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Analysis of Physical Concepts in Nganjuk Tourism Banyu Biru Hot Springs

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ABSTRACT

Banyu Biru hot springs is one of the tourist attractions in Gondangwetan Village, Jatikalen District, Nganjuk Regency, which has geothermal manifestations in the form of hot springs, which indicate the existence of a geothermal reservoir below the surface. This study aims to analyze the physics concepts found in Banyu Biru hot spring tourism, as well as the physics that shapes it. This study uses qualitative research in the form of a literature review. The research was conducted by collecting library sources, classifying data, managing data, citing references, abstracting data, interpreting data, and drawing conclusions. Based on the results and discussion, it can be concluded that the Banyu Biru hot springs are a local culture in the Nganjuk Regency area. The formation of the Banyu Biru hot springs was influenced by the location of Nganjuk Regency which is between Mount Wilis and Mount Pandan. Based on the location of Nganjuk Regency, it is possible that it has something to do with the volcanic activity of the volcano. The geothermal phenomenon at the Banyu Biru hot springs was discovered after drilling a well to irrigate the rice fields. The hot water has a temperature of approximately 37°C with a depth of 250-300 meters. Apart from that, the Banyu Biru hot springs in Nganjuk Regency can be studied physically, namely there are concepts regarding geothermal energy, geothermal energy, geothermal systems, conduction and convection. This study can raise public awareness of local cultural identity through the integration of local wisdom into physics education.

INTRODUCTION

Physics is science or the science of nature in a broad sense. Physics analyzes non-living natural phenomena or matter within the scope of space and time. Physics studies the behavior and properties of matter in very diverse fields, from the smallest particles that make up all matter to the behavior of the material of the universe. Physics is called a fundamental science because every other natural science (biology, chemistry, geology, etc) studies certain types of material systems that obey the laws of physics (Yusniati & Yusuf, 2023).

One of the challenges in learning physics is creating experiences by involving students' active role in building comprehensive mastery of physics concepts. These physics concepts can be developed by students to solve physics problems. Mastery of concepts is students' ability to accept and understand theoretical concepts and physics principles correctly so that they can be applied in everyday life. In the physics learning process, teachers are expected to be able to guide students to understand concepts and connect them with other concepts and not just memorize them. Reasoning abilities and concept maturation are really needed in studying physics to connect one concept (Halmuniati et al., 2023).

Learning applied to improve students' understanding of concepts in the application of physics concepts can be linked to ethnoscience (Dani et al., 2023). Ethnoscience is a science that studies or examines knowledge systems and cognitive types of certain cultures (Irawan & Muhartini, 2019). In some cases, ethnoscience has similarities with local wisdom. Local wisdom is a local wealth related to a way of life that adapts policies based on traditions that apply in an area, so that local wisdom not only contains cultural norms and values, but also contains all elements of ideas that related to technology, health care, development and aesthetics (Jamson, 2015).

Tribes spread throughout Indonesia have a variety of distinctive local wisdom (Rezky, et al, 2023). One of the local wisdoms in Indonesia that is interesting to study is the local wisdom of the Javanese tribe. Nganjuk Regency is one of the areas in East Java that has the potential to develop tourism in the area. Nganjuk is an area in Indonesia with geothermal manifestations, one of which is the Banyu Biru hot springs located in Gondangwetan Village, Jatikalen District, Nganjuk Regency. The beginning of this hot water bath was because a well was drilled to make a flow for the rice fields, but the water that came out was hot water with a depth of around 250-300 meters which had a hot temperature of around 37° C (Kamilah, 2022).

Philosophically, local wisdom is related to scientific phenomena. This is reinforced by research conducted by Verawati & Wahyudi (2024) that local wisdom in communities is related to science. In this context, research needs to be conducted to understand local wisdom scientifically. The importance of this is supported by several references in understanding the context of science and local wisdom in scientific thinking (Suarmika et al., 2020; Erman & Wakidah, 2024; Arjaya et al., 2024).

In this context, scientific analysis is needed to understand the in-depth concept of Banyu Biru local wisdom. Science is not only related to the events of surrounding objects, but also includes the physics of physical phenomena and the structure of the earth (De Laurentis et al., 2023; Kersting et al., 2021; Hesse & Cassak, 2020). To further focus, this study limits itself to the concepts of physics and earth science in analyzing the scientific concept of banyu biru, thus making it a novel research topic.

The novelty of this study lies in the examination of physics concepts at the Banyu Biru hot spring resort as an object of ethnoscience that is analyzed scientifically through a literature review focusing on the concepts of temperature and heat. This study discusses local phenomena such as geothermal energy, conduction, and convection in the context of physics education, which previously only discussed from the perspective of tourism. Based on the description above, researchers realize the need to identify the Banyu Biru Hot Springs as a local culture of the East Java community in physics learning. And it was appointed as a research topic integrated into the concepts of temperature and heat which aims to analyze the physics concepts in the Banyu Biru hot spring tourism.

RESEARCH METHOD

Research Design

This study uses a descriptive qualitative exploratory design with a phenomenological approach (Damarsha et al., 2024; Suprapto et al., 2022; Aspers & Corte, 2019). The research flow design is illustrated in the figure 1 below.

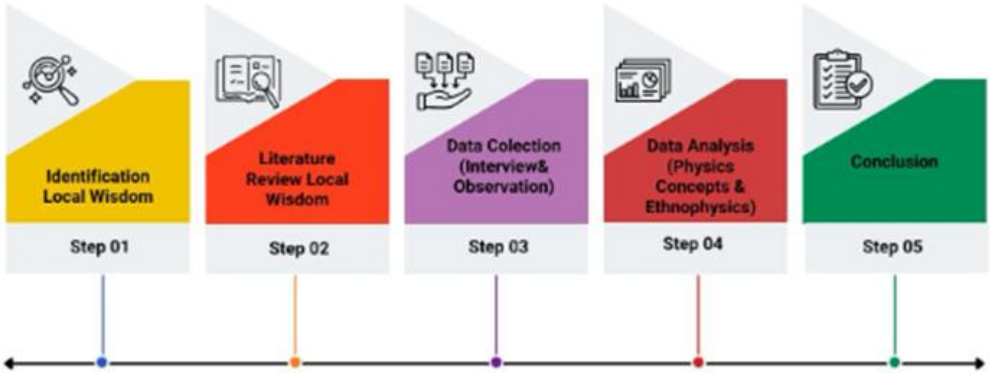

Figure 1. Descriptive Qualitative Research Flow

In the first stage, researchers identified local wisdom phenomena to be used as research subjects. At this stage, researchers selected local wisdom that could be studied through the concept of physics. In the second stage, the researchers conducted a literature review of local wisdom related to the concept of physics. In the third stage, the researchers collected data through interviews and observations. In the fourth stage, the researchers analyzed the data from the interviews and observations. In the final stage, the researchers concluded the results of the research.

Data Collection

This data collection technique uses purposive sampling of informants based on the required criteria (Campbell et al., 2020; Safitri et al., 2023). Interviews were conducted with informants who already understood the local wisdom about *Banyu Biru hot springs*. This made it easier for researchers to obtain information about the local wisdom of *Banyu Biru hot springs*. In the ethnophysics study, the researcher used observational data and literature reviews related to the physical phenomena of *Banyu Biru hot springs* (Darmalaksana, 2020).

Data Analysis

The research analysis technique involved reducing the data from the interviews with informants and observations through an ethnophysics approach (Sari et al., 2023). Additionally, according to Nurhidayat et al. (2020), data reduction enables researchers to analyse initial data into data that is more relevant to the research objectives. Primary data obtained from observations and interviews will be examined in relation to existing physics concepts. Secondary data, which consists of articles related to ethnophysics in *kayangan api*, will also be examined.

RESULTS AND DISCUSSION

Introduction to Banyu Biru Hot Springs

Nganjuk Regency is located between the slopes of Mount Wilis to the south and to the north of Mount Pandan (Delfianto, 2021). One of the geothermal sources in Nganjuk Regency is located in the middle lane of East Java province, namely in the agricultural area between the slopes of Mount Wilis and Mount Pandan. Based on the location of Nganjuk Regency, it is possible that it has something to do with the volcanic activity of this volcano. The geothermal phenomenon at the Banyu Biru hot springs, Gondangwetan Village, Jatikalen District, Nganjuk Regency, was discovered after drilling a well to irrigate rice fields, the hot water had a temperature of approximately 37°C with a depth of 250-300 meters. The existence of these hot springs indicates the existence of a geothermal reservoir beneath the surface. This geothermal source can potentially develop into a tourist attraction (Luthfin A & Jubaidah NA, 2023).

Based on previous research, the potential of Banyu Biru hot spring tourism was discovered in 2007 to facilitate irrigation of rice fields in Gondang Wetan Village, which obtained an artesian well from Nganjuk Regency. When drilling was carried out on the well, it turned out that the water source that came out was a hot spring. After analysis by previous researchers, the hot spring source was found to have a temperature of 75°C and did not contain sulfur, making it good for health and surrounding plants. The health benefits include its use as an alternative treatment or therapy for rheumatic diseases. This has attracted visitors seeking alternative treatments, marking the beginning of the utilization and management of Banyu Biru hot spring tourism (Muzaqi et al., 2024).

Analysis of Physics Concepts in Banyu Biru Hot Springs

a) Geothermal Energy (*Geothermal*)

Geothermal energy or geothermal is energy produced by magma in the bowels of the earth. Geothermal energy is formed beneath the earth's surface or in the earth's core naturally. The composition of the layers of the earth consists of the innermost part of planet earth, namely the inner core *which* is solid, then the outer core *which* is liquid *and* the mantle *which* is semi-liquid because in this layer, rocks experience physical changes due to temperature and pressure. The deeper you go into the bowels of the earth, the higher (hotter) the temperature will be. Geothermal energy is generally associated with the presence of volcanoes (Wijayanti, 2023).

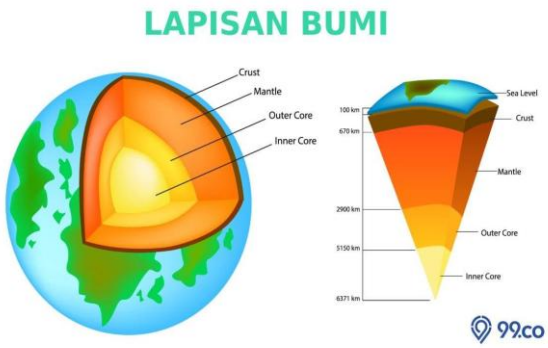

Figure 2. Layers of the earth (Source: https://buddyku.com/)

Geothermal energy is energy formed from the flow of water on planet Earth which is heated by magma so that heat is produced. From the research results, areas with geothermal potential are identical to areas located at the junction of two plates. At a depth of several kilometers the area emits constant steam and hot springs. Geothermal heat is related to the mechanism of magma formation and volcanic activity on earth.

b) Geothermal Formation

As in Indonesia, there are usually geothermal formations in volcanic pathways which can influence geological processes that occur along volcanic pathways. When magma deforms into a breakthrough form and a volcano erupts, faults form along the path of the volcano causing uplift. In the formation of a mountain system, this uplift process causes the affected area to be lifted higher than the surrounding area. Because in that area the rainwater that is absorbed will be much more than in the surrounding area. This area became a place for meteoric groundwater during geological time whose path was a source of water for the surrounding lowlands. On the other hand, fault lines created by uplift allowing hot water and steam to penetrate the earth's surface indicate the existence of a geothermal system.

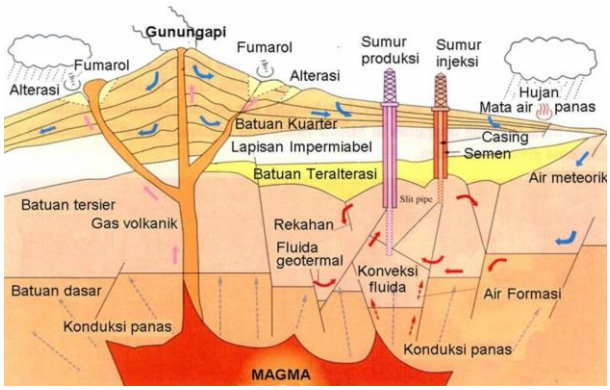

Figure 3. Geothermal system (Source: https://4.bp.blogspot.com/)

Inside the rock there will be water that has been heated and gathered because it is surrounded by a waterproof layer caused by the water and steam in it so that it is in a state of high hydrostic pressure. Hydrostatic pressure is the pressure caused by the force that exists in a liquid against an area of pressure located at a certain depth. A point in a liquid located at a depth h from the surface of the liquid experiences the gravity of the liquid above it. The gravity force is distributed evenly over the cross-sectional area A, resulting in hydrostatic pressure, namely:

$$P = \rho g h \qquad (1)$$

Information:
P = hydrostatic pressure (N/m^3 or Pa)
ρ= density (kg/m^3)
g= acceleration due to gravity (m/s^2)
h = depth (m)

At very high pressure, saturated steam will occur in the reserve rock which will become a liquid phase, causing the reserve rock system to have two vapor phases, namely the first, the condensed liquid-vapor phase and the second, the actual vapor phase. After that, the hydrostatic pressure will decrease and be released due to drilling which results in the water having a high temperature and then turning into steam.

c) Geothermal Systems

Surface manifestations usually indicate the existence of a geothermal energy system. Some surface manifestations show symptoms, namely fumaroles and solfatara, hot springs, hot mud, soil vapor, geysers, craters and alteration rocks. The essential components of a geothermal system, according to Suharno (2010) are:

1) Heat source (heat source).
2) A reservoir or porous rock where hot steam is trapped inside.
3) Caprock or covering layer in the form of claycap (impermeable rock).
4) Geological structure (faults, fractures and unconformities).
5) Water catchment area or subsurface water flow (recharge area).

When rainwater (meteoric) containing hydrothermal reservoirs in geothermal fluid will seep through the subsurface and be heated by a heat source (Figure 3). Water that flows through permeable rock gaps propagates through the rock (conduction) and propagates fluid (convection), which occurs basically due to buoyancy force (Singarimbun A, 2020).

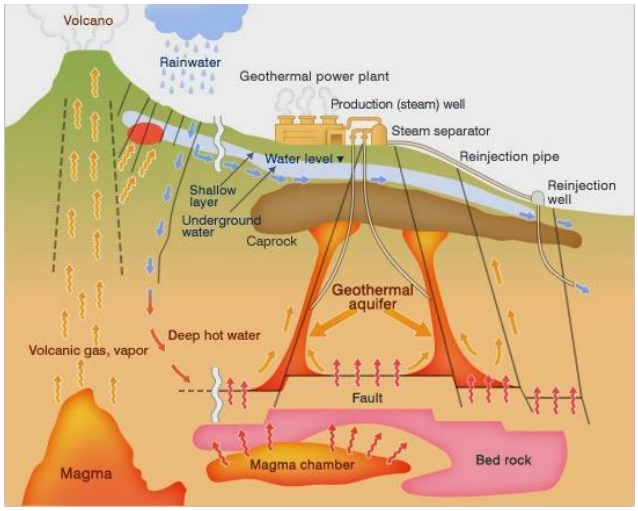

Figure 4. Geothermal System (Source: https://arriqofauqi.blogspot.com)

d) Conduction and Convection

Basically, geothermal systems are formed from the transfer of a heat source to its surroundings which occurs by conduction and convection. Heat transfer by conduction is a process where heat flows from an area with a higher temperature to an area with a lower temperature in one medium (can be liquid or gas) or between different media in direct contact (Ashari, 2016). Meanwhile, convection heat transfer occurs due to contact between water and a heat source.

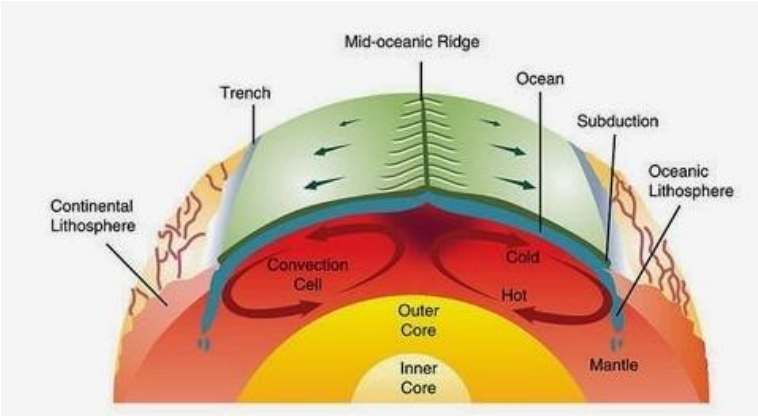

Figure 5. Convection current (Source: https://ocunp.blogspot.com/)

Heat transfer by convection basically occurs due to the buoyant force of water because gravitational force has a tendency to move downwards, however, if the water comes into contact with a heat source, a heat transfer event will occur so that the water temperature becomes higher and the water becomes lighter. The process of geothermal formation is related to convection currents. Groundwater is trapped in impermeable rock and is above a magma chamber or hot rock which is in direct contact with magma causing the water temperature above it to be relatively high (100^{o}C - 250^{o}C). At relatively high temperatures, the groundwater experiences evaporation, if there are cracks or fractures on the surface that connect the surface to the place where the heated groundwater is trapped, then manifestations of heat will be visible on the surface (Farel Robawa, 2016). This event causes the movement of water, namely hotter water upwards and colder water moving downwards, resulting in water circulation or convection currents (Nenny, 2001).

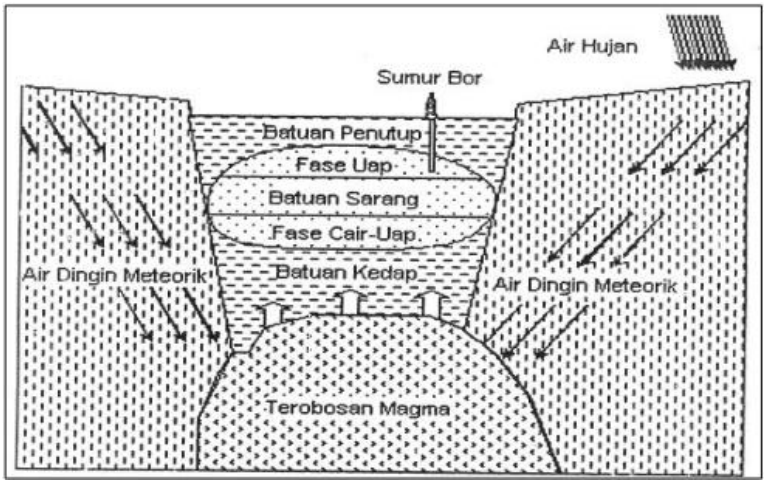

Figure 6. Geothermal System

CONCLUSION

Based on the results and discussion, it can be concluded that the Banyu Biru hot spring is part of the local culture in the Nganjuk Regency. The formation of the Banyu Biru hot spring was influenced by the location of Nganjuk Regency, which is situated between Mount Wilis and Mount Pandan. Based on the location of Nganjuk Regency, it is possible that this is related to the volcanic activity of the mountains. The geothermal phenomenon at the Banyu Biru hot spring was discovered after drilling a well for rice field irrigation. The hot water has a temperature of around 37°C at a depth of 250-300 meters. In addition, the Banyu Biru hot spring in Nganjuk Regency can be studied physically, namely the concepts of geothermal energy, geothermal systems, conduction, and convection. This study hopes to contribute to providing scientific information and realizing the SDGs program. This study is limited to the concepts of physics in geology through observation. Further research is recommended to conduct in-depth analysis and contribute to education.

AUTHOR CONTRIBUTIONS

Galuh Dwi Krisanti: Conceptualization, Methodology, and Validation; **Siti Nur Aisah:** Conceptualization, Methodology, and Validation; **Adrian Bagas Damarsha**: Methodology, Formal Analysis, Resources, and Writing - Original Draft; **Nadi Suprapto**: Data Curation, Project Administration, and Writing - Original Draft; **Setyo Admoko**: Data Curation, Project Administration, and Writing - Original Draft; and **Kifle Kassaw Mulatu**: Data Curation, Project Administration, and Writing - Original Draft.

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