# STUDIES REGARDING OBTAINING UNCONVENTIONAL FUELS FROM SLUDGES COMING FROM TERTIARY TREATMENT OF SOME WASTEWATERS

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## ABSTRACT

Sludge obtained in the tertiary stage of wastewater treatment can become a source of potential fuels. Up to now, the methods applied for making the best use of such sources have aimed at obtaining energy through indirect processes and using sludge for agricultural land improvement. However, most conversion methods applied on a national scale have major technical and economic disadvantages, as well as a negative impact on the environment.

The present paper summarizes the research work performed by the authors for the direct use of sludge under the form of solid fuel, as well as the optimisation of the disposal of sludge resulted from biological wastewater treatment.

## INTRODUCTION

One of the major issues arising from treating municipal wastewater and wastewater from animal breeding is the effective management of sludge resulted in the tertiary stage.

In a medium-sized city with a population of about 350,000 inhabitants, the daily amount of sludge containing 80-85% water is around 100 tons. The separation of water by centrifugation before or after the mineralization stage can reduce sludge humidity with 35-40%. The specific energy consumption remains unchanged, irrespective of the applied method.

On discussing the technology of sludge fermentation for biogas production and sludge mineralization, one can notice that part of the sludge that can be converted to methane and therefore used as energy. This part is indicated by its organic fraction [1].

The design, building and use of digesters required for biogas production and traditional energetic plants or gas turbines require considerable investment. However, when applying the combined method for energy production and the concomitant discharge of low-impact residues, the major issue is not the efficiency of the plants, which depend on the operators' technical performance and training level, but the management of the fermentation sludge that can be used only in agriculture, for soil fertilisation [2].

This use of sludge is a far-fetched hypothesis which the real situation of Romanian agriculture contradicts. In Romania, average agricultural areas cover less than 20 ha and the potential beneficiaries are reluctant to use sludge as compost because of its origin and because they lack the material resources required for its transport and use in the field.

Water and sewerage companies cannot be forced to sign thousands of contracts with such reluctant beneficiaries or to pay for the expenses required for transporting fermented sludge to the fields, especially if the chosen sludge management variant involves the humid sludge. Consequently, after centrifugation, the resulted biological sludge is stored in the treatment plants, covering large areas and hindering access to equipment.

As mentioned above, the fraction of organic carbon that can be converted to biogas can be used more effectively through the direct use of dry sludge as non-conventional fuel. This leads to the elimination of its inorganic fraction under the form of ash resulting from burning. The following experiments deal with both the description of the thermal-technical behaviour of such fuel and the improvement of its original properties [3].

## EXPERIMENTAL PART

### Thermogravimetric study of sludge

Several sludge samples collected from a biological treatment plant were subjected to monotonically increasing heating in two technical variants. This was done in order to determine sludge behaviour during burning and the total mineralization temperature, given that the value of the residual carbon concentration in waste and fuels is limited both for economic and environmental protection reasons. Sample behaviour and mineralization varying with the increasing temperature are shown in Table 1[1]. All experiments were performed in the calcination kiln (30-minute calcination time at constant mass). Sludge initially subjected to calcination was also dried at 105°C.

| **Temperature** °C | **N1** Residue/ 100 g humid substance (%) | **N2** Residue/ 100 g humid substance (%) | **N3** Residue/ 100 g humid substance (%) | **Observations** |
|---|---|---|---|---|
| 400 | 9,1 | 9,3 | 8 | - smouldering, smoke release<br>- dark residue (N2 almost black)<br>- no embers |
| 450 | 8,9 | 8,6 | 7,7 | - smouldering, smoke release<br>- dry ground colour residue (light grey) |
| 500 | 8,5 | 8,3 | 7,6 | - smouldering, smoke release<br>- dry ground colour residue (light grey)<br>- embers |
| 550 | 7,9 | 7,3 | 7,5 | - burning with a flame and little smoke<br>- dry ground colour residue (light grey)<br>- embers |
| 600 | 7,8 | 4,3 | 7,4 | - burning with a flame<br>- burnt ground colour residue (light brown)<br>- embers |
| 650 | 7,7 | 4,2 | 7,4 | - burning with a flame<br>- burnt ground colour residue (light brown)<br>- embers |
| 700 | 7,6 | 4,2 | 7,3 | - burning with a flame<br>- burnt ground colour residue (light brown)<br>- embers |

**Table 1** Behaviour of sludge during the burning process

[1] Initial humidity: 82% for all samples; N1 (September 8, 2013); N2 (September 16, 2013) and N3 (September 26, 2013)

The variation in the ash amount in the studied samples is given in figures 1 and 2, in which **CC1** – calcination kiln (30-minute calcination time up to constant mass), and **CC2** – quartz kiln (5-minute calcination time)

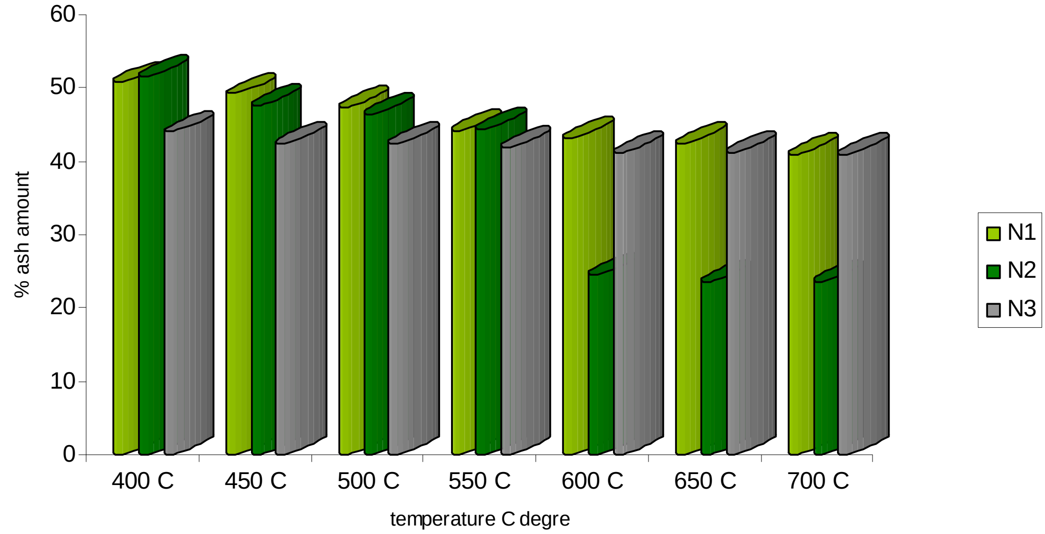


**Figure 1** Variation in the amount of ash resulting from burning sludge in the CC1 experimental conditions

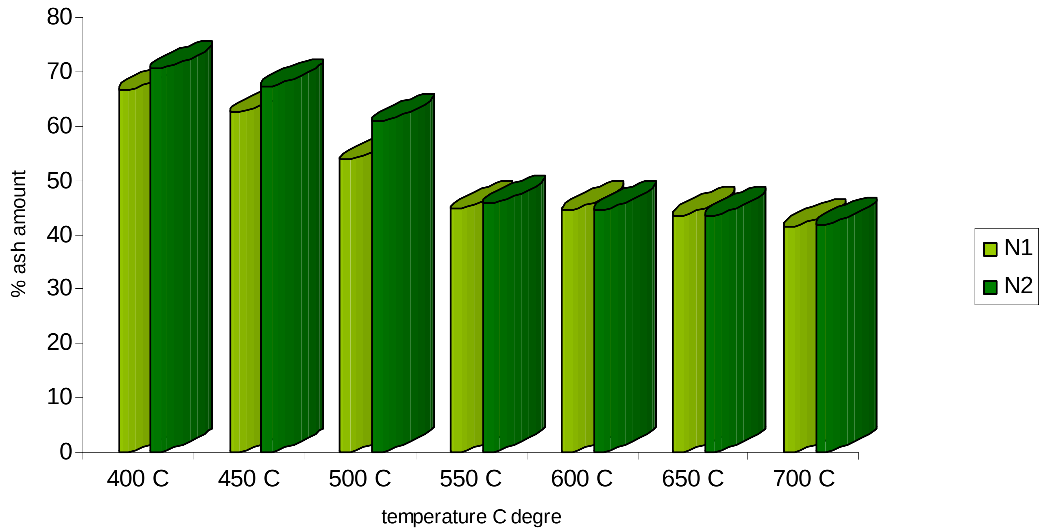


**Figure 2** Variation in the amount of ash resulting from burning sludge in the CC2 experimental conditions

The above facts indicate that within the 400÷500°C temperature range sludge smouldered and released smoke; samples N1 and N3 released more smoke than N2; sludge burnt with a flame but without smoke at all temperatures above 600°C, The variation in the residue mass after burning is much smaller in all three sludge samples (N1, N2, N3) within the 600÷700°C range than for the other temperatures and the colour of the residue is constant, The differences between the ash amounts within the 600÷700°C range may be caused by a higher quantity of clay material in N1 and N3 than in N2, The differences between the samples before burning were noticeable also visually: N1 and N3 were dark-grey to black, while N2 was black,

**Determination of the lower heating values of active biological sludge and a type of hydrocyclone bituminous coal**

The lower heating value of the sludge samples was determined on an automatic bomb calorimeter of the IKA C4000 type, Samples subjected to calorimetric measurements were previously dried at 105°C up to constant mass, An average value of the initial dry substance concentration of 23% was determined, The average lower heating value was 12,115 kJ/ kg, and the average sulphur amount was below 0,1%, The average loss during calcination was 49% in relation to the dry mass,

For comparison purposes, the lower heating values of several usual solid fuels are given in table 2,

| Fuel | Lower heating value kJ/ kg | Relative specific consumption kg conventional fuel/ kg |
|---|---|---|
| Anthracite from Anina | 22805 | 1,285 |
| Bituminous coal from Valea Jiului | 19766 | 1,114 |
| Lignite from Rovinari | 7806 | 0,439 |
| Oak wood | 15233 | 0,858 |
| Beech wood | 14788 | 0,833 |
| Conventional fuel | 17742 | 1,000 |
| **Alternative fuel** | **12115** | **0,682** |

**Table 2** Lower heating values of several usual solid fuels compared to the studied non-conventional fuel

The average lower heating value places the tertiary-stage municipal wastewater treatment dry sludge among alternative fuels of definite use, However, in order to improve its burning qualities, it was mixed with a type of bituminous coal from Valea Jiului, which was processed by washing in hydrocyclone, The same experimental measurements of the precise dry substance concentration, lower heating value and sulphur concentration were performed for the bituminous coal beforehand, The hydrocyclone coal samples were also dried at 105°C up to constant mass and an average value of the initial dry substance concentration of 88,3% was determined, Under the circumstances, the average lower heating value was 19,194 kJ/kg, and the average sulphur concentration was 0,72%, The average loss during calcination was 52% in relation to the dry mass,

**Optimisation of non-conventional fuel by the addition of hydrocyclone bituminous coal**

The hydrocyclone bituminous coal added to increase the heating value of the non-conventional fuel obtained by drying sludge resulted from municipal wastewater treatment varies both with the increase in the total sulphur concentration in the improved fuel and the share of the hydrocyclone bituminous coal price within the production costs, Consequently, in order to maintain the sulphur concentration to an acceptable value of less than 0,2%, at a maximum ¼ increase of the production costs, maximum 23,5% of washed coal can be added,

This leads to a fuel type of an average heating value of about 14,700 kJ/ kg, which places it among solid fuels that are comparable to hard wood fuels,

## CONCLUSIONS

The studies conducted so far lead to the conclusion that by drying the municipal wastewater treatment sludge, one can obtain a type of solid fuel of definite use, owing to both the heating value which is much higher than that of lignite and the sulphur content which is much lower than in any coal type [4, 5],

Such qualities can turn the described non-conventional fuel into an object of interest not only for those who want to improve burnt lignite for thermoelectric power cogeneration, but also the operators of plants treating municipal wastewater resulted from the food industry and animal breeding activities, Subsequently, plant operators are provided with an easy way to dispose of the tertiary-stage sludge in a proper manner [6, 7],

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