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Olive Pomace and Cherry Stones used as Biofuels

Andreja MARZI
Primary School and Kindergarten Ankaran

Abstract: The aim of the article is to show how to encourage students to deepen their knowledge and their enthusiasm for research. In this way we can also promote the popularization of science and technology as well as the identification of students talented in specific research areas.This article presents an example of writing a research assignment undertaken by students in the final year of primary school (class 9, i.e. age 14-15). During school lessons, we did not discuss biomass as fuel in detail, but we found the topic very interesting, which is why we decided theat we would focus on it in our research paper. We live in the age of diminishing supplies of fossil fuels and consequently a growing interest in the renewable energy sources, including biofuels.Through research assignment, we wanted our students to learn more about the characteristics of biofuels which we haven't discussed in detail in class. Biofuel is a solid, liquid or gaseous fuel, obtained from a relatively recently deceased biological substance. In addition to looking for information in literature and electronic resources, we conducted experiments in which we measured how many degrees a particular quantity of water heats up by the burning of various fuels, and the amount of residue left after burning. The fuels we used were: pellets, briquettes, olive pomace, cherry stones, biodiesel, ethanol and sawdust.We established that different types of fuel emit, when burnt, different amounts of heat. Water heated up the most when burning ethanol, while it heated up the least when using biodiesel. Experiments showed that different fuels burn for different amounts of time, leaving a residue which depends on the type of fuel.

Keywords: Research assignment, Biofuels, Experimental work

Introduction

Renewable energy sources

The motives for using renewable energy resources have been changing throughout human history. In the initial phase of technological development renewable energy sources were the only source that people used. All activities depended on local and natural energy resources and building materials. The middle of the 19th century marked the beginning of the era of extensive use of fossil fuels and the development of technologies for their conversion into other forms of energy. At the end of the 20th century scientists started to warn people about the harmfulness of carbon dioxide, which is created in the process of burning fossil fuels. Calling people's attention to the need for fairer development in all regions of the world lead to the formation of the theory of sustainable (and environmentally friendly) development. In this context, the efforts towards the use of renewable energy sources grew stronger.

What are renewable energy sources? We must understand that all sources of energy are derived from nature. Renewable sources are those sources that can be used again and again as they are available in plenty and are not going to perish anytime soon. They are sources of energy we obtain from constant natural processes such as the wind, solar radiation (solar power stations), water current in rivers or streams (hydroenergy), Earth's heat fluxes (geothermal energy), the tides and waves of the seas and oceans (tidal energy and wave energy), photosynthesis by which plants build biomass (wood, vegetable oils that we convert into biodiesel, bioethanol, biogas).

The main advanteges of renewable energy sources include the fact that their use reduces the emissions of greenhouse gases; these energy sources are also free, they are durable and have a great potential. Renewable

energy sources cannot be stored in nature except in the form of biomass and the heat of oceans. Thus we have to use various devices for storing the energy of renewable resources, which lessens their efficiency and makes their exploitation more expensive.

The second decade of the 21st century is a favourable time for further development of technologies linked to renewable energy sources. The European Union decided to pursue the objective of reducing greenhouse gases emissions by 40 percent by the year 2030. Using the existing technologies, this can be achieved through greater use of the energy from nuclear power plants or by expanding the use of renewable sources of energy in all forms: direct solar radiation and the energy of water, wind and biomass. In recent years, wood, other solid biofuels and renewable waste have presented the crucial part of renewable energy sources.

Figure 1 shows the primary production of energy from renewable sources in EU during the period 1990-2016.

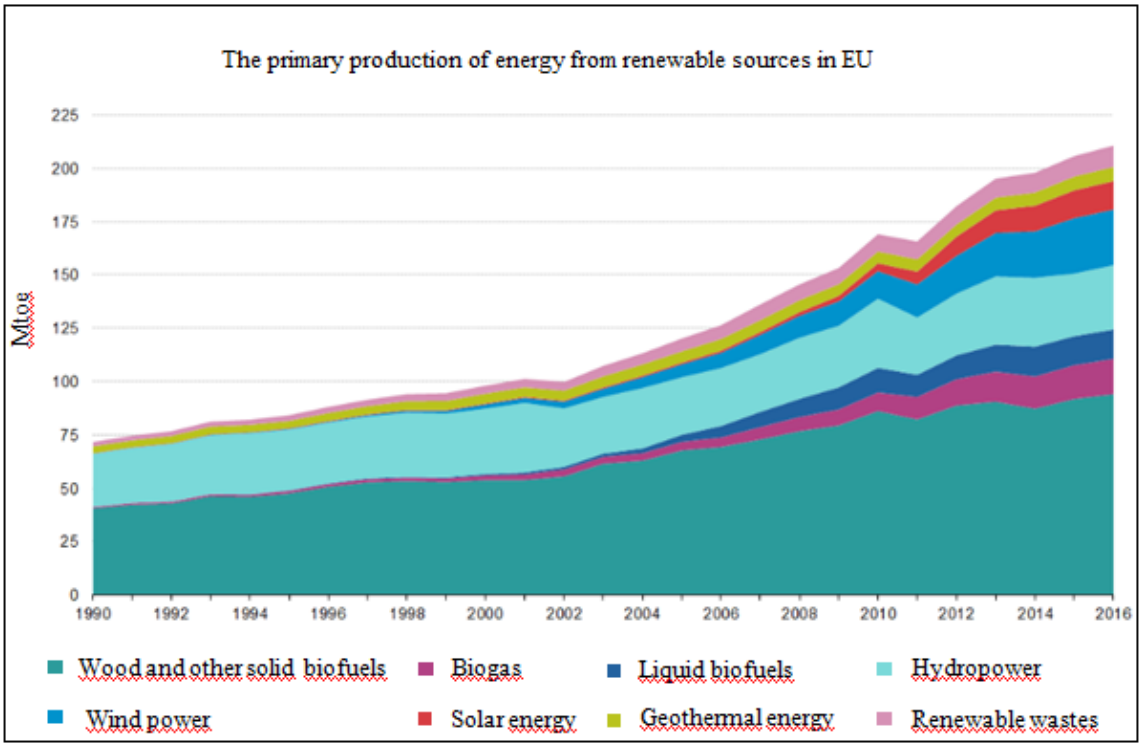

Figure 1. The final water temperature (source: eurostat)

Biomass and Biofuels

According to the *Directive on renewable energy resources***,** biomass derives from different kinds of organic materials: energy crops (oil plants; plants containing sugar), wood, forest waste and agricultural waste, and biodegradable waste from households, fishery and industry.

Approximately 0,01 percent of solar energy received by the Earth is used for the production of organic matter in plants, but despite the low rate of energy recovery the binding of solar energy into biomass is one of the most important energy conversions. The contribution of biomass as regards covering the total energy needs of humanity is circa 14 percent. Among various kinds of biomass wood and scrap wood are used the most. The share contributed by other kinds of biomass such as agricultural waste (straw, animal manure), wood scrap from forest waste and the processing of wood as well as energy crops is growing.

Biomass can be used for heating, for generating electricity and producing biofuels. Fuels produced from biomass with the described procedures can be classified into three groups:
- solid biomass (wood biomass, agricultural crops);
- liquid biofuels (bioethanol, biodiesel) ;
- gases from biomass (biogas, wood gas, landfill gas).

Bioethanol is an alcohol which is nowadays produced by sugar fermentation, especially from corn and sugar cane, but also from corn stalks, prairie grasses, fast-growing trees, sawdust and algae. By using bioethanol we can reduce emissions of greenhouse gases by 22-56 percent (and even by 91 percent, by using cellulose ethanol – a fuel barely known to date). However, production of corn ethanol leads to a great consumption of fossil fuels and releases a lot of CO_2, so many scientists are currently in double mind as regards the processing of corn into fuel. For the time being it is mostly used as a complement to petrol.

Biodiesel is a methyl ester produced from biomass. It is formed through the esterification of vegetable oils and animal fats (usually canola, soya and oilseed rape). High quality biodiesel can be used in normal diesel engines, independently or in mixtures with diesel. Its use can reduce carbon dioxide emissions by 68 percent.

Olive pomace (pulp) is one of the more interesting biofuels, which can be completely dried and compressed into blocks that can be then used for heating. While olive pomace remains nearly unknown as a fuel in Slovenia, it is already being used as an energy resource in the Near and Middle East and some other parts of the world (Spain, Turkey).

Wood biomass is an ancient, but at the same time modern, environmentally friendly and familiar source of energy. If we want to keep waste gas emission below the permissible level, wood biomass needs to be treated in a suitable way and the heating devices (stoves) should be in working order.

Methods

Experimental work

Our essential research method was laboratory work. We precisely determined the experimental procedure and prepared the needed laboratory equipment. We decided that we would do our laboratory work at school, in Chemistry room, in the framework of Chemistry Club.

In the experimental part we tried to answer the following questions: how many °C do various fuels heat up a particular amount of water and what amount of residue is left after the burning of solid fuels.

Laboratory equipment

For our experiments we needed: an empty spirit burner, a laboratory balance, a stand and a gauze, a beaker, a holed aluminium container, a thermometer, a measuring cylinder and a stopwatch.

Fuels that were used

The fuels we used during our experimental work were the following: pellets, briquettes, sawdust, olive pulp (undried and dried for one hour at 105°C), cherry stones (undried and dried for one hour at 105°C), biodiesel, ethanol and fuel oil.

We decided to use olive pomace because we live in a region which is known for the production of olive oil and the locals use the leftovers of the process of pressing olives also at home as a fuel in central heating appliances. Cherry stones can also be used as a fuel.

The work procedure

We measured the amount of heat emitted during the burning of various fuels. We observed this indirectly, through measuring the temperature of water heated by the release of heat during the burning of a specific fuel.

On a piece of paper we weighed 20 g of solid fuel; we measured out 20 ml of liquid fuel with the help of a measuring cylinder. We put some old newspaper (0,9 g) and a combustion tablet (3 g) into the aluminium container, while the liquid fuel was poured into the burner. We put on protective glasses and continued with our work. On the lower stand we put a container with a solid fuel, or the burner with a liquid fuel, while we put a gauze and a beaker containing 50 ml of water on the upper stand . With the thermometer we measured the initial water temperature and noted it down. Then we ignited the combustion tablet and watched the burning process and the changes in water temperature. Temperature was read every 5 minutes. After all of the fuel burnt out, we noted the final water temperature and the total burning time. We also weighed the mass of the residue.

Results and Discussion

Final temperature of water after the burning of various fuels

The final temperature of water after burning of a particular fuel can be seen in the following diagram:

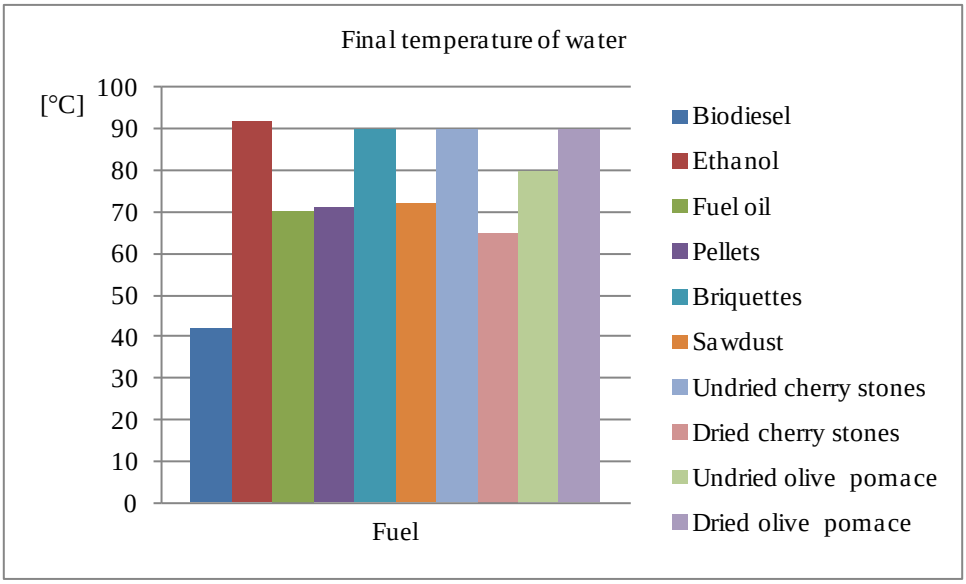

Figure 2. The final water temperature

Ethanol gave off the most heat during burning (the final water temperature being 92°C), while biodiesel produced the least heat (the final water temperature being 42°C). (see fig. 2)

Residue left after the burning of solid fuels

After weighing the residue left after burning, we arrived at the following findings. (see fig. 3)

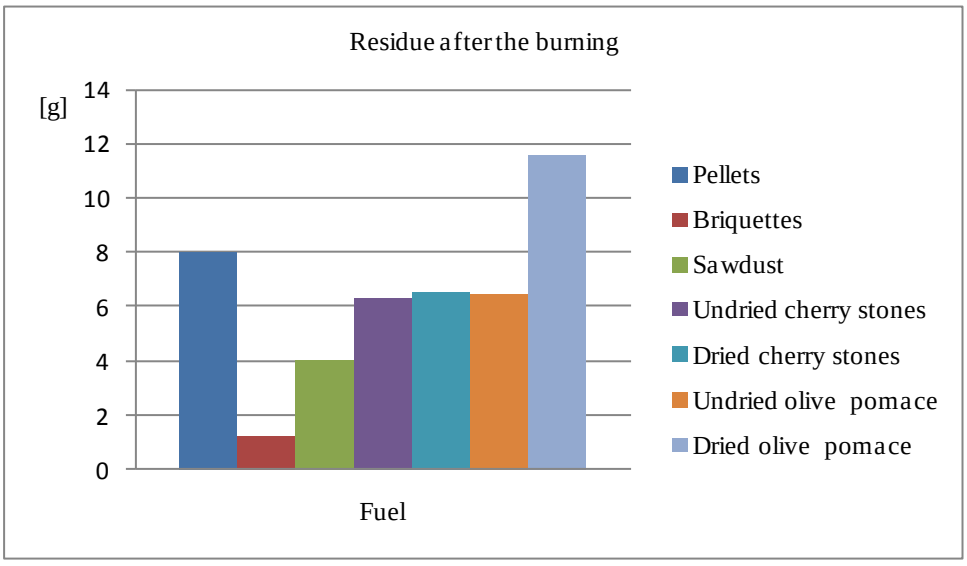

Figure 3. The residue after the burning of solid fuels

We found that briquettes burnt down almost completely - the amount of residue left after burning this fuel is the smallest. The greatest amount of residue is left after burning dry olive pomace (see fig.3).

Burning Time

The burning time of a particular fuel can be seen in the following table.

Table 1. Burning time of different fuels

Fuel	Burning time [min]
Biodiesel	35
Ethanol	23
Fuel oil	60
Pellets	23
Briquettes	16
Sawdust	18
Undried cherry stones	11
Dried cherry stones	14
Undried olive pomace	13
Dried olive pomace	13

Fuel oil burnt the longest (60 min and more), while undried cherry stones burnt for the shortest time (11 min). (Table 1)

Conclusion

The results of experiments showed us the following that different kinds of fuel emit different amounts of heat during burning (for example, the final temperature with biodiesel is 42°C, while the final temperature with ethanol is 92°C). Some substances take more time to burn, some less (for example, fuel oil burns for more than an hour, while undried cherry stones burn for eleven minutes). After the burning of all kinds of fuels we noticed a residue, even if only in the form of soot. Amongst all the samples, ethanol gave off the most heat. Each of the fuels used left a residue after burning, namely different amounts of soot and ash (for example, the burning of briquettes gave us 1,2 g of residue, while dry olive pomace left 11,6 g of residue).

This report presents an example of making a research paper in elementary school, which is not the same as proper research work. This is especially true when it comes to the originality of hypotheses that form the basis of research and the precision with which these are tested. Students upgrade their existing knowledge with a different, research-oriented approach which includes doing experiments and forming conclusions independently. In their work, students can deploy their creativity and critical thinking skills, especially in connection to trending topics and everyday subjects of their interest.

Teacher plays a significant role in directing and monitoring research work done by students of this age group. He or she needs to be equipped with good professional, psychological and didactic knowledge, he or she needs to be acquainted with the systematics of research work, and he or she also needs to be able to establish good relationships with students and between students.

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Author Information

Andreja Marzi
Primary School and Kindergarten Ankaran
Regentova ulica 4, 6280 Ankaran, Republic of Slovenia
Contact e-mail: *andreja.marzi@osv-ankaran.si*