Zero-Waste Approach for greenhouse fruit vegetables

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1. Introduction

After harvesting greenhouse vegetables, the greenhouse foliage, including ropes and clips contains both biomass and plastics, making waste disposal difficult. Consequently, separation of the biomass from the plastics is an important part in the further recycling of organic material and possibly the plastics. It is therefore necessary to consider which separation techniques can be used to further separate the different materials. In this work both wet and dry separation techniques were tested experimentally for tomato and pepper waste.

2. Materials & Methods

First, sieve tests were done using a sieve tower equipped with 2 sieves with pore sizes of 5.6 mm and 2 mm. The sieve tests were carried out on 4 different fractions. Three fractions of separated material, consisting of a biomass fraction, clip fraction and rope fraction, and one fraction of unseparated material. The aim was to separate the plant material and plastic material, based on difference in particle size, into different fractions so that these fractions could be used in the wind sifter tests. Sieve tests were also carried out to check the possibility of using a drum sieve, with several pore sizes, to carry out the separation. An image of the starting material is shown in Figure 1.

Figure 1: greenhouse waste - tomato

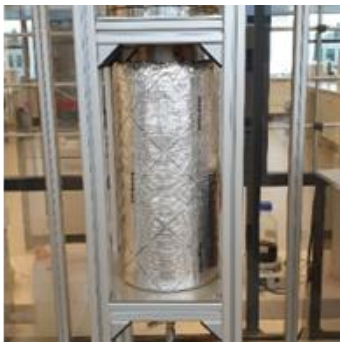

Figure 2: High pressure reactor.

In a wind sifter, separation takes place based on difference in absorption of kinetic energy of the generated airflow between the particles. This depends on the shape and mass of the particles. It was also investigated at which airflow particles flew over. An advantage to this technique is that it also allows separating streams that are all lighter than water. In addition, the density of the different particles was measured to check whether separation based on difference in density is possible.

Next, pulp formation was examined. The idea is to make pulp from the biomass fraction without damaging the polypropylene (PP) rope to allow separation after pulping. The pulp can then be used for paper and cardboard production. Pulping of the greenhouse waste (tomato) was carried out in the reactor shown in Figure 2. Different pulp conditions were tested, both under elevated pressure (Kraft process) (P. Bajpai, 2018) and at atmospheric pressure and boiling temperature in acid, base and solvent environment (M. Akgul and H. Kirci, 2009) (P. Musekiwa et al., 2009).

3. Results & Discussion

The sieving tests results have shown that most of the material was retained on the top sieve (> 5.6 mm). On the bottom pan (< 2 mm) of the sieve tower, mainly soil and other fine dust and contaminants were observed. After separating the biomass, ropes and clips, the ropes began to clump together, preventing them from being separated into different fractions in the sieve test. This also happened with the non-separated material. The ropes tangle together and surround biomass, making the separation biomass - ropes more difficult and in many cases no longer possible. Consequently, the ropes are mainly (> 97%) in the upper fraction of the sieve test (> 5.6 mm).

Separation with a drum sieve is possible. However, the disadvantages are that there is still a significant amount of biomass in the rope fraction that cannot be separated and the clips have to be separated in advance.

From the wind sifter tests, it was observed that the rope fractions fly over fastest, then the wood particles and last the clips. This means that the ropes fly over at low wind speeds, the biomass at medium wind speeds and the clips do not or at very high wind speeds. This behaviour was observed at the 3 different sieve fractions. Results are shown in Figure 3 and Figure 4.

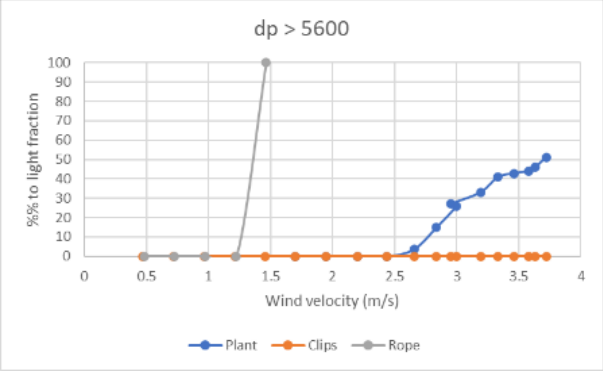

Figure 3: Results wind sifter.

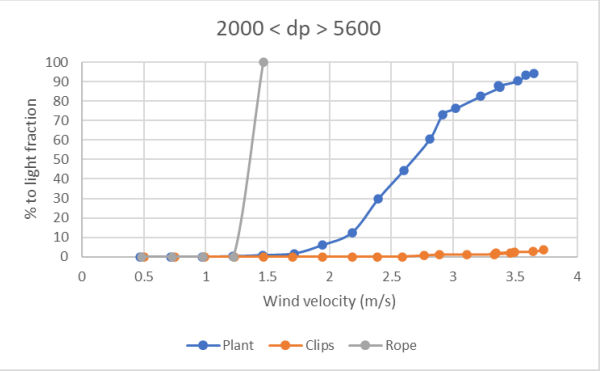

Figure 4: Results wind sifter.

The results of the density measurements showed that all materials have a density smaller than that of water and that the densities of the different materials are close to each other, making float-sink separation based on difference in density difficult/impossible.

Finally, pulp formation at the studied conditions of media, pressure and temperature did not produce desirable results. These results indicated that other conditions have to be tested and thus tests at high pressures are ongoing.

4. Conclusion

It is possible to obtain biomass with high purity using a drum sieve and wind sifter. However, there is still a high amount of biomass in the rope fraction, due to the fact that the ropes tangling together. The problem with the clips can be avoided by manual removal or with metal clips. The problem with the ropes cannot be avoided, but using polylactic acid ropes ensures that composting is possible without contamination. Pulp formation tests are ongoing.

References

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