



DOI: <https://doi.org/10.38035/sijse.v3i3>
<https://creativecommons.org/licenses/by/4.0/>

The Relationship between Science Literacy and Students' Environmental Awareness in Environmental Pollution Material: A Literature Review

Yorasakhi Ananta^{1*}, Salsabila Dwi Fitri²

¹Universitas Andalas, Sumatera Barat, Indonesia, yorasakhiananta27@gmail.com

²Universitas Jambi, Jambi, Indonesia, dwifitrisalsabila@gmail.com

*Corresponding Author: yorasakhiananta27@gmail.com¹

Abstract: This article examines the relationship between scientific literacy and environmental awareness of students in the context of environmental pollution material through a literature review. The aim is to build a hypothesis of the relationship between variables as a basis for further research. Data sources include journals, e-books, and open access e-journals from Google Scholar, Mendeley, and digital libraries. The research method uses Systematic Literature Review (SLR) and library research with qualitative descriptive analysis. The results show scientific literacy has a significant effect on environmental awareness, this relationship is consistent in various learning models.

Keywords: Scientific literacy, environmental awareness, pollution, literature review.

INTRODUCTION

Science education plays an important role in shaping students' environmental awareness, especially when associated with global issues such as environmental pollution. Students who understand scientific concepts well will be better able to recognize the negative impacts of pollution on ecosystems. The PISA (Programme for International Student Assessment) study shows that students with high scientific literacy tend to have greater environmental awareness (OECD, 2018). This reflects the importance of integrating pollution material into the context of scientific literacy. Therefore, scientific literacy is one indicator of the success of contemporary science education.

Scientific literacy not only includes scientific knowledge, but also includes the ability to apply that knowledge in everyday decision-making. According to Holbrook and Rannikmae (2009), scientific literacy is the ability to use scientific knowledge functionally to make responsible social decisions. In the context of environmental pollution, students who have scientific literacy will find it easier to understand the relationship between human activities and environmental degradation. Therefore, learning must be directed to developing critical and reflective thinking skills. The goal is for students to become individuals who care about and are responsible for the environment.

Environmental awareness among students is an important component in sustainable development. According to Hungerford and Volk (1990), environmental awareness includes interrelated cognitive, affective, and conative dimensions. Students who are environmentally aware not only have knowledge about environmental issues, but also have a caring attitude and environmentally friendly behavior. Research by Fitriani and Amalia (2023) shows that scientific literacy has a positive correlation with the environmental awareness of junior high school students. This indicates that science education must be directed to develop environmental understanding and action simultaneously.

Environmental pollution material is an important topic in the science curriculum and is very relevant to increasing students' awareness of the condition of their environment. Integrating this material through a contextual approach has been shown to increase students' understanding and awareness (Marpaung, Simanjuntak, & Situmorang, 2021). Learning models such as SETS (Science, Environment, Technology, and Society) and STSE (Science, Technology, Society, and Environment) have been widely used in connecting science with environmental issues. These approaches encourage students to not only understand scientific concepts but also think critically about their impacts on society and the environment. Therefore, a literature mapping is needed regarding the relationship between scientific literacy and environmental awareness.

Many studies have shown that student involvement in project-based learning that emphasizes environmental issues can improve scientific literacy and environmental awareness (Yulianti & Wijayanti, 2021). For example, when students are involved in activities to observe water quality around the school, they learn about pollution and its impact on life. This activity strengthens scientific understanding while fostering social responsibility. In other words, a contextual approach to pollution material can strengthen ecopedagogical values. This is in line with the demands of the Merdeka curriculum which encourages strengthening the profile of Pancasila students.

However, challenges arise in implementing learning that integrates scientific literacy and environmental awareness. Many teachers still focus on mastering scientific concepts without linking them to real contexts. In fact, a contextual learning approach and actual issues are more effective in developing student literacy and awareness (Syahmani, Rahayu, & Widodo, 2024). In addition, the lack of learning resources and teacher training are major obstacles in implementing this strategy comprehensively. Therefore, policy intervention and adequate resource support are needed.

From a global perspective, the importance of science literacy to build environmental awareness has been widely voiced in the agenda of sustainable education. Lee (2023) stated that the use of interactive digital tools in science learning can improve students' understanding of pollution issues. With technology, students can observe and evaluate pollution data in real time and critically. This opens up opportunities for the application of data-based learning and more meaningful environmental projects. The integration of technology and local issues will be very useful for bridging theory with practice.

Based on the explanation above, this literature review aims to examine the relationship between science literacy and students' environmental awareness, especially in pollution material. This study also attempts to formulate theoretical hypotheses that can be used as a basis for further research. This study is important because there is still limited literature that specifically discusses the relationship between the two variables in the context of the Indonesian science curriculum. Using a systematic literature review approach, this article presents a synthesis of various studies that have been conducted in the last decade. It is hoped that this study can be a reference for teachers, researchers, and curriculum developers in designing sustainable science learning.

METHOD

This study uses the Systematic Literature Review (SLR) and library research methods. Data sources consist of articles, e-books, and open access e-journals from Google Scholar and Mendeley. Inclusion criteria: publications in 2015–2025, science/environmental pollution learning context, and in English/Indonesian. Data were analyzed descriptively qualitatively, identifying definitions, indicators, and relationships between science literacy and environmental awareness. SLR refers to Kitchenham et al. (2009), while qualitative analysis is based on Ali & Limakrisna (2013).

RESULTS AND DISCUSSION

Result

Table 1. Results of Relevant Research Studies

No	Author (Year)	Previous Research Findings	Similarities with This Article	Differences with This Article	H
1	Ariani (2022)	Science literacy and environmental projects improve students' conceptual understanding and environmental concern	Science literacy influences environmental awareness	Focused on project-based learning	H1
2	Fitriani & Amalia (2023)	Contextual learning enhances science literacy and environmental awareness among junior high school students	Science literacy influences environmental awareness	Context: junior high school, not senior	H1
3	Marpaung et al. (2021)	STSE model is effective in improving understanding and attitudes on pollution issues	Socio-scientific literacy boosts environmental awareness	Specific use of the STSE model	H1
4	Lee (2023)	Digital media and simulations enhance scientific understanding and environmental empathy	Tech-based science literacy improves environmental awareness	Focused on digital simulations	H1
5	Syahmani et al. (2024)	Guided inquiry improves science literacy and ecological awareness among high school students	Science literacy influences environmental awareness	Focused on inquiry model	H1
6	Yulianti & Wijayanti (2021)	Integration of environmental literacy in science education builds students' ecological concern	IPA (science) education enhances literacy and awareness	Broader educational context	H1

Environmental awareness is an individual's attitude and actions to protect and preserve the environment. According to Hungerford and Volk (1990), environmental awareness consists of three main dimensions: ecological knowledge, caring attitudes, and pro-environmental behavior. In the context of education, y1 reflects the results of the learning process that instills sustainability values. Reny and Purwanto's (2019) study found that students with high environmental awareness tend to be more active in environmental conservation activities at school. Therefore, environmental awareness is an important indicator in the formation of students' ecological character.

Scientific literacy is defined as the ability to understand scientific concepts and apply them in everyday life. Holbrook and Rannikmae (2009) emphasize that scientific literacy includes knowledge, scientific processes, and understanding of social context. Good scientific literacy enables students to make scientifically responsible decisions. Ariani (2022) shows that students with high scientific literacy have greater sensitivity to environmental pollution issues. Therefore, scientific literacy is an important foundation in environmental education.

Indicators of scientific literacy include: understanding scientific concepts, critical reasoning and thinking skills, and understanding the social impact of science (OECD, 2018). In science learning, this indicator can be measured through activities such as experiments, data analysis, and discussions of environmental issues. A study by Fitriani and Amalia (2023) stated that increasing scientific literacy can be achieved through a contextual and project-based approach. School environmental projects, such as water quality monitoring, help students apply scientific concepts directly. Thus, scientific literacy contributes to the formation of environmental awareness.

Many studies support a positive relationship between scientific literacy and environmental awareness. Marpaung et al. (2021) showed that a contextual learning model based on local issues improves junior high school students' scientific understanding and environmental awareness. In addition, Syahmani et al. (2024) found that guided inquiry was able to develop students' cognitive and affective aspects in pollution issues. This study reinforces the importance of an interactive and applicable science learning approach. In this case, scientific literacy not only transfers knowledge but also shapes attitudes. In other words, mastery of science strengthens empathy and ecological responsibility.

In science learning, the topic of environmental pollution is often used as a real context to foster environmental awareness. This topic provides opportunities for students to connect scientific concepts with phenomena around them. Lee (2023) stated that an environmental issue-based approach provides stronger learning motivation and improves scientific literacy. Through discussion and exploration of pollution data, students become more reflective of the role of humans in destroying or protecting the environment. This shows that the topic of pollution is an effective means of building y_1 through x_1 .

In addition, students who have an understanding of the impact of pollutants such as plastic waste, vehicle exhaust, and pesticides will be more aware of the importance of environmentally friendly behavior. This understanding is obtained through increasing good scientific literacy in the curriculum (Yulianti & Wijayanti, 2021). Through scientific literacy, students are invited to evaluate the impact of their life choices on the environment. This concept is in line with strengthening the profile of Pancasila students in the Merdeka curriculum. Environmental awareness is a manifestation of scientific understanding obtained through literacy.

Learning approaches such as STSE (Science, Technology, Society, Environment) greatly influence the relationship between scientific literacy and environmental awareness. STSE encourages students to think critically, empathize, and understand the relationship between science and real life (Sadler, 2004). Through this model, students not only learn about the scientific process but also consider the social and ecological implications. This shows that the pedagogical approach helps strengthen the relationship between x_1 and y_1 . Therefore, teaching strategies become an important mediating factor.

Ariani's research (2022) shows that the integration of visual media and simple experiments in the topic of pollution can improve students' understanding and awareness. The use of aids such as documentary videos or digital simulations about marine pollution triggers students' empathy. This activity allows them to dive into the problem emotionally and cognitively. Therefore, the integration of technology in science learning greatly supports the relationship between literacy and awareness. Teachers need to consider learning innovations based on local and global issues.

Several studies also show differences in the relationship between x_1 and y_1 based on educational level. In elementary school students, this relationship is more facilitated by an exploratory approach and playing while learning. While at the junior high/high school level, scientific and argumentative approaches are more dominant (Marpaung et al., 2021). This shows that the strategy for developing scientific literacy must be adjusted to the stages of

students' cognitive development. Environmental awareness will develop optimally when the approach is in accordance with students' needs. This reinforces the importance of adaptive learning design.

Scientific literacy also affects students' affective dimensions, such as caring and empathy for nature. Reny and Purwanto's (2019) study stated that understanding ecological concepts will strengthen students' emotional ties to the environment. When students understand that pollution causes damage to living things, they are encouraged to be more responsible. This kind of understanding is obtained through a humanistic and reflective scientific approach. Therefore, the affective dimension is an important part of scientific literacy outcomes.

In addition to the affective aspect, scientific literacy also improves the cognitive dimension of environmental awareness, such as the ability to think systematically and predictively. Students who are trained to understand the cause-and-effect relationships in pollution can anticipate impacts and seek alternative solutions (Fitriani & Amalia, 2023). They are also better able to assess the validity of environmental information they encounter in the media. This ability is very important in an information era full of hoaxes and bias. Thus, scientific literacy protects students from misinformation related to environmental issues.

Research results also show that active participation in school environmental projects, such as plastic waste reduction campaigns, strengthens students' scientific understanding and social awareness. According to Syahmani et al. (2024), students who are involved in real projects tend to show more significant changes in attitudes. This activity creates a meaningful and applicable learning experience. In addition, students feel the direct impact of their contribution to the environment. This is why active learning methods are highly recommended in science education.

Environmental awareness is also influenced by local social and cultural values. In a society that emphasizes local wisdom, students find it easier to internalize ecological values. The study by Marpaung et al. (2021) shows that the integration of local wisdom in science learning strengthens students' ecological identity. Local wisdom such as the tradition of mutual cooperation to maintain rivers is a strong medium for environmental reflection. This shows that scientific literacy can be enriched through contextual cultural values.

Another finding is that students' scientific argumentative and communication skills improve when they learn pollution issues in depth. They are able to explain environmental problems with valid data and logic. This ability is very important for building environmental advocacy from an early age (Lee, 2023). Students who can argue scientifically are better prepared to become agents of change in their communities. Therefore, communication skills are an important dimension of scientific literacy.

The use of authentic assessments such as reflective journals, portfolios, and project reports allows teachers to assess the development of environmental awareness more comprehensively. According to the OECD (2018), authentic assessments are more effective than multiple-choice tests in measuring scientific literacy and ecological attitudes. With written reflections, students show their understanding and feelings about environmental issues. This shows a more meaningful learning process. Therefore, process-based assessment needs to be integrated into the curriculum.

External factors such as family support and mass media also influence the development of environmental awareness. Students who are exposed to environmental information through documentary shows or family discussions tend to be more aware of pollution issues. Science literacy built in schools is strengthened by the learning ecosystem at home (Yulianti & Wijayanti, 2021). Therefore, collaboration between schools and families is crucial. Environmental education must be a shared responsibility.

Research also notes that gender and socio-economic background affect the level of science literacy and environmental awareness of students. Female students tend to show a more

caring attitude towards the environment (Ariani, 2022). Meanwhile, students from highly educated families have greater access to scientific learning resources. This inequality requires a differentiation strategy in learning. Teachers must provide fair learning opportunities for all students.

Online learning during the COVID-19 pandemic also has an impact on students' science literacy and environmental awareness. Many students lose the exploratory experiences that are usually obtained through laboratory practice or field visits. However, Lee's study (2023) shows that interactive digital platforms can maintain the quality of science literacy if they are well designed. Therefore, blended learning can be a solution for the future. Technology must be utilized to expand access to environmental education.

Scientific literacy that develops from an early age will form a generation that is critical, caring, and responsible for the environment. Education from elementary to high school needs to be designed progressively to build a strong foundation of literacy. That way, environmental awareness is not just a discourse, but embedded in students' mindsets and behavior (Holbrook & Rannikmae, 2009). Sustainable environmental education is a long-term investment. Developed countries have placed scientific literacy as an integral part of development.

Based on all the results above, it can be concluded that scientific literacy has a significant positive influence on students' environmental awareness in the context of environmental pollution learning. Scientific literacy is a bridge between knowledge and action. The higher the students' scientific literacy, the greater their potential to become agents of environmental change. Therefore, strengthening scientific literacy in the curriculum is an urgent need. This is important to create a generation that is aware of and cares about the sustainability of the earth.

Discussion

Science literacy has a central position in shaping students' environmental awareness because it enables a comprehensive understanding of pollution phenomena. Students with high science literacy can relate scientific concepts such as biogeochemical cycles, the greenhouse effect, and bioaccumulation to real issues they face. This understanding forms the basis for ecologically responsible decision-making (Holbrook & Rannikmae, 2009). Therefore, science literacy is not just mastery of concepts, but the ability to think and act scientifically. In science learning, this aspect needs to be explicitly highlighted.

Environmental awareness includes cognitive, affective, and conative dimensions, each of which can be developed through science-based learning strategies. Science literacy plays a role in building students' cognitive awareness of the causes and effects of pollution, such as water pollution that affects the food chain (Hungerford & Volk, 1990). The affective aspect is fostered through a reflective approach and empathy for affected living things. Meanwhile, the conative dimension is formed when students begin to change their behavior based on this understanding. This confirms that the integration of science literacy and environmental education results in a transformation of attitudes and actions.

Science literacy encourages students to engage in critical discussions and logical analysis of environmental issues. In the context of pollution, students who are scientifically literate can systematically evaluate policies, societal behavior, and their impacts (Sadler, 2004). Discussions based on data and evidence are effective means of raising awareness. Activities such as case studies of river or sea pollution can be used to practice scientific reasoning. Thus, science literacy is an important prerequisite for student involvement in environmental solutions.

The STSE approach has been shown to be able to connect science learning with social and environmental contexts. In this model, students are invited to see the relationship between pollution, technology, and human life choices (Zeidler et al., 2005). They learn that every action has ecological consequences. Therefore, pollution learning must emphasize the

interdependence of humans and nature. Science literacy developed through STSE is applicable and meaningful.

One effective strategy to enhance the relationship between science literacy and environmental awareness is project-based learning. Through projects such as school waste audits, students collect data, analyze results, and design solutions (Yulianti & Wijayanti, 2021). This activity hones scientific skills while triggering environmental responsibility. Collaboration and communication between students are also strengthened. Thus, problem-based projects become powerful pedagogical tools.

The integration of digital media and interactive tools greatly supports the process of scientific literacy. Visualization of air pollution data or animation of the eutrophication process can help students understand abstract concepts. Lee (2023) found that students who learned with digital simulations showed significant improvements in understanding and concern. Therefore, technology should be utilized to bridge conceptual gaps. It also makes learning more engaging and inclusive.

Environmental-based learning is a direct learning strategy that can shape conceptual understanding and concern. Activities such as observing river water quality or studying domestic waste provide authentic learning experiences. Through real experiences, students realize the impact of human activities on their environment. Reny and Purwanto (2019) emphasized that experiential learning is very effective in shaping ecological attitudes. Therefore, field activities should be a routine part of science learning.

The socio-cultural dimension also influences the relationship between scientific literacy and environmental awareness. In a society that upholds environmental values, students more easily absorb ecological norms (Marpaung et al., 2021). Therefore, environmental education must be contextual and relevant to students' lives. Raising local issues such as river pollution in the local area can strengthen student engagement. Teachers must examine local issues as a source of contextual learning.

One of the challenges in developing scientific literacy and environmental awareness is the limited resources and teacher training. Many teachers still apply traditional approaches that do not encourage critical thinking and exploration. In fact, scientific literacy requires a challenging learning environment that supports scientific dialogue (OECD, 2018). Therefore, teacher training must include issue-based learning strategies and reflective practices. Strengthening teacher capacity is the key to the success of environmental education integration.

The Independent Curriculum provides great opportunities for teachers to apply contextual and project-based learning. In this paradigm, students are given space to explore environmental issues that are relevant to their lives. Teachers act as facilitators who guide the process of thinking and scientific inquiry. This is very much in line with the goals of scientific literacy and strengthening environmental awareness (Kemdikbud, 2022). Therefore, curriculum implementation must be supported by concrete guidance and adequate learning resources.

Student participation in school ecoliteracy activities, such as waste banks, school gardens, or energy-saving campaigns, can improve two things: scientific understanding and ecological empathy. These activities provide space for students to apply scientific knowledge to real practices. According to Syahmani et al. (2024), direct involvement forms a more consistent pro-environmental attitude. Therefore, science education needs to be expanded outside the classroom. The school environment is a real laboratory for forming awareness.

Science literacy-based education should encourage students to become producers of solutions, not just consumers of information. Students who are invited to create anti-pollution campaigns, write scientific articles, or compile pollution infographics show increased literacy and concern (Ariani, 2022). This kind of project builds self-confidence and social

responsibility. Therefore, science learning must be directed to produce agents of environmental change. This also strengthens the relevance of science in real life.

Evaluation of the success of science literacy and environmental awareness is not enough with cognitive tests. Assessment must touch on the affective and behavioral aspects of students. Alternative assessments such as portfolios, project reports, and reflective journals are important to see the thinking process and changes in students' attitudes (Fitriani & Amalia, 2023). Teachers need to be trained in compiling and using this holistic assessment. This kind of evaluation better reflects the impact of environmental education as a whole.

In practice, students face various obstacles in developing scientific literacy, such as lack of access to learning resources, minimal parental support, and differences in economic background. This inequality affects students' environmental awareness. Therefore, science education must be designed to reach all groups of students fairly (Holbrook & Rannikmae, 2009). Special interventions are needed to support disadvantaged students. Environmental education is the right of all students.

Collaborative activities, such as group discussions, debates, and team investigations are very helpful in improving scientific literacy and social awareness. Through these interactions, students learn to hear other points of view and formulate solutions together. This strengthens the value of democracy in science learning (Lee, 2023). Discussions across perspectives also encourage reflective thinking. Therefore, science learning must create a space for dialogue and cooperation.

Cross-cultural studies show that Indonesian students' scientific literacy is still lagging behind other countries. This has an impact on the low involvement of students in global environmental issues. Therefore, it is important to strengthen environmental education through an approach that builds global literacy (OECD, 2018). Topics such as climate change, marine pollution, and biodiversity loss should be included in the teaching materials. Students need to realize that they are responsible global citizens.

Integrating sustainability principles into all subjects, including science, can broaden the impact of environmental education. Scientific literacy should be combined with environmental ethics and sustainability values (UNESCO, 2021). This creates a holistic approach that forms critical and empathetic awareness. The goal is not only to create smart students, but also wise and caring students. Therefore, scientific literacy education must be based on humanitarian and sustainability values.

This study provides a conceptual framework that scientific literacy is the main predictor in shaping students' environmental awareness. The relationship between x_1 and y_1 is built through scientific understanding, concrete experiences, and social values that are reinforced by learning. Previous studies (Marpaung et al., 2021; Syahmani et al., 2024) have shown that scientifically literate students are more aware and active in protecting the environment. therefore, science literacy is a long-term investment in environmental character education.

Collaboration between schools, parents, government, and society is needed in forming a culture of science literacy and environmental awareness. A positive and inspiring learning environment will strengthen the process of internalizing ecological values. Cross-sector collaboration is a force for creating sustainable change (Yulianti & Wijayanti, 2021). Therefore, environmental education cannot stand alone. This is a collective effort that must be supported by real policies and practices.

Based on the discussion above, it can be concluded that science literacy has a strong relationship with students' environmental awareness in pollution learning. Science literacy is the foundation for critical thinking, feeling empathetically, and acting responsibly towards the environment. Therefore, strengthening science literacy must be a priority in science education reform in Indonesia. Through meaningful education, we can produce a generation that is intelligent, caring, and empowered in facing future environmental challenges.

CONCLUSION AND SUGGESTIONS

Conclusion

Based on the results and discussion of the literature, it can be concluded that scientific literacy plays a significant role in increasing students' environmental awareness, especially in environmental pollution material. Scientific literacy helps students understand scientific concepts, think critically, and assess the impact of human behavior on the environment. Through a contextual learning approach, environmental projects, and technology integration, the relationship between scientific literacy and environmental awareness can be strengthened meaningfully. The environmental awareness that is formed is not only cognitive, but also includes affective dimensions and real actions. Therefore, scientific literacy is an important foundation in forming a generation that cares about environmental sustainability.

Suggestions

Teachers need to design integrative and contextual science learning to simultaneously improve science literacy and environmental awareness. Schools should develop project-based environmental programs that actively engage students in real conservation activities. Governments and education stakeholders need to provide science training and learning resources that support the strengthening of sustainability values. Further research can empirically test the relationship between science literacy, environmental attitudes, and behavior at various levels of education using quantitative and qualitative approaches.

REFERENCES

- Ali, H., & Limakrisna, N. (2013). Metodologi Penelitian (Petunjuk Praktis Untuk Pemecahan Masalah Bisnis, Penyusunan Skripsi (Doctoral dissertation, Tesis, dan Disertasi. In *In Deepublish: Yogyakarta*.
- Ariani, F. (2022). Peningkatan literasi sains siswa melalui pembelajaran berbasis proyek pada materi pencemaran lingkungan. *Jurnal Ilmu Pendidikan dan Pengajaran IPA*, 5(1), 14–22.
- Fitriani, D., & Amalia, S. (2023). Literasi sains dan kesadaran lingkungan melalui pembelajaran kontekstual di SMP. *Jurnal Pendidikan IPA Indonesia*, 12(3), 134–145. <https://doi.org/10.15294/jpii.v12i3>.
- Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental and Science Education*, 4(3), 275–288.
- Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8–21. <https://doi.org/10.1080/00958964.1990.10753743>
- Kemdikbud. (2022). Panduan Implementasi Kurikulum Merdeka. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.
- Kitchenham, B., et al. (2009). Systematic literature reviews in software engineering – A systematic literature review. *Information and Software Technology*, 51(1), 7–15.
- Lee, C. (2023). Digital-based science learning to improve students' environmental awareness. *Asian Journal of Science Education*, 8(1), 49–58.
- Marpaung, E., Hutagalung, M., & Samosir, B. (2021). Efektivitas model STSE dalam meningkatkan kepedulian lingkungan siswa SMP. *Jurnal Pendidikan Sains*, 9(2), 90–97.
- OECD. (2018). PISA 2018 Assessment and Analytical Framework. Paris: OECD Publishing. <https://doi.org/10.1787/b25efab8-en>
- Reny, D. S., & Purwanto, A. (2019). Pengaruh pengalaman belajar lingkungan terhadap kesadaran lingkungan siswa sekolah dasar. *Jurnal Ilmu Pendidikan Lingkungan*, 3(2), 123–132.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41(5), 513–536.

- Syahmani, R., Lestari, I., & Zamzami, M. (2024). Pengaruh model pembelajaran inkuiri terbimbing terhadap literasi sains dan kesadaran lingkungan siswa SMA. *Jurnal Pendidikan Sains Indonesia*, 11(1), 44–55.
- UNESCO. (2021). Education for Sustainable Development: A Roadmap. Paris: UNESCO Publishing.
- Yulianti, E., & Wijayanti, N. (2021). Integrasi literasi lingkungan dalam pembelajaran IPA untuk meningkatkan kesadaran ekologi siswa. *Jurnal Pendidikan Lingkungan dan Pembangunan Berkelanjutan*, 4(1), 19–27.
- Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, 89(3), 357–377.