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# Plastic Recycling Problems and it's Health Aspects in Tehran

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**Abstract:** The main objective of a solid waste management system is to effectively safeguard the public health, safety and welfare. This study demonstrates the present status of plastic waste management in Tehran and outlines the principle guidelines and policies regarding collection, handling and recycling of plastic waste and its microbial pollution in Tehran. Results showed that about 2,125,688 and 2,355,740 tons of Municipal Solid Waste (MSW) were generated per year in Tehran in 1999 and 2003, respectively. The plastic has grown than other category of MSW in Tehran from 8.01% by weight in 1999 to 9.61% in 2003. Approximately 50 tons per year of total plastic waste recycled and the others dispose in the Kahrizak landfill. The thermoplastic waste produced annually has begun to increase from 1.5% by weight in 1999 to 2.88% in 2003. According to the studies on plastics recycling in Tehran, there are a significant difference in terms of technological and scientific aspects of recycling between industrial countries and our country. Plastic recycling is carring out mechanically in Tehran. However, this simple method is not scientifically approved for collection, separation, recycling process and products generation. The results obtained by microbial tests form samples of recycled products showed the contamination of products such as Bacillus, Staphylococcus, Serratia and Entrobacter. Thus, the generated products have low quality because of lack of continual monitoring and technical program on plastic recycling and lack of public participation.

**Key words:** Municipal solid waste, plastic recycling, recycling scheme, public participation

## INTRODUCTION

The pursuit of a higher quality of life is a continuing goal for the people of this world. This has contributed to the increased consumption of goods and services. A consequence of such consumption is the production of increased pollution and large amounts of wastes. The goal of any sustainable growth should be that the efficiency of energy utilization in every step of the system, from the production of the goods to the disposal of the wastes, be maximized.

Plastic as a part of Municipal Solid Waste (MSW), has played an important role in transforming the lifestyle over the past 30 years and is increasingly used in production and consumption in all other societies, both developed and developing[1]. plastic also take up a growthing percentage of MSW stream and pose environmental challenges[2]. Its low density, strength, user-friendly design and fabrication capabilities and low cost, are the drivers to such growth[3].

There are four major ways of reducing and disposing of solid waste; source reduction, recycling, landfill and incineration[1]. Landfill dominates solid waste management in Iran. However, the costs, public opposition, health and environmental concerns have made some of these methods such as landfilling disposal options[4]. A more significant problem for landfilling is that plastic waste now constitute about 10% by weight and about 20% by volume of municipal waste stream[2]. So, the high volume to weight ratio of plastics means that on a volume basis, plastics represent between 10 and 30% of waste going to landfill[5,6]. With severe restrictions on landfill and incineration, reduction of the volume of MSW has become an increasingly important objective of solid waste management. This can be achieved through source reduction and recycling.

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Plastics recycling should always play an important role in any future plastic waste management program since in addition to reducing the amount of waste disposed in landfills, it can also contribute to the conservation of raw petrochemical products and energy saving. Plastics recycling, however, is considerably less than paper and glass[7,8]. One reason plastics are recycled less often than glass or metal is because the sorting step is very labor-intensive and, hence expensive[2]. Although the public perception of plastics and the plastics industry is not favorable at the current time, it is anticipated that these feelings many change in the future as plastics develops its own history. As a results the generation of plastic waste is expected to increase quite significantly in the future. Accordingly greater emphasis should be placed on the recycling of plastic wastes into useful and cost-effective application[8].The purpose of this study is to discuss plastic in the solid waste stream in Tehran. This study aims to:

- Determine the characteristics of MSW in Tehran, specially quantity of types of plastic wastes in Tehran.
- Analyze the components of a existing Tehran recycling program.
- Discuss the theory and problem associated with recycling program implementation.
- Determine the microbial quality of recycling plastic and recycling plastics products.

## MATERIALS AND METHODS

This study discusses the plastic wastes generation in the MSW stream and the microbial pollution of the recycled plastic wastes. The generation of plastic wastes was evaluated in 22 urban zones of Tehran. Several random samples of MSW were taken from above mentioned city zones; thus the overall weight of samples were one ton in each zone. After that the mixed samples (1 ton) were screened to determine the various kinds of generated plastics for each zone. Also, the generation trend of the various kinds of plastics was compared during 1999 to 2003.

In order to determine the microbial pollution of the recycled plastics, in five stages in which three samples were taken from grind plastic wastes, extrodered-granulated plastic wastes and manufactured products that the overall comprised 15 samples. Firstly one gram of each sample were added to 9 mL of Tripticase Soy Broth (TSB). Then, the tubes were placed in incubator with 37°C. Then, three dilution: $10^{-1}$, $10^{-2}$ and $10^{-3}$ were made from the tubes that turbidity appeared in them. To determine the bacterial count 1/100 mL of each dilution were added to the nutrient agar. Also, 1/100 mL of the main sample was inoculated on Blad agar and Mckonky agar. All the microbial examinations were followed according to standard methods[9].

## RESULTS

Tehran, the capital of Iran is the single giant metropolitan area of Iran and is the largest commercial, industrial and political center of the county. The generation of MSW in Tehran metropolitan is increasing in quantity and variety as a result of technological developments and rapid industrialization. The quality of the Tehran environment is a matter of growing concern to the city's authorities and the importance of efficient solid waste management is increasingly recognized[10]. Table 1 shows that 8.01% of total solid waste stream (2,125, 658 tons per year) is plastic wastes in 1999. Therefore, it was concluded that 168568 tons plastic wastes were generated annually. Table 2 shows the MSW generated annually in 2003, which total solid waste stream was 2,355,740 tons, in which the plastic waste was 9.61% for various kind of plastics. Approximately 50 tons per year of the total plastic wastes were recycled in Tehran. The thermoplastic waste produced annually, has begun to increase, approximately from 1.5% by weight in 1999 to 2.88% in 2003. Table 1 and 2 shows the generation trend of the various kinds of plastic during 1999 and 2003. Also, Fig. 1 and 2 show Tehran MSW components in 1999 and 2003. Although source separation program has been conducted in past years, the results showed that all plastic wastes are not separated and collected because of several reasons including: lack of public participation; no comprehensive educational program for public; and no integrated organization. Thus, performing recycling process becomes difficult, because of mixed MSW components. There are two ways to retrieve plastic wastes. The first method consists of collecting plastics after they enter the MSW stream, while the second method involves the collection of plastics before they enter the MSW stream. Thus the plastic wastes are collected and sold to small salvage dealers. Then they are given to recycling stations. The flow chart of a plastic waste recycling system is illustrated schematically in Fig. 3. Basically, the major operations involved in a waste management process include the collection of the plastic waste outside or inside the

Table 1: Types and percentage of plastics in MSW on urban zones of Tehran (1999)

| | Urban zones | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plastics waste | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | Average |
| Thermoplastic | 1.50 | 1.44 | 2.68 | 1.32 | 1.84 | 2.34 | 1.29 | 1.34 | 1.65 | 1.58 | 1.50 | 1.32 | 1.250 | 1.56 | 0.97 | 1.30 | 1.25 | 1.34 | 1.42 | 1.22 | 1.50 |
| Thermoset Plastic | 0.05 | 0.02 | 0.02 | 0.06 | 0.06 | 0.09 | 0.10 | 0.27 | 0.03 | 0.07 | 0.04 | 0.05 | 0.012 | 0.08 | 0.09 | 0.05 | 0.09 | 0.19 | 0.10 | 0.03 | 0.08 |
| Rubber | 0.12 | 0.00 | 0.03 | 1.15 | 0.17 | 0.02 | 0.00 | 0.02 | 0.33 | 0.00 | 0.31 | 0.05 | 0.000 | 0.00 | 0.33 | 0.31 | 0.00 | 0.00 | 0.00 | 0.08 | 0.15 |
| Bags, sacks, containers and other | 5.30 | 7.48 | 7.76 | 6.28 | 7.39 | 6.70 | 6.06 | 6.49 | 7.48 | 5.93 | 6.56 | 6.16 | 5.770 | 6.23 | 5.96 | 5.97 | 6.45 | 6.73 | 5.60 | 6.29 | 6.43 |

Table 2: Types and percentage of plastics in MSW on urban zones of Tehran (2003)

| | Urban zones | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plastic waste | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | Average |
| Thermo plastic (except PET) | 0.73 | 2.23 | 2.10 | 1.35 | 3.17 | 2.36 | 1.55 | 1.43 | 1.94 | 2.34 | 2.87 | 4.14 | 0.19 | 1.86 | 1.82 | 1.30 | 1.88 | 0.99 | 5.20 | 3.61 | 2.48 | 2.17 |
| Thermoset | 0.10 | 0.39 | 0.33 | 0.12 | 0.10 | 0.10 | 0.08 | 0.18 | 0.23 | 0.38 | 2.23 | 1.97 | 0.20 | 0.00 | 0.03 | 0.18 | 2.55 | 0.03 | 0.86 | 0.07 | 2.13 | 0.58 |
| Poly Ethylene Terephthalate (PET) | 0.86 | 1.03 | 1.08 | 0.40 | 0.60 | 0.80 | 0.41 | 0.57 | 1.04 | 0.55 | 0.53 | 0.61 | 0.14 | 0.39 | 0.39 | 0.63 | 1.06 | 0.52 | 1.98 | 0.91 | 0.43 | 0.71 |
| Rubber | 1.26 | 0.21 | 1.36 | 3.42 | 1.56 | 0.42 | 0.34 | 1.27 | 0.23 | 0.38 | 0.48 | 0.00 | 0.02 | 0.00 | 0.34 | 0.00 | 0.19 | 0.19 | 0.64 | 0.26 | 2.31 | 0.71 |
| Bags, sacks, containers and other | 6.08 | 5.45 | 5.57 | 8.30 | 6.39 | 5.10 | 3.87 | 6.65 | 7.27 | 5.14 | 5.77 | 4.32 | 8.45 | 8.73 | 4.91 | 5.85 | 7.96 | 6.26 | 6.21 | 5.07 | 5.73 | 6.15 |

Table 3: Microbial examinations of the recycled plastics and their products

| | Colony counts (number of colony) | | | | |
|---|---|---|---|---|---|
| Type of samples | Dilution $10^{-1}$ | Dilution $10^{-2}$ | Dilution $10^{-3}$ | Types of bacteria | Real number of colony in samples per mL |
| Collected plastic waste | Non-countable | >100 | 60 | Bacillus, Stagphyococ | 6x106 |
| Collected plastic waste | Non-countable | 150 | 60 | Bacillus | 6x106 |
| Collected plastic waste | Non-countable | >100 | 100 | Bacillus | 107 |
| Grind plastic waste | Non-countable | Non-countable | 500 | Entrobacter | 5x105 |
| Grind plastic waste | 150 | 70 | 14 | Bacillus | 14x105 |
| Grind plastic waste | Non-countable | 200 | 100 | Bacillus, Entrococ, Staphyloco | 107 |
| Extruded plastic waste | Non-countable | Non-countable | 1000 | Serratia, Staphylococ | 108 |
| Extruded plastic waste | Non-countable | 300 | 100 | Bacillus | 107 |
| Extruded plastic waste | 300 | 200 | 100 | Bacillus | 107 |
| Granulated plastic waste | Non-countable | Non-countable | 250 | Bacillus, Entrococ | 25x106 |
| Granulated plastic waste | Non-countable | 500 | 200 | Bacillus | 2x107 |
| Granulated plastic waste | Non-countable | 100 | 10 | Bacillus | 106 |
| Manufactured products | Non-countable | Non-countable | 100 | Entrobacter | 107 |
| Manufactured products | Non-countable | 250 | 200 | Bacillus, Staphylococ | 2x107 |
| Manufactured products | 400 | 100 | 30 | Bacillus | 3x106 |

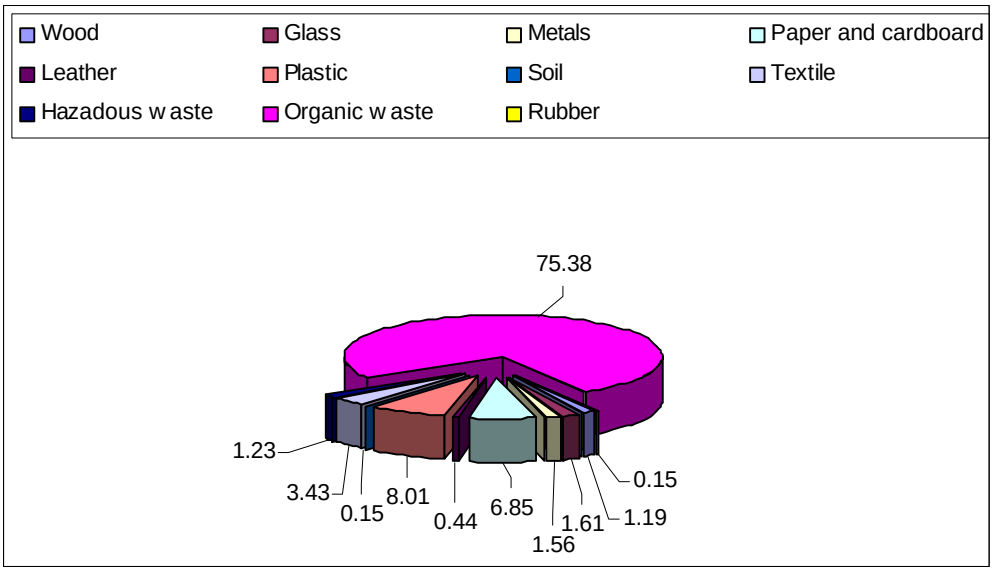


Fig. 1: Components of municipal solid waste of Tehran in 1999 (in percent)

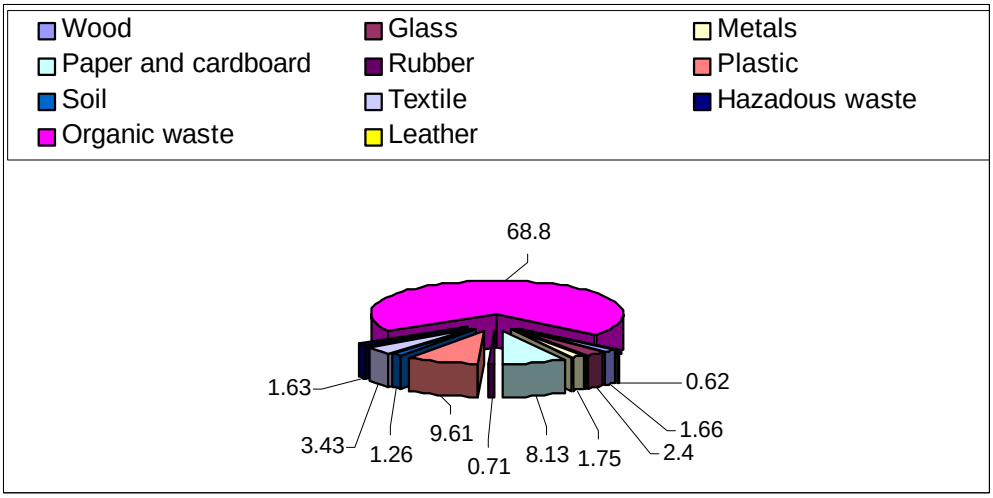


Fig. 2: Components of municipal solid waste of Tehran in 2003 (in percent)

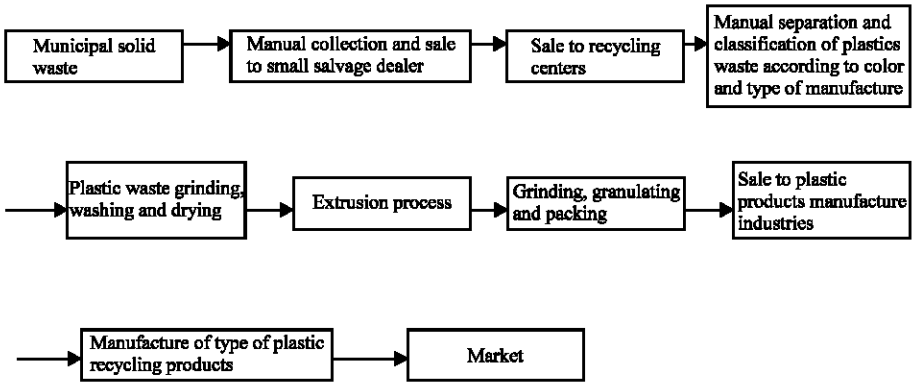


Fig. 3: Flow chart of plastic waste recycling system in Tehran

municipal waste stream, its recycling into useful products and establishment of markets for the recycled products.

The problem mostly faced with in plastics recycling is that health aspects is not respected. To highlight the significance of the health issues, microbial examination on the recycled plastics and their products were carried out. The results of Table 3 showed the following bacteria, Staphylococ, Bacillus, serratia, Entrobacter and Entrococ.

## DISCUSSION

According to the earlier studies on plastics recycling in Tehran, there are a significant difference in terms of technological and scientific aspects of recycling between industrial countries and our country. Strategies, which are environment friendly such as recycling and resource conservation, comprise a component of sustainable development. Generally, there exists potential desire and motivation for plastic recycling in developed countries. As the quality of recycled material is enhanced, the people will be more interested in using recycled products and their markets will be better[11]. Results show that the plastics have grown quiet faster than other category of MSW in Tehran from 7.93% by weight in 1999 to 9.30% in 2003. It is projected to continue to grow faster than other categories of MSW in the future because plastic has played an important role in transforming the lifestyle and is increasingly used in production and consumption in all societies.

Results show that the methods used for plastics collection and separation are not appropriate in terms of health and technical aspects. Because of lack of continual monitoring and technical program on plastic recycling, it is resulted in health problems. Table 3 shows that these plastic wastes are usually very contaminated and are therefore difficult to recycle economically at the present

time. A successful recycling program depends on consumers, government and industry[12]. However, without stable, long-term demand for the recovered material, recycling will fail[1]. As more localities in Iran introduce recycling programs, the lack of demand for recycled plastics has emerged as a major obstacle to plastic recycling. There are many anecdotal accounts of the successful use of recycled plastic for specific products, but there has not yet been a comprehensive assessment of the potential for users of plastic to absorb this material.

The results obtained by microbial tests for samples of recycled products showed the contamination of products. Although, pathogens were not found in the results. Some opportunistic microbes existed in the samples which can be potentially dangerous for vulnerable people. It should be noted that all microorganisms cannot be destroyed by extrusion process in which exposure time to heat is not enough. Thus, using recycled plastics in products especially for food or children toys may induce health risks.

Quality of recycled products are generally low. That is because of low-tech of recycling process, amortized machines, mixing of different types of plastics and miscellaneous materials such as paper, wood, leather, etc. In fact, there are many technological and economical constrainst that currently limit the full and efficient recycling of plastic waste into useful products. First, plastic wastes are often contaminated with other materials such as dirt and metals that can damage the equipment used in the reprocessing of the waste. Second, plastics are not homogenous materials like aluminum or paper, but consist of a large number of grades with different molecular structures and properties. Each plastic component in a mixed waste has a different melting behavior, rheology and thermal stability. Third, plastic mixtures are usually insoluble and form discrete phases within a continuous phase. Unless different phases have good adherence, the finished products will have poor mechanical properties and low sales potential. Fourth, plastic waste feed stocks are not usually uniform over time. Therefore, the processes used in the recycling operations should be flexible enough to accommodate various compositions. Finally, plastic wastes have a relatively low density. Thus, they are usually compacted or ground-up before transportation to reduce shipping cost. In addition, recycling will never be completely successful unless the economics and the market requirements are favorable. Construction is an example of a potentially very promising market for recycled plastic products. The development of new construction materials using recycled plastics is therefore very important to both the construction and the plastic recycling industries[8].

The result showed that, unfortunately, there exists no national standards to use plastic wastes as fillers with virgin resins or new materials, while it is recommend to introduce 5-10% of recycled plastics for new products manufacturing in developed countries. Extensive researches have been made on recycling products after being used by consumers and recycling is of significant importance in developed countries. Both economic and environmental impact assessment (EIA) have been carried out in developed countries. EIA was carried out in terms of energy consumption, air and water pollution from collection of raw materials to the manufacturing and consumption phase. According to the comparison of packaging of yogurt either in plastic or in glass indicated that in glass containers manufacturing process, air pollution, water pollution and waste volume are 3, 5-6 and 5-6 times more than plastics containers, respectively. Plastics application results not only in decreasing raw material use but also in decreasing of transportation; in other words, 40% of goods weight was related to glass containers, while this reduces to 7% when using plastic containers. In addition, fuel consumption reduces 30% when plastic containers are used for yogurt packaging.

In spite of the importance of participation for recycling schemes there has been relatively little attention about it. The perception of plastics by members of the public may have significant effects on their willingness to participate in recycling schemes[13].

Plastic recycling is carring out mechanically in Tehran. However, this simple method is not scientifically approved for collection, separation, grinding, extrogen, granulization and products generation. Since the generated products have low quality, the overall efficiency in terms of investment, time and energy consumption is not very high so that usable life of these products is short. During recycling process the different kinds of plastics made of various polymers are mixed together to generate the final products. Thus, the overall quality of the final products decreases.

As a results, the following points should be take into account for plastic recycling across the country:

- The first stage in the implementation of a mandated recycling program involves drafting the legislation and reorganizing the government infrastructure to support the program. The recycling systems would work most efficiently if each county and municipality were required to design their own system.

- Technically and scientifically improvement of wasted plastic recycling.
- Intersectional cooperation between involved organization.
- Encouraging public participation and awareness regarding source separation of solid wastes. The more public participation increase for source separation, the higher efficiency will be achieved.
- Setting criteria and standards for produced recycled materials to improve the quality.
- Providing financial support to encourage recycling development in county governments, municipalities and private companies.
- Developing a market for recyclable materials.
- Providing promotion, education and, when necessary, enforcement of recycling activities. In fact, changing the conventional attitudes and throwaway behavior through education is likely to be most difficult part of the program[4].
- Technically and Scientifically improvement of wasted plastics recycling.

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