Analytical perspective on waste management for environmental remediation

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Increasing numbers of publications reveal researchers' interest in waste management. After a short discussion on disposal strategies for wastes, we explore new ways of reusing wastes. Our main focuses are tannery waste, fly ash, food waste and compost. We also discuss the role of analytical chemistry in using waste for environmental remediation. Promoting clean methodologies in remediation is the best way to address future environmental challenges.

Keywords: Analytical chemistry; Clean methodology; Compost; Fly ash; Food waste; Environmental remediation; Recycling; Tannery waste; Waste management; Waste recovery

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1. Introduction

Waste is usually the product of industry or commerce, but it also comes from residential use, agriculture, medical facilities, radioactive sources, and light industries (e.g., dry-cleaning establishments). Wastes are mostly industrial by-products, whereas toxic wastes are poisons, even in very small or trace amounts. The growing concern for waste-management worldwide is reflected in the rise of publications (Fig. 1). A glance at waste-generation data [1] reveals that, compared to developed countries, developing countries generate much less waste. Whether developed or developing countries, we need waste-treatment strategies for environmental remediation.

Waste management is a pressing issue. The mass of waste produced throughout the world has been growing considerably for many decades, especially in affluent countries, as depicted in the data connecting national gross domestic product and waste generation per capita [2]. Human activity has become a major force in shaping the environment – a manifestation of the population explosion. Rapid urban growth and industrialization increase generation of solid waste. Many cities and towns in developing countries are in a miserable state of environmental degradation and face serious health risks, due to dumping of domestic refuse on streets and in public areas. The lack of adequate collection of wastes from roadsides and dustbins leads to severe contamination of water resources. Waste cannot be dumped without due concern and preparation, because not only is it unpleasant, unhygienic and potentially disastrous to our environment, but it also requires space and incurs expenditure to deal with the consequences of waste disposal. Our use of commodities challenges the capacity of air, water and land to cope with environmental problems. This situation fundamentally affects many other aspects of our society, such as the economy, energy and climate. We need to fulfill our human needs and prosper while taking into account and dealing with the problems of waste generation. The best way to tackle waste-related problems is to prevent waste generation, and to favor waste minimization, recovery, recycling and reuse.

2. Recovery, recycling, reuse and disposal

There are several waste-treatment strategies in use – all with the same goal in mind of using less material, reducing toxics and recovering more resources. Waste-treatment methodologies and technologies include landfill, open dumping, incineration, composting, recycling

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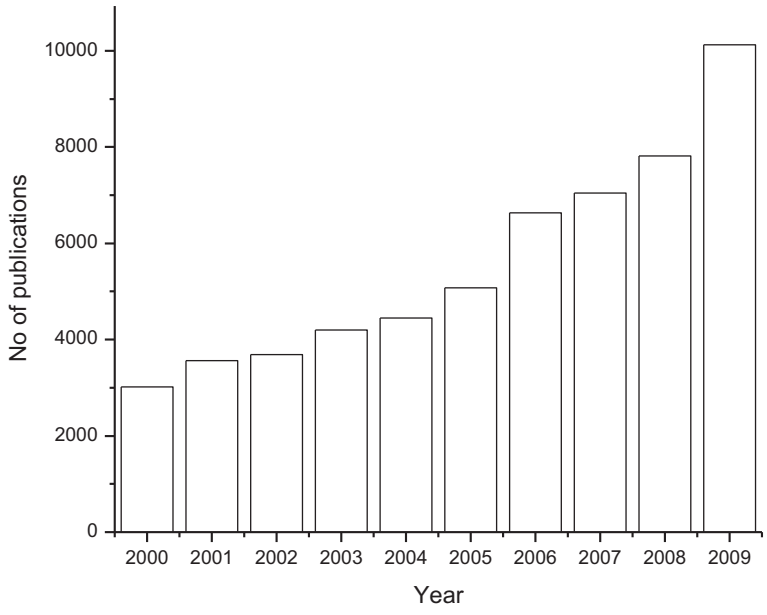

Figure 1. Literature published on waste management.

vermicomposting, pyrolysis, gasification, combined pyrolysis and gasification, anaerobic digestion (bio-methanation) and pelletization. Among these, landfill, open dumping, incineration, composting and recycling are traditional, whereas the others are comparatively new options.

Solid waste includes food residues, plastic and polyethylene, paper and cardboard, metals, glass, textiles, leather, rubber, synthetic materials and inert materials (stones, bricks, and ashes), which can be again classified into two groups – biodegradable and non-biodegradable. Natural recovery systems make use of food, organic and green waste (biodegradable) and then deal with in-vessel compost systems, while recycling is a logical option for materials not suitable for composting (non-biodegradable). Metals, plastics and glass are the most common of these materials. Automated and manual methods are used to sort out materials from construction sites (e.g., brick, tiles and concrete), which, after being sorted, may be re-used.

According to Mor et al. [3], solid-waste landfill is a common method of management in developing countries. Due to limited land availability, this is not a favored option [4]. In addition to lack of space, emission of leachates and gases to the environment needs to be taken into consideration.

Incineration is one of the attractive options for waste treatment in the South East Asian region [5]. Incineration transforms original waste into other forms (e.g., fly ash), which, in turn, requires landfill for disposal, so incurring cost additional to the operational cost of the incinerator, which also emits greenhouse gases into the atmosphere [6].

There is a noticeable contrast between the type of waste generated in developed and developing countries; developed countries generate more recyclable wastes, whereas developing countries generate more biodegradable wastes [7]. The waste composition of developing countries makes it clear that composting is the best possible option to deal with solid waste. Case studies show that developing countries are opting for composting [8].

Resource recovery is a major element in solid-waste management. Waste recycling can help to eliminate and thus to minimize waste. One of the main goals of sustainable waste management is to maximize recycling and reuse. Reuse of waste is important from many points of view:

- it helps to save and to sustain natural resources that cannot be replenished;
- it decreases pollution of the environment; and,
- it helps to save and to recycle energy in production processes.

According to the ''waste-hierarchy'' pyramid (Fig. 2), disposal of waste is the least favored option while prevention of waste is the most favored.

Fig. 3 shows the waste-management system for solid waste from waste source to final disposal. Waste at its source is sorted out into organic, recyclable and residual wastes. After bio-treatment of the organic fraction and recycling of the recyclables, the total residual waste is either incinerated or used for landfill.