REDUCING ENVIRONMENTAL IMPACTS THROUGH EFFICIENT RECYCLING WASTE MANAGEMENT

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Abstract: This paper presents the major problems which there are in the waste management of our planet. Effective sustainable solutions are proposed in order not only to reduce any associated environmental impacts but also to support sustainable development in our society. Also projections are made of efficient recovery schemes. In the end, useful discussion and conclusions are made for the necessity of using proper recycling technologies.

Keywords: recycling, environmental impacts, waste management, sustainable development.

1. INTRODUCTION

Nowadays, the most characteristic thing of our modern society is the plethora of consumption goods and their complicate life cycle. Sustainable Development requires a change, an evolution in the way society operates. The flow of resources is one of the key fields in which our material hungry society is unsustainable. Waste management is the discipline that is concerned with resources once society no longer requires them.

It is well known that life cycle of particular goods includes: exploitation of raw materials and treatment; trading of goods; production of waste and waste management. Solid Waste Management (SWM) could be characterized as the most important parameter in life cycle of goods. The latter is verified due to the fact that on the effectiveness of SWM is dependent a huge amount of energy saving and exploitation. Therefore, effective SWM means effective energy use-management conserving natural resources and saving of raw materials (Bilitewski, *et al.* 1994; Kollias, 2004; Paralika, 2003; Skordilis, 1994, 2001; Tchobanoglous *et al.* 1993; USEPA site and other sources in the internet).

Environmental problems are becoming more complex as the necessities of our life are getting increased in time. Problems like global warming, hazardous waste, loss of rain forests, endangered species, acid rain, the ozone layer depletion, the municipal waste crisis could give a sense of our environmental crisis. Moreover, it must be taken into account that the humankind's population is always growing up in time - it has been estimated that in 2050 the population of earth will be double reaching fourteen billion – fact that will have as result a life with very limited resources, meeting some times a gloomy environment. Critical natural resources will be expended to support the relative demands and consumptions of goods for future human populations. Therefore, enormous waste streams will be generated. It is obvious that without taking any measures in time, there will be an environmental disaster with unexpected consequences. In these circumstances, it is imperative necessary to find efficient sustainable ways to recycle the waste streams and put them back to the industrial stream of goods, minimizing any environmental impacts.

Therefore, sustainable designs focusing on renewable resources are necessary for the future of our planet. Moreover, the waste generation rate is increased day by day not only due to population growth up but also due to the increasing necessities of goods in our industrial daily life. Thus the most pressing problem within SWM is the waste generation rate and the efficient confrontation of its environmental impacts (Koliopoulos, 1999, Koliopoulos *et al.* 2003, 2007; Kollias, 2004; Skordilis, 2001). The particular waste definitions and their characteristics should be taken into account in the particular recycling schemes; these are determined in the following figure (figure 1).

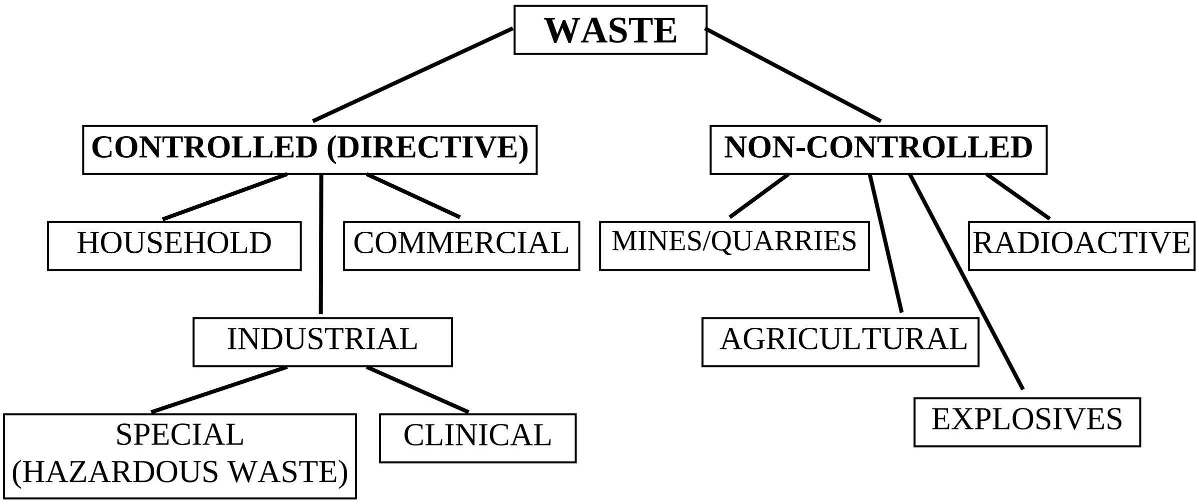

Fig. 1 Waste definitions

2. PRINCIPLES OF RECYCLING

Recycling is the process of collecting certain materials that would otherwise be considered waste and turning them into new recycled products, avoiding the use of raw materials. This transformation consists of the reprocessing of discarded materials into a similar product or to other things totally different (from this perspective, the recycling process is reported in the literature to exist in three stages, respectively primary, secondary and tertiary recycling). (Bilitewski, *et al.* 1994; Kollias, 2004 ; Tchobanoglous *et al.* 1993).
The recycling process supposes to be followed the next three main steps: collection and processing the old materials; manufacturing and purchasing the recycled products (figure 2).

Fig. 2 Steps of the recycling process

Collection and processing

The first step required for recycling is collecting recyclable materials. Apart from the common materials that are usually recycled such as paper, plastics, glass, aluminium, etc. there are a lot of other materials that could be recycled. Concerning the recyclable material of a waste product, two separate and distinct issues should be considered: firstly, "*could a product or a material technically be recycled?*" and secondly, "*in real life could a product or a material practically be recycled*? The difference between these two definitions of a recyclable material is controversial in the product/packaging-labelling world. Some say that any product or material that can technically be recycled should be labelled "recyclable." Others say that the attribute "recyclable" should only be used on a label if, in fact, it can really be recycled in the community, where the product or package is sold. While recyclables such a glass or newspapers can be recycled almost everywhere, other recyclables like plastics or motor oil can only be recycled in a limited number of areas, where relative systems have been set up. In this case, the following question could be appeared: Is it economically feasible to recycle a product? Sometimes raw materials are cheaper than recycled ones, according to particular governments' subsidies and policies. Transportation issues should also taken into account in environmental management strategic scenarios, giving answers to the following question: Is it better for the environment to use a local raw material or a recycled one transported from a great distance? All the above questions should be answered and carefully to be considered any alternative scenarios in order to apply the optimum environmentally friendly recycling decision.
The collected recyclable materials are then processed. This includes sorting the materials into groups, cleaning and getting them ready to be sold to manufacturers, using proper technologies. The manufacturers will turn the materials into new products.

Manufacturing

Manufacturing is the second step in recycling loop. Today many products are made out of either total or partial post consumer (recycled) materials. Daily, we use many items, which are made by recycled materials. Newspapers, paper towels, office paper, plastic bottles and aluminium cans are not only made to be used once as recycled materials, but also they can be recycled again. Sorting of waste is necessary to take place in the recycling stream of particular materials and especially in electrical or electronic wastes, using proper technologies for the recycling of several metals which there are on the surfaces or on circuits of old devices. Such recyclable materials could be applied in electrical and electronic manufactories instead of the use of raw ones. Furthermore, recycled materials could be used in innovative applications such as recovered glass in roadway asphalt; cement mixture or pulverized ceramic material from demolition materials in landfill designs; recovered plastic in carpeting, park benches, foot bridges and others.

Purchasing recycled products

The last step, but certainly not the least, involves the purchasing of recycled products. When consumer purchase products that are manufactured at least partly from recycled materials, the recycling loop is closed. Buying recycled products has both environmental and economical benefits. Using goods made by recycled materials - that otherwise would be disposed into a landfill or an incinerator - results in many environmental benefits. It conserves the landfill space, reduces the need to manufacture raw materials which, in turn, involves great energy consumption and significant pollutants, avoiding the production of any greenhouse gases' emissions that contribute to global warming. Moreover, the purchasing of recycled products is beneficial for the local and global economy. It creates dynamic markets for the collected materials, processing and using them in the manufacturing of new competed products to raw ones. This creates new jobs and helps the strengthening of economy.

However, although everyone knows about recycling, less people make a conscious effort to supply recycling activity by purchasing products made by recycled material. In these circumstances, an extended campaign should be necessary so as to inform the importance of recycling to any parties of our society, from government, industry and organizations to schools, universities, small businesses and people at home. An important support in this direction will be provided by the outcomes of the ongoing educational Erasmus Project "*Eco-design: An innovative path towards sustainable development*" (Barsan, A., 2006; http://www.unitbv.ro/proiecte/modecodesign/index.htm).

3. A CASE STUDY OF A RECOVERY SCHEME

Nowadays, a lot of complicate long hand wrought calculations could be easily made in short time using new software technologies and numerical analysis principles. The development of flexible software tools are necessary with efficient algorithms and graphic environment (Aitken, 2000; Mousas, 2006; Stephens, 1999; Tomaras, 1999). They should be friendly and easily accessible to any interested user. Such programs could be used either in life cycle analysis of a product or in the evaluation of the effectiveness and the final design of a recycling scheme. The software tools could be used for evaluation of several recovery and recycling demands, determining the final materials' balance quantities for the particular recovery technologies. After the recovery of recyclables materials there is the recycling and finally the use of them as goods in the society using proper technologies (recovery, recycle, reuse-3 R's policy). Mainly are used the shredder, the classifier and the magnetic separator for the materials' separation and recovery before the final processing recycling technologies. Below is peresented a useful application of a case study for the total quantity demand of particular materials' recovery facilities (MRFs). Therefore, knowing the total quantity demand of MRFs in a recovery unit (ton/d) and the separation processes operating time (h/d) could be calulated the loading rates of MRFs, selecting the proper designs which are provided by the manufacturers of MRFs. A software application was utilized, written in visual basic programming language, in order to calulate an effective materials' separation and use of proper processing technologies in the design of materials' recovery facilities. The examining application can be used either as educational material to students or as a useful software tool in the carrer of graduates. Similar useful case studies, applications and references can be found in the outcome chapters of educational Erasmus Project *"Eco-design: An Innovative Path towards Sustainable Development"*, which is focused on the research of eco-design principles and use of efficient modern recycling technologies (Barsan, A., 2006; http://www.unitbv.ro/proiecte/modecodesign/index.htm).

The input characteristics of the examining case study are the followings:

- a production of 1000 ton/day of MSW;
- the various separation processes are based on 16 h/day operating time.

The following conditions have been assumed based on the bibliography (Tchobanoglous *et al.* 1993):

- bulky materials and other ones are equal to 1% of total MSW generated in the community;
- 60% of the aluminum cans are recovered and delivered to buyback centers by the residents of a region;
- initial moisture content of a waste composition is taken equal to 20%;
- moisture content lost during shredding equals to 20% of initial value;
- heavy fraction materials contained in light fraction = 6 % of heavy fraction (based on weight);
- light fraction matrials contained in heavy fraction = 10 % of light fraction (based on weight after shredding);
- recovery factor for ferrous metals = 85 %.

The examining waste synthesis of a region by weight is: food wastes 47 %, paper 15 %, cardboard 5 %, plastics 8.5 %, textiles 2 %, rubber 0.25 %, leather 0.25 %, yard wastes 10 %, wood 1%, misc. organics 0%, glass 4 %, tin cans 2 %, aluminum 0.5 %, other metals 2 %, dirt, ashes, etc. 2.5 %.
Therefore, based on the above assumptions for the examining waste systhensis, is calculated the total quantity (ton/d) and the loading rate (ton/h) for the selection of a proper design of MRFs, which should be provided by individual manufacturer.
The amount of material received at MRF less white goods, bulky goods, and other contaminants removed during first-stage manual presort is: 990 ton/d
For the operation of shredder the total quantity is 987 (ton/d) and the loading rate is 61.7 (ton/h).
For the operation of classifier the total quantity is 872.2 (ton/d) and the loading rate is 54.5(ton/h).
For the operation of magnetic separator the total quantity (ton/d) is 176.4 and the loading rate is 11(ton/h).
Hence, a small of heavy fraction quantity of the initial production 1000 ton/day of MSW has to be disposed into landfill. Landfill is considered as more economic waste disposal method than incineration one.

4. CONCLUSIONS

Collecting and processing secondary materials, manufacturing products with recycled content, and finally purchasing recycled products, it creates a recirculation of goods that ensures an overall success and value to any efficient sustainable recycling schemes. In order to recycling work efficiently, every associated industrial sector has to be implied into any available recycling phase in the life cycle of a product. Proper modern environmental friendly recovery technologies should be used, as it was presented above, for a sustainable development of our society. An extended campaign is necessary so as to inform the importance of recycling to any parties of our society, from government, industry and organizations to schools, universities, small businesses and inhabitants at home. Educational materials well edited with case studies should be developed so as to be easy readable and comprehensive and easily accessible to any one.

Everybody can make recycling a part of his daily routine. As consumers of goods and producers of wastes, we actively can participate in any recycling schemes, making recycling a reality in our life. We should follow a sustainable way, making sure that we recycle everything that can be recycled and purchasing as many products made by recycled materials as we can. Buying recycled products, we create an economic incentive for recyclable materials to be collected, manufactured, and marketed as new products. The latter fact means that not only new jobs and economic growth is coming up, defeating unemployment but also there is minimization in any associated environmental impacts, supporting the sustainable development of our community.

Moreover, the software numerical tools are useful to be developed for data utilization collected by digital, making efficient designs of sustainable technologies. The waste input properties and particular characteristics of recyclables materials have to be taken into account for the design of any recovery or recycling technologies. Also these tools can be used as case studies in any educational materials so that students and graduates to improve their skills. In this way, students and graduates will get proper high level qualifications of modern know-how in order to join any future efficient internship between universities and industry, improving their professional competence in the European arena.

Acknowledgements

The authors would like to thank the support of this work by the Erasmus Project “Eco-design: An Innovative Path towards Sustainable Development”, 51388-IC-1-2005-1-RO-ERASMUS-MOD-4, funded by E.U. The conclusions expressed herein represent the findings of the authors and do not necessarily represent the views of E.U., or of the participants in the relative Project.

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