LIFE CYCLE ASSESSMENT AND SOLID WASTE MANAGEMENT: THE SYSTEMS

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SUMMARY: Life cycle inventory analysis is a very important stage on a life cycle assessment study as it includes the compilation and quantification of materials and energy consumption and emissions to air, water and land, for all processes within the system boundary. The result is an inventory of the environmental burdens for each system under study. In order to perform an inventory, systems should be modelled and relevant materials and energy inputs and outputs selected. The systems usually studied on solid waste management: incineration, landfilling, recycling and composting are presented as the environmental burdens, inputs and outputs that will compose the inventory.

1. INTRODUCTION

Life cycle analysis is the second stage on a life cycle assessment study, after goal and scope definition and before impact assessment and interpretation of the results (Xará et al, 1999). It involves data collection and calculation procedures to quantify relevant inputs and outputs of the system under study, that will be considered as environmental burdens. In order to prepare this data collection, each system should be modelled in such a way that all operations performed are included and detail described and, materials, energy inputs and outputs clearly identified. It is helpful to describe the system using a process flow diagram showing the unit processes and their interrelationships (ISO 14041, 1998). Each of the unit processes should be analysed to define operations occurred and flows associated.

On waste management, life cycle assessment is used to compare management options as incineration, landfilling, recycling and composting. Due to the great variability of systems and technological processes available, each life cycle assessment study should clearly present the systems under study including the technological processes and operations related. Therefore the study is valid for these systems and these technological processes and, differences between management options should take care of this

Systems presented are those available or projected for the northern region of Portugal and will be detailed in some projects that are undergoing. In some cases, extreme conditions are both

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considered because the option between them is not always the same and to perform a sensitivity analysis. For example, on composting the compost resulting from the process could be used as soil conditioner or landfilled or used as fertiliser after correction with nutrients. Since those options depend on the market availability, the three options are considered and analysed on further studies related with municipal solid waste (MSW) management. All systems presented consider that treatment starts after the wastes arrive the respective unit.

2. INCINERATION

The incineration system here considered may be divided in the following steps or unit processes (Figure 1):

- combustion chamber
- boiler for energy recovery
- flue gas cleaner
- bottom ash landfilling and/or bottom ash treatment for recovery
- fly and boiler ashes stabilisation
- stabilised fly/boiler ashes landfilling

Wastes enter on combustion chamber and combustible and thermally reactive components are burned with excess of air. For this operation, air for combustion and energy for wastes handling and mixing are needed. From this unit process, two streams are produced: flue gas that then goes to the boiler where energy is recovered and bottom ash further landfilled or used after some treatment. On boiler energy is recovered from hot gases.

After leaving the boiler, gas is treated on a semi-dry gas cleaner with auxiliary materials as calcium hydroxide solution. Particles produced are retained in a filter. Air emissions are released through stack. Ashes from boiler and gas cleaner are stocked together and stabilised with cement and other additives. Stabilised ashes are then landfilled and leachate produced is considered in compliance with water emissions regulatory limits. The solid residue on landfill is considered an inert product. No landfill gas is generated since there is no significant organic carbon available on the material landfilled.

Bottom ash is then magnetically separated; magnetic products are recovered for steel making industry, non-magnetic products are stocked and may be directly landfilled or used by the civil engineering market. The recovered products will substitute raw materials and, therefore, environmental burdens associated with obtention of this material must be considered (See point 4. Recycling).

To operate all the unit processes, including maintenance, energy is required.

3. LANDFILL

Landfilling process could be divided on the following stages (Figure 2):

- landfilling operation,
- leachate treatment,
- gas burning (flare or motor)

Landfilling operation inputs are wastes and energy for general operation and wastes handling in the form of electricity and vehicle fuel. On landfill decomposition of some wastes occurs. Two streams are produced: leachate and gas landfill.

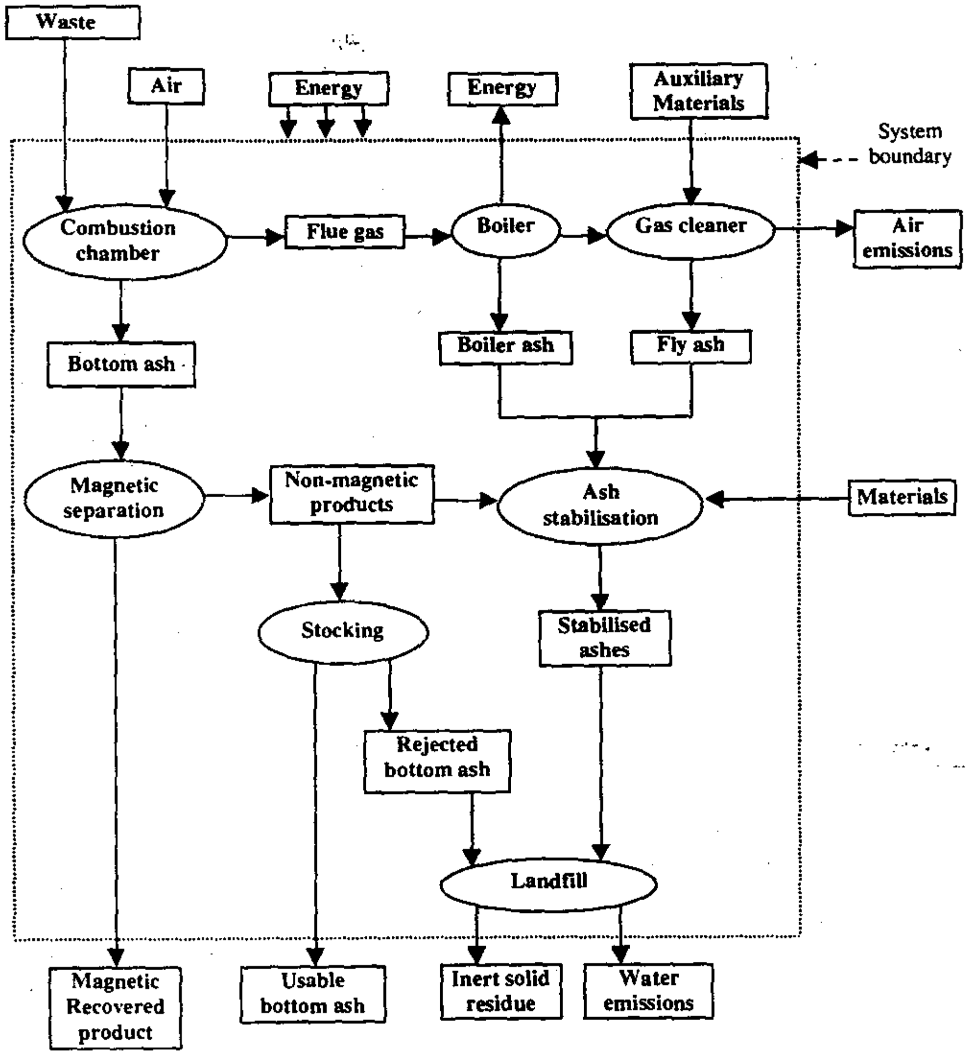

Figure 1. Diagram flow for incineration process.

Leachate is adequately collected and treated to comply with the regulatory limits and further emitted as water emissions. The sludge obtained from this treatment will be landfilled too.

Gas from landfill can be used in motor engines to produce electrical energy or in heat production, burned as a flare or directly released to atmosphere. In the case of electrical production the gas must be treated prior to motor feeding in order to avoid corrosion.

The solid residue produced in the system is considered as an inert product, thus it is an output of the system.

The inputs of materials and energy are considered during the landfill life that exceeds the period of wastes deposition.

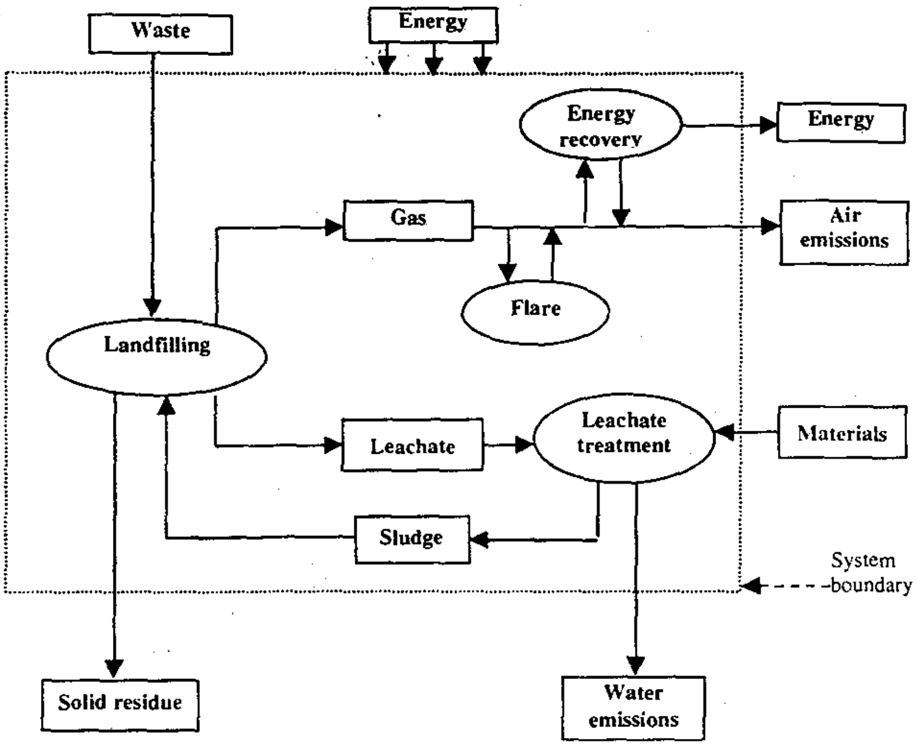

Figure 2. Diagram flow for landfilling process

4. RECYCLING

On recycling, material is recovered and sometimes treated and prepared for a new use, on the same or other applications. Inputs in the recycling system are materials and energy necessary for the process; outputs include emissions that depend on the material, process and recovered product. Since this product will substitute the original one, when market is available, the environmental burdens associated to the primary material obtention must be subtracted (Figure 3).

Dependably on the material under study the recovery process is different. It is very important to well define the product, its characteristics and exactly which or whose products it could substitute since are these products that must be considered on analysing the environmental burdens of the extraction process.

5. COMPOSTING

Composting is a biological treatment of the organic fraction of solid waste and it consists on biodegradation by microorganisms present on materials. It could be considered seen as either a method to reduce the volume and stabilise material or a recycling process. When market is available, the recovered material could be used. Otherwise, is landfilled.

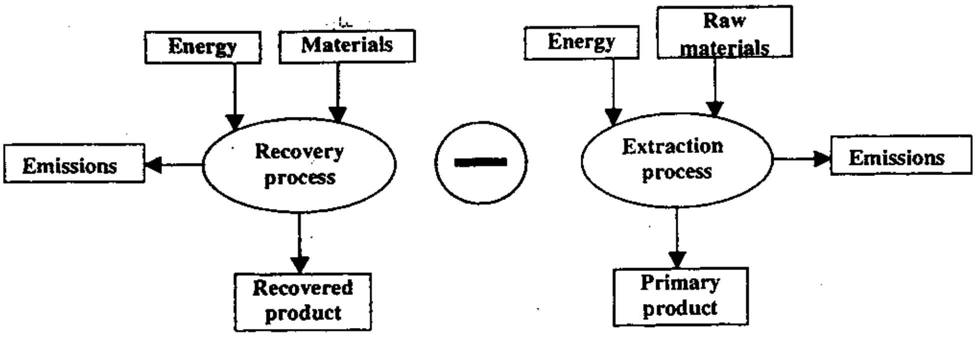

Figure 3. Diagram flow for recycling process.

Composting is divided in two unit processes (Figure 4): the composting process itself and the compost cleaning. Waste material is degraded with the presence of air and under an adequate moisture level. The addition of nutrients as nitrogen, phosphorous and potassium is needed to reduce the residence time of the process. From this process air emissions result. The raw recovered compost is then cleaned in order to separate plastic, metals, glass and other materials.

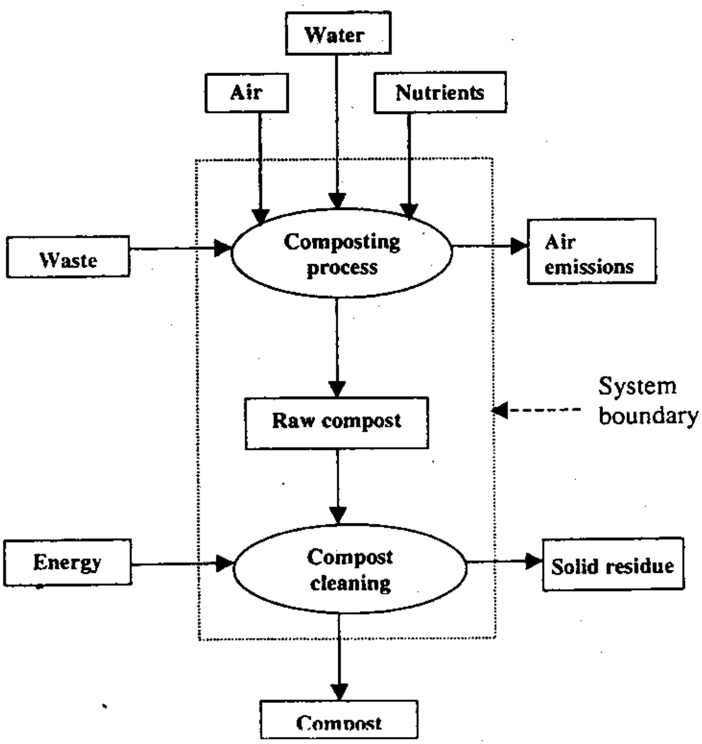

Figure 4. Diagram flow for composting process.

The resulting compost could be used as soil conditioner, landfilled or corrected with nutrients and dried in order to allow its use as fertiliser. When used as soil conditioner or fertiliser, composting is considered as a recycling process and the correct approach is similar to that presented before, i.e., a credit must be given to overall process.

6. CONCLUSIONS

From each system to be considered on a life cycle assessment study, selection of relevant inputs and outputs is of crucial importance since it allows and facilitates planning data collection, the most time consumption task, therefore, more efficiently done.

On a life cycle assessment study, to evaluate wastes management options, the systems available or possible to set up should be considered not only to compare different processes but also to analyse improve capabilities of existing systems.

Concerning recycling it is important to define exactly products recovered since the burdens associated to the processes needed to obtain the primary product must be well identified and quantified. Also, on composting, a potential case of recycling, a care must be taken on this matter and the use or not of the compost must be integrated on system analysis.

REFERENCES

ISO 14041 (1998) Environmental management - Life cycle assessment - Goal and scope definition and inventory analysis, International Organisation for Standardisation, Switzerland.

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