EDUCATIONAL RESOURCES ON THE WEB REGARDING WASTE MANAGEMENT, RECYCLING AND EXTENDED PRODUCER RESPONSIBILITY

Prof. Aldo T. Marrocco

Abstract

The educational resources presented in this paper consist of text, images, videos, animations and games. They can be used for teaching about waste recycling, with the method that the teacher considers most appropriate. Part of the manuscript is devoted to the concepts of Extended Producer Responsibility, which now is the inspiration for the legislation of some countries. The laws on Extended Producer Responsibility are creating design changes in products so that they are more easily and economically manageable at end-of-life, both for recovery and recycling of materials.

Keywords: extended producer responsibility, recycling, waste

Resumen

Los recursos educativos presentados en este artículo consisten de textos, imágenes, videos, animaciones y juegos. Pueden ser usados para la enseñanza relacionada al reciclaje de desperdicios, utilizando el método que el maestro considere más apropiado. Parte de este manuscrito está dedicado a los conceptos de Responsabilidad Extendida del Productor, lo cual es la inspiración para legislación en algunos países. Las leyes sobre Responsabilidad Extendida del Productor están creando cambios en los diseños de los productos para que sean más fácilmente y económicamente manejables al final de su vida útil, tanto para la recuperación como para el reciclaje de los materiales.

Palabras claves: responsabilidad extendida del productor, reciclaje, desperdicios

OVERVIEW AND INTRODUCTION

Population growth on a global scale and other socio-economic changes taking place in the world contribute to an increase in the amount of waste generated. Affluence is associated with waste production; the citizens of the richer countries generally produce more waste than the others. The emerging economies increasing their wealth, in their turn, tend to produce more waste. There is a trade in waste for recycling.[1,2] Recycling activities are growing, but their intensity should be further increased. Waste reduction at source should also be pursued, in order to successfully reduce the related pollution.[3]

According to a document from the World Bank, Europe is facing a huge cost for the cleaning up of soils and ground waters contaminated by illegal dumping.[4] In Europe it is, therefore, being experienced that the organization of a proper waste disposal system, earlier, would have been much cheaper and, above all, less harmful for the environment and human health. The Great Pacific Garbage Patch is an area of marine debris concentration in the North Pacific Ocean; the debris type mainly found here consists in floating plastic pieces.[5] In several articles, the size of this patch has been compared in extent to the area of a large American state. In reality, the area of this large and continuously moving garbage patch is difficult to measure accurately; some videos show its images.[6] Still today, Europe and USA recycle only 21.3% and 7% of plastic, respectively.[7,8] These facts, among many others, may suggest the opportunity of a more rational waste management on global scale.

A technique that reduces the mass of municipal solid waste (MSW) consists in their incineration. Nevertheless, in several countries there is the tendency, still, according to the above mentioned document of the World Bank, to reduce the use of incinerators. The operation of the latter is, in fact, associated with emissions of toxic substances including dioxins, furans and mercury. In addition, the toxic ash left after incineration must, then, in its turn, be disposed of in landfills. Furthermore, incinerators are capital intensive, and their duration is limited to 20-30 years.

In the most modern sanitary landfills the methane produced by the fermentation of organic matter in the absence of oxygen is recovered. This gas can be used as an energy source through its combustion, thus, avoiding, at the same time, its emission into the atmosphere. This is important since methane, generated both from poorly operated landfills and from illegal dumping of MSW, constitutes the largest source of anthropogenic greenhouse gases. Methane is, in fact, known to scientists as having an influence on climate change 21 times more intense than carbon dioxide. The disposal of MSW in the most modern sanitary landfills entails also recovery and treatment of leachate that flows to the bottom from decomposing waste. Clearly, long-term experience does not yet exist on how long the bottom of such landfills can last and hence protect the groundwaters from leachate contamination. In regions with a high population density and relative scarcity of water, the aquifers are a resource of the utmost importance that needs to be protected carefully. In addition, waste disposal in landfills or incinerators can, at best, allow the recovery of the energy, but not of the materials, which often are not renewable.

Natural organic substances such as food waste and yard trimmings can constitute even 50% of the total mass of MSW. The presence of humid organic substances in the MSW destined for incineration lowers the combustion temperature and, thus, negatively impacts on emissions. When natural organic substances are separated at source, they can be used to produce compost and, in addition, the incineration of the remaining MSW proceeds with less toxic emissions. When MSW is to be landfilled, separating at source natural organic substances may greatly reduce the generation of methane, carbon dioxide and leachate.

TEACHING TOOLS THAT DEAL WITH WASTE RECYCLING

Waste education perhaps cannot be considered a fascinating subject, but negative emotions can be overcome through knowledge which can dispel any misconceptions. Several years ago, in Pisa, a touring exhibition consisting of posters involved all the middle schools. This exhibition, visited by most classes of Pisa, dealt with the segregation of household waste at source for recycling. Many of these classes understood the importance of this subject and, autonomously, decided to ask the municipality to install bins in the city for separate waste collection. The municipality decided to positively respond to the numerous requests by installing, in many parts of the city, the recycling bins. Through this touring exhibition, the goal of informing the classes was reached and, not less important, the commitment by the municipality was stimulated.

The teaching tools that deal with waste recycling have been downloaded for free from the Internet.[9-23] They consist of text, images, animations and games which may help get young students interested in this subject. They can be used with the method that the teacher considers most appropriate.

CRITICAL METALS

The so-called "Critical Metals" (CM), because of the applications which they have in the environmental technologies (e.g. photovoltaic, automotive catalysts, electric cars), are considered important for sustainable development. Their utmost importance in the modern environmental technologies may stimulate the interest of young people. The CM have in common both a rapid growth in their global demand, and the creation of risks due to their physical scarcity or the regional concentrations of mining, which can be a source of tensions. A United Nations Environment Programme (UNEP) document deals with applications, reserves, recycling and related problems of this numerous group of chemical elements.[24] For example, 47% of the platinum (Pt) global demand is devoted to its applications in automotive catalysts. The price of Pt, pushed up by a continuous growth of the demand, almost quadrupled between 1998 and 2007. It can be efficiently recycled from its scrap, but the need is felt that more countries develop the necessary infrastructure for its collection. Most of Pt (77%) is mined in South Africa.

Indium (In) has several industrial applications. Its use in thin-film solar panels has a very strong growth potential and is pushing up demand. There are serious supply risks for In, since its global reserves are limited. Its price rose from 100 U.S. dollars/kg at the end of 2002 to 900 U.S. dollars/kg in 2006, then stabilizing around 500 U.S. dollars/kg. Indium pre-consumer recycling is practiced by the same industries that utilize In, using the scrap generated during the production process. Post-consumer recycling is practiced as well, thanks to the recovery of indium-containing old scrap. Japan, although not having its own natural reserves, is the second largest producer of indium in the world, thanks to a well-organized recycling system. A major technical problem is its low concentration in the scrap that contains it. This makes the recycling of In difficult and expensive, nevertheless, it remains important.

Among the main industrial applications of lithium (Li) is the production of Li-ion batteries for mobile phones, laptop computers and electric cars. At the moment, the world reserves of lithium are not an immediate concern and, therefore, its low price does not stimulate recycling. This situation might quickly change, given that already there is a forecast of a quickly growing demand for electric cars with Li-ion batteries. In fact, this change may have a tremendous effect on the growth of Li global demand. A problem related to Li recycling consists in its oxidation during pyrometallurgical processes; it then moves into the slag phase as oxide. A share of 73% in the estimated global lithium reserves is located in Chile. Uncertainty about the future supply of these materials and an often difficult substitutability makes CM recycling of paramount importance. The need is felt that the recycling technology of some CM and the infrastructure for the collection of waste containing CM are better developed.

EXTENDED PRODUCER RESPONSIBILITY

Two documents on the Extended Producer Responsibility (EPR) could be useful for a teaching unit that introduces some concepts and information related to the zero waste philosophy.[25,26] In the optimistic hypothesis of a future World Community that recycles 60% of the MSW that it generates, the related environmental problem will be postponed, which is very important, but not resolved. This would mean, in fact, that still 40% of the MSW generated by the World Community in increasing amounts will have to be incinerated or landfilled, thus, increasing pollution and wasting materials.[27] This is clearly unthinkable in the view that human beings continue to live on our planet for thousands of years.

Nowadays, the necessary infrastructure for separate waste collection often does not exist. Furthermore, many materials cannot be recycled because of technical difficulties and the costs of dismantling the objects from which the former can be extracted. Many parts are difficult and sometimes dangerous to remove; the labor for their recovery can constitute a threat for the health and safety of the operators. According to the concepts of EPR, which inspire the legislation of some countries, producers of consumer goods are responsible for collecting and disposing their own products, when these latter arrive at end-of-life. The producers are, thus, aware of bearing the disposal cost of what they produce. Hence, they are stimulated to design objects that are easily and economically manageable at end-of-life, both for the recovery and recycling of materials. In fact, the cost for end-of-life management depends on the labor required to dismantle products and on the disposal cost for material that cannot be recycled; the revenue obtained from the recovered materials can, of course, be subtracted. The cost of disposal is internalized into the price that the buyer pays at the time of purchase, thus, being supported by those who benefit from the product and not by all taxpayers.

Two documents from the Georgia Institute of Technology may help to understand the problems faced by designers to create products easy and cheap to dismantle for the recovery and recycling of materials.[28,29] The materials recovered can be altered, unrecognizable, or both, therefore, unusable. Moreover, the presence of toxic substances, whose legal disposal is expensive, adds to the cost of end-of-life management. In the automotive industry, a huge variety of plastics are used; they are often not compatible with each other, hence, they cannot be processed together. In addition, they are often difficult to distinguish from each other. Mixing for processing different types of recovered plastics leads to the so-called downcycling, which results in a product of lower quality which is difficult to recycle again, if at all. Even between plastics, and the paints used for them, there can be the possibility of compatibility or not. A batch of plastic to be recycled, if contaminated with paint, even to an extent of 1%, could be ruined. Consequently, the commercial value of many recovered plastics can be 3-10 times lower than the corresponding virgin material and often drops even to 0. A metal can have platinizing or weldings made with a different metal that often cannot be easily separated for recycling operations. As a consequence, after several cycles, the metal is increasingly contaminated. This may change its properties, also entailing a reduction of commercial value.

In many cases, the expected revenue from recovered materials can be so low as to make recycling not economically feasible. In several countries (e.g. Sweden and Canada), laws based on the concepts of EPR are already in place for a number of industrial products. The laws on mandatory EPR or governmental encouragements for a voluntary approach to EPR are producing design changes in products.

Marking of plastics is being widely adopted to favour identification and make recycling easier; to avoid the mixing of materials, the labels on the products can be made with the same resin type or can be molded in. There is the example, among many others, of a company that has halved the number of parts, and reduced to less than 1/3 the number of resins used in the construction of printers. The strategy of the company also includes reduction of the amount of materials used, as well as, development of materials with less environmental impact and more value at end-of-life.

In general, there is a tendency to decrease the number of components and screws, as well as, towards a unification of the materials. To facilitate recycling, in some cases, the use of composites of metal and plastic has been abolished. There is also a tendency to limit the use of toxic materials, more expensive to dispose of legally. For example, lead-free solders and chrome-free metal plates have been developed. A greater use of recycled materials in the production of manufactured goods can be observed; this contributes to developing a growing demand for recycled materials which, thanks to the EPR, are produced in increasing amounts. Quick technological progress makes products obsolete faster.

Many producers are working towards a longer product life and easier maintenance and repairs. Some computer brands are designed for easy replacement of the electronic components that allow upgrading of the equipment and hence performance. The easy upgradeability of the equipment helps the owner to prevent its early obsolescence, thus, extending its life. Some manufacturers have started refurbishment, when possible, and sales of second-hand parts. In this way, the value of a recovered object is much higher, as compared to the value of the same object considered just as simple recyclable material. At the same time, the energetic costs of complete reprocessing are avoided.

According to the concept of EPR, the commitment of the designers in the creation of products should also entail no penalization of function, structural integrity, safety and durability. Still, according to this concept, negative environmental impacts during other phases of the life cycle in favour of changes that facilitate end-of-life management are to be avoided. Meetings are favoured that involve designers and dismantlers, to allow the former to acquire the knowledge necessary to design in such a way as to facilitate the work of the latter. Of course, responsible behaviour of consumers is always of the utmost importance, and reducing waste production at source remains the first choice for the environment. The favourable influence that recycling, repair and reuse activities may have on job creation, in addition to diverting materials from landfills, is beyond the scope of this manuscript. Nevertheless, two interesting readings are suggested about this subject.[30,31]

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AUTHOR

Prof. Aldo T. Marrocco – Former Mathematics and Science teacher at I. C. Comprensivo “Toniolo”. Pisa, Italy. Electronic mail: aldo_marrocco@yahoo.it