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Emission and Health Costs Estimation for Air pollutants from Municipal Solid Waste Management Scenarios, Case Study: NO_x and SO_x Pollutants, Urmia, Iran

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Abstract

Since all human activities somehow lead to the production of wastes, landfill practices should be chosen in such a way that they can respond to the increasing production of solid wastes and the pollutions they cause. SO_x and NO_x pollutants have detrimental effects on human health. Both of these pollutants in question can potentially be hazardous to human health. The framework of this study includes an evaluation of life cycle seeking to describe and quantify the impact of resource use and emissions, waste products, processes and policies on the environment. So, in this study two scenarios are defined based on solid waste life cycles using the Integrated Waste Management Software (IWM) model in which the data is calculated using ISO-14040 and ISO-14044 standard methods. Economic values of the effects of these pollutants on human health are estimated according to SimPacts software. In this software the IWM model is used for assessing the health effects and costs. This study is done to describe and to evaluate the available plans for scoring the different impacts of alternative waste management Scenarios for Urmia city, including landfill, composting and recycling. The procedure of this research includes investigating NO_x and SO_x emission rates from the municipal solid waste disposal in Urmia and also assessing the cost of damage to human health. The results of this study showed that the number two scenario with a combination of 70% composite and hygienic landfill is selected as the top management scenario with the least damage costs to the human health. In addition, investigating 12 consequences, such as mortality, Chronic Bronchitis and damages resulting from the restricted activity days are determined as the most important side effects of the emissions of these pollutants.

Keywords: NO_x and SO_x Pollutants, Municipal Solid Waste, Urmia, IWM, SimPacts

1 Introduction

NO_X and SO_X are the most important produced gases in landfills from the municipal solid wastes. Both of these two pollutants threaten the human health and cause damages to the society. Both of them can be hazardous to the human health, for example an increase in the values of NO_X and SO_X has such consequences as nasal cavity problems, respiratory problems, nervous problems, liquid stock in the lungs and finally death. They also damage the plant life. Generally, air pollution is the cause of economic and environmental harms. For example, the costs of the damages to the human health because of the air pollution have been estimated between 55-670 million dollars by the health damage cost evaluation institute in the United States in 1990-1991 [1]. Besides, in 1992, the annual value of life in the US was estimated about 3 million dollars which was defined as the statistical value of the life while in Italy the mortality cost was about 16643.8 million dollars [2]. In New Zealand, air pollution from all the pollution producing sources annually cause more than 1600 million soon death, 930 million bedridden patients and 2.6 million cases report the fatigue from being forbidden from working in the urban areas [3] .Furthermore, there are other studies working on this issue[4, 5, 6, 7]. Some studies including POP investigate the chronic effects of air pollution on mortality which has led to major differences in measuring methods [8]. Thus, this study tries to estimate the amount of these pollutants produced in municipal landfills in the intended sites and to identify their influence on the environment and to estimate the damage costs. In this study SimPacts Model software is used for investigating and evaluating the equivalent damage costs. This model is a coherent evaluation for calculating human health and the effects and the environmental costs related to the produced greenhouse gases in the atmosphere from the constant sources. This model also has been used for estimating the emission rates of different pollutants in recent studies and has been admitted by the European Union. In this model the effects of air pollution on human health is evaluated by the analysis of the pathways in terms of the emission of the pollutants in the environment. This software consists of different methods for calculating the pollutions resulting from the combinations with N, S, CO and other poisonous

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elements. It calculates the effects of air pollution on human health by the analysis of the pathways of the emission of the pollutants in the air and their dispersion in the receptor. Comparing to other available models, it has the advantage of needing moderate amount of data and being applicable in the areas with determinate amount of available data. In this software the analysis of the multi-dimensional effects is based on the environmental protecting factors. Finally, this software calculates the financial cost regarding to different diseases which can be a good criterion for several studies done in this area and also for the investigations of the damages to the Urmia dwellers. It can be said that the amount of SO_X and NO_X has been rare. In most countries, especially the developed ones, such evaluations have been paid much attention and there have been done some investigations. There are a few studies evaluating the recycling of the solid wastes in Iran. The evaluation of the recycling of the solid wastes in Lavan Island is an example [9]. Furthermore, different effects of SO_2, NO_x and the secondary pollutants (sulphate and nitrate) on human health have been reported such as mortality[10] , chronic bronchitis [11], restricted routines damages [12], being bedridden because of the respiratory problems, hard coughing in children[13], heart failure in the elderly people [14], asthma [14], bronchitis broadening (adults suffering from asthma) [14], respiratory signs (adults suffering from asthma) [14], using bronchitis broadening (children with asthma) [15], children affected with asthma [16].

Urmia as the capital of West Azerbaijan province and with a population of almost more than 508712 people is among the biggest cities of Iran. According to the studies done by the municipality of Uramia 450-500 tons of waste is produced a day,73 percent of them are analyzable and bio degradable which include food wastes and 27 percent of them are dry waste which include paper, glass, rubber, and textile. Unfortunately, the solid waste management system has not progressed in accordance with the population growth and the technology development which has caused an undesirable situation in this region [17]. Today, solid waste management is one of the main elements of protecting health and the environmental health. Municipal wastes are the most important sources of producing wastes which have generally allocated the most production rate to themselves. Generally, these wastes are managed by recycling, Incineration, compositing and finally landfilling. The waste management methods with the idea of protecting human health and investigating their effects on the environment are increasingly evaluated worldwide.

There is a landfill for wastes on Sarv road of Nazlu region 20 kilometers from the west north of Urmia. It is 79 hectares wide overlooking Nazlu and Lak villages. Dolme river is the only running river around the landfill where runs along the secondary road leading to the center of the landfill. Waste gathering and transferring to landfills travel a distance of 17 kilometers to the landfills from the nearest to the farthest solid waste producing sources. In addition to that, the mentioned solid wastes in the plan are gathered home to home. Practically, the usual municipal wastes are classified as dry and wet wastes. Urmia with four urban regions produces 440 tons usual wastes a day. Investigating the quality of the municipal wastes plays a considerable role in the municipal waste management. Choosing a plan for selecting the management alternative methods such as recycling, compositing, sanitary landfill and landfill leachate management needs awareness of the quality of wastes and their components. Physical analysis of the wastes is an influencing parameter in waste management system. Table 1 shows the percent of Urmia waste components presented by the Urmia municipality waste management organization in 1391 [18].

Table 1. Physical analysis of Urmia wastes

Material	Wet waste	Plastic	Paper	Glass	Wood	Iron	Bread	Rubbish	Bone	Textile	Special	Rubber
Percent	72/2	9/8	5/1	2/3	0/8	1/1	0/4	1/1	0/4	2/5	3	1.3

2 Materials and Methods

Since all human activities produce waste, the waste management methods should be chosen in such a way that they can respond to the increasing growth of waste production and the resulting pollution. To apply the municipal solid waste management system (IWM) determined based on the standards of ISO14040 and ISO14044 , at first the physical conditions and the quantity and the quality of the wastes were identified in the controlled area for studying , for the next step different disposal scenarios are evaluated [19,20]. In the end after valuing these evaluations the best scenario is selected and introduced for practicing. The environmental protection information center (EPIC) and the rubber industries and the complete recycling solution association (CRS) and consequently the Canada environmental protection center presented a model for evaluating the environmental effects of different waste management systems in Canada. The main purpose of this model is providing a scale for evaluating the functions of different environmental elements of the available waste management systems for the municipalities of Canada. This model is presented on the basis of the most reliable general information with a commitment of a periodical reviewing of the information for making sure of the data being updated. This scale is just a director and does not introduce any best system. The best system for a society must also consider the social and political effects. This scale applies an environmental evaluation of the recycling view for evaluating the environmental effects related to the managing of the waste component issues of different waste processing steps. The evaluation of the recycling is increasingly applied for evaluating the waste management strategies too. It should

be mentioned that there is a fundamental difference in recycling the products and the wastes. Recycling a product starts with the extraction of raw materials and ends with the final removal of the product, but on the other hand waste recycling starts with throwing away an object as a waste material and ends either with changing into other forms or the final disposal. The main purpose of this model is considering the main components of the municipal wastes such as paper, plastic, glass, aluminum, steel, food and garden wastes. Each of these materials can be managed using different elements of the integrated waste management system and so share the systematic evaluation of the managing alternatives.

SimPacts is suitable software for investigating different effects on and damages to the human health and the environment from the emission of the pollutants. It emphasizes on an exact and logical approximate of the effects of the pollutant emission. Not much data is needed here so it has the limited database among all other similar models.. For example, for investigating a health risk the user needs the emission rates of the pollutants and the density of the population in the intended area. Of course, the more exact the input the more reliable the output. Meanwhile, this software should be calibrated for different countries. Its calibration coefficient is based on the life of a man in Iran comparing to the European Union which is gained by the following formula:

The currency value in the intended country (Iran) = (PPPGNP in Iran/PPPGNP in EU) × the currency value in Europe. This value in I.R. Iran equals to 0.413.

3 Results

In this study two scenarios are considered. The values allocated to each group of the total 450-500 tons of mixed municipal daily produced wastes in Urmia is presented briefly in table 2.

The scenario number 1 is defined in IWM software determining 50 percent of the recycled waste and the sanitary landfill. Using the IWM software output the emission rates of the pollutants NO_x and SO_x are determined in this scenario. In this landfill there is no gas trap or recycled energy, the landfill leachate is not collected and there is no drainage for it, anyway it's better than the present situation because it is considered as a sanitary landfill. Scenario number 2 is defined in IWM software determining 70 percent of waste composite and sanitary landfill. The establishment of a composite factory next to the disposal sites facilities is one of the conditions of applying this scenario. In this scenario the gas is trapped (50% output) and the energy is produced (30% output). Here NO_x has a higher emission rate comparing to the previous scenario because the compositing process increases the value of Nox production. The values of the pollutants emission are gained by evaluating the lifecycle based on the different disposal forms in each scenario. However, it should be mentioned that this amount of production is during the time when the materials are produced, the materials which are thrown away as waste afterward. Thus, there is a lack of information about the density of these pollutants production in this period and the area being studied. According to IWM results, the emission rates of NO_x and SO_x pollutants in each of these scenarios are estimated based on kilogram/day which can be seen in table 3.

Table 2. The studied scenarios

	The amount of transferred for recycling	The amount separated for composting	The amount transferred to the landfills
Scenario No. 1 (50% recycled + landfill)	0.0	34.76	321.34
Scenario No.2 (70% composite + landfill)	0.0	204.13	151.97

Table 3. The emission rates of the pollutants based on kg/d

	Scenario no.1	Scenario no.2
NO_X (kg/day)	4.706	14.33
SO_X (kg/day)	4.133	1.88

According to the input and the applied model SimPacts software gives the following results. In tables 4 and 5 the damage cost values resulting from the emission of SO_x and NO_X from the solid municipal wastes for the various Health effects on human health can be seen. The costs are classified in lower, higher and middle (as the damage cost). Anyway, the highest and the lowest costs are calculated based on 0.68 reliability distance (based on normal distribution).

The amount of the emission is calculated for both scenarios and the comparison of the damages from both pollutants can be seen in figure 2. The damages costs from the emission of NO_x and SO_x pollutants for both scenarios by SimPacts software are presented in 1. The damages can also be seen in the following diagrams.

Table 4. The damages to the human health from NO_x emission based on $/year

Responding functions facing the pollutants	Scenario no.1			Scenario no.2		
	Damage cost	The least cost	The most cost	Damage cost	The least cost	The most cost
mortality	0E+03	6E+01	0E+02	0E+02	8E+01	5E+02
Chronic bronchitis	5E+03	8E+02	2E+03	9E+03	7E+02	0E+02
Routines restriction damages	7E+03	5E+02	5E+02	7E+02	4E+01	2E+02
Bed ridding	1E+00	4E-01	7E+00	4E+00	8E-01	3E-01
Hard cough in children	7E+01	7E+00	9E+01	6E+01	2E+00	5E+00
Heart failure in the elderly	0E+01	7E+00	0E+00	2E+00	7E-01	4E+00
Adults had cough	9E+02	2E+01	5E+01	0E+01	9E+01	7E+01
Adults asthma	9E+02	3E+01	0E+01	4E+01	1E+00	1E+01
Adults with asthma and respiratory signs	0E+00	0E+00	0E+00	5E+00	8E-01	4E-01
Coughing and asthma in children	5E+01	1E+00	8E+01	5E+01	7E+00	1E+00
Children asthma	3E+01	0E+00	1E+00	3E+00	9E-01	8E+00
Children with asthma and respiratory signs	2E+00	4E-01	7E+00	5E+00	9E-01	8E-01
total	3E+03	8E+02	9E+03	7E+03	5E+02	4E+02

Table 5. The damages to the human health from SO_x emission based on $/year

responding functions facing the pollutants	Scenario no.1			Scenario no.2		
	Damage cost	The least cost	The most cost	Damage cost	The least cost	The most cost
Mortality	6.11E+03	3.82E+02	1.53E+03	1.36E+04	8.47E+02	3.39E+03
Chronic bronchitis	2.01E+03	2.23E+02	6.69E+02	4.45E+03	4.94E+02	1.48E+03
Routines restriction damages	6.87E+02	7.63E+01	2.29E+02	1.52E+03	1.69E+02	5.08E+02
Bed ridding	2.82E+00	3.13E-01	9.39E-01	6.24E+00	6.94E-01	2.08E+00
Hard cough in children	3.11E+01	3.46E+00	1.04E+01	6.90E+01	7.67E+00	2.30E+01
Heart failure in the elderly	2.66E+00	2.96E-01	8.87E-01	5.90E+00	6.55E-01	1.97E+00
Adults had cough	1.29E+02	1.43E+01	4.30E+01	2.86E+02	3.18E+01	9.54E+01
Adults asthma	5.59E+01	6.21E+00	1.86E+01	1.24E+02	1.38E+01	4.13E+01
Adults with asthma and respiratory signs	3.90E+00	4.34E-01	1.30E+00	8.66E+00	9.62E-01	2.89E+00
Coughing and asthma in children	2.57E+01	2.86E+00	8.58E+00	5.71E+01	6.34E+00	1.90E+01
Children asthma	6.65E+00	7.39E-01	2.22E+00	1.48E+01	1.64E+00	4.92E+00
Children with asthma and respiratory signs	1.66E+00	1.84E-01	5.52E-01	3.67E+00	4.08E-01	1.22E+00
total	9.07E+03	7.10E+02	2.51E+03	2.01E+04	1.57E+03	5.57E+03

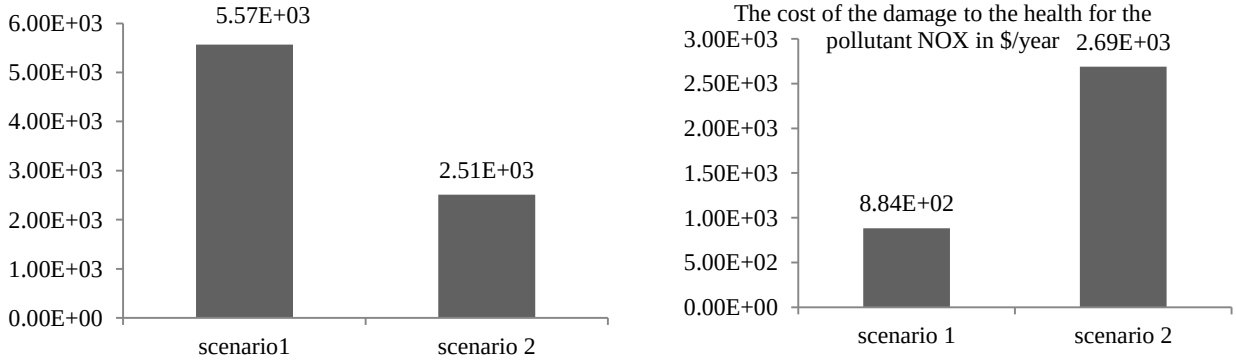

Figure 1. The damages from the emission of NO_x and SOx pollutants in scenarios no. 1 and 2 in $/year

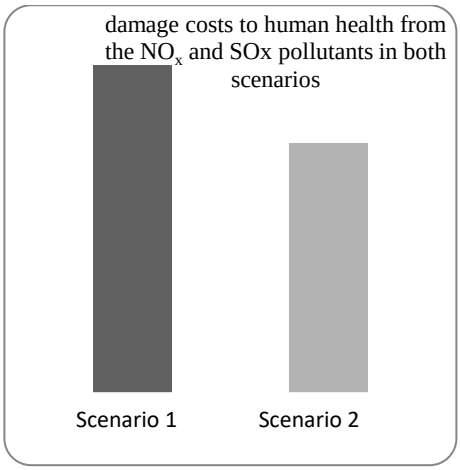

Figure 2. Evaluation of damage costs of the pollutant in scenarios 1 and 2

As it can be seen in figure 2, regarding to the less amount of the pollutants emission in scenario 2 comparing to scenario 1, the amount of the damages to health from these pollutants is calculated by Simpacts software for scenario 2.According to figure 3 the mortality and chronic bronchitis and the routine restriction damages frequencies are much more than other disease. The emissions of these pollutants cause more damage costs to these diseases. The damage costs to human health can be clearly seen in these three distinguishing disease.

4 Discussion and Conclusion

In this study the municipal waste management in Urmia with a production rate of 450-500 tons a day and a comparison of different scenarios regarding to the damage costs to the human health were investigated. The intended options for processing the wastes are landfill with recycling and composting. There are a combination of these options in both scenarios. IWM model is used for making a list of the options and SimPacts software is used for evaluating the effects and finally the options are compared to each other in terms of the damage costs to the human health. In the present study, by the evaluation of the effects of scenarios 1 and 2 by the SimPacts software the amount of the damages to the human health was determined. Mortality damages, chronic bronchitis routines restriction damages in each scenario were also determined. Based on SimPacts output and the comparison of the two scenarios, the results suggest that changing the municipal wastes in the landfills of Urmia and designing Sanitary landfill is the best option regarding to the least damage to the human health. At present in the area being studied, Urmia city, the wastes are only recycled into rubber. This activity has been begun for two years now but not applied in all the four regions of the city. Thus, it is suggested that the municipal waste recycling system started widely throughout this city and beside the rubber recycling other wastes such as paper, glass, iron also be recycled so that the buried wastes decrease in volume and there is the least damage to the health from NO_x and SOx pollutants. To do this and based on the studies done , the establishment of a compositing factory next to the disposal sites facilities is necessarily recommended to those responsible in this issue to attend to so that the wastes after recycling go into the compositing cycle in order to have less damage cost to the human health.

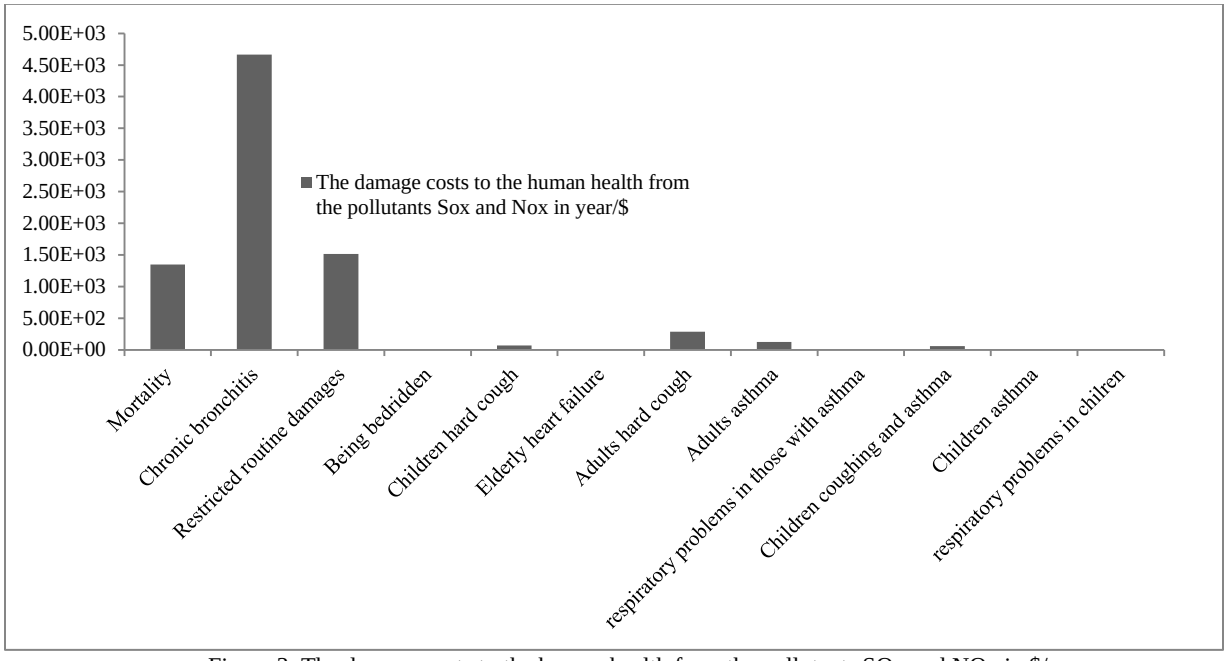

Figure 3. The damage costs to the human health from the pollutants SOx and NOx in $/year

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