Non-technical abstract

One of the bulk by-products of torrefaction is carbonized solid fuel (CSF). CSF is the carbon-rich product obtained from municipal solid waste (MSW). CSF is thermally decomposed mostly under a torrefaction process. Torrefaction is considered as low-temperature pyrolysis, frequently called as waste roasting. Recent research showed that CSF may be used to replace fossil fuels and may be considered as a tool of potential relevance to sustainable waste management. The Waste to Carbon concept is the conversion of organic waste into valuable materials, including fuel with high carbon concentration. The torrefaction turns waste into CSF with a calorific value reaching similar values to black coal.

Besides the positive effects of CSF, some negative effects have also been reported. The CSF may contain potentially harmful and toxic substances including volatile organic compounds (VOC). The content of these pollutants, their emission depends on the properties of the feedstock and torrefaction temperature. The application of CSF as a fuel requires practical issues of storage, handling and application. Thus, it needs to be ensured that CSF does not pose any excessive risk to humans by inhalation of harmful VOCs. A detailed understanding of the reasons for such negative effects is not investigated and understood deeply yet. The emission of organic pollutants from CSF may occur, causing a risk to human health. There is limited information on the impact of various torrefaction conditions and content of MSW components on the chemical characteristics of CSF produced from MSW feedstock. Therefore, the objective of the proposed research is to evaluate the effects of torrefaction temperatures and the content of morphological components of MSW on the qualitative and qualitative emission of potentially harmful compounds from CSF.

The scientific aim of this project is the qualitative and quantitative characterization of the VOCs emission from CSF in relation to torrefaction temperature and the content of fabrics, kitchen waste, paper, different plastics, rubber, wood, and its mixtures.

The project has an interdisciplinary character, and will include the following tasks:

Task 1. CSF generation from MSW – the aim of the task will be the production of CSF from the components of MSW under controlled conditions of torrefaction. The effect of this task is obtaining the CSF samples which will be analyzed in tasks 2 and 3.

Task 2. Determination of physical, and chemical properties of MSW components, and generated CSFs – the aim of the task will be the physical and chemical characterization of feedstock and CSF for evaluation of the phenomenon of pollutants transformation during thermal treatment. The effect of this task is obtaining the database of the MSW and CSF properties which will be utilized for the model construction in task 4.

Task 3. Investigation of the VOCs emission from CSF - the aim of the task will be the characterization of VOCs emission from CSF to air, and the evaluation of the human risk by modeling of VOCs concentration level during the storage and comparison with human health threshold values. The effect of this task is the database of the VOC emission from MSW and CSF, which will be utilized for the modeling in the task 4.

Task 4. Determination of the model of the impact of technological parameters of CSF production and the MSW feedstock quality on the VOCs emission from CSF – the aim of the study will be the building the mathematical model, which may be useful for prediction of the potential risk posed by CSF to the environment and human health. The effect of this task is obtaining the model of the VOC emission from CSF which will be validated in task 5.

Task 5. The validation of the model of the impact of technological parameters of CSF production and MSW feedstock quality on the VOCs emission from CSF – the aim of this task is to validate obtained model predictions (task 4) with the result of the VOCs emission from CSF produced from real MSW. The effect of this task will be the validation of the model of the influence of torrefaction technological parameters and MSW components content on VOCs emission from CSF'. This task will be done during Ph.D. student internship at Iowa State University.

An effect of the proposed research will be the determination of the data covering the potential impact on the human health of CSF generated due to MSW torrefaction. This research may show potential impact on the work environment of MSW torrefaction at the early stage of basic research. Presented problems, related to the potential negative influence of CSF on human health are novel and open a new niche for investigations and experiments. It is expected that results will provide the procedure of CSF human health risk due to exposure on VOCs evaluation, which could be used for examination of CSF. The proposed project involves original, experimental, as well as interdisciplinary research undertaken to develop new knowledge about the phenomena of VOC emission from CSF produced from MSW, under different torrefaction temperatures. This investigation and analysis will be focused on the identification, and on a better understanding of VOCs formation and release from CSF, the influence of external and internal factors on the emission, and the potential impact on human health. The compliance of CSF with existing VOC threshold values has been tested before not significantly, which could be highly relevant for human health and safety.