



The 1<sup>th</sup> International and The 4<sup>th</sup> National Congress on  
Recycling of Organic Waste in Agriculture  
26 – 27 April 2012 in Isfahan, Iran  
Investigation the Potential of Recycling Urban Solid Wastes  
(Case Study: Ardakan City)



<sup>1</sup>H. Zarei Mahmoodabady; <sup>2</sup>M. CHabok; <sup>3</sup>Fa. Morady, , GA.Rigi Cheshmali<sup>4</sup>

<sup>1</sup>Department of Environmental Engineering, Maybod Campus, Islamic Azad University, Yazd, Iran

<sup>2</sup>Consulting of Sanat Pooyan Sabz Kavir Company, Esfahan, Iran

<sup>3</sup>Teacher of Maybod Education Department

<sup>4</sup>M.Sc graduated of agriculture biotechnology, Iran

## ABSTRACT

Recycling is a solution to control the problem of managing urban solid wastes such as incineration and sanitary landfill. It consists re-processing of products and materials, which have been consumed several times. The methods which are presently used for recycling and processing the wastes of Ardakan City consists of collection by wastes collectors, separation by urban service labors and separation in landfill. Existence of unofficial and non-hygienic recycling workshops in the region, presence of unauthorized factors who are mostly non-local and usually call homes with carts or Nissan cars and buy the household dry wastes, lack of sufficient training to recycle, absence of processing and technical knowledge in processing field, low public and specialized knowledge on recycling among managers and citizens, unhygienic items produced by recycling and hucksters going door to door with a highly unsuitable clothes and carrying a containing the wastes and garbage in the area are among the problems, weaknesses and limitations that exist in the processing and recycling in the district.

The results of research show that recycling elements such as plastic, metals, glasses, paper, cardboard and boxes in production origin is possible in the region. With respect to 648 grams waste per capita in a day and population of 54500, around 35.5 tons wastes are produced in the city of Ardakan. 58.53 % of wastes are made of organic materials (highest amount in summer with 68.88 % and least amount in winter with 47.48 percent, 8.9% is paper, newspaper and card boxes, 3.8 % is glass, 6.30 % metals and 10.1 % is plastic and PET. In sum, around 87.63 percent of wastes of Ardakan city could be consumed again (compost and recycle) and since 29 percent of the wastes are dry recyclable wastes, around 10 tons dry recycle could be recycled. In sum, annual 12535.5 tons wastes are recyclable of which amount, 3656 tons are dry wastes.

Since daily 3056 kilograms papers and cardboard, 3022 kilograms plastic, 2164 kilograms metals and 447 kilograms PET are recyclable in the origin and the approximate price of each one of the above-mentioned items in the zone in Rials per kilogram is 800 Rls., 2800 Rls., 3000 Rls., And 2000 Rls. The total price of the recycled elements is 18292400 Rials per day. This is a significant amount and could meet demands of parts of relevant costs related to collection, transportation and final disposal of urban wastes. By performing recycling plans in production origin, not only there will be savings in raw materials, but also new jobs will appear. In addition, environment pollution is decreased and the transfer of diseases cause by wastes in the society is prevented significantly.

**Keywords:** Recycle, Solid waste, Ardakan

\*  **Corresponding Author:** [hadyzareei@yahoo.com](mailto:hadyzareei@yahoo.com)

## INTRODUCTION

Establishing wastes collection and disposal management system is one of the cases that has basic importance for controlling production, saving, consuming materials and process of collecting and burying wastes. The comprehensive wastes management is a selection of combining techniques technologies and material plans to achieve its goals; that is, protecting environment and controlling pollutions caused by these materials (Abbaspour, 1998). The

mentioned management should cover the entire sections (urban, industrial, agricultural, hospital, ... wastes). In 1992 in Rio, different issues were discussed under topic of Earth and a report was presented as agenda 21. In the “wastes” part of this report, it was confirmed that if necessary actions are not taken in wastes area, with respect to increasing the 5.3 billion population of 1992 to 8.5 billion in 2025 and by considering the increase in wastes per capita, the volume of wastes produced by people will be 4 to 5 times more and it was emphasized that following actions should be taken as the basis of future plans in all countries: lowering the volume of wastes, developing techniques for re-use and recycling wastes and encouraging and reinforcing wastes management system in favor of environment (Majlesi, 2007).

Recycling is a process in which, the materials are collected and separated to be used as raw materials for producing new products (Omrani, 1995). Recycling is the major and substructure part of any wastes management comprehensive project. Recycling could not solve the problem of wastes management in the society; however, it can prevent the arrival of considerable amount of wastes to landfill and or wastes burn installation. The recycling plans need a strategic design. When recycling is performed properly, it will turn into a favorable activity of citizens to management urban solid wastes (Imandel, 1998).

## MATERIAL AND METHODS

To perform household wastes management studies in any city, it is necessary to know the constituents of wastes; that is, physical and chemical analysis, measurement of weight, volume, quality and quantity wastes parameters in four seasons. Hence in this method, based on the most recent instructions available in world, the wastes of different parts of Ardakan city were collected for ten days in the mid of each season so after evaluation and conforming the conditions as they could be used a basis in studying the quality of wastes in Ardakan City. Therefore, the methods of collecting wastes baskets from houses without previous knowledge of habitants of the houses was adopted. Then, with respect to the geographic, social, economic, urban and cultural textures situations, the city was divided into few blocks. The sampling days were Saturday to Thursday and in all blocks of the city and the sampling of each region finished in one day.

Sampling was made in all seasons and for each month separately. That is, each month, samples were taken from 10 block. The procedure was that, every morning, a van and sampling container were moved in the concerned region and three samples with one cubic-meter volume were prepared. First, each sample was weighed and its weight was noted down. Then materials, which were separated, consisting papers, plastic, glasses, metals, bones, woods, textiles and organic materials as well as other materials were separated. After this stage, weight of each one of the groups was divided into total weight of the sample to calculate their weight percentage. In this way, the weight percentage of all samples and their constituents were calculated and measured. Along with this, the density of samples was measured. The procedure was that weight of each sample was divided into volume- one cubic meter in this research and ultimately the obtained number showed the density. For the purpose of making an optimized design of different stages of waste management, such as transportation and process of materials recycling, determining final method of discharge and determining the production rate are required. This was found from proportion of population of families subject of study and number of times the wastes were collected and the collection dates were calculated per man per day in kilogram scales.

## RESULTS

### Study the sources and amount of wastes production and per capita in Ardakan city

The important sources of producing urban wastes are residential, trading, educational center, administrative, medical treatment, construction activities, water treatments, incineration, different industries and agricultural activities. Based on the studies, it was known that 35.5 tons household wastes were collected from Ardakan city and Turkabad village by municipality workers and transportation to landfill (table1). Since population under municipality services

Ardakan city and Turkabad amounts to 54500, the per capita production in a day 0.648 kilograms solid waste.

Table 1: Amount and type of production wastes as per different sections in Ardakan City

Type of wastes	Qty/Kg/day	Qty/Ton/Yr
Household	35300	12885
Business & administration	3500	1277.5
Industrial	2100	766.5
Hospital	600	219

### Physical analysis of wastes of trade-administrative units in Ardakan city

To calculate the amount of production wastes of trades, administrative, general and educational units in the city of Ardakan, the units were identified and amount of wastes of each unit are weighed. Based on studies, an average 3 to 4 tons wastes were produced in administrative and trading units and in proportion of population in Ardakan city, the per capita production of these units are 57 to 75 grams per day. The result is that average production of wastes per day in Ardakan city (by calculating daily administrative and trading wastes of 66 grams per capita), is calculated to be 648 grams per day.

Population ÷ Administrative, trade wastes = Waste production per capita of businessmen

3000 ÷ 53000 = 57 grams per day, waste production per capita of businessmen

4000 ÷ 53000 = 75 grams per day, waste production per capita of businessmen

The production of waste per capita \* population = Amount of daily products (in kilograms)

54500 \* 0.648(g) = 35316 Kg, 35.3 tons per day = the daily products in kilogram: 35.3

Table (2): amount of products wastes per day in different blokes of Ardakan City

Name of region	Number of families	Number of members	Weight of waste (Kg)
Sadrabad	4	12	9.1
Baghestan	3	12	7.200
Mazrae Seyf	3	12	7.5
Jafarkhan	4	15	8.9
Bazarnow	5	23	12
Charkhab	5	21	11.5
Torkabad	4	15	8.7
Shraifabad	4	15	8.8
Shahrak Fajr	3	12	8.3
Shahrak Valiasr	3	13	7.9
Deylam	3	17	7.4
<b>Total</b>	<b>41</b>	<b>164</b>	<b>97.7</b>



Table 3: Calculation of wastes production per capita in Ardakan City

Number of families	41
Population	167
Family dimensions	4.1
Waste quantity/ Kg	97.3
Wastes products per capita/day/gram	582

Table 4: Amount of waste production in Ardakan City as per day, week, month and year

Topics	Qty
Waste products of each citizen per day	648 gr
Waste products of each citizen per week	4.5 kg
Waste products of each citizen per month	19.7 kg
Waste products of each citizen per year	236.5 kg
Waste products of each family per day	2.6 kg
Waste products of each family per week	18.2 kg
Waste products of each family per month	79 kg
Waste products of each family per year	949 kg
Waste products of Ardakan city per day	35316 kg
Waste products of Ardakan city per week	247.2 ton
Waste products of Ardakan city per month	1060 ton
Waste products in Ardakan city per one year	12884.5 ton

### Physical analysis of Ardakan solid waste

The first step for determining a proper and careful urban wastes management is to gain knowledge of specifications of the wastes that have important role in evaluation, design and selecting suitable facilities in different stages of wastes management. Determining the quality and compound of wastes is important in their physical, chemical and biological aspects. The information and physical data of wastes composition has important role in the selection and implementation of equipment and facilities of disposal system, wastes recycling and the possibility to recycle materials and energy.

Table 5: Physical analysis of wastes in Ardakan City as per different seasons of the year

Season	Wastes weight	Density	Decaying substance	Paper	Cardboard	Rubber	Plastic	PET	Textiles	Glasses	Ferrous metals	Other metals
Fall	132.98	237.29	68.14	5.88	7.88	2.68	11.7	1.75	5.55	7.83	2.94	8.98
Spring	114.22	237.93	78.55	3.16	5.56	1.71	7.11	2	6.69	1.6	1.27	4
Summer	109.16	227.38	75	2.05	4.7	1.5	9.6	0.83	4.88	2.22	0.38	4.08
Winter	117.95	235.88	56	4.99	8.21	2.01	13.49	1.23	6.16	6.53	1.56	7.11
Total	474.21	238.48	277.69	16.08	26.35	7.9	41.9	6.11	23.55	18.18	6.15	24.16
Average	118.6	234.62	69.42	4.02	6.58	1.975	10.48	1.52	5.88	4.54	1.53	6.04
Percent	100	-	%58.53	3.4	5.5	1.6	8.8	1.3	4.95	3.8	1.3	5

Based on table, 29 percent of products wastes of Ardakan city are made of materials that could be recycled in the production origin and by recycling them in the production origin, in addition to lowering the weight of wastes, there could be savings in using materials and resources. In 58 percent of wet wastes, mainly foods and plants wastes, the products could be used for fertilizer productions. 58.53 percent of wastes consist of organic materials (highest amount in summer in 68.88% and the least amount are in winter with 47.48%), 8.9% is paper, newspaper and cardboard, 3.8 % is glass, 6.3 % is metals and 10.1 %t is plastic and PET. In sum, 87.63 percent of wastes in Ardakan city could be re-used (compost and recycle).

### Study the existing situation of recycling and processing wastes In Ardakan city

Methods that using in Ardakan city in order to recycling and processing waste are:

#### Collection by huskers

Methods which are mostly used in Iran, like any other developing country like India is that, there are huskers who collect different plastic, paper, glass and bread wastes in inbound stations, blocks and stations. In addition, there are other huskers known as “Namaki” who have collect wastes and particularly breads in blocks from houses in exchange of objects, money or salt. In general, due to lack of specific control. In this method, the process of separation and collection will bring no profit for the municipality and in addition the subsequent losses will come along, among which, one may recall undesirable and non-hygienic use of those materials in processing plants and creation of false jobs.

#### Separation by municipality workers during collection

It has been frequently seen that municipality workers collect separated materials from citizen or divide special cases (plastic, metals,...)from wastes during collection operations (picture 1). In fact, in some extent, this is done by the huskers for the municipality or by the municipality workers; however, if this method is taken under supervision and control, it could make a great help to the collection and separation materials properly. This happens if municipalities present a developed plan to citizens and make municipality workers to take actions for following those plans. As an example, distributing bags for collecting dry and wet materials separately. On the other hand, the citizens (by proper education) learn to collect the wastes separately in the bags

(offered in different colors) and hand them over to the municipality workers in proper time intervals.



Fig.1: Recycling and non-hygienic separation by municipality workers during collection process

### **Warehouses and workshops of buying wastes**

At present, there are seven warehouses in the city for recycling and purchasing wastes, most of them are run by Afghan migrants. In these workshop, the wastes of garbage of the city which are collected by people, shopkeeper and urban service labors are purchased. It has been observed that manager of each workshop hired few Afghan young labors and collects dry wastes from houses by those labors (Picture 2).

### **Separation in landfill**

From the utilization date from landfill of Ardakan, two Afghan contractor with coordination of municipality of Ardakan (official and non-official) separate the materials. That is, the vans of wastes delivery discharge the waste in the determined spots after entry to burial place. Each contractor has some Afghan workers under recruitment (most of them are unemployed or seek work). In the beginning, worker collect and separate wastes such as paper, card box, plastic and wet wastes in a non-hygienic and bad situation (picture 3). In next stage, the remaining wastes are burned and after a few days, only metals (iron, tins, copper, zinc, ... ) remain and labors separate and isolate them. Workers separate the wastes such as paper, cardboard, plastic, Pet and wet wastes in a very non-hygienic ways (picture 3). In next stage, they burn remaining wastes and after few days, only the metals (iron, tins, copper, zinc, .... ) remain and they separate them.





Fig. 2: Workshop buys dry wastes in Imam Street in non-hygienic way



Fig.3: A view of recycle in landfill of Ardakan city

### DISCUSSION AND CONCLUSION

Existence of non-official and non-hygienic workshops for recycling materials in the region, presence of unauthorized persons mostly non-local who usually turn to houses with carts or Nissan cars that buy the dry wastes of the families, insufficient training for recycling, absence of technology and modern know-how in processing, low public and specialized knowledge on recycling process among managers and citizens of the region, non-hygienic status of products made from recycled materials and huskers with serious unsuitable place carrying sacs containing wastes in the region are among problems, weaknesses and limitations in processing and recycling the wastes in the region.

With respect to 648 grams per capita per day and 54500 population, 35.3 tons of wastes are produced in Ardakan city every day. 58.53 percent of wastes consist of organic materials (highest amount in summer in 68.88% and the least amount are in winter with 47.48%), 8.9% is paper, newspaper and cardboard, 3.8 % is glass, 6.3 % is metals and 10.1 % is plastic and PET. In sum, 87.63 percent of wastes in Ardakan city could be re-used (compost and recycle) and since 29 percent of it is dry wastes, around 10 tons of dry wastes could be recycled per day. In sum, 12535.5 tons wastes are produced per year of which, 3656 tons are dry wastes. Table number 6 shows the percentage and recyclable substances of wastes in Ardakan in day and year and table 7 shows the amount of recyclable wastes in Ardakan per citizens and families.

Table 6: the percentage and recyclable substances of wastes in Ardakan in day and year

Elements	percent	Qty / kg/day	Qty / ton/year
Paper & cardboard	8.9	3056	1116
Plastic	8.8	3022	1100
PET	3.1	447	163
Glass	8.3	1305	476
Metals	3.6	2164	790

<b>Total</b>	-	9994	3645
--------------	---	------	------

Table 7: Amount of recyclable wastes in Ardakan per citizens and families

<b>Title</b>	<b>Quantity</b>
Amount of recyclable wastes of each citizen per day	189 gr
Amount of recyclable wastes of each citizen per week	1323 gr
Amount of recyclable wastes of each citizen per month	5750 gr
Amount of recyclable wastes of each citizen per year	69 kg
Amount of recyclable wastes of each family per day	756 gr
Amount of recyclable wastes of each family per week	5292 gr
Amount of recyclable wastes of each family per month	23 Kg
Amount of recyclable wastes of each family per year	276 Kg
Amount of recyclable wastes of Ardakan City per day	10017 Kg
Amount of recyclable wastes of Ardakan City per week	70119 Kg
Amount of recyclable wastes of Ardakan City per month	305 tons
Amount of recyclable wastes of Ardakan City per year	3656 tons

Daily decrease of about 10 tons (29 percent) of weight of production wastes due to recycling causes that first, there will be savings in the costs of collection and final disposal; Second, a part of costs of urban services are provided from selling recycle materials. It should be noted that the recycled materials have low density and therefore take a large volume and the transportation and collection costs decreases more than 20 percent. On the other hand, by recycling this part of wastes, the size of land needed to bury the wastes lowers and this makes further saving in burial costs. Recycling waste in production origin decreases non-decaying materials of waste and this is favorable for producing compost from the wastes as a final disposal options since it lowers impurities of composts processed from urban wastes. If the decaying part of urban wastes where the non-decaying materials of it is ordinarily recycled in production origin are buried in sanitary way, after few years, the buried materials of them could be taken out to be used as fertilizers in soils that have shortage in organic substances and use the place again for burying wastes.

By adopting a recycling plan in production origin, while there will be savings in raw materials, new jobs could be created. In addition, environmental pollution will be lowered and many diseases that are transferred as a result of handling wastes in the society are controlled significantly. Since approximately 3056 kilograms paper and cardboard, 3022 kilograms plastic 2164 kilograms metals and 447 kilograms PET could be recycled in production origin and the approximate price of each one of the above-mentioned substances in Ardakan is 800, 2800 3000 and 2000 Rials respectively the total price of the recycled substances becomes 18292400 Rials per day. This is a significant amount and could cover a part of expenses of collecting, transporting and final disposal of urban wastes.



Table 8: Profits earnable from recycling dry wastes in Ardakan City

Elements	Percent	Qty( Kg)	Price( Kg/Rls)	Income (day/Tumans)	Income (year/Tumans)
Paper	8.9	3056	800	244480	89235200
Plastic	8.8	3022	2800	846160	308848400
PET	1.3	447	2000	89400	32631000
Metals	6.3	2164	3000	649200	236958000
<b>Total</b>	<b>25.3</b>	<b>8689</b>	<b>-</b>	<b>1829240</b>	<b>667672600</b>

It should be noted that the numbers in table are without consideration to current cost and capital expenses and only show sales.

To recycle introduction origin, one of the approaches could be development of regulations and laws in this area and having executive guaranty for laws and relevant regulations. As an example, there should be some laws that require people to hand over to the municipality worker only their decaying wastes and the labors in municipality department do not collect objects that would not be decayed. However; the experiences of different countries and cities have shown that executing such plans not only is unsuccessful for wastes recycling projects, but also it has been harmful in hygienic terms and if the municipality workers do not accept non-decaying materials, there should be other environmental risks. Another approach is that municipality announce to citizens to collect decaying and on-decaying wastes separately and give special time for collecting each. In this approach, municipality should directly separate the non-decaying wastes from the decaying materials and pay off the recycling costs from this income. However, due to the social and cultural views of Ardakan city, this does not seem favorable.

The third approach is a completed form of second approach. In this approach, municipality buys the non-decaying materials form people. Of course, the trivial profit might make this plan unattractive for people and does to bring people participation; therefore, the only practical way for recycling urban wastes as experienced in other countries is to change the attitude and improve people's knowledge through education. In this method, people receiving trainings to change their attitudes on wastes and thus, they volunteer to participate and by their participation, this hygienic plan will be successfully launched. The subject that will have high importance will be the training methods and quality; for, if the training is wrong or incomplete, no desirable result will be gained. Therefore, training plan should be scientifically and reasonably. Obviously, improving people's knowledge and growing a positive perspective in connection with recycling will be followed by an over all participation that would guaranty the success of plan.

The certain subject is that the culture of re-using waste materials has been existing in the region and our ancestors practically throw nothing out. Since success in performing recycling and separating from origin requires comprehensive cultural and social studies and if all aspects are not carefully considered, there might be some negative reaction in citizens. The time that this

goal oriented event is executed in the region and the percentage of success in the plan are important issues; therefore, we suggest that a 5-year plan could be the best method of managing urban wastes- that consists of recycling and division from production source- and since the plan will be executed in this city for the first time, to gain experiences and achieve results and the goals of plan and with respect to the different production sources of wastes (household, hospital, industrial) and subsequently variety of physical compounds and constituents of the wastes, it is better to take followings:

Executing a plan for recycling and division from origin should be done step by step and through determining city blocks and setting a suitable time plan so in next stages and after preparing ground of recycling culture and dividing from origin, the plan could be performed across the city easily and with least executive barriers. Therefore, for establishing and implementing division system from origin, following executive steps are suggested. The executive procedures and managerial approaches should be presented for each stage accordingly.

### **The five-year plan for executing division from origin in the city of Ardakan**

In this plan, it is suggested to perform the system of separating materials from origin in a five-year plan across the city in following schedule. Since the main step in the process of separating from origin is training, the above-mentioned time plan is mostly developed based on educational goals and at the end of the first five-year plan, the collection of dry and recycled wastes become a public issue. Since origins of wastes products, including houses, organizations, residential townships and plants are spread across the city, the collection system should be changed and the city could be divided into three zones or blocks. After giving a code to each block, the three blocks could be assigned to three qualified contractor to perform separation from origin and collection in the most desirable way.

Table 8: Schedule and executive five-year plan for separating the wastes in Ardakan city from the origin

Phase	Limit and range of plan	Necessary time	Starting time
<b>One</b>	All governmental and non-governmental organizations	One year	First year
<b>Two</b>	All governmental and non-governmental organizations + residential townships	One year	Second year
<b>Three</b>	Limits of phases 1 + 2 and one third of urban limits	One year	Third year
<b>Four</b>	Limits of phase 3 + two third of the city	One year	Fourth year
<b>Five</b>	The entire city	Permanently	Fifth year

### **References**

- Imandel, Karmatollah, Abbaspour, Majid, Study Recycling of Paper and Cardboards in Tehran, Ecology Journal, No. 19
- Imandel, Karmatollah, Mohammadnejad Moghaddam, Akbar, 1998, Recycling bread wastes in the country and the health issues involved, Ecology journal, No. 17
- Dabiri, Minoos 2000, Environmental Pollutions, Tehran University Press
- Abdoli, Mohammad Ali, 1993, Urban Solid Wastes and Control Methods Management System, Recycling and Processing Organization of Municipality Tehran
- Omrani, Ghasemali, 1995, Solid wastes, I.A.U. Press
- Abbaspour, Majid, 1998, Environmental Engineering, I.A.U. Press
- Majlesi, Nayereh, 1992, Solid Wastes Materials Management (Principles of Engineering and Managerial Issues), 2<sup>nd</sup> Vol. Recycling and Processing Organization Publication
- Yaghmaian, Reza, 1998, Solid Wastes, Education and Technical Complex Publication of Tehran
- Majlesi, Monireh, 2007, Role of Public Participation in the Mechanized Collection System, Third National Congress of Wastes Management