

*Original Research Article*

# Eco Literacy in Z Generation Regarding Waste Management as a Critical Dimension of Sustainable Urban Green Space

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## Abstract

Green spaces will only be adequately maintained with the active support of residents. Eco-literacy in the Z generation is essential in encouraging the behavior of those who care about the environment. The research was conducted using quantitative methods by sending questionnaires to Z-generation respondents. The questionnaire uses Likert scale including indicators scientific integration, program sustainability, internet literacy, the importance of waste management, concerns about waste, and volunteers. The majority of Z generation agrees that scientific integration educates them about environmental challenges and waste management. Concerning programmed sustainability, they are neutral about waste management programmed in schools. They appreciate environmental issues and try to educate the people using the internet. They feel good waste management will affect the environment, agree that Z generation is concerned about waste, and volunteer extensively for the environment.

**Keywords:** Urban green space; volunteer; internet literacy; waste management

## 1. Introduction

Green open space refers to areas in urban environments that are covered with vegetation, such as parks, gardens, and open areas (Shepley et al., 2019). Green open space will only be maintained and improved in the long term when policies and supported by its residents (Wald and Hostetler, 2010). Green spaces will only be adequately maintained with the active support of residents. Green spaces can face environmental challenges such as pollution, soil degradation, and biodiversity loss. These issues can affect the overall health of ecosystems within green spaces. Modernization and population growth have led to shifts in people's lifestyles and perspectives, resulting in consumptive behavior and a culture of instant results (Puluhulawa and Puluhulawa, 2021). It is undeniable, people living around green open spaces produce waste. Increasing amounts of solid waste is a global challenge, with a 70% increase observed annually, and is expected to reach 3.5 billion metric tons by 2050 (Govani et al., 2021). Solid waste management (SWM) refers to all the activities and actions required to manage waste from inception to final disposal. The management and disposal of this waste is a challenging task for all countries, with current practices having adverse environmental and economic impacts.

Recycling plastic waste is the most important research topic in terms of plastic waste management (Li et al., 2021). Plastic waste recycling efforts are continuously carried out with the aim of minimizing the emergence of plastic waste. Without concrete action, the situation may worsen, leading to a deterioration in the quality of the environment and the survival of society. Eco-literacy in the Z

generation is essential in encouraging the behavior of those who care about the environment. Generation Z, which is a group born between the mid-1990s to mid-2000s, faces unique and pressing environmental challenges, including climate change, environmental damage, and various sustainability issues. Generation Z belongs to the age group of 18-25 years

Environmental education helps generation Z to better understand existing environmental issues, such as climate change, biodiversity loss, pollution, and so on. This allows them to become more aware of the negative impacts that human actions have on the environment. Through environmental education, generation Z can understand the importance of adopting more sustainable behaviors. They can practice waste reduction, recycling, saving energy, and other ways to reduce their environmental footprint. Previous research has been conducted in China. The study investigated the motivations of Generation Z consumers in China to engage in plastic pollution reduction and increased recycling intentions, finding that self-expression and social pessimism were key drivers. But until now there is still little information about eco literacy in Z Generation (Wang et al., 2022).

The purpose of this study is to analyze eco literacy in Z Generation regarding waste management as a critical dimension of sustainable urban green space. The research was conducted using quantitative methods by sending questionnaires to Z-generation respondents. The questionnaire uses Likert scale including indicators scientific integration, program sustainability, internet literacy, the importance of waste management, concerns about waste, and volunteers.

## 2. Methods

This research uses quantitative methods, by conducting a survey of class XII senior high school students at MAN 1 Ngawi in August 2023. The number of samples in the study was 69 students. According to Roscoe's theory, determining a sample size of more than 30 and less than 500 is appropriate for most studies with unknown population sizes (Mandeville and Roscoe, 1971). The instrument used is a closed questionnaire with Likert scale, which consists of six indicators related to waste management; scientific integration, sustainability program, internet literacy, the important of waste management, concern about waste, and volunteers. The data were analyzed using descriptive statistics to describe the condition of the research subjects related to understanding and awareness of waste management. We use SPSS software. The statements used in this research consisted of 21, namely:

1. Science lessons gave me sufficient knowledge about the importance of waste management
2. Religious studies helped me understand the importance of environmental issues
3. Social science lessons gave me knowledge about the benefits of waste management
4. My school has exciting programs related to waste management and the environment
5. My school cares about environmental issues
6. My school involves me in programs about waste and the environment
7. With the help of the internet, I understand environmental problems
8. With the help of social media, I understand the importance of environmental issues
9. Social media helps me meet people who also care about environmental issues
10. I believe environmental issues are important
11. I believe waste affects the environment
12. I really care about efforts to sort organic and inorganic waste
13. I pay great attention to the problem of waste that pollutes water bodies such as rivers and seas
14. I am worried that waste mismanagement will hurt me
15. I am worried that rubbish that is thrown away carelessly will hurt me
16. I am annoyed with people who throw rubbish everywhere
17. I am worried that the waste problem will cause the world to become uninhabitable
18. I will volunteer to clean up trash at home and school

19. I will participate in environmental care programs held by my school
20. I will take part in campaign activities to clean the environment
21. I will sort the trash that can be recycled

### 3. Result and Discussion

In this study, the number of respondents with gender was 63.89% female and 36.11% male. As many as 100% of respondents answered using the internet or social media. This supports environmental literacy responses. This study discusses students' perceptions and attitudes regarding waste management. There are parameters used in this study.

#### 3.1. Scientific Integration

Scientific integration regarding waste management refers to a comprehensive and interdisciplinary approach that combines various aspects to address waste management challenges. The scientific integration approach emphasizes the importance of science in addressing waste management challenges (Marshall and Farahbakhsh, 2013). Waste management and processing technology, often ignores materiality and its impact on society (Gregson and Crang, 2010). From the aspect of scientific integration, there are three subjects that are related to waste and environmental issues; science, religion, and social. Based on the results of research, the majority of students stated that science lessons provide sufficient knowledge about the importance of waste management (71%). However, it turned out that there were 8.7% of students who disagreed with this statement. The chart about the respondents' answers about Scientific integration is shown in figure 1.

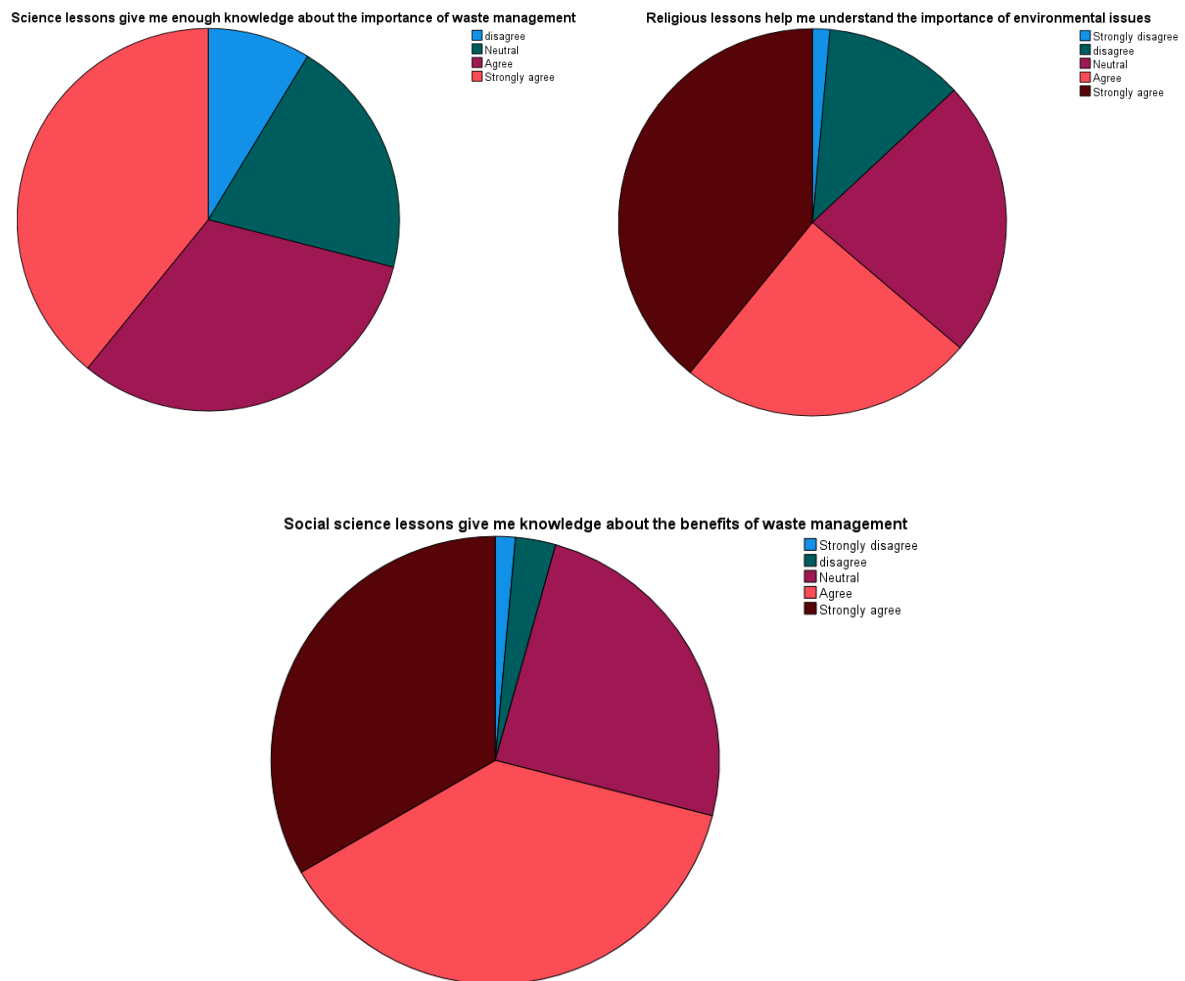


Figure 1. The respondents answers about Scientific integration

The science learning curriculum in Indonesia does teach topics related to ecosystems and environmental change. This topic discusses environmental problems, causes, and impacts on humans, including one of them is the problem of waste. However, the curriculum may not comprehensively cover practical waste management solutions or effectively incorporate these teachings with religious and societal viewpoints. This omission could limit comprehension and hinder the development of a more comprehensive approach to waste and environmental education. Religious teachings frequently highlight the ethical duty of environmental care, while social studies can provide a framework for understanding waste management in relation to society and cultural norms. By integrating these disciplines, students may acquire a more holistic comprehension and be better prepared to participate in efficient waste management strategies.

Various media and learning methods are designed and innovated to understand the material to students, such as the preparation of modules and worksheets oriented to Education for Sustainable Development (Kusumaningrum, 2022; One Fase Kurniawan et al., 2023), Implementation of Project-Based Learning (Aninda et al., 2020; Hapsari et al., 2016), and the application of Active, Joyful, and Effective Learning in learning (Choirunnisa and Irsadi, 2014; Supriyatin et al., 2018). Science learning that is integrated with environmental education can improve students' environmental care attitudes (Yanti and Yusliani, 2020).

In addition to science subjects, as many as 63.7% of students feel that religion lessons have helped them to understand environmental issues. In the curriculum of religious subjects in Indonesia, competency achievements are listed so that students have noble character, knowledge, confidence, and responsibility in interacting with the natural environment (Hayadin, 2019). There are various efforts made by educators in designing religious learning so that students can care about environmental issues, such as compiling syllabi, learning that is integrated with environmental care, assignments, and evaluations (Anggraini et al., 2022; Ridwan, 2022). Islamic education that is environmentally sound is important to be given to students so that they can preserve nature and avoid destruction in utilizing resources (Hidayat and Suwanto, 2020). In religion, especially Islam, there are many Qur'anic verses and hadiths that discuss the environment (Nurulloh, 2019).

Through social lessons, students also felt they gained knowledge about the benefits of managing waste (71%). As with other subjects, environmental education is integrated into social science learning in schools. Even since elementary education, efforts to insert environmental education have been carried out in social studies learning (Adela and Permana, 2020; Andriani and Bakhtiar, 2017). In geography learning, in particular, there are efforts to internalize the character of environmental care carried out by teachers through *Geography Partner Schools* (Hadi H, 2017).

### 3.2. Program Sustainability

The environmental sustainability program referred to here is a school program that supports efforts to preserve the environment, both in the form of education and waste management programs. Based on the results of the questionnaire, as many as 47.8% of students stated that the school has an interesting program related to waste management and the environment. The questionnaire showed that MAN 1 Ngawi school still did not have an attractive program, as more than half of the students disagreed. MAN 1 Ngawi, as the school used as the location of the study, is not an *adiwiyata* school. Therefore, this is the answer that students have not fully agreed on the existence of interesting programs in waste management and the environment. Based on observations in the school environment, waste management efforts have not been sorted, so all types of waste are still mixed together. Unlike schools that include *adiwiyata* schools, usually in schools there are various programs held in order to realize good school environmental management. Sekolah *Adiwiyata* is a school that has successfully implemented an environmental care and culture movement in schools (Minister of Environment and Forestry of the Republic of Indonesia Number P.53/MENLHK/SETJEN/KUM.1/9/2019). Various programs as the

Environmental Care and Culture Movement in Schools (PBLHS) can be designed by adiwiyata schools, such as school sanitation efforts, waste management by involving students in waste bank and composting programs, 3R programs, planting and maintaining trees/plants, water and energy conservation, innovation in implementing environmentally friendly behavior in schools, and conducting environmental care campaigns.

However, based on the results of the questionnaire, the school has had environmental concerns issues supported by evidence as many as 57.9% who said they agreed. Concern for environmental issues by the school is an important capital in the education element in order to overcome environmental problems because schools are a means to foster environmental awareness for students (Ahmad et al., 2015; Arani et al., 2016; Barraza and Walford, 2002). Student involvement in the program on waste and the environment is moderate (50.7%). This percentage is not high because the intensity of the program is not much interesting environment and student awareness is not high.

### **3.3. Internet Literacy**

The increasing volume of municipal solid waste (MSW) due to population growth and urbanization requires efficient waste management strategies to reduce environmental hazards and public health risks (Ram and Kumar, 2021). The use of digital communication tools such as email, online learning platforms, and social media can be used to disseminate information and educate students about the importance of solid waste management. The presence of the internet is a means that facilitates the delivery of messages related to environmental issues and environmental care movement campaigns (Mallick and Bajpai, 2019). The existence of information about environmental issues and campaigns through the internet, including social media, increases people's knowledge, motivates, and encourages them to carry out pro-environment movements (Boulianne et al., 2020; Robelia et al., 2011). This is in line with the results of surveys that have been conducted among students that the presence of the internet makes students understand environmental problems (84%), the presence of social media understands the importance of environmental problems (86.9%), and social media brings them together with people who care about the environment (81.1%). The internet also provides an extensive selection of instructional tools and real-time environmental information, raising students awareness and knowledge. Social media can raise environmental awareness and inspire sustainable practices. Social media helps students develop global responsibility for the environment by connecting with similar people and organisations. Interactive internet platforms and forums allow students to share ideas and participate on environmental projects. The research shows that internet literacy empowers students to become knowledgeable and proactive environmental leaders. For students, the internet is a suitable media choice to get information about the environment (Ahmad et al., 2015).

### **3.4. The Importance of Waste Management**

Effective waste management education equips students with the ability to address global concerns about waste generation and its ecological impact, which is essential for sustainable development (Khairuddin et al., 2023). The perception of the importance of waste management among students has a high percentage. This research shows that students have a high awareness of the importance of waste management. This can be seen from several indicators, such as the importance of environmental issues for them (88.4%), the impact of waste problems on the environment (95.7%), their concern for efforts to separate organic and inorganic waste (69.5%), and their concern for waste pollution in waters (78.3%). This data indicates that most students understand how important it is to protect the environment by managing waste appropriately. Additionally, this high awareness demonstrates the potential of students to become agents of change in promoting good waste management practices in their communities. With a strong understanding of these issues, students can play an active role in environmental conservation efforts, both at school and outside of school. The high perception of students towards waste management

is the starting point in the practice steps in the field. Although according to Ahmad et al. (2015) there is a weak relationship between knowledge and real practices of sustainable environmental management. Previous studies many students are involved in waste separation and recycling, but challenges such as inadequate resources and poor attitudes hinder effective practice. 67.8% of students are aware of household waste management, but only 26.3% understand waste minimization (Thakur et al., 2023). In another study, students showed good knowledge of the definition and effects of solid waste, but lacked the awareness to manage solid waste properly (Molina and Catan, 2021). Therefore, increasing student awareness in waste management, comprehensive education and adequate infrastructure are essential to empower students in effective waste management practices.

### 3.5. Concerns About Waste

Solid waste management is a serious problem worldwide (Norsa'adah et al., 2020). The results showed that generation Z was worried that mismanagement of solid waste management would adversely affect them. A total of 46.4% of respondents answered strongly agree, but there was respondent answered disagree by 2.9%. Generation Z is also worried that littering will have a bad impact on them, with 68.1% agreeing. They also feel annoyed when there are people who litter. Mismanagement activities, littering cause generation Z to worry that solid waste will cause the world to become uninhabitable with respondents answering 73.9% strongly agree. Figure 2 displays the chart related to the respondents' responses about waste concerns.

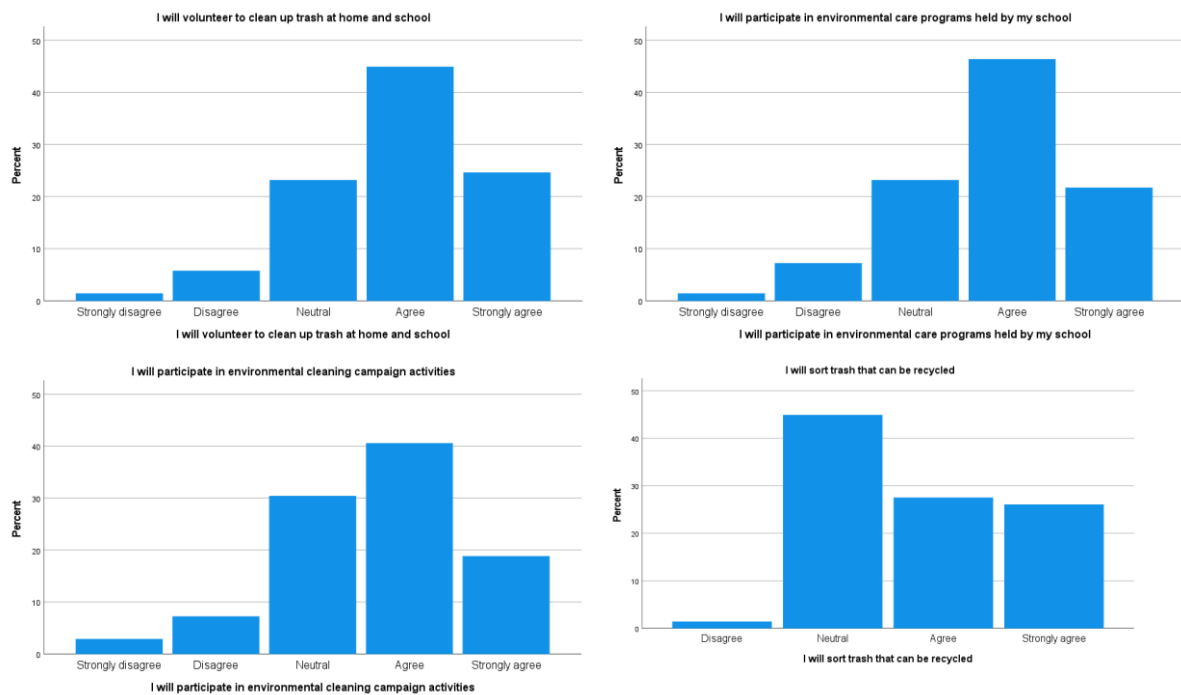


Figure 2. the chart related to the respondents' responses about waste concerns

Generation Z is concerned with the environment and worried about the long-term effects of waste mismanagement on their quality of life. The high percentage of highly agreeing responders implies these worries are common. Concern at garbage shows a desire for more responsible behaviour and stronger waste management regulation. The worry that solid waste could make the globe unsustainable adds to their urgency to address these challenges. These findings highlight the necessity for schools to include comprehensive waste management instruction in their academic programmes in order to promote proactive and sustainable environmental practices.



### **3.6. Volunteers**

Volunteer-based interventions can also help identify other good ways of waste management (Kalyanasundaram et al., 2021). Volunteer waste is a volunteer activity carried out to deal with waste problems (Ariefahnoor et al., 2020). The results showed that respondents answered strongly agreed by 24.6%, 21.7%, 18.8%, 26.1% respectively will volunteer to give away waste at home and school, participate in environmental care programs held by schools, participate in cleaning campaign activities environment, and sorting waste that can be recycled. These results show that generation Z is willing to volunteer for solid waste management.

The high percentage of respondents who expressed their willingness to participate in various environmental activities reflects a high awareness of the importance of maintaining environmental cleanliness and sustainability. This active participation can increase the effectiveness of waste management programs in schools and communities. In addition, the voluntary involvement of Generation Z also shows their potential as agents of change in creating a cleaner and healthier environment. With the right support, schools can harness this enthusiasm to build a culture of caring for the sustainable environment. The high percentage of respondents who expressed their willingness to participate in various environmental activities reflects a high awareness of the importance of maintaining environmental cleanliness and sustainability. Active participation can increase the effectiveness of waste management programs in schools and communities. Furthermore, Generation Z's voluntary involvement in creating a cleaner and healthier environment demonstrates their potential as agents of change. With the right support, schools can harness this enthusiasm to build a culture of caring for the sustainable environment. Activities that can be done by volunteers include cleaning the environment from waste, educating the community about the importance of waste management (Nindya et al., 2022), and develop innovations to solve the waste problem (Awasthi et al., 2019).

## **4. Conclusions**

This study aims to analyze eco literacy in Z Generation regarding waste management as a critical dimension of sustainable urban green space. The majority of Z generation agrees that scientific integration educates them about environmental challenges and waste management. Concerning programmed sustainability, they are neutral about waste management programmed in schools. They appreciate environmental issues and try to educate the people using the internet. They feel good waste management will affect the environment, agree that Z generation is concerned about waste, and volunteer extensively for the environment. Z generation can volunteer by cleaning the environment from waste, educating the public about the importance of waste management, and developing innovations to overcome waste problems. Generation Z is neutral about school waste management programs, showing a lack of enthusiasm or interest in such programs. This study was limited to homogeneous samples. It is recommended that further research can use heterogeneous samples, so that researchers can provide a more comprehensive understanding of the behavior or phenomenon being studied.

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## **References**

Adela, D., Permana, D., 2020. Integrasi pendidikan lingkungan melalui pendekatan ecopedagogy dalam pembelajaran IPS di Sekolah Dasar. *Jurnal BELAINDIKA (Pembelajaran dan Inovasi Pendidikan)* 2,

17–26.

- Ahmad, J., Md. Noor, S., Ismail, N., 2015. Investigating students' environmental knowledge, attitude, practice and communication. *Asian Social Science* 11, 284–293.
- Andriani, P., Bakhtiar, A.M., 2017. Integrasi Pendidikan Lingkungan Hidup pada Pembelajaran Ilmu Pengetahuan Sosial Di Sekolah Dasar. *DIDAKTIKA : Jurnal Pemikiran Pendidikan* 24, 100.
- Anggraini, G., Muhibbin Syah, Asep Nursobah, Bambang Samsul Arifin, 2022. Integration of islamic religion and character education with environmental education at adiwiyata junior high school. *Journal of Social Science* 3, 341–352.
- Aninda, A., Permanasari, A., Ardianto, D., 2020. Implementasi pembelajaran berbasis proyek pada materi pencemaran lingkungan untuk meningkatkan literasi Stem Siswa Sma. *Journal of Science Education and Practice* 3, 1–16.
- Arani, M.H., Bagheri, S., Ghaneian, M.T., 2016. The role of environmental education in increasing the awareness of primary school students and reducing environmental risks. *Journal of Environmental Health and Sustainable Development* 1, 9–17.
- Ariefahnoor, D., Hasanah, N., Surya, A., 2020. Pengelolaan sampah Desa gudang tengah melalui manajemen bank sampah. *Jurnal Kacapuri: Jurnal Keilmuan Teknik Sipil* 3, 14–30.
- Awasthi, A.K., Li, J., Koh, L., Ogunseitan, O.A., 2019. Circular economy and electronic waste. *Nature Electronics* 2, 86–89.
- Barraza, L., Walford, R.A., 2002. Environmental education: a comparison between english and Mexican school children. *Environmental Education Research* 8, 171–186.
- Boulianne, S., Lalancette, M., Ilkiw, D., 2020. "School Strike 4 Climate": Social Media and the International Youth Protest on Climate Change. *Media and Communication* 8, 208–218.
- Choirunnisa, I.F., Irsadi, A., 2014. Penerapan active, joyful and effective learning (Ajel) berbasis bioedutainment materi perubahan lingkungan. *Journal of Biology Education* 3, 50229.
- Govani, J., Singh, E., Kumar, A., Zacharia, M., Kumar, S., 2021. New generation technologies for solid waste management. In: *Current Developments in Biotechnology and Bioengineering*. Elsevier, pp. 77–106.
- Gregson, N., Crang, M., 2010. Materiality and Waste: Inorganic Vitality in a Networked World. *Environ. Plan. A* 42, 1026–1032.
- Hadi H, S.A., 2017. Internalisasi karakter peduli lingkungan dan tanggap bencana pada siswa sekolah melalui Program Geography Patner School. *Prosiding Seminar Nasional Pendidik dan Pengembang Pendidikan Indonesia dengan Tema "Membangun Generasi Berkarakter Melalui Pembelajaran Inovatif"* 176–188.
- Hapsari, D.D., Lisdiana, Sukaesih, S., 2016. pengaruh pembelajaran berbasis proyek berbantuan modul daur ulang limbah pada literasi sains. *Journal of Biology Education* 5, 302–309.
- Hayadin, H., 2019. developing students attitude toward environment through religious education in schools. In: *ICEASD&ICCOSED 2019: International Conference on Environmental Awareness for Sustainable Development in Conjunction with International Conference on Challenge and Opportunities Sustainable Environment Development*. Europe Alliance for Innovation (EAI), p. 388.
- Hidayat, R., Suwanto, S., 2020. Membumikan etika politik islam nabi muhammad saw periode madinah dalam konteks perpolitikan indonesia. *Juspi: Jurnal Sejarah Peradaban Islam* 3, 124–141.
- Kalyanasundaram, M., Sabde, Y., Annerstedt, K.S., Singh, S., Sahoo, K.C., Parashar, V., Purohit, M., Pathak, A., Lundborg, C.S., Roust, K., 2021. Effects of improved information and volunteer support on segregation of solid waste at the household level in urban settings in Madhya Pradesh, India (I-MISS): protocol of a cluster randomized controlled trial. *BMC Public Health* 21, 1–11.
- Khairuddin, D., Ismail, N.N., Kamaruding, M., 2023. enhancing solid waste management education: understanding engineering students preferences for teaching and learning methods. *Asian Journal Respiratory Education Social Science*. 5, 48–56.
- Kusumaningrum, M.E., 2022. Pengembangan modul pembelajaran biologi berbasis education for



- sustainable development (Esd) berpotensi meningkatkan IOPENDIX: Jurnal Biologi Pendidikan dan Terapan 8, 48–70.
- Li, L., Zuo, J., Duan, X., Wang, S., Hu, K., Chang, R., 2021. Impacts and mitigation measures of plastic waste: A critical review. *Environmental Impact Assessment Review* 90, 106642.
- Marshall, R.E., Farahbakhsh, K., 2013. Systems approaches to integrated solid waste management in developing countries. *Waste Manag.* 33 4, 988–1003.
- Mallick, R., Bajpai, S.P., 2019. Impact of social media on environmental awareness. In: *Environmental Awareness and the Role of Social Media*. IGI Global, p. 10.
- Mandeville, G.K., Roscoe, J.T., 1971. Fundamental research statistics for the behavioral sciences., *Journal of the American Statistical Association*.
- Nindya, S., Cantrika, D., Murti, Y.A., Widana, E.S., Kurniawan, I.G.A., 2022. Edukasi pengolahan sampah organik dan anorganik di desa reja tabanan. *Bubungan Tinggi: Jurnal Pengabdian Masyarakat* 4, 352–357.
- Norsa'adah, B., Salinah, O., Naing, N.N., Sarimah, A., 2020. Community health survey of residents living near a solid waste open dumpsite in Sabak, Kelantan, Malaysia. *International Journal of Environmental Research and Public Health*.
- Nurulloh, E.S., 2019. Pendidikan islam dan pengembangan kesadaran lingkungan. *Jurnal Penelitian Pendidikan Islam* 7, 237.
- One Fase Kurniawan, Fenny Roshayanti, Syaipul Hayat, 2023. Pengembangan pembelajaran biologi berorientasi esd melalui pengolahan sampah untuk meningkatkan kemampuan dasar bekerja ilmiah siswa Sma Negeri 3 Pematang. *Didaktik : Jurnal Ilmiah PGSD STKIP Subang* 9, 1349–1358.
- Puluhulawa, F., Puluhulawa, M.R., 2021. Plastic waste in modern era: Developing plastic waste management for sustainability. In: *E3S Web of Conferences*. EDP Sciences, p. 3001.
- Ram, C., Kumar, A., 2021. Municipal solid waste management: recent practices. In: *Nanobiotechnology for Green Environment*. CRC Press, pp. 37–65.
- Ridwan, S., 2022. Pembelajaran pendidikan agama islam dalam membangun karakter peduli lingkungan siswa di Sekolah Menengah Pertama Negeri 1 Sumberbaru Jember.
- Robelia, B.A., Greenhow, C., Burton, L., 2011. Environmental learning in online social networks: Adopting environmentally responsible behaviors. *Environmental Education Research* 17, 553–575.
- Shepley, M., Sachs, N., Sadatsafavi, H., Fournier, C., Peditto, K., 2019. The impact of green space on violent crime in urban environments: an evidence synthesis. *International journal of environmental research and public health* 16, 5119.
- Supriyatin, S., Nurnawati, N., Heryanti, E., 2018. Pengaruh penerapan active, joyful, and effective learning (ajel) pada materi perubahan lingkungan terhadap sikap peduli lingkungan siswa. *Biosfer: Jurnal Pendidikan Biologi* 9, 69–75.
- Wald, D.M., Hostetler, M.E., 2010. Conservation value of residential open space: Designation and management language of Florida's land development regulations. *Sustainability* 2, 1536–1552.
- Wang, W., Mo, T., Wang, Y., 2022. Better self and better us: Exploring the individual and collective motivations for China's Generation Z consumers to reduce plastic pollution. *Resources, Conservation and Recycling* 179, 106111.
- Yanti, Y., Yusliani, E., 2020. Meta-Analisis: Pengaruh integrasi pendidikan lingkungan dalam pembelajaran ipa terhadap sikap peduli lingkungan siswa. *Jurnal Penelitian dan Pembelajaran Fisika* 6, 9–16.
- Gregson, N., Crang, M., 2010. Materiality and Waste: Inorganic Vitality in a Networked World. *Environ. Plan. A* 42, 1026–1032.
- Khairuddin, D., Ismail, N.N., Kamaruding, M., 2023. Enhancing solid waste management education: understanding engineering students preferences for teaching and learning methods. *Asian Journal Respiratory Education Social Science* 5, 48–56.

- Marshall, R.E., Farahbakhsh, K., 2013. Systems approaches to integrated solid waste management in developing countries. *Waste Manag.* 33 4, 988–1003.
- Molina, R.A., Catan, I., 2021. Solid waste management awareness and practices among senior high school students in a state college in Zamboanga City, Philippines. *Aquademia* 5, ep21001.
- Ram, C., Kumar, A., 2021. Municipal solid waste management: recent practices. in: *nanobiotechnology for green environment*. CRC Press, pp. 37–65.
- Thakur, H., Khan, S., Kaur, N., 2023. A descriptive study to assess the awareness, knowledge, and practices among government senior secondary school students on household waste management in the Gohar block of District Mandi, Himachal Pradesh. *International Jurnal Community Medical Public Health* 10, 4876.