Production of forest residues from fire safety zones (FSZ) and their potential for biogas production

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Fire safety zones (FSZ) are crucial for the management of forest fires. These zones require regular maintenance by typical deforestation activities which generate large quantities of forest residues. The latter include trees, such as those prevailing in the forest. The residues are usually disposed of adjacent to the FSZ. There is an increasing however interest for sustainable valorization of forest residues, such as for energy production. In this work a FSZ of a low-altitude Mediterranean Pinus forest (Thasos island, North Greece) (Figure 1) was studied and the quantity of forest residues generated (tree trunks, branches, needles) during FSZ maintenance was recorded. The study further aimed to evaluate the potential of biogas production from the generated pine needles and compare it with conventional energy crops (maize silage) used in anaerobic digestion facilities. The pine needles were milled and digested before use in anaerobic batch reactors.

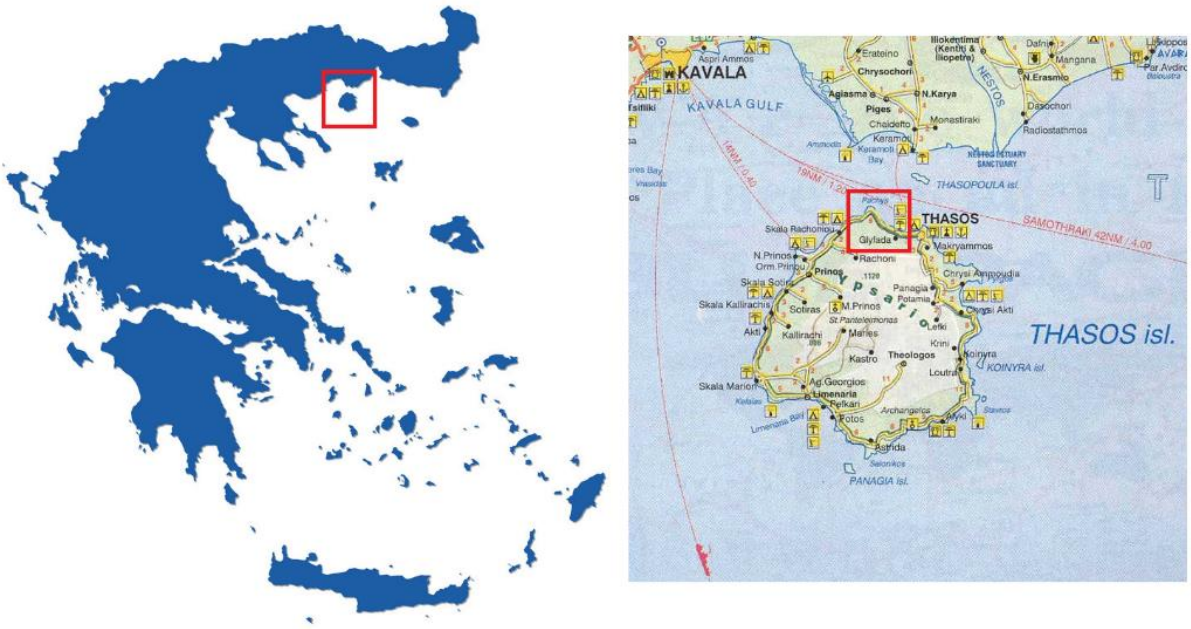

Figure 1. Location of Thasos island (left) and the FSZ under investigation (right).

Twenty-five (25) sampling sites each with an area between 200 to 400 m^2 were selected within the FSZ during typical maintenance operations. The vegetation cover consisted mainly of *Pinus brutia* trees having a height 2 to 12 m and a diameter 4 to 27 cm. During FSZ maintenance the trees were chopped and the trunk was separated from the branches. The volume occupied by the branches was recorded. The average number of trees removed from the FSZ under consideration was 22±11 per 1000 m^2 FSZ, while the volume of branches collected was 11±8 m^3/1000 m^2 FSZ (Figure 2). The apparent density of the separated *Pinus brutia* branches was 215 kg/m^3 consisting 31.7% w/w of pine needles. The biogas yield values of *Pinus brutia* needles was equal to 709±50 m^3/tn VS which was significantly higher compared to the respective values from maize silage (530±15 m^3/tnVS). Considering the amount of pine needles collected per 1000 m^2 of FSZ, the specific biogas yield can be as high as 230 m^3/ 1000 m^2 FSZ compared to 710 m^3 per 1000 m^2 of energy crop. Forest residues, such as those generated by FSZ, can be valorised for biogas production. Pinus forests are especially susceptible to forest fires, therefore valorisation of the generated pine needles can provide an additional benefit for environmental protection.

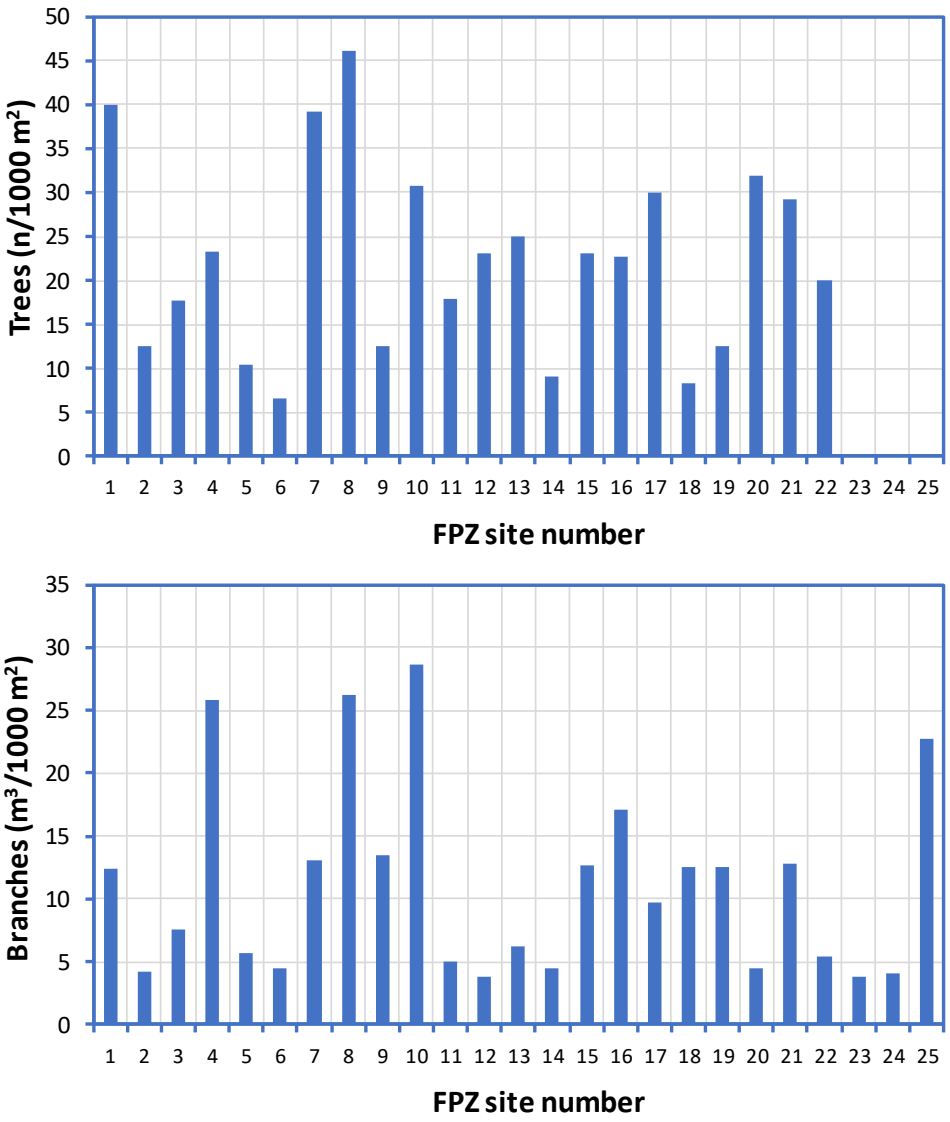

Figure 2. (a) Number of *Pinus brutia* trees and (b) volume of branches collected during FSZ maintenance.

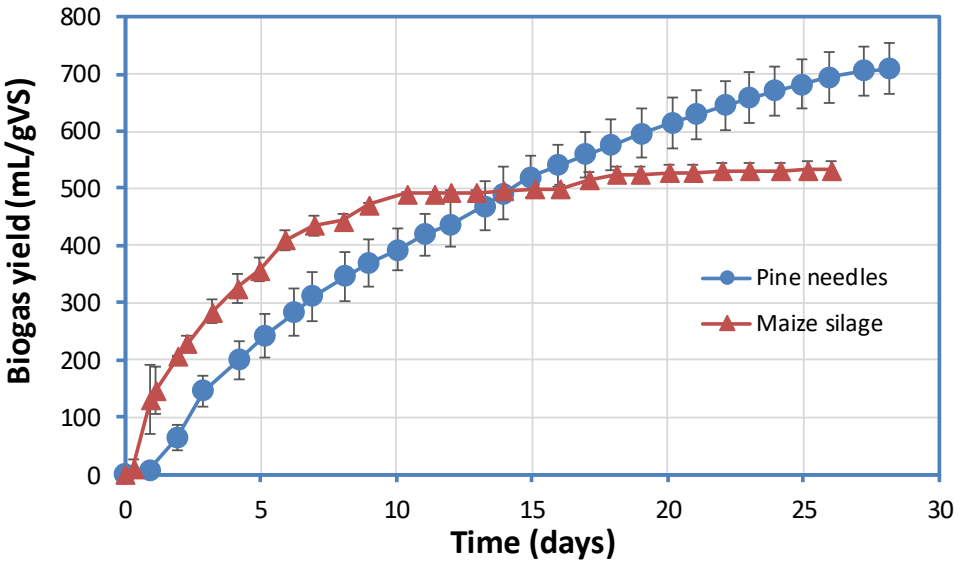

Figure 3. Cumulative biogas yield values during batch anaerobic digestion of pine needles and maize silage.