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Analysis of Hydraulic Afflux Potency For Micro-Hydropower Plant Along Otamiri River Reach In Imo State.

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ABSTRACT
The power crisis that hit the States of Nigeria for about two weeks in May 2015 and the continuous epileptic power supply, which imposed high-cost alternatives and grounded most businesses, inspired this research. The reason at that time according to the National Electricity Regulation Commission report was that 18 out of 23 power plants in the country were unable to generate electricity due to the shortage of gas supply to the thermal plants. This research presents the estimation of the hydraulic afflux potency of the Otamiri River. The study involves the estimation of the longest straight reach with a good positive slope of the river using Google Earth map and topographical survey. The study also identified the focal longitude and latitude points, the different elevations of the two points, determined the slope of the River, evaluated the height of the dam, estimated hydraulic pressure from the dam, and identified the capacity of the turbine and micro plant for the dam. The analysis revealed that at pointsP10 to P11 of study location with longitudinal and latitudinal values of $5^0 28'19''$N $7^0 28'04''$E and $5^0 28'04''$N $7^0 02'07''$ E respectively, has the highest value of hydraulic afflux potency of 1232kW with 480.22m reach and an elevation difference of 8m. The total length of the river is 72km and it runs from Egbu to Oyigbo. It is recommended that the dam should be sited between points P10 and P11 which has the highest value of hydraulic afflux potency, good slope, and also a good length of backwater curve.

Key words: *Hydraulic, Afflux, Dam, Slope, Elevation, Micro-Plant, Turbine.*

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I. INTRODUCTION

Generally, electricity with other basic infrastructures such as good roads and water supply is treated as an essential service for economic growth and development. Electricity is inevitable for survival and necessary for the promotion of education, health, transportation, and infrastructure.

In the last decade, problems related to the energy crisis such as electric power demand and supply and climate change have posed some limitations worldwide. These limitations are continuously and exponentially increasing, and suggest the need for technological alternatives as a solution. According to Price et al (1997), one of these technological alternatives is generating electricity as close as possible to the consumption site, using renewable energy sources that do not cause environmental pollution, such as wind, solar, tidal, and hydro-electric power plants.

Hydroelectric power is a form of renewable energy resource, which comes from flowing water. To generate electricity, water must be in motion. When the water is falling by the force of gravity, its potential energy converts into kinetic energy. This kinetic energy of the flowing water turns blades or vanes in a hydraulic turbine the form of energy is changed to mechanical energy. Celso (1998) stated that the turbine turns the generator rotor which then converts this mechanical energy into electrical energy and the system is called a hydroelectric power station. According to the international energy agency (IEA), large-scale hydroelectric plants currently supply 16% of the world's electricity. In Dilip Singh (2009), such kind of projects requires tremendous amounts of land impoundment, dams, and flood control, and often they produce environmental impacts. Micro-hydro-electric power plants are one of the alternative sources of energy generation that is environment friendly, easy to be operated, and low operation cost. They are the smallest type of hydroelectric energy system. They generate between 5kW and 100 kW of power when they are installed across rivers and streams. Micro-hydro-electric power plants act much like batteries, storing power in the form of water.

According to Celso (1998), the advantages that micro-hydro-electric power plant has over the same size wind, wave and solar power plants are:

a. High efficiency (70-90%), by far the best of all energy technologies.
b. High capacity factors (> 50%) compared with 10% for solar and 30% for wind power plants.
c. Slow rate of change: the output power varies only gradually from day to day not from minute to minute.
d. The output power is high during the rainy season.

It is not possible to quickly forget the power crisis that hit the Nigerian state for about two weeks during May 2015. This unfortunate reality grounded most businesses and the ones that were not grounded had to use electricity at very high costs. The reason at that time according to the National Electricity Regulation Commission (NERC) report, was that 18 out of the 23 power plants in the country were unable to generate electricity due to a shortage of gas supply to the thermal plants, with one of the hydro stations faced with water management issue leading to the loss of over 2,000 megawatts (MW) in the national grid. In Udo (2015), this implied a low level of 1,327 MW from the total generation capacity of 4,800 MW. Nigeria's power grid has collapsed not less than six times from January to September 2019 (Adekoya, 2019). Businesses in major cities in Nigeria suffer an average monthly power outage of 239 hours equivalent to two weeks, raising operational costs and impacting negatively on profits.

Therefore, it is pertinent to say that the foundational cause of Nigeria's unreliable power supply is the over-reliance on natural gas and more than the occasional shortage of the main energy source used to generate electricity. Others are significant power infrastructure deficits, overuse and poor maintenance of existing electricity assets, inadequate management capabilities, and a dearth of technical skills. Weak transmission capacity is another challenge that causes high loss in the power sector due to the poor, dilapidated, and low maintainability state of transmission systems.

According to Omoju (2014), the transmission networks may even collapse when new independent power plants are integrated into the main grid. So it has become necessary to build independent micro grids that will alleviate the load demand on the seemly weak transmission network. These micro-grids are best sought as micro-hydro-electric power plants for a sustainable renewable energy source.

OBJECTIVE OF STUDY

The following goals and objectives will guide this research:

1. To determine the longest straight part of the river, using a Google earth map or topographic survey.
2. To know the focal longitude and latitude point of the straight part.
3. To determine the slope of the river.
4. To determine the height of the dam.
5. To determine the hydraulic pressure from the dam.

SCOPE OF STUDY

The study is targeted at giving us the highest hydraulic afflux potency,and the heightof the dam along Otamiri River, also where the dam will be situatedalongthe straight part of the river reach which will form the water backwater curve. We will, first of all, determine the straight long parts, then determine the slope of the river at that point, and also determine the height of the dam along the river afterward the hydraulic pressure from the dam will be obtained.

HYDROPOWER POTENTIAL AT OTAMIRI

Hydropower is referred to as water power or hydraulic power; it is the energy that comes from the force of moving water or water in motion (Sharma and Sharma, 2003). The fall and movement of water is a part of a natural continuous cycle called the “Water Cycle" Or "Hydrologic Cycle". Gravity drives the water thereby moving it from high ground to low ground. The force of moving water can be extremely powerful, this force is what is used to generate energy for hydroelectric schemes or projects. In other words, hydropower is the motive energy or mobile energy contained in water which can be converted into electricity through hydropower plants (Deschande, 1986). According to Kucsre *et al.* (2011), hydropower is a clean, renewable and reliable energy source that serves national environmental and energy policy objectives. It is one of the most important renewable sources for the production of electric power due to several obvious reasons. It is renewable, unlike wind, supply variability within a shorter period is less and most importantly Green House Gas (GHG) emission is the least. It is derived from the falling water, either from rivers or streams flowing downhill along the river course due to the force of gravity. The energy associated with this flowing water is known as kinetic energy that is released through the friction of flowing water with the rocks and the sediment in the river beds (Kucsre et al., 2011). Harnessing the kinetic energy from the flowing water for driving the turbine generates hydropower. Hydropower functions by converting the energy of moving water or flowing water into electricity, the volume of water flow and height (head) from the power plant to the water surface created by dams determine the quantity of electricity generated (Khang, 2006). Hydropower is dependent on the head or level of water and the volume of flow of water to generate electricity (Bhattacharya, 1988). The growing concern over environmental degradation caused by fossil fuel-based systems, opposition to large hydropower projects on grounds of displacement of land and population, environmental problems with nuclear fuel-based systems, and the ever-rising shortage of power highlights the need for tapping alternate energy sources for power generation (Inamdar *et al.*, 2006). Hydropower is a renewable energy source where power is derived from the energy of water moving from higher to lower elevations. It is a proven, mature, predictable, and typically price-competitive technology. Hydropower has among the best conversion efficiencies of all known energy sources (about 90% efficiency, water to wire). It requires a relatively high initial investment but has a long lifespan with very low operation and maintenance costs (Eickemeser *et al.,* 2001). The main objective of this research is to evaluate the hydropower potential of the Otamiri River based on the basic information of the river discharge (flow), rainfall, and depth cross-section.

THE OTAMIRI RIVER

The Otamiri River is one of the main rivers in Imo State, Nigeria. The river takes its name from *Ota Miri*, a deity who owns all the waters that are called by his name, and who is often the dominating god of Mbari houses. The river runs south from Egbu past Owerri and through Nekede, Ihiagwa, Eziobodo, Olokwu Umuisi, Mgbirichi, and Umuagwo to Ozuzu in Etche, in the Rivers State, from where it flows to the Atlantic Ocean. The length of the river from its source to its confluence at Emeabiam with the Uramiriukwa River is 30 kilometers (19 mi).

The Otamiri watershed covers about 10,000 square meters (3,900 sq m) with an annual rainfall of 2,250 to 2,500 millimeters (89 to 98 inches). The watershed is mostly covered by depleted rain forest vegetation, with mean temperatures of 27 °C (81 °F) throughout the year. Conversion of the tropical rainforest to grassland with slashes and burn practices is degrading soil quality.

The Otamiri River continued after it was joined by the Nworie River at Nekede in Owerri, and the Nworie River's reach is about 9.2 km (5.7 m) long. While the result from the Google Earth map studied the reach of Otammiri is 72km. The Nworie River is subject to intensive human and industrial activities and is used as a source of drinking water by the poor when the public water system fails. The Nworie is polluted by organic wastes but in 2008 was not above acceptable levels of chemical pollution. Waste management in Owerri is inefficient and contributes to the pollution of the river. Most of the wastes from Owerri are dumped at the Avu landfill in Owerri West on the Port Harcourt highway, which creates a high concentration of phosphate and nitrate in the Otamiri.

South of Owerri, the river flows through an alternating sequence of sands, sandstones, and clay shales. Random sand samples from the bank of Otamiri River between Chokocho and Umuanyaga, Etche Local Government Area, Rivers State showed that 86 percent of the sand particles are within the ideal range for glass making.

II. RESEARCH METHODOLOGY

1. Measurement of River Properties: The Rivers will be visited and tests conducted on them using suitable measurement methods and data collated. The river parameters will be calculated. The river properties were measured.
2. Analysis of River Flow Rate and Hydro Potency: Analysis of the collated data will be done to calculate their respective flow rates and hydro potency.

Measuring Flow rate and Head

Flow is the quantity of water moving past a given point over a set period which is expressed as a volume in gallons per minute (gpm) or cubic meters per second (m^3/s), and head (H) is the vertical distance that water descends in altitude as a result of gravity. Water flow can be measured by some simple methods. The bucket method and Area/speed method are two methods commonly used in measuring flow rate. The bucket method can be used in measuring flow rate especially in low flow streams or in a small river. The method is used to count the time needed to fulfill a bucket and the flow rate is calculated by dividing water volume in the bucket by time-consuming. On the other hand, the area and speed method is used in streams with a higher flow. Water flow can be measured by constructing a weir of known dimensions and measuring the time necessary for the pooled water to rise to a known height. An object can be placed and timed to float from the upstream to the

downstream line. Flow rate is the product of water volume, water movement, and correction factor (*usually 0.6 for rocky stream bottoms*).
In a case where it is hard to construct a weir, the area and speed method can be used. This method will calculate the cross-sectional area (C_s) as the product of width and the average depth of the river as expressed in Equation 1. Then, the flow rate can be found by multiplying the cross-sectional area with water speed flow. Flow rate *(Q)* is equal to the product of the average speed of water flow (V_{avg}) and the cross-section area of the media(S) as presented in Equation 2. According to Ernesto *et al.*, (2006) this method can be formulated as follows:

$$C_s = \frac{(a+b)}{2}\sum_{i=1,2,3,\ldots n}^{n}\left(\frac{h_i}{n}\right)(m^2)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..1$$

$Where: a\ is\ width\ of\ top\ river\ (m);\ b\ is\ width\ of\ bottom\ river\ (m);$
$h_i\ is\ height\ of\ water\ in\ the\ river\ at\ i\ intervals\ (m);\ n\ is\ number\ of\ heights$
Since the velocity both across the flow and vertical is not constant, it is necessary to measure the water velocity at several points to obtain a mean value. The velocity can be measured by a floating object, which is located in the center of stream flow. The time (t) in seconds elapsed to traverse a certain length *(L)* in meter is recorded.

$$V_{avg} = \frac{0.75\text{L}}{\text{t}}\left(\frac{m}{s}\right) \qquad (2$$

$Where: 0.75\ is\ the\ correction\ factor.$
Then the flow rate can be calculated as:

$$Q = V_{avg} \times S \qquad \left(\frac{m^3}{s}\right)\ldots\ldots\ldots\ldots.(3)$$

DETERMINATION OF DAM HEIGHT

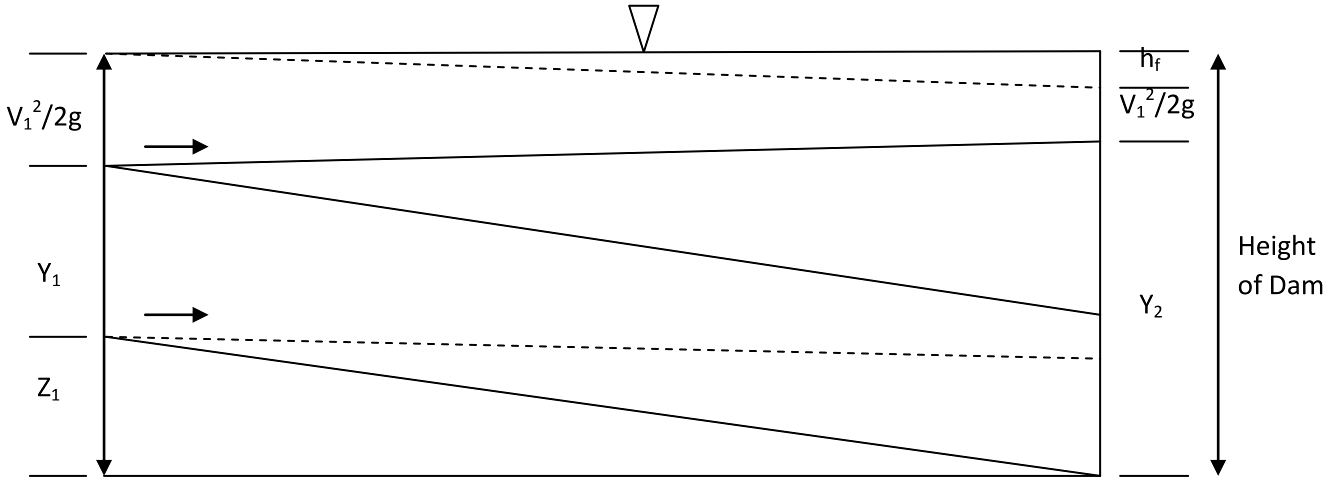

Figure 1: Longitudinal water surface profile at the back of the dam
The length of the backwater curve is given as:

$$L = \frac{E_2 - E_1}{S_b - S_e} \qquad (4)$$

E_2 *is* energy at point 2
E_1 *is* energy at point 1
S_b is bed slope
S_e is energy slope
Making energy subject of the formulae, we have:

$$L(S_b - S_e) = E_2 - E_1 = {(y_2 - y_1)^3}/{4y_1y_2} \qquad (5)$$

$Where\ y\ is\ water\ stage(m)$
$The\ water\ stage, y\ is\ given\ as:$

$$y_1 = {Q}/{BV_1} \qquad (6)$$

$Where\ Q\ is\ discharge\ (m^3/s)$
$B\ is\ one\ meter\ breadth\ of\ the\ river\ (m)$
$V\ is\ velocity\ (m/s)$

From Bernoulli's equation:

$$Z_1 + y_1 + {V_1^2}/{2g} = y_2 + {V_2^2}/{2g} + h_f \, (7)$$

Where Z_1 is difference in elevation
g is acceleration due to gravity
h_f is head loss due to friction
The velocity is given as:

$$V = {Q}/{A} \quad ; \mathrm{A} = \mathrm{B} * \mathrm{y} \; (8)$$

$$V = {Q}/{\mathrm{B} * \mathrm{y}} = {q}/{y} \qquad (9)$$

$$\therefore \mathrm{q} = {Q}/{B} \qquad (10)$$

Where q is discharge per unit width.
Putting equation 9 into 7 we have:

$$Z_1 + y_1 + {q^2}/{2gy^2} = y_2 + {V_2^2}/{2g} + h_f \qquad (11)$$

Where head loss due to friction, h_f can be calculated with the formula:

$$h_f = {K_L V^2}/{2g} \qquad (12)$$

where K_L coefficient of friction usually 20,
v is velocity, g is acceleration due to gravity
The height of the Dam is therefore given as:

$$H_d = Z_1 + y_1 + \left({q^2}/{(2gy_1^2)} \right) + \left({(K_L V_2^2)}/{2g} \right) \qquad (13)$$

DETERMINATION OF THE BREADTH OF THE RIVER
Discharge of the river is given as:

$$Q = AV = {\left(By \left(R^{\frac{2}{3}} \times S^{\frac{1}{2}} \right) \right)}/{n} \qquad (14)$$

Making the breadth of the river subject formula, we have:

$$B = {Qn}/{y \left(R^{\frac{2}{3}} \times S^{\frac{1}{2}} \right)} \; (15)$$

Where R is hydraulic radius which is y (for a wide channel)
$n$is Manning's roughness coefficient for river (0.003)

2.4 DETERMINATION OF HYDRO POTENCY

Hydro energy potency in Imo State can reach 550 MW and 0% has been used in hydro and micro-hydropower plants. The development of hydropower plants depends much on geographic location, rainfall, and catchment area. These conditions determine the variation in hydropower plant capacity.

Abdul et al, (2011) reported that the theoretical hydro potency (hydropower) produced by a micro-hydro system depends entirely on the flow rate of the water, vertical height (or head) of the waterfalls, and the acceleration of water due to gravity as shown in this equation:

Hydraulic potency is given as:

$$H_p = \rho g Q H \qquad (16)$$

Where: H_p is hydro potency, ρ is density of water; g is gravitational force
Q is flow rate, H is the effective pressure head of water

The theoretical power is a rough calculation of hydro potency in a river. Some losses reduce power during the conversion process in the hydro system. Therefore the electrical power produced by a micro-hydro system is given as:

$$E_p = \rho g Q H \eta_o \qquad (17)$$

$where: E_p \ is \ electric \ power, \eta_o is \ overall \ efficiency \ of \ the \ system$

TURBINE SPECIFICATION

All hydroelectric generation depends on falling water. Stream flow is the fuel of a hydro-power plant and without it, generation ceases. To ensure the control of the turbine speed by regulating the water flow rate, certain inertia of rotating components is required. Once the hydro potency, specific speed, and net head are known, the turbine type, the turbine fundamental dimensions, and the height or elevation above the tailrace water surface that the turbine should be installed to avoid cavitation's phenomenon can be calculated.

In Abdul et al (2011), the head loss due to cavitation's, the net head, and the turbine power must be recalculated for Kaplan or Francis turbine type. In general, the Pelton turbines cover the high-pressure domain down to *(50m)* for micro-hydro. The Francis types of turbine cover the largest range of head below the Pelton turbine domain with some over-lapping and down to *(10m)* head for micro-hydro. The lowest domain of the head below *(10m)* is covered by the Kaplan type of turbine with fixed or movable blades. For low heads and up to *(50m)*, also the cross-flow impulse turbine can be used. A survey on the suitable turbine for the calculated hydraulic potency and flow rate will be recommended.

TOPOGRAPHICAL STUDY

A precise detailed study of the surface features of a water region was made to provide a feasibility report of the project.

SLOPE DETERMINATION

The slope of the river was calculated from the parameters gotten from the goggle earth map study. It will be calculated using the formulae.

$$S = \frac{\Delta \text{elevation}}{\Delta \text{x}} \qquad (18)$$

$Where: s \ is \ \ slope \ of \ the \ river$
$\Delta elevation \ is \ difference \ in \ elevation$
$\Delta x \ is \ length \ of \ backwater \ curve.$

LENGTH OF BACKWATER CURVE

The Otamiri River will be checked horizontal and vertical curve or straight part and the slope or flat pattern of the river flow. The length of the backwater curve has been given as shown in Equation 4.

ENVIRONMENTAL IMPACT ASSESSMENT

Along with consideration for technical and economic merits and the responsiveness of this proposed sustainable development to an urgent extent or anticipated social and economic needs, its environmental sustainability and potential impacts will also be assessed. This is because the cost of retroactive restoration of tile integrity of the degraded environment is much greater than that of preventing the degradation. The magnitude and importance of the potential impacts of a project depend on the type of operation, method of execution, and sensitivity of the ambient environment. Information on the potential impacts of the project and the sensitivity of the environment is necessary to identify potential environmental problems early in the project to enhance the design of appropriate environmental improvements, to guide the implementation.

SURVEYED FIELD RESULT
The diagram of Otamiri using Google Earth map was presented as shown in Figure 2.

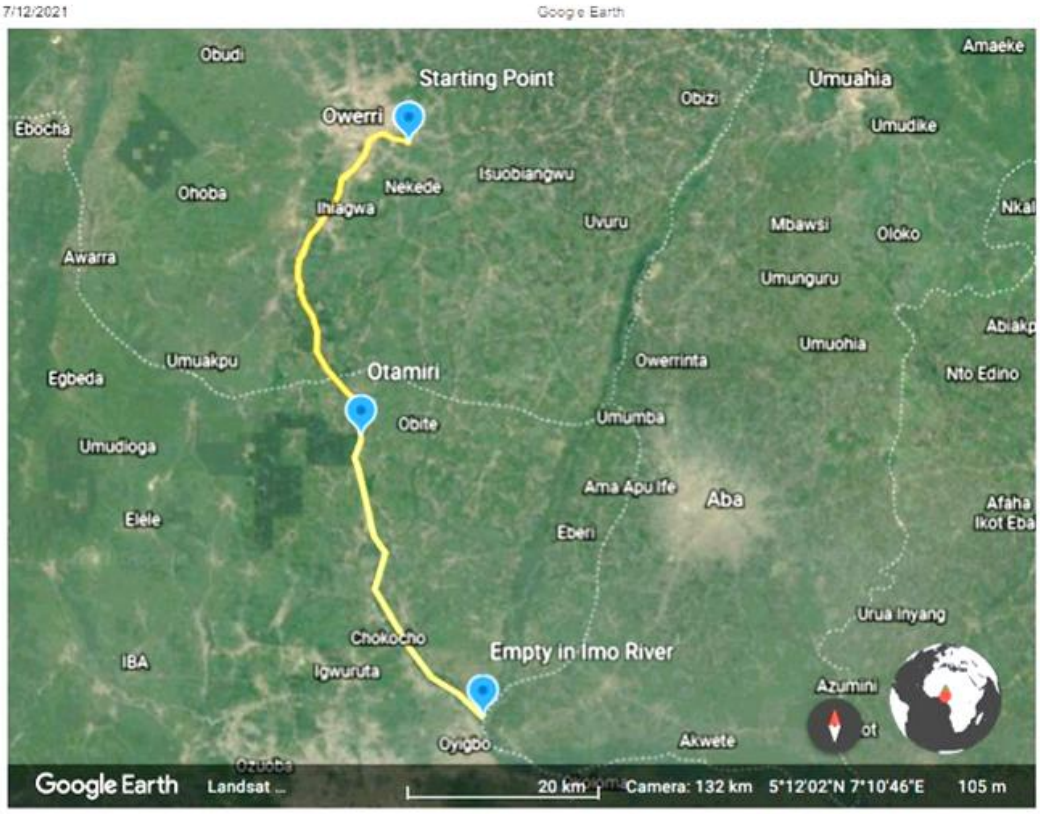

Figure 2: Surface Topographic Map of Otamiri

The Google Earth map show the reach of Otammiri River from Owerri, Nekede, Ihiagwa, Mgbirichi and Umuagwo to Ozuzu in Etche in River State.

The surveyed field data of Otamiri was well studied and presented as shown in Table 1.

Table 1: Otamiri Survey Data

Points	Longitude	Latitude	Elevation	Length
1	5^{0}27’44”N	7^{0}04’21”E	58m	
				114.04
2	5^{0}27’48”N	7^{0}04’19”E	58m	
				481.19
3	5^{0}27’55”N	7^{0}04’11”E	52m	
				376.46
4	5^{0}27’59”N	7^{0}04’07”E	53m	
				876.38
5	5^{0}28’01”N	7^{0}03’56”E	49m	
				691.97
6	5^{0}28’06”N	7^{0}03’28”E	50m	
				577.31
7	5^{0}28’17”N	7^{0}03’08”E	51m	
				272.28
8	5^{0}28’24”N	7^{0}02’50”E	50m	
				386.94
9	5^{0}28’23”N	7^{0}02’41”E	51m	
				849.12
10	5^{0}28’19”N	7^{0}02’30”E	50m	
				480.22
11	5^{0}28’04”N	7^{0}02’07”E	42m	
				382.85
12	5^{0}27’51”N	7^{0}01’59”E	41m	
				5496.76

13	$5^0$27’38”N	$7^0$01’57”E	41m	
				910.47
14	$5^0$27’14”N	$7^0$01’47”E	40m	
				1868.4
15	$5^0$26’21”N	$7^0$01’10”E	39m	
				776.52
16	$5^0$26’05”N	$7^0$00’51”E	39m	
				161.37
17	$5^0$26’03”N	$7^0$00’46”E	39m	
				55.93
18	$5^0$26’03”N	$7^0$00’44”E	39m	
				38.02
19	$5^0$26’02”N	$7^0$00’44”E	40m	
				2.96
20	$5^0$26’01”N	$7^0$00’44”E	38m	
				32.42
21	$5^0$25’59”N	$7^0$00’44”E	39m	
				38.08
22	$5^0$25’59”N	$7^0$00’44”E	39m	
				37.91
23	$5^0$25’58”N	$7^0$00’44”E	38m	
				32.57
24	$5^0$25’58”N	$7^0$00’43”E	39m	
				45.06
25	$5^0$25’57”N	$7^0$00’44”E	38m	
				28.40
26	$5^0$25’56”N	$7^0$00’42”E	39m	
				37.23
27	$5^0$25’56”N	$7^0$00’41”E	39m	
				42.98
28	$5^0$25’57”N	$7^0$00’41”E	38m	
				29.48
29	$5^0$25’57”N	$7^0$00’39”E	38m	
Total				72km

The survey Data shown the point p10 and p11 with the longitudinal and latitudinal values of $5^0$28’19’’N $7^0$28’04’’E and $5^0$28’04’’ N $7^0$02’07’’E respectively

Table 2: Detailed properties of Otamiri River and hydro potency

Points	D_E (m)	D_x(m)	Slope	Q(m^3/s)	y(m)	V (m/s)	$H_f(m)$	H_D (m)	$H_p(kW)$
4-5	4	876.4	0.005	5.9	0.75	0.18	3.53	9.41	428.9
2-3	6	481.2	0.013	5.9	0.75	0.47	9.36	17.50	897.1
13-14	1	910.5	0.001	5.9	0.75	0.04	0.84	3.60	92.61
19-20	2	2.96	0.676	5.9	0.75	2.58	51.5	54.46	3140
24-25	1	45.1	0.022	5.9	0.75	0.85	20.7	20.70	1032
10-11	8	480.2	0.017	5.9	0.75	0.65	23.3	23.30	1233

Detailed properties of Otammiri River and hydro potency shown the longest straight reach with a good position slope, Elevations of the two point, height of theDam and hydraulic pressure

ANALYSIS

The values of Table 4.2 which are the different points were shown step by step on how the computation of the hydraulic potency was.

$$\Delta\, elevation = 50 - 40 = 8m \qquad (19)$$

Where: the Δx $is\ the\ river\ reach\ of\ point$ 10 to 11

Properties of the section

$$\text{Slope } (S_0) = \frac{\Delta\, elevation}{\Delta\, x} = \frac{8}{480.22} = 0.0167 \qquad (20)$$

Properties of the River

Table 3: Properties/Details of point P10 to P11

Point	Coordinates	Elevation (m)	Δx	$\Delta\, elevation$
10	5^0 28ʹ 19’’N 7^0 02’ 30’’	50		
			480.22	8m
11	5^0 28’ 04’’N 7^0 02’ 07’’	42		

From the hydrology data of the Anambra/Imo River basin development authority yearbook.
$Q_{min}\ is\ 5.9\, m^3/s$
$Stage\ y_1\ \ is\ 0.75m$

Table 3: Detail point P10 to P11 with the Elevations
$Z_1\ is\ 8m$
$Height\ of\ Dam, H_D$
From Equation (15) B can be deduce as futher as shown in Equation (21) below;

$$B = \frac{Q}{\left(Y_1 \left(Y_1^{2/3} \right) S_0^{1/2} \Big/ n \right)} \qquad (21)$$

Then substitute the parameters as early obtained we have;

$$B = \frac{5.9}{\left(0.75 \left(0.75^{2/3} \right) 0.0167^{1/2} \Big/ 0.03 \right)} \qquad (22)$$

$$B = \frac{5.9}{2.66} = 2.21m \qquad (23)$$

Substitute B in Equation 10, we have;

$$q = \frac{5.9}{2.21} = 2.67 \qquad (24)$$

Then q will in turnbe put into Equation (9) we have;

$$v = \frac{q}{y} = \frac{2.67}{0.75} = 3.56 \qquad (25)$$

$$Q^2 \Big/ 2gy_1^2 = 2.67^2 \Big/ 2 \times 9.81 \times 0.75^2 = 0.646 \qquad (26)$$

$$K_L V^2 \Big/ 2g = 20 \times 3.56^2 \Big/ 2 \times 9.81 = 12.92 \qquad (27)$$

Refer to Equation 13,
$H_D = 8 + 0.75 + 0.646 + 12.92 + 0.95\ (free\ water\ board) = 23.3m$ (28)
$Hydraulic\ potency, H_p\ \ is\ \rho gQH\ or\ \gamma QH$ as stated in Equation 16. Thus;
$H = H_D - h_f \left(h_f = 2m \right)$ (29)
$H = 23.3 - 2 = 21.3m$ (30)
Hence; putting H back into Equation 16; we obtain Hp as shows in Equation 31 below;
$\therefore H_p$ = 1000 x 9.81 x 5.9 x 21.3 = 1232822.7w = 1232.8227kw (31)
The difference in elevation at six different points of the river was shown in Table 4

Table 4: Difference in elevation and slope at six different points of the river

Points	Δ elevation(m)	**Slope**
4-5	4	0.00456
2-3	6	0.0125
13-14	1	0.0011
24-25	1	0.0222
10-11	8	0.0167

$Where\ \Delta elevation\ (m) is\ height\ of\ the\ first\ point - the\ height\ of\ the\ second\ point.$
The slope of the river at the six different points of the study was shown in Table 4which was obtain with the help of Equation (18). Table 4 shown the Elevations at six different point of the river and slope at six different point of the river.
Otamiri River properties from the water discharge and water stage table as shown in the appendix.
$Minimum\ stage = 0.75\ m$
$Maximum\ stage = 1.02\ m$
$Minimum\ discharge = 5.9\ m^3/s$
$Maximum\ discharge = 9.38\ m^3/s$
The breadth of the Otamiri River is evaluated from the principle model or equation of manning's velocity as expressed below.

The computed breadth of the advantage points of the study was presented in Table 5

Table 5: Breadth of the river at different points

Points	Breadth(m)
4-5	4.23
2-3	2.60
13-14	8.60
24-25	1.92
10-11	2.21

Table 5 show the expected height and breadth of the Dam at the strategic location

The expected height of the dam at the strategic location in line with other properties was computed and presented in Table 6which was obtained by the help of Equation 13 and 10.

Table 6. The height of the dam at different points of the river.

points	Z1(m)	B(m)	$q(m^2/s)$	$H_d(m)$
4-5	4	4.23	1.395	9.41
2-3	6	2.60	2.270	17.50
13-14	1	8.60	0.686	3.60
19-20	1	0.35	16.850	54.46
24-25	1	1.92	3.070	20.70
10-11	8	2.21	2.670	12.92

Table 6 shown the height of the Dam, breadth and pelton wheel height
The Hydro potency at the corresponding height of the dam as shown in Table 2 with its variables.

4.3 DISCUSSION OF RESULT

Otamiri is one of the major rivers in Imo state that serve as one of the tributaries of Imo River which is the main drainage of the State. That is where the Imo State Water Board use to harvest their water for supply after treatment. Figure 4.1 shows a clear part of the river in a line diagram of GoogleEarth map. The figure shows that the river started from Egbu to Oyigbo, where it emptied into Imo River.

However, the study further in the collection of the properties of the Otamiri River was obtained as shown in the appendix in water stage and water discharge tables from AIRBDA. The survey tools and Google Earth map were of big help in determining the coordinates and the paths of the river as shown in Table 1. The Table shows the terminal point of each straight path of the reach of the river. And also indicates the longitudinal and latitudinal focal point with its elevation, the path distance with the camera location of each point.

From the same Table 1, it shows that the total length of the river is 72km while a good number of the path has a long reach and good slope where a Dam can be installed.
Table 2 shows the calculated hydro potency of different parts of the river reach. The table shows that the highest hydro potency occurred at points P10 – P11 which is 1233kW.

CONCLUSION

Based on statistical analysis and hydrological information, gathered with regards to the study area (Otamiri River) and its catchment area, the Hydro potency at various points; P2-P3, P4-P5, P10-P11, P13-P14, P24-P25 are 897.13, 428.88, 1232.82, 92.61, 1032.34, respectively. The hydropower system or plant to be used in the catchment area in a runoff river system is because there is no elevation or head to generate the high amount of energy required to drive the turbine.

RECOMMENDATION

From the statistical analysis obtained from the Goggle Earth map, it is recommended that point P10-P11 with longitudinal and latitudinal values of 5^0 28` 19`` N, $7^0$ 29` 04``E – 5^0 28` 04`` N, $7^0$ 02` 07`` E with the highest value of hydro potency and good slope with good length of backwater curve, will be considered favorable or stable for the construction of dam and hydropower generation.

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