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Reverse logistics applied to used cooking oil: a study of soap production as a way to enhance sustainability.

Reverse logistics applied to used cooking oil: study of soap production as a sustainability enhancement

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Summary

This article prioritizes the empowerment of Environmental Education as a strategy to address the improper disposal of used vegetable oil, a common practice in communities with low access to information. Although national policies and international agreements focused on sustainability exist, this problem persists silently. The study originated after carrying out environmental preservation projects with high school students from the Fagundes Varela State School in Braúnas-MG, including a technical visit to the sanitary landfill in the neighboring municipality. During a discussion, it was identified that the used oil was not being disposed of in an environmentally appropriate manner. The students conducted research in their micro-regions, confirming the incorrect disposal. From this, an environmental education intervention with a qualitative-quantitative approach was developed, applying questionnaires before and after the educational activities. As a sustainable solution, an ecological soap recipe was developed from used oil, articulating the principles of Reverse Logistics and the Circular Economy. The results showed an expansion of knowledge and greater awareness among the population involved, demonstrating the role of the school in training young protagonists capable of acting as socio-environmental multipliers. The project contributed to mitigating environmental impacts, reducing waste, and stimulating sustainable practices, promoting socio-environmental responsibility and local entrepreneurship with a global perspective.

Keywords: Environmental education, Circular economy, Reverse logistics, Waste vegetable oil, Sustainability.

Abstract

This article focuses on enhancing Environmental Education as a strategy to address the improper disposal of residual vegetable oil, a common practice in communities with limited access to information. Although there are national policies and international agreements aimed at sustainability, this problem persists silently. The study originated after the implementation of environmental preservation projects with high school students at Escola Estadual Fagundes Varela, in Braúnas-MG, including a technical visit to the landfill of the neighboring municipality. During a discussion circle, it was observed that the residual oil was not being disposed of in an environmentally appropriate manner. The students conducted research in their micro-regions, confirming the improper disposal.

Based on this, an environmental education intervention was developed using a qualitative-quantitative approach, applying questionnaires before and after the educational activities. As a sustainable solution, an ecological soap recipe was developed from used oil, integrating the principles of Reverse Logistics and the Circular Economy. The results highlighted an increase in knowledge and greater awareness among the population involved, demonstrating the school's role in shaping young leaders capable of acting as socio-environmental multipliers. The project helped to mitigate environmental impacts, reduce waste, and promote sustainable practices, fostering socio-environmental responsibility and local entrepreneurship with a global perspective.

Keywords: Environmental education, Circular Economy, Reverse Logistics, Residual vegetable oil, Sustainability.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

1. Introduction

Unplanned urban sprawl and high consumption standards have intensified
significantly increases the pressure on natural resources, resulting in major environmental impacts.
magnitude on a global scale. Among the main consequences of this process are:
climate change and the high levels of environmental pollution resulting from activities
anthropogenic factors pose global challenges. In this context, it becomes imperative to...
formulation and implementation of public policies and technological solutions capable of mitigating such
Impacts in the context of the 21st century.

According to the Ministry of Environment and Climate Change (MMA, 2010) and the
National Solid Waste Policy (PNRS), Law No. 12.305/2010, defines solid waste.
such as materials in solid or semi-solid states resulting from domestic, industrial activities,
commercial and service waste, whose disposal requires environmentally sound management.

Article 9 establishes the National Solid Waste Policy, highlighting guidelines for its management and
Solid waste management, and the following order of priority must be observed: no
generation, reduction, reuse, recycling, treatment of solid waste and final disposal
environmentally sound disposal of waste, (BRAZIL, 2010).

The large production of solid waste, as well as residual cooking oil, is becoming established.
being one of the main causes of these environmental impacts, contributing to climate change,
from the emission of methane gas during its decomposition process, being one of the gases that cause
of the greenhouse effect. According to the Federal Constitution of 1988, in Article 225, everyone has the right to
An ecologically balanced environment, a common good for the people, and essential and healthy quality.
of life, imposing on the Public Authorities and the community the duty to defend and preserve it for the
present and future generations (BRAZIL, 1988). Emphasizing collectivity, the methodology
careful consideration is given to the responsible and environmentally sound disposal of used cooking oil.
Highlighting the discharge limit for effluents, as established by the National Environment Council,
discharge of effluents, including oils and greases, determining the limit concentration for oil.
vegetable oil, being 50mg/L (CONAMA, 2011). Improper disposal of used cooking oil,
Originating from its use in food preparation and frying, once disposed of down the sink, it causes a series of problems.
of problems such as clogged pipes, environmental impacts, and health risks.
The oil forms a top film on the water, affecting humans and aquatic phytoplankton and zooplankton.
Due to its density, it prevents oxygenation. During its decomposition, the formation of
from methane gas, resulting from bacterial fermentation. Increasingly expensive wastewater treatment.
In a worrying context, where 1 liter of oil can contaminate up to 25,000 liters of water, in
resulting from improper disposal (BIODIELBR, 2007).

In the current context, actions and policies implemented with advanced technologies are necessary.

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Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

aiming to implement and develop solutions to mitigate and eradicate the problem. Emphasized by National Solid Waste Plan through legislation (Decree 11.043 of 2022).

Article 3. State, microregional, metropolitan region or solid waste plans Urban, intermunicipal, and municipal agglomerations must comply with the Policy. National Solid Waste Policy and the National Solid Waste Plan (BRAZIL, 2022).

> According to the Brazilian Association of Solid Waste and Environment (ABREMA), actions such as the implementation of basic sanitation are essential, in addition to the health benefits, mitigating the burden on public health. It is estimated that, between 2016 and 2021, the total health expenditure in Brazil to treat problems caused by the inadequate disposal of waste was R$ 1.85 billion (ABREMA, 2024).
> The current context presents solid waste as a high-level source of raw material for the production of new products, returning these products to the economic chain through reverse logistics and mitigating the extraction of new natural resources. According to Gerlt, residual cooking oil is considered waste and therefore presents certain advantages in biofuel programs. This makes cooking oil an even more valuable raw material for biofuels, as it has a low carbon intensity once it has been used, generating environmentally sound carbon credits.
> Showing an increase in imports of used cooking oil raw materials, which went from less than 300 million pounds in 2021 to more than 3 billion pounds in 2023, (ASA, 2024).
>
> Promoting sustainable actions, based on the circular economy and reverse logistics, in addition to income generation, is an essential need. Residual cooking oil, in particular, can be used in the production of soap, detergents, paints, animal feed, and especially biofuel. According to data from Earth: More Ideas and Less Waste in 2022, a quarter of the used cooking oil (UCO) produced globally is collected for recycling. This highlights the need to expand public awareness regarding costly maintenance costs for sewage networks, which account for 47% of blockages in the system.
>
> Hotels and restaurants in the United States generate approximately 3 billion gallons of used cooking oil per year. In 2022, the U.S. collected less than a third of that volume, despite having one of the most developed used cooking oil collection systems globally; substantial volumes are still not collected (Earth, 2022).

Through joint actions with supplier companies, based on collective action, environmental education, and public awareness, the Brazilian Association of Vegetable Oil Industries established the... collection and gathering of 700,000 liters of used cooking oil in 2023, aiming to achieve 1 million in 2024 (ABIOVE, 2021). Highlighting the extremely high disposal rate of used cooking oil. in a context of loss of valuable raw materials and revenue, in the reintroduction of materials, in production chain, with the production of biofuels.

Entitled environmental education and raising public awareness, one of the actions priorities. Highlighting the problems and costs that used cooking oil can cause, to the environment, to aquatic life, and to significant maintenance of pipelines and disposal. of treated effluent. Highlighting expenses related to sick people, in addition to the economic value. Promoting income generation for families and increased revenue. Mitigating the consumption of new natural resources. Therefore, this article aims to highlight the importance of recycling cooking oil. residual, prioritizing projects to raise public awareness about the harmful effects of reuse. from cooking oil, in terms of food waste and final disposal, to improper disposal,

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026
from this residue. Characterizing itself as a product of great value in the production of biofuel.

2. Justification

This article presents the recycling of used cooking oil as a way...
to curb the problem of improper disposal in nature, especially in bodies of water.
promoting the circular economy, aligned with sustainability and reverse logistics, where the population,
Produces ecological soap, both for consumption and as a source of family income. Mitigating risks.
sanitary facilities, enabling the optimization of basic sanitation and prevention and safety for public health.
According to United Nations reports, 1.4 million people worldwide die from these diseases every year.
Infections caused by contaminated water and inadequate sanitation. These are diseases such as
Diarrhea, cholera, and typhoid fever, among others (UN, 2025).

The National Health Surveillance Agency (ANVISA) highlights the inherent dangers.
The reuse of cooking oil in food preparation over a long period generates compounds.
unpleasant, including substances that may pose health risks to the consumer, such as
Irritation of the gastrointestinal tract, diarrhea, among others. Therefore, it was titled a Report.
Technical Order No. 11, dated October 5, 2024, regulating the Brazilian Standard for the use and disposal of...
of the oils and fats used for frying, 1- the amount of free fatty acids should not exceed
0.9%; 2- the content of polar compounds is not greater than 23%. 3- the values of linolenic acid,
The amount of nutrients present in fried foods should not exceed the limit of 2% (ANVISA, 2004).

Reports from the Global Recycling League Table (EUNOMIA, 2024), which analyzes global recycling
rate indices, showed in 2024 that countries such as Austria and Wales...
They show higher rates, reaching over 50%, while North American countries such as
The United States of America reached just over 30%, with Canada following closely behind.
table. South American countries, such as Brazil, have a very low rate, reaching just over
4%, while countries with similar economies, such as Argentina, have a rate of
approximately 8% and Colombia with more than 10%. In this context, in the same reference year,
A high rate of efficiency was shown in the recycling of some waste materials such as aluminum, where
Brazil achieved 100% recycling of this waste, followed by Chile, Argentina, and Germany.
and Japan, achieving over 90% in the recycling of this urban solid waste. Also presenting the
The state of Maine (USA) recycled 83%, while the state of West Virginia recycled 6%, placing it in 50th position.
compared to the 50 states of the USA, (EUNOMIA, 2024, pp. 11 and 24). Demonstrating the
potential for expansion, adding value to all types of Municipal Solid Waste.
Highlighting the need for recycling policies, technologies, and actions to implement the
Recycling of materials. Although actions have been implemented, in the context of,

...energy production, reducing air and water pollution, and decreasing greenhouse gas emissions.

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Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

greenhouse effect. The United States' track record of success in promoting economic goals should to serve as a model for other countries (WHITE HOUSE, 2025).

According to reports by Ball Corporation and Eunomia Research & Consulting, (2021), Only the US fails to generate enormous revenue when it sends potentially hazardous waste to its proper disposal. economically, the waste is sent to landfills to be buried and incinerated.

• $6.5 billion worth of materials are lost in landfills annually that could be recovered through more effective recycling practices.
•Nationally, the value of material diverted from landfills is US$26 billion, which This represents only 32% of the value that could be recovered annually (BALL & EUNOMIA, 2021).

To promote environmental education and preservation, highlighting the importance of recycling. solid waste, as a source of capital and promotion of a sustainable circular economy, in addition to reduction of the pressure on natural resources. Promoting students as critical agents and disseminators of sustainable actions and practices, capable of developing methodologies and practices that can solve problems for the population on a global level. Promote emphasis on prevention and environmental preservation, mitigating the replacement of new natural resources, boosting the management and economic benefits, on a global scale, (Zaman, 2016.

An average person saves about 219 kWh of energy and emits about 48 kg of greenhouse gas. It reduces the greenhouse effect (GHG) and saves approximately 38 liters of water. Global waste management systems Urban solid waste potentially contributed around US$201.5 billion, or about US$60 billion. per person, in economic benefits annually (Zaman, 2016).

Highlighting the need to expand knowledge and information regarding practices. Sustainable individual and collective goals through the implementation of effective policies, entitled a technological implementation and new business markets, using raw materials and inputs derived from solid waste, mitigating the depletion of new natural resources. On a global scale, the prominence of new labor markets, increased PIT (Public Employment and Income) and outsourcing of public spending, with proper treatment and disposal of Municipal Solid Waste (MSW).

3 Materials and Methods

The project was developed by high school students from the Fagundes Varela State School. in the municipality of Braúnas, in the interior of Minas Gerais. Initially, a technical visit was carried out to landfill of an adjacent city, which receives the solid waste produced by municipality of Braúnas. Based on all the knowledge acquired at the landfill, a roundtable was held. A conversation with the students, in order to encourage the proper disposal of cooking oil. The project was

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

developed from research, occurring in two stages, before and after the project's implementation.

A simple questionnaire was proposed for young people to carry out the research in the microregions where live there. The city of Braúnas has a population of 4,445, according to data from the Brazilian Institute of Geography and Statistics (IBGE, 2025). According to data from the Water and Sanitation Institute of By 2025, more than 65% of the population will live in rural areas, which hinders access to information. The estimate was that all communities, or micro-regions, would be reached.

Figure 01 - Sanitary Landfill, waste improvement in the initial phase;
Figure 02 - Sanitary landfill in its final phase and methane gas control;

Fig. 01 Source: Prepared by the author, 2024.

Fig. 02 Source: Prepared by the author, 2024.

• The sanitary landfill of the neighboring city is actively receiving solid waste, to be... compacted, (FIG.01).

• Sanitary landfill of the neighboring city, receiving the controlled combustion of methane, (FIG.02).

First stage questionnaire;

RESEARCH 01 - Initial investigative research;

1. Do you use cooking oil in your home?
2. Do you reuse oil when preparing food?
3- How do you dispose of the oil after use?
4- Are you familiar with using waste oil to produce soap?
5- Are you aware of the environmental impacts caused when these substances are disposed of on the ground or down the sink?
6- Have you already obtained information regarding proper disposal?
7- Are you willing to store the oil for recycling, for donation, or start producing soap with the residue?

Source: produced by the author.

The initial research was investigative in nature, where students were encouraged to To develop the research and promote the awareness campaign among family members and neighbors. Next. The results of the research were presented and discussed in a roundtable discussion. High levels of misinformation among the population regarding the reuse of cooking oil. Waste and disposal in the soil and down the kitchen sink. Awareness campaigns were developed. Regarding consumption and disposal methods, posters will be displayed in strategic locations, as well as...

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

disposal of residual cooking oil. In this context, two recipes were developed.

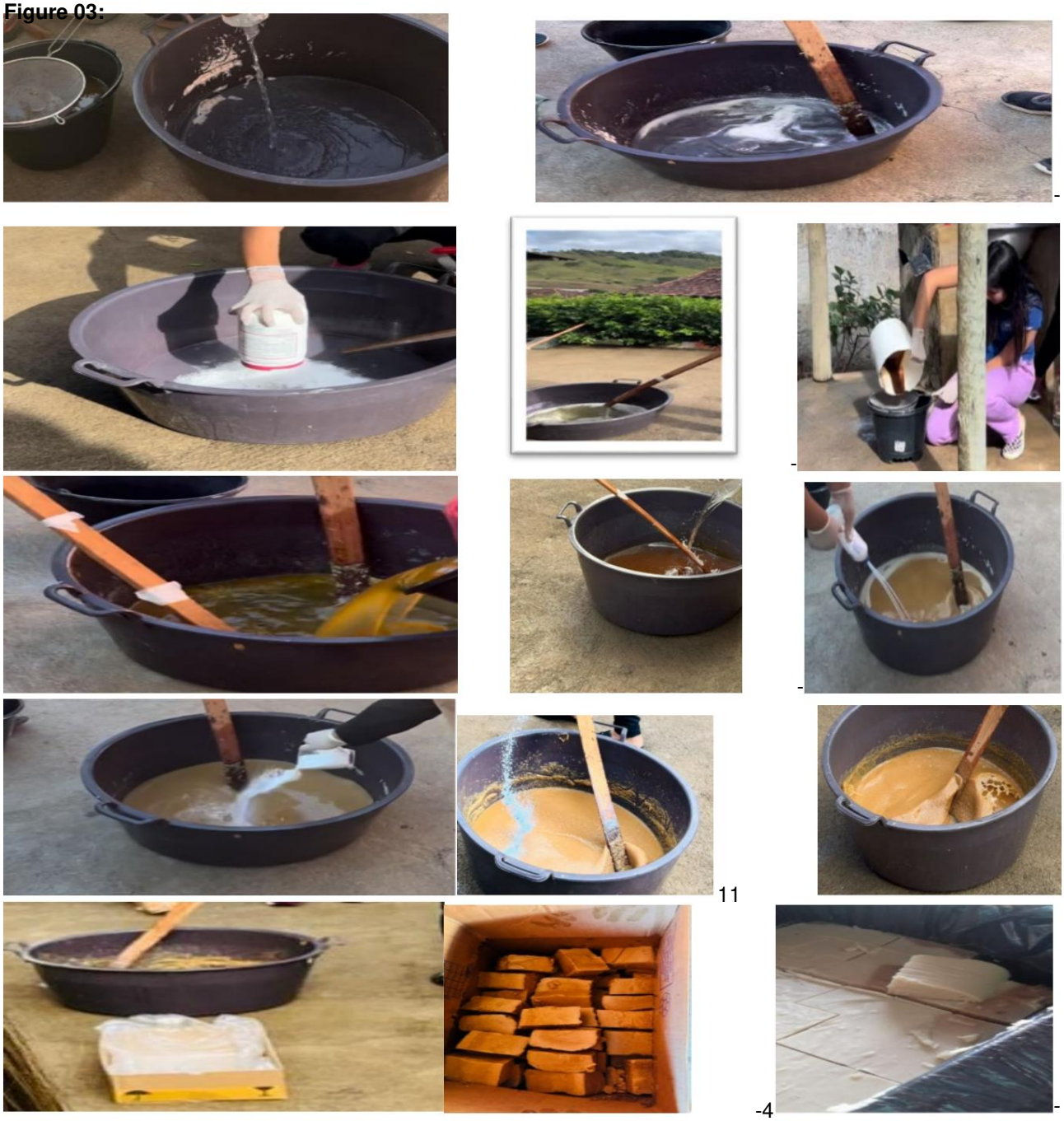
Experimental biological soap making, from the recycling of residual cooking oil, as a way of

To solve the problem and strengthen family income, 12 liters of oil were recycled in this context.

of kitchen waste, totaling the equivalent of two experiments, over 7 days.

1- Soap Production Workshop;

Figure 03:



Source: Prepared by the author, 2024.

4 - Experimental procedure;

Strain the oil and set it aside. In a larger container, such as a bucket or deep bowl, place the water and add...

Add the pine and soda, stirring until completely dissolved. Then add the oil and stir until...

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

The mixture should have a consistent and homogeneous texture. Add the detergent and continue mixing well.

Add the laundry detergent, bleach, baking soda, and white vinegar for the second step.

The recipe was supplemented with eucalyptus essence, followed by the alcohol vinegar. Stir until...

Let it thicken to the point where it can be turned over in the container. Wait approximately two hours.

Check the firmness of the soap and cut it into pieces. After cutting, wait another three hours, to...

Remove from the mold completely. Set aside 2 recycled cardboard boxes lined with plastic.

The consistency varies depending on the ambient temperature, therefore it is recommended to store it in... A cool, well-ventilated place, away from direct sunlight. This will affect the cutting and finishing time. total production. The initial cut, after it has gained firmness, is ideal to facilitate the final process. A Recipe 01 is indicated for washing dishes and recipe 02 is indicated for washing clothes, receiving Different detergents and fragrances are used to enhance washing effectiveness and overall results.

The used oil was recycled at the school and in the homes of students and nearby neighbors. The soap produced, it was used at the school itself and by the students, who, after packaging it, took it home and to neighborhood.

Throughout the processing, all safety, health, and environmental protocols were followed. in accordance with technical standards for the use and handling of chemical products, as per defined by (Brazilian Association of Technical Standards - ABNT 2023). Corroborating the importance, of carrying out the production process in open and ventilated environments, taking into account Given the use of chemical elements, all preparation is done cold, inhibiting sensitivity and Irritability during the preparation and occurrence of chemical reactions. The entire process was accompanied by teachers.

Table 1 – Ecological Soap Recipes

Ingredients	**Recipe 01**	**Recipe 02**
Used cooking oil	6 liters	6 liters strained
Caustic soda		1kg
Pine	strained 1kg 1l	1l
oil, detergent,	500 ml of lemon	500 ml of coconut
water,	1 l	1l
bleach, white	200 ml	200 ml
vinegar, laundry	200 ml	200 ml
detergent.	200 g	200 g
Sodium bicarbonate,	200 g	200 g
Eucalyptus essence.	-	20ml

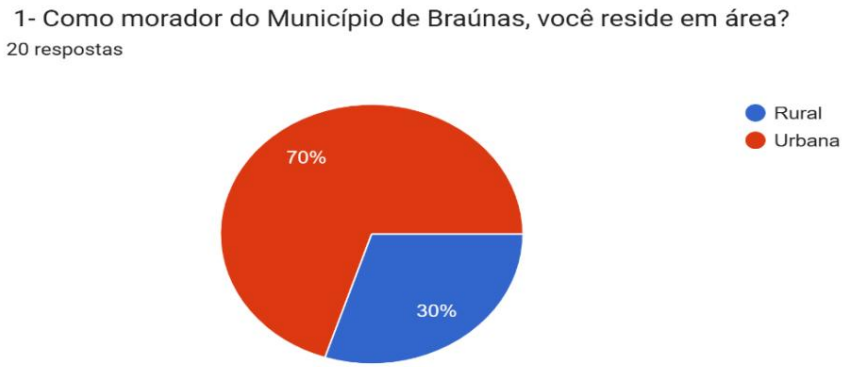
Source: Prepared by the author, 2024.

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026 4. Results and Discussion

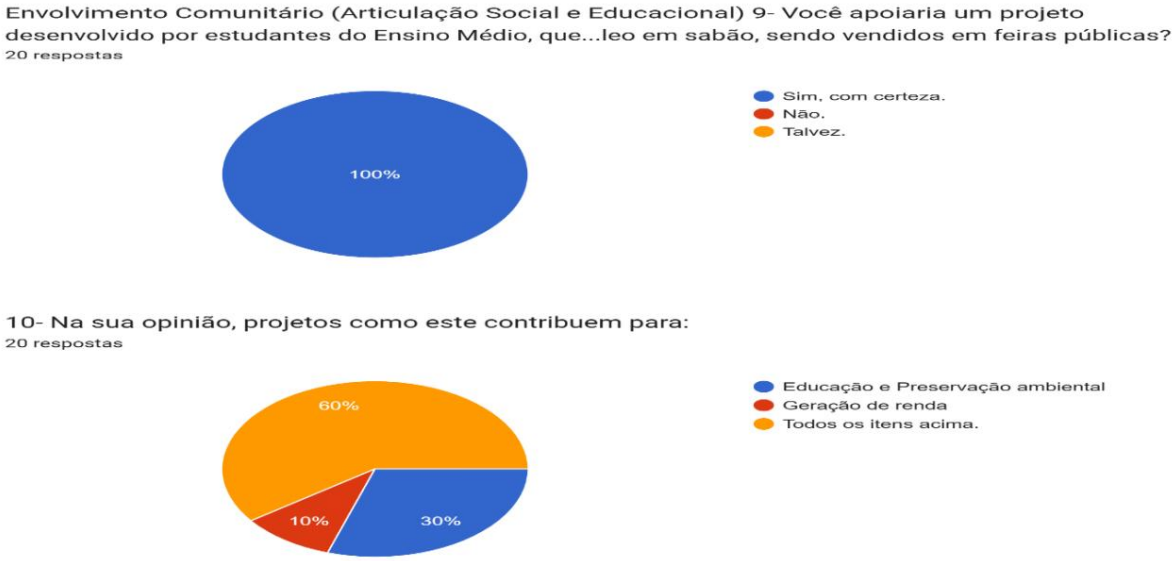
The project emphasized solving the problem faced in small, rural municipalities. formed by microregions and clusters. Although, a great effort was made to to reach the entire population of the municipality through campaigns promoting the reuse and proper disposal of this waste. Also highlighting the leading role of youth in enacting and implementing solutions to... problems faced by global society. In this context, young people have achieved Having gained knowledge of how a sanitary landfill works, they produced recipes for ecological soap, with For purposes of different uses, they conducted research before and after the project's execution, aiming to success with different results between the 1st and 2nd stages of the research. Respectfully, all cultural aspect of the current population.

RESEARCH 02 - Second stage of the research, results analysis;



RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026



Source: Prepared by the author, 2025.

The second stage of the research aimed to analyze the results and changes of
The behavior of the population after the campaign carried out by the students. Presenting the following
As a result, 20 people responded to the survey, with 70% of the respondents living in urban areas.
while 30% are in rural areas. Regarding the use of cooking oil, 60% use it daily, 30%
a few times a week and 10%, rarely, using other oils, such as coconut oil and shortening.
animal. Regarding the damage caused to the environment, 95% responded that they are aware of it, with 5%...
corresponding to a person, claiming to be unaware of the fact. Regarding the reuse of oil for
Regarding soap production, 95% of respondents said they are familiar with the reverse logistics process.
Regarding the reuse of oil, 5%, or one person, admitted to having no knowledge of how much.
The reuse of waste. They were also questioned about recycling campaigns and...
acquiring the product at open-air markets, whether they would be willing to contribute, in the donation of the waste and
Regarding the purchase of this product, 100% of those interviewed said yes, they would support its continuation.
project. They were also questioned about the relevance of the project, with 60% indicating they believed in it.
that contribute to education and environmental preservation, 30% to income generation, and 10% believe
that both factors are relevant to education, environmental preservation, and income generation.
The last question was open-ended and optional, although important for the outcome of the survey, where the
The interviewee was encouraged to express their opinion regarding the importance and reuse of oil.
Recycling kitchen waste by producing soap instead of discarding it. The responses were quite significant.
highlighting the population's concern for the environment and the health of the population and of life.
aquatic, also highlighting the source of income from the production of ecological soap, making use of
Own income and sales, in the generation of extra income, strengthening family well-being.

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

In your opinion, how important is it to reuse used cooking oil instead of discarding it into the environment?

Answers;

• Reusing oil contributes to the environment and generates income.

• Important for improving the quality of our health and the environment.

• Generate income and cleanliness because I take the opportunity to make soap.

• It prevents oil from polluting the soil and bodies of water, damaging sewage systems, and some other forms of pollution.

Reused materials can still be used as a source of income.

• Because it would be very good for the environment and for people's well-being, and would not infect the environment.

environment

• It generates income and contributes to the environment.

• Reusing cooking oil is a simple action that prevents pollution and preserves natural resources.

and contributes to a more sustainable future.

• In my opinion, the oil can be used to make soap for personal use or even to generate

An extra income for the family.

Source: Prepared by the author, 2024.

5.1 Sustainability, Circular Economy aligned with Reverse Logistics and Environmental Impacts, Promoting Strategic Operationalization for the 21st Century

The circular economy presents itself as a fundamental pillar for the enactment of new

Technologies and foundations, in the literature, promoting and recovering materials that would otherwise be discarded.

incorrectly, returning to the production chain, starting from Reverse Logistics. Driving the

global market, through increased GDP and the generation of new economic businesses and jobs.

According to (FOUNDATION, 2015).

In recent years, the circular economy has featured prominently in political discussions.

Economic and business-related. But the concept remains eclectic and lacks a definition.

scientifically endorsed. For the purpose of this economic analysis, the circular economy is defined

as an economy that provides multiple value creation mechanisms that are decoupled from

consumption of finite resources, (EUROPEAN COMMISSION, 2015).

Since waste cooking oil is a potentially valuable raw material in the production of

Biofuels, in the generation of electricity, because they have a lower carbon content.

contributing to the mitigation of greenhouse gas emissions into the atmosphere.

Establishing itself as an input in the production of animal nutrition, soap and paints, among others.

Others. Based on sustainability principles, promoting well-being and social equity. Mitigating,

making the final disposal of solid waste more costly, thus reducing the pressure on landfills.

inhibiting the spread of methane gas, produced during the decomposition of residual cooking oil.

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026

The circular economy approach alone would generate an estimated net annual gain of 108 billion. dollars, resulting from waste prevention and sustainable business practices and management. Integrated waste management (ISWA, 2024) Reverse Logistics neutralizes negative externalization, inhibiting Pollution of water bodies prevents damage to networks and pipes, and contributes to... preservation of aquatic ecosystems and reduction of socio-environmental costs and expenditures to the public coffers public. It consolidates the economic value of sanitation, sewage and treatment of Wastewater. Making the reduction of future problems a reality through damage remediation. In this context, It is worth highlighting that the Recycling Incentive Law (LIR), established by Law No. 14,260/2021,

It is an initiative that promotes the strengthening of recycling in Brazil through incentives. fiscal. Its objective is to promote projects that stimulate the circular economy and reduce the generation of Reduce waste and increase the use of recyclable and recycled materials, contributing to sustainability. and social inclusion, (SINIR, 2021).

This corroborates the prominence of the circular economy and reverse logistics, starting with recycling. Reducing, reusing, and transforming these waste materials into new products, fostering the supply chain. productive economic growth and promotion of social inclusion.

6. Final Considerations

It is concluded that environmental education constitutes a strategic instrument for transformation. of socially normalized practices, especially with regard to the improper disposal of oil. from kitchen waste. Raising awareness among students and the community has proven to be fundamental for the compression of the environmental, health, and economic impacts resulting from improper disposal. of this residue.

The proposal to reuse waste oil for soap production became evident. as a viable alternative from a socio-environmental and economic perspective, by promoting the mitigation of environmental damage, reduction of risks to public health and increased value of previously used raw materials discarded. Furthermore, such an initiative shows potential for fostering social entrepreneurship, expand income-generating opportunities and strengthen markets aligned with the principles of sustainability.

From the perspective of the circular economy, based on reverse logistics, the reintegration of waste in the production chain reaffirms the possibility of reinterpreting environmental liabilities as assets. economic. This approach contributes to the consolidation of more sustainable production models. and resilient, capable of responding to contemporary environmental challenges.

Thus, highlighting the need for integrated actions that articulate Education Environmental issues, effective public policies, and appropriate technological solutions aimed at reducing, reuse and recycling of waste, in line with the principles of development.

Year VI, v.1 2026 | Submission: 03/28/2026 | Accepted: 03/30/2026 | Publication: 04/01/2026
Sustainable on a global scale.

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