



## Identification of urban waste based on environmentally friendly products in biology education

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### ABSTRACT

Environmental issues are a major concern worldwide. Improperly managed waste is one of the causes of environmental damage. Household waste is the largest contributor to waste in Indonesia. Household waste consists of food scraps, plastic, cans, bottles, and other liquid waste. This study aims to identify the types of materials that can be used as recycled products in biology education especially environmental education learning, processing methods, and suitability with learning plans. The method in this research is systematic literature review (SLR). Reference searches used the Publish or Perish 8 application by analyzing articles indexed by Google Scholar. After conducting the identification, screening, eligibility, and inclusion processes, 10 articles were obtained from Google Scholar. All articles were explained for their suitability with the content of the material in the Environmental Education lesson plan. The findings in this study indicate that materials that can be processed into environmentally friendly products are plastic packaging, plastic bottles, diapers, and used cooking oil. This waste processing can be done using easily available additional materials and simple tools. This study provides a reference for household waste management, contributes to reducing the volume of waste ending up in landfills, supports environmental conservation by encouraging the utilization of waste that is still useful, and increases awareness and implementation of sustainable waste management practices in the community.

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## INTRODUCTION

Environmental issues related to waste have become a global issue. Waste issues require special attention, given the aging of the earth. Population density contributes to a significant amount of waste on Earth (Lingga et al., 2024). Human activities are the largest contributor to environmental damage (Shetty et al., 2023). Household waste is increasing along with population growth (Scherer et al., 2020; Sinan et al., 2022). Improperly managed waste will cause serious problems. Flooding and environmental damage are the result of waste generated by human activities. Furthermore, plastic waste dumped into the ocean will pose problems for marine ecosystems and human health. Microplastics pose a health problem. Microplastics can enter the human body through food, drinking water, air, and skin contact (Putra et al., 2024). Microplastics impact the digestive and endocrine systems, have carcinogenic potential, and impact the respiratory system (Amanu et al., 2024). Waste requires significant attention and wise management. Household waste is one of the largest sources of waste in many urban and rural communities. According to recent studies, approximately 75% of household waste is organic, with the remainder being inorganic (Gau et al., 2022). Meanwhile, plastic waste, inorganic waste, and agricultural waste continue to pose major challenges due to suboptimal management and their negative impacts on health and the environment (Syafi'atun et al., 2022). Household waste produces approximately 0.62 kg of waste per day, 99% of which is organic waste (Sarker et al., 2024). This indicates an increase in public awareness of household waste and a wise approach to waste management.

Household waste management plays a crucial role in maintaining ecological balance. Current household waste management uses an end-of-pipe approach, where waste is collected, transported, and stored in a final disposal site (Adifa & Wibero, 2024; Primanto & Puspitasari, 2025). However, landfills that have accommodated a lot of waste will release methane gas (CH<sub>4</sub>) into the atmosphere, thereby increasing greenhouse gas emissions and contributing to global warming (Ratnawati et al., 2023). In addition, piles of waste that emit methane gas can explode and are very dangerous, such as the incidents at the Leuwigajah landfill in 2005 (Tempo.co, 2023); the Putri Cempo Solo landfill in 2023 (News.detik.com, 2023); the Rawa Kucing Tangerang landfill in 2023 (walhijakarta.org, 2023); the Batu Putih West Sumbawa landfill in 2023 (ppid.sumbawabaratkab.go.id, 2023); and the Galuga Bogor landfill in 2025 (news.detik.com, 2025). In addition, the Indonesian Zero Waste Alliance as of January 2024 reported that there were 38 landfill fires in various regions of Indonesia caused by methane gas trapped in piles of waste (Z. Arifin, 2024). Various cases of explosions at landfills are very dangerous and have claimed lives.

The generation of plastic waste and other non-biodegradable waste is also a major environmental problem. Environmental damage caused by waste includes flooding (George & Fabre, 2021; Rossevelt et al., 2024) damage to marine ecosystems (Sagita et al., 2019) air pollution (Putra & Kurniawati, 2023), soil contamination (Hartanto, 2025), and climate change (Alkhajar & Luthfia, 2020). Furthermore, microplastics enter the human body through drinking water, seafood, and salt (Gunadi et al., 2020).

Environmental issues are a major focus, particularly those caused by waste. Waste problems can be addressed by cultivating an environmentally conscious character (Daud et al., 2022). This development of a caring character can begin through instilling habits in students' learning and skills (Rahmatiani & Repelita, 2025). In environmental education learning, it has been designed how this learning can be the first step for students to get to know their environment and protect it. Therefore, proper and wise waste management must be integrated into learning.

Environmental Education plays a crucial role in building public awareness and capacity, especially among the younger generation, to understand and apply the principles of sustainable household waste management. Environmental education is a compulsory course for university students. In environmental education courses, students are not only equipped with environmental knowledge but also taught skills for preserving the environment. Practical waste management practices need to be implemented consistently and consistently to foster a strong character for environmental stewardship.

Students' knowledge and skills regarding waste management can be taught contextually (Azrai et al., 2024; Fajeriadi et al., 2025). Students can obtain or collect waste themselves, for example, from plastic packaging or plastic bottles (Pujiastuti & Iswatiningsih, 2025). Processed waste can be transformed into more useful, environmentally friendly products. This study aims to identify the types of household waste, their processing methods, and their suitability for the environmental education course's lesson plan.

## METHODS

### Research Design

This research design is a Systematic Literature Review (SRL) (Pursell & McCrae, 2020). This study will conduct an in-depth analysis of articles discussing household waste management. The articles used are those that discuss household waste management other than food waste.

### Population and Samples

The population and sample used in this study were all articles searched using the Publish or Perish 8 application. The population consisted of 100 articles indexed by Google Scholar. After going through the article screening stage, a sample of 10 articles indexed by Google Scholar was obtained. Demographic data Table 1.

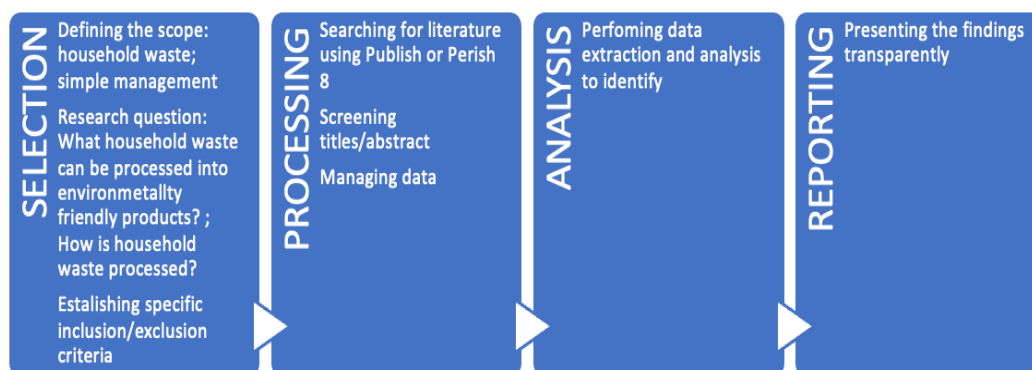
**Table 1.**  
Demographic Sample

Criterion	Inclusion	Exclusion
Publication Period	2020-2025	Before 2020
Study Focus	Focus in the dry household waste such as bottles, plastic, etc. Waste processing is not on a factory scale.	This article discusses the processing of wet waste, such as food and vegetable scraps, and industrial-scale dry waste processing.
Types of Research	Empirical research, Literature review, Qualitative/quantitative studies	An opinion study
Source Type	Articles published in National Journal indexed Google Scholar	Articles published in other than Google Scholar

Table 1 shows the sample demographics. A five-year research and publication period was selected to ensure that the analyzed studies were current and relevant. Articles were screened based on titles and abstracts to ensure compliance with keywords and inclusion and exclusion criteria.

### Procedure

The first step was to formulate a research question. The research questions were: 1) What materials can be used to make environmentally friendly products?; 2) How is this waste processed?; and 3) What research results can be used as practice in Environmental Education lectures (in accordance with the Semester Learning Plan for the Environmental Education course)? In this study, the protocol used refers to scientific procedures and the rationale for a systematic literature review (SPAR-4-SLR) (Paul et al., 2021). Procedures in the study are shown in Figure 1.



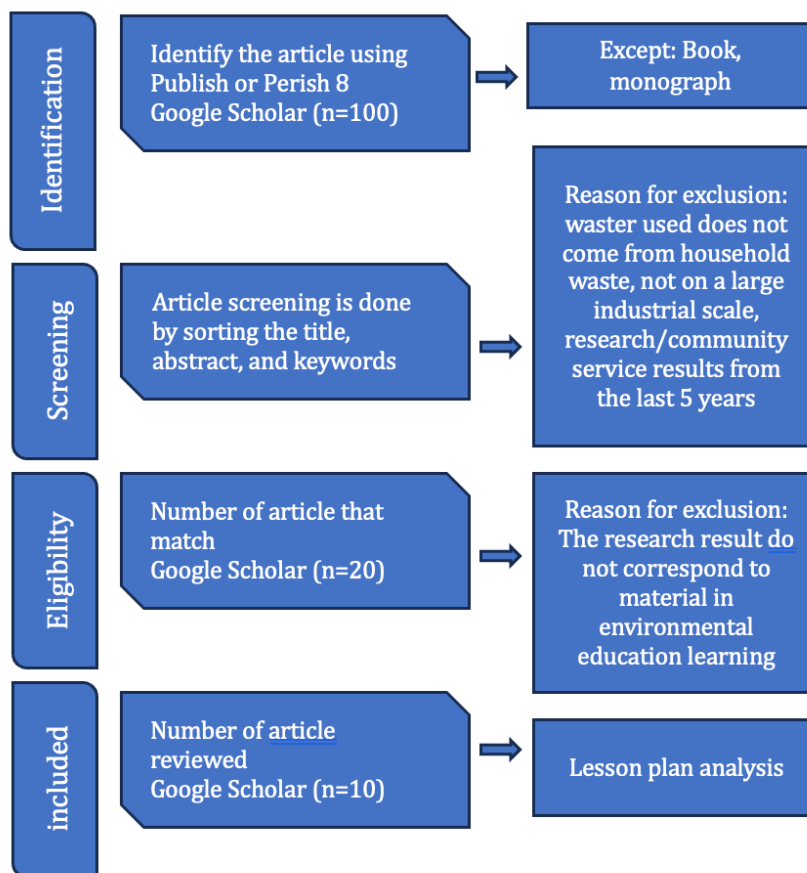
**Figure 1.** Procedures

Figure 1 illustrates the procedures in this study. This study consists of four stages: selection, processing, analysis, and reporting. The search used the Publish or Perish 8 application by analyzing articles indexed by Google Scholar. The keywords used were household waste, environmentally friendly products, plastic waste, and used cooking oil waste. The publication year was limited to 2020-2025. All articles obtained were then selected. Books, monographs, and duplicate articles were eliminated. Then, they were screened again by reading the abstracts. Articles with chemical waste processing, using large industries, inappropriate titles, and publications before 2020 were eliminated. Next, check the suitability of the articles by reading the contents of the results and discussion. Research findings that

were inadequate or inconsistent with the lesson plan were eliminated.

### Data Analysis Techniques

Data analysis was carried out by analyzing the lesson plan for environmental education courses. These articles were then presented through visualization and published. The detailed research process and stages can be seen in [Figure 2](#).



**Figure 2.** Data Analysis

[Figure 2](#) illustrates the data analysis. The findings yielded 100 articles, followed by a uniform filtering process, yielding 20 articles. The sorted articles were then aligned with the lesson plan (RPP), resulting in 10 articles.

## RESULTS AND DISCUSSION

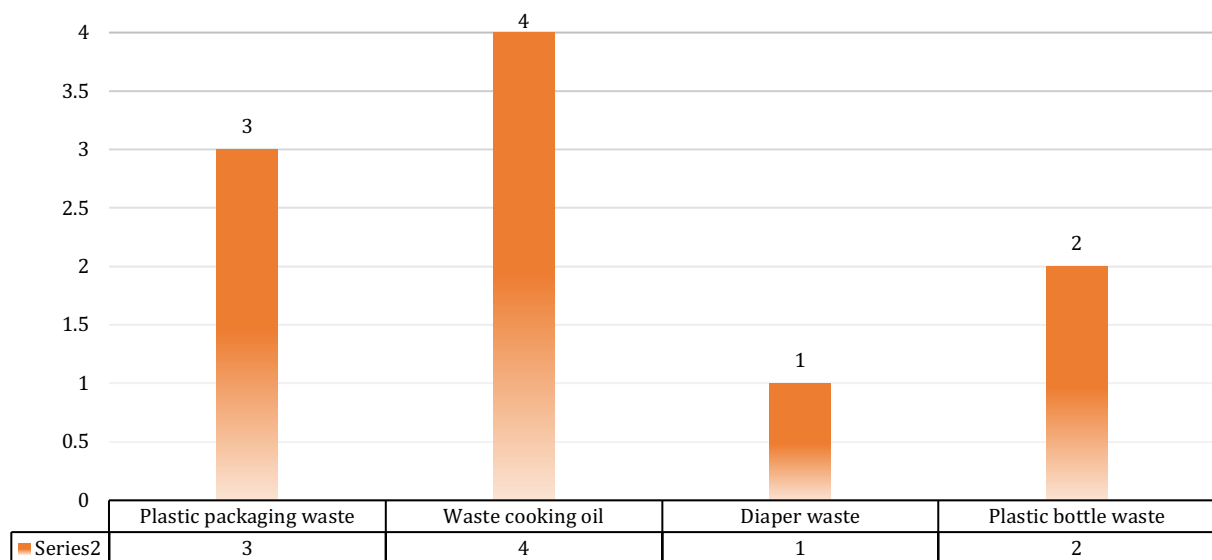
This study analyzes the types of materials that can be recycled, how they are processed, and their suitability for environmental education course lesson plans. The results of the analysis regarding the types of materials that can be recycled are shown in [Table 2](#).

**Table 2.**  
Types of waste materials that can be recycled

Article code	Research Objective	Autor(s)	Year	City & Country	Types of Waste Materials
P1	1. Introduction to Ecobricks 2. Utilizing plastic waste to make Ecobricks	Ikhsan & Tonra	2021	Ternate, Indonesia	Plastic packaging waste
P2	1. Providing insight into the dangers of cooking oil waste	Prabasai, & Rineksane	2023	Yogyakarta, Indonesia	Waste Cooking Oil

Article code	Research Objective	Autor(s)	Year	City & Country	Types of Waste Materials
	2. Processing cooking oil waste into laundry soap				
P3	Assistance and counseling on making aromatherapy candles from used cooking oil	Inayati & Dhanti	2021	Purwokerto, Indonesia	Waste Cooking Oil
P4	Utilization of used cooking oil waste into solid laundry soap	Hidyus et al.	2024	Weru, Indonesia	Waste Cooking Oil
P5	Analyzing the effect of hydrogel fermented with EM4 for 7 days on increasing the content of Nitrogen (N), Phosphorus (P), potassium (K), and moisture content (water content).	Prasetyo et al.	2021	Yogyakarta, Indonesia	Diaper Waste
P6	Improving community skills in processing plastic waste	Rohaeti et al.	2024	Magelang, Indonesia	Plastic packaging waste
P7	Utilization of waste cooking oil for solid soap and candles	Ernawati et al.	2024	Balikpapan, Indonesia	Waste Cooking Oil
P8	Utilization of plastic bottle waste into flower pots	Mas'ud et al.	2023	Surabaya, Indonesia	Plastic bottle waste
P9	Utilizing household waste into works of art	Tulfitri & Lilianti	2020	Palembang, Indonesia	Plastic packaging waste
P10	Utilizing used mineral water bottles to make piggy banks	Rejokirono et al.	2023	Yogyakarta, Indonesia	Plastic bottle waste

Table 2 shows the types of materials (household waste) that can be recycled. Identification results revealed four types: plastic packaging waste, plastic bottles, used cooking oil, and disposable diapers. The 10 articles addressed various questions related to the types of materials used. Research objective P1 introduced ecobricks and how to make them. P2 explained the impact of used cooking oil waste and the production of soap from it. P3 provided outreach and assistance in making aromatherapy candles from used cooking oil. P4 utilized used cooking oil waste to make solid soap. P5 analyzed the effects of hydrogel on used diaper waste as a planting medium. P6 improved community skills in plastic waste processing. P7 utilized used cooking oil waste to make soap and candles. P8 utilized plastic bottle waste to make flower pots. P9 utilized plastic waste to make works of art. P10 utilized mineral water bottles to make piggy banks. The proportions for each type can be seen in Figure 3.



**Figure 3.** Types of household waste that are processed

Figure 3 shows that the most frequently written articles about waste were about used cooking oil waste, plastic packaging waste, plastic bottle waste, and diaper waste. There were four articles about used cooking oil waste, three articles about plastic packaging waste, two articles about plastic bottle waste, and one article about diaper waste.

Article code P1, waste processed into Ecobricks. Used plastic is washed thoroughly, then cut into small pieces, placed into plastic bottles, and compacted. This ensures the Ecobricks are strong and sturdy when assembled into chairs, tables, or other items. Ecobricks are the perfect solution for recycling used plastic into more useful materials (Amjad & Diaz-Elsayed, 2024)

Article code P2, waste in the form of used cooking oil. The processing of used cooking oil consists of three stages: purification, surfactant production, and dishwashing soap formulation. The stage of removing oil from dirt by filtration through a multi-stage filter, followed by a neutralization and bleaching process using activated charcoal. The surfactant production stage uses a saponification process with potassium hydroxide (KOH) to produce a soap base from fatty acids/oils. The final stage is the formulation of dishwashing soap. At this stage, ingredients such as softeners, dirt removers, foam enhancers, and fragrances are added to the soap base. Processing of waste cooking oil is necessary because waste cooking oil will become a pollutant for the environment if disposed of freely in nature (Kumar et al., 2025)

Article code P3: The waste being processed is used cooking oil. The processing process involves filtering the used cooking oil using activated charcoal for at least one hour. After soaking, filter the oil to separate the charcoal and oil. Mix clear used cooking oil with palm wax or stearic acid. Use a 1:1 ratio of palm wax to used cooking oil. Heat this mixture over steam until all ingredients are melted. Once melted and all ingredients are dissolved, remove from heat. Then, add the candle dye and aromatherapy oil. Pour the mixture into a mold and place the wick in the center. Once the wax has melted, the aromatherapy candle is ready to use. Using aromatherapy candles from used oil is more economical and reduces the number of pollutants in the environment (Suharyani et al., 2023). Article code P4: In this article, the waste being processed is used cooking oil. The process of making solid laundry soap from used cooking oil involves purification, dissolving NaOH or caustic soda, mixing the soap mixture, and freezing. Laundry soap made from used cooking oil effectively removes grease and is also less expensive (Arief Rahmatulloh et al., 2024).

Article code P5: The waste being processed is diapers. The diaper waste processing method involves using diaper waste containing urine. The outer layer of the diaper waste is cut to extract the hydrogel inside. The hydrogel is fermented with EM4 for 7 days. After that, it is mixed with soil until homogeneous, and is ready for use. Using hydrogel as a planting medium helps maintain soil moisture (Abdullah et al., 2025). Article code P6: The waste being processed is plastic packaging waste. Plastic waste is processed into brooches, wallets, cleaning cloths, and so on. Processing waste into souvenirs like brooches, wallets, and other items can be financially profitable because the raw materials used are readily available (K et al., 2024).

Article code P7, the process of making aromatherapy candles from used cooking oil waste: Mix used cooking oil, paraffin oil, and stearic acid on a hotplate. Add essential fragrances and color with crayons. Then, mold and thread the wick onto the candle. Solid soap manufacturing process: Waste cooking oil + NaOH + Stearic acid + distilled water. Melt the stearic acid powder on a hotplate, mix until homogeneous (thick), Pour into molds, cool until solid. Aromatherapy candles made from used cooking oil can be used as an alternative for health therapy (Thimmapuram, 2024)

Article code P8, making a plant pot from a plastic bottle: Prepare a used plastic bottle, create a pattern as desired, cut the plastic bottle according to the pattern, paint the shaped plastic bottle, and dry the painted plastic bottle. To make a hanging decorative pot, you can hang it with a rope on both sides. Article code P9, how to process plastic into creative sandals: Wash and dry reusable plastic bags. Then, cut them lengthwise. Braid them and shape the cardboard into the sandal pattern (as the base). Glue the cardboard base with plastic braid. Repeat this process until finished. The sandals are ready to wear. How to make a decorative room lamp: Choose a medium-sized used bottle, wash and dry it, then cut it. Arrange the spoons by attaching them to the bottle in an orderly fashion, resembling a pineapple pattern. Then, color the spoon heads with pylox. Use rag paper to create a pineapple leaf shape, then attach it and add a light to the inside. The lamp is ready to use.

Article code P10, How to turn plastic waste into a piggy bank: Prepare a medium-sized plastic bottle Cut the top off the bottle and dry the inside with a dry cloth Attach double-sided tape to the used bottle Then, wrap the bottle with the double-sided tape in wrapping paper Next, cut a circle out of cardboard to the size of the bottle and make a small hole in it, then attach the wrapping paper Then, attach the hole to the bottle. The hole will serve as a place to insert coins or bills. Create a beautiful piggy bank. Household waste is generally processed into ecobricks, aromatherapy candles, solid laundry soap, liquid laundry soap, souvenirs, creative sandals, decorative lamps, and piggy banks. Next, analyze the suitability of the lesson plan in [Table 3](#)

**Table 3.**  
Analysis of Conformity with the Lesson Plan

Article Code	Findings	Environmental Compliance
P1	Plastic food packaging waste is turned into ecobricks.	Natural Resource Management
P2	Waste used cooking oil is turned into liquid laundry soap.	Environmental problems
P3	Waste used cooking oil is turned into aromatherapy candles.	Environmental problems
P4	Waste used cooking oil is turned into solid laundry soap.	Environmental problems
P5	Waste diapers are turned into planting media.	Environmental problems
P6	Waste plastic is turned into souvenirs.	Natural Resource Management
P7	Waste used cooking oil is turned into aromatherapy candles and solid soap.	Environmental problems
P8	Waste plastic bottles are turned into plant pots.	Natural Resource Management
P9	Waste plastic is turned into creative sandals and decorative lamps.	Natural Resource Management
P10	Waste plastic is turned into piggy banks.	Natural Resource Management

[Table 3](#) shows the results of the suitability analysis of the learning plan for the environmental education course, which shows that there is suitability with the material on Natural Resource Management and Environmental Problems. Plastic waste has a relatively long degradation period. Plastic packaging waste includes Low-Density Polyethylene (LDPE). Traditional disposal methods include burying/landfilling, dumping at sea, or incineration. LDPE degrades relatively quickly compared to other types of plastic. Traditional degradation estimates are hundreds of years (Hoseini et al., 2023). The Winogradsky bacterial/column degradation method takes approximately 450 days to reach 99% degradation (Suyatmo & Wiasih, 2024). Plastic bottle waste includes High-Density Polyethylene (HDPE). The estimated degradation time is approximately 250 years in the soil for thin bottles (Chamas et al., 2020). In a study on the comparison between several types of disposable drinking bottle plastics, such as Polyethylene terephthalate (PET), recycled PET, and virgin PET, it was shown that disposable drinking bottle plastics contributed the greatest environmental damage (Silva et al., 2024).

Plastic waste must be used wisely. The use of plastic in everyday life can be gradually replaced, for example, by bringing a tumbler to reduce the use of bottled water, carrying a cloth tote bag when shopping, and carrying a lunch container. In addition, the government also needs to actively campaign to the public to reduce plastic use and educate them about the negative impacts of plastic waste (Aromi et al., 2024; Bagaskara et al., 2024; Qarina et al., 2025).

In addition to plastic waste, used cooking oil dumped on the ground will reduce the groundwater absorption capacity. The oil forms an airtight layer on the soil surface, inhibiting infiltration and air circulation in the soil pores (Odo et al., 2024). Furthermore, discarded used cooking oil will also disrupt soil microorganisms. Compounds such as triglycerides, saturated fatty acids, and heavy metals in used cooking oil can suppress the population of natural decomposing bacteria, thus reducing soil fertility (Nuraini, 2022). Soil coated with oil will deprive roots of oxygen and air. The public is still unaware of the dangers of used cooking oil dumped into the surrounding environment. Collaboration between stakeholders is essential to campaign against the dangers of waste cooking oil and its treatment (Alfakihuddin & Paratih, 2022; Anizar et al., 2023).

Used cooking oil dumped in water will cause eutrophication and reduce the oxygen levels. A layer of oil on the air surface will inhibit oxygen diffusion, resulting in oxygen deprivation for fish and other biota (Putra & Kurniawati, 2023b). Complex organic compounds (oxidized, aldehydes, and ketones) in used cooking oil will change the pH and color of the air (Hedar, 2021). Furthermore, improperly burned used cooking oil will emit hazardous volatile compounds that are carcinogenic and cause respiratory problems (Rahmadani, 2024). Continuous disposal of used cooking oil into nature will slow the natural degradation process, cover the air and soil surfaces, reduce local biodiversity, and become a source of greenhouse gas emissions (Hasanah, 2023; Meng et al., 2023). Diaper waste is also an environmental problem. Disposable diapers contain components that are difficult for nature to degrade (Allison et al., 2024). The use of disposable diapers must be accompanied by sustainable management (Andri, 2022; Bellaby, 2022; Tarigan et al., 2025). Diaper waste can be recycled into plant-growing media and plant pots (Putri et al., 2024; Sakti, 2025)

## CONCLUSION

1) the types of household waste that can be recycled are plastic packaging, plastic bottles, used cooking oil, and diapers, 2) Processing of plastic bottle waste includes making souvenirs, diapers can be processed into planting media and plant pots, and used cooking oil can be recycled into aromatherapy candles and soap, 3) the results of this analysis can be integrated into biology learning, especially environmental education on the material of resource management and environmental problems.

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