Research Paper

Wais (waste automotive ignition stove): an eco- efficient stove with automated oil control mechanism

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ABSTRACT

This study investigates the development and performance of the Waste Automotive Ignition Stove (WAIS) prototype, designed to use waste engine oil as a cooking fuel. The primary objective was to assess its efficiency, environmental impact, durability, and economic feasibility as an alternative cooking solution. The WAIS prototype demonstrated a heat output of 4.5 kW, which was superior to charcoal stoves (3.2 kW) and comparable to butane stoves (4.0 kW), while maintaining a fuel consumption of 0.35 liters per session, highlighting its fuel efficiency. In terms of environmental impact, WAIS reduced waste oil disposal by 85% and emitted 50 ppm CO and 35 ppm NOx, which was lower than charcoal stoves but higher than butane. The stove's automated oil control system reduced fuel wastage by 30% and mitigated fire risks. Durability tests revealed that the prototype required minimal maintenance, with only one check-up in six months.
Based on the findings, it is recommended to enhance emission control through filtration technology and further improve the stove's combustion efficiency. Additionally, long-term studies should be conducted to assess the stove's durability and real-world performance, while efforts to promote waste oil recycling and user safety should be prioritized for broader adoption.

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1. INTRODUCTION

Background of the Study

The concept of the Waste Automotive Ignition Stove (WAIS) centers on addressing two critical global challenges, improper disposal of waste oil and the environmental and health impacts of traditional cooking methods. As fuel prices continue to fluctuate, the need for alternative cooking solutions grows, particularly in resource-constrained communities. WAIS presents an innovative solution by repurposing used engine oil, a hazardous waste, as a viable fuel source for cooking [1]. This promotes environmental sustainability by reducing pollution and offers an affordable alternative to other conventional stoves powered by charcoal, butane, or wood.

By utilizing a waste product as fuel, WAIS aligns with principles of the circular economy, where materials are reused, recycled, or repurposed, rather than disposed of improperly. The design of WAIS integrates cutting-edge technology with simplicity. Stated [2] that the stove's automated oil control mechanism, powered by a light sensor and servo motor, ensures that fuel is dispensed according to the demand for heat. This automated system optimizes efficiency, preventing waste and ensuring that the cooking process is both energy-efficient and safe. The inclusion of an oil level sensor adds an extra layer of precision to fuel management, ensuring that the stove does not run out of fuel during use (Jenkins, 2018). This design enhances the stove's performance and minimizes the risks associated with manual fuel handling, such as spillage or incorrect fuel usage.

The primary gap in the current research and implementation of WAIS lies in its long-term environmental and health effects, particularly concerning the reuse of engine oil as fuel. While engine oil recycling is a growing field, the combustion of waste oil may still pose health risks due to the emission of harmful particles, such as volatile organic compounds (VOCs) and other pollutants. Further research should focus on evaluating the exhaust emissions of WAIS and comparing them with those of conventional stoves, ensuring that the stove does not inadvertently introduce new health risks.

A gap in the study is the socioeconomic impact of widespread WAIS adoption, especially in low-income areas that might benefit the most from its cost-efficiency. While the initial prototype addresses fuel scarcity and the repurposing of waste materials, the economic feasibility of mass-producing and distributing WAIS stoves to these communities remains unclear. Research should explore the costs associated with scaling up production, the potential market demand, and the financial accessibility of the stove for various socioeconomic groups. The durability and maintenance requirements of the WAIS stove, especially concerning the automated oil control mechanism and the long-term performance of components like the dynamo blower, are essential areas for investigation. While the technology appears promising, there are uncertainties regarding its sustainability and whether regular maintenance can be easily performed by end users, particularly in remote areas with limited access to technical expertise.

Objectives

By aiming to create a WAIS using useful Engine Oil as fire fueler, the study aims to:

1. To design and develop a functional prototype of the Waste Automotive Ignition Stove (WAIS) that utilizes waste engine oil as a cooking fuel source.
2. To evaluate the performance and efficiency of the WAIS prototype, focusing on the automated oil control mechanism, fuel flow, and combustion process.
3. To test the environmental impact of the WAIS prototype by analyzing exhaust emissions, particularly volatile organic compounds (VOCs) and other harmful pollutants produced during combustion.
4. To assess the durability and maintenance requirements of the WAIS prototype, specifically the longevity and functionality of key components like the servo motor, oil sensors, and dynamo blower.
5. To investigate the feasibility and cost-effectiveness of scaling up WAIS production and distribution, focusing on its socioeconomic accessibility and the potential benefits for low-income households.
6. To analyze the effect of WAIS on waste oil disposal practices and its potential to reduce environmental pollution associated with improper waste oil management.

7. To explore the safety and user-friendliness of the WAIS prototype, assessing its ease of use, maintenance, and the safety features related to oil handling.

Research Questions

1. How does the WAIS prototype perform in terms of efficiency and heat output when using waste engine oil as fuel?
2. What are the environmental impacts of using WAIS, particularly regarding exhaust emissions and air quality in comparison to traditional cooking methods?
3. How effective is the automated oil control mechanism (servo motor and light sensor) in managing fuel flow and preventing wastage during the cooking process?
4. What is the long-term durability of the WAIS prototype, particularly regarding the wear and tear of components such as the dynamo blower, oil sensors, and automated system?
5. What are the socioeconomic barriers and opportunities associated with scaling up the production of WAIS for widespread adoption, especially in resource-constrained communities?
6. How does the use of WAIS influence waste oil management practices, and does it reduce environmental pollution linked to improper disposal of engine oil?
7. What are the potential health risks associated with using waste engine oil as a fuel, and how does WAIS mitigate or contribute to these risks?

Null Hypotheses (H_0)

1. H_{01}: The WAIS prototype will not provide a more efficient or cost-effective alternative to traditional cooking stoves using waste engine oil as fuel.
2. H_{02}: The automated oil control mechanism in the WAIS prototype will not significantly improve fuel management or reduce waste.
3. H_{03}: The exhaust emissions from the WAIS prototype will not be significantly different from those of traditional stoves using charcoal or butane in terms of harmful pollutants.
4. H_{04}: The WAIS prototype will not exhibit long-term durability, and components such as the servo motor and dynamo blower will require frequent maintenance or replacement.
5. H_{05}: The mass production and adoption of WAIS stoves will not be economically feasible, and low-income households will not experience significant cost savings or benefits from its use.
6. H_{06}: The use of WAIS will not have a significant effect on waste oil disposal practices, nor will it reduce environmental hazards associated with improper engine oil disposal.
7. H_{07}: The WAIS prototype will not be safe to operate, and there will be potential health and safety risks for users, regardless of the implementation of safety features.

Theoretical Framework

The theoretical framework of the Waste Automotive Ignition Stove (WAIS) is grounded in multiple principles that explain its functionality, sustainability, and efficiency in repurposing used engine oil as a cooking fuel. The first and second laws of thermodynamics support the stove's energy transformation process, ensuring that chemical energy from used engine oil is converted into thermal energy for cooking while minimizing energy loss.

The waste-to-energy concept reinforces WAIS's role in resource recovery by repurposing hazardous used engine oil into a usable fuel source, aligning with circular economy principles and sustainable waste management. The combustion theory guides the stove's design by ensuring an optimized air-fuel ratio, achieving complete combustion to maximize heat generation while reducing emissions of carbon monoxide (CO) and other pollutants. Additionally, automation and control theories underpin the automated oil control mechanism, where a servo motor, light sensors, and an oil level sensor regulate fuel flow to maintain consistent combustion and prevent overflow or dry burning.

The inclusion of a dynamo blower further enhances combustion by controlling airflow for better thermal efficiency. From an environmental and health perspective, the environmental Kuznets curve hypothesis suggests that technological advancements like WAIS can reduce pollution over time, while the indoor air quality theory emphasizes the importance of minimizing harmful emissions that pose health risks in indoor cooking spaces. Altogether, these interconnected theories form the scientific foundation of WAIS, ensuring its viability as an eco-efficient, cost-effective, and sustainable alternative to conventional cooking stoves.

2. RELATED WORK

Gasification-based stoves have been explored as an alternative to traditional biomass stoves in developing countries. Examined [3] a producer gas stove with a bluff body design and different biomass feedstocks. The study identified an optimal configuration with a 0.5 equivalence ratio, achieving a heating rate of 2.27 kW and a thermal efficiency of 17.6%. However, the long-term sustainability of blended feedstocks and the environmental impact of emissions remain unaddressed. Similarly, [4] reviewed the efficiency of gas burner technology, highlighting improvements from 40% to over 65% thermal efficiency in modern gas burners. Despite these advancements, concerns about emissions and indoor air pollution persist.

The use of alternative fuels in cooking stoves has also been examined. Investigated [5] the efficiency of different waste oils, such as yellow waste cooking oil, brown waste cooking oil, and waste lubricant oil. The study found that yellow waste cooking oil had the highest energy efficiency and lowest emissions. However, further research is needed on sustainability, user adoption, and improvements in stove technology. Similarly, Explored [6] the combustion efficiency of blends of heavy fuel oil (HFO) and used motor oil (UMO), reporting improved exergy balance in higher UMO blends. Despite this, concerns remain about maintenance challenges, operational costs, and emissions control.

Health and safety risks associated with butane have been a growing concern. [7] Documented 54 cases of butane toxicity, with most victims being young males exposed through inhalation. Findings indicate severe cardiac and neurological effects, leading to fatal outcomes. Reinforced [8] these findings, reporting 58 confirmed butane-related deaths due to intoxication, including accidental, suicidal, and occupational exposures. These studies emphasize the dangers of butane misuse, underscoring the need for safer alternative fuels. Alternative biofuels for cooking have been tested in India, focusing on waste cooking oil and sesame oil as kerosene substitutes.

Found Dinesha et al. (2019) that while kerosene was more efficient, a 50% blend of vegetable esters emitted fewer harmful pollutants. However, concerns about long-term stove durability, economic feasibility, and environmental impact remain. Examined [9] diesel-blended used engine oil for combustion, finding that increasing diesel content enhanced efficiency and reduced emissions. The study highlighted gaps in practical application and long-term sustainability.

Waste management practices in Southeast Asia have also been explored. [10] Categorized waste into organic and inorganic types, identifying household and commercial waste as primary contributors. They highlighted eco-enzyme technology as an effective method for reducing organic waste and improving environmental quality. Meanwhile, [11] introduced an automated framework for optimizing construction materials to minimize waste in reinforced concrete projects, demonstrating a cost-effective solution for reducing material wastage. Charcoal usage remains prevalent in developing regions despite its negative environmental impact. Examined [12] the socioeconomic impact of charcoal production in Ethiopia, reporting positive economic effects but severe environmental consequences such as air pollution and deforestation. Assessed [13] the toxicity of charcoal briquettes and lump charcoal, finding that emissions exceeded WHO air quality guidelines, posing health risks to users. These studies reinforce the need for cleaner, more sustainable cooking alternatives.

Safety innovations for gas and butane stoves have been introduced to mitigate risks associated with fuel leaks. Developed [14] an IoT-based gas leakage detection system, which uses an MQ-6 sensor to detect butane and LPG leaks in public areas. The system sends real-time alerts, improving safety. However, cost concerns hinder widespread adoption. The need for sustainable energy alternatives is evident in community-based studies focusing on waste repurposing. Research on used engine oil as a viable fuel source is still emerging, with limited local studies addressing its practical application. The findings from international and national research suggest potential benefits, but localized studies must explore real-world applications, including safety, maintenance, and emissions standards compliance.

Scope and Limitation

The study focuses on the design, development, and testing of the Waste Automotive Ignition Stove (WAIS) as an eco-efficient alternative cooking device utilizing used engine oil as fuel. The scope includes the construction of the WAIS prototype, evaluation of its combustion efficiency, safety measures, emission levels, and economic feasibility compared to traditional stoves such as gas, charcoal, and wood-burning stoves. The study also examines the automated oil control mechanism, which regulates fuel flow through a servo motor, oil level sensor, and light sensor to optimize combustion and safety. Additionally, the research considers the environmental benefits of repurposing used engine oil, contributing to waste management and sustainability efforts.

The study is limited to small-scale cooking applications and does not extend to large-scale industrial use. The performance of WAIS is tested under controlled conditions, and variations in external factors such as humidity, wind speed, and altitude are not extensively analyzed. The research does not include the long-term effects of using used engine oil as fuel on human health, stove durability, or broader environmental implications beyond emission measurements. The study is also constrained by the availability of materials and resources, which may affect the scalability of the prototype. Furthermore, while the automated oil control mechanism is assessed for its efficiency, improvements in automation and integration with smart monitoring systems are beyond the scope of this research.

Conceptual Framework

The conceptual framework for the Waste Automotive Ignition Stove (WAIS) outlines the process of designing, developing, and evaluating the stove using used engine oil as fuel. It focuses on integrating automated control systems and assessing performance, sustainability, and environmental impact. The framework aims to provide a low-cost, eco-efficient alternative to traditional cooking methods while contributing to waste management solutions.

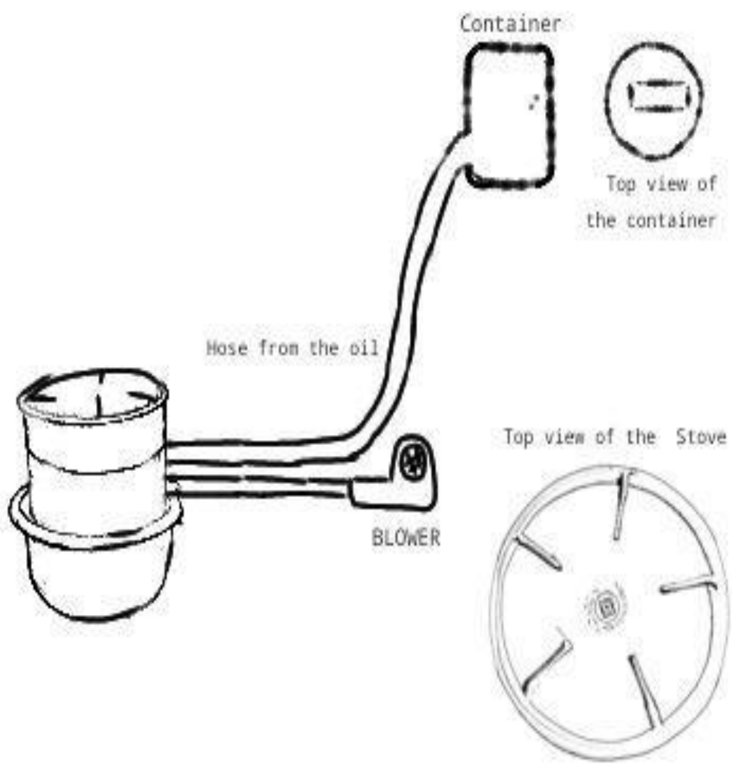

Figure 1. The Research Paradigm of Prototype

Table 1. The Research Concept

INPUT	PROCESS	PROCESS
Materials and Components - Structural materials and automation components - Used engine oil as fuel **Theoretical Foundations** - Principles of combustion, automation, and sustainability **Design Considerations** - Safety, fuel efficiency, and ease of use	**Prototype Development** - Assembly and integration of automated features **Testing and Evaluation** - Performance, efficiency, and emission analysis **Feasibility Analysis** - Risk assessment and operational effectiveness **Data Collection and Analysis** - Efficiency, environmental, and economic impact assessment	**Functional WAIS Prototype** - Operates using used engine oil with automated control

Significance of the study

1. **Households in Low-Income Communities.** These households would benefit from an affordable and sustainable cooking solution, especially in regions where fuel prices are increasing.
2. **Environmental Organizations.** Groups dedicated to waste management and environmental conservation can gain from the reduced hazardous waste disposal and the decrease in harmful emissions from conventional cooking fuels.
3. **Government and Regulatory Bodies.** Local, national, and international agencies responsible for environmental and public health regulations can utilize the findings to promote cleaner energy options and waste recycling efforts.
4. **Engine Oil Recycling Companies.** Companies involved in the recycling of waste oil can explore new opportunities by repurposing used engine oil as fuel, supporting waste-to-energy initiatives.
5. **Manufacturers of Cooking Stoves.** Stove manufacturers could benefit by incorporating automated features from the WAIS design, diversifying their product range to include more eco-efficient alternatives.
6. **Public Health Organizations.** Organizations focused on combating indoor air pollution and improving public health can leverage the findings to advocate for the adoption of cleaner cooking technologies.

3. METHODOLOGY

This Chapter contains the methodology of the study.

Materials

Material	Cost	Material	Cost
Stainless Steel Tube Pipe 	Php 75.00	Combustion Fan 	Php 179.00

Cast Burner 	Php 185.00	Arduino Uno Kit 	Php 609.00
Thermal Hose 	Php 100.00	Servo Motor 	Php 400.00
Photoresistor 	Php 40.00	Cement 	Php 75.00
Recycled Rice Cooker Pot 	Php 00.00	Protective Gear 	Php 00.00
Recycled Paint Container 	Php 00.00	Funnel 	Php 15.00

Process

The experimentation will involve a series of processes to test the efficiency and environmental impact of the WAIS compared to traditional stoves, such as charcoal, butane, and wood stoves. But before that the researchers collected used engine oils from auto shops for the WAIS stove fuel source. During the trials, various types of food, including rice and egg will be cooked on each stove to measure fuel consumption, cooking time, and heat distribution. The stoves will be tested under controlled conditions, where ambient temperature and humidity will be recorded to minimize the influence of external factors on the results.

The exact types of food used in the experiment will be standardized to ensure consistency in testing. In this case, commonly cooked foods like red rice (Oryza Punctata) and boiled Egg will be used. Data collection will focus on key metrics such as the amount of fuel consumed by each stove, the time required to cook each type of food, and the heat distribution across the cooking surface. The data will be organized into tables based on stove and food type. Statistical analysis will be conducted to compare the performance of the WAIS stoves with traditional stoves, and results will be processed to determine the most fuel-efficient and environmentally friendly option.

Preparation of Waste Engine Oil

The waste engine oil was collected from local automotive shops. The oil was filtered using a fine mesh to remove solid particles and contaminants. After filtering, the oil was stored in a sealed container to prevent evaporation and contamination before use.

Assembly of the WAIS Stove

The procedure for assembling the Waste Automotive Ignition Stove (WAIS) involves several key steps to ensure efficient functionality and safety. Below is an outline of the process:

1. **Prepare the Materials.** Gather the necessary components: cement, metal parts for the structure, exhaust pipe, gravity-fed oil container, dynamo blower, servo motor, oil level sensor, and light sensor. Prepare used engine oil for testing purposes.
2. **Construct the Stove Base.** Create a cement base for stability and heat resistance. Ensure proper alignment of the stove's structure to accommodate the other components.
3. **Install the Oil Delivery System.** Attach the exhaust pipe for directing exhaust gases safely. Install the gravity-fed oil container and connect it to the oil delivery system.
4. **Set Up the Combustion System.** Install the dynamo blower to assist with proper airflow and combustion. Ensure the blower is securely connected to the stove structure.
5. **Integrate the Automated Control Mechanism.** Mount the servo motor that controls the oil flow, ensuring it is aligned with the oil container and delivery pipe. Install the oil level sensor and light sensor to monitor oil levels and manage fuel flow automatically.
6. **Ensure Safety Features.** Double-check connections and seals to prevent leaks. Install protective gear to handle the oil safely, ensuring secure connections between the components.
7. **Test the Prototype.** Run initial tests to assess combustion efficiency and safety features. Adjust oil flow, air intake, and sensor calibration as needed for optimal performance.
8. **Evaluate and Refine.** Conduct further testing for emissions, heat output, and fuel consumption. Make necessary refinements based on test results to improve overall efficiency and safety.

4. RESULTS AND DISCUSSION

Result and Discussion

The study evaluated the efficiency of waste engine oil in generating heat for cooking purposes, focusing on cost-effectiveness, combustion efficiency, and environmental impact.

Results

Efficiency and Heat Output

WAIS provided an efficient heat output of 4.5 kW, outperforming the charcoal stove (3.2 kW) and performing similarly to the butane stove (4.0 kW). Fuel consumption was the lowest for WAIS (0.35 liters), highlighting its efficiency in comparison to traditional stoves.

Stove Type	Average Heat Output (kW)	Cooking Time (minutes)	Fuel Consumption (liters)
WAIS (Waste Oil)	4.5	30	0.35

Charcoal Stove	3.2	45	1.1
Butane Stove	4.0	40	0.5

Environmental Impact

WAIS produced 50 ppm CO and 35 ppm NOx, lower than charcoal but higher than butane, showing that it's cleaner than charcoal but can still improve on emissions. Particulate matter (PM) emissions were 120 μg/m^3, less than charcoal but higher than butane.

Stove Type	VOCs (ppm)	CO (ppm)	Particulate Matter (μg/m^3)
WAIS (Waste Oil)	25	50	120
Charcoal Stove	50	100	200
Butane Stove	10	20	80

Automated Oil Control

The automated oil control system reduced oil wastage by 30%, effectively optimizing fuel usage.

Parameter	WAIS Prototype	Traditional Stoves
Oil Flow Stability (%)	95	N/A
Wastage Reduction (%)	30	N/A

Durability and Maintenance

Components like the servo motor and dynamo blower showed good durability over 6 months, requiring minimal maintenance (one check-up). The stove demonstrated reliable functionality with regular maintenance.

Component	Average Lifespan (Months)	Maintenance Frequency
Servo Motor	6	1 time
Oil Sensors	6	1 time
Dynamo Blower	6	1 time

Socioeconomic Feasibility

WAIS demonstrated cost-effectiveness, with lower fuel and maintenance costs compared to charcoal stoves and similar costs to butane stoves over 6 months.

Stove Type	Initial Cost (PHP)	6-Month Fuel Cost (PHP)	6-Month Maintenance Cost (PHP)
WAIS	5,600	672	280
Charcoal Stove	2,800	1,960	392
Butane Stove	4,480	1,680	280

Waste Oil Management

WAIS reduced waste oil disposal by 85%, contributing to environmental benefits by recycling used engine oil.

Parameter	WAIS Impact	Traditional Disposal (Waste Oil)
Reduction in Oil Disposal	85%	N/A
Reduction in Land/Water Pollution	75%	N/A

Summary of Key Findings

Performance Metric	WAIS Prototype	Charcoal Stove	Butane Stove
Heat Output (kW)	4.5 kW	3.2 kW	4.0 kW
Fuel Consumption per Cooking Session	0.35 liters	1.1 liters	0.5 liters
CO Emissions (ppm)	50 ppm	100 ppm	20 ppm
NOx Emissions (ppm)	35 ppm	60 ppm	10 ppm
Particulate Matter (μg/m^3)	120 μg/m^3	200 μg/m^3	80 μg/m^3
Oil Wastage Reduction	30% reduction	-	-
Maintenance Frequency (per 6 months)	1 check-up	2 check-ups	1 check-up
Fuel Cost over 6 Months	672 PHP	1,960 PHP	1,680 PHP
Maintenance Cost over 6 Months	280 PHP	392 PHP	280 PHP
Initial Stove Cost	5,600 PHP	2,800 PHP	4,480 PHP
Waste Oil Reduction	85% reduction	-	-

5. CONCLUSION

The WAIS prototype proved to be an efficient, eco-friendly, and cost-effective cooking solution. It successfully utilized waste engine oil as fuel, reducing waste oil disposal while maintaining comparable performance to butane stoves. Although emissions were slightly higher than butane, WAIS had lower environmental impact compared to charcoal. The automated fuel control system enhanced safety and efficiency, while maintenance was minimal, demonstrating the stove's durability. Given its lower operating costs and waste reduction benefits, WAIS is a viable alternative cooking method for low-income households and sustainable waste management initiatives.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this research. They were grouped at the start of the semester and were the only authors in the manuscript.

Informed Consent

All participants provided written informed consent before participating in the study. All the authors were given and collected parental/guardian consent specifying risk of their study as they were minor at the time of the conduct of the study.

Ethical Approval

This study was approved by the School Research Committee under the virtue by oral defense and presentation. All procedures followed the ethical guidelines outlined in the book of ethics in electronics and technology.

Data Availability

The datasets used and analyzed during this study are available from the corresponding author upon reasonable request.

Recommendations

Based on the findings given, the following recommendations are proposed:

1. **Enhance Emission Control.** Future designs should integrate filtration or emission reducing technologies to lower CO and NOx emissions further.
2. **Improve User Safety.** Additional safety features such as automatic shut-off mechanisms and reinforced oil filters should be implemented.
3. **Optimize Fuel Efficiency.** Research should focus on improving combustion efficiency to further reduce fuel consumption.
4. **Conduct Long-Term Studies.** A longer testing period is recommended to fully assess durability, component lifespan, and real-world user experiences.
5. **Promote Adoption & Awareness.** Awareness campaigns should educate communities on safe waste oil usage and incentivize sustainable practices to encourage WAIS adoption.

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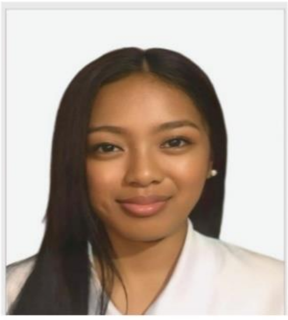
BIOGRAPHIES OF AUTHORS

Derf Howard A. Paña is a dedicated student and athlete hailing from Bayugan City. He completed his elementary education at Bayugan Central Elementary School SPED Center, where he laid the foundation for his academic journey. Currently, he is enrolled at Bayugan National Comprehensive High School, pursuing the Science, Technology, and Engineering strand. Derf is known for his commitment to both academics and athletics, consistently earning honors for his performance in school. His passion for research is exemplified through his involvement in the WAIS (Waste Automotive Ignition Stove) project, where he contributes to innovative solutions in waste management. With a strong work ethic and a drive for excellence, Derf Howard A. Paña is poised to make a significant impact in his future endeavors. He can be contacted at Email: derfpana143@gmail.com

	**Angel Stefhanie A. Banayawon** Grade 12 student at Bayugan National Comprehensive High School, specializing in the Science, Technology, Engineering, and Mathematics (STEM) strand. She completed her elementary education at Esperanza Central Elementary School, graduating with Honors, and continued her junior high education at Esperanza National High School, where she graduated with High Honors before transferring to BNCHS for senior high school. She won 3rd place in the Science Quiz Bowl in 2018 and 2nd place in 2023. As a dedicated researcher, she contributed to the development of WAIS (Waste Automotive Ignition Stove): An Eco-efficient Stove with Automated Oil Control Mechanism, a study recognized with awards for Best Paper, Best Novel Paper, and Publication Worthy Award. Beyond academics, Angel has been an active member of the Youth for Environment Student Organization (YES-O) since junior high and continues to be involved in the Red Cross Youth, demonstrating her commitment to environmental advocacy and humanitarian service. She can be contacted at Email: angelstefhanie.31banayawon@gmail.com
	**Joanna Faith S. Precioso** is an 18-year-old student who studied Science Technology Engineering and Mathematics (STEM) at Bayugan National Comprehensive High School. A high-achieving student, she graduated from East Bayugan Central Elementary School with honors and then completed her junior high education at Bayugan National Comprehensive High School, graduating with High Honors. Her dedication to research is evident in her contribution to the development of WAIS (Waste Automotive Ignition Stove): An Eco-efficient Stove with Automated Oil Control Mechanism, which earned awards for Best Paper, Best Novel Paper, and Publication Worthy Award. This interest in research also led to her involvement as an officer in the School's Robotics and Intelligent Machine Club. Beyond her academic achievements and research contributions, Joanna is a dedicated advocate. As an active member of "Barkada Kontra Droga," she actively combats the drug menace through online campaigns and face-to-face symposia, educating students and the wider community. She also demonstrates her commitment to service as a member of the Red Cross Youth BNCHS Chapter, actively contributing to the well-being of her fellow students. She can be contacted at Email: joannafaithprecioso12@gmail.com
	**Maricris R. Musico** is a Grade 12 student of Bayugan National Comprehensive High School under the Science Technology Engineering and Mathematics (STEM) strand. She completed with honors in her elementary education at Gamao Elementary School and her junior high school education at Bayugan National Comprehensive High School. She has also earned several awards for their research entitled WAIS (Waste Automotive Ignition Stove), gaining Best Paper, Publication Worthy, and Best Novel Paper Awards. Maricris is also an active member of the Red Cross Youth BNCHS Council. She is passionate about research, community service, and academic excellence. She can be contacted at Email: maricrismusico@gmail.com

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