Municipal Solid Waste thermal treatment – An overview on the environmental aspects

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Municipal solid waste (MSW) management is a problem that affects the entire world. The Waste Framework Directive (WFD) - Dir. 2008/98/EC governs waste management in the European Union [WFD, 2008]. This Directive is codified in the Consolidated Environmental Act (TUA, Italian Legislative Decree 152/2006)[D. Lgs. 152/2006] under Italian law.

The WFD is based on various waste management ideas, including:

- Reducing resource consumption;
- Taking into account the complete life cycle of materials/products;
- Achieving the best environmental outcomes overall;
- Using the expanded producer responsibility system to implement the "polluter pays" idea.

The hierarchy of operations that the Directive defines for waste mechanism is as follows:

- Prevention;
- Reuse;
- Recycling;
- Recovery (i.e., energy recovery);
- Final disposal in landfill.

This hierarchy specifies the priority for the application of management operations, according to which prevention of waste generation is preferable to any other management method. And since prevention is part of the production process of the waste, the first real management intervention is the second priority, reuse.

In fact, when residue has been produced, the first choice is to reuse the material (in the same process that produced it) and the second, to recycle it after a treatment. If neither of these options is sustainably viable, then it is preferable to use the waste material for recovery (such as energy recovery in thermal treatment plants) before sending it to final disposal in a landfill.

The WFD also specifies that it is possible to deviate from this general hierarchy in particular cases if a greater environmental benefit can be demonstrated on that basis: for example, via a Life Cycle Assessment (LCA).

The last amendment to the WFD was introduced at the end of May 2018 with the introduction of the so-called "Circular Economy Package".

The "Circular Economy Package" reinforces some concepts that were already contained in the WFD, and also clarifies some definitions, in order to improve the collection and processing of statistical data on waste management. Particular attention is paid to the target of keeping materials within the cycle of production and consumption as long as possible, so as to minimise the need for virgin materials and the amount of waste to send to final disposal.

From the viewpoint of average MSW production in European countries, the amount is more or less stable throughout the year. The shift to environmental, economic, and social sustainability depends on effective management. It is important to note that the environmental and social sustainability (ESS) is the adaption and integration of precautionary environmental and social principles and considerations into decision making processes. The paradigm for waste management is evolving as a result of this shift; although waste is solely seen as a burden in a linear economy, it may be seen as a resource in a circular economy (and this is, for example a solution in order to improve also the ESS). The annual amount of MSW generated worldwide is 2.01 billion tonnes, and by 2050, that amount is predicted to increase to 3.40 billion tonnes [WFD, 2008]. As a consequence, the production of energy from waste that cannot be reused or recycled can represent a solution in line with the principles of circular economy, and can contribute to energy diversification. The Waste-to-Energy (WtE) process can currently be achieved by several different technologies, such as anaerobic digestion, the production of waste-derived fuels, (co-)incineration in combustion plants and in cement and lime production, or in dedicated facilities, or indirect incineration following a pyrolysis or gasification step. Among the WtE technologies, incineration is the most established process, accounting for more than 1400 plants worldwide [Eurostat]. Incineration or "direct combustion" is the complete, rapid exothermic oxidation of the waste organic fraction in the presence of an adequate excess of oxygen. Incinerators work with many different types of waste, including MSW, products discarded after the completion of their use phase (such as End of Life Tyres), Solid Refuse Fuels (SRF), Industrial Waste (IW), and Industrial Hazardous Waste (IHW). In addition to being a solution for waste management, incineration provides heat and can generate steam and electricity. Gasification, often known as "indirect combustion," is another WtE process that involves the thermochemical decomposition of MSW to produce combustible gas (syngas) and a later combustion step for energy recovery (two-step oxidation). Germany and Italy have the most gasification facilities, but the Scandinavian nations have the biggest individual plants, according to a European project report. A thermochemical conversion process known as gasification can handle a wide range of feedstocks, including biomass, municipal solid waste, and other solid waste. The organic content of the waste is converted mainly to carbon monoxide and hydrogen, along with lower amounts of methane, although syngas is generally contaminated with undesired products such as particulates, tar, alkali metals, chloride and sulphide. The obtained syngas, though, can be used to produce chemicals (such as fertilizers and fuels, or for power generation.

Air pollutants such precursors of SO_X, NO_X, HCl, particulate matter, components of hydrocarbon, dioxins, and CO_2 are direct emissions from thermochemical conversion technologies. However, specialized flue gas treatment methods are able to significantly reduce air pollution from these emissions.

So, as indicated gaseous emissions represent one of the main, potential, environmental (and human health) impacts of energy-intensive industries. The flue gas is treated in order to significantly lower the amounts of principal contaminants before being released into the atmosphere (macro and micro pollutants). Due to the increasingly stringent regulations and concrete technological advancements, which have resulted in the development of highly sophisticated systems that enable emission values to be achieved at the upper limit of the measurable threshold, the flue gas depuration line is very articulated and complex.

In addition to the release of primary pollutants, thermal treatments plants are responsible for the release of Greenhouse Gas (GHG), in particular CO_2, into the atmosphere, which are themselves responsible for the phenomenon of climate change. Unlike what happens for primary pollutants for the CO_2 there are no consolidated abatement/reduction technologies on an industrial scale and no limit concentrations to be respected.

In this paper the flue gas emissions from thermal treatment are analyzed in order to better understand the potential environmental impact of these kinds of processes.

References

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