Self oxidation of Romanian lignite during storage

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Abstract: - Due to large emissions of pollutants, the Romanian coal fired power plants will operate less frequently, but they will play an important role in ensuring the stability of power system. A long storage period leads to a devaluation of lignite. The paper shows a correlation between the baseline characteristics of the stored lignite, weather conditions and storage time which can be an effective tool for establishing measures to reduce the spontaneous heating of coal and to provide spontaneous combustion.

Key-Words: - Lignite, stock pile, spontaneous heating, calorific value, storage period

1 Introduction

During summer, when serious droughts led to a decrease in nuclear electricity output (because of not enough cooling water in the Danube) and to a decline of hydro electricity outputs, the lignite-fired power plants proved to be crucial for covering the Romanian electricity consumption that increases dramatically due to the demands of air conditioning. Moreover, as Romania has the largest and most stable power system in the Balkan Peninsula (and is synchronously interconnected within the UCTE), it contributed to stabilizing of the entire region, affected as a whole by the high temperatures and droughts. Although Romania develops modern power plants, the lignite-fired power plants will play a serious role in Romanian Energy Strategy.

The electricity generation structure is shown in figure 1.

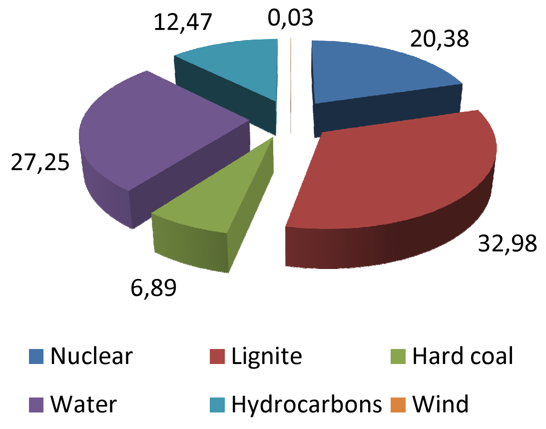

Fig. 1. Electricity generation structure in Romania (2009)

Almost 40 % from electricity was generated in coal fired power plants.

The total coal reserves of Romania amount to approximately 1 gigatonne of hard coal and 3 gigatonnes of brown coal and lignite and are sufficient to cover power generation needs for 70 years. More than 90% of the Romanian coal reserves are in the Oltenia Region - figure 2 - and could be efficient exploited in open pits.

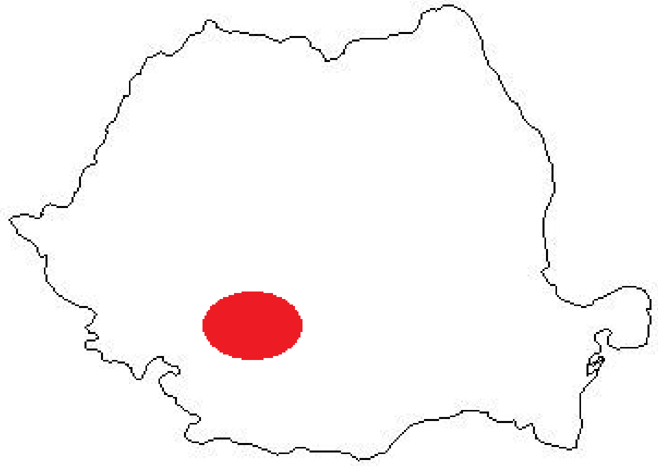

Fig. 2. Location of Oltenia region

2 Problem Formulation

Lignite, also known as brown coal, is the lowest grade of coal and shares some characteristics with peat. It tends to have a carbon content of 25-35 per cent, high levels of moisture and an ash content ranging from 6-19 per cent.

The fact that moisture can account for up to two-thirds of its weight, coupled with its much lower heat content then conventional coal, makes it uneconomic to transport over long-distances and therefore has kept it out of the global coal trade. As a result, it is primarily used by power plants built close to mining operations.

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The extracted lignite is not immediately delivered, and it must be stored in stockpiles for longer or shorter time, depending on demand.

Stockpile systems perform two main functions: they serve as a buffer between material delivery and processing, and they can blend the coals. Stockpiles are normally designed as open stores. Stockyards play an integral and vital part in the coal chain, with virtually all transport systems and most coal producers and consumers making use of stockpiles. Stockpiling is carried out at coal mines, coal preparation plants, transhipment facilities and end user sites.

With mounting pressure to minimise the amount of capital tied up in stockpiles with no return on the investment, there is a need to optimise coal inventories wherever coal is stockpiled. Issues such as optimum stockpile size, stockpile turnover period, timely stock management, and the ability to take advantage of cheaper coals when available on the market have therefore all assumed greater importance.

Freshly mined high volatile coal when stored in bulk undergoes low temperature atmospheric oxidation due to the presence of methane and other volatile matter on the surface. This exothermic oxidation causes the rise in temperature of the coal and if the heat is not removed, a stage comes when coal begins to burn on its own. This is called spontaneous combustion which leads to outbreak of fire in the stored coal.

If the temperature rise due to oxidation does not exceed a critical value (70 - 75 ^{o}C for Romanian lignite), spontaneous ignition does not take place but the quality of coal is affected depending on the degree of oxidation.

After a decade of steady growth, the energy consumption dropped dramatically in 2009 and the demand for coal decreased – figure 3.

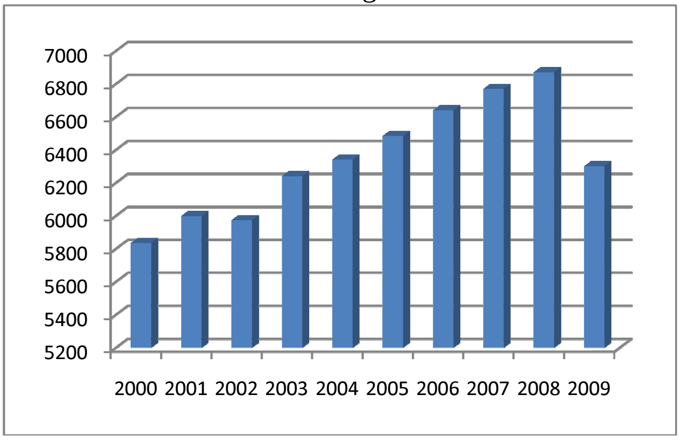


Fig. 3. Average energy consumption in Romania

The storage period of lignite increased and fires started in some stockpiles. The paper presents a study on coal temperature during storage according to storage time and environment parameters.

3 Problem Solution

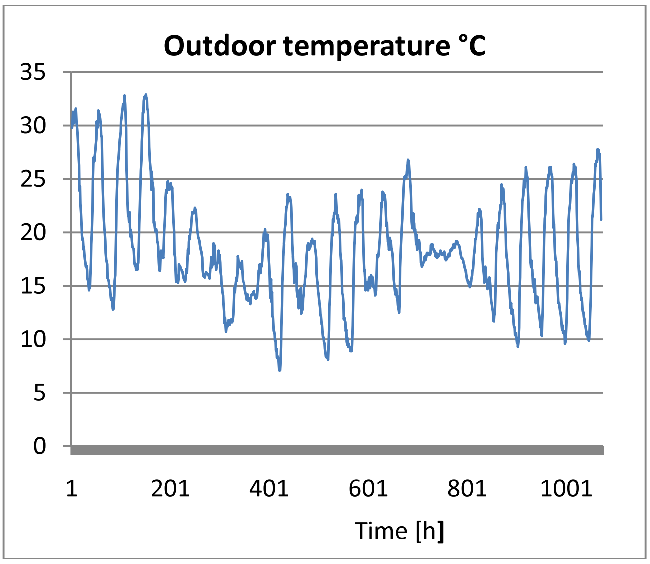
During the study, there were measured and recorded the following parameters:

- For lignite stockpile: temperature, calorific value, the percentage of moisture, volatile matter and ash.
- For the environment: temperature, relative humidity, air pressure, wind direction and speed, rainfall.
- Lignite samples taken periodically from the test: calorific value, the percentage of C, H, N, O, S, moisture, volatile matter and ash.

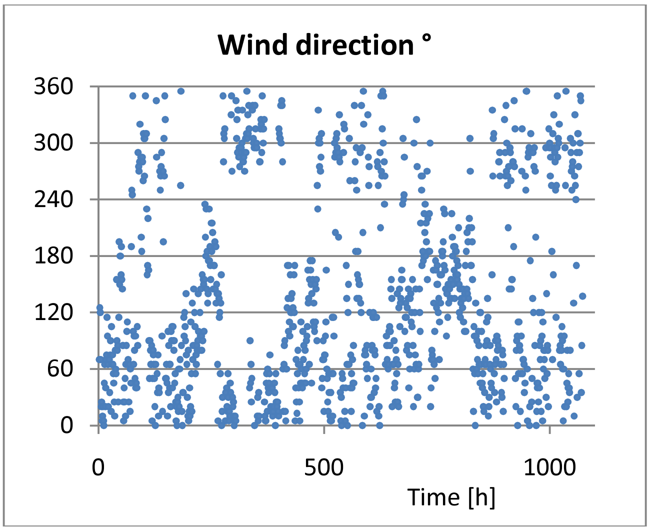
The apparatus used: RTD, humidity sensors, data loggers, weather station, thermal camera, bomb calorimeter..

3.1.Environmental parameters measurement

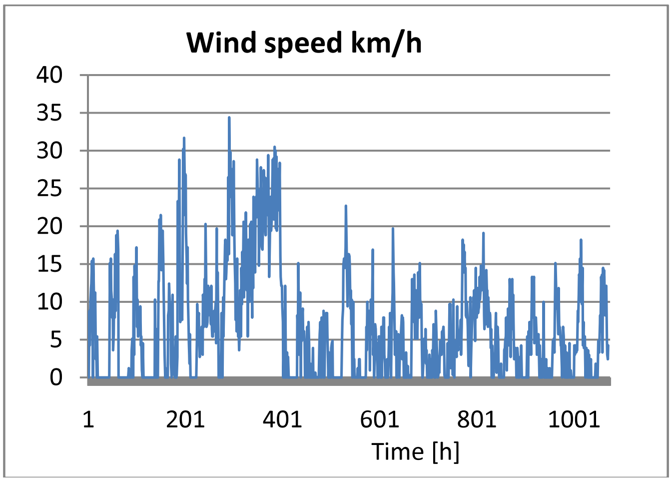
The environmental parameters are shown in fig. 7 ..11.



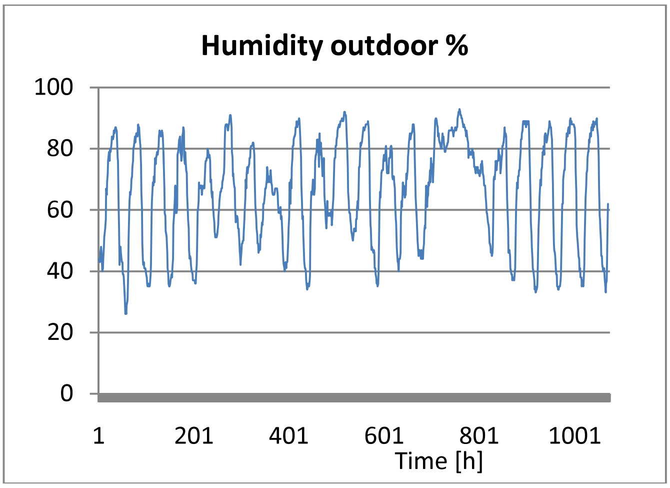
Fig, 7. Outdoor temperature [^{o}C]



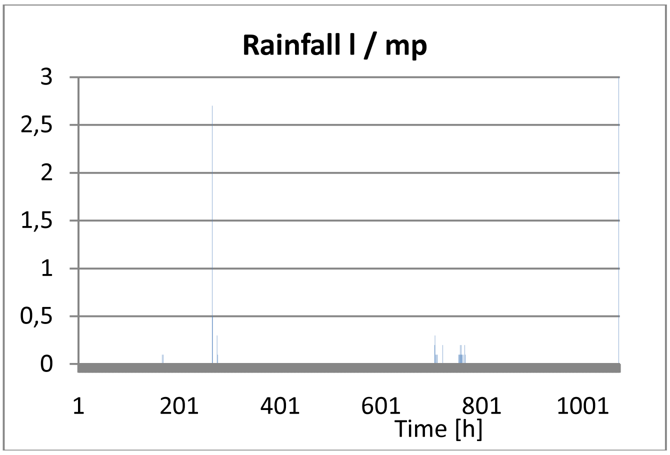
Fig, 8. Wind direction [^{o}]



Fig, 9. Wind speed [km/h]



Fig, 10. Humidity outdoor [%]



Fig, 11. Rainfall [l/mp

The measurement period was very low in rainfall, as shown in fig. 11, the rains being rare and brief. The amount of precipitation is small and it didn't noticeably affect the moisture of lignite deposited.

The coal deposit is located on a hill at Lupoaia and for this reason, there is always breeze and even gusts of wind. Even if instantaneous values of wind reached levels of 35 k m / h, the average of the wind speed in the considered period was 6,48 km / h. Although the wind direction changes frequently, its main direction is E - NE.

The relative humidity varied in quite wide limits, between 38% and 91%, with an weighted average value of 69%.

3.3. Temperature measurement

The analysis of lignite was performed in the days: 1, 2, 3, 5, 7, 10, 15, 20, 25, 30, 35, 38 at University's laboratories and samples of days 1,5, 15 and 30 were performed at laboratory of CE Turceni also.

The stack temperature was measured continuously with 12 RTD located at different levels in the stack – figure 4.

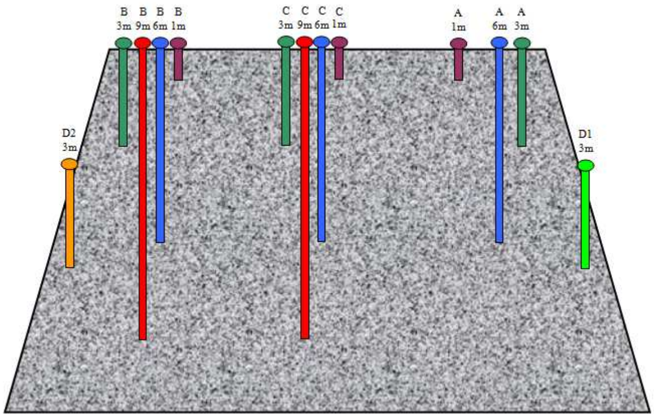


Fig. 4. RTDs positions in the test area

Also, the stockpile surface temperature was recorded at intervals of about three days with a thermal camera - fig. 5 and 6.

Fig. 5. Lignite stock pile – day 30

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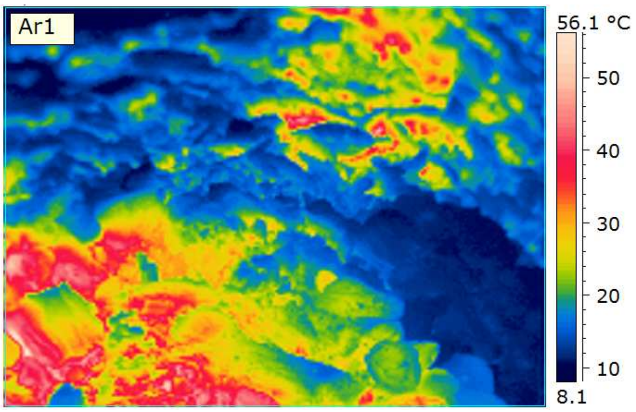

Fig. 6. Infrared image of lignite stock pile – day 30 moisture lignite deposited.

The temperatures measured by RTDs are shown in fig. 12 .. 16.

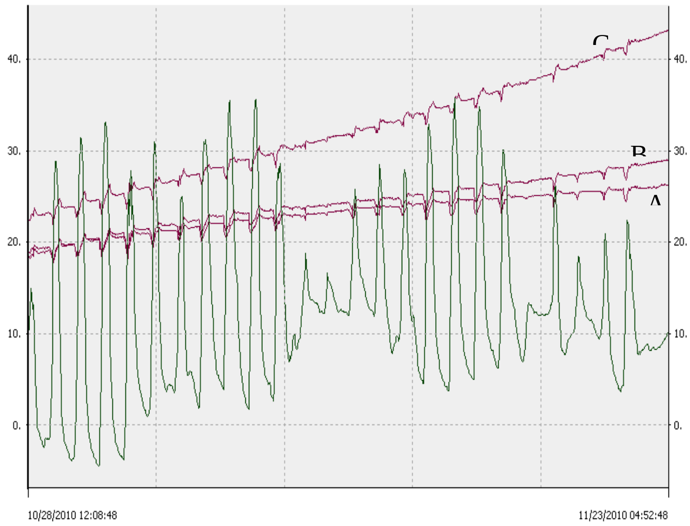

Fig. 12, Stockpile temperature at 1 m depth

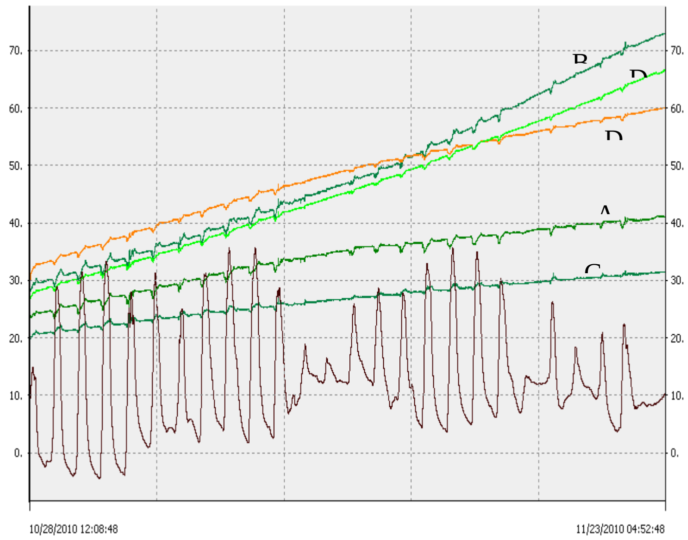

Fig. 13. Stockpile temperature at 3 m depht

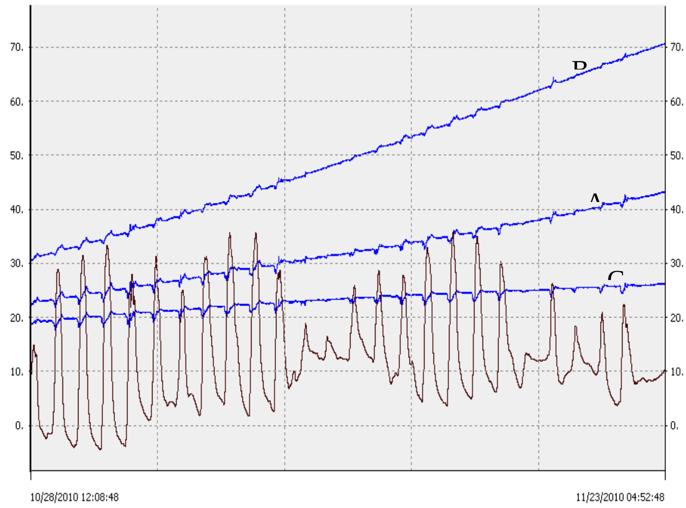

Fig. 14. Stockpile temperature at 6 m depht

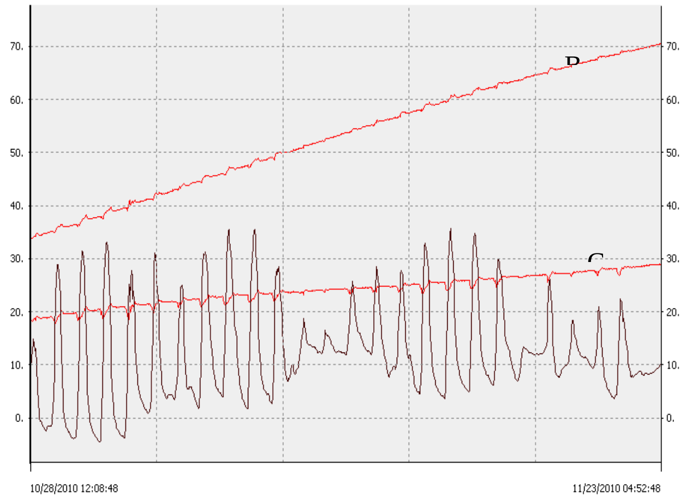

Fig.15. Stockpile temperature at 9 m depht

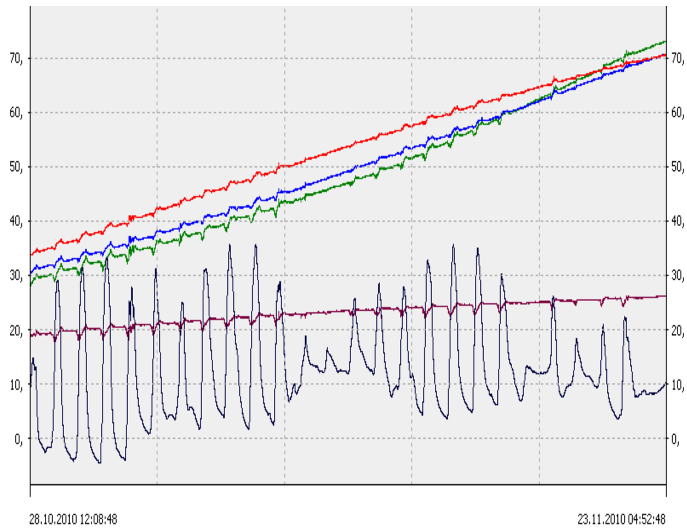

Fig.16. Stockpile temperature for eastern side

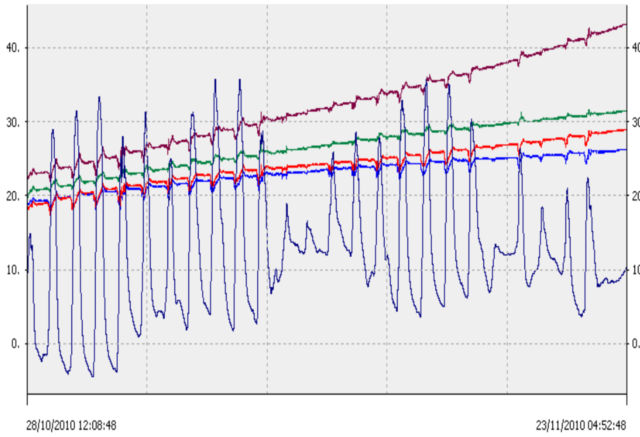

Fig.17. Stockpile temperature for central side

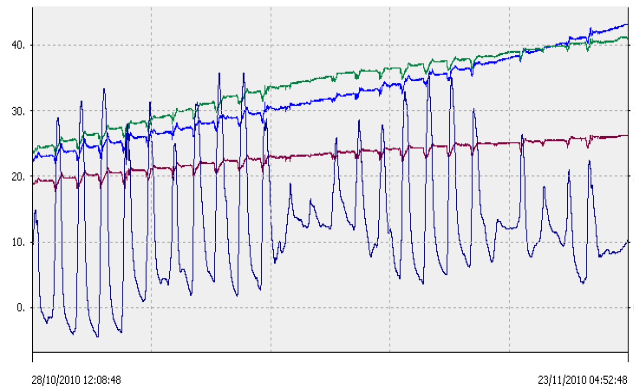

Fig.18. Stockpile temperature for western side

Note that while the temperature in the central and western part of the stack reaches about 40 ^oC, the temperature on the eastern side is almost 70 ^oC. This is because that the eastern side is exposed to wind and the fresh air promotes the oxidation of lignite.

3.3.Calorific value

The analysis of lignite was performed in the days: 1, 2, 3, 5, 7, 10, 15, 20, 25, 30, 35, 38 and samples of days 1,5, 15 and 30 were performed at an independent laboratory also.

The calorific values range was between 1775 and 2250 kcal / kg – figure 19.

The regression line equation, obtained by the method of least squares is:

$$Q_i^i = 2153{,}88 - 10{,}04 \cdot \tau \quad [\text{kcal/kg}] \qquad (1)$$

where τ is the time in days.

The calorific value decreased with 17.32% reported to the value when the stockpile was formed.

This happens mainly due to the fact that the lignite particle size of the stack varies extremely broad, from 1 mm to 600 mm slabs, promoting air circulation and thus oxidation of coal. Air circulation is supported by the fact that the pile is not compacted. However, in the first week, the calorific value has only a small decrease because the coal moisture decreases during this period due to evaporation of water and lack of precipitation.

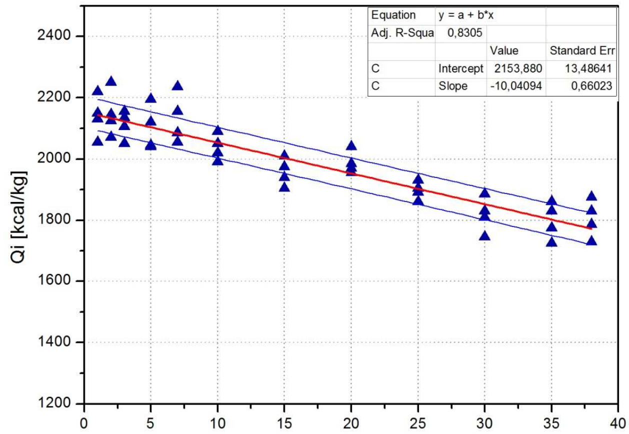

Fig. 19. Calorific value

The total moisture of lignite has a slight increase and ash rose about 2%. Oxygen content increased slightly, while the carbon content has a more pronounced decrease of about 3%.

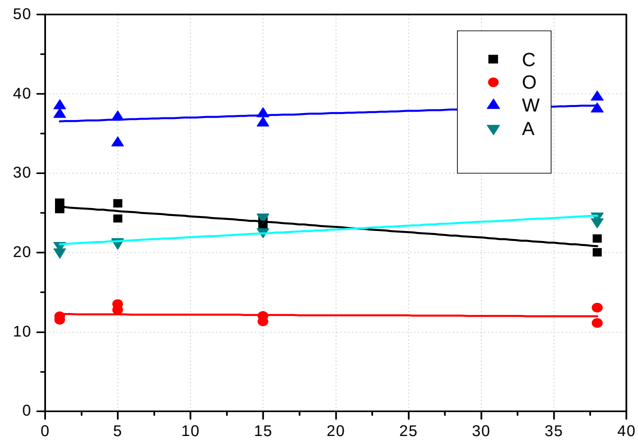

Fig. 20. Content of carbon, oxygen, humidity and ash

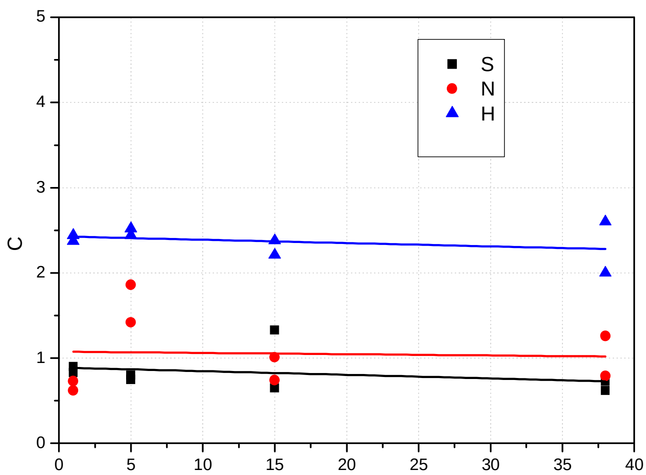

Fig. 21. Content of sulfur, hydrogen and nitrogen

The percentage content of sulfur and hydrogen has a slow decrease, while nitrogen content remains practically constant.

4 Conclusion

Low demand on coal market has led to the extension of storage time of lignite, with adverse consequences on its quality.

The paper examines changes in lignite quality parameters depending on the storage time and environmental parameters in order to determine an optimal storage period of lignite.

The measurements were made at Lupoaia open pit, for a period of 38 days, the beneficiary requiring to end the study due to high temperatures in some parts of the stockpile (over 70 °C).

There were measured the parameters for the lignite stockpile and environmental parameters. The period was very low rainfall and, although it was expected to decrease the moisture of coal, this has not happened due to high moisture content in the air. The percentage contents of carbon, sulfur and hydrogen decreased (greater on carbon), while the percentage of ash and oxygen contents increased.

Following the processing of results, it was determined a relationship that allows the estimation of the calorific value of stored coal connected to lignite characteristics and environmental conditions

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