The effect of discharge and water level on the electric voltage generated by the watermill

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Abstract. Potential energy is stored in water (in falling water) and kinetic energy (in flowing water) so that many studies have used water as alternative energy. This research was conducted to investigate the electric voltage generated by the waterwheel with different water flows and water levels. How to make a waterwheel are: (1) Prepare tools such as a plastic wheel, dynamo type (5V), cables, and lamps. (2) Connect the end of the plastic wheel to the end of the rotating dynamo. (3) Connect the cables to both ends of the dynamo. (4) Connect the two free ends of the cable to the lamp. (5) Test the waterwheel on running water and connect the cable to the multimeter if you want to measure the voltage and current. The method used in this research is a demonstration experiment. The results of the study indicate that the electric voltage caused by the rotation of the wheel by running water can turn on the light. The greater the flow of water that flows, the greater the voltage generated and the lights get brighter. Furthermore, the experiments in this study can be used for the science learning process to students.

1. Introduction
Nowadays, increasingly fast technological developments result in increased demand for electrical energy [1]. The need for energy, especially electrical energy, cannot be avoided [2]. Therefore, the use of renewable energy sources that can produce electrical energy is a priority. Indonesia has many natural resources that can be used as a producer of electrical energy, one of which is water energy [3,4]. Water energy is a renewable energy source that comes from the flow of water which is used to create electrical energy [5]. Water is a source of energy that is cheap and relatively easy to obtain, because in water is stored potential energy (in falling water) and kinetic energy (in running water) so that many studies have used water as an alternative [6]. Renewable energy technology provides great hope as a pollution-free alternative to replace fossil fuel and nuclear power installations to meet the needs of electrical energy [7,8]. This research was conducted by changing the discharge and water level to determine the effect on the performance of the waterwheel.

In previous research, the mechanical energy of water flow, which changes from the potential energy, is used to drive a turbine or water wheel. Typically, turbines are used to generate electrical energy, while pinwheels are used for direct mechanical energy utilization, which is then converted into electrical
energy. The research objective to be achieved is to determine the effect of discharge and water level on the electric voltage generated by the waterwheel so that we will find out which discharge and water level are the most effective for generating electricity.

Based on the concept of novelty, it can be stated that this research can contribute to science education. This research can be implemented in terms of providing input to all of us who want to make a waterwheel so that the waterwheel that we make can produce the best electrical voltage.

2. Method
For the method we use Quantitative Research to gathers numerical data for finding out how many, how much, how often, or to what extent our research. As illustrated in Figure 1, the first thing to do before the research is to calculation the components that will be used and then after that, prepare the materials and tools to be used. The materials and tools used include dynamo type 5V to drive waterwheels, waterwheels made of plastic, wooden planks as a base, clamp cables, a lamp and of course water as electricity producing energy. If it has been prepared so, the next step is to make a waterwheel. Making a waterwheel is easy in a way first, connect the end of the plastic wheel to the end of the rotating dynamo. Second, connect the cables to both ends of the dynamo. Third, connect the two free ends of the cable to the lamp. Fourth, test the waterwheel on running water and connect the cable to the multi-tester if you want to measure the voltage and current. After making the waterwheel, testing the effect of waterwheels on the variable to be used is discharge water and water level. And then after that, repeat the research from this research that we find. After that collect the data by using observation then analysis the result of the data and conclusion of this research.

![Figure 1. Research method](image1)

3. Result and Discussion
Figure 2 shows the waterwheel model made. It can be seen that there is a connection between the dynamo and the wheel. When the wheel is exposed to water and rotates, the dynamo will also move and produce an electric voltage. When the voltage is high enough, the light will turn on.

![Figure 2. The waterwheel model made.](image2)
Table 1 shows the relationship between water discharge and water level with the resulting stress. From the table above, it can be seen that the greater the water discharge and the higher the water level, the greater the voltage generated. The smallest lights are with a voltage of 1.17, but the lights only turn on temporarily. Meanwhile, with a voltage $> 1.17$, the light is on for a long time.

Table 1. The relationship between water discharge and water level with the resulting stress.

| No | Water Discharge $d$ (l/s) | Water Height cm | Voltage ($V$) | Lamp Condition |
|----|--------------------------|----------------|-------------|---------------|
| 1  | 0.2                      | 10             | 1.10        | Off           |
| 2  | 0.2                      | 20             | 1.13        | Off           |
| 3  | 0.2                      | 30             | 1.17        | On (dim and didn’t last long) |
| 4  | 0.4                      | 10             | 1.18        | On            |
| 5  | 0.4                      | 20             | 1.19        | On            |
| 6  | 0.4                      | 30             | 1.21        | On            |
| 7  | 0.6                      | 10             | 1.21        | On            |
| 8  | 0.6                      | 20             | 1.24        | On            |
| 9  | 0.6                      | 30             | 1.26        | On            |

This harmonizes with Aliah and Kimin's statement in their journal (Table 2) that water discharge give a big effect to the work of the waterwheel, even though they didn’t use water height as variable. If the water discharge is big, then the voltage and efficiency that produced by the waterwheel will be big too and vice versa.

Table 2. Effect of water discharge on voltage (Aliah dan Kimin experiment result).

| No | Water Discharge (m³/s) | Voltage ($V$) |
|----|------------------------|--------------|
| 1  | 1.8                    | 15.1         |
| 2  | 1.7                    | 10.8         |
| 3  | 1.6                    | 8.5          |

To find out the relationship between water discharge, water level, and the resulting stress, we attach the following multiple correlation statistical tests.

Basis for Decision Making
- If the value is sig. F change $< 0.05$, then it is correlated
- If the value is sig. F change $> 0.05$, then it is not correlated

Relationship Degree Guidelines (Pearson Correlation Value)
- 0.00 - 0.20 = no correlation
- 0.21 - 0.40 = weak correlation
- 0.41 - 0.60 = moderate correlation
- 0.61 - 0.80 = strong correlation
- 0.81 - 1.00 = perfect correlation

From the results of statistical tests (see Figure 3), it can be seen that the sig. F change is 0.000 $< 0.05$, which means that it is correlated. Thus, it can be concluded that there is an effect of water discharge and water level on the resulting stress. It can also be seen from the results of the statistical test above that the Pearson Correlation value is 0.985, which means it is in the range 0.81 - 1.00 which means
perfect correlation. With this value, it can be concluded that the water discharge and the water level greatly affect the resulting stress.

| Model | R     | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change |
|-------|-------|----------|-------------------|-----------------------------|-----------------|----------|-----|-----|---------------|
| 1     | .985  | .971     | .961              | .00991                      | 971             | 100.6    | 2   | 6   | .000          |

a. Predictors: (Constant), Water Height, Water Discharged

Figure 3. Statistical tests.

4. Conclusion
Waterwheels can produce electrical energy besides makes it easy and everyone can do it. Even make a simple waterwheel can produce electrical energy which can be said to be almost equivalent to a battery commonly used. This can also happen if you have attention of what a variable can influence it. The variables used are water discharge and water level. From the data obtained water discharge greatly affects the electrical energy generated as well as the water level. The minimum water discharge needed to produce energy is 0.2 l/s with a water level of 30 centimetres. And then a large water discharge with a low water level still can produce energy. Therefore, water discharge and water level is more important in producing electrical energy.

5. References
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