Comparative Life Cycle Assessment of two different technologies for converting the organic fraction of MSW into compost

M. Mercurio[1], G. Costa[1], C. Potena[2], D. Broglio Montani[2], A. Carrera[2], F. Lombardi[1]

[1]Department of Civil Engineering and Computer Science Engineering, University of Rome "Tor Vergata", Rome, 00133, Italy
[2]Sorain Cecchini Tecno s.r.l., Rome, Italy
Keywords: organic fraction, MSW, composting, LCA.
Presenting author email: mario.mercurio@alumni.uniroma2.eu

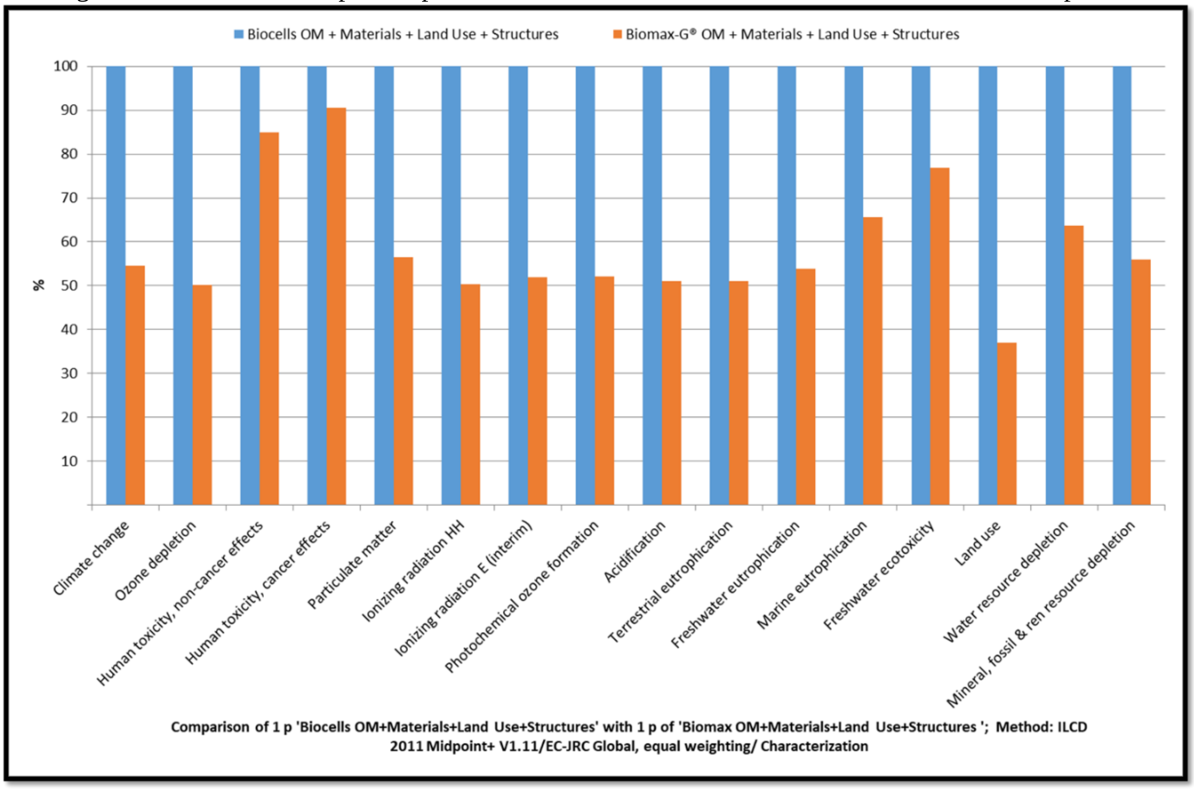
The growing concern towards the environmental impacts of processes and technologies, including those employed in the waste management sector, has promoted the adoption of methodologies to evaluate the performance of specific technologies, not only from a technical point of view, but also considering their environmental footprint. Life Cycle Assessment (LCA) is one of the most robust methods for assessing the environmental impacts associated with a product or a process by accounting for resource consumption and emissions during the entire production chain, from the extraction of raw materials to the management of processing residues and emissions. In Italy, the improvement in the separate collection of recoverable fractions from Municipal Solid Waste (MSW), which has reached 63% in 2020, has led to an increase of the quantity of the separately-collected organic fraction. Specifically, the amount of the Organic Fraction of MSW (OFMSW) collected in Italy reached 6.6 million tons in 2020, which represents about 43% of all the potentially recyclable MSW generated in the same year[1]. In this scenario, the number of plants treating OFMSW has progressively increased, e.g. by 14 units in 2020 compared to 2019[1]. The main types of processes applied to treat OFMSW consist in aerobic stabilization, which allows to obtain compost as end product that is employed as soil conditioner, and anaerobic digestion which allows to recover biomethane, besides compost or fertilizers. Each type of treatment can be applied employing a variety of technologies and each of these present different potential impacts related to their specific electricity, fuel, heat and water requirements, emissions to air and water, as well as residues generation.

In this paper two of the main technologies currently employed to convert OFMSW into compost, i.e. a static in-vessel process (Biocells) and a dynamic windrow process (Biomax-G®), are analysed through a comparative LCA, making reference to treatment capacity of 25000 tons/y of OFMSW. Specifically, the environmental impacts were calculated in three phases: 1) considering only the operation of the plant, 2) including its construction and main equipment, 3) considering also the avoided impacts related to compost production.

The life cycle analysis was performed following the UNI EN ISO 14040 standard[2], comparing the two treatment scenarios in each of the three phases reported above. In the first scenario the composting process was assumed to be performed in Biocells, static reactors in which the waste is placed for a specific residence time. The second scenario was associated to compost production in a plant employing Sorain Cecchini Tecno's (SCT) patented technology, Biomax-G®[3], that can be schematised like a continuous flow reactor, since the waste is moved and periodically turned by augers supported by an overhead moving crane. The main differences in the two types of treatments consist in the flows of air and water provided, and also in the mode of feeding the waste to the composting units: through moving belts in the first case and with wheel loaders in the second one. For both scenarios, the modelled system included all the activities performed in the plants, from pre-treatment to final refining, and also landfill disposal of the processing scraps. To focus the comparison on the two different composting technologies, the waste pre-treatment and final refining processes, as well as the quantity and quality of the produced compost and scraps, were assumed to be the same in the two scenarios. As a functional unit, the size of the treatment plant (i.e. 25,000 t/y of OFMSW) was assumed. In both types of treatment plants, besides the OFMSW, the addition of lignocellulosic waste (LW) (around 5000 t/y) and structuring scraps (SS), recirculated from the process (around 10000 t/y in the case of scenario 1 and 5000 t/y for the scenario 2) was considered. The impact assessment phase was carried out using Simapro 9.1.1., selecting the method "ILCD 2011 Midpoint+ V1.11 / EC-JRC Global, equal weighting".

One of the main results of the inventory analysis was that the annual electricity consumption of the Biomax-G® scenario was 54% lower than that of the Biocells scenario. This finding significantly affected the results in terms of the characterization of potential environmental impacts. In fact, as shown in Figure 1, the resulting impacts of the Biocells scenario, in this case reported for phase 2, i.e. including both the operation and construction of the plant and main equipment, were always higher than those of the Biomax-G® scenario. A very similar trend was obtained also for the resulting impacts of the two scenarios for phase 1, i.e. considering only the operation of the plant.

Figure 1. Results of the impacts reported in terms of characterization for the two scenarios for phase 2



In particular, the lower energy consumption that characterized the composting plant using the Biomax-G® technology had a direct effect on the 'climate change' impact category; in fact, the impact of this technology resulted half of the one of the Biocells system in each of the phases considered. The two scenarios present instead comparable impacts in terms of the 'Human toxicity cancer effect' and the 'Human toxicity non-cancer effect' impact categories. These impacts showed to be mostly related to the production of the steel employed in the construction of the plant and of the equipment, as well as for the production of the material employed in the manufacturing of the conveyor belts, and although the material use differs depending on the type of plant, the overall impacts are similar. As for the 'freshwater ecotoxicity' and the 'water resource depletion' impact categories, also in this case the difference in the impacts was less pronounced. The Biomax-G® plant presents actually a higher consumption of water for the biological process but the water is mostly recirculated. The 'land use' impact category, instead, showed the highest differences between the two scenarios , related to the fact that 16.000m^2 were found to be required for the Biomax-G® scenario as opposed to the 49.000m^2 necessary for the Biocells scenario. The results show that the plant in which the Biomax-G® technology system is implemented would use about 65% less land than the plant employing the Biocells technology system.

As for the impacts resulting for the third phase, for both scenarios the production of compost from OFMSW allowed to obtain beneficial effects on the 'Climate change' and 'Land Use' impact categories when considering the avoided production of peat moss.

At the Conference the description of the two scenarios and assumptions made, as well as the full results of the inventory and impact assessment phases will be presented and discussed.

References

(1) ISPRA_Rapporto Rifiuti Urbani_Edizione 2021 https://www.isprambiente.gov.it/it/pubblicazioni/rapporti/rapporto-rifiuti-urbani-edizione-2021
(2) ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework.
(3) *Sorain Cecchini Tecno | Home page.* https://www.sctecno.com/en/index.htm (accessed 2023-02-22).