Study of Fluid Dynamics In Waterfall Damarwulan Jember As Material For Designing Student Work Sheet

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ABSTRACT

This study aims to reviewing the dynamics of the fluid in the flow Damarwulan waterfall as material to design student worksheets in physics high school. This type of research is descriptive. The results showed that the water flow speed in the cross sectional area of 7,167 cm² and 2,876.2 cm² was 4.7 cm/s and 14.1 cm/s. Measurements on another stream with a cross sectional area of 4,752 cm² and 1,697.5 cm² current rate is 9.4 cm/s and 28.2 cm/s. While the water flow speed in the waterfall show at a height of 5.49 m and 3.01 m is 10.37 m/s and 7.68 m/s. The density rate waterfall A and B of 1.05 m³/s and 0.78 m³/sso potential micro hydro generated is 56,866.765 W and 23,117.44 W. The results of research conducted that data in accordance with the theory, so can be used as material for designing student worksheets for learning physics in high school.

INTRODUCTION

Learning in schools has an important role in conveying knowledge to students so it needs a media that contains information and ideas that can facilitate learning of learners, ie learning resources (Sitepu, 2008). Learning resources are not only obtained from teachers and books or text books that are theoretical, but can also be obtained from the surrounding environment. This is in line with Brahim's opinion (2007) which states that the existence of nature around is a potential that can be used to support the activities of learners in the learning process.

This is supported by UU no. 20 of 2013 on the national education system which states that curriculum development is done by referring to the national standards of education and curriculum at all levels and types of education developed with the principles of correction in accordance with educational units, local potential and learners so that the development of learning processes in schools need Referring to local
potentials in the area. The local potential in question is the occurrence, event, problem or phenomenon contained in the environment of the students' learning area (Marlina, 2013).

It is also in harmony with the factual nature of physical learning with facts, phenomena in the results of thought and experimental results that have been done by physicists. Physics is not only characterized by the existence of a collection of facts or products alone but also marked the emergence of scientific methods and attitudes. Physics explains the phenomena of nature as simply as possible and seeks to find the connection between reality. Based on that, then in the process of physics learning, concepts and data in the form of matter and matter must be in real condition so that it will be easy to accept the mind.

But in reality there are still many physics lessons that do not contain contextual teaching. This is supported by research conducted by Jaya (2012) which states that conventional print material only contains the definition of a concept, a set of formulas, sample questions, and practice questions. The material presented in the printed material is abstract and complicated so that students are reluctant to read it let alone learn it. The teaching material presented in the teaching material is never associated with actual objects or events in the real world that are familiar with the learner. The problems presented in the teaching materials are also academic. This results in low physical learning outcomes.

One way to make physics learning easier to understand by learners through the development of contextual based physics teaching materials. The development of contextual based physics teaching materials has been done by previous researchers such as Noor & Wilujeng (2015) who stated that a context based SSP approach can improve students' science process skills. This is based on the results of data analysis showing differences in pretest and posttest score from 62.14 to 74.78 with a gains score of 12.64. Similar research has also been conducted by Risnawati et al (2013) which states the use of contextual modules is more effective in improving students' science process skills. This is evidenced through data from the results of research which shows that the value of N-gain in the experimental class is higher that is 0.60 while the N-gain value in the control class is 0.40. Based on the results of the above two studies proves that the contextual teaching of physics is more effective in forming the concepts of physics to the students, so as to improve student learning outcomes. However, research conducted by researchers only contain phenomena-phenomenon of physics based on everyday events without reviewing the original data in the field. Therefore it is necessary to take data empirically on a phenomenon in order to explain the concept of physics with the correct data.

One of the phenomena that can explain the concepts and data in the form of matter and problems in accordance with real conditions is through waterfall events. Waterfall is one of the phenomena of physics that contains concepts and applications about fluid dynamics and business and energy. One of the concepts related to dynamic fluid in the phenomenon of waterfall can be seen through the difference of water flow rate and the amount of water discharge. While the concept of business and energy on the phenomenon of waterfalls is the use of potential energy and kinetic energy flow of water for the manufacture of electrical energy using a waterwheel.

Waterfall damarwulan located in ledokombojember can serve as one of the alternatives in explaining the concept of fluid-related dynamic as well as business and
energy. This is because the waterfall damarwulan is a waterfall that has a cascade type that is falling free waterfall while maintaining contact with the wall waterfall. Waterfall cascade type has a high waterfall with the category of medium, wide waterfall with the category and the vertical cliff slope. This type of waterfall is formed due to the erosion that causes water to flow through the formation of rocks from a certain height.

Damarwulan waterfall area has three waterfalls in the flow, each has a height of 5 meters to 25 meters. The three waterfalls are connected to each other through the river. The width of the river flow of waterfalls damarwulan not always the same, but varies from large to small as well as from small to large. In addition, the depth of river waterfall damarwulan also vary not always the same. The existence of these differences will certainly affect the size of the velocity of water flow. Through the difference of height, width, depth and speed will be used as material to determine the amount of flow discharge waterfall damarwulan.

The amount of discharge flow damarwulan waterfall has a relatively medium speed that can be utilized as an alternative energy source to make electrical energy. This electrical energy is the result of the conversion of the kinetic energy of water derived from the flow speed of the waterfall due to the difference in altitude. Through it can be studied the amount of microhydro energy potential contained in the flow of waterfall damarwulan.

METHODS

Data collection methods in this study is through primary data obtained from direct observation in the field and through secondary data based on mathematical calculations. The research location is located at DamarwulanLedokombo waterfall in Jember District. There are two different measurement points taken based on the equality of the problem formulation, ie first along the waterfall and second stream at a waterfall that has a certain height. Modeling of measurement points can be seen in the appendix.

Observations were conducted to collect primary data to be analyzed in this study. Measurements at the first point are conducted along the Damarwulan waterfall stream by collecting data of depth (s), cross-sectional width (d), flow length used (l), cross-section (A), velocity velocity (v), water volume (V), debit (Q), kinetic energy (Ek) and the resulting microhydro (P) potential. Measurements at the second point are carried out at the waterfall by collecting data in the form of volume (V) and the cross-sectional area (A) tub/bucket used, the discharge (Q) at the waterfall, the height of the waterfall (h₀), the height used as the independent variable Measurement of velocity (h₁), velocity (v), potential energy (Ep), kinetic energy (Ek) and large microhydro energy potential (P).

After the primary data from observation is obtained then will cross check with secondary data result of mathematical calculation.

Water discharge is the amount of water flowing from a particular cross section (river, waterfall, channel, springs) of time unity or in unit SI system of discharge is expressed in units of cubic meters per second (m³/dt). The common water debit is also called the flowing water strength, the volume of flowing water or the flowing water supply, which is different in its use.

\[
Q = \frac{\Delta V}{\Delta t} = \frac{A_v \Delta t}{\Delta t} \quad \text{............... (1)}
\]

\[
Q = v.A \quad \text{............... (2)}
\]

Where :

\( Q = \) debit air (m³/s)
v = flow rate (m/s)
A = selectional area (m²).

(Adullah, 2007: 262-263)

The magnitude of the flow each time or called the discharge, will depend on the area of the flow and the average flow rate. The discharge rate approach can be done by measuring the flow profile and measuring the flow velocity. Measurement of the cross-sectional area of the free channel (natural channel) as in the river, the most commonly used method is the mathematical method and the calculus is the object divided into several rectangles.

Measurement of the area of the flow is done by measuring the water level and the width of the river bed. In order to get more precise results, measurement of the face height using a depth sensor. Further measurement of flow velocity there are many methods, such as buoy method, using velocity head rod tool, current meter tool or using flow water sensor (Harto, 1993). However, the measurement of the flow velocity used in this study uses a flow water sensor to obtain more accurate results.

The potential for hydropower and its utilization is generally very different when compared with the use of other personnel. We need to know that the potential energy of the waterfall is to utilize energy because of the height or potential which is then converted into kinetic energy to move the fins and turn the turbine further into electrical energy. So with the energy equation kinetic, we can find the amount of energy contained in the waterfall is as follows:

\[ P = \frac{1}{2} \rho \cdot Q \cdot v^2 \]

where:
P = power (Watt)
\( \rho \) = density of water = 1000 kg/m³
Q = debit (m³/s)
v = flow rate (m/s)

(Ridwan: 2010: 8)

RESULTS AND DISCUSSION

The first measurement is to measure the velocity of water flow in different cross-sectional areas. The measurement begins by measuring the flow depth using the trapezoidal integral method integral approach. The first measurement is performed at location A by measuring the depth to determine the cross-sectional area. Based on the measurement of the depth, the results of cross-sectional area of both sides of the flow are 7167 cm² and 2,876,5 cm². The following table shows the measurement of depth and cross-sectional area:
Table 1. Results of measurement data of cross-sectional area at location A

<table>
<thead>
<tr>
<th>No</th>
<th>Sectional Flow</th>
<th>Sectional Width (cm)</th>
<th>Range Depth (cm)</th>
<th>Range of Trapezoidal Area (cm²)</th>
<th>Sectional Area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A₁</td>
<td>227</td>
<td>13-57</td>
<td>27-847.5</td>
<td>7167</td>
</tr>
<tr>
<td>2</td>
<td>A₂</td>
<td>116</td>
<td>14-32</td>
<td>236.5-457.5</td>
<td>2876.5</td>
</tr>
</tbody>
</table>

Further measurements by measuring the velocity of water flow on each side of the cross-sectional area. Speed measurements are made repeatedly with the results of the data indicating the difference in speed and discharge at cross section A₁ and cross section A₂. The flow velocity on the A₁ cross section is 4.7 cm/s, while the flow velocity at A₂ is 14.1 cm/s. The flow discharge at A₁ section is 33684.9 cm³/s, while the flow discharge at cross section A₂ is 40558.65 cm³/s. The data of flow rate measurement in area a can be seen in table 2.

Table 2. Repeated measurements of flow velocity at location A

<table>
<thead>
<tr>
<th>No</th>
<th>Sectional Area (cm²)</th>
<th>A₁ Speed Flow at A₁ (cm/s)</th>
<th>Water discharge at A₁ (cm³/s)</th>
<th>Sectional Area (cm²)</th>
<th>A₂ Speed Flow at A₂ (cm/s)</th>
<th>Water discharge at A₂ (cm³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7167</td>
<td>4.7</td>
<td>33684.9</td>
<td>14.1</td>
<td>40558.65</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>116</td>
<td>4.7</td>
<td>33684.9</td>
<td>14.1</td>
<td>40558.65</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>116</td>
<td>4.7</td>
<td>33684.9</td>
<td>14.1</td>
<td>40558.65</td>
<td></td>
</tr>
</tbody>
</table>

Subsequent measurements are carried out at the B site of the stream. At location B we measured two different cross-sectional areas at points B₁ and B₂. Measurement of depth at location b obtained result that the cross section area of B₁ and B₂ is 4,752 cm² and 1,697.5 cm². The data of measurement of depth and cross-sectional area at location B are as follows.

Table 3. Result of measurement data of cross-sectional area at location B

<table>
<thead>
<tr>
<th>No</th>
<th>Sectional Flow</th>
<th>Sectional Width (cm)</th>
<th>Range Depth (cm)</th>
<th>Range of Trapezoidal Area (cm²)</th>
<th>Sectional Area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B₁</td>
<td>217</td>
<td>4-34</td>
<td>94.5-480</td>
<td>4752</td>
</tr>
<tr>
<td>2</td>
<td>B₂</td>
<td>125</td>
<td>6-25</td>
<td>25-360</td>
<td>1697.5</td>
</tr>
</tbody>
</table>

Further measurements by measuring the velocity of water flow on each side of the cross-sectional area. Speed measurements are made repeatedly with the results of data showing the difference in speed and discharge at cross section B₁ and point B₂. The flow velocity at the cross section of B₁ is 9.4 cm/s, while the flow velocity at the cross section of B₂ is 28.2 cm/s. The flow discharge at cross section B₁ is 44668.8 cm³/s, while the flow discharge at cross section B₂ is 47869.5 cm³/s. The data of flow rate measurement in area b can be seen in table 4.
The result of fluid dynamics study related to the relation of cross section area to flow velocity can be seen in Table 2 and Table 4. Table 2 shows the differences in the cross-sectional area causing the difference in flow velocity at each cross section. A cross section 7167 cm² has a flow rate of 4.7 cm/s, while in cross section A₂ with 2876.5 cm² has a flow rate of 14.1 cm/s. This is in accordance with Table 4 which shows the flow velocity in the cross-sectional area of 4752 cm² smaller than the flow velocity at the 1697.5 cm² cross-sectional area. Based on the data in Table 2 and Table 4 it can be concluded that the flow velocity is inversely proportional to the cross-sectional area.

This is consistent with the principle of continuity which states that the amount of water flowing per unit of time is always the same at each cross section. This is shown in the discharge column at each location in the waterfall damarwulan almost the same. In table 4 shows that the discharge at location B is at points B₁ and B₂ of 44668.8 cm³/s and 47869.5 cm³/s. While in table 2 shows the difference of discharge at point A₁ and A₂ is too big ie at A₁ of 33684.9 cm³/s and at A₂ of 40558.65 cm³/s. In table 2 and table 4 shows that the amount of discharge at each location is not the same. This is due to several factors namely the form of irregular flow cross section so that the measurement of the cross-sectional area using the trapezoidal rules, as well as the accuracy of flow meter measuring 1 liter/minute.

The next measurement is done at the waterfall area. In this study used two waterfalls namely waterfalls A and B as the object of research. Methods of waterfall height measurement is done using a tool using trigonometric principles. Through distance measurements, and angles formed against the peak of the height will be obtained large waterfall height. Data taken in the measurements at each location of the waterfall include the height of the waterfall and the speed of the waterfall. The following measurements of the height and speed of the waterfall at locations A and B:

### Table 5. Measurement of altitude and speed of Damarwulan waterfall

<table>
<thead>
<tr>
<th>No</th>
<th>Waterfall</th>
<th>Height to Eye (m)</th>
<th>Angle (°)</th>
<th>Distance (m)</th>
<th>Height Waterfall (m)</th>
<th>Speed Flow at Waterfall (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>0.67</td>
<td>47</td>
<td>4.5</td>
<td>5.49</td>
<td>10.37</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>1.47</td>
<td>14</td>
<td>6.2</td>
<td>3.01</td>
<td>7.68</td>
</tr>
</tbody>
</table>

Table 5 shows that waterfall location A and waterfall location B have different heights. Waterfall at location A has a height of 5.49 meters, while the waterfall at location B has a lower altitude than the waterfall location A of 3.01 meters. The difference in the height of the waterfall causes a difference in the flow rate of the waterfall at the base of the waterfall. At the waterfall location A flow velocity at the bottom of the waterfall is 10.37 m/s, while the flow velocity at the base of the B
waterfall location is 7.68 m/s. Data measurements of water flow velocity and subsequent altitude were used to analyze the large potential of microhydro owned by waterfall damarwulan. The following is the result of measurement of microhydro potential at Damarwulan waterfall.

The result of fluid dynamics study related to altitude relation to flow velocity can be seen in table 5. Table 5 shows that the flow rate of the waterfall which has a height of 5.49 meters is 10.37 m/s, while the flow rate of the waterfall has a height of 3.01 meters of 7.68 m/s. This indicates that the higher the height of the waterfall the greater the flow rate of the waterfall. This corresponds to the free fall and noulil formula which states that the altitude is proportional to the square of the velocity \((h \sim v^2)\).

<table>
<thead>
<tr>
<th>Waterfall</th>
<th>Water Discharge ((m^3/s))</th>
<th>Speed Flow at Waterfall ((m/s))</th>
<th>Height Waterfall ((m))</th>
<th>Gravitation ((m/s^2))</th>
<th>Density of Water ((kg/m^3))</th>
<th>Microhydro Potential ((W))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.05</td>
<td>10.37</td>
<td>5.49</td>
<td>9.8</td>
<td>1000</td>
<td>56,866.75</td>
</tr>
<tr>
<td>B</td>
<td>0.78</td>
<td>7.68</td>
<td>3.01</td>
<td>9.8</td>
<td>23117.44</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 shows that the difference in the flow rate of the waterfall at location A and location B. At waterfall location A with a height of 5.49 m and flow velocity at the bottom of the waterfall 10.37 m/s has a flow rate of 1.05 m\(^3\)/s. At waterfall location B with a height of 3.01 m and flow velocity at the bottom of the waterfall 7.68 m/s has a flow rate of 0.78 m\(^3\)/s. The difference in flow discharge at waterfalls leads to differences in microhydro potential. At the waterfall location A has a microhydro potential of 56866.75 W while at location B has a microhydro potential of 23117.44 W. This indicates that the magnitude of microhydro potential energy is influenced by three factors namely waterfall height, waterfall speed and flow rate of waterfall. The magnitude of the microhydro potential is influenced by the two kinetic energy kinetic energy due to the flow velocity and potential energy due to the difference of position.

The result data of study on damarwulan waterfall is used as the basis in arranging the student worksheet. The design of the contextual student worksheet on the subject of fluid dynamics compiled in this study consists of several parts of teaching materials, sample questions, and practice questions. Teaching materials contain the translation of the material according to the subject presented and some supporting parts such as the picture of the event process and the concept behind the event. Examples of questions and problems to solve to improve students' understanding of the material. Exercise questions to load questions that must be done students so that students know the level of students' understanding of the material. Teaching materials, exercise questions, and examples of problems in the design of student worksheets using images and data from the results of studies on waterfalls damarwulan. The following is a student work sheet design of fluid dynamics material at damarwulan waterfall.
CONCLUSION

Based on the result of research of fluid dynamics study which has been done in waterfall Damarwulan Ledokombo Jember District through data collection using direct measurement method and cross mathematical check, it can be concluded that waterfall can be used as a contextual example of dynamic fluid learning support in SMA. This is because the data of direct measurement results indicate conformity with the concepts and theories contained in the dynamic fluid. The data of the research results are then compiled and made into the work plan of the students with the contextual content. Materials that can be taught as dynamic fluid learning attendees through the design of contextual worksheets include flow and debit rates, the principle of continuity, bernoulli law and free fall motion, and microhydro potential. Each material prepared in the student worksheet plan consists of materials, questions and examples of contextually charged questions.

REFERENCES


