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Exploration of Physics Concepts in Milkfish Cultivation as An Ethnoscience Study in Sidoarjo

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Abstract

Indonesia has a cultural diversity embedded in the local wisdom of the region and has become an invaluable asset. Local wisdom is a form of native science of the community that has not been conceptualized scientifically but still can be a potential source of learning for students to study science as a form of ethnoscience. One of the local wisdom in Sidoarjo Regency is the milkfish, a city icon. This research aims to explore the concept of physics in milkfish cultivation. It can be developed to be applied in science learning in schools. This study is a qualitative descriptive study using observation methods and interviews directly with pond workers. In addition, researchers also conduct literature studies to strengthen the analysis of the data obtained. According to the findings, physical concepts are contained in the management system of milkfish ponds, including measurement materials, static fluids, dynamic fluids, thermodynamics, optics, and relativity.

Keywords: Ethnoscience; Physics; Milkfish Cultivation; Local Wisdom; Science Literacy

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INTRODUCTION

Local wisdom, which is part of the indigenous science in the local community, is unconditional science knowledge and formalized textually and contextually (Sudarmin, 2014). Local wisdom is not necessarily science that has no scientific theoretical basis. Local wisdom is still a concrete experience, while scientific knowledge is already a reproducible concept, principle, theory, or law (experimentally tested in a laboratory) which has been recognized by the scientific community and characterized as objective, universal, and accountable (Suastra, 2015; Sumarni et al., 2016). Local wisdom continues to be revived in the community environment and used in everyday life, one of which is in the people's livelihood activities in their area.

Milkfish cultivation has become a culture of several regions in Indonesia. One of them is in Sidoarjo Regency, making shrimp and milkfish a city icon. According to data from the Fisheries Office of Sidoarjo (2019), about 45% of the agricultural cultivation production in Sidoarjo is the production of milkfish. This result isn't spared from the pond management system in Sidoarjo, which

is good so that the milkfish output is large enough quantities. This pond management system can be a source of learning for students associated with science. Indigenous knowledge of fisheries and agricultural systems communities can often provide potential ideas and learning to utilize and manage sustainable natural resources (Agusanty & Arief, 2021; Mulyoutami et al., 2004).

Each student comes from a different background. Students bring many ideas to the classroom based on different experiences and backgrounds, including statements that interpret other science concepts (Handayani et al., 2019). It is possible to make something experienced or believed by students as a source of scientific knowledge. According to Kurniawan and Syafriani (2020), improving the understanding of student concepts can be done by providing media approach support that follows social and cultural conditions in the environment around students. Studying the local wisdom can help students understand the close relationship between humans and nature, seeing from the cultural context of their surrounding environment (Zidny et al., 2021).

The approach that can be taken to integrate local wisdom in the area into science learning in schools is the ethnoscience approach. The original science of society can be transformed into science through ethnoscience (Masfufah & Ellianawati, 2020; Sudarmin & Rahayu, 2015). The development of science rooted in ethnoscience has been done by reconstructing local wisdom or traditional knowledge of the community. This reconstruction resulted in a review of new findings expected to be adapted as supporting learning materials. In addition, reconstruction can be an opportunity to provide awareness to students of the potential of areas that can be developed and the importance of maintaining environmental conditions (Sudarmin et al., 2017).

The application of local wisdom in learning has positive impacts on students. Students are judged to learn more effectively by using the surrounding environment or equipment. It will give rise to students' curiosity so that students are encouraged to make observations, ask, try, and make conclusions based on the experience of the scientific method that they went through (Damayanti et al., 2017; Wiyanto et al., 2013). Learning results obtained from experience from the scientific process will last longer in the students' memory (Juariah et al., 2013; Damayanti et al., 2017). On the other hand, five learning advantages that integrate local wisdom into learning are: 1) learning is more relevant to the real world; 2) it equips the specific competencies of students as life skills; 3) it encourages the birth of creativity in students; 4) encourage the birth of professional entrepreneurs; and 5) encourage cooperation with the community (Asmani, 2012; Sarah et al., 2019).

Meanwhile, physics is one of the subjects that enter the scope of natural science. Physics subjects are considered quite difficult for students and regarded as less attractive. Based on research conducted by Hamdi & Rahim (2020), some students find it difficult to understand the concept of physics. According to the students, physics subjects are not related to everyday life, so they think of not becoming closer to the environment after studying physics. Students do not know the in-depth purpose of studying the concept of physics in the future. Therefore, we can see how important it is to integrate the environment around students into the physics learning materials. It is also a challenge for teachers to connect the local potential of the area that can be incorporated into the material as a

supporter of student understanding related to the physics concepts taught in school.

Research conducted by Misbah & Fuad (2019) has successfully explored local wisdom in South Kalimantan and connected it with the physics concepts. Research conducted by Wulansari & Admoko (2021) has explored the idea of physics, including Newton's Law in Dhadak Merak Dance from Ponorogo. In addition, Tamelan et al. (2021) has successfully explored the physics concepts, including Newton's Law, temperature and heat, and the kinematics of motion in making Traditional Woven Mats.

In line with them, this research aims to investigate the farm management system in Sidoarjo Regency to find the indigenous knowledge of the local community that can be reconstructed into scientific knowledge, especially on the concept of physics. Furthermore, the exploration of the indigenous knowledge of this community can later be applied in learning in schools as an integration between ethnoscience and learning materials. Through this ethnoscience-based learning, students are expected to understand the concepts of science more deeply, apply the knowledge they absorb into the surrounding environment and be aware of how important the area's local culture is to continue to be preserved.

METHOD

This research was conducted in descriptive qualitative. We use exploratory research to explore the physics concept on the management of milkfish ponds. Exploratory research cannot establish whether a phenomenon exists (Strydom, 2013; Casula, Rangarajan, & Shields, 2021), especially the physics concept conducted in this research. We also use grounded theory to define the physics equation that works on milkfish ponds' management. Grounded theory lets the researchers simultaneously develop an approach from data collection, coding and analysis, and theoretical sampling (Kolb 2012; Casula, Rangarajan, & Shields, 2021). The study was conducted at one milkfish cultivation in Kalanganyar, Sedati, and Sidoarjo. The data was obtained through interviews with farmworkers involving field records and audio recordings. Three participants answered open-ended questions related to the systematic management and state of the milkfish pond as a whole. However, it does not rule out the possibility that participants will develop by applying the snowball sampling technique until they reach a saturation point where no other possibilities can be collected to support the research objectives (Ardila & Hartanto, 2017).

In addition to interviews, structured observations are made by researchers to match the results of interviews with conditions seen by researchers directly in the field. Data analysis is carried out continuously from the beginning to the end of the study. As a supporter of data, researchers conducted a literature study on physical concepts that would later be found in observations and interviews (Dewi et al., 2019). Literature studies are conducted by searching for articles and journals relevant to the purpose of the research. Finally, the research data are validated by triangulation involving all three data collection techniques to properly understand a problem (Bowen et al., 2017; Nuroso et al., 2018).

RESULT AND DISCUSSION

The results of exploration from the Tambak Cemandi show the value of local wisdom and ethnoscience potential that can be applied as a reference for science learning. The results of the Tambak Cemandi exploration are listed in Table 1.

Table 1 Exploration results of tambak cemandi

No.	Documentation	Exploration Results
1.	 Figure 1. *Timbangan Kodok* Source: infopublik.id  Figure 2. *Timbangan Duduk* Source: jatimtimes.com	*Timbangan Kodok* and *Timbangan Duduk* are used to weigh the weight of the milkfish to be marketed. *Timbangan Kodok* is used for fish in units, while *Timbangan Duduk* is used for many fish.
2.	 Figure 3. Water irrigation on ponds Source: Research Documentation	Tambak Cemandi is a saltwater pond that comes from seawater. Irrigation on ponds relies on the tides of the sea. Seawater flowed through the pond irrigation system, from the wide river to the small sewers of the flood gates before heading to the pond.
3.	 Figure 4. Pond Floodgates	Filling the water on the pond is done by opening the floodgates equipped with a minimum of two nets to minimize the entry of potential predatory pests, wild fish, competing organisms, and disease seeds. In addition, ponds in the inner area have greater depth than the coast.

No.	Documentation	Exploration Results
	Source: Research Documentation	
4.	 Figure 5. Use of Blowers on Ponds Source: Research Documentation	In addition to the floodgates, the water filling on the pond can be done through a blower as a water pump. When the tide is not too high, the rope uses a blower to suck up the water and drain it into the pond.
5.	 Figure 6. Aeration System for Milkfish Fry Source: Research Documentation	The breeding pond of milkfish supplies oxygen to the water manually by opening a slight hole in one floodgate as the entrance of the water and another door as an exit.
6.	  Figure 7. Oxygen for The Delivery of Milkfish Saves Source: Research Documentation	The delivery of milkfish seedlings is done by inserting several milkfish saplings into a large plastic bag. The tether provides oxygen to the plastic bag containing the fish before delivery.
7.		*Perayang* is used to trap shrimp as an additional livelihood for farmworkers besides milkfish harvest. Traps are installed by submerging *Perayang* into the water for the night. Shrimp that goes into *Perayang* can't get back out.

No.	Documentation	Exploration Results
	Figure 8. *Perayang* Source: Research Documentation	
8.	 Figure 9. Theodolite Source:pengadaan.web.id  Figure 10. Use of GPS to Measure Area Source: (Firmansyah, 2016)	The Fisheries Office of Sidoarjo uses a tool called theodolite to measure the area of the pond. Theodolite can determine the height of the ground with a horizontal angle and an upright angle. In addition, GPS is used to see the pond area in a picture of satellite imagery.

Analysis of physical concepts related to the results of these findings can be spelled out as follows.

Timbangan Kodok and Timbangan Duduk

Timbangan is measuring instrument to determine the mass of objects. The patching in Tambak Cemandi uses two types of scales, namely *timbangan kodok* and *timbangan duduk*. *Timbangan kodok* is used to consider the weight of a small amount of milkfish. In contrast, *Timbangan duduk* is used to weigh large numbers of fish. Both are types of manual scales. Manual scales work manually through human intermediaries often used in everyday life (Wahyudi et al., 2018). This type of scale uses a spring system to perform a weight measurement process by measuring the spring's distance with the range prepared due to load (Hulu, 2018). *Timbangan kodok* uses pendulum child scales which weigh 50-1000 grams. In contrast, the scales of *timbangan duduk* can measure up to 500 kg.

Students are expected to understand physical materials regarding measurements related to quantities, units, and measuring instruments through both of them. The use of *timbangan kodok* and *timbangan duduk* can be conveyed as narratives that exemplify magnitudes and units in everyday life as a form of physical literacy.

Waterways

Tambak Cemandi uses a natural irrigation system where the water in the pond is saltwater that comes from the sea. Seawater flows through rivers that

connect the coast with ponds. The width of the rivers and waterways on these ponds are different. Water from a wide river has flowed first into the canal of ponds that have a smaller width. The water flow has a discharge that can be measured using the following equation.

$$Q = A.v = \frac{V}{t} \qquad (1)$$

In addition, cross-sectional differences between rivers and pond flood gate channels can be applied to the continuity fluid flow equation. This continuity equation connects the velocity of the inner fluid from one place to another, in the case of this milkfish pond from the river to the pond's floodgate channel.

The measurement of water discharge in milkfish pond waters is shown in Figure 11.

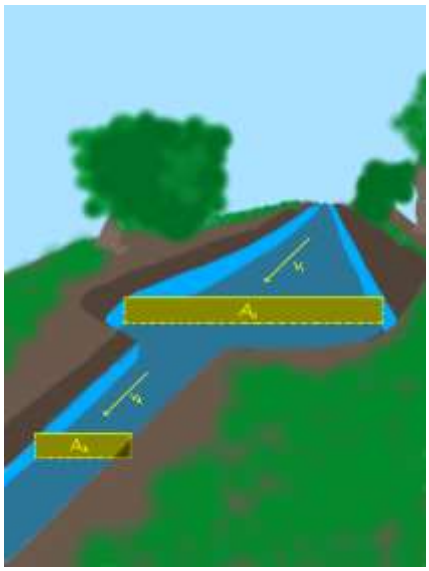

Figure 11 Measurement of water discharge in milkfish pond waterways

The equation can be written as follows.

$$Q_1 = Q_2$$

$$A_1 v_1 = A_2 v_2 \qquad (2)$$

Where Q_1 acts as a water discharge in the flow of the river, Q_2 as the discharge of water in the irrigation flow of the pond, A_1 is a large cross-section of the river, A_2 is the large cross-section of the pond irrigation canal, is v_1 the speed of water flow on the river, and v_2 is the speed of water flow in the irrigation canal of the pond.

Floodgates and Blowers

Water enters through the floodgates installed on each plot of ponds. The more it enters the propagation area, the larger the pond plot has a greater depth. It indicates that the site where the initial entrance of the water has a greater height than the inner pond area. That means water flows from a high place to a lower position.

However, at certain times, the water coming from the sea is not too high, so it takes help to suck the water until it flows into the pond area. The tool is used in the form of a blower in a huge size. The size is enough to move the water with large amounts so that pond water management is not constrained even though the tide is not too high. In addition, it suggests the water can flow from a low to a higher position.

If we look at the physics concepts, the irrigation of this milkfish pond corresponds to dynamic fluid matter. More specifically, the topic of physics that corresponds to this phenomenon is Bernoulli's law.

The application of Bernoulli's Law on Milkfish Pond Blowers is shown in Figure 12.

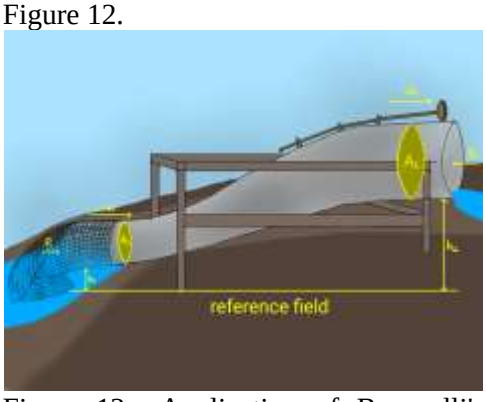

Figure 12 Application of Bernoulli's law on milkfish pond blower

The applicable equations of Bernoulli's applicable law can be written as follows.

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2 \quad (3)$$

Where P_1 is the pressure in the direction of the flow of water enters a small cross-section of the blower, P_2 is the pressure in opposite the direction of the flow of water, v_1 is the speed of water flow at a small cross-section, v_2 is the speed of water flow on a large cross-section, h_1 is the small cross-sectional height of the field of reference, h_2 is the height of the large cross-section of the field of reference, ρ is the mass type of water, and g is the acceleration of gravity.

Aeration

Dissolved oxygen is an important water quality changer in aquaculture (Nasrul et al., 2018). The system of adding dissolved oxygen in a pond is known as aeration. The use of aeration can be done with the help of a tool called an aerator. Aeration can be done in two ways: air is inserted into the water by being immersed (splasher aerator) or air bubbles released into the water (bubbler aerator) (Nugraha et al., 2017).

Tambak Cemandi, especially in the nursery area of milkfish, uses a simple aerator system by utilizing differences in water levels and watergate boards that are left open with small holes. Water enters at one door and exits at the other so that the volume on the pond area remains. It gives rise to a small shower that flows from the hole on the water door board. If attributed to the physics concepts, this phenomenon characterizes the application of dynamic fluids to the topic of leaking water tanks.

The application of Bernoulli's law for the case of water tank leakage in milkfish pond aeration is shown in Figure 13.

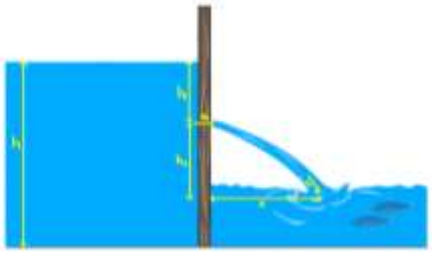

Figure 13 Application of Bernoulli law for cases of leaking water tanks in aeration of milkfish fry ponds

Bernoulli's law's applicable equation for the case of the applicable leaking water jackfruit can be written as follows.

$$v_0 = \sqrt{2gh_1} \quad (4)$$

$$v_t = \sqrt{v_0^2 + 2gh_2} \quad (5)$$

$$x = 2\sqrt{h_1 . h_2} \quad (6)$$

$$t = \sqrt{\frac{2h_2}{g}} \quad (7)$$

Where v_0 is the initial velocity of water flow, v_t is the final velocity of water flow, h_1 is the distance of the hole from the starting surface of the water, h_2 is the height of the hole from the endpoint of the fall of water, x is the distance of the range of water flow horizontally, t is the length of water pouring, and g is the acceleration of gravity.

Fish Delivery

In making the delivery, the seedlings of milkfish are put in a large plastic bag that is given an oxygen supply. Oxygen administration is done by applying pressure to the oxygen gas from the tube to the plastic bag. The oxygen administration will make the plastic bulge prominent. In addition, the oxygen put in the plastic bag will press the plastic wall outwards.

Boyle's law on oxygen replenishment for milkfish delivery is shown in Figure 14.

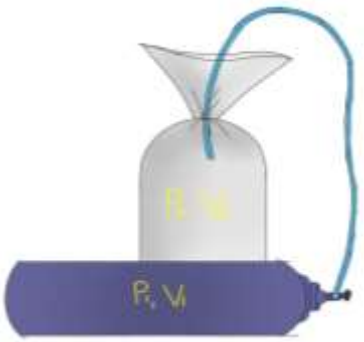

Figure 14 Boyle's law on oxygen filling for the delivery of bandeng fish

This phenomenon can be related to thermodynamics in closed systems and constant temperatures. The law that applies to this concept is Boyle's law. The equation can be written as follows

$$P_1V_1 = P_2V_2 \qquad (8)$$

Where P_1 is the pressure in an oxygen gas tube, P_2 is the pressure in a plastic bag, V_1 is the air volume in a gas cylinder, and V_2 is the air volume in a plastic bag.

In addition, the water in the plastic bag puts pressure on the fish in the water, as shown in Figure 15.

Figure 15 Hydrostatic pressure at the time of milkfish delivery

This pressure is known as hydrostatic pressure.

$$P_h = \rho g h \qquad (9)$$

Where P_h is hydrostatic pressure, ρ is the mass of the water type, g is the acceleration of gravity, and h is the depth of the fish from the surface of the water.

Perayang

In addition to livelihood, pond workers also cooked shrimp trapped in a container called *perayang*. The man who had been baited was then drowned for the night until the next day was retrieved. This tool is made of pieces of bamboo assembled, which shrimp can enter but cannot come out anymore. *Perayang* is inserted into the pond until all parts of its body are submerged in water.

The sinking of the material can be attributed to the physical matter regarding static fluids. The drowning of *Perayang* in the pond can be attributed to Archimedes' law, as shown in Figure 16.

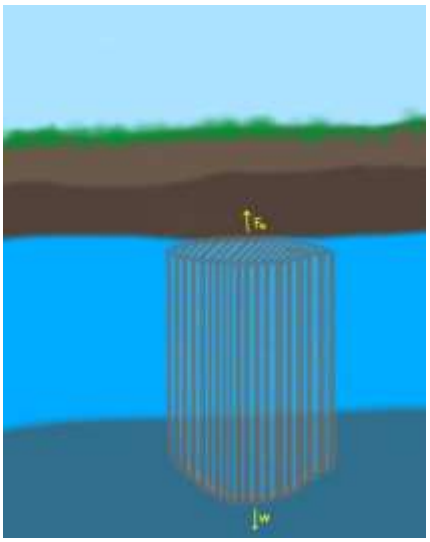

Figure 16 *Perayang* Sink into Water

The applicable equation can be written as follows.The magnitude of the water pressure force can be expressed in the following equation.

$$W = m_{perayang} \cdot g = \rho_{perayang} \cdot g \cdot V \qquad (10)$$

$$Fa = \rho_{air} \cdot g \cdot V_{bf} \qquad (11)$$

Where W is the weight of *perayang* in water, $m_{perayang}$ is the mass of *perayang*, $\rho_{perayang}$ is the mass type of *perayang*, V is the total volume of *perayang*, Fa is the lifting force of *perayang* (Archimedes' force), ρ_{air} is the mass of the type of water, V_{bf} is the volume of *perayang* that is dyed in water, and g is the acceleration of gravity.

Perayang will sink when the force of water pressure is less than the object's weight. *Perayang* will remain suspended at its present depth when the force of water pressure is equal to the object's weight. *Perayang* will float when the force of water pressure is greater than the object's weight.

Theodolite and GPS

At some time, the Fisheries Office of Sidoarjo will survey the cultivations in Sidoarjo Regency. One of the agendas carried out is the measurement of pond areas. The task is done with the help of a modern tool called theodolite. The tool is a comprehensive measurement tool for determining the angle formed between two points at the time of measurement and obtaining coordinates in a region (Suhendra, 2011; Tribhuwana, 2018). The pond owner will show the boundaries of the pond area while the workers from the Fisheries Office will measure it. The principle of theodolite is more like a telescope mounted on a mounting mount that can move vertically to calculate the height of objects (altitude) and the direction of horizontal to calculate the angle (azimuth) (Akrim et al., 2021).

On the other hand, google maps are also used in mapping the pond area. This feature is called Global Positioning System (GPS). It is a tool or system that can provide information about the position of users as globally as possible on the earth's surface that is satellite data (Santoso & Rais, 2015; Tribhuwana, 2018). Calculating the area can run quickly by entering the coordinates of the boundaries of the region that have been determined and then appeared on the map (Firmansyah, 2016).

Theodolite work that characterizes telescopes can be included in the material of optical instruments. This material is discussed tools that use lenses or mirrors to utilize the properties of light to help vision. In addition, the use of GPS is included in the physical material regarding dilation. GPS systems have deviations due to relativistic effects that cause satellites to lag behind time on earth, so GPS needs to make corrections by regulating frequency (Barry & Humairo, 2019). The theory of gravity also reveals that a clock in motion (e.g. a clock on a satellite or in a moving car) is slower than a clock at rest, resulting in a large difference in the GPS mechanism by up to several kilometres because of relativistic time dilation (Hartini, 2019). In explaining the topic of dilation, the narrative about the use of GPS can be added to the measurement of pond areas as an application of physics literacy.

CONCLUSION

Based on the results, it can be concluded that there are physics concepts in some aspects of the management of milkfish ponds. Aspects of ponds related to the physics concepts include scales, aqueducts, blowers, aeration systems, fish delivery systems, the use of Perayang, and measurement of pond areas with theodolite and GPS. Physical matter is found in the form of measures (quantities and units), static fluids (hydrostatic pressure and Archimedes' law), dynamic fluids (water discharge, continuity equations, and Bernoulli's law), thermodynamics (Boyle's law), optical devices (theodolite), and relativity (time dilation on GPS systems). Further research can be done

by reviewing other concepts. It is advisable to look for more references to help analyze the study of existing concepts in the management of ponds.

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