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ORIGINAL ARTICLE

Recycling of Dry Household Waste Materials on Urban Environmental and its Economical Evaluation Analysis (Case Study: Ahvaz City-Iran).

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ABSTRACT

Recycling is a ring in the chain of solid waste management and is the most important method for mitigating the solid waste problems and is of special importance in the national economy. In Iran, in the last two decades the concept of recycling has been functionalized. Ahvaz with a population of over 1115133 produces more than 1409 tons of wastes every day. The study method is based on valuating recyclable materials and also by cost-benefit analysis method. In this research, the study of economic value of recyclable domestic wastes in districts of municipality of Ahvaz has been addressed using cost-benefit analysis in the first six months of the year 2008. The net benefit resulting from recycling which is the difference between gross interest and recycling costs is illustrated by calculating the costs and revenues of recycling. Also, in this study it is shown that recycling can save solid waste management costs (collection, transportation and landfill) and can create revenues for the municipalities. Then, costs and revenues present value has been calculated during 2008 to 2012 using Net Present Value (NPV). Because NPV of this project is positive, recycling domestic wastes is economically justified and requires more attention from authorities. The net benefit resulting from the entire recycled materials in the first six months of 2008 in the total eight districts of municipality of Ahvaz is approximately 54857983200 Rials. Recycling 89940063 Kg of dry wastes in the mentioned districts has resulted in the reduction solid waste management cost as much as 15559630899 Rials in the six months of 2008 and has created revenue for the municipality.

Key words: Ahvaz city, Cost benefit, Dry residue, Economic value, Recycling

Introduction

Solid waste management hierarchy creates a clear vision for designing solid waste management and creates strategies and highlights different options in the order of importance [1]. Its aim is to create the best possible scientific method for solid waste management to minimize the amount of solid waste. Recycling of urban waste materials avoids the cost of incineration and residue burial expenses which are

necessary affairs to protect natural resources and environment [2]. With developing recycling industry and establishing advanced recycling plants in cities, they can lead to economical advances with spending minimum of costs. Recycling is a solution that its cost is affordable. Because it costs less to municipalities than land filling or burning the residues. [3]. Considering the growing population and increasing attention to the protection of the environment, recycling and reuse problem in the

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production cycle have gained a great deal of attention.

Recycling, if it's done on the basis of criteria and hygienic aspects, regardless of pollution controlling, can cause in 50 percent cost saving in cost collection and transportation of materials that include 80 percent of their total costs of solid waste management [4].

The idea of recycling and recreating solid waste have been implemented due to preventing unfair plunder of natural resources, reducing energy consumption and to reduce costs of burying waste materials; thus recycling or reusing raw materials lead to the reduction in the use of disposable materials and it also compensates its shortage. Therefore, concerning the recycling system, the idea of both the ecologists and economists will be taken into account [5]. But the important issue that will be considered comprehensively, will be deemed as more economical; although reduction of utilizing natural resources, energy, and raw materials lead to national cost saving. This will neglect other costs as well. The economy of recycling largely depends on the cost of other waste management methods, the marketing of recycled materials, and the cost of functionalizing the recycling programs. It has always been thought that recycling is not hygienic, economical, and it has also been ignored. The price of recycling is another main reason in recycling economy. Unstable and low prices have caused sluggish market in second-hand materials. Without a reliable market and a great deal of space to store materials, this will not be a practical plan. Cost-effective recycling program demands economical cooperation of many consumers [6]. Considering the pre-mentioned issues, people's opinions about recycling materials even with economical materials should be directed.

Materials and methods

The methodology in this paper is based on the valuation of recycled materials in the market of these materials in Ahvaz. At first, the scientific finding in the field of recycling activates in different countries and the economical-environmental benefits were investigated through the web. Then, the economical values of recycled materials in Ahvaz based on current data were scrutinized thoroughly. First of all, costs and revenues of recycling were calculated, then after subtracting the cost of recycling from gross income, net present value was obtained. Present value of costs and revenues using the net present value of economic index are calculated. The economic index that is used in this paper is net present value (NPV).

A: *Cost-benefit Analysis:*

In solid waste management projects, to obtain an appropriate and real response and also to compare variety of options from an economical view point, cost - benefit analysis is used, which is more reliable than other methods [7]. To calculate net profit this method has been used.

B: *Net Present Value:*

Net present value is the result of net present of revenues minus the present value of costs. The formula to calculate net present value is:

$$\sum_t \frac{B_t - C_t}{(1 + r)^t}$$

According to the analysis of cost-benefit, to implement any project or policy, the amount of NPV must be positive. In such, a case a project or plan is economical. If the amount is negative, it has no economical justification and should not be invested [5].

Considering the act that costs and expenditure will be made during the implementation period, net present of revenues and incomes will be calculated, then the cost from the revenue will be reduced. The investment project concerning recycling demands a primary cost that is shown as C_0 . The project revenues are shown as $TR_0, TR_1, \dots,$ and TR_n . Recycling cost including current costs (Workforce, cost of repairing and preserving the equipments, raw materials, so forth) that are shown in VC_0, VC_1, \dots and VC_n . Since costs and revenues occur during various episodes that have no value, to evaluate the project, the costs, and the revenues, at first they should be converted into the present value; then subtracting the costs from the revenues will be possible.

The present value of TR_0 equal to TR_0 , TR_1 equal to $\frac{TR_1}{1+r}$ and TR_n equal to $\frac{TR_n}{(1+r)^n}$ that r refers to interest rate of market; thus, the present value of current expenses are $VC_0, \frac{VC_1}{1+r}, \dots, \frac{VC_t}{(1+r)^t}$.

The current value of C_0 or primary cost is C_0 itself, because it occurs at the first stage. To understand the economical justification of the project, the difference between the present value of total revenues and total present value of project costs have been obtained that is the net cost or profit of the project and it is calculated by means of the following formula:

$$NPV = \sum_{t=0}^n \frac{TR_t - VC_t}{(1+r)^t} - C_0$$

The statistical survey is related to Ahvaz eight urban districts. The data in these districts are related to the amount of domestic waste separation of recyclable dry waste, household waste collection rate of these districts, quantitative analysis of household waste and prediction of costs and revenues from recycling of dry waste for future contractors (if the source separation of stations will be created), the costs of solid waste management and they also have been the estimation of daily cost of recycling materials. Having done the aforementioned stages to gain the conclusion, concluding the data, then the analysis and description of each table and chart related to income, expense, and net profit from recycling were calculated. In this research Microsoft Excel, the statistical software for data analysis has been used.

Results and discussion

The Quantity and Quality of Household Waste Materials:

Ahvaz, with 1115133 inhabitants living in 235577 households residing in eight municipal districts [8]. The urban waste materials consist of variety of residential, commercial, administrative, educational, hospital, etc, that are transferred to be dumped in Boroumi by municipal employees and contractors. The overall urban solid waste materials that were collected in 2008 in Ahvaz were 1409 tones every day (Table I) [9].

According to the performed calculation, based on the income resulting from each recycled item presented in table 4, the total income of contractors in Ahvaz is 60809.9 million Rials (each US dollar is equal to 10400 Rials, the Iranian currency). As it is noticeable in table IV, the average income of contractors is higher if the complete recycling of plastic is more than the other dry waste materials and their income would be less if the glass is recycled completely.

The highest rate of domestic waste material is 60.11% that is related to Putrescible materials. Tables II and III indicate the physical comparison of domestic waste materials in Ahvaz in 2008 that are shown according to each urban district.

Total revenue from selling recyclable dry waste material taken from separating stations of sources in all eight districts in Ahvaz during the first six month in 2008. 60809983200

Total net profit from selling recyclable dry waste material taken from separating stations of sources in all eight districts in Ahvaz during the first six month in 2008 is as follows:

Gross income – cost= 60809983200 – 5952000000 = 54857983200 Rials

Total net profit from selling recyclable dry waste material per month:

$54857983200 / 6 = 9142997200$ Rials

Total net profit from selling recyclable dry waste material per day:

$9142997200 / 31 = 249935393$ Rials

The cost of collection, transportation, and disposal of waste materials in all eight districts in Ahvaz per kilogram is described in table V, [10].

With total recycling of 89940063 kilograms of recyclable waste material produced from eight districts in Ahvaz during the first six months in 2008, there has been a great deal of saving in waste management costs.

With total recycling of recyclable household waste material, there has been a great deal of saving in the costs of collection transportation, and disposal of waste materials, that is, 173 Rials per kilograms that is $89940063 * 173 = 15559630899$ Rials absolute income for the municipality of Ahvaz in case of recycling of household materials through all eight districts of Ahvaz during the first six months in 2008; thus 15.559 million Rials can be saved that can cause an income for the municipality.

With recycling of 89.940 thousand kilograms of dry waste materials in urban areas of Ahvaz during the first six months in 2008, it was shown that 172133937 kilograms sepulchral waste out of 262.074 Thousand kilograms will remain; thus the municipality instead of paying 45.338 million Rials during the first six months in 2008 for collection, transportation, and burial of waste materials, will be forced to pay 29.779 million Rials. This difference leads to the reduction of costs and creation of much income for Ahvaz municipality (Table VI).

The calculation of the previous table with assuming constant income during six years from 2008 to 2013 has been calculated. Also, in the annual waste management costs %15 and in the annual recycling costs %10. After calculating income and expenses, if the current value of investment costs and the net income of the project are calculated and added up, the NPV of the project could be obtained. In this paper, NPV has been calculated under two scenarios. In the first scenario the reduction is %10 and in the second one it is %14.

A: the calculated NPV based on the first scenario ($r=10\%$):

$$NPV = 140835228198 + \frac{144312717168}{(1+0.1)} + \frac{148371350128}{(1+0.1)^2} + \frac{153104249367}{(1+0.1)^3} + \frac{158619103380}{(1+0.1)^4} + \frac{165040406247}{(1+0.1)^5} - 10000000000 = 710918325517 \text{ Rials}$$

B: the calculated NPV based on the second scenario (r=%14):

$$NPV = 140835228198 + \frac{144312717168}{(1+0.14)} + \frac{148371350128}{(1+0.14)^2} + \frac{153104249367}{(1+0.14)^3} + \frac{158619103380}{(1+0.14)^4} + \frac{165040406247}{(1+0.14)^5} - 10000000000 = 654821958446 \text{ Rials}$$

Table I: The rate of domestic waste material based on Ahvaz eight urban districts in 2008.

District	Amount of waste annually (Kg)
1	94900000
2	40150000
3	52560000
4	85775000
5	56940000
6	90155000
7	60955000
8	32850000
Total	514285000

Table II: Comparison of final results of physical analysis of household waste materials in different seasons in Ahvaz. (Percent).

Type	Spring	Summer	Fall	Winter	Average
Putrescible materials	63.5	55.7	57.12	64.14	60.11
Paper and paperboard	11.8	13.55	16.57	13.4	13.83
Wood	0.76	1.28	1.72	0.51	1.07
Plastic	11.5	14.5	12.88	11.77	12.66
Pet	0.64	0.32	1.62	2.07	1.16
Textiles	2.65	4.67	4.14	3.18	3.66
Metals	0.9	0.98	1.08	1.05	1
Glass	2.17	3.82	3.4	2.86	3.06
Construction garbage	1.19	3.43	1.75	1.27	1.91
Bone	1.12	2.7	0.67	0.45	1.23

Table III: Comparison of final results of physical analysis of household waste materials in eight districts in Ahvaz. (Percent).

Type	District1	District2	District3	District4	District5	District6	District7	District8
Putrescible materials	62.09	59.08	53.30	67.77	60.65	65.33	54.02	58.46
Paper and paperboard	10.49	10.82	15.27	12.02	10.59	11.41	23.52	14.87
Wood	1.27	1.36	1.16	0.37	1.93	0.94	1.16	0.94
Plastic	12.60	11.66	13.18	11.32	15.30	11.77	15.19	10.53
Pet	3.18	10.20	2.17	0.85	1.73	0.70	2.05	5.49
Textiles	3.52	4.66	5.68	3.19	1.67	3.87	3.40	4.12
Metals	1.76	2.15	1.61	1.31	0.64	0.68	0.39	1.49
Glass	3.27	4.38	4.87	2.65	4.07	3.45	2.14	3.28
Construction garbage	2.16	2.59	6.61	1.61	1.68	1.71	2.40	0.59
Bone	0.09	0.09	0.69	4.74	4.41	0.72	0.41	0.25

Table IV: Prediction of total revenue from selling recyclable dry waste material taken from separating stations of sources in all eight districts in Ahvaz during the first six month in 2008.

Type of recyclable dry waste	The amount of recyclable dry waste eight districts in Ahvaz during the first six	The Gross profit of 8 contractors of source separation bases during the first 6month in 2008 (Kg/Rial)	Gross income (Kg/Rial)
Paper and paperboard	34740391	300	10422117300
Glass	8919965	50	445998250
Plastic	33284960	600	19970976000
Pet	6956884	1400	9739637600
Metals	3163525	5850	18506621250
Box	2874338	600	1724632800

Table V: The cost of collection transportation, and burial of waste materials during the first six month in 2008 in Ahvaz.

Type of cost	Rial per Kilogram
Collection	64
Transportations	55
Final disposal	54
Total	173
The cost of collection, transportation, and disposal of 1409000 kilogram waste	243757000
Monthly cost	7556467000
The cost of the first six month in 2008	45338802000

Table VI: The annual net interests from recycling (assuming constant income) during 2008 - 2013.

Year	Income (Assuming constant income)	reduction of management solid waste costs	reduction of management solid waste costs+ income=benefits of annual recycling	Recycling costs	Net profit
2008	121619966400	31119261798	152739228198	11904000000	140835228198
2009	121619966400	35787151068	157407117168	13094400000	144312717168
2010	121619966400	41155223728	162775190128	14403840000	148371350128
2011	121619966400	47328507287	168948473367	15844224000	153104249367
2012	121619966400	54427783380	176047749780	17428646400	158619103380
2013	121619966400	62591950887	184211917287	19171511040	165040406247

Table VII: Net profit from total recycled materials among all districts in Ahvaz in the first six months in 2008.

District	Gross income	Costs	Net profit
1	12757609800	744000000	12013609800
2	7802318700	744000000	7058318700
3	6933036050	744000000	6189036050
4	8569782600	744000000	7825782600
5	5769684450	744000000	5025684450
6	7433188050	744000000	6689188050
7	6872313250	744000000	6128313250
8	4672050300	744000000	3982050300
Total	60809983200	5952000000	54857983200

Table VIII: The final result of the economic index of recyclable household waste materials in Ahvaz in scenario no.1

Reduction rate (%)	NPV (Rials)
%10	710918325517

Table IX: The final result of the economic index of recyclable household waste materials in Ahvaz in scenario no.2

Reduction rate (%)	NPV (Rials)
%14	654821958446

Since the calculated scenario is positive, thus it could be concluded that the waste recycling in Ahvaz is economically profitable.

Conclusion:

The amount of dry household waste materials in the first six months in Ahvaz in 2008 has been 89.9 million kilograms collectively, that from this amount of waste materials that is almost 262 million kilograms, around %34.32 (Including glass, plastic, etc) is recyclable; thus, %65.68 (almost 172 million kilograms) is wet material that can be converted into organic fertilizer. From dry waste materials, the amount of plastic is higher than the others and glass less than all.

Ahvaz doesn't have separating stations from source and recycling, yet. Dry waste materials are collected by informal staff and are sold to shops and workplaces that work illegally. Materials can be separated into two ways; either separating all

materials from the source individually, or in scrambles ways [11]. If the collection is done in scrambles ways, there will be a great deal of recyclable materials in recycling stations that must be separated from one another, but if the separation is done separately and individually, that is, people and citizens separate the materials individually, there will be reduction in separating costs. The total future income from recycling for people in all eight districts in Ahvaz, are calculated 54.857 million Rials based on the sell of dry waste materials in the first six months in Ahvaz in 2008.

The income from selling plastic was the most profitable and the income from selling glass, the least profitable. Total net profit from total recycled materials has been 9.142 million Rials per months in the first six months in Ahvaz in 2008, that is, 294 million Rials net profit every day. The net profit gathered from district number one has been the most, and in district number 8 has been the least one. Absence of implementing recycling process can lead

to the loss of 9.142 million Rials; thus with assuming constant costs, the tonnage of collecting waste materials can also be effective. With waste recycling, cost saving of waste management (cost of collection, transportation, etc) can be obtained. In the first six months in Ahvaz in 2008, the recycling of 89.940 kilograms of household waste materials saved almost 15.559 million Rials in the cost of waste management and caused an income for the municipality.

Considering the positive NPV it can be concluded that, the recycling of household waste materials is economically justifiable and it should be invested in. Tables VIII and IX indicate the final result of the economic index of recyclable household waste materials in Ahvaz.

Recommendations:

Summary of the most important suggestions for effective implementation of recycling household waste in Ahvaz include:

- Protecting the interests of the private sector and the continuous stewardship of the authorities on how the private sector (contractors) will be activated later, in terms of quantity and quality of their performance by special agents of environmental health office municipalities, and regional organizations to encourage recycling as well as contractors that with the highest quality waste separation and have good quality.
- Creating separate source stations in all eight districts of Ahvaz.
- The establishment of special tanks separated from the main source in the field margin, Main Street, the busy sidewalks in front of offices and organizations, and busy neighborhood.
- Creating price stability in the market for recycled products and goods in Ahvaz.
- Training employees and contractors and workers on how to enable recycling and proper hygienic separation of recycled materials.
- Prizes awarded to agencies and institutions that most recover recyclable materials altogether.
- Prohibiting unauthorized locations other informal groups and recovery of the city of Ahvaz.
- To share the land with a minimum rental cost for contractors to lower their costs in order to motivate them and encourage more recycling of waste.
- Establishing waste recycling stations in the landfills of Ahvaz (Boroumi area).

- Broadcasting information, culture and education in different school levels, including elementary, middle schools and high schools for awareness regarding the separation of origin and health benefits, environmental and economic recovery and to encourage their active participation in this and education administrators in the field of familiarity with relevant recovery plan in Ahvaz.
- Implementation of economic analysis and consider the indirect economic benefits of recycling, such as reducing energy consumption, environmental protection, increasing employment, protect natural resources, reducing pollution and improving quality of life costs.
- Supply special vehicles for collecting dry wastes to be recycled in Ahvaz.
- Obtaining the cost of waste collected from the citizens of Ahvaz to control waste and increase production without consumption of material and non-recyclable.

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