The Possibility of Using *Potamogeton Crispus* for Energy Purposes

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Abstract Eutrophication is a very undesirable process, because the lake in which this process takes place losses most of its amenities. The deterioration of the water quality in the case of eutrophicated reservoirs is caused by the inflow of biogenic compounds that accelerate the development of plankton and higher forms of plant life. A perfect example of such a reservoir is Winiary Lake, located in the city of Gniezno in the Wielkopolska Voivodeship. The lake is located in the city centre, so it is exposed to strong anthropogenic pressure, which led to the degradation of the reservoir. There have been several attempts to restore the Winiary Lake, with various results. Currently, the condition of the lake has improved and it is overgrown with macrophyte, Potamogeton crispus—Curly-leaf pondweed. This pondweed is regularly pruned to extend its vegetation period. In this work the preliminary results of heating value and heat of combustion of the collected biomass will be presented.

Keywords Potamogeton crispus · Eutrophication · Biomass · Green energy

1 Introduction

For many years the eutrophication of lakes has been the object of research for many scientists. It is particularly severe for shallow lakes where there is no thermal stratification [1, 2]. In such lakes, the processes that occur in the littoral zone play a significant role, and macrophytes play a special role [3]. Plant groupings that occur in water reservoirs or on their outskirts can act as a filter that catches and then neutralizes biogenic elements and suspensions from the catchment. The function of a specific buffer for a certain pool of inflow substances from the catchment is possible when the aquatic vegetation exists in a sufficiently high density [4]. The interest in this subject increased when, after the tests, it was found that the filtration

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efficiency of plant groupings is comparable with the filters used at that time in sewage treatment technologies. Far more effective method was creating artificial water reservoirs in which plantations developed, especially those with high accumulative capacities. The effectiveness of this method resulted in increased interest in the use of water and aquifer plants for the treatment of industrial and municipal sewage and rainwater. Wastewater treatment technologies using plant groupings are based on the ability to absorb and accumulate a significant amount of elements, the content of which exceeds the demand for plant growth and development. Depending on the type of plants used for this process and plans for their further use, plant groupings can be removed once or repeatedly during the vegetation season. Pruned and removed biomass can be used as a fertilizer, a substrate in biogas plants or as biomass for combustion.

2 Research Material

The Curly-leaf pondweed (Potamogeton Crispus L.) is a perennial plant belonging to the family of Pseudomonas. It is a popular plant in both hemispheres of the globe. It develops primarily in the zone of elodeids (living zone of hydrophytes) at a depth of 1–3 m. The Curly-leaf pondweed has leaves immersed in water with a length of about 10 cm. At the end of the shoots in the period from May to autumn, inflorescences grow in the form of ears, it is a part of the plant that protrudes above the surface of the water [5]. This plant is classified as ryzophytes, i.e. plants that are rooted or hooked with special shoots to the ground, forming benthos. The flowers are found in the spike type inflorescences, in the amount of 2–10 pieces in one ear [6]. It forms winter buds, so-called turions, these creations fall to the bottom when vegetation ends due to storage of starch in the cells. After the winter season, in the spring of the next year, the internodes of the turions develop summer shoots, then they root down, which in turn leads to the formation of new generations of the plant. The Curly-leaf pondweed has several reproduction strategies: rhizomes, seeds, stolons, fragmentation, turions, or continuous growth of peak shoots. The Curly-leaf pondweed grows very well in clear and transparent water, it means that in these reservoirs the water is of good quality. In addition, during its growth and development, the plant absorbs nitrogen and phosphorus, that is one of these elements, which are responsible for the progress of the eutrophication process. It is worth adding that a large potential expansion of this species was found due to the production of a large number of inflorescences, what is more it can be a kind of protection of the plant against unfavourable environmental conditions, as well as ecological threats [6].

3 Research Object

Winiary Lake is a small (about 14.4 ha) reservoir located in the city of Gniezno, it is a very shallow lake (maximum depth 4.2 m, average 2.1 m) with a volume of 302,4 thousand m^3 [7]. The city of Gniezno lies in the Gniezno lake district, which is the poorest rainfall area in Poland. Within the administrative borders of the city, there are lakes located (including Jelonek and Winiary), which are exposed to the pressure of the urban agglomeration. The limited possibility of water exchange in the lakes causes that sedimentation and accumulation processes of suspended solids and dispersed components prevail in them. The lakes have lost their self-cleaning ability and would be doomed to total degradation without immediate restoration measures. As part of the project co-financed from the EU Life + Financial Instrument, the restoration of the Winiary Lake was started, the inactivation of phosphorus in bottom sediments was done, through the direct dosing of phosphorus-binding reagents (PIX, Phoslock) to the deposits and increasing the redox potential. As a result of the comprehensive measures that were taken, in the years of 2009–2010, there was a clear reduction in phosphorus concentrations in the lake, increased transparency and the disappearance of cyanobacterial blooms [8, 9]. Unfortunately, the improvement in the quality of water in Winiary Lake was short-term (Fig. 1 and Table 1).

The results of the tests carried out by the accredited laboratory in 2016 show that oxygenation of lake water was very good, at each examined point it was above 7 mgO_2/l. The concentration of general phosphorus and phosphates was low. The presence of phosphates in the lake's water depth determines the possibility of algal blooms, including cyanobacteria. On the basis of the analyzed results it is clearly visible that the content of this parameter in lake water did not exceed the critical value of 0,1 mg/l. Ammonium nitrogen and nitrate nitrogen were not tested in the lake. An appropriate level of general nitrogen content of 1 mgN/l was noted. The high content of dissolved organic compounds in water is evidenced by high BOD (4.65–5.12 mg O_2/l) and COD_{Cr} (36.9–37.2 mg O_2/l), with low chlorophyll-a concentration (1,3–2,7 μg/l). For a few years now, on the Winiary Lake there has been a Curly-leaf pondweed which covers 3/5 of the lake's surface. Since 2017,

Fig. 1 Map of Winiary Lake [10]

Table 1 Basic parameters of water in Winiary Lake in 2016

L. p.	Tested parameter	Unit of measurement	The results of analyzes from the first measurement point on Winiary Lake	The results of analyzes from the second measurement point on Winiary Lake
1.	Dissolved oxygen	mgO_2/l	7,58	8,97
2.	General nitrogen	mgN/l	0,9	1
3.	BOD	mgO_2/l	5,12	4,65
4.	COD_{Cr}	mgO_2/l	36,9	37,2
5.	General phosphorus	mgP/l	<0,01	<0,01
6.	Phosphates	mg PO_4/l	<0,1	<0,1
7.	pH	–	8,5	8,7
8.	Iron	mgFe/l	<0,1	<0,1
9.	Chlorophyll “a”	μg/l	1,3	2,7
10.	General suspension	mg/l	20	17

the pondweed has been regularly pruned to extend the vegetation period of the plant and the mown biomass is removed outside the water reservoir.

4 Purpose of Research

The aim of the research is to check the possibility of using biomass from Curly-leaf pondweed for energy purposes as a raw material for combustion. The most important parameters such as: humidity, heat of combustion and heating value, were determined in this work. The obtained results, based on literature data, were compared with other raw materials used for combustion.

5 Research Methodology

Dry material was used for the analysis. In order to determine the humidity, a drying-weight method was applied, in accordance with the PN-EN ISO 18134-3 standard. This method is based on measuring the loss of mass resulting from evaporation of water during drying at 105 °C.

Combustion heat and heating value were determined using a colorimeter. In order to carry out the tests, samples were made in the form of tablets weighing approx. 1 g, for this purpose a previously dried Curly-leaf pondweed was used. The tablets obtained this way were placed in the crucible that is a part of the calorimetric bomb. The ignition of the sample took place through a resistance wire that touched it at least in two places. The determination of the heat of combustion involved the complete combustion of a sample of material in an oxygen atmosphere, under pressure in a calorimetric bomb that was submerged in a water jacket and measuring the increase in water temperature at the same time. The research was based on the PN-C-04375-2: 2013-07 standard for testing solid and liquid fuels, determination of the heat of combustion in a calorimetric bomb and calculation of heating value.

6 Research Results and Discussion

The moisture content of the tested sample was 6.67% (Fig. 2), which is low compared to hard coal and woodchips [11]. However, it should be noted that the dry material was analyzed. Whereas, the dry matter content of Curly-leaf pondweed is about 9%.

The heat of combustion is called the amount of heat released during the entire combustion of the unit of mass of fuel in the oxygen atmosphere. The given parameter takes into account the heat of condensation of water vapour. The Curly-leaf pondweed is characterized by a heat of combustion of 9.12 MJ/kg, which in comparison to hard coal (32 MJ/kg) and woodchips (19.4 MJ/kg) is a low result (Fig. 3).

The heating value is a parameter that determines the amount of heat generated during the complete combustion of the fuel without taking into account the condensation of the water vapour. For this reason, the heating value of the sample is lower than the heat of its combustion and depends on the humidity.

In case of Curly-leaf pondweed, the heating value was just 7.74 MJ/kg, which is a poor result compared to other fuels (Fig. 4).

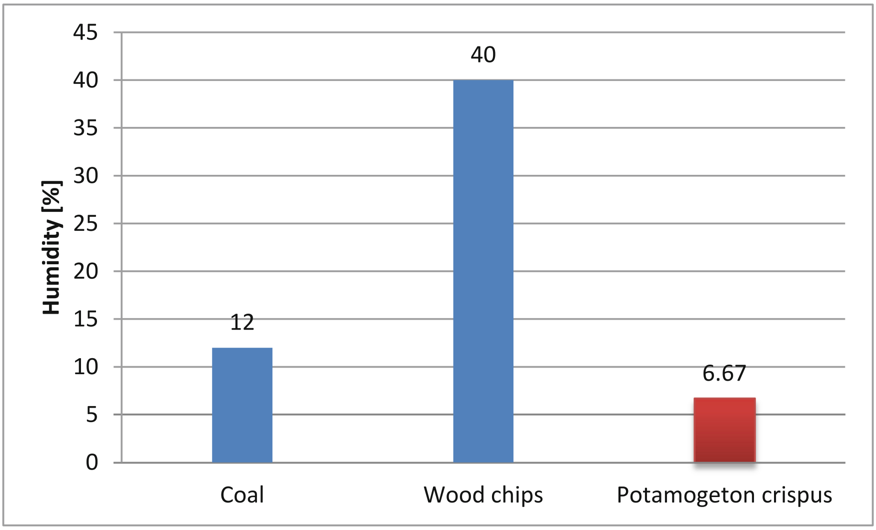

Fig. 2 The moisture of the Curly-leaf pondweed in relation to other raw materials used for combustion [11]

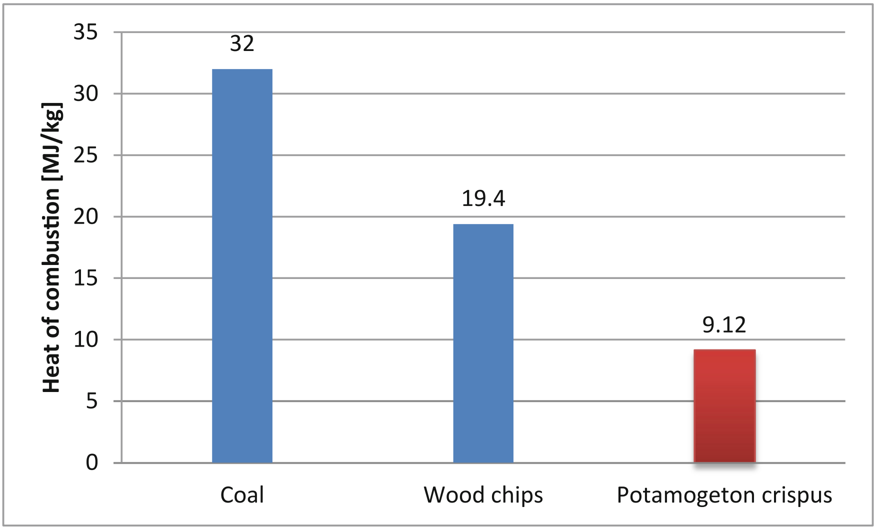

Fig. 3 The heat of combustion of Potamogeton crispus in relation to other raw materials used for combustion [11]

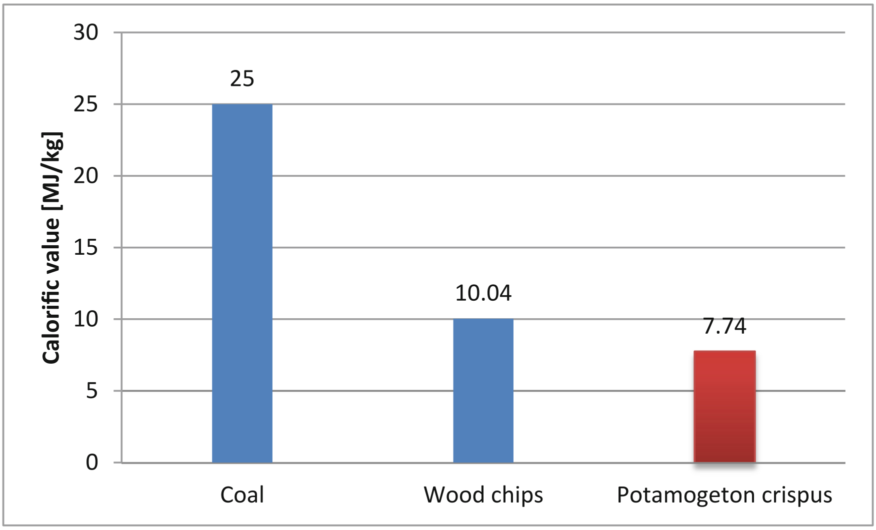

Fig. 4 Heating value of Potamogeton crispus with reference to other raw materials used for combustion [11]

7 Conclusions

1. The research that were carried out showed little validity of the use of Potamogeton crispus biomass for direct combustion, this is mainly due to the low content of dry matter in the raw substrate.
2. The heat of combustion and the value of Potamogeton crispus is more than three times lower than in the case of hard coal.
3. The removal of pruned biomass from the water reservoir counteracts the excessive fertilization of the lake, which improves its quality.
4. The conducted research does not exclude the use of Potamogeton crispus for other energy purposes, therefore other methods of using the obtained biomass should be developed.

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