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Life cycle assessment of biomass production from drained wetlands areas for composite briquettes fabrication

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Abstract

The area of wetlands after peat mining in Belarus is about 190,000 hectares and once peat harvesting has ceased it is impossible to grow any cultural plants for some years. One of the perspective directions is rewetting wetlands after peat extraction that stimulate vegetation of natural grass, like reed, rush and others which are growing in natural conditions. The grass biomass may be used for energy purpose, in particular for composite briquettes fabrication, which contents in 50 % from grass and 50 % from peat. The LCA method based on the standards series ISO 14040 was used for evaluation of environmental impact of growing and production of composite briquettes from wetland biomass. The goal of LCA was comparison two scenarios of biomass production for composite briquettes. Product system B (PSB) based on biomass harvesting with simultaneous shredding and product system A (PSA) based on biomass mowing, raking for drying and bailing. The basic LCA impact categories were: climate change, acidification, photo oxidant formation, eco toxicity and human toxicity. The product system A (mowing and baling biomass) achieved better results in 3 categories out of 5, and especially eco toxicity and human toxicity. And if for climate change the indicator results for both systems were close, for acidification, eco toxicity and human toxicity PSB systems impact was significantly higher to compare to PSA. It may be explained by peat using for biomass drying in product system B. The contents of SO_2 and Hg in the peat in several times higher to compare to diesel and gas, while PCB and GCB are contained only in the peat.

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Keywords: wetland; biomass; bioenergy; composite briquettes; life cycle assessment

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1. Introduction

Peatlands cover 3 % of the world's area but contain 30 % of the soil organic carbon. About 15 % of the world's peatlands have been drained for different human purposes, mostly for agriculture, forestry and peat extraction [1]. Drainage has a negative effect for the functioning of global wetlands and their services including flood protection, water purification, biodiversity and carbon (C) sequestration [2]. Drainage of these systems has resulted in strong degradation by oxygen intrusion, enhancing aerobic decomposition of organic matter and carbon emission. Together with compaction and consolidation, this has caused fast land subsidence. In Republic of Belarus wetlands formerly covered about 15 % of country area, extending to almost three million hectares [3]. Approximately 1.5 million hectares have now been drained and mostly used for agriculture, forestry and peat extraction. The area of wetlands after peat mining in Belarus is about 190,000 hectares [4]. A soil condition after peat mining are not favorable and once peat harvesting has ceased it is impossible to grow any cultural plants for some years, with the most critical period being the time after planting [5]. These areas are used for several purposes, such as forestation, flooding and fishing, growing cranberries and others. One of the perspective directions is rewetting of post-mining peatlands that stimulate vegetation of wetlands grass, like reed, rush and others are growing in natural conditions. There is special term – paludiculture in nowadays practice (latin 'palus'= swamp), that means land management techniques for biomass cultivation from wet and rewetted peatlands [6, 7]. Common Reed it is dominated specie on drained wetlands areas. It is a tall, thin, highly productive grass which was mostly distributed in Europe and nowadays efforts to rewet and restore drained wetlands increased the reed growing area [8]. Common reed and other grasses it is perspective sources of bioenergy from wetland areas that not require new arable lands, but it is necessary to estimate and environmental aspects for grounding of best practical methods of using biomass.

LCA methodology provides a comprehensive systems-based analysis of the energy and environmental performance of a product system based on the standards series ISO 14040 [9]. LCA it is method that is used for environmental impact assessment of various types of bioenergy. For instance, a lot of LCA devoted to assessment of diesel and biodiesel production [10–14]. The significant interest for LCA analyzing has ethanol, which may be produced from different type of feedstock. A number of LCA developed for ethanol production from different type of crops and it's biomass (residues and straw) [15, 16]. LCA is also used for improving of environmental impact [17, 18].

There are some publications concerning LCA of biomass production on the base of reed and other grasses. Most of them devoted to giant reed, sorghum, or tall fescue that produced as normal agricultural crops on arable lands [19–22]. Nevertheless, in several publications the LCA of natural grasses were investigated. Such, LCA of common read for bioethanol production was fulfilled in China [23]. Atmospheric impact of bioenergy based on reed canary grass on a drained boreal organic soil on the base of LCA was investigated in Finland [24]. It was found that, on an average, this system produces 40 % less CO_2-equivalents per MWh of energy in comparison with a conventional energy source such as coal. Other article devoted to reed production from abandoned peat extraction areas that close to conditions of our experiments [25]. The results indicate that, from the perspective of atmospheric impact, the most suitable is cultivation of reed canary grass to compare to other crops.

There are some directions of energy production from biomass, such as direct firing, bioethanol production, fabrication of pellets and briquettes. The purpose of our investigation was comparison of different scenarios of wetland biomass production for composite briquettes manufacturing on the base LCA.

2. Materials and methods

Our experiments were fulfilled on post-mining peaty soils in Grodno region, Lida district, close to the Lida peat Factory (LPF), the biggest peat briquette company production in the region. The degraded peaty soils are very heterogenic with different contains of nutrients, different decomposition depth of peat layer and level of peat decomposition, water regime and underground water level [26]. As the result, it is necessary to apply different kind of agricultural practice more suitable for concrete type of peaty soil and conditions of area flooding. The prevailing grasses on experimental lands were common reed and canary. LCA of 2 basic scenarios of biomass production was estimated in depends of soil conditions and water regime (Fig. 1):