IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 13, Issue 5 Ver. I (Sep. – Oct. 2018), PP 01-09
www.iosrjournals.org

Hydro Power Generation In Nigeria, Environmental Ramifications

R.C Ijeoma & I. Briggs
Electrical/Electronic Engineering Department, Captain Elechi Amadi Polytechnic, Rumuola, Rivers State Nigeria

Abstract: *Electricity is the bedrock of every nation development and can be transported instantaneously & pollution free at consumer end. There are three hydro power generating stations that contribute to the nation's grid, namely Kainji, Jebba and Shiroro Hydro Power Station. This study employs survey method that applies the diligent study of hydro power generating stations and their various environments. This research exploits the application of questionnaires, interviews & investigation, and personal observations in data gathering. The analyses of the various data collected were in tabular exhibitions, mathematical models, pictorial charts, percentages and graphical illustrations. Results obtained from the hydrological water balance analysis of the hydro electric power stations, for 1MWH of electric energy, the quantity of water the power stations consumes are 11,811.65m^3 and 13,792.85m^3 for kanji and shiroro power stations respectively. The total hydro stations installed capacity is 1938.4MW. It has been discovered that in the management of the environmental ramification of electric power generation in Nigeria, the factors involve depends on the type of power stations. In conclusion, the pitfall built-in electricity generation by different generating modes is highlighted .This work shows that electricity is being generated at the expense of the neighboring environment, and it's harmful to human existence. It's recommended that, environmental problems are carefully considered in the planning, designing and execution of electricity generation schemes for sustainable power generation.*
Keywords: *Electricity, Hydro Station, Energy Consumption, Environmental Ramifications*

Date of Submission: 05-09-2018 Date of acceptance: 21-09-2018

I. Introduction

Electricity is the bedrock of every nation development and can be transported instantaneously & pollution free at consumer end makes it attractive as compared to other forms of energy. According to Okoro and Chikuni (2010), the per capita consumption of electricity in any country is an index of the standard of living of the people in that country.

Nigeria is richly blessed with numerous energy resources, which offers the nation opportunities to tap into the strength of the various energy media available. The energy sector however, has not exploited this gift of nature; the progress in the use and development of oil and gas, in past years has created an impression that hydrocarbon is the major viable energy medium available to Nigeria. This has negatively impacted on a comprehensive assessment and use of all Nigeria's energy resources. In order to ensure that Nigerians can enjoy a reliable and robust energy system at a reasonable cost, it is essential that supply be generated from a variety of sources. With the cost of oil being uncertain, alternative energy options need to be assessed and development plans expedited to enable a broad-based infrastructure.

Sule and Salami (2013) reported that, the environmental ramifications associated with electricity generation, transmission and distribution have become of great importance in power systems planning, design and operations. In every technologically advanced countries of the world, public electricity distribution and supply dominates the industrial scene in the scale of its capital investment requirements, huge tonnage of primary fuel it consumes and its rapid growing demands for large, complex and technically sophisticated plants and equipments.

According to Ibe and Okedu (2015), maintaining a reliable electric power generation is therefore a very important issue in power system design and operation. Nigeria, being the threshold of industrial development, has high energy demand. The country is endowed with rich reserves of conventional energy resources like; crude oil, natural gas, coal and hydro potential. Currently, the national energy consumption mix is dominated by oil, which is approximately 53 percent, seconded by natural gas which approximates to 39 percent and then hydroelectricity that is almost 7 percent. Coal, nuclear power, biomass and other renewable sources are presently not the major part of Nigeria's energy consumption mix. Meanwhile, in Nigeria electrical power stations are either thermal power stations or hydro power stations. The constructions of electric hydro-generating stations are highly dependent on inflow of water into their reservoirs.

The construction of the hydro plants involves displacement of people from their natural habitats and destruction of species of plants and animals. Therefore, the construction of power generating stations has substantial impact on its immediate environment. These consequences may be positive impacts that are useful to the environment and also negative impacts that are hazardous to the environment. The effective management of these impacts of electric power generation in Nigeria, so as to ensure a conducive, balance and sustainable environment is highly desirable. These impacts can be hydrological, social, economical, cultural, meteorological or human health impacts. The management of the power system in Nigeria is a monopoly vested presently on Power Holdings Company of Nigeria (PHCN).

II. Methodology

A. Study Design

This paper adopts the survey method that employs the meticulous study of power generating stations and their various environments. The study employs the application of questionnaires, interviews and investigation, and personal observations, in data gathering.

However, the approach adopted in the analysis of data collected were tabular exhibitions, mathematical models, pictorial charts, percentages and graphical illustrations. The study will ascertain the ramification from hydro electric power stations, preventive mechanisms, positive environmental impacts and proffer means of managing the ramifications of electric power generation.

B. Hydro Electric Power Stations Hydrological Water Balance Analysis

The in-flow and outflow of water at Kanji, Jebba and Shiroro hydro power stations have affected the hydrological balance of water bodies in Nigeria and as such it has ramified on the environment. These ramifications have resulted to flooding, erosion, evaporation etc. These phenomenal ramifications on the people, villages and houses in the hydro power stations sited communities, affecting terrestrial and aquatic habitats. Meanwhile, the monthly hydrological water balance on the Kanji reservoir operation for 2015 is shown on the table below.

Table 1: Hydrological Monthly Water Balance on the Operation of Kainji Reservoir in 2015.

MONTHS	AVERAGE IN-FLOW (BILLION m^3)	AVERAGE OUT-FLOW (BILLION m^3)	AVERAGE EVAPORATION (BILLION m^3)	RESERVOIR LEVEL AT THE END OF MONTH (BILLION m^3)	STORAGE BALANCE AT THE END OF MONTH (BILLION m^3)	WATER USED FOR POWER GENERATION (BILLION m^3)	ENERGY GENERATED (MWH)
JANUARY	1026	824.84	92.52	141.17	11.305	2.2092	207,773.00
FEBUARY	521	1062	89	139.73	9.619	2.5684	232,948.00
MARCH	200	995	87	137.57	7.2692	2.665	229,645.00
APRIL	63	839.27	82.33	135.24	5.0417	2.1754	178,106.00
MAY	25	551	55	133.46	3.1475	1.4748	114,740.00
JUNE	79	362.57	28.27	132.6	2.8677	0.9398	72,122.00
JULY	424	311	14	132.72	2.9597	0.8331	62,899.00
AUGUST	877	309	20	133.46	3.955	0.8276	61,943.00
SEPTEMBER	1587	291	22	137.33	77.0388	0.754	58,205.00
OCTOBER	1310	496.52	39.35	138.77	8.5372	1.3299	109,875.00
NOVEMBER	1297	650.5	48.63	139.58	9.4475	1.686	145,279.00
DECEMBER	1371.8	630.9	49.07	140.48	10.48	1.6898	147,999.00
TOTAL						19.153	1,621,534.00

Source: Noise control handbook of principles and practices by David and Arthur (2016).

Thus, the total water used for power generation= $19.153 \times 10^9 m^3$,

The total energy generated =1,621,534MWH.

Amount of water consumed per energy generated

$$= \frac{\text{total water used}}{\text{total energy generated}} = \frac{19.153 \times 10^9 m^3}{1{,}621{,}534\,MWH} = 11{,}811.65\ m^3/MWH.$$

Therefore to generate 1MWH of electricity, the hydro power station consumes about 11,811.65 m^3 of water.

Meanwhile, the disturbances occurring in the natural water flow can result from water in-flow into the hydro power stations. The water in-flow into Kanji hydro power station between 2001 to 2015 is tabulated below in the form of the annual computed in-flow, measured in billion meter cube (billion m^3).

Table 2: Kanji Reservoir Annual Computed In-Flow (2001 To 2015)

YEAR	IN-FLOW (Billion m^3)
2001	28.10
2002	31.20
2003	30.40
2004	30.30
2005	31.40
2006	28.90
2007	30.60
2008	27.60
2009	25.90
2010	35.20
2011	33.20
2012	30.80
2013	29.70
2014	32.10
2015	26.90

Source: PHCN Review Volume II: Impact Of Climatic Change on the Performance of the Power Supply System by Ben Caven, (2016).

However, the intake level or quantity of water into the hydro power generating stations differs. It varies with respect to the position of the hydro power stations and the prevailing seasons experience at a particular point in time.

Table 3: Hydrological Water Balance on the Operation of Shiroro Reservoir in 2015.

MONTHS	AVERAGE IN-FLOW (BILLION m^3)	AVERAGE OUT-FLOW (BILLION m^3)	AVERAGE EVAPORATION (BILLION m^3)	RESERVOIR LEVEL AT THE END OF MONTH (BILLION m^3)	STORAGE BALANCE AT THE END OF MONTH (BILLION m^3)	WATER USED FOR POWER GENERATION (BILLION m^3)	ENERGY GENERATED (MWH)
JANUARY	1026	824.84	92.52	141.17	11.31	2.21	207,673.00
FEBUARY	521	89	89	139.73	9.62	2.57	212,948.00
MARCH	200	87	87	137.57	7.27	2.67	197,645.00
APRIL	63	995	82.33	135.24	5.04	2.18	178,106.00
MAY	25	551	82.33	135.24	5.04	2.18	124,740.00
JUNE	79	362.57	28.27	132.6	2.87	0.94	68,122.00
JULY	424	311	14	132.72	2.96	0.83	60,744.00
AUGUST	877.7	309	20	133.96	3.96	0.83	61,943.00
SEPTEMBER	1587	291	22	137.33	7.04	0.75	58,305.00
OCTOBER	1310	496.52	39.35	138.77	8.54	1.33	20,022.00
NOVEMBER	1297	650.5	48.63	139.58	9.45	1.69	125,677.00
DECEMBER	1371.8	630.9	49.07	140.48	10.48	1.69	124,676.00
TOTAL						19.87	1,440,601.00

Source: Noise control handbook of principles and practices by David and Arthur (2016).

Since, the total water used for power generation= 19.87 $x10^9 m^3$,

The total energy generated =1,440,601MWH.

Amount of water consumed per energy generated

$$= \frac{\text{total water used}}{\text{total energy generated}} = \frac{19.87 \text{ x } 10^9 \text{ m}^3}{1{,}440{,}601 \text{ MWH}} = 13{,}792.85 \text{ m}^3/\text{MWH}.$$

Thus, 1MWH of electricity is generated from 13,792.85m^3 water consumed in hydro power station.

Meanwhile, to illustrate the annual variation of water in-flow in the shiroro hydro power station, the data of water in-flow from 2001 to 2015 is tabulated below as seen in table 4.

Table 4: Shiroro Reservoir Annual Computed In-Flow 2001 To 2015.

YEAR	IN-FLOW (Million m^3)
2001	3096
2002	3101.1
2003	4241
2004	3906
2005	3165
2006	3209
2007	3354
2008	3399
2009	3489
2010	3819
2011	3146
2012	3910
2013	3912
2014	3950
2015	4049

Source: PHCN Review Volume II: Impact Of Climatic Change On The Performance of the Power Supply System by Ben Caven, (2016).

C. Electric Power Stations And Their Installed Capacities

The various electric power stations installed capacity differs and so do they vary in terms of their outputs. The numbers of units in the different power station differs. These variations are illustrated in table 5 below.

Table 5: Power stations and their installed capacities

Power Station	Installed Capacity(Mw)	Numbers Of Units	Plant Type
kanji	760	8	hydro
Shiroro	600	4	hydro
jebba	578.4	6	hydro
total installed capacity	1,938.4	18	

Source: PHCN publications on Ughelli thermal power station, 4th November, 2013.

D. Energy Consumption Pattern

The rate at which electric energy is been consumed differs according to sectors. This means that the energy consumption by residential areas differs from commercial energy consumption, and this in turn varies from industrial energy consumption**.** The annual energy consumption between 2004 to 2014 is shown in table 6.

Table 6: Energy Consumption Pattern (2004 To 2014)

Year	Energy Generated (MWH)	Residential Energy Consumed (MWH)	Commercial Energy Consumed (MWH)	Industrial Energy Consumed (MWH)	Total Consumption (MWH)	% Energy Consumption	% Energy Losses
2004	15,463,145	5,948,475	2,687,099	2,037,463	10,673,037	69.02	30.97
2005	16,166,613	5,743,068	2,060,140	2,068,566	9,871,774	61.06	38.93
2006	14,933,689	4,370,081	2,163,241	2,183,439	8,716,761	58.36	41.63
2007	16,787,333	4,807,918	2,639,990	2,241,157	9,689,065	57.71	42.28
2008	15,656,201	4,583,559	2,430,179	2,056,998	9,070,736	57.93	42.06
2009	15,845,038	4,935,222	2,631,875	2,252,468	9,819,565	61.97	38.02
2010	16,656,201	5,244,256	2,601,069	2,143,267	9,988,592	59.96	40.03
2011	16,006,821	6,034,325	2,700,321	2,427,861	11,162,507	69.73	30.26
2012	15,986,743	5,957,605	3,001,231	3,498,512	12,457,348	77.92	22.07
2013	16,898,456	6,745,632	2,790,243	2,934,571	12,470,446	73.79	26.20
2014	16,768,345	7,004,560	3,165,342	2,134,532	12,304,434	73.37	26.62
Total	177,168,585	61,374,701	28,870,730	25,978,834	116,224,265		

E. Questionnaires Analysis

This study assesses the impacts of electric power generation on the Nigerian environment. Thus, the study is more of a descriptive research.

Thus, questionnaires were distributed to various establishments and feedbacks were gotten as seen in table 11. Some of the questionnaires were sent through e-mails, others by phone conversations and the rest questionnaires data were gotten from direct interview conversations.

Table 7: Questionnaires Distribution

Establishment	Copies Given Issued Out	Copies Received	Percentage %
Federal Environmental Protection Agency	10	8	80
Federal Ministry Of Health	10	8	80
Power Holding Company Of Nigeria	10	8	80
Kanji Hydro Power Station	10	9	90
Shiroro Hydro Power Station	10	8	80
Jebba Hydro Power Station	10	7	70
Power Station Host Communities	45	43	95.56
Total	105	91	

- **Environmental Impact Assessment Analysis of the Hydro Power Stations.**

In this section, we tend to ascertain how the construction of the various hydro electric power stations in Nigeria affects the people, houses, villages and lands around its vicinity. From the data collected using the questionnaires, the averages of the data is put in a tabular form and this is shown on table 8 below.

Table 8: Villages/Peoples/Houses displaced and Land Mass used During the Construction of Hydro Power Stations

	Power stations	Number people displaced	Number People available	Number of villages displaced	Number of villages available	Number of houses displaced	Number of houses available	Land mass used
1	Kanji	45,000	90,378	240	580	4,325	6,386	480sq/miles
2	Jebba	10,000	56,689	150	630	855	5,978	Not available
3	Shiroro	13,000	61,020	200	620	1280	6328	Not available
	Total	68,000	208,087	590	1830	6490	18,692	

III. Results And Discussions

- **Results On Hydrological Balance**

The results obtained from the hydrological water balance analysis of the hydro electric power stations were, $11{,}811.65m^3$/MWH and $13{,}792.85\ m^3$/MWH for kanji and shiroro hydro power stations respectively. Thus, this entails that to generate 1MWH of electric energy from the hydro power stations, the quantity of water the power stations consumes are $11{,}811.65m^3$ and $13{,}792.85m^3$ for kanji and shiroro power stations respectively.

Although, the data for accessing the rate of water consumption per electric energy generation for jebba hydro power station were not available, the results from the hydrological water analysis for kanji and shiroro hydro power stations exhibited significant differences. In view to this, it is obvious that the rate at which each of the hydro power stations consumes water for the production of 1MWH of electric energy varies from power station to power station.

These are due to the variations in:

i. The average water in-flow and out flow of the power stations reservoirs.

ii. The average evaporation rates of the power stations reservoirs.

These will cause the water storage balance not being the same for all the hydro power stations. At such, water utility for each reservoir at any given point in time differs, thus energy generation rate also differs.

However, in kanji hydro power station, from table 1 during 2011, the trend appears to be at its peak. This entails that the water in-flow was relatively very high ($33.20 \times 10^9 m^3$). Thus, the water level was at its highest point given the available data. This made the electric energy generated to be very high during 2011.

Furthermore, in shiroro power station, table 2 exhibited a characteristic highest peak ($4241 \times 10^6 m^3$) in-flow during 2011. Hence, the reservoir water level was highest given the data available for shiroro electric power station.

F. Installed Capacities Of Electric Power Stations Result

Considering Table 5, the variations in the installed capacities of the various power stations can further be illustrated with a bar chart. This is seen in figure 6 below.

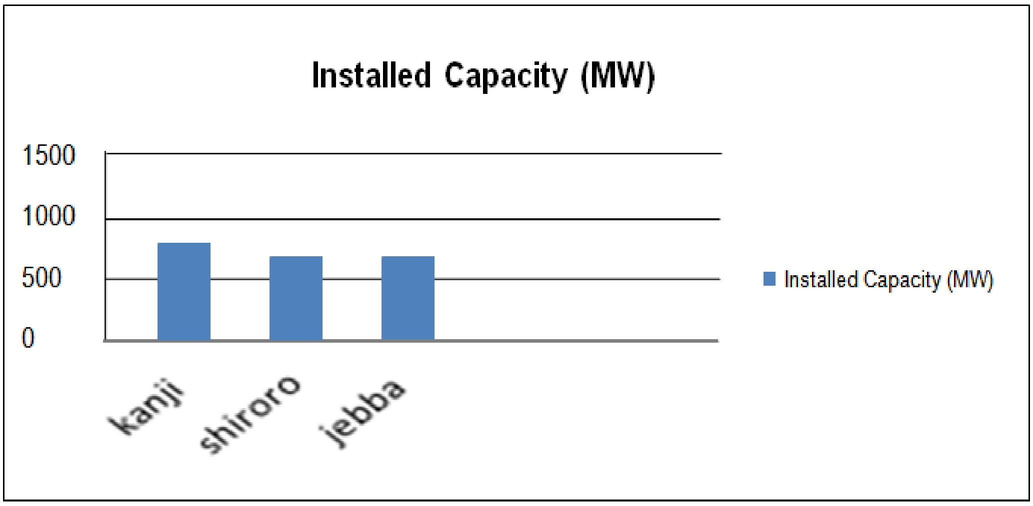

Figure 1: Bar chart representation of power stations and their installed capacities

The Total Hydro Power Station Installed Capacities

The total hydro power station installed capacities can be obtained by:

Total hydro stations installed capacity

= kanji installed capacity + shiroro installed capacity + jebba installed capacity.

Thus,

$$\text{Total hydro stations installed capacity} = 760 + 600 + 578.4 = 1938.4 \text{ MW}$$

The total hydro stations installed capacity is 1938.4MW. From the total installed capacities obtained, it has been ascertain that 33% of the installed capacity is from hydro power stations and this is also the percentage overall input of the hydro power stations to the national electricity generation.

G. Energy Consumption Pattern Interpretation

Considering Table 6 the energy consumption pattern is presented in the chart results as seen below.

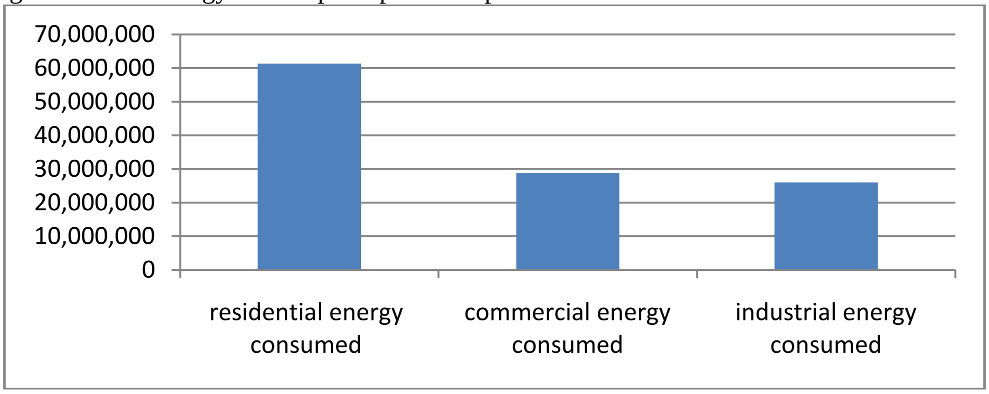

Figure 2: Bar chart representation of energy consumption by various sectors

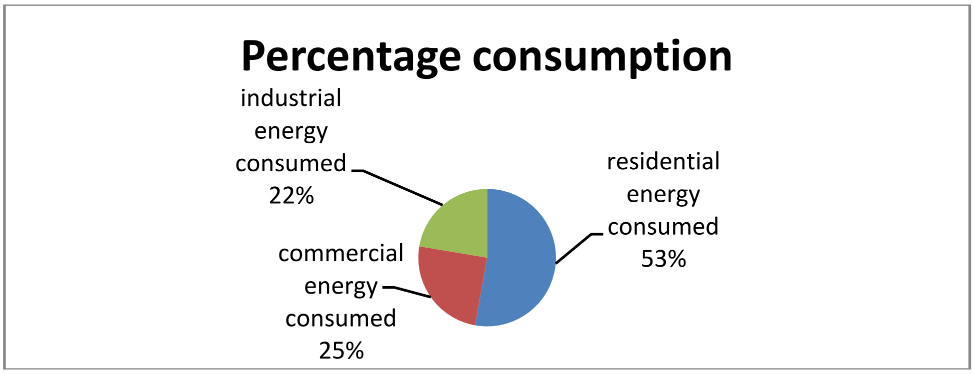

Figure 3: Pie chart percentage representation of energy consumptions by various sectors.

From the percentage analysis of the energy consumption, it is obvious that the residential energy consumption is highest (53%), followed by commercial energy consumption (25%) and then, the industrial energy consumption (22%).

H. Environmental Ramification Assessment Results

The ramification of the construction of power stations in the various localities where the power stations are been sited have been analyzed. The visual basic software developed for computation of percentage was used to model the percentages of the people, houses and villages displaced at the time of the constructions of the power stations. The percentage results for the numbers of people, houses and villages displaced is tabulated below in table 9.

Table 9: Percentage Displacements Due To Power Stations Construction

Power Station	Percentage Of People Displaced (%)	Percentage Of Houses Displaced (%)	Percentage Of Villages Displaced (%)
Kanji Station	50.00	66.67	41.38
Shiroro Station	17.86	14.30	23.81
Jebba Station	21.31	20.23	32.26

As in table 9 above, during the construction of kanji hydro power station, half of the population of people residing within the kanji station locality where been displaced. Seven-tenth of the houses where displaced and about four-tenth of the villages where displaced. It then entails that many people were left homeless as at then within the kanji power station vicinity.

Also, it can be deduced from table 9, that for every power station constructed, a certain percentage of the people, houses and villages residents within the power station area where been displaced.

IV. Discussion

The in-flow of water is not proportional to the out-flow, this will create an imbalance in the immediate environment. Some water that would have been used for irrigation will be diverted to the reservoir. This will affect agricultural activities. Also part of the water stored in the reservoir evaporates as temperature rises, thereby creating additional water losses to the environment. It was observed that the annual inflow of 2011 (for kanji hydro power station) and 2003 (for shiroro hydro power station) reduced the water level at River Niger. This reduction had substantial effect on the immediate environment.

The construction of hydro power stations has significant impacts on the lives and activities of the inhabitants of the area. Table 10, below show the occupations of the indigenes of the power stations environments before and after the construction of the stations.

Table 10: Indigenes Occupations Before and After the Construction of the Hydro Electric Power Station.

Power station	Occupations before the construction of power station.	Occupations after the construction of power station.
Kanji hydro station	1. Farming (activities like land clearing, cultivation and harvesting).	1. Contractors to power stations with few still carrying out farming activities.
	2. Animal husbandry	2. Fishing, very limited
	3. Fishing which involves inshore fishing, deep sea fishing	3. Trading
	4. Horticultural activities	4. Civil service jobs
	5. Construction of agricultural implements and tools , and fishing boats	5. Teaching
	6. Sea/river transportation activities	6. Few still farming
Jebba power station	1. Fishing which involves inshore fishing and deep-sea fishing	1. Improved trading
	2. Sea/river transportation activities	2. Teaching
	3. Horticultural activities	3. Civil services jobs
	4. Construction of farming tools and boats	4. Contractors to power station
	5. Animal husbandry	5. Few still Fishing.
	6. Trading	6. Security guards to the power stations
Shiroro power station	1. Animal rearing	1. Construction to power station
	2. Horticultural activities	2. Fishing, though limited
	3. Horticultural activities	3. Security guards
	4. Seal/ river transportation	4. Truck driving
	5. Petty trading	5. Civil service jobs
	6. Fishing which involves inshore and deep sea fishing	6. Teaching

Table 11: Health Hazard Associated with Indigenes before and after Construction of Hydro Electric Power Station.

Power Stations	**Health hazard before construction of power station.**	**Health hazard after the construction**
	Malaria	River blindness with reduced victim
Kanji	Cholera	Guinea worm with increased victims
	River blindness with increased victims	Positive skin snips for oncholericiasis
	Headache	Synchiostosomiases
	Guinea worm	Ascaris
		Cholera with increased victim
		Headache with increased victim
		Dysentery
		Malaria with increased victim
		High blood pressure
Jebba	The same kinds of health hazards were experienced as in those of kanji.	The same kinds of health hazards were experienced as in those of kanji.
Shiroro	The same kinds of health hazards were experienced as in those of kanji.	The same kinds of health hazards were experienced as in those of kanji.

In this research, there were several parameters studied. It was discovered that in the management of the environmental effect of electric power generation in Nigeria, the factors involve are dependent on the type of power stations.

V. Conclusion

The dangers inherent in the generation of electricity by different generating modes have been highlighted in this work. This paper has shown that electricity is being generated at the expense of the surrounding environment, and this is detrimental to human existence. Thus, electricity generation is associated with environmental degradation which if not adequately checked might almost undermined a nation's development because it is said that power is the bedrock of development. It is not enough to ensure that an electric power generating project yields economic advantage at present without anticipating the environmental challenges that could result from electric power generation, which may yield positive results on the short run but will be unsustainable on the long-run.

An electric power scheme depending on the type of mode applied requires the use of resources like coal, oil, natural gas, large amount of water etc., and these results in the replacement of natural ecosystem by artificial ones. This presents not only very important impacts on the biophysical environment but it also causes changes in social and economic structures of the society. These factors are often accounted for in planning, design and implementation of electric power schemes.

However, the impacts can be grouped into two:

1) **Negative impacts,** which includes:

i. Health hazard
ii. Increases in noise level
iii. Climate change
iv. Human movement and migration
v. Scaring away of wildlife

2) **Positive impacts,** such as:

i. Employment opportunity to indigenes
ii. Enjoyment of electricity
iii. Provision of pipe borne water
iv. Provision of schools and hospitals
v. Construction of road

VI. Recommendation

This work shows that electricity is being generated at the expense of the neighboring environment, and it's harmful to human existence. It's recommended that, environmental problems are carefully considered in the planning, designing and execution of electricity generation schemes for sustainable power generation.

Reference

[1]. Sule, B. F. and Salami, A.W. (2013), "Hydrological and Environmental Impact of Hydropower Dam Operation in Nigeria", University of illorin Press

[2]. Okoro, O. I. and Chikuni, E. (2010), "Power Sector reforms in Nigeria: Opportunities and Challenges", Journal of Energy in South Africa, Volume 18, No. 3, pp. 52-57
[3]. Adeloye E. A.,(2010), "Social Aspect and Environmental Impact of Hydro Development in Nigeria", NEPA review 3
[4]. Ayodele A. I., (2012), "Electricity development in Nigeria: Pattern of Nigeria 's Electric Energy Use", pp 30-32, Universal Press, Ibadan.
[5]. Azubuike, A.M., (2014), "Environmental and Economic issues in small-scale hydropower development", Unpublished
[6]. Ben Caven, (2016), "Impact Of Climatic Change On The Performance Of The Nigerian Power Supply System", PHCN Review, Volume VI, pp 10-11
[7]. David M. Lipscomb and Arthur C. Tayler, (2016), "Noise Control Handbook of Principles and Practices", Longman publishers, New York
[8]. Desgauliers G.T. (2012), "Energy Models For Planning And Policy Assessment",pp. 342-401
[9]. Donnelly E.L.(2013), "Electrical Conductors And Insulations Theory And Practice"
[10]. Abrahamision, D.E. and Pogue, R.E.(2009), "The environmental impacts of a growing nuclear power industry", Minnesota Academy of Science Press, New York
[11]. Foell, W.K., Green, C. W., and Hanson, M.E. (2011), "Environmental Considerations in Renewable Energy Policy", Washington D.C
[12]. Furlan, G., Rodriquez, H. and Violini, G., (2006), "Non-conventional Energy Sources", ACIF series Volume 3, World Scientific publishing Co. Ltd. Singapore
[13]. Hawkins, A. (2012), "Electricity Supply and the Environment" Waterlow Publishers Ltd, London
[14]. Hottel, H.C. and Howard, J.B., (2013), "New Energy Technology Facts and Assessments", Massachusetts Institute of Technology Press, London
[15]. Ibe, A.O. and Okedu, K.E., (2015), "Optimized Electricity Generation in Nigeria", Nigerian Journal of Engineering Management (NJEM), Volume 8 No. 4, pp 7-16
[16]. Ada, U.U., (2012), "NEPA Management Development in Nigeria", Caxtom Press (Invest. African) Limited, Ibadan
[17]. Lawal Y. O.(2010), "Maintenance Culture: The Nigeria Situation", Nigeria Journal of Engineering Management (NJEM), Vol. 1.No. 4
[18]. National Environment Protection (Effluent Limitation) Regulations,(2016), Published by Federal Environmental Protection Agency for Federal ministry of Environment
[19]. Niels, H. And Heathcote, V. (2011); "The Early Meaning Of Electricity", Annals Of Science 63 (4): pp. 261–275
[20]. PHCN publications on Ughelli thermal power station, (2016)
[21]. Olatomiwa L. J. and Nwohu, M. N., (2014), "Reliability Evaluation of Hydro-Electric Power Stations in Nigeria", pp. 320-327
[22]. Oyebande, L. (2013), "Integrated and Sustainable Development of the Water Resources of the Nigerian Basins", pp 23-34, John Wiley and Sons Publishers, Wallingford New York
[23]. Onyekwere, O. (2014), "Laws To Break Nepa Monopoly"

R.C Ijeoma "Hydro Power Generation In Nigeria, Environmental Ramifications "IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 13.5 (2018): 01-09.