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The Role of Home Composting in Waste Management Cost Reduction

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Abstract**—**Due to the economic and environmental benefits of producing less waste, the US Environmental Protection Agency (EPA) introduces source reduction as one of the most important means to deal with the problems caused by increased landfills and pollution. Waste reduction involves all waste management methods, including source reduction, recycling, and composting, which reduce waste flow to landfills or other disposal facilities. Source reduction of waste can be studied from two perspectives: avoiding waste production, or reducing per capita waste production, and waste deviation that indicates the reduction of waste transfer to landfills. The present paper has investigated home composting as a managerial solution for reduction of waste transfer to landfills. Home composting has many benefits. The use of household waste for the production of compost will result in a much smaller amount of waste being sent to landfills, which in turn will reduce the costs of waste collection, transportation and burial. Reducing the volume of waste for disposal and using them for the production of compost and plant fertilizer might help to recycle the material in a shorter time and to use them effectively in order to preserve the environment and reduce contamination. Producing compost in a home-based manner requires very small piece of land for preparation and recycling compared with other methods. The final product of home-made compost is valuable and helps to grow crops and garden plants. It is also used for modifying the soil structure and maintaining its moisture. The food that is transferred to landfills will spoil and produce leachate after a while. It will also release methane and greenhouse gases. But, composting these materials at home is the best way to manage degradable materials, use them efficiently and reduce environmental pollution. Studies have shown that the benefits of the sale of produced compost and the reduced costs of collecting, transporting, and burying waste can well be responsive to the costs of purchasing home compost machine and the cost of related trainings. Moreover, the process of producing home compost may be profitable within 4 to 5 years and as a result, it will have a major role in reducing waste management.

Keywords**—**Compost, home compost, reducing waste, waste management.

I. Introduction

DUE to the high volume of daily production of urban and industrial waste, proper management of them is of particular importance in all countries, especially from the environmental and health perspective. Regarding the limitations of suitable waste disposal sites and the undesirable effects of landfills and other methods of waste disposal or control on public health and the environment, moving towards optimal waste management with a view to sustainable development is among the main goals of developed and developing societies.

One of the best ways to dispose of waste at recycling centers is to convert them into compost. This process plays a very important role in the optimal management of waste, which not only reduces the economic, health and environmental problems but also plays an important role in the production of organic materials and replacement of dangerous chemical fertilizers and also releases water and soil ecosystems from contaminated waste products. Therefore, controlling solid waste materials, including trash, and reducing the production of waste are unavoidable requirements of urban management [1].

Compost production is in fact a biodegradation process in which corrosive organic waste is converted to useful materials for plants under aerobic or anaerobic conditions. Bio-compost (a compost fertilizer that originates only from organic wastes) includes the organic part of the waste (detached domestic waste) and the wastes from gardens and fields (mostly residues of leaves and branches).

Since most of Iran's soils are considered arid and semi-arid, and their organic material content is less than 1%, the use of organic fertilizers will not only increase the production of agricultural products, but also prevent erosion and degradation of soil. Organic materials are known as one of the soil fertility elements due to their structural effect on physical and chemical properties of soil as well as its fertility [2]. Hence, since more than 80% of the waste produced in cities is organic and convertible to compost, and on the other hand, due to the simplicity, relatively low-cost and generalizability of the process of compost production for waste recycling, it is worth doing more studies and investigations on the application of this biotechnology that has significant effects on the health of the environment [1].

II. Importance and Necessity of Domestic Composting

Composting organic materials of the residential sector and residue of green spaces in central installations will significantly help to reduce the amount of landfill waste and provide other environmental benefits. The other option that helps to achieve these environmental benefits while reducing the costs of collection, transmission and processing is the management of organic materials by the residents at the place of production. The most important option is composting in backyards [3].

Encouraging backyard composting is one of the most cost-effective waste reduction tools. Promotion and improvement of home-made compost can be increased through programs

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such as selling the composters with subsidies and/or providing them free of charge. Educating the people who buy the composters is required to ensure the correct use of these bins by them. The reduction potential is contingent on participation and educational activities [4]. The costs of implementing this strategy include the following [3]:

- The cost of providing and distributing free composters for each home (e.g. X Rials per composter × number of households)
- The costs of promotion and education

Implementation of this strategy and encouragement and education for composting in the backyards are recommended for the following reasons [3]:

1. It is a cost-effective program to increase the rate of waste diversion
2. The amount of waste managed in homes will increase; therefore, the amount of waste that needs to be collected and buried will increase as well.
3. It encourages other activities (for example, horticulture) that are very useful for individuals and communities.
4. It may reduce the amount of organic matter that enters the landfills. Hence, the environmental hazards of organic matter in the landfills will decrease.
5. It is an option that will be considered by the public, especially by those who are interested in home-made compost and waste diversion.

III. Experiences of Other Countries

In other countries of the world, there has been a lot of research and work on the production of home-made compost, a summary of which is presented here.

Fredericton, the capital city of New Brunswick, Canada, in cooperation with the FBYC[1], holds an auction of the composters with subsidies at a price of 30$ per composter once in May. FBYC also provides education of Master Composter every two years, and hold workshops for various centers. In 2008, 70 master composters were trained for free because of doing 40 hours of compost-related activities [4].

The township of Langley in British Columbia, Canada, carried out studies on backyard composting and identified the following barriers [3]:

- Availability of other disposal methods, such as trash cans and food shredders
- Not understanding the benefits of home composting
- Not knowing how to do backyard composting
- Problems associated with the preparation of composters
- Concerns about smell and insect accumulation
- Saying that home backyards were small
- Imagining it to be dirty compared to other options

In order to overcome these barriers, the township created a website containing composting films and other required information. Furthermore, they offered the composters for 35$ and the aerators for 15$. The township also held workshops and conferences on vermicomposting [3].

The city of Davis, California, has implemented a program for reduction in origin, which provides the residents with free bins of compost. Residents interested in composting are being trained on how to produce compost and use it to improve agriculture. They also receive a composting manual. After studying the manual, they will be tested (general questions including how to avoid smell, and basic questions including the amount of moisture and the ratio of carbon to nitrogen) and, finally, they will be given a certification [5].

The use of master composter training can improve composting and recycling. Volunteers are trained in composting and provide the training to their neighborhood. It can be effective that in this method, volunteers and their influence in the neighborhood are used. An expert and skilled person is required to provide training and educational courses of master composters. This strategy can be an effective marketing technique. Its impact on the degree of diversion depends on the number and quality of the training provided. In this strategy, leading citizens are trained in composting and recycling in order to train the people of specific neighborhoods and regions. This strategy has the potential to work with environmental NGOs. The potential for waste diversion varies depending on the number and quality of the training programs [6].

In its effort to promote compost in Manitoba's residential region in Canadian, Manitoba Resource Conservation Company trained 60 compost masters in Winnipeg through a volunteer program. In the fall of 2007, Manitoba Resource Conservation Company provided a training course for master composters in the cities of Steinbach, Morden and Stone Wall. In order to qualify as a master composter, volunteers must attend the provided training course. In the end, the participants will undertake to do 30 hours of volunteer work over the next two years in their region or workplace. No fees for participation in this course are received from the participants since it is free of charge. The participants will receive a Master's Certificate in Composting from Manitoba Resource Conservation Center, as well as a membership in the Center, a booklet, compost books and tools, and compost newspapers and magazines (every other month) [6].

In the city of Seattle, Washington, a master composter training program is a key factor in reducing waste in the city. The goal of this program is to increase the preservation of natural resources through the participation of citizens and providing them with educational services. Citizens are encouraged to recycle organic waste in their backyards for gardening activities. The program outlines how climate change is reduced by removing carbon dioxide from the atmosphere and brought back to the Earth. In this training program, each participant has to pay 500$ for receiving training materials, manuals and compost bins. In addition, a deposit of 150$ is required which will be returned after 35 hours of compost-related activities [4].

IV. Different Methods of Home Composting

Bio-composting and vermicomposting are home-composting methods.

[1] *Fredericton Backyard Composters*

A. Stages of Preparing Home-Made Bio-Compost

There are five essential components to prepare compost, based on which high quality compost can be produced. These components include: brown (carbon) and green (nitrogen) materials, appropriate particle size, size of compost mass, humidity and aeration. For composting, compost materials should first be divided into small pieces (10-20 centimeters). This not only accelerates material decomposition, but also makes it easier to mix the materials in the compost mass and turn the mass over for aerating and accelerating the decomposition. Then, equal amounts of brown ingredients (such as leaves) and green materials (kitchen waste) are combined together. Brown and green materials provide energy and protein, respectively. If the amount of green materials is much higher, it will smell badly. In this case, the amount of brown materials needs to be added to balance the mixture. Then, microorganisms get active and require moisture for their activity. If the amount of moisture is low, the bacteria will not work and will fall asleep, and if the amount of moisture is high, the oxygen in the mass will be reduced and the compost will change into slime. Then, anaerobic microorganisms will begin to function and make bad smell [7].

If turning over the compost revealed that the mass moisture is low, some water will be sprayed into the mass and some pieces of plastic or a few pieces of wood will be placed on it. The mass will be put in the shadow not to lose its moisture quickly. If the weather in the region is dry, some water will first be sprayed into the brown materials and they will be then mixed with the green materials. In addition to moisture, microorganisms need oxygen for their activity. The oxygen needed for the bacteria is provided by turning the mass over or making some holes at the bottom of the container. The holes at the bottom of the container also help drain when the moisture content of the mass is high. A good mix of the materials as well as appropriate moisture will cause the microorganisms to get activated. As a result, heat will be produced, and this indicates that the composting process is going on well, and aeration of the mass can reduce the heat produced. Depending on the compost, aeration can be weekly, monthly, or annually [7].

The mass size varies depending on the amount of materials that is being composted and the type of device which is selected, but the ideal size is 1 cubic meter. If the mass is large and there are optimal conditions, such as adequate food, air and moisture, material decomposition will occur very quickly, and the heat will reach 70 °C. Notice that a larger mass is more applicable to turn over the materials and send the air to the middle of the mass. After a few months, the compost mass will be ready and humus, which is an appropriate fertilizer for plants, will be produced [7].

Using appropriate compartments, one can provide optimum conditions such as mass moisture, temperature, and suitable ventilation for the conversion of waste into organic fertilizers in order for microorganisms to get active. The step-by-step procedure is as follows: in the first layer, crushed wood and stones are put on the surface of the soil at the bottom of the composting compartment. They help air circulation in the lower part of the mass. Food waste and leaves are put in the second layer. In the third layer, some soil is added to the bin to increase the required microorganisms. The layers are repeated in the same way to fill the container. After a few days, the compost mass will subside, which is a good indication of the proper functioning of the mass. The mass should be turned over every now and then. The increased number of turning over the mass will increase the processing speed and compost ripening [2].

B. Stages of Preparing Home Vermicompost

One of the methods of home composting is the use of earthworms. Red worms are appropriate for the production of vermicompost, because they are resistant to temperature variations and they convert many substances (equal to their weight) into compost throughout the day.

First, appropriate composting boxes need to be provided. For these boxes, there should be cracks and holes in their bottom and body to allow air to pass easily. In order for the bottom of the boxes not to be destroyed by the worms after a while, newspapers can be used. Put some soil on the newspaper (approximately 1 cm) and add some water (about 2 times as much as the height of the soil). Due to its relative moisture (80-60%), suitable conditions may be provided for the activity of the worms. Organic waste is then added layer by layer, and the earthworms begin to make organic fertilizer by moving upward and through new layers containing food. With continuous drilling, the worms allow the air to penetrate more depth of the bed and, by providing aerobic conditions, increase the speed of the conversion of waste to fertilizer.

It should be noted that the organic wastes used in the composting and vermicomposting methods are natural kitchen wastes such as fruit skins, vegetables, grass and leaves, etc. Materials such as meat, fat and oil are inappropriate [2].

V. Estimating the Reduction of Waste Management Costs Caused By Home Composting

To illustrate the reduction of waste management costs resulting from home composting, an example is provided. In this example, the cost and benefit of a five- member household with a per capita total waste production of 650 grams per day are reviewed. Given that about 70% of the total waste is wet organic materials [5], if 80% of the compostable organic materials are wet waste and if 25% of the compostable wet waste is converted to compost, the calculations are as follows.

Total waste of a five-member household:

$$5 \times 650 = 3250 \text{ gr} \quad (1)$$

$$\text{Total wet waste: } 3250 \times 0.7 = 2275 \text{ gr} \quad (2)$$

$$\text{Total compostable wet waste: } 2275 \times 0.8 = 1820 \text{ gr} \quad (3)$$

$$\text{Turns into compost: } 1820 \times 0.25 = 455 \text{ gr} \quad (4)$$

According to statistics, the cost of collecting, transporting and burying each kilogram of waste is about 120 Tomans

(~0.03$).

Reduction in the cost of not collecting, transporting and burying per day:

$$\left(\frac{1820}{1000}\right) \times 120 = 218.4 \text{ Tomans (~0.05\$)} \quad (5)$$

Profit from not collecting, transporting and burying compostable waste per year:

$$218.4 \times 365 = 79716\ Tomans \text{ (~19.64\$)} \quad (6)$$

Considering a composting machine with a capacity of 300 kg at a cost of 250000 Tomans (~61.60$), the training costs of 50000 Tomans (~12.32$), and the sales price per kilo of compost as 120 Tomans (~0.03$), the time for return of capital is calculated as follows:

Initial investment:

$$250000 + 50000 \text{ Tomans (~73.92\$)} \quad (7)$$

As the project starts in March, in the first year the compost will be prepared after 5 months, i.e. in September, and from the second year the compost will be prepared after March:

If the sales price per kilo of compost is 120 Tomans (~0.03$), the income from compost sales in the first year:

The compost is produced monthly:

$$0.455 \times 30 = 13.65 \text{ kg} \quad (8)$$

The compost is produced in the first year:

$$7 \times 13.65 = 95.55 \text{ kg} \quad (9)$$

$$95.55 \times 120 = 11466 \text{ Tomans (~2.82\$)} \quad (10)$$

Income from the sale of compost from the second year:

$$12 \times 13.65 = 163.8 \text{ kg} \quad (11)$$

$$163.8 \times 120 = 19656 \text{ Tomans (~ 4.84\$)} \quad (12)$$

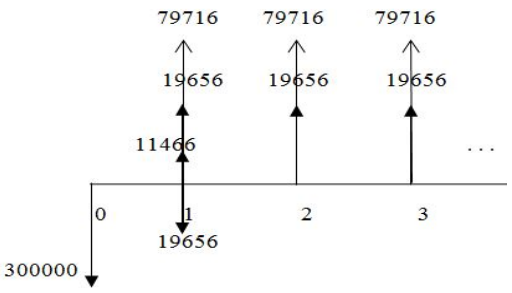

Fig. 1 Diagram of cash flow

Considering the above mentioned information and the bank interest rate of 15%, the calculations are as follows:

$$P = F\left(\frac{P}{F,i,n}\right) \quad (13)$$

$$P = A\left(\frac{P}{A,i,n}\right) \quad (14)$$

$$300000 = (-19656 + 11466) \times \left(\frac{P}{F,15,1}\right) + (19656 + 79716) \times \left(\frac{P}{A,15,n}\right) \quad (15)$$

$$n = 4.5 \text{ year} \quad (16)$$

Using the invoice table, it takes about 4.5 years to return the initial capital, and from that time on, the project will start to profit, and since then, it will have a major role in reducing waste management costs by about 55%.

Calculating the Project Profit:

The useful life of the compost is considered 10 years.

$$19656 \times \left(\frac{P}{A,15,10}\right) + 79716 \times \left(\frac{P}{A,15,10}\right) + (11466 - 19656) \times \left(\frac{P}{F,15,1}\right) - 300000 = 191606 \text{ Tomans (~ 47.21\$)} \quad (17)$$

VI. Conclusion

Organic material composting in the residential sector will significantly help to reduce the amount of burial waste and environmental benefits and reduce the costs associated with waste collection, transfer and processing. Encouraging backyard composting is one of the most cost-effective waste reduction tools. Promotion and improvement of backyard composting can be increased through programs such as sales of subsidized composters (subsidy payments). Educating the people who buy composters is required to ensure the correct use of these bins by them. The potential for reducing waste is dependent on participation and educational activities.

The costs of implementing the home-made compost project include the cost of buying a composting machine and the cost of training the use of it. The profits of implementing the home-made compost project involve the profit from the sale of the produced compost and the savings associated with lowering the costs of collecting, transporting, and burying compostable wet waste. Studies have shown that the benefits of the sale of produced compost and the reduction of the costs of collecting, transporting and burying waste can well respond to the costs of purchasing a household compost machine and the cost of related trainings, and the home-made compost project will be profitable within 4.5 years.

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