Mechanical Biological Treatment as an Effective Alternative for Landfilling of MSW in City of Shiraz

Mahak Sabouri & Farideh Gheytasi

BEHMAND TECHNOLOGY, Tehran, Iran

Mechanisch-biologische Abfallbehandlung als wirksame Alternative zur Deponierung in Shiraz

Abstract

Mechanical Biological Treatment (MBT) seems to be a more appropriate disposal solution than other alternatives for Iran. Although MBT will not eliminate the need for a landfill, it will greatly reduce both the quantity and toxicity of left over waste. This paper presents a proposed method to implement MBT in the historical city of Shiraz (city of Persepolis). This paper will initially describe the current disposal system utilized in the city of Shiraz. Later on, the amount of material can be diverted from the landfill through a MBT system will be calculated and the environmental, economical and social advantages of the proposed method will be estimated.

Keywords

Mechanical Biological Treatment, organic waste, compost, solid waste disposal systems, landfilling

1 Introduction

In the last few years reliance on the municipal solid waste disposal systems has been highly increased in Iran. Consequently, solid waste management has become a great environmental concern. More than 45,000 tons [1] of waste is produced in Iran daily, most of which are dumped into the landfill sites. However, shortage of proper places for landfill sites close to large cities as well as environmental impacts of non-sanitary landfills, make this method less attractive.

Biological waste treatment, mainly composting, which is being practiced in the last ten years in different cities in Iran, seems like a more appropriate disposal solution than other alternatives. This is due to the presence of high percentage of organic material, low calorific value and high moisture content in our municipal solid waste.

Shortage of nutrients in the soil of many places in Iran is another reason to increase the demand for composting. High quality organic fertilizer as a final product of the efficient composting plant can be a good substitute to environmentally unfriendly synthetic fertilizers which are vastly used in agricultural industry.

Municipal Solid Waste (MSW) is a major feedstock for composting plants in Iran. High quality production requires a relatively clean waste input which is normally achievable

through segregation of municipal waste at the source or by implementing a MBT system. Meanwhile, the national law for waste management, issued in June 2004, has caused a general trend towards the recovery and recycling of the large amount of waste produced in the whole country.

The proposed MBT system is a way of treating residual municipal wastes after the source segregated recycling had taken place in order to recover further value and to divert the organic waste stream away from the landfill. Aim is to cleanse the waste by removing useful materials and getting a biowaste fraction from it. Having this waste contaminated with non-segregated materials that cannot be recycled by the process, goal of the proposed approach is to improve the quality of the waste to be composted. In the proposed process, the extracted biowaste is treated in an aerobic process. In the proposed system it is possible to produce a fine fraction of the material from the waste that is suitable for agricultural purposes.

2 Study Area

Shiraz city has a moderate climate and with a population of 1.2 million spread across an area of 30,000 km^2 this city is located in the Fars province at the center of Iran [2]. This city is one the top tourist attractions in the country.

Province's economy is based on its agricultural products such as grape, citrus, cotton and rice. Agriculture has always been a major part of the economy in and around Shiraz. [3] This is partially due to a relative abundance of water compared to the surrounding deserts.

At the present time, 810 tones of MSW waste are produced daily at this city. Having a source separation and a sanitary landfill for more than 7 years, Shiraz has been one of the pioneer cities in the field of waste management in Iran [3]. However, the current waste management system is wasting a lot of recyclable and fermentable material by throwing them into the landfills.

For the time being, the system is based on wet-dry separation (like most other cities in Iran). For dry waste, householders are given two plastic bags for free, in two colors (white for paper and cardboard and orange color for the other recyclables). Recently, there is a program to send every household two plastic baskets similar colors to the bags to enhance the recycling rate at residencies [Fig. 1-a] [3].

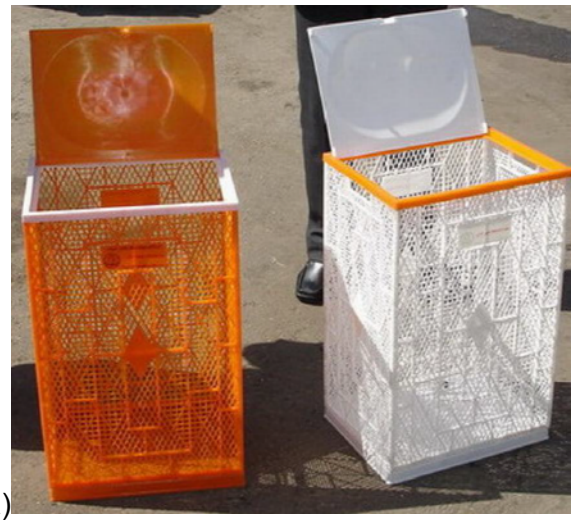
a)  b) 

Figure 1 Seperation at source at Shiraz: a) Plastic baskets; b) Female personnel at recyclables collection system

Dry waste sorted using the above mentioned bags, is collected every 15 days from doorsteps or by the bins located at the street. This job is carried out by women personals with 28 small and big vans [Fig. 1-b]. With this collection system, 7 tones of recyclables are daily separated at source. The collected material is taken to the recovery station where waste is manually sorted. The sorted materials will be sold to end users or distributors, or they will be sent to the recycling sites directly. 10 tones of hazardous waste and hospital waste are separately landfilled daily.17 tones of green waste from groceries and fruit markets are collected by a special collection system everyday. Collected green waste is Vermi-composted in a site close to the landfill. The remaining 780 tones of the waste are collected each day either from doorsteps as wet/mixed waste or from the streets. The collected mixed MSW is transported to a landfill equipped with a biogas collection system [3].

Additionally, 2900 tones per day construction and demolition wastes and 300 tones per day residual wastes are collected by individual services and they are disposed in another landfill dedicated to this purpose [3].

3 Proposed method of approach

The new scheme is designed considering the Shiraz MSW type. The high rate of organic materials (72%), high moisture content (67%) and high C:N ratio (34) [4]. There is a new law recently introduced in Iran that bans importing the synthetic fertilizers. At the same time the necessity of soil amendments for the agricultural lands in the Fars Province calls for a high capacity composting plant.

Enabling the recovery and reuse of discarded material is a critical element of sustainable development which will leave to waste reduction. Meanwhile, preservation

of natural resources and pollution prevention are also part of the environmental concerns forcing the need to divert as much materials as possible from the landfills.

3.1 Proposed MBT Plant

As described in figure 2, in the proposed scheme 780 tons left over of mixed waste per day that used to be landfilled by the current waste management system will be instead transported to the proposed MBT plant. In the current methodology the other waste flows are estimated to remain unchanged.

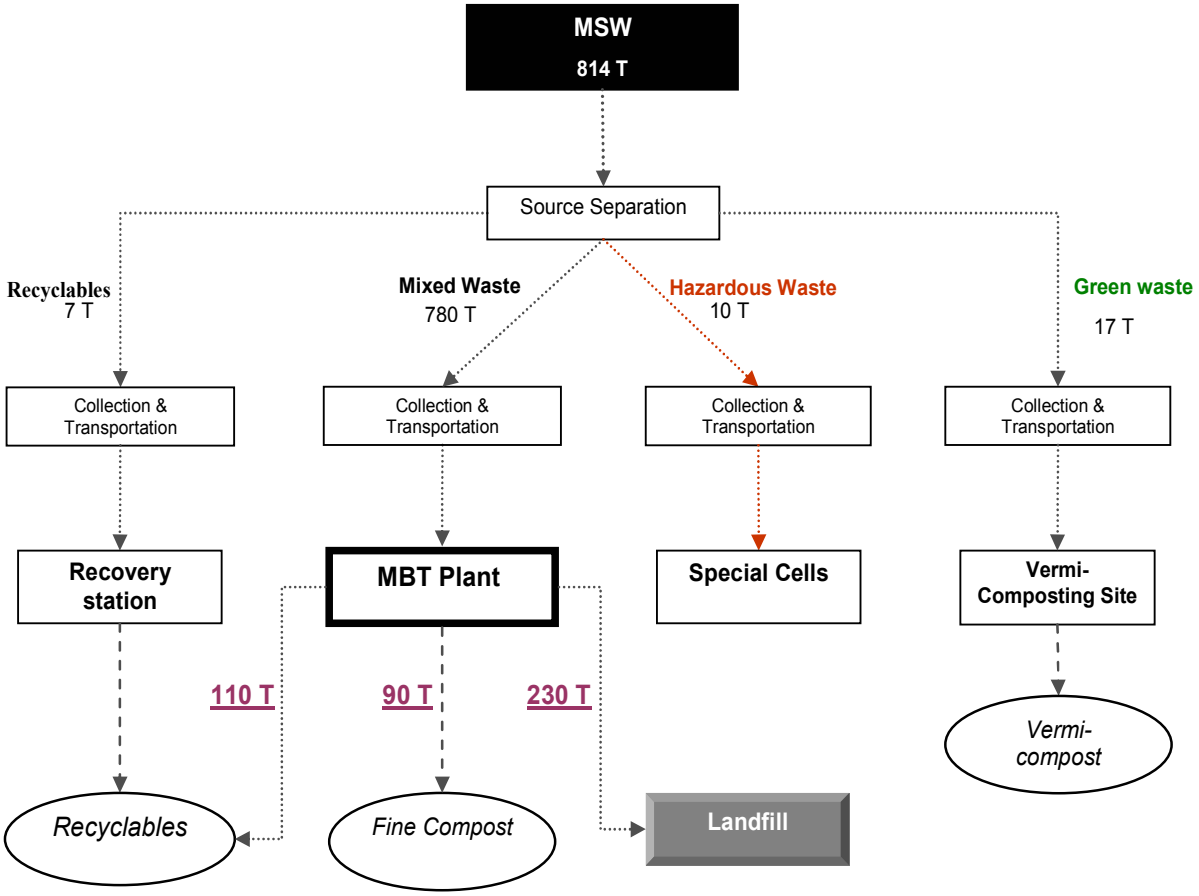


Figure 2 New scheme for Shiraz MSW management

At the MBT Plant (Figure 3), mixed waste delivered by collection vehicles is unloaded into tipping pits in the reception area. Waste is transported to a bag splitter to ensure plastic bags are opened and their contents are spread over the conveyor belt. Prior to loading the waste into the bag splitter oversized items would be manually removed.

The material on the conveyer belt will be screened and the oversized pieces i.e. those larger than 75 mm will be separated. Oversized pieces that include metals, plastic, cans and textiles will be sent to a manual sorting line for further separation. Before doing so, a system of electromagnets and separators will remove ferrous and non-ferrous metals, respectively.

There is also a blower which removes the light plastic bags and flattens the compacted waste piles on the conveyer for easy separation in the following stages of the process. All plastic containers, papers/cardboard, aluminum cans and steel cans sorted by labors will be stored at separate storage bins. These materials will be compacted and turned into bales for easy handling and transportation.

Rejected and non-recyclable wastes are passed to the end of the line. Then using another conveyer belt they are moved to the compactors where the volume of material that is going to be transported to landfill will be reduced.

The remaining materials that are passing beneath the 75 mm sieve drum are sent to the fermentation unit. For further cleansing of the organic waste stream from ferrous materials, there is both a magnet that removes the remaining small metal parts and a blower to remove the light particles.

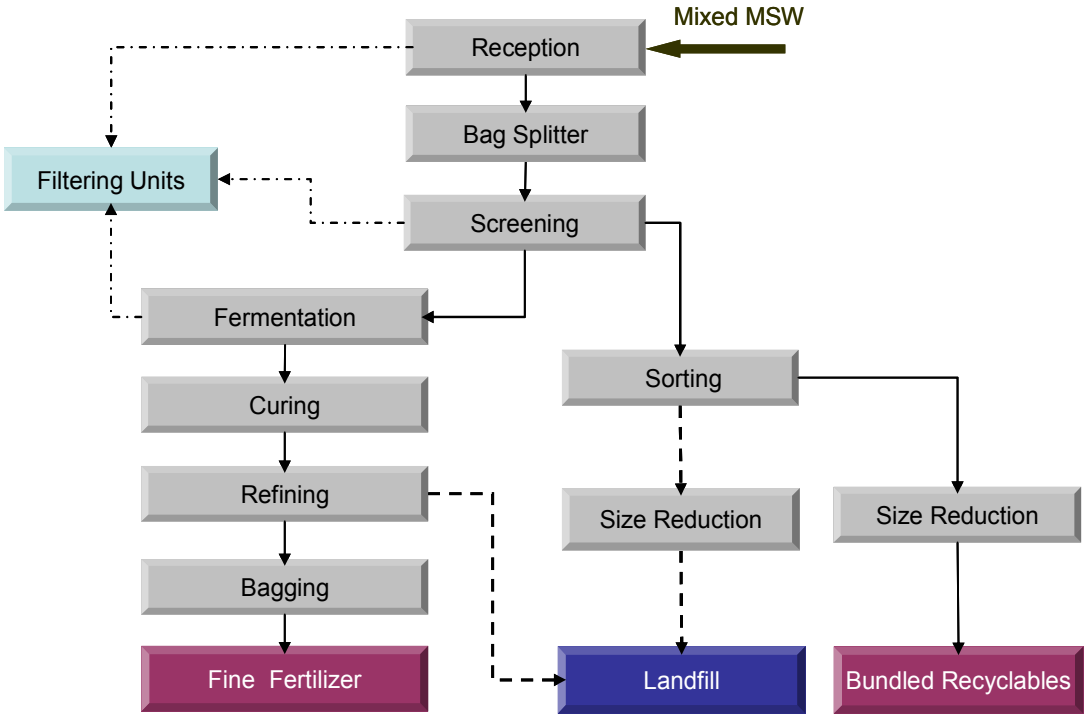


Figure 3 Flow diagram of proposed MBT plant

Cleaned organic materials are transported to fermentation unit. This unit consists of two halls parallel to one another. Organic waste up to the height of maximum 2m is spread on halls using a spreading machine. Biological Fermenting of organic waste is performed using both aeration from the bottom through the perforated floor and the mechanical mixing from the top by a screw mixer. The oxygen present in the airflow accelerates the fermentation stage where the temperature of the waste reaches 50-60°C. Temperature probes continuously record the temperature inside the waste to monitor the decomposition process and to ensure the minimum requirement of 60°C for 2 days is attained. Automatic control of the airflow by the computer system ensures that this

temperature range is maintained. The biowaste will be processed in a period of 3-4 weeks. This stage results in approximately a 50% reduction in the mass of water present.

When this stage of the waste processing is completed, the waste is transferred to the maturation and dehumidification site for the maturation and drying stages. The material will be formed into windrows of 1.5 to 3 meters in height and will be periodically turned by a turner. In order to provide the required oxygen for drying and final maturation of the compost, ducts below the maturating piles will let the air to flow through the waste material. The immature compost will remain here until it is dusty dry. This period will take about 6-8 weeks.

The dry sanitized waste material is transported by the loader to a feed hopper using a crane grab. By a combination of screening, sieving and weight separation, the waste is divided into three categories: small pieces of Inorganic materials, glass & stone and fine compost. Fine compost transported either bagged or stockpiled ready for collection. The rest materials are sent to landfill.

Odors released during fermentation are mitigated by using the natural bio-filter composed of stacked wood parts. The Leachate formed at the fermentation and reception halls are collected through the channels and are spread over the composting piles at the maturation site to enhance the degradation of organic waste. If needed, spreading the leachate will also keep the required humidity within the compost. Later on, the rest of leachate is sent to the Leachate Treatment Unit located at the site.

4 Experimental results

Use of the proposed system creates following benefits for the Local Authorities:

- Additional recycled material is created.
- Significant landfill diversion is achieved.

Although landfill in Shiraz [Fig. 4-a] is equipped with gas collection system (collecting and burning the gas in wells [Fig. 4-b], without any energy recovery), diverting the biological portion will certainly reduce the emission of greenhouse gases in large quantities. The proposed method will divert almost 450 tones of organic materials from landfill daily and hence will reduce the landfilling cost significantly.

Similar plants as the one proposed in this paper have been already manufactured by PalaTech Company (a local manufacturer and a sister company of Behmand Technology Co.) and installed in three different locations in Iran where they have produced acceptable results. As a successful case of implementing the proposed approach, *Babol Composting Plant* (*BCP*) [Fig. 5] is selected to be explained in this paper. Babol is a city

located in North of Iran, close to the Caspian Sea where the weather is highly humid and the high rate of humidity content of the MSW makes its treatment more difficult. A MBT system similar to the one explained earlier in this paper has been running in this plant for more than two years [Fig. 5].

a)  b) 

Figure 4 Shiraz Landfill: a) Daily covering and gas collection pipes; b) Biogas burning wells

This plant is treating 150 tones of MSW per day with high efficiency. The compost produced by this plant is tested by national laboratories and has got excellent results in terms of nutrients and hygiene factors. The composting method used in *BCP* is based on an old "Thyssen" composting method. However, this method has been modified to meet the specific waste characteristics in Iran and different regional climate conditions.

The MBT plant in Shiraz will be a modified version of the current MBT plant in Babol thanks to the company's practical experiences in Iran and the new advanced technologies in waste management industry in the world.

a)  b) 

Figure 5 Babol composting Plant: a) Fine compost Produced at BCP; b) BCP site close to city of Babol in Northern Iran

Implementing this modified MBT plant, it is expected to have the sorting rate of recyclables and the quality of the final compost product increased. At the same time, the new design is utilizing better operational techniques. Due to additional filtration systems for Leachate and odor, Shiraz MBT plant will benefit from a more advanced environmentally sustainable technology.

In Table 1, properties of the two plants are compared. [5]

The price of the fine compost produced using similar methodology versus the MBT system proposed in this paper is 20 USD per ton [5].

Cost of the mixed recyclables according to the waste analysis and the local recyclable markets is around 75 USD per ton [5].

Table 1 Comparison of two MBT plants in Babol and Shiraz[ii] [iii] [6]

Properties	Babol MBT Plant	Proposed MBT Plant for Shiraz
Capacity (tones/day)	150	780
Type of Input waste (Humidity, Organic Content)	75-80%, 75%	68%, 72%
Number of Employee	30	60
Main Units	Reception hall - Sorting line - Fermentation halls - aeration system - Refining unit	Reception hall - bag splitter - Sorting line - Magnets - Blowers - Compactors - Fermentation halls - Aeration system - Maturation Site - windrow turners - Refining unit - Filtration systems - advanced control and monitoring systems
Investment (USD)	1,053,000	6,842,000
Machinery[i] Cost (USD)	274,000	580,000
Monthly Utility Cost (USD)	5,000	7,000
Produced Fine Compost (tones/day)	20	92
Separated Recyclables (tones/day)	17	107

The proposed system for Shiraz can have the financial advantages as shown in table 2.

The investment cost for MBT plant with 780 tones per day mixed MSW waste reception capacity in Iran, as a turn-key project including designing, manufacturing, installation

[i] Including loader, truck, personnel's bus, …

[ii] The information of Babol site is related to year 2003.

[iii] 1 USD assumed to be 9500 Rials in March 2007 (Iran Currency)

and commissioning of all units in addition to the required operating machineries (excluding the cost of land) in year January 2007 rates, is estimated to be around 7,420,000 USD.

Operation costs including employee's salary, maintenance and utility costs are estimated to be around 140,000 USD per month. Using aforementioned expenses, the incomes and saving of the new system, Pay Back Period (PBP) of approximately 27.7 months is calculated.

Table 2 Income and savings of proposed plant

Subject	Income (USD/Month)	Saving (USD/Month)
Separated Recyclables at MBT site	263,804	
Produced Fine Compost	64,633	
Reducing the landfilling cost (Inc. Equipment and Application)		77,713
TOTAL	328,437	77,713

5 Future Work

Finding dominant waste disposal solution, the proposed MBT plant should be examined within different operational conditions as explained below:

1. The proposed method should be applied to other cities enjoying the improved source separation system.

   The amount of recyclable materials that can be separated at source will certainly effect the income and, hence the PBP of a MBT plant. *Behmand Co.* is one of the companies in the country doing feasibility study for three different cities in this regard.

2. Solutions for other places with different climate conditions.

   This system (manufactured by Palatech Co.) is already running in three different areas in Iran (In Mashhad and Sabzevar in North West with dry hot summer and cold winters, and in Babol in north with humid climate). But the above mentioned process should be examined in all kinds of climates.

3. As our global view, intention is to expand our work to other countries with similar consumption patterns and, hence waste type across the boards.

The proposed technique is based on Iranian's consumption pattern which is completely different than those of developed countries. There should be more countries in the region where we can develop this disposal solution as an alternative to those solutions that require high investment for implementation of the system. This is however an appropriate solution instead of simply discarding the waste either at improper damping sites or by burning in an unsuitable condition.

4. Implementing a granulation unit to increase the value of the final product.

   Granulating composts is one of the best methods to increase the effectiveness of the organic fertilizers. Granulated organic fertilize will have the following advantages:

   - Releasing nutrients at a slower, with a more consistent rate
   - Making compound formulated fertilizer
   - Ease the storage and transportation of waste materials
   - Better handling properties, with little tendency to cake or dust

There is a granulating unit of organic fertilizer, designed and manufactured in Iran for the first time by Palatech Co. in year 2006. This unit is now processing 50 tons of compost everyday and it is producing a granulated and formulated fertilizer with 500% added value compared to the compost humus. [iv]

6 Summary

In this paper the necessity of a MBT plant for a city with 810 tonnes waste production per day is determined. The result of the reported work proved that a MBT composting plant can be a reasonable solution regardless of its high investment cost for city like Shiraz. The estimated PBP is excluded the environmentally benefits of the proposed plant. So, if the amount of the Leachate and GHG that can be eliminated by the proposed method added to the current amount, the results would become much better.

7 Literature

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[iv] Granulating unit located in Ghorveh city, in Kurdistan Province in west of Iran.

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Author's address

Mahak Sabouri & Farideh Gheytasi

Behmand Technology Co.
2nd floor, No.65, Taheri Str., Africa Blvd.
1966944155 Tehran
IRAN
Telephone: +98 21 220 410 40
Email: M.Sabouri@behmand.ir
Website: www.behmand.ir