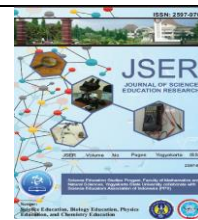




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Metal Industry Waste at Pesarean Village Tegal Regency: Analysis Impact and Potential as Supplement Science Learning

Y. Arfiani^{1,2*}, M. Rahayuningsih³, A. Marianti⁴, A. R. E. Nugraheni⁵

¹Science Education Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang

²Science Education Program, Faculty of Teacher Training and Education, Universitas Pancasakti Tegal

³Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang

⁴Biology Education Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang

⁵Science Education Program, Faculty of Education, Khon Kaen University

*Corresponding Author. Email: yuniarfiani@students.unnes.ac.id

Keywords

Waste Industry Metal, Pesarean Village, Tegal Regency, Impact and Potential, Science Learning

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Phone*: +628562584220

Abstract

This research aims to explore the impact of open burning and dumping on the local metal industry, analyze policies and their implementation regarding these practices, and utilize this pollution issue in learning. Using documentation techniques, interviews, literature studies, and secondary data, the study reveals significant environmental impacts, including air, soil, and water pollution, as well as health risks to the community. The findings of this research are that the problem of metal pollution in Pesarean Village can be included as a complement to environmental physics learning on several materials, namely the environment of water, land, air, pollution, and global warming. Two main impacts are identified: open burning releases harmful gases and particulate matter, leading to respiratory illnesses among workers and residents, while open dumping contaminates soil and groundwater, posing risks to human health and the environment. The government of Tegal Regency has implemented relocation and remediation policies to address these issues. However, challenges such as community resistance and resource constraints hinder policy implementation. The study suggests that the case of Pesarean's metal industry could serve as supplementary learning material for Environmental Physics courses at the university level. By integrating this real-world case into the curriculum, students can better understand environmental issues and develop critical thinking skills to propose effective solutions.

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INTRODUCTION

Many companies in the industry mature This ignores the impact period medium and long-term operation, both in the sector housing area and non-residential. The industry is businesses to make money from material raw or half so. Industry produces goods and services. The materials collected are good in a way direct nor not directly, processed to produce more products beneficial for the public. The term "industry" is used to describe an action company during the production process. Problem environment life becomes more important Because growth industries in various regions and sectors must pay more attention big on the problem (Kong et al., 2022; Mulya Pratomo & Setyadharma, 2020).

In literature about problem environment, three frequent categories used are pollution environment (known as pollution), utilization land in a way no exact (known as utilization land), and draining or its over source Power nature (known as subtraction source Power nature). Problem environment life will Keep appearing all over the Earth throughout resident earth no quick think and try a safe and balanced environment (Peng et al., 2021). Pollution environment, according to Article 1 point 12 of Law Number 23 of 1997, occurs when substance energy, being life, or other components are included in the environment live by activity so that the quality down until to level certain causes environment life no works Again by its designation. Pollution environment not only will damage the ecosystem

but also endanger the health of man. Every type of pollution affects the environment, such as pollution of air, land, water, and sound (Iordache et al., 2010; Kampa & Castanas, 2007).

Pesarean Village is in the District Adiwerna, Tegal Regency. The area is wide 130.83 hectares. With a height of 9.8 meters above the surface sea, 12,444 people are living there. This area is surrounded by sub-districts Jatibarang (Brebes Regency) in the west, District Dukuhuri next door north, Talang and Pangkah subdistricts next door East, District Slawi and Dukuhwaru next door south, and subdistrict Jatibarang next door north. Pesarean Village is famous for its industry of iron casting metal that uses base brass and aluminum; center sale junk metal copper, aluminum, and brass; factory vendors House ladder; and industry stove oil. In the middle 1980s, industrial Pesarean Village metal started to develop, followed by the industry House ladder which produces tin or casting metal with standard battery scrap and materials used. Burning produces waste solid that contains as much Pb 250 kilograms in black or 1000 kilograms of battery used produces about 150 kilograms of waste congested. Exhaust gas also contains particles of dust, SO₂, NO₂, and metals tin (Akhmad & Kusaeri, 2022; Sutjiatmi et al., 2023).

Metal heavy is one of the sources of pollution. Residual metal heavy can enter to environment through waste industries that don't process with Good. Metal heavily pollutes air, water, and land. Industry metal in Pesarean Village, District Adiwerna, Tegal Regency, continues to give rise to problems in an environment that hasn't been resolved. Because of the small industry House ladder or industry small in it, the industry Pesarean Village Metal is included in the category of settlement. Craft metal, stoves, drums, and equipment house ladders are field an industry that started in 1975 and is growing fast. Smelting and casting metal in Pesarean Village uses material standard dry or not use water, so produces waste solid, gas, and smoke. Industry smelting uses tin, brass, copper, and aluminum, and foundries use cell phone casing, doors, belts and goods trashy other. Industry smelting metal Still uses furnace manual burn which does not own a chimney, even though it contains smoke metal containing SO₂ and particles dust, as well as waste solid (powder or particles) and scale combustion (material chemistry) (Lee et al., 2009; Pudjiarti & Darmanto, 2020).

In Pesarean Village, District Adiwerna, Tegal Regency, Central Java, there is a pollution industry of very heavy metals, including B3 waste, which is dangerous and poisonous. Pollution Waste in this area is very serious. The sample test results in blood tests carried out in 2011 on 50 residents of Pesarean Village show that 46 among them were

contaminated with lead and 12 in between they are in condition dangerous. BPPT data also shows that five children in the area were born with a disability, incl paralysis, and mental retardation. Analysis of the impact of industry on the environment in Pesarean Village Tegal Regency is required Because a polluted environment caused by industry Has a significant impact on life surrounding the community (Briffa et al., 2020).

The old problem in Pesarean Village regarding the impact of the metal industry has entered community science which is closely related to school science. This shows that the relationship between school science and community science is complementary in various aspects. School science provides a foundation of theoretical knowledge and academic skills through a structured curriculum, while community science applies that knowledge to solve real problems relevant to people's daily lives. Learning in schools tends to be more theoretical and centered in laboratories, while community science is more contextual, involving active community participation in research and practical applications. Collaboration between the two can improve students' understanding and skills, as well as have a positive impact on social conditions and the community environment. Thus, the synergy between school science and community science plays an important role in creating a society that is knowledgeable, skilled, and able to face future challenges.

Based on these, this study focuses on impact burning free and free dumping from industry metal. Research purposes include: 1) Exploring the impact of Open Burning and Open Dumping activities in industry metal Pesarean Village Tegal Regency; 2) Analyzing policy and implementation policy Open Burning and Open Dumping activities in industry metal Pesarean Village Tegal Regency, and 3) Potential problems with open burning and open dumping activities as a supplement to environmental physics learning.

The results of this study can later be useful to provide an overview to the community regarding how the management of the metal industry can be done to minimize its negative impacts on the community. In addition, this study was also conducted to see the potential for metal pollution problems in Pesarean Village to be included as a complement to environmental physics learning in several materials.

RESEARCH METHOD

This study was done with technique documentation to object research, interviews with resource persons, study literature, and secondary data from several informants, including perpetrator industry metal in Pesarean Village, the Head of

Pesarean Village, the Head of the Tegal Regency Environmental Service, and the community local. Interview results and documentation later will be sources for done analysis impact activity industry metal in Pesarean Village Tegal Regency. To obtain data on the potential of the metal industry as a supplement to science learning, an analysis of

environmental physics learning outcomes was carried out, and identification of the relationship between the material in these achievements and existing problems. The research method is briefly presented in Figure 1.

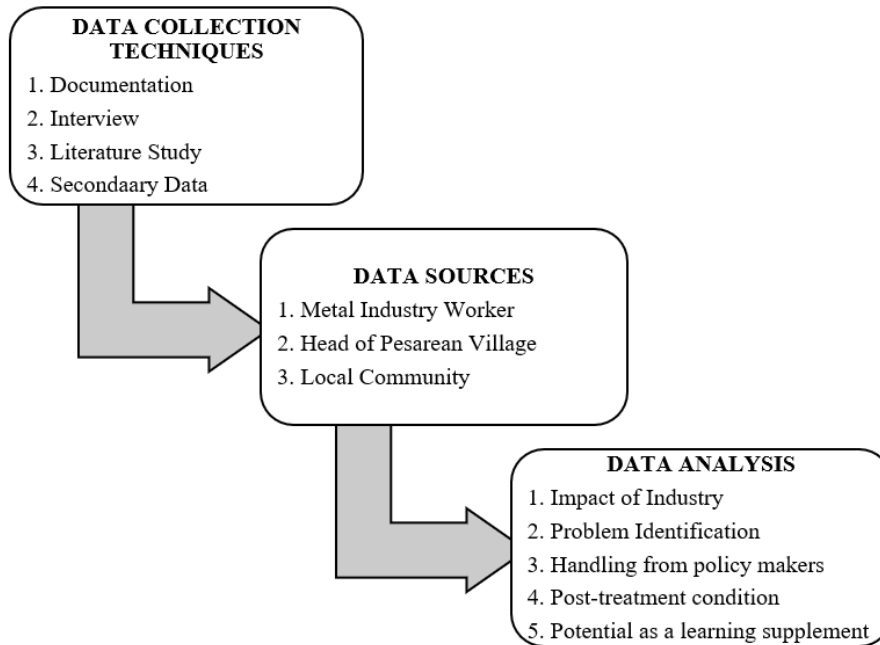


Figure 1. Research Stage

RESULT AND DISCUSSION

Analysis Impact of Open Burning on Industry Pesarean Village Metal

There are two types of business metal in Pesarean Village: smelting metal that uses material standard processed tin, brass, aluminum, and copper to become goods half So or ingots. On the other hand, foundry metal uses materials that wreck it like cellphone casings, used doors, used belts, and materials that wreck others are processed and become goods new, usually from goods. Industry smelting metal is different Because the material standard melted down moreover formerly becomes powder to make it easier to process become product half so. During the melting process, materials standard used for smelting metal are still shaped as powder and can inhaled by people when they breathe and settle inside the body. This can cause diseases such as ASTHMA, ISPA, Ulcers Stomach, Infections Acute System Breathing, etc.

Industry casting metal is not undergoing a melting process. This is due to the processing process material standard more friendly environment than the melting process. The rest of the industry casting metal can be cleaned without

polluting the environment. Industry smelting metal process material standard for producing concentrated gas and smoke. Chemicals contained Still is there, so the smell is very thick and pungent. If inhaled, it will be very suffocating and annoying to respiratory workers working in industry smelting metal.

Analysis Impact of Industrial Open Dumping Pesarean Village Metal

Processing dry metal No using water, so remainder or waste industry smelting metal shaped congested. Garbage pollutes the environment including settlement residents' industry smelting metal because waste is thrown away so quickly. At first, one perpetrator industry, followed by the actor's industry smelting different metals. Waste size big polluting land settlement residents will produce land become black is also dangerous environment life nearby. Apart from annoying the land population, the waste company smelting metal also damages Sunan Amangkurat's grave in Pesarean Village Because location business smelting metal near Sunan Amangkurat's tomb. Hoard waste metal can be seen in Figure 2.



Figure 2. Hoard waste metal around settlement residents of Pesarean Villa

The open dumping industry has a significant impact on soil conditions, causing contamination that damages the physical and chemical properties of the soil. One of the main impacts is changes in soil texture. Research shows that leachate from open dumping contains heavy metals and dangerous chemicals that cause the degradation of soil structure. The soil around dumping sites often becomes more compact and loses its porosity, which reduces the soil's ability to absorb water and support plant life (Lee et al., 2009).

In addition, the color of the soil around the dumping area often changes, usually becoming darker or having strange spots. This discoloration is caused by the accumulation of toxic organic and inorganic materials, including heavy metals such as lead, cadmium, and chromium. Darker colors usually indicate the presence of anaerobically decomposed organic matter, while spots can be caused by heavy metal precipitation on the soil surface (Voltr et al., 2021; Zonayet et al., 2023).

The chemical composition of soil is also greatly affected by open dumping practices. Research shows that soil near open dump sites has much higher concentrations of heavy metals than soil in unaffected areas. Heavy metal contamination such as arsenic, lead, and mercury can disrupt the balance of nutrients in the soil, damage soil microorganisms, and disrupt the natural cycle of organic matter (Zhang et al., 2016).

To reduce these negative impacts, it is important to adopt more sustainable waste management practices and tighten environmental regulations. The use of techniques such as controlled landfills, leachate processing, and regular monitoring of soil quality can help mitigate the damage caused by open dumping. The development of sustainable management strategies is also important to protect public health and the environment (Ben-Moshe et al., 2013).

Policies and Barriers Government Regency related to Industrial Areas Pesarean Village Metal

The government Tegal Regency adopted a policy to reduce pollution of waste industry metal in Pesarean Village. Policy This was made to reduce pollution that has been happening and show that the policy has succeeded in reducing pollution in Pesarean Village. Industry smelting metal causes polluting waste settlement and the tomb of Sunan Amangkurat. Industry casting metal No pollute settlement metal Because their waste for No too dangerous and easy cleaned.

The Government Tegal Regency made three policies: Policy Relocation of Industry Metal to the PIK Kebasen area, Policy Encapsulation (Encapsulating Waste Industry Metals), and Policy Cleaning/ Remediation (Cleaning Waste Smelting Metal). Policy This is made following governing law waste material dangerous and poisonous, PP No. 101 of 2014. PIK (Village Small Industry) is an area provided by the PIK Cooperative for relocating entrepreneurs cor metal that is in settlements so that the impact of pollution on the environment settlement can be stopped. Amount craftsmen smelting metal already relocated A total of 31 craftsmen, while those who have not relocated as many as 12 craftsmen. Facilities and infrastructure in the PIK area such as road plot paved, arrangement location plot organized with neat, there is channel drainage, a toilet, and a wastewater treatment plant, far away from the settlement very precise people for center craftsman melting/casting metal.

Policy second is policy encapsulation. By policy encapsulation, waste solid that collects in the center industry Hamlet Plambon, Pesarean Village, was included in capsules made from geomembranes American technology. Next, waste industry smelting metal will be buried to 4 meters deep, with land clay lined on the edge capsule. Capsule B3 waste will be buried in the ground usually roomy used Pesarean Village children to play football. The theory that has been studied shows that policy encapsulation can endure for two centuries.

After the trial, a lot of consideration and approval was done about policy encapsulation,

which is theoretical and can keep waste for two centuries. However, after trial, this policy can't apply because wide-field football will use no comparable amount of waste produced. Therefore, it is recommended that policy encapsulation not be applied to overcome the waste. This is because if policy is still applied, those only will give rise to problem new.

The next policy is clean-up or remediation. The Danish International Development Agency (DANIDA) proposed policy processing or remediation for changing waste from industry smelting metal to become material standard for making paving blocks through a tender system. Policy This is an NGO initiative working on the environment. As replacement policy encapsulation, policy cleaning uses the tender system to utilize waste produced by industry smelting metal for block paving at the cheapest cost. This Policy is considered effective because it will not change location and will not pollute the environment and water. Several previous PT utilize B3 waste will follow policy This. PT Lut Putra Solder, located in Tegal Regency, is one of them.

Policy This aims to take waste industry smelting metal, including B3 waste, which has been polluted by land settlement residents and the tomb of Sunan Amangkurat, and then used to make paving blocks. This policy uses various types of jobs and level skills to get different tenders in a suite for finished jobs, instead of a single tender for all functions. Companies that can follow the tender system are companies that can utilize B3 waste from industry smelting metal. This company must have more knowledge and abilities to make good and winning tender systems more price economical. Companies This is recommended for drawing up different tenders to ensure that the most competent company can complete the tender. In addition, it is recommended that the tender amount is not too big to avoid any coordination required among contractors.

From the third policy made, only policy relocation and cleanup-Policy Encapsulation (Encapsulating Waste Industry Metals) and Policy Cleaning/ Remediation (Cleaning Waste Smelting Metal)-is sufficient for handling pollution waste industry smelting metal. If implemented to overcome pollution waste industry smelting metal, policy encapsulation will be better. Amount of huge waste No comparable location to be used for hoarding waste with capsule Geomembranes.

There are obstacles found when implementing policy. Society rejecting existing policies is one of the obstacles to the implementation of policy. Policy time relocation socialized; society rejects it for various reasons. Limitations source Power society also becomes a constraint. Policy relocation

is difficult Because lack of knowledge about B3 waste and awareness health. Policy relocation needs time ten years.

Post-Remediation Soil Characteristics

Soil contamination is where the soil has been contaminated with other substances so that it can change the characteristics of the soil. Soil characteristics include several main parameters that are important for understanding the condition and quality of the soil. Physically, soil characteristics can be seen from several things, for example, soil texture, soil structure, soil density, soil water content, and soil color (Cao et al., 2022; Ibrahim et al., 2023).

Based on the results of interviews conducted, the characteristics of the soil before and after being contaminated with B3 waste have different characteristics. Physically, the soil characteristics before it is polluted have a brownish-black color which indicates a healthy balance of minerals and organic matter in the soil. Meanwhile, the condition of the soil after being contaminated with B3 waste has a dark black color because it is exposed to chemical pollutants. The density of the soil before it is polluted is relatively low, allowing plant roots to penetrate the soil easily to absorb water properly. After being polluted, soil density increases due to the deposition effect of chemicals from B3 waste, which can compact the soil. However, based on the results of interviews with residents, plants can grow well when the soil is polluted. The condition of the land after remediation can be seen in Figure 3.



Figure 3. Post-remediation Land Conditions

There are also soil characteristics after land relocation which include soil texture, color, and soil density. The soil texture after relocation becomes stickier compared to the soil outside the relocation area. The color of the soil became yellowish brown because the relocation soil came from a mountainous area. Even though the soil density has decreased, the soil water content is still low, which is indicated by the soil being barren and there are only a few living plants in the form of small grasses.

This comparison shows that land contaminated with B3 waste experiences various significant physical changes that require intensive efforts to be relocated so that it can function properly again according to its intended use. Post-remediation soil conditions are presented in Figure 4.



Figure 4. Post-remediation Soil Conditions

B3 waste contamination (Hazardous and Toxic Substances) has a significant impact on the texture, color, and composition of the soil. Contamination by heavy metals such as cadmium, lead, and mercury cause changes in the structure of soil aggregates. Soil particles can become denser and aggregate, which reduces porosity and water infiltration capacity. This results in decreased soil aeration and increased risk of soil erosion due to loss of soil structural stability (Abidin et al., 2022).

Changes in soil color due to B3 waste contamination vary depending on the type of contaminant. For example, soil contaminated by heavy metals such as chromium may show a red or orange color change due to chemical reactions between the metal and soil minerals. In addition, contamination by organic compounds such as hydrocarbons from industrial waste or oil causes the soil to become darker or even black. This color change is often the first visual indication of contamination (Lee et al., 2009; Zhang et al., 2016).

The chemical composition of soil is also drastically affected by B3 waste contamination. Increased concentrations of heavy metals in soil disrupt the balance of essential nutrients, change soil pH, and often result in reduced soil fertility. Heavy metals can displace important nutrient ions in soil colloid complexes, thereby reducing nutrient availability for plants. In addition, the activity of soil microorganisms is important for organic matter decomposition, and nutrient cycling is also disrupted, which hurts long-term soil fertility.

These impacts not only reduce soil quality but also pose health risks to humans and ecosystems. Contaminated soil can release pollutants into the ground and surface water, which then enter the food chain through plants growing in the soil. Handling

and remediation of contaminated soil is very important to reduce this negative impact. Strategies such as phytoremediation, the use of bioremediation agents, and physical isolation techniques of contaminated soil have been proposed and tested in several recent studies to effectively address this problem (Regmi et al., 2022; Sharma et al., 2018).

Potential Industrial Case Pesarean Village Metal For used as Supplement Science Learning

Problem-related Industry Pesarean Village Metal's potential can lift as a supplement to science learning at the college level. One of the appropriate courses with that issue is environmental physics subject. This subject provides science education students with knowledge about problems, environments, life happens consequences exist phenomena physics as well as experience handling impact. There are 12 (twelve) teaching materials, these are: 1) The Nature of Environmental Physics; 2) Water Environment; 3) Soil Environment; 4) Air; 5) Sound; 6) Radiation; 7) Environment and Environmental Ethics; 8) Environmental Pollution; 9) Management Waste Electronic; 10) Global Warming; 11) New and Renewable Energy; and 12) Handling Impact Problem.

Environmental Physics needs learning that does not only supply ability cognitive just but also affective and insightful skills environment (green behavior). Green behavior is a concept developed in pedagogy for preparing the participant's own competence ecological form knowledge, attitudes, and skills friendly life with the environment. Results of observations and interviews with students and lecturers' guardian eye Environmental Physics lecture show that implementation of the Environmental Physics lecture course Already invites students to study problem environments but still tends dominant in equipping cognitive with concepts of physics, focusing on in-class activities, as well scope the material not yet accommodate in a way contextual related issues environment. This matter causes students' critical thinking skills not to be trained enough to link draft physics with the issue environment in the local area. Issues intended environment like the effect of House glass, interrelation activity man with the environment, global warming, changing climate, and crisis energy (Munguia et al., 2023; Sagala et al., 2019).

Based on problems in learning physics environment as well as teaching material on the eyes studying physics environment, issues pollution Pesarean Village metal can enter as supplement learning like presented in Table 1.

Table 1. Material compatibility with Issue Pollution Industry Pesarean Village Metal

No	Teaching Materials	The studies raised
1	Water Environment	Change properties of water (properties physics, properties chemistry, properties biology) Water pollution as impact of open dumping
2	Soil Environment	Soil Properties Pollution of land as impact of open dumping
3	Air Environment	Pollution air as impact of open burning
4	Environment and Environmental Ethics	Pollution environment and its impacts Related Community Perceptions Ethics Environment
5	Pollution Environment	Impact and Solutions
6	Global warming	Impact carry on Air Pollution due to open burning
7	Handling Impact Problem	The solution is already there done

In studying environmental physics, relating the properties of soil, water, and air to the problem of open dumping of metal waste and open burning can be done by understanding the environmental impacts resulting from these activities. Based on Table 1 regarding soil properties, the practice of open dumping of metal waste results in soil contamination with heavy metals such as lead (Pb), cadmium (Cd), and chromium (Cr). These heavy metals can change the physical and chemical properties of soil, such as lowering soil pH, changing soil structure, and reducing soil water absorption capacity. The study by Mouhoun-Chouaki et al. (2019) showed that the soil around landfills shows a significant increase in the concentration of heavy metals that are harmful to plant growth and soil organisms.

When related to water properties, leachate from landfills containing heavy metals can seep into groundwater, resulting in pollution of water sources used for human consumption and irrigation. Groundwater around a landfill in Lagos, Nigeria, showed significant increases in concentrations of heavy metals, which can harm human health if consumed over the long term (Sodamade et al., 2020). Regarding air properties, the practice of open burning of waste results in the emission of air pollutants such as dioxins, furans, and heavy metals which are dispersed into the atmosphere. These pollutants can cause various health problems such as respiratory diseases and cancer. Open burning of waste produces significant emissions of toxic pollutants that affect local and regional air quality (Ramadan et al., 2022).

The combined impact of open dumping and open burning worsens overall environmental conditions. Soil contamination by heavy metals reduces soil fertility and increases the risk of transferring pollutants to plants, which can then enter the food chain. Water pollution worsens access to clean water and increases the burden of water treatment. Emissions from burning waste worsen air pollution and contribute to climate change. The combination of these practices not only

pollutes the immediate environment but also has long-term impacts on human health and ecosystems (Ferronato & Torretta, 2019; Munguia et al., 2023).

Contextual learning with direct observation of environmental conditions is very important in increasing students' understanding of concepts. This approach allows students to link theories learned in class with practical realities in the field, thereby deepening understanding and triggering critical thinking. For example, by directly observing the impact of open dumping and open burning of metal waste on soil, water, and air, students can see how theories regarding the physical and chemical properties of soil and environmental pollution apply in real situations (Choudhary et al., 2021; Dewi et al., 2021; Khalil et al., 2017).

Direct observation also helps students develop better analytical and problem-solving skills. When confronted with environmental data and phenomena directly, they learn to identify problems, analyze data, and find relevant and effective solutions. This creates a more holistic and integrative learning experience, combining the theoretical and practical aspects of environmental education (Choudhary et al., 2021; Khalil et al., 2017). Teachers can make their own learning materials according to their area. Indonesia memiliki banyak cultures, humanity, diversity, and environments. With this unique identity, it can be used to connect science concepts to everyday life so that education can improve significantly, different from education in other countries (Putra et al., 2021).

In addition, contextual learning with direct observation increases student engagement and learning motivation. Real-field experience tends to be more interesting and motivating than textbook-based learning alone. Students who are actively involved in field observations and research are more likely to feel connected to the subject matter and understand the importance of scientific concepts in real-life contexts. Science learning by including environmental problems can also

improve critical thinking skills (Pangestu et al., 2020).

CONCLUSION

Government Tegal Regency has made several policies to reduce pollution waste industry metal. One of them is the relocation industry in Pesarean Village to the PIK Kebasen area, which is far away from the settlement. Regulating law materials dangerous and poisonous already arranged waste industry metal. The government of Tegal Regency must involve the public in the formulation of policy next, though they do own sufficient knowledge. This is done for rejection No has been going on for a long time and the policy is already in place made can be beneficial for the public.

The study suggests that the case of Pesarean's metal industry could serve as supplementary learning material for Environmental Physics courses at the university level. The problem of metal pollution in Pesarean Village can be included as a complement to environmental physics learning on several materials, namely the environment of water, land, air, pollution, and global warming.

There are several limitations in this study, namely related to the condition of the soil, water conditions, and air conditions after industrial relocation. This provides recommendations for further researchers to conduct observations related to the content of substances in the soil after the implementation of relocation, whether it is indeed free from pollutants, especially metals.

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