Applying Microwave Imaging Techniques to Domestic Compost Production

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SPOKE, WP E TASK DI APPARTENENZA

Spoke 8 Circular economy in agriculture through waste valorization and recycling

WP 8.1 Producing new products to upgrade waste value

TASK 8.1.2 Valorization of the waste by biotechnology processes to obtain for high value molecules or new products

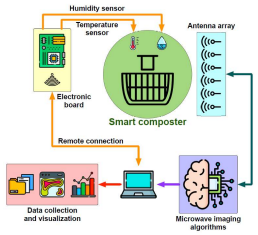
ABSTRACT/INTRODUZIONE

Compost is a key organic amendment for sustainable agriculture. Derived from various biomasses, organic amendments are rich in organic matter and nutrients, thereby enhancing soil fertility and promoting plant growth. These products undergo specific processes to stabilize and sanitize the organic matter they contain, ensuring safe use. Composting is one of these processes. It results in a humus-like product of fin particles where the original material is no longer identifiable the well-known compost.
Composting is a naturally occurring process that relies on anaerobic microorganisms to transform and stabilize solid organic matter. However, due to the lengthy and variable nature of the spontaneous natural process, it has been refined to be carried out in specialized facilities in a faster and more controlled way. In both cases, composting is exothermic, and the energy released is partly used by microorganisms and partly released as heat, increasing the temperature of the composting mass and making the temperature a distinctive indicator of different phases of the composting process.

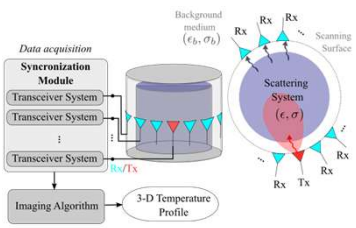
Home compost production requires regular monitoring of temperature and humidity, as well as interventions to ensure the correct maturation of the mass and high-quality compost. This work studies the adoption of *microwave imaging* (MWI) as a supporting tool to detect, locate, and monitor biomass hot spots, which are detrimental to the entire production. In this regard, it provides a threefold contribution: first, the dielectric characterization and temperature profiling of the compost; second, the introduction of a robust low-power wireless temperature sensor; finally, the validation of the MWI for retrieving the thermal profile of hot spots via numerical experiments, considering critical design aspects such as spatial resolution, operating frequency and number of wave probes.
The proposed imaging technique combines information from a network of temperature sensors and scattered electromagnetic field samples to simplify the linear imagery-based strategy. Furthermore, the MWI system is supported by an electronic system equipped with temperature, humidity, and pH sensors to integrate the information and validate its functionality in the prototype phase. Overall, we demonstrate that it is feasible to use MWI for compost temperature monitoring.

MATERIALI/METODI

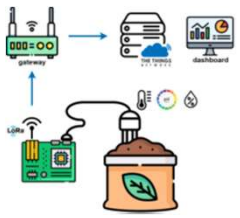
Conceptualization



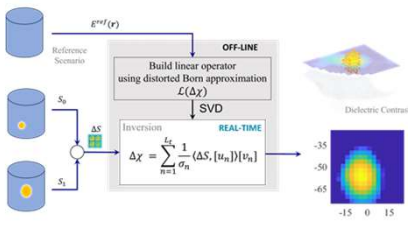
Proofing and Prototype Desing



Prototyping



Imaging Algorithm



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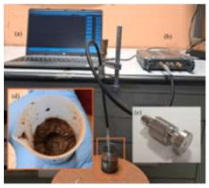
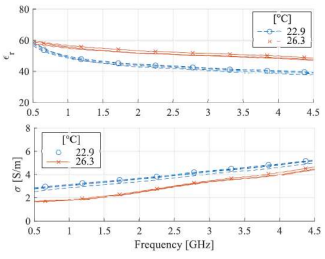
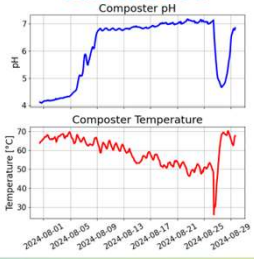
Dielectric Characterization



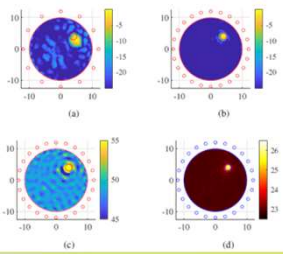
Experimental setup for characterization. (a) Laptop, (b) Vector Network Analyzer, (c) Dielectric Probe, and (d) Compost sample.



Data collected



Numerical Validation



Retrieved profiles.

(a–b) Normalized $\Delta\chi$ [dB]
(c) relative permittivity
(d) Temperature [°C].

Dimensions in [cm].

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