jurisdiction. It is located in the mainstream of Njaba Local Government area and extends to Isu, Oru East and Oguta local Government areas of Imo state. The river flows towards the Southern part of the Njaba Local Government area and later diverts western ward. The river originated from Amucha Community and transverses through Okwudor and Umuaka communities and emerges at Awo- Omama and flows through Nkwesi until it empties into Oguta Lake. The river is perennial and it is used as a source for the community water use. The river bed sediments consists of fine/medium to coarse well drained aggregates and as a result the excavation of aggregates takes place along the river bed.

Otamiri River is a perennial river located in the border of Owerri North and transcends through Owerri West and Ohaji Egbema Local Government Areas in Imo State. The river flows across the some major communities in Owerri North, Owerri West and Ohaji Egbema Local Government Areas. It is a peremial river that stands as an economic feature within the local government areas through which it transverses. The river flows along the western boundaries of the Owerri municipal and serves such communities as Egbu, Nekede, Ihiagwa, Obinze, Mgbirichi and Umuagwo. Otamiri River started from Egbu Community and empties into Okorcha River at Etche town Rivers State of Nigeria. Otamiri River which is part of the Imo River system hosts a major irrigation scheme in River State.

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E. Renewable Energy as a Reliable Source of Energy

Existentially, energy comes in different forms such as mechanical, electrical, chemical, light / solar and nuclear. Energy is convertible from one form to another just as chemically energy in diesel oil is converted to electrical energy through a diesel generator. The light and heat energy from the sun and nuclear energy in atoms of materials can be transformed into electrical energy. Other forms of energy include water (hydro) wind, wave and tide. These forms of energy have sources by where they are obtained for instance heat energy can be sourced by burning such materials as wood, coal, gas, charcoal, sawdust, petrol, kerosene etc. all these sources of energy are depletable and release carbon monoxide which is noxious to health and deplete the ozone layer. Such sources of energy as sun, water (hydro), wind, tide and wave are not depletable but are renewable and known to be environmentally- friendly when harnessed.

Wood can be burnt to supply heat to generate steam and the steam can be harnessed to generate electricity. The African timber and plywood mill in Sapele Delta State and Epe industries Ltd have used wood wastes to generate electricity. Coal is burnt to produce heat for raising steam and the steam can be used to run locomotive or generate electricity. The electrical power generating station at Oji River, Enugu State uses coal to generate electricity. Natural gas is used in some of our chemical, textile, brewing and glass industries mainly for heating. Electrical power stations in Ughelle, Sapele, Aba and Port Harcourt also use gas to generate electricity. In a nuclear, power station a radioactive element such as Uranium is used to generate electricity through the usage of heat evolved during the nuclear reaction. Nigeria does not have a nuclear power plant even though we have Uranium deposit in Gombe State. The stations described above are developed from non-renewable energy sources.

Energy from the sun commonly called solar energy is used in generating energy through the application of photocells which accumulate these energies from the sun and later convert them into electricity through inverters. A generating station powered by the sun is sustainable especially in the tropics where we have hot temperature resulting from intensive sunshine. Moving water possesses high kinetic energy which can be appropriated for electric power generation. The degree of kinetic energy possessed by moving or running water can be illustrated with the disasters caused by flooding which included even pushing down buildings and other foundation -based structures, sweeping away of vehicles and heavy goods. The kinetic energy power of water can be increased through the construction of dams to enable the water come from a height with a high velocity. The running water coming from such a height can be used to turn a turbine for electricity generation and such is known as hydropower station. Wind blows are phenomena that take place at a high velocity and causes trees and buildings to fall. This energy possessed by wind can be converted to electrical energy through a wind mill. In a similar manner wave energy can be harnessed to drive turbines for electricity generation.

II. METHODOLOGY

The methods employed in this research were majorly the guaging of the river, determination of the available water in the rivers and the calculation of the apparent electric power which can be generated.

A. Stream Guaging of the Selected Rivers

The rivers were guaged by using the area- velocity method which involved the determination of the cross sectional area and velocity of flow. The procedures used for the stream guaging are outlined below:

i) The width of chosen point at the river reach was divided into convenient section and strips to enable the mean depth of the river to be determined. It was at this point that the width of the river was also determined.
ii) From the chosen point, a distance L_m was established and marked out downstream.
iii) At this point, floats were introduced and allowed to float through the marked distance and the time taken to make the travel was recorded using stop watch. It was recorded in seconds. This step was repeated to establish more reliable values. At this point an average velocity V_m was determined.
iv) The dept d_m was collected on a daily basis and was combined to calculate the discharges as illustrated below:

B. CALCULATION OF DATA

From the primary data determined through the guaging process, other secondary data were obtained as shown below:

(i) Measured width of the river, b in metres
(ii) Average depth d_m of the river was determined by finding the average depth of the depths at the various strips thus:

$$d_m = \frac{d_1 + d_2 + d_3 + d_3 + d_4 \ldots d_n}{n} \qquad \ldots\ldots 2.1$$

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(iii) The cross sectional area of the river is determined thus;

$A_C = bd_m$ in m^2……………..Equation 2.2

(iv) The surface velocity was determined by dividing the traveled distance L_m by the time T taken for the travel thus;
$V_s = L_m / T$ in m/s………………………………………. 2.3

(v) The discharge for each day was determined thus;
$Q = A_C V_S = bd_m V_S$ in m^3/s…………………………… 2.4
The discharges were determined from January to December of the respective years.

(vi) Correction of surface velocity
Corrected surface velocity $V_s = fv_s$………………Equation 2.5

C. Estimation of Available Quantity of Water

The average monthly discharges and their corresponding time were obtained for each sub-basin and used in drawing the hydrographs. A hydrograph analysis was done through the estimation of the available volume of water in the respective rivers of Njaba and Otamiri. The water in the river consists of the base flow and the runoff. While the base flow is the ground water contribution to the river flow, the runoff comes from the rains.

The base flow was obtained by drawing a tangent horizontally to the abscissa linking the two rising limbs of the hydrograph. The surface water quantity represented by the upper part of the separated hydrograph, was determined by calculating the entire upper area which was divided into regular shapes. The base flow or the groundwater within the sub-basin, constitutes the lower part of the separated hydrograph. The computations were done to determine the available water.

D. Determination of Apparent Electric Power

Production of electric power by using the energy of flowing water is an excellent use of water as no water is consumed or lost in the process. In this case, only a certain minimal head is required, which is dissipated in producing the power.

The amount of energy generated when Q cumecs of water is allowed to fall through a head difference of H metres is given:

Water energy developed = $Y_w QH$………………………………2.1
where Y_w = unit weight of water
= $9.81 kN/m^3$ (in S.I. units)
Q = Average discharge in cumecs
H = Head in metres
Water energy required for the given Head, H
= 9.81QH kNm/sec (i.e. kw)……………………………2.2
The power in Kilowatts, is therefore given as:
= 9.81 QH (kW)………………………………………..2.3
Introducing the efficiency of the turbine δ the power generated
= 9.81δQH kw……………………………2.4
Using 80% efficiency for the turbine we have;
H. P. generated = 9.81x 0.8 x QH
= 7.84 QH kW.
Electrical Energy = 7.84 QH kW
Where Q = Design discharge (cumecs)
H = Design Head in metres

III. PRESENTATION AND ANALYSIS OF RESULTS

A. Discharge Data

The guaging process undertaken in the sample rivers of Njaba and Otamiri yielded discharge results as shown in Tables 3.1 and 3.2

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Table 2: Water Discharge For Njaba River

WATER DISCHARGE: (M^3/S) **RIVER SYSTEM: IMO**

STATION: AWO OMAMA **NAME OF RIVER/STREAM: NJABA RIVER**

LOCATION: Lat: 05^0 39 N, **LONG: 06^o 57^IE**

HYDROLOGICAL YEARS 2007/2008

DAYS	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	0.98	1.93	2.17	3.11	3.32	3.13	2.17	4.21	2.93	4.21	2.93	0.98
2	1.15	1.85	2.61	3.19	3.43	4.02	2.17	4.11	3.05	4.21	2.93	0.98
3	1.09	1.91	2.61	3.17	3.74	4.13	2.17	3.91	3.19	4.21	2.93	0.98
4	1.09	1.93	2.45	3.19	4.02	4.21	2.17	3.91	3.37	3.00	2.93	0.98
5	1.13	1.95	2.50	3.19	4.30	4.21	2.17	4.02	4.21	3.26	2.93	0.98
6	0.98	1.93	2.61	3.19	4.30	4.21	2.17	4.02	4.21	2.93	2.93	0.98
7	0.85	1.93	2.61	3.21	4.30	4.21	2.17	4.02	4.21	4.21	2.93	0.98
8	0.85	1.93	2.67	3.30	3.78	4.21	2.17	4.02	4.21	4.21	2.93	0.98
9	0.85	1.98	2.69	3.37	3.24	4.21	2.17	4.02	4.02	4.21	2.93	0.98
10	0.98	1.95	2.74	3.34	2.93	4.21	4.21	2.93	3.08	4.21	2.93	0.98
11	0.98	1.95	2.76	3.37	2.93	4.28	4.21	2.93	3.50	2.93	2.93	0.98
12	0.98	1.98	2.65	3.39	2.82	4.28	4.21	3.17	2.93	2.93	2.93	0.98
13	1.19	1.93	2.69	3.24	2.85	4.21	4.21	3.69	2.65	2.93	2.93	0.98
14	1.32	2.02	2.67	2.93	2.91	4.21	4.21	4.21	2.85	2.93	2.93	0.98
15	1.46	2.04	2.69	2.93	3.02	4.21	4.21	3.91	2.93	2.93	2.93	0.98
16	1.09	2.04	3.04	2.82	3.30	4.21	4.21	3.08	2.93	2.93	2.93	0.98
17	1.00	2.09	3.08	2.82	4.21	4.21	4.21	2.93	2.93	2.93	2.93	0.98
18	0.98	2.00	3.15	2.91	4.21	4.21	2.17	2.92	2.93	2.93	2.93	0.98
19	0.98	2.09	3.11	3.02	4.21	4.21	2.17	2.93	2.93	2.93	2.93	0.98
20	1.15	2.09	3.19	3.30	4.13	4.21	2.17	3.00	2.93	2.93	2.93	0.98
21	1.09	2.04	3.17	4.21	4.00	4.21	4.21	3.11	2.93	2.93	2.93	0.98
22	1.13	2.06	3.19	4.21	4.28	4.21	4.21	3.11	2.93	2.93	2.93	0.98
23	1.15	2.09	3.19	4.21	2.17	2.17	4.21	2.98	2.93	2.93	2.93	0.98
24	1.41	0.15	3.19	3.24	2.17	2.17	4.21	2.91	4.21	2.93	2.93	0.98
25	1.41	2.17	3.21	2.93	2.17	4.21	4.21	2.93	4.21	2.93	2.93	0.98
26	1.48	2.17	3.30	2.93	2.17	4.21	4.21	2.93	4.21	2.93	2.93	0.98
27	1.41	2.17	3.37	2.82	4.28	4.21	4.21	2.93	4.21	2.93	2.93	0.98
28	1.37	2.13	3.34	2.85	4.21	2.17	4.21	2.93	4.21	2.93	2.93	0.98
29	1.37	22.15	3.37	2.91	3.19	2.17	4.21	2.93	4.21	2.93	2.93	0.98
30	1.37	2.17	3.39	3.02	3.15	2.17	4.21	2.93	4.21	2.93	0.98	
31	1.48		3.37	3.41	3.13	4.17		2.93		2.93	0.98	
Max	**1.48**	**2.17**	**3.39**	**4.21**	**4.20**	**4.21**	**4.21**	**4.21**	**4.21**	**4.21**	**2.93**	**0.98**
Mea	**1.15**	**2.03**	**3.10**	**3.33**	**3.45**	**3.90**	**3.39**	**3.37**	**3.20**	**3.23**	**2.77**	**0.98**
Min	**0.85**	**1.85**	**2.17**	**2.82**	**2.17**	**2.17**	**2.17**	**2.91**	**2.65**	**2.93**	**0.98**	**0.98**

Source: Anambra-Imo River Basin Development Authority

Table 3: Water Discharge for Otamiri River

WATER DISCHARGE: (M^3/S) RIVER SYSTEM: IMO STATION: NEKEDE
NAME OF RIVER/STREAM: OTAMIRI LOCATION" LAT: $05^0 26^1$N LONG: 070 27 HYDROLOGICAL YEAR: 2007/2008

DAYS	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1	7.70	7.10	7.10	7.34	8.12	9.24	8.96	8.54	7.98	7.84	7.70	7.58
2	7.70	7.34	6.98	7.22	8.26	9.10	8.96	8.54	7.98	7.84	7.70	7.58
3	7.46	7.34	7.70	7.70	8.32	9.24	9.10	8.54	7.98	7.84	7.70	7.58
4	7.34	7.22	7.10	7.58	8.54	9.24	9.38	8.40	7.98	7.84	7.70	7.58
5	7.46	.22	7.10	7.22	8.26	9.24	9.10	8.12	7.98	7.84	7.70	7.58
6	7.46	7.10	7.22	7.46	8.82	9.24	9.24	8.12	7.98	7.98	7.70	7.58
7	N.R	7.22	7.10	7.34	9.24	9.24	9.24	8.12	7.98	7.98	7.70	7.58
8	N.R	7.22	7.10	7.10	8.40	10.98	9.24	8.26	7.98	8.26	7.70	7.58
9	7.70	7.10	7.10	7.46	8.40	11.78	9.56	8.26	7.98	7.98	7.70	7.58
10	7.98	7.10	7.10	7.34	8.68	9.24	10.08	8.40	8.12	7.84	7.84	7.58
11	7.58	7.22	7.10	8.54	9.38	9.10	9.56	8.40	7.98	7.84	7.84	7.58
12	7.46	7.22	6.98	7.70	9.10	9.38	9.10	8.40	7.98	7.98	7.84	7.84
13	7.46	7.10	7.70	7.70	9.10	9.24	9.10	8.26	7.98	7.98	7.84	7.98
14	7.46	7.10	7.10	7.70	9.10	9.24	9.24	8.26	7.98	8.40	7.84	7.84
15	7.46	7.10	7.22	9.10	8.54	9.24	9.56	8.12	7.26	8.26	7.70	7.84
16	7.34	7.10	7.22	8.12	8.68	9.10	8.96	8.12	8.12	8.26	7.70	7.70
17	7.34	7.10	6.98	7.84	9.10	9.10	8.82	8.12	7.98	7.98	7.70	7.70
18	7.34	7.10	7.10	7.84	9.10	9.10	8.68	7.98	7.98	7.98	7.70	7.70
19	7.46	7.10	7.10	7.84	9.10	9.24	8.68	7.98	7.84	7.98	7.70	7.70
20	7.46	7.10	6.98	7.84	8.68	9.96	8.68	7.98	7.84	8.12	7.70	7.84
21	7.34	7.10	6.98	7.84	8.96	8.96	9.56	7.98	7.84	7.84	7.70	7.70
22	7.34	7.10	8.40	7.70	8.82	9.10	9.56	7.98	7.98	7.84	7.70	7.70
23	7.34	7.10	8.12	7.98	8.82	8.96	9.56	7.98	7.84	7.84	7.70	7.70
24	7.34	7.10	7.22	7.84	9.10	8.96	9.24	7.98	7.84	7.84	7.70	7.84
25	7.46	7.10	7.10	8.12	9.10	9.10	9.10	7.98	7.98	7.84	7.70	7.84
26	7.34	7.10	7.10	7.98	9.10	8.96	9.10	7.98	7.84	7.70	7.58	7.98
27	7.22	7.10	7.10	7.84	9.24	8.96	9.10	7.98	7.84	7.70	7.58	7.98
28	7.22	7.10	7.22	8.12	9.10	8.82	9.38	7.98	7.84	7.84	7.58	7.98
29	7.10	7.10	7.34	7.98	9.10	8.68	9.24	7.98	7.84	7.84	N.R	7.98
30	7.10	7.10	7.46	8.12	9.24	8.82	9.10	7.98	7.84	7.70	N.R	7.98
31	N.R	7.22	N.R	8.68	9.24	N.R	8.68	N.R	7.98	7.70	N.R	7.98
Max	7.98	7.34	8.40	9.10	9.38	11.78	10.08	8.54	8.26	8.40	7.84	7.98
Mean	7.43	7.13	7.24	7.79	8.88	9.25	9.20	8.16	7.95	7.91	7.66	7.73
Min	7.10	6.98	6.98	7.10	8.12	7.94	8.68	7.98	7.84	7.0	7.70	7.58

Source: Anambra Imo River Basin Development Authority

B. Hydrograph Design

The average monthly discharge data were used to design hydrographs for the two selected rivers. The discharges are plotted on the vertical axis while the horizontal axis is occupied by time. The developed hydrographs are shown in figures 3.1 and 3.2 for Otamiri and Njaba rivers respectively

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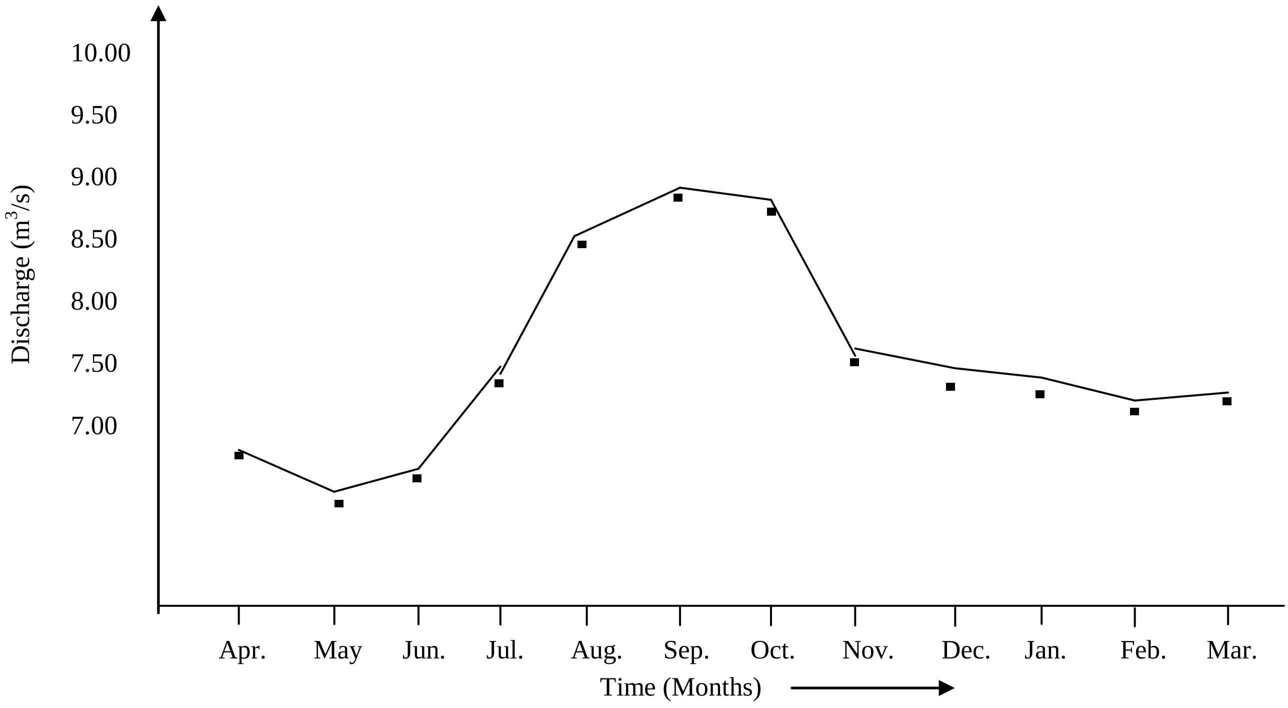

Fig. 1: Hydrograph of Otamiri River for 2007/2008 Hydrological Year

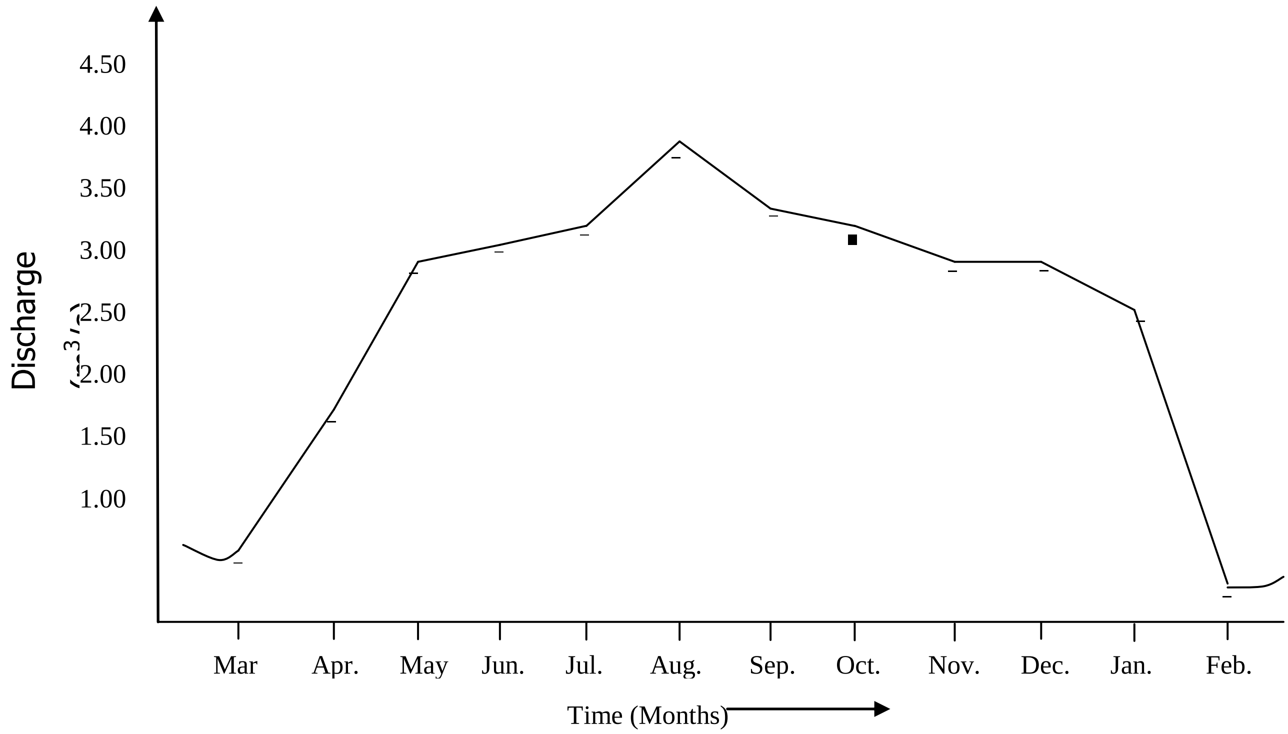

Fig. 2: Hydrograph of Njaba River for 2007/2008 Hydrological Year

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C. Available Quantity of Water

The available quantity of water was estimated by determining the area within the hydrographs. The results of the estimations were shown on Table 3.3

Table 3: Quantity of Water in Njaba and Otamiri River

S/N	River	Groundwater (m^3)	Runoff (m^3)	Total (m^3)
1	Njaba	27,669,600	58,644,000	86,313,000
2	Otamiri	226,100,160	1,944,000	228,044,160

D. Apparent Electric Power from the Selected Rivers

Assuming a head (H) of 30 metres, turbine efficiency (∂) of 80% and the determined average discharge (Q) of 2.825 m^3/s and $8.0275m^3/s$ for Njaba and Otamiri rivers respectively,, the quantity electricity that can obtained from the rivers can be estimated.

From equation 2.4, the amount of apparent power obtainable from Njaba river put thus:

P = 9.812δQH kw

$= 9.81\times0.8\times2.825\times30$ KW = 665.536KW

Similarly, the apparent power obtainable from Otamiri river is put thus;

P = $9.81\times0.8\times8.0275\times30$ KW=1890.38 KW = 1.890 MW

E. Analysis of Results

From the results, it was discovered that the rivers selected were perennial rivers with high volume of base flow with the Njaba river having about $27,669,600m^3$ while Otamiri River has $226,100,160m^3$. This is a clear indication that the Sample Rivers can conveniently host hydropower stations and sustain them both in dry weather and rainy conditions. During rainy periods the volume of water in these rivers are bound to increase due to the runoff contributions; this places the rivers at a very vantage point as a suitable hydropower site. Njaba river possesses total of 86,313,000 cubic metre volume while Otamiri river has 228,044,160 cubic metre volume. With the available water the quantity of electricity which can be obtained from these rivers were estimated and it was discovered that the Njaba river can sustain the production of an apparent power to the tune of 0.67MW while the Otamiri river has the capacity of sustaining the generation of 1.89MW. However, it should be understood that these values could be reduced or increased depending on the system, infrastructural and equipment factors.

IV. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

In view of the persistent electric power supply problems which had incarcerated this country resulting to the current poor rate of industrialization, infrastructural underdevelopment and unmechanised system of agriculture with such attendant consequences as abject poverty as noticed in the rural areas and stunted national growth in all ramifications, it has become necessary for electric power supply be sourced from our rural communities especially from renewable energy sources which have been considered to be environmentally –friendly. There are many perennial rivers with high hydro-potentials in Imo State which can harnessed to produce electric power . The research has successfully delved into the exposition of the amount of electric power which can be obtained from just two rivers out of the too many rivers abundant in the state. It has been established through this research that Njaba and Otamiri rivers alone can add a total of 2.556MW apparent power to the quantity from the national grid. Power has been known to be a catalyst that stimulates all round development; it is therefore obvious that its production in our rural communities will lead to the total and positive transformation of the rural communities in terms of industrialization, job creation, and agricultural production.

B. Recommendations

Based on the findings made in this research, the following recommendations are made;

i) The potentials of most perennial rivers in Imo State should be harnessed especially for the purpose of electricity production,.

ii) Electricity production should be hinged on renewable energy source to minimize green house gas emission for the preservation of the global environment.

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iii) Improvement of electric power supply to the rural communities should be pursued with vigor through the utilization of available renewable energies in such communities.
iv) Owing to the indispensable nature of rivers as a major source of renewable energy, rivers within Imo State should be gauged annually to ensure proper management and sustainability.

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