Alternative Fuels:

Repurposing Waste Motor Oil into a Biodiesel Fuel Supplement at The Island School

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INTRODUCTION

Motor oil is used in all internal combustion engines to lubricate moving parts and dissipate heat. Motor oil breaks down over time, and must be replaced during an oil change. In larger countries such as the United States there are large processing plants in place to clean or reuse the waste motor oil (WMO), however on small islands such as Eleuthera, these facilities are not economically viable. Proper waste management, especially for WMO, is a challenge for small islands. WMO is typically burned or dumped on the ground, both of which cause severe environmental impacts. The purpose of this study is to convert WMO into clean motor oil (CMO) and blend it with biodiesel and diesel so that it can be used in diesel engines. This would both get rid of an excessive waste product stored on campus and lessen the amount of costly diesel bought for the Cape Eleuthera Island School (CEIS) campus. Diverting a hazardous waste product from the landfill has numerous environmental benefits.

Image 1: A look at waste on the CEIS campus.

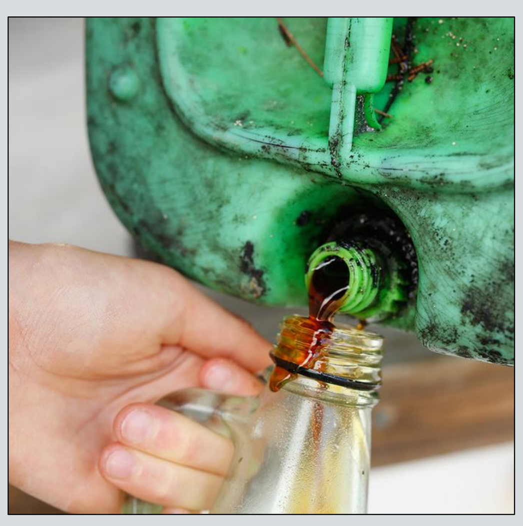

Image 2: Alternative fuel use on the CEIS campus.

BACKGROUND

Traditionally, waste motor oil can get re-refined into other fuels and lubricants, as well as recycled and turned into asphalt. These processes require large treatment facilities that aren't available on Eleuthera. Due to these lack of resources, people resort to many improper disposal methods: simply burning the waste product or pouring it on the ground near the area where the oil change was made. When burned, toxic chemicals pour into the atmosphere. This is not a sustainable solution and is contributing to climate change and is hazardous to human health . When poured onto the ground, it will seep into the soil and harm any wildlife it comes into contact with. Just one gallon of WMO will contaminate one million gallons of clean water.

The vans, boats, and backup generators on the CEIS campus generate 200-250 gallons of WMO per year. Around the island, automobiles and the three diesel power plants contribute to WMO generation. While it is not known how much WMO is generated on island from automobiles, the three power plants generate an estimated 10,000 gallons of WMO per plant per year. Currently, this is either stored on island, shipped off at high cost, or improperly disposed of and none of these are sustainable solutions. WMO has a high energy content, and if handled properly, can be extracted for use in internal combustion engines.

Image 3: Proper waste management is a challenge to many rural communities.

METHODS

In order to use this WMO in the fuel blends, it first had to be cleaned using two processes: settling and centrifugation.

Settling:
- Uses gravity to separate out dirt and water from WMO
- Does not clean the WMO to the standard needed to use in the fuel blend

Centrifugation:
- Rotating centrifuge exerts a 36 g-force onto the WMO
- More dense contaminants are forced to the outside and are collected as byproduct
- Less dense motor oil concentrates in middle and is collected as CMO

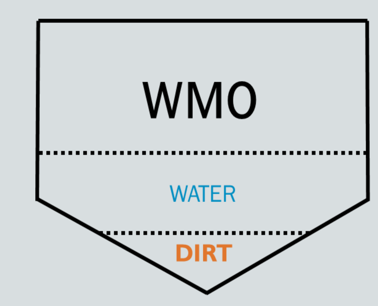

Figure 1: Side view of settling

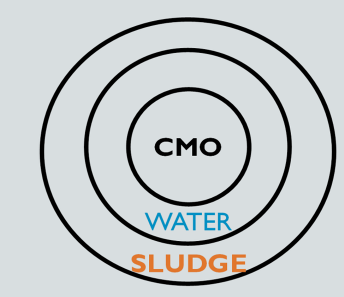

Figure 2: Top view of centrifuge

Testing Methods:
First, the density was found by measuring the volume and mass of each blend. Then, the flow rate of each blend was found in order to see if they fell within the desired viscosity range of diesel to biodiesel, by timing how quickly 100 mL of the blend flowed through a 3 mm hole.

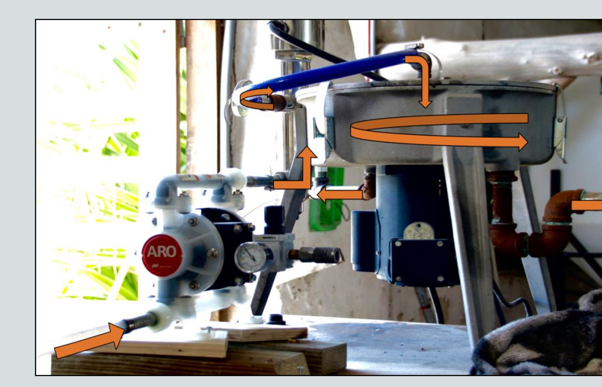

Image 4: Diagram of how WMO flows through the centrifuge.

RESULTS

FUEL BLEND	BIODIESEL (%)	DIESEL (%)	CMO (%)
B50 (control)	50	50	0
C10	50	40	10
C15	50	35	15
C20	50	30	20
C25	50	25	25

Figure 3: Fuel blend ratios.

Four out of the five fuel blends contain a mix of CMO, diesel, and biodiesel. The control fuel blend, B50, is the fuel that the CEIS campus is planning on switching to, and this project is supplementing the diesel used in this control blend. In each fuel blend, a higher percentage of CMO is added. Figure 4 shows that all fuels had a similar BSFC to B50, except C10, which outperformed B50.

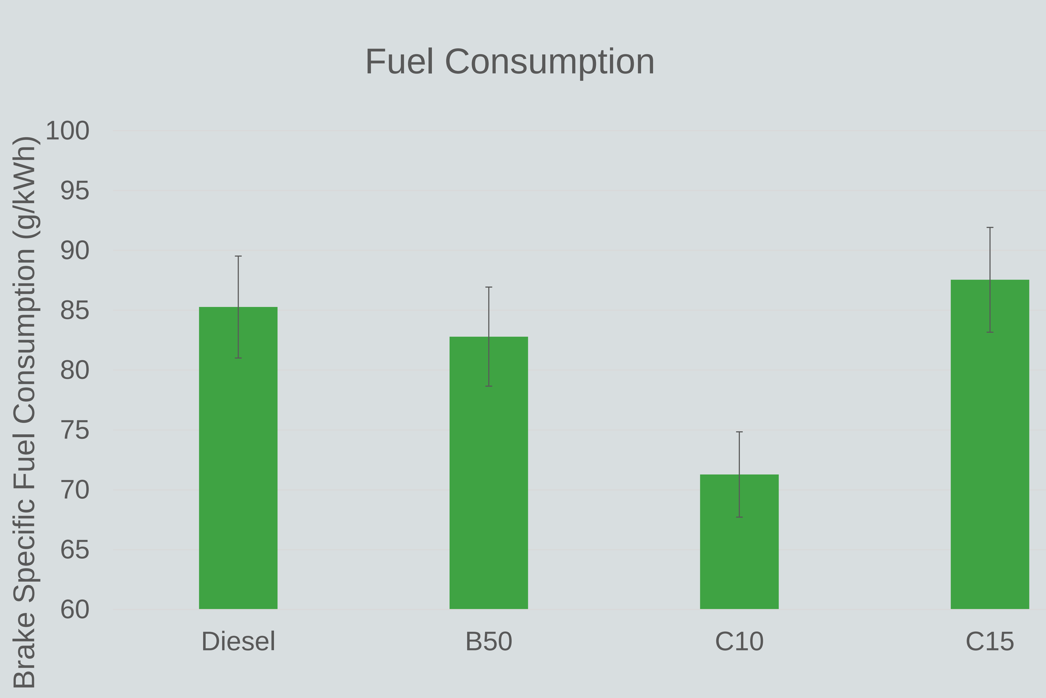

Figure 4: Brake Specific Fuel Consumption for select fuel blends.

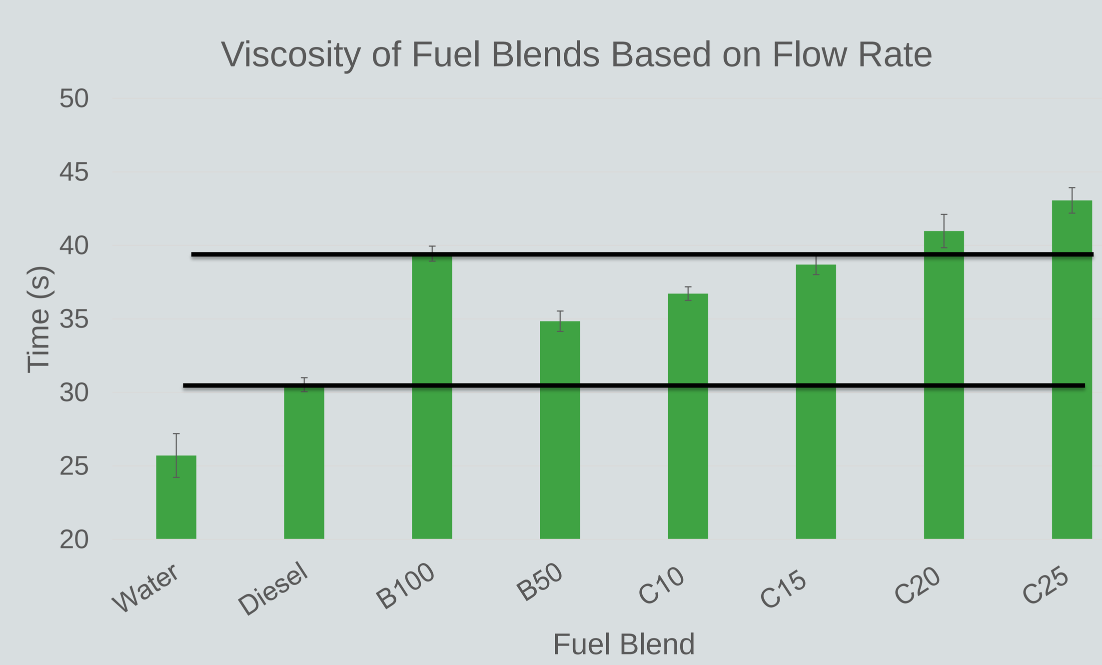

Figure 5: Fuel blend relative viscosities based on flow rate.

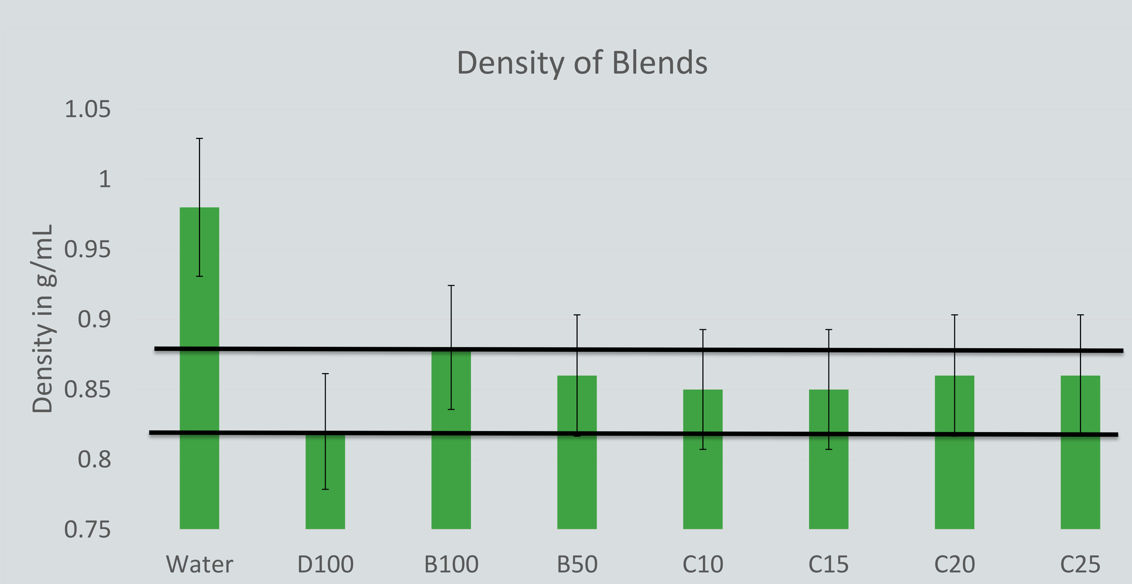

Figure 6: Fuel blend densities.

Figure 5 shows C10 and C15 were both within observed viscosity range of diesel and biodiesel. C20 and C25 both had a viscosity higher than that of biodiesel. Figure 6 shows that all fuel blends had a density between that of diesel and biodiesel.`

FUEL BLEND	$/GAL	$/YEAR	ROI (MONTHS)
B50 (control)	$4.26	$0	N/A
C10	$4.04	$4,300	6
C15	$3.93	$6,450	4
C20	$3.83	$8,600	3
C25	$3.72	$10,750	2.5

Figure 7: Costs of fuel blends.

As shown in Figure 7, the fuel blends have a final cost between $4.04 and $3.72 per gallon for C10 and C25, respectively. B50 is more expensive at $4.26 per gallon. The ROI ranges from 6 to 2.5 months for C10 and C25, respectively. Operational expenses, shown in Figure 8, are $2.55 per gallon CMO. Labor accounts for 78.4% of these costs.

EXPENSES	$/GAL WMO	$/YEAR	% TOTAL COST
Electrical	$0.11	$255.88	4.3%
Transport	$0.34	$716.60	13.3%
Labor	$2.00	$4,210.53	78.4%
Maintenance	$0.10	$218.60	3.9%
TOTAL	$2.55	$5,401.61	100.0%

Figure 8: Operational expenses of cleaning WMO.

DISCUSSION

This research has shown that WMO can be converted into CMO and blended with biodiesel as a fuel supplement in diesel engines. The fuel consumption is comparable to B50, and even lower in the case of C10. Repurposing WMO into a fuel reduces hazardous waste and diesel imports. By offsetting diesel imports, carbon emissions associated with the drilling, refining, and shipping of diesel are also offset. This reduces life cycle carbon emissions of a CMO-based fuel. Eleuthera currently produces over 30,000 gallons of WMO per year. With no recycling infrastructure on island, most of this WMO is stored in aging 55 gallon drums. If only 20% of this were to leach into the ocean, it would contaminate over six billion gallons of water, which covers the entire surface area of Rock Sound Bay.

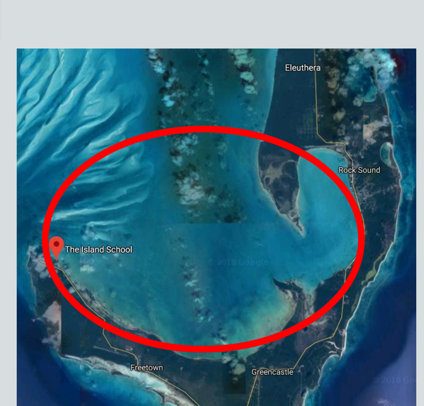

Image 5: Potential for contamination from WMO spill.

MOVING FORWARD

Future research should work towards automating the centrifugation system, as nearly 80% of operational expenses were for labor. Further, larger batch testing is desired in order to acquire more information on the fuel blends created, along with looking at engine wear over time while running on these fuel blends. Finally, using a dynamometer would be a useful tool to implement during future fuel blend testing in order to further asses the fuel performance.

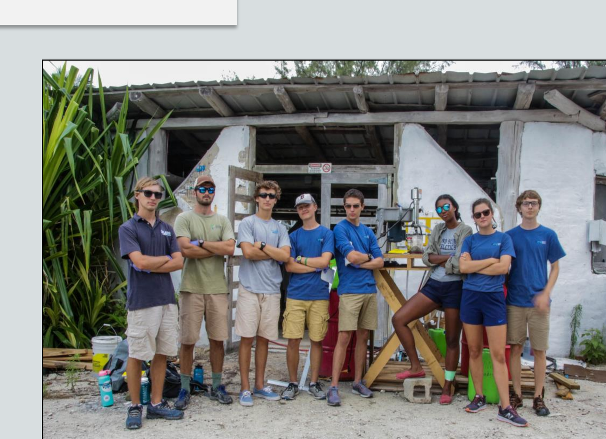

Image 6 (right): Alternative Fuels Research Team in front of the centrifuge system

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