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Transforming Municipal Waste into a Valuable Soil Conditioner through Knowledge-Based Resource-Recovery Management

MH Golabi[1*], Kirk Johnson[1], Takeshi Fujiwara[2] and Eri Ito[2]

[1]*College of Natural and Applied Sciences, University of Guam, Mangilao, Guam 96923, USA*

[2]*Solid Waste Management Research Center, Okayama University, 3-1-1 Tsushima Naka, Okayama, 7008530, Japan*

[*]**Corresponding author**: MH Golabi, College of Natural and Applied Sciences, University of Guam, Mangilao, Guam 96923, USA, Tel: + 671 735-2134; Fax: 671 734-4600; E-mail: mgolabi@uguam.uog.edu

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Abstract

Guam is a small, isolated tropical island in the western Pacific with a population of over 160,000 people. Although population growth and life style have been shown to have strong effects on the character and generation of waste, very little is known about consumption patterns and behavior of the people of Guam in this regard. Currently landfilling is the only discard method available to the island. Placement of huge volumes of organic waste material in landfills not only causes environmental problems for the island but in fact constitutes loss of valuable resources that could be composted and made available for land application as a soil amendment in forest lands, farm fields, and home gardens. Composting on the other hand reduces both the volume and the mass of the raw material while transforming it into a valuable soil conditioner. Here we present some of the results of survey questionnaires that was developed and conducted over the past two years that is anticipated to help waste operating managers and decision makers to determine societal consumption behavior and residential life style as the first step toward development of an effective waste-management strategy for the island of Guam. In this regards, we are also presenting an example of a large scale composting method developed in Isfahan, Iran, for recycling of organic wastes of municipal origin.

Keywords: Waste management; Environmental crisis; Landfill; Waste recycling; Composting; Zero-waste Management strategy

Introduction

Rapid increases in the volume and variety of solid and hazardous waste as a result of continuous economic growth, urbanization, and industrialization are a burgeoning problem for national and local governments, which must ensure effective and sustainable management of waste [1]. Between 2007 and 2011, global generation of municipal waste has been estimated to have risen by 37.3%, equivalent to roughly an 8% increase per year [1]. The EU has estimated that its 25 member states produce 700 million tons of agricultural waste annually [1].

As reported by the United Nations Environmental Program [1], developing countries face difficult challenges to proper management of their waste; most effort is devoted to reducing the final volume and to generating sufficient funds for waste management. If most of the waste could be diverted through material and resource recovery, then a substantial reduction in final volumes of waste could be achieved, and the recovered material and resources could be used to generate revenue to fund waste management. This scenario forms the premise for Integrated Solid Waste Management; a system based on the 3R (Reduce-Reuse-Recycle) principle [1].

Appropriate segregation and recycling systems have been shown to divert significant quantities of waste from landfills and to convert them into resources [2]. On Guam, over the past several decades, solid-waste generation and disposal have transitioned from a concern needing a remedy to a crisis of monumental proportions.

Although Guam is a small, isolated tropical island with a population of just over 160,000 people, the island generates more than 90,000 tons of waste material each year [3]. The need for a comprehensive solid-waste management and recycling plan is therefore urgent if Guam is to minimize cost and avoid the undesirable environmental effects of legal and illegal dump sites. A comprehensive waste management would also allow for the use of recyclable as well as green and other organic refuse that is currently discarded in landfills as sources of producing organic soil conditioner for a sustainable agricultural cropping system in Guam and the other island in the Micronesian region.

Waste reduction and recycling are fundamental to any future waste-management strategy on Guam and other islands of Micronesia. Accurate information on waste generation, especially waste characteristics, is also needed for study of the feasibility of such strategies on Guam and its neighbors. Unfortunately, presently available data on Guam [4,5] are not reliable enough for development of a comprehensive management and recycling strategies, and information is lacking on social behavior and life style that may strongly affect the character and production of waste.

Basic data from the unregulated local Ordot landfill over the past several years suggest that Guam residents produce on average more waste per capita than the rest of the United States [6]. Because any waste-management policy must find meaning and purpose within the framework of consumption patterns if it is to be effective at all. Residents must come to know and understand what, how much, and more importantly why they consume and hence must become aware of the impact that such consumption has on their island's environment and economy and on the social and cultural life of their community.

Residents' education about awareness of the types and amounts of waste generated and its handling are essential parts of any waste-management strategy that would be economically feasible, culturally acceptable, and environmentally sustainable while maintaining the integrity of the island's natural resources.

Survey questionnaire for educational purposes

To collect the necessary data, we have developed and used questionnaires as a surveying tool. The results are expected to help us understand the social behavior and the residents' life style as the first step toward the development of a sound and effective waste-management strategy for the island of Guam.

To determine not only the composition of waste by components but also citizens' consciousness and knowledge about waste reduction and recycling, we developed a citizen questionnaire designed for statistical analysis not only as a management tool but also as a way of educating the general public. The contents of the survey questionnaire included (1) educational background of head of the household, (2) public awareness of environmental problems associated with waste, (3) waste characteristics and willingness to segregate its components, and (4) participation in reduce-reuse-recycle activities.

By analyzing survey results, we hoped to develop a model of waste generation and citizens' consciousness of reduce-reuse-recycle principles for use in a comprehensive waste-management strategy. We expect that the survey results representing a true sample of the citizens of Guam will aid in the distribution and processing (collecting, compiling) of waste necessary to obtain high recovery ratios.

Determination of the waste generation and characterization

Although reports by the European Commission [7] and studies by Martinho and Silveira [8] recommend sampling of waste containers placed in public areas (e.g., apartment complexes) as an ideal sampling technique, doing so would entail higher costs than did our survey.

Our approach not only obtained up-to-date data but also contributed to education of the public about waste management while promoting "zero waste." It also educated the public, private sector, as well as government agencies about composting and recycling of large-scale organic wastes. The survey approach has revealed that up to 77% of household waste on Guam is organic (food stuffs, yard wastes, newspapers, etc., Figure 1) in nature. This humongous amounts of wastes generated in a small island could easily be recycled through large-scale composting, as it is done at the Isfahan 'composting factory' described below (Figures 2–10). The remaining 23% of the nonorganic waste material like plastic bottles, cans, durable goods, etc., could also be recycled, leading to a "zero waste" management strategy that might require no land-filling cost for the community.

We therefore introduce here the idea of zero-waste management by presenting an example adopted in the city of Isfahan, Iran. We hope that presentation of such an example will lead local government leaders and the private sectors on Guam and the other islands of Micronesia, as well as major cities around the world, to consider adopting such a strategy.

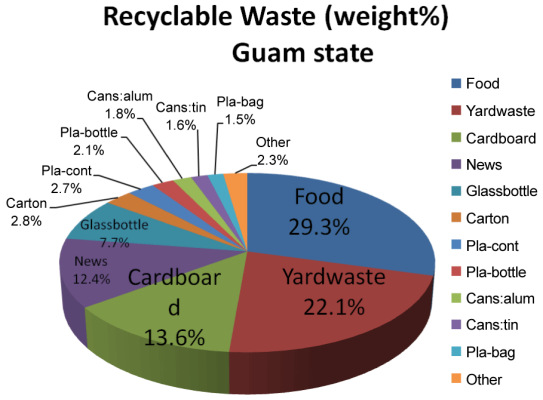

Figure 1: Recyclable waste produced by a Guam household. Pla-cont, plastic containers; pla-bottle, plastic bottles; Pla-bag, plastic bags; News, Newspapers; alum, aluminum cans.

Zero Waste Management Strategies

Different zero-waste management strategies and techniques have been developed and adopted in different countries [9], but the strategy used in the city of Isfahan, Iran, which includes large-scale mechanical composting as a major component is of particular interest to Guam and the neighboring islands in the Micronesian region. The Isfahan composting operation is not only a recycling facility but also an organic fertilizer production plant that uses the organic waste generated by the city of Isfahan as a major source for its production lines.

Isfahan compost facility and recycling techniques

The Isfahan compost facility has two production lines, each able to handle 750 tons of garbage per day. Garbage is gathered at night at the transfer stations and sent to the recycling facility in both small and large hauling trucks (Figure 2). Upon delivery, the garbage is pushed to the conveyors by front-end loaders, and the receiving station is cleared as soon as trucks leave the site (Figure 3). Conveyors then carry the trash to vibrating screens that separate plastics, glass, cloth, etc. The trash is then carried on the conveyors to hammer mills, equipped with double rotors and anti-explosives, which break up the large pieces included in the bulk of trash (Figure 4).

A second set of vibrators is used to unpack organic materials and loosen everything else. Next, two magnets separate metals from the rest (Figure 5). The metals, aluminum cans, etc., all fall into a separate compartment (Figure 6) and are transferred to the other section of the facility for further processing and/or recycling/packaging. The remaining garbage is then carried by vibrating conveyors to drum sieves for screening through different mesh sizes and for further screening (Figure 7).

Figure 2: An Isfahan compost factory waste-gathering and transportation vehicle.

Figure 3: A large front-end loader pushes the garbage to the conveyors, immediately and cleaning the drop-off site.

HAMMER MILL SET IN ISFAHAN COMPOST FACTORY - IRAN

دستگاه خرد کن در کارخانه کمپوست اصفهان

Figure 4: A hammer mill equipped with double rotors and anti-explosives, which is used for breaking up large pieces.

Figure 5: Magnets used to separate metals form the remainder of the waste stream.

Figure 6: The metals trapped by the magnets fall into a separate compartment for transfer to other sections of the plant for further processing.

Additional sorting

Additional drums further screen plastics, glass bottles, wood, cloth, paper, etc. At this stage, items like fabric and cloth are separated, placed in a special compartment, and hauled away to be pressed into bales, which are sold for processing into pulp and other biodegradable material [9].

Separation of organic matter

Organic materials (technically waste containing carbon, including paper, plastics, wood, food wastes, and yard wastes; and other materials derived from plant or animal sources and decomposable by microorganisms [1] pass through drums of 50-mm mesh size and are then sent on separate conveyors to fermentation sections (Figure 8), where it is placed in windrows and mixed for aeration every four days

(Figures 9 and 10) until the material become a mature compost and ready for marketing after a comprehensive laboratory testing.

Figure 7: Drum sieves, used to screen garbage through mesh into different size classes for further screening on vibrating conveyors.

Figure 8: Organic materials being conveyed to composting windrows for the fermentation process.

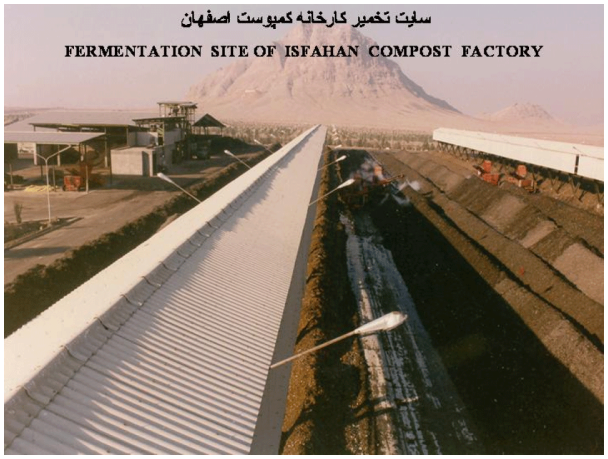

Figure 9: Composting windrow during the fermentation and turning process.

Figure 10: Mixing and turning of organic waste by a compost turner, which turns each windrow every four days.

Facility production capacity

Each year, from over 270,000 tons of input, the facility produces approximately 30,000 tons of fine mature compost, of which are sold to farmers, ranchers, horticulturists, and private gardeners as soil amendment/soil conditioner. Also, the facility produces about 12,000 tons of coarser compost as mulch, which is sold to municipalities for landscaping and for maintaining green spaces in many parks in Isfahan. The remaining biodegradable materials (fabrics, discarded cloth, etc.) are also sold to other cities within Iran as well as other neighboring countries for use in the pulp production and other similar manufacturing.

It is worth mentioning that all the products are tested at the factory's state-of-the-art laboratory for quality assurance before they are shipped to vendors and general customers and users of compost and mulch.

Figure 11 provides a flow-chart summary of the steps from waste collection to final compost production at the Isfahan 'composting factory.

Relevance of the Isfahan composting technology for Guam

The survey project described above served as a part of a comprehensive approach that includes increasing public awareness of comprehensive waste-management strategies for the island of Guam as well as the other islands in the western Pacific.

In addition to waste characterization by means of the survey questionnaires, presentation of the "Isfahan Waste Management System" also provides a knowledge-based foundation that we hope will lead to adaptation of the technology for Guam and neighboring islands. Because of the amount of the waste generated on Guam and the limited space available for landfilling, the Isfahan waste management technology appears to be the most practical and feasible

method that Guam and other islands in Micronesian could possibly adopt as a sustainable waste-management strategy.

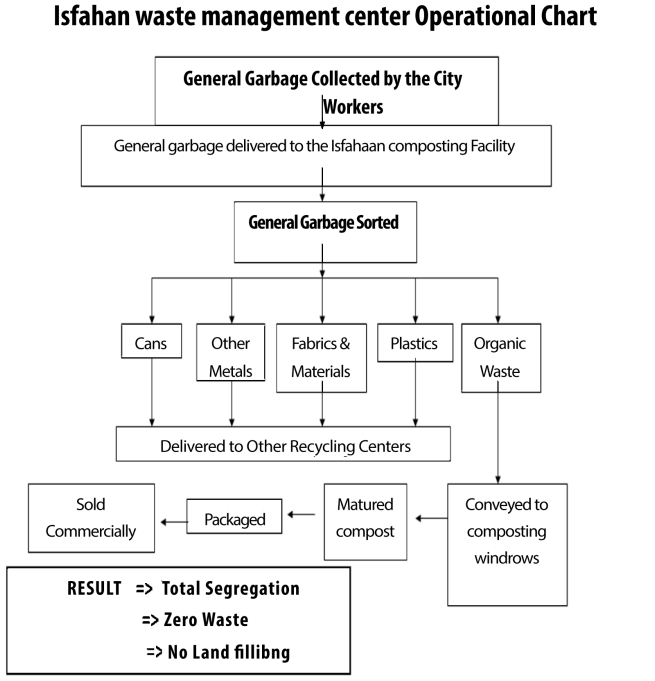

Figure 11: Chart showing the steps from waste collection to final compost production.

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