

# The Effect of Moisture and Ash on the Calorific Value of Cow Dung Biomass <sup>†</sup>

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**Abstract:** Cow dung biomass was taken from December 2017 to April 2018. After drying and crushing, analytical moisture was determined, followed by the content of ash, total carbon, total sulfur, heat of combustion, and calorific value. Research has shown that the moisture of the biomass burned has a significant impact on both the ash content and its calorific value.

**Keywords:** solid fuels; cow dung; biomass; energy value; renewable energy

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## 1. Introduction

In Poland, biomass is the most widespread and used renewable energy source. According to the Directive adopted by the Council of the European Union 2001/77/EC [1], biomass is a biodegradable fraction of products, waste, and residues of the agricultural industry (including herbal and animal substances), forestry, and related industries, as well as biodegradable industrial and urban waste fractions. Biomass of animal origin are solid animal waste (manure) and liquid animal waste (slurry) [2].

In this study, physicochemical properties of cow dung biomass was characterized. The tests were carried out in accordance with the technological procedures of the Institute for Chemical Processing of Coal in Zabrze. The obtained results of our cow dung biomass study was compared with the results obtained for dried feces of domestic animals (cattle) in India (Vyskov) and in the Indian Himalayas in the summer 2009 [3]. Additionally, the comparative analysis included cow dung biomass data obtained in the Czech Republic [3]. The analysis allowed determination of the quantitative dependence of the analytical moisture content and ash on the calorific value in terms of the energy suitability of cow dung fuel.

## 2. Materials and Methods

We obtained the solid biomass of cow dung solid from a privately-owned farm located in the village of Dziekonia, in the Podlasie Voivodeship. There were 40 cows on the farm, which lived year-round in the barn, indicating an intensive fattening. The combined total sample of cow dung manure was collected once a month from 10 primary samples from the cowshed.

The physicochemical analysis of biomass was carried out after drying the raw material in a laboratory dryer at 40 °C. Drying time of the sample was extended to 10 h, because the use of drying time (8 h) in accordance with the procedure did not cause the biomass to dry (too high total moisture). After drying, the sample was equilibrated with ambient humidity and ground to analytical grain. For the study, samples of ground biofuel with a fraction below 0.42 mm were prepared. During the research, the energetic properties of cow dung biomass, total moisture, and moisture content in the analytical sample, ash content, total carbon, and sulfur content were determined, and the hydrogen content was calculated. Then, the heat of biomass combustion was determined and its calorific value

was calculated. For the determination of the moisture content in the analytical sample and ash in the biomass, the LECO thermogravimetric analyzer 701 was used. The heat of burning solid waste was determined using the AC500 LECO calorimeter and then their calorific value was calculated. Simultaneous determination of carbon (C) and sulfur (S) content in biomass was carried out on the LECO SC-144DR analyzer.

### 3. Results and Conclusions

The current energy policy of Poland, consistent with the European Union’s directions, aims to replace the energy obtained from fossil fuels with that from renewable sources, including biomass. Europe is moving towards increasing the share of renewable energy to 20% in 2020 and to 40% in 2030. The implementation of the European Union objectives imposed on Poland the obligation to produce energy from renewable sources from 3.1% in 2005 to 15% in 2020. There is a need to look for new, alternative and generally available heating materials, which will have a low, competitive price, and at the same time a high energy value. One potential solution is the investigation of cow dung biomass.

The basic energetic parameter characterizing biomass is its calorific value, which is determined for samples of known moisture content [4]. According to our results, the moisture content of burnt biomass affects its calorific value. In the sample with a lower moisture content (2.7%), the calorific value of cow dung biomass was higher (17.57 MJ/kg) and in the samples with higher moisture contents (from 5.3% to 7.5%) the calorific value of biomass was smaller (from 15.83 MJ/kg to 16.24 MJ/kg) (Table 1). It was confirmed, therefore, that the calorific value of solid biofuel increases with decreasing moisture. The drier the biofuel, the less energy is needed to evaporate water in the combustion process, and the more efficient the energy process [5]. Other authors reported that the biomass dried to 10–20% moisture content reached a calorific value of 15–17 MJ/kg and the biomass with moisture of 50–60% had a calorific value of only 6–8 MJ/kg. This shows the need for a deeper drying of biomass before its disposal [6].

In the process of fuel combustion, ash, and its amount also play important role [7]. On the basis of the results of research from India and the Czech Republic, it was found that the greater content of ash (from 20% to 32%) had a negative effect on the effective calorific value of fuel (Vankát A. et al, 2010). It is important for fuels with lower heating values of the combustible substance. The lower ash content (up to 12.5%) is advantageous because it indicates low contamination of the mineral substance, which can then be used, for example, as fertilizer [8].

**Table 1.** Parameters of combustion of animal manure.

Animal	Own Research December 2017 (Poland)	Own research January 2018 (Poland)	Own research February 2018 (Poland)	Own research March 2018 (Poland)	Own research April 2018 (Poland)
Analytical moisture (%)	2.7	5.3	6.8	6.5	7.5
Ashes (%)	10.7	13.1	12.1	13.0	10.1
C (%)	46.10	43.63	43.81	43.56	44.10
H (%)	5.41	5.10	5.07	5.03	5.15
S (%)	0.26	0.28	0.25	0.25	0.23
Higher calorific value (MJ·kg <sup>-1</sup> )	18.84	17.42	17.13	17.22	17.45
Lower calorific value (MJ·kg <sup>-1</sup> )	17.57	16.24	15.83	15.94	16.12
Total moisture (%)	87	85	88	86	84

Biomass cow dung, due to its energetic properties, is an alternative source of energy that can be successfully used in Polish power plants and combined heat and power plants. The tests confirmed its suitability for this purpose.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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