

PHYSICO-CHEMICAL CHARACTERIZATION OF SEDIMENT MODRAC LAKE AND ITS POSSIBLE USE FOR ENERGY PURPOSES

Aida Crnkić, Zorica Hodžić, Aldina Kesić, Nusreta Donlagić, Almasa Babajić
University in Tuzla, Univerzitetska no. 4; 75 000, Tuzla, Bosnia and Hercegovina

ABSTRACT

Periodic tests of water quality in the reservoir lake Modrac indicate a tendency of serious deterioration of water quality in the lake Modrac, especially in the summer. According to the results of water quality shows a high content of suspended material in the water, originating mainly from the separation of coal in Banovici and Đurđevik.

The aim of this paper is to investigate and define the physico-chemical characterization of sedimentary layers at the mouth of the rivers Turija and Spreča in Modrac, and in the area of 50 m from the mouth, and on the basis of established physical-chemical characteristics of the sediment assessment of the possibility of using sediment in energetic purposes.

Based on the physico-chemical characteristics of sedimentary layers showed the possible use of sedimentary layers from the site Spreča river mouth into the lake, as well as a low calorie fuel but because of the present non-combustible material (moisture content and ash) and small average heat capacity, its use as a clean energy source for the production of electricity is limited. Quantitative indicators of the quality of sedimentary layers in terms of energy use show that the use of the sediment as an energy limited and would require a significant investment, which would take place in several directions.

Keywords: *water quality, physico-chemical characterization, sediment.*

1. INTRODUCTION

In Tuzla Canton, which is the first water poorest area in Bosnia and Herzegovina, an essential water resource of surface water is an artificial reservoir, lake Modrac, which was built in order to provide process water for industrial and power plants. From 2007 water from this lake has been used to supply the city of Tuzla with drinking water after treatment in the water factory "Cerik". River basin Spreča, which flows into the lake represents more than 60% of the entire basin of this river.

These streams are characterized by a large amount of suspended matter and dissolved organic and inorganic substances. As these substances are constantly discharged into surface water streams, they are continuously found in the accumulation, which leads to the creation sediment deposits mainly at the mouth of the river Spreča into the lake and the wider area of the lake, which is influenced by pouring rivers.

Given the constantly flooding of the lake with deposits from the river Spreča, eolian coating, coating of abrasion coast and entering large amounts of suspended matter, according to measurements from 1985 morphometric characteristics of the lake have changed significantly. According to previous measurements for a period from 1965 till 2002 total amount of sediment in the lake is 12 331 590 m³/year, of which from the river Spreča entered 10 256 300 m³ or 262 903 m³/year. The greatest impact on water quality in the lake has mining operations in the upper catchment area of the river Spreča and its tributaries, Oskova and Gostelja[1] .

The usage of these layers would clean the lake and if we confirm that they have certain usability, they could be used in a cyclic process that usually takes place in nature, where what is considered waste in one industrial branch can be used in another one. This represents the basis of industrial ecology[2] .

The aim of this paper is to investigate and define the physical and chemical composition of sedimentary layers at the mouth of the river Spreča is in the range of approximately 50 m from the mouth, and on the basis of established physical and chemical characteristics of sediments the possibility of using the sludge as fuel can be assessed.

2. MATERIAL AND METHODS

Sampling of sediments from rivers Spreča, Turija, and lake Modrac was carried out. As the aim of the research conducted is to determine the physico-chemical characteristics of sedimentary layers in lake Modrac and its tributaries, samples were subjected following tests:

The collection and preparation of samples[3]

Collecting samples for testing from the sedimentary layers (bottom) of rivers and the lake is carried out using semiautomatic tool for soil sampling - ISO 10381-3: 2003. The mass of the test sample was about 500 g / sample.

Sieve analysis of samples was performed after the removal of free moisture from samples. Screening was performed on the system screens "Fritsch" diameter of 1.0; 0.50, 0.25, 0.10, 0.075 and 0.040 mm - ISO 1953:1994.

To speed up the drying process determining free moisture was carried out in an oven "Heraeus" under the same conditions, ie 20 ° C and $\varphi = 50\%$, up to a constant sample weight.

Because the sediment of rivers and lake Modrac contains large amounts of carbon particles, which is evident from the sensory analysis, the analyses related to the quality of coal [4], were also performed on the samples:

Immediate analysis (determination of hygroscopic moisture, ash, non-combustible material, burn-matter, carbon residue, volatile matter, volatile, C_{fix} , and upper and lower heating value), Elemental analysis (content of carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur) Chemical analysis of ash (silicate analysis)

3. RESULTS AND DISCUSSION

The current 120 years old method of selling separated and classified classes of raw coal would have to be replaced by selling products of enriched coal (with a reduced percentage of ash, sulfur, moisture), such as briquettes, pulverized coal, gas from coal (degassing and gasification of coal) and in further perspective liquefaction. At this moment coal briquetting and powdering represents the best technical and economical solution[5,] [6].

Valuation of coal from sediment layers from the lake is, in addition to economical value, which is reflected in the transformation of waste fractions of coal[7]

or extension of their applications, also has ecological significance of large-scale – prevention of filling of lake Modrac.

From the beginning of exploitation and processing of coal, significant amounts of fine coal fractions plumpness (-0.5 +0) mm are formed in separation process.

These fractions are discharged in the form of waste water and thus transported to lake Modrac. As the consequence of this process, the suspended matter in the process of sedimentation are graded, and larger and heavier particles are deposited, while finer sediment is carried by water over a distance of several hundred meters to several kilometers to the river estuary. Measurements have shown that tiny particles of sediment layers from rivers Spreča and Turija are present on the dam.

An assessment of quality of sediment from the lake and its relation to energy potential [8]is based on the identified characteristics that refer to the quality of sediment from lake Modrac. The study has shown that sediment from the Turija estuary does not contain particles of coal, and these sediments are not considered as potential energy.

To determine whether there are realistic indicators to justify the investment in the exploitation of sediment and construction or reconstruction of existing facilities for low-calorie burning fuel, immediate sediment analysis was performed. With the results of silicate analysis, we will get a complete picture of using the sediment as a fuel. The results of immediate analysis are presented in the table 1. below:

Table 1. Immediate sediment analysis

Location	Parametres of immediate analysis* % m/m									Lower calorific value
	W_h	A	UN	SG	I	V^{daf}	KO	C_{fix}	GW	kJ/kg
Spreča estuary										
MM 1	7,36	63,23	70,59	29,41	20,02	68,07	72,62	9,39	51,00	5 074
MM 2	7,98	61,97	69,95	30,05	20,77	69,11	71,25	9,27	56,58	5426
MM 3	8,35	61,72	70,07	29,93	19,42	64,88	72,23	10,50	49,00	6011
MM 4	9,02	59,50	68,52	31,48	19,88	63,15	71,10	11,60	48,57	6323
MM 5	9,74	54,83	64,57	35,43	21,28	60,06	68,98	14,15	50,10	8605
MM 6	7,82	68,23	76,05	23,95	13,98	58,37	78,20	9,96	31,48	3176

* W_h - hygroscopic, A-ash, UN- total non-combustible, SG- burn-matter, I- volatile matter; V^{daf} - volatile matter, KO- coke residue; C_{fix} - related carbon; GW-total moisture

Calorific value of sedimentary layers from the Spreča estuary ranges from 3176 to 8605 kJ / kg, and the average calorific value is 5769 kJ / kg. Content of non-combustible material ranges from 64.57 to 76.05% m / m, and the burn-matter from 23.95 to 35.43% m / m

Heating value of coal is directly dependent on the content of bound carbon C_{fix} - the higher the content C_{fix} the higher is heating value of coal. This relation between parameter C_{fix} and calorific value of the sediment is evident in the diagram 1. The highest content C_{fix} and the lower heating value is in the location 5 (70 meters right from the Spreča estuary).

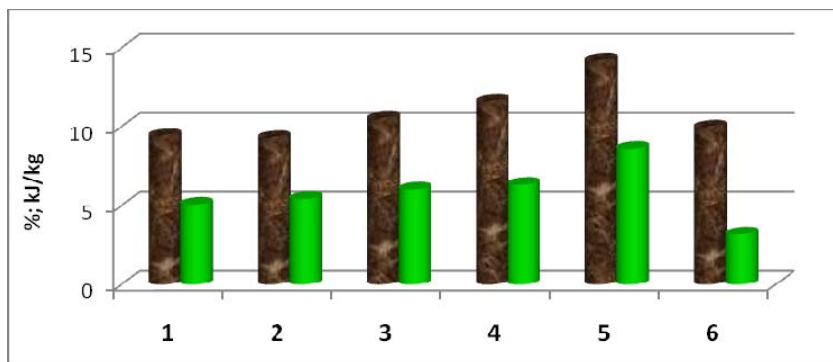


Diagram 1. The relation of content C_{fix} (green) and Lower calorific value (H_d)(brown)

Grain-size analysis showed that sediment drift from the river Spreča consists of grit particles - 0.5 mm, with a dominant share (approx. 90%) Class - 0071 mm. Clayey ingredients are dominant in its mineralogical composition

Based on the chemical analysis of the ashes and determined aluminum oxide, iron, calcium and magnesium, it is obvious that clay minerals and iron oxides are predominantly present in the sediment, while carbonates of calcium and magnesium are in subordinate relation.

The reason for the low calorific value of the sludge (approximately 5 769 kJ / kg)[9] ,lies in the fact that the ash content in the sediment is over 60% m / m. Mineral impurities in coal are present after combustion in the form of oxides, SiO₂, Al₂O₃, Fe₂O₃, Cao, MgO, etc., and make the ashes. Ash or mineral substances are generally undesirable, because the combustion in large systems can cause undesirable side effects (creates large amounts of slag). Higher ash content makes the combustion of coal and coking difficult and increases transport costs.

The moisture content affects calorific value of sedimentary layers. Moisture content ranged from 48.57% to 56.58%. Moisture adversely affects the quality of coal (combustion energy is spent on evaporation, the speed of coking is hampered). In addition, it increases the volume of flue gases produced during the combustion of coal.

Quantitative indicators of the quality of the sedimentary layers in terms of energy use show that the use of the sediment as an energy is limited (high ash and moisture content) and would require a significant investment, which would be implemented in several directions.

The first direction would be to improve the heat capacity of the sediment in the process of mixing with higher quality coal fractions, in order to obtain fuel with sufficient use value, which should be implemented in the existing incineration plants.

Another direction would be performed after the quantification of sediment in lake Modrac. If significant amounts of sediment were found the exploitation economically justified, then technology for incineration of organic waste and low-fat fuel would be considered.

The third direction would be finding ways for briquetting – the process of compressing coal dust under pressure to obtain a suitable form for use.

The techno-economic analysis of the feasibility of implementation of any proposed direction, or procedure must be conducted together with the detailed studies of sediment in terms of quantification of sedimentary layers at the Spreča estuary.

4. REFERENCES

- [1] Petrović, M., Gutić, S.: Primjena flokulanata u procesu prečišćavanja onečišćenih voda na separaciji RMU «Banovići» D.D. Banovići, Rudarsko geološko građevinski fakultet u Tuzli, XXIX Zbornik radova, Tuzla, 2008. godine.
- [2] Studija mogućnosti korištenja komunalnog čvrstog otpada u energetske svrhe na teritoriji Autonomne pokrajine Vojvodine i Republike Srbije, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, 2008.
- [3] Standardi: *Kvalitet tla: Uzimanje i priprema uzoraka*: BAS ISO 10 381 – 3:2003, BAS ISO 1953:1994
- [4] Standardi: *Ugalj: Imedijatna analiza*: BAS ISO 331:1999, BAS ISO 5068:2005, BAS ISO 1171:2005, BAS ISO 5071-1:2005, BAS ISO 5 073:2001, BAS ISO 9831:2005.: *Elementarna analiza*: BAS ISO 13878:2000, BAS ISO11 446:2000, BAS ISO 10694:2000. *Hemijska analiza pepela (silikatna analiza)*: BAS ISO 1008:2003, BAS ISO 1009:2003, BAS ISO 1011:2003, BAS ISO 1013:2003, BAS ISO 1014:2003, BAS ISO 1015:2003, BAS ISO 1018:2003.
- [5] Ecoal: World Coal Institute. Volume 26. London. Velika Britanija, 1998.
- [6] Ekspertna grupa za izradu SPP: Strateški plan i program razvoja energetskog sektora Federacije BiH, Sarajevo, Vlada FBiH, 2008.
- [7] R. Stanojlović, Z.S. Marković, J. Sokolović, D. Perić: Possibility for coal valorization from fine class (- 0,5+0) mm of raw coal in anthracite mine "Vrška Čuka", 6th Conference on Environment and Mineral Processing, pp. 607-612, Czech Republic, 2002.
- [8] J. Sokolović, R. Stanojlović, Z.S. Marković, Z. Štirbanović: Ekološki i ekonomski aspekti tretiranja finih klasa uglja, EkoIst' 06. Sokobanja, 2006., 216-221.
- [9] A.Babajić: Istraživanje mogućnosti primjene sedimentnih nanosa iz jezera Modrac, Magistarski rad, Tuzla, 2012.