International Conference on Applied Energy 2019
Aug 12-15, 2019, Västerås, Sweden
Paper ID: 609

THE IMPLEMENTATION OF MICRO HYDRO POWER AT DIWAK RIVER, SEMARANG, CENTRAL JAVA, INDONESIA

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ABSTRACT

Nowadays, the electrical needs in Indonesia become a very important sector, but the electrification is still at the 6th position in the Southeast Asia region, therefore in 2019, the government aims to increase the electrification to be 99.99 percent. However, it must also be balanced by the increase in the use of New and Renewable Energy (NRE). This is in accordance with the target of the Ministry of Energy and Mineral Resources to achieve 23 percent of the use of NRE in 2025. One of the areas in Indonesia that has the potential for the utilization of applied renewable energy is Diwak Village, Semarang, Central Java. The New and Renewable Energy is the micro-hydro power (MHP). Therefore, this research aims to determine the potential of the micro-hydropower in Diwak Village, Semarang. Basically, the micro-hydro power (MHP) could be used for an area that has stable water flow discharge and the amount of slope. The methods are calculating float method for flow discharge data, Rock Mass Rating (RMR), and calculating the capacity power. As a result, lithologies at the location are the volcanic and autoclastic breccia. The flow discharge in Diwak River is 0.29 m^3/ sec, and the minimum power that will be generated with its discharge is 40.29 KW. These results sum up that the flow has good potential in utilizing MHP in Diwak Village.

Keywords: renewable energy, power, discharge, Micro-hydro, Diwak.

1.1 Introduction

Nowadays, the electrical needs in Indonesia have become an inseparable aspect of people's daily needs, but the electrification ratio in Indonesia is still at the 6th position in Southeast Asia that reached 98.3 percent in 2018 (ASEAN Centre for Energy, 2019). This number implies the fact that there is still enough space to optimize the electrification percentage in Indonesia. Therefore, the government set the target to achieve 99,99 percent at the end of 2019.

On the other hand, the Ministry of Energy and Mineral Resources continues to promote new and renewable energy resources and increases the use of renewables up to 23 percent by 2025. Renewable energy sources, such as solar, wind, geothermal, and hydropower have excellent potential to generate electricity. Among those sources, hydropower is the most reliable source. One of the hydropower energy is known as Micro-hydro Power (MHP), a type of hydroelectric power scheme that produces of 5 up to 100 KW of electricity using flowing steam or water flow.

There are several areas in Indonesia which have potential as micro-hydro utilization areas. One of them is in Diwak River, Semarang, Central Java. Thus, this study aims to find out the potential power generated if MHP is developed in this area.

1.2 Material and methods

This study used primary and secondary data. The primary data consists of measuring flow data using the float method, slope, and rock strength index using Rock Mass Rating (RMR). The secondary data includes the population and the average precipitation data in Diwak Village, Semarang.

1.2.1 Lithology

Lithology determination using petrological analysis to know the type of rock, texture, structure, and mineral composition. The outcrop could reflect the base rock characteristic and useful to help geotechnical assessment (Fig 1).

Selection and peer-review under responsibility of the scientific committee of the 11th Int. Conf. on Applied Energy (ICAE2019).

Figure 1. Field observation to get lithology and the geometry of the Diwak River

1.2.2 *Geotechnical (Rock Mass Rating)*

Geotechnical Analysis are Required in order to define the ground stability around the researched area, *Rock Mass Rating* (RMR) to be exact. According to Bieniawski (1989), usage of *Rock Mass Rating* (RMR) Method is to provide quantitative and qualitative data through certain rock analysis; strength of intact rock material, rock quality designation, spacing of discontinuities, condition of discontinuities, and ground water condition.

1.2.3 *Rainfall in Semarang*

According to World Weather and Climate Information 2019, rainy season in Semarang highly falls in January, February, November, and December. Rainfall becomes an important aspect because it will affect the water volume in the river.

1.3 *Theory and Calculation*

Discharge measurements were carried out on the Diwak 1 and Diwak 2 River using the Float method. This method needs two types of information, cross sectional area of the water flowing in the stream and the speed that water is flowing. Normally, this method applied an eggplant which has a same density with water and capped to makes an ideal float as shown in Figure 2.

The formula was:

$$Q = \frac{V}{t} = \frac{l \, x \, h \, x \, w}{t} \quad \text{..... (1)}$$

Q stands for flow rate (m^3/s), V stands for volume (m^3), got from long (l), height (h), and width (w). T stands for time (s).

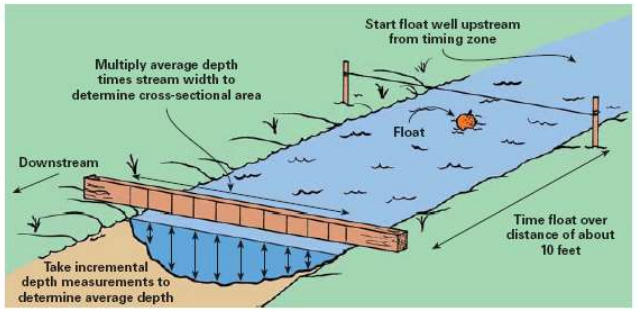

Figure 2. The Float Method of Estimating Flow (Suneco Hydro Turbines)

The number of the flow rate then will be calculated in capacity power calculation. Based on equation (2) below, by using Standard International unit, the power was being calculated by:

$P_{theoritical} = Q \times g \times H$ ..... (2)

$P_{turbine} = P \times \mu_{turbine}$ ..... (3)

$P_{generator} = P_{turbine} \times \mu_{generator}$ ..... (4)

Where P is the power generation (kW), Q is stream flow (m^3/s), H is the effective head or the elevation (m), *g* is acceleration due to gravity (m/s^2), $\mu_{turbine}$ is 0.7 and $\mu_{generator}$ is 0.8 (Arismunandar, 1991).

1.4 *Results*

1.4.1 *Geomorphological Aspect*

The study was conducted on two branches of the Diwak river. The difference between them is on the presence of waterfalls. River 1 has a waterfall, namely Grenjeng waterfall. It is 7 m high, but River 2 does not. However, the waterfalls indicated a steep slope, which is one of the main aspects

of micro-hydro power. Based on the field observation, the research location had 25 meters of elevation and a fairly steep slope of 45°.

1.4.2 Geological and Geotechnical Aspect

Field observation in Diwak River has revealed two kinds of lithology, volcanic breccia, and autoclastic breccia. The determination of this type of lithology is based on petrology analysis.

1. Volcanic Breccia; black, block-sized andesitic fragments (>64 mm) and ash matrix.

Figure 3. Volcanic Breccia in Diwak

2. Autoclastic Breccia; black, homogenic fragments and matrix, crystalline texture.

Figure 4. Autoclastic Breccia

Lithology related with geotechnical aspect. This Geotechnical Analysis used the Rock Mass Rating (RMR) method based on Bieniawski (1989). The RMR score of volcanic breccia rocks is 61 (Table 1). It imlied that volcanic breccia included in the Good Rock quality (Bieniawski, 1989). So, it is quite resistant and stable want to be a location for developing micro-hydro power.

Table 1. Rock Mass Rating of Volcanic Breccia in Diwak

Lithologies	Volcanic Breccia	
RATING		
compressive strength	Strong Uniaxial Comp. Strenght : 50-100 Mpa Point Load Index : 2-4 Mpa	**7**
RQD **Palmstrong, 1982**	82	17
Spacing of Discontinuities	60-200 mm	**8**
Condition of Discontinuities	Slightly rough surface, Separation <1 mm, Highly weathered walls	**19**
Groundwater Condition	Damp	**10**
Total Rating		61

1.4.3 Hydrogeological Aspect

Flow measurements were carried out on the Diwak 1 and Diwak 2 River using the Floating method. Tables 2 and 3 showed the results of measurements of discharge in Diwak 1 and 2. Table 2 is the result of calculating river discharge in the dry season, while Table 3 is the calculation of river discharge in the rainy season.

The results of the calculation show that the Diwak 1 had a greater discharge number, thus the potential for the development of the MHP is greater to be developed in the Diwak River 1. The discharge generated in the Diwak 1 was 0.29 m^3/s and 1.33 m^3/s.

Table 2. Flow Rate on Dry Season

River	h	w	L	V	t	Q	H
Diwak 1	0.29	2.1	10	6.1	20.74	**0.29**	25
Diwak 2	0.3	2.2	10	6.6	31.36	0.21	25

Table 3. Flow Rate on Rainy Season

River	h	w	l	V	t	Q	H
Diwak 1	0.58	2.1	15	18.27	14	**1.33**	25
Diwak 2	0.8	2.2	12	21.12	16.5	1.33	25

1.5 Discussion

The result showed that flow discharge of the river is 0.29 m^3/s in the Diwak 1 and 0.21 m^3/s in the Diwak 2. It revealed that the flow in Diwak 1 is bigger, so, by 0.29 m^3/s, the electrical power that can be produced is about **40.29 KW** for each operation (Table 4) (sample based on Flow Rate in Dry Season). We assume that the operation system works for three times in a day. As a result, the power will get to **3626.1 KWH per month.**

Table 4. Estimation of Micro-Hydro Electricity Power

River	Q	H	P	Pt	Pg
Diwak 1	0.29	25	71.94	50.36	**40.29**
Diwak 2	0.21	25	51.57	36.10	28.88

Furthermore, the micro-hydro power plant needs preliminary design for future planning model conceptual design in Diwak Village. In this research, the micro-hydro power plant planning consist of six part. First is spill point, which in this part river stream will be divided into two and the other one will flow to artificial river. Artificial River will flow to water dam. Water dam save water before drain it into the turbine and generator house or power house through pipe. Final part the water will return to the main river. Based on power plant design water discharge could controlled by water dam and pipe. Meanwhile the elevation difference controlled by placement of water dam and power house (Figure 5).

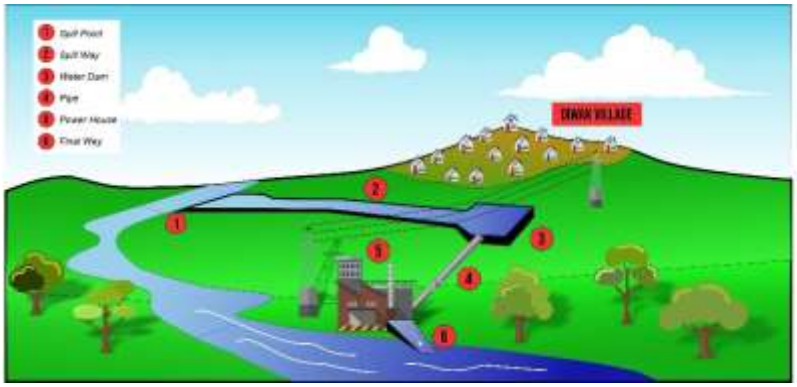

Figure 5. Micro-hydro Planning Conceptual Model at Diwak River

1.6 Conclusions

In this paper, the necessity of exploring energy from new and renewable sources and impact of micro-hydro as a new and renewable source has been presented. This electrical energy will be distributed approximately 3626.1 kWH per month to light up the village. It concludes that Diwak River has huge potential for developing a micro-hydro power. As a result, this energy will help people to have access to reliable and affordable electricity services, not only in Diwak but also can be applied to other rural areas in Indonesia, as long as it has elevation and water flow.

ACKNOWLEDMENT

Authors would like to thank Geological Engineering Department, Faculty of Engineering, Universitas Diponegoro for providing support and financial assistants to do the research.

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