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Original Article

Reduction of cost and emissions by using recycling and waste management system

Redução de custos e emissões através do uso de sistema de reciclagem e gestão de resíduos

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Abstract

In order to evaluate the level of sustainability of an integrated waste management system (IWMS), it is necessary to analyze the impact criteria. Therefore, the purpose of this study is to provide a model for IWMS optimization with the two goals of minimizing the cost and the emission of greenhouse gases of the entire system. Environmental and health problems caused by the lack of proper waste management include the increase in disease, increase in stray animals, pollution of air, water, land, etc. Therefore, it is very important to identify the indicators and improve the efficiency of the waste management system. In the present research, with descriptive-analytical approach, it has been tried to clarify and evaluate the effective indicators in two dimensions of production-segregation and collection-transportation, and find ways to improve the efficiency of the system. In this article, five waste management systems including, incineration, landfill without gas extraction system, plasma incineration, recycling and aerobic decomposition are introduced and their performance in energy production and emission reduction are compared. The results of the evaluation of the basic waste management system (b) show that the amount of pollution is equivalent to 850 kg CO_2 per ton of waste. While the amount of emission in the fifth comprehensive management system is reduced to 450 kg CO2 per ton of waste. According to the results obtained in this study, in all the management systems presented, the process of burying waste in sanitary landfills has the greatest effect in increasing pollution. This means that the pollution caused by burying the waste in the sanitary landfill will be reduced with the construction of the gas extraction system and the plasma method and use in electricity production. Despite the increase in initial costs, using the right technology and using the right waste system based on the type of waste and waste recycling has an effect on the efficiency of the system.

Keywords: cost reduction, waste system, recycling, plasma, waste disposal.

Resumo

Para avaliar o nível de sustentabilidade de um sistema integrado de gestão de resíduos (SGRI) é necessário analisar os critérios de impacto. Portanto, o objetivo deste estudo é fornecer um modelo de otimização do IWMS com os dois objetivos de minimizar o custo e a emissão de gases de efeito estufa de todo o sistema. Os problemas ambientais e de saúde causados pela falta de uma gestão adequada dos resíduos incluem o aumento de doenças, aumento de animais ociosos, poluição do ar, da água, da terra etc. Na presente pesquisa, com abordagem descritivo-analítica, procurou-se esclarecer e avaliar os indicadores eficazes em duas dimensões de produção-segregação e coleta-transporte, e encontrar formas de melhorar a eficiência do sistema. Neste artigo, são introduzidos cinco sistemas de gestão de resíduos, incluindo incineração, aterro sem sistema de extração de gás, incineração de plasma, reciclagem e decomposição aeróbica, e seu desempenho na produção de energia e redução de emissões é comparado. Os resultados da avaliação do sistema básico de gestão de resíduos (b) mostram que a quantidade de poluição é equivalente a 850 kg de CO_2 por tonelada de resíduos. Enquanto a quantidade de emissões no quinto sistema de gestão abrangente é reduzida para 450 kg de CO_2 por tonelada de resíduos. De acordo com os resultados obtidos neste estudo, em todos os sistemas de gestão apresentados o processo de enterramento de resíduos em aterros sanitários é o que tem maior efeito no aumento da poluição. Isto significa que a poluição causada pelo enterramento dos resíduos no aterro sanitário será reduzida com a construção do sistema de extração de gás e do método de plasma e utilização na produção de energia elétrica. Apesar do aumento dos custos iniciais, a utilização da tecnologia certa e do sistema de resíduos adequado com base no tipo de resíduos e na reciclagem de resíduos tem um efeito na eficiência do sistema.

Palavras-chave: redução de custos, sistema de resíduos, reciclagem, plasma, eliminação de resíduos.

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1. Introduction

The integrated waste management system (IWMS) is considered as an important environmental issue affecting the phenomenon of global warming. Also, global warming necessitates changes in urban solid waste management systems. Solid waste management deals with the resources and the method of using these resources in the production of goods, as well as the method of disposal of the goods at the end of its life (Rey et al., 2022; Mojahed et al., 2022b; Sherafatizangeneh et al., 2022; Ishenin et al., 2021).

In recent years, environmental issues have been paid attention to by various countries with economic development. The rapid growth of population and urbanization, continuous economic and industrial development and increase in people's living standards have led to consumerism and more waste production (Prata et al., 2019; Jamalpour and YAGHOOBI-DERAB, 2022). The amount of waste produced in Jahanbin is estimated at 7 to 10 billion tons per year [Chaitkin et al., 2022; Tightiz and Yoo, 2023). It is estimated that 47% of this amount of waste is buried, 31% is recycled and 22% is burned. Therefore, more than 70% of these wastes are not reused or recycled correctly, and this indicates a lack of a large volume of resources and a lot of pressure on the primary resources of the planet (Ghaderloo et al., 2023).

Regular problems with solid waste management are complicated by many factors, such as the quantity and quality of produced waste, the rapid expansion of urban areas, financing problems, the rapid development of technology, and the limitations of energy and raw materials. The management of urban solid waste in developing countries is a very complex issue due to the rapid increase in population, rapid and unplanned urbanization, and the existence of public health problems due to the lack of proper sanitary infrastructure. In addition, the ability of governments to manage waste is limited and often this participation is ineffective and insufficient. Also, the existence of informal workers, people's resistance to pay for receiving services, inefficient collection system, illegal burial and lack of specific legal framework are among the other problems of this sector (Razzaq et al., 2021; Goswami et al., 2023; Najafi & Nasiri, 2019), the importance of the dimensions of production and separation, collection and transportation). There is a lot of waste in the management system.

A specific type of waste disposal system cannot be the most appropriate option for all types of waste. Therefore, in order to dispose of waste, a comprehensive method consisting of several types of disposal processes should be considered (Gholivand et al., 2021). In this context, it has been used to evaluate the environmental performance of different methods of waste incineration and the processes of exhaust gas purification from waste incinerators (Adegbeye et al., 2020; Ahirwar and Tripathi, 2021; Asadipour et al., 2005). Also, the environmental effects of recycling and incineration of plastic waste have been compared (Murti et al., 2023), the environmental effects of food waste and disposal processes of this type of waste have been evaluated (Donoso et al., 2022), the better efficiency of recycling than the process of burial in a sanitary landfill, in Small communities have been proven (Das et al., 2019).

In this study, the amount of emissions under the various waste management system (WMS) in Iran is compared. Also, the impact the effoicacy of Intehrated WMSs on gpolution is studied. The results of this study can be used in choosing the appropriate management method in cities garbage disposal system system.

2. Method

Handling and segregation includes activities related to waste management until their delivery in storage tanks for collection. Handling also includes moving the filled tanks to the collection point. Separation at the source plays a very important role in waste handling and storage, and paying attention to public health and aesthetic considerations of the storage place is also very important. In this paper five model are considered as including collection, transport and landfilling (P1). Other four methods along with P1 and incineration include recycling (P2), anaerobic digestion (P3), recycling and anaerobic digestion (P4) and plasma method and at high temperature in waste incinerators (P5). The processes considered in each of the management systems are shown in Figure 1. The boundaries of each system include the transfer and collection of waste from the point of origin and various disposal processes in each of the management systems (P1-P5). In all five management methods (P1-P5), the amount of waste and its components are the same. Also, in processes that exist directly or indirectly in different management systems (P1-P5), the same amount of waste is processed.

Waste management system (P1) is defined as a basic management which includes waste collection, transportation and landfilling. In order to understand the impact of different management options, in addition to the basic management method, four other waste management methods are also considered. In the type 2 management method (P2 system), 30% of the recycled waste materials are separated and recycled at the source. Of the remaining waste, 70% of the combustible waste is directed to the incinerators and the rest is buried in the landfill. In type 3 management method (P3 system), 30% of the organic materials (domestic waste) in the waste are separated at the source and sent to the anaerobic decomposition (compost), in this method, 70% of the combustible waste is present. The remaining waste is sent to the waste incineration furnace and the rest of the waste is buried in the landfill (Tightiz and Yoo, 2022a).

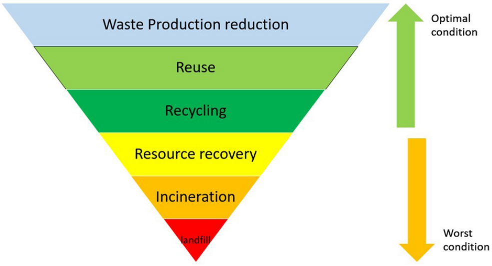

Figure 1. Waste management process ss (P1-P5).

In type 4 management method (P4 system), using separation at the source, 30% of the recycled materials in the waste and 30% of the organic materials of the waste are separated at the source and recycled and anaerobically decomposed, respectively. Then 70% of the flammable materials in the remaining waste are disposed of in the incinerator and the rest of the waste is buried in the landfill. In the fifth method (P5), it is the same as the 4th method, with the difference that waste burning is done by plasma method and at high temperature in waste incinerators to minimize the emission of greenhouse gases.

In this study, the development of management systems is such that a useful product is produced from the desired waste and processing process and replaces a similar product produced from raw resources. For example, in the case of waste incinerators, electrical energy recovered from waste incineration replaces the energy produced by power plants, as well as soil amendment using manure obtained from anaerobic decomposition instead of chemical fertilizers and using recycled products instead of similar products produced from raw resources are possible. In this study, it is assumed that recycled goods and goods produced from raw sources have the same characteristics. Therefore, the expansion of these waste processing systems, due to the production of goods, causes a reduction in the amount of waste and the use of raw resources.

If there is a need for electrical energy, this energy is provided from the combined cycle power plant in Mazandaran region. The concept of energy in each of the management systems includes energy that is directly used in the management systems and ancillary systems. For example, in the case of waste management through recycling, the energy required for recycling and transporting waste from the source of production to the place of recycling is considered as the energy of this type of management system.

In this study, it is assumed that separated materials (paper, plastic, glass, aluminum and iron) will be transported to a place 200 km away from city for recycling. This distance is considered according to the actual location of the area. Also, the place of anaerobic decomposition and waste incineration is assumed same. The purpose of this study is to evaluate the emission of greenhouse gas from waste, under the existing management system and other comprehensive waste management systems. The composition of waste (average of 2019-2022) is shown in Table 1.

The value of 30% has been chosen to separate the origin of recycled materials based on the standards of the Environmental Organization (Tesfaye et al., 2023; Mojahed et al., 2022a). 70% separation of combustible waste is considered according to the maximum capacity of common waste incineration centers. This type of waste incinerators has been used for three decades in different regions (Ferrer et al., 2022; Guo et al., 2021; Saeedfar and Afghary, 2012). The participation rate of different disposal methods (burial in landfill, incineration, recycling) in each of the waste management methods is shown separately in Table 2.

At this stage, all inputs and outputs related to production resources, raw materials, energy and environmental emissions that are located in the boundaries of the system (Figure 2) are collected.

In order to calculate the amount of greenhouse gases coming out of the waste collection and transportation system, as well as the emissions caused by fuel consumption in the machines used for spreading and compacting waste at the sanitary landfill site, the environmental organization's emission factors have been used (Khorsandi et al., 2022; Shariati et al., 2013). Energy consumption and gas emissions caused by management systems have been obtained through a field study. The amount of carbon dioxide emitted from waste has been calculated using the carbon dioxide emission factor (Khan et al., 2022). In order to calculate the amount of methane gas coming out of the landfill, the amount of each compound in the waste is multiplied by the emission factor corresponding to that substance (Areche et al., 2023).

According to the studies, the information related to the gas emission caused by the recycling of materials has been obtained separately for each material. These recycled materials include cardboard, paper, plastic, glass, iron and aluminum (Shaari et al., 2022; Tightiz and Yoo, 2022b).

Table 1. Waste Composition.

Compounds	Amount in percent
Organic materials	61
Paper	13
Glass	7
Wood	0.3
metal	2.7
Plastic and rubber	8.9
Cloth	3.3
PET	2.5
Others	9.3

Table 2. The Contribution of waste processing processes in each management systems.

Waste management system	The amount of processed waste compared to the total available waste				
	P1	P2	P3	P4	P5
Burning (Plasma %)	-	0.57 (0)	0.49 (0)	0.44(0)	0.44(100%)
Burial in sanitary waste landfill without gas extraction system	1	0.32	0.32	0.27	0.27
Recycle	-	0.11	-	0.11	0.11
Anaerobic decomposition	-	-	0.18	0.18	0.18

The emission factor in common combined cycle power plants in Iran (79% natural gas, 15% fuel oil and 6% diesel) has been used to calculate the environmental impact of electrical energy recovery from waste processing (Nanda and Berruti, 2021). Fertilizer produced from anaerobic decomposition of waste is a suitable alternative to weak chemical fertilizers and soil conditioners (Vyas et al., 2022). The average amount of P_2O_5, N and K2O in one ton of soil conditioner is 1.7, 1.4 and 5.4 kg, respectively. Considering the emission factor in chemical fertilizer production, the environmental impact of fertilizer recycling from anaerobic decomposition of waste is calculated (Shah et al., 2021).

2.1. Effects evaluation method

In this study, greenhouse gas emissions (GHG) and emission are investigated. The amount of emission in each of the waste gases (N_2O, CH_4, CO_2, CO) is different. Equivalent factors are used to calculate and compare the heating effects of each of these gases. These factors for CO, CH_4, CO_2 and NO_2 gases are 2, 1, 21 and 310, respectively (Chen et al., 2020; Farhud, & Mojahed, 2022).

In this study, using data related to waste, waste management and impact assessment, greenhouse gas output from waste is investigated. Also, due to the high impact of the gas extraction system of the sanitary waste landfill on the amount of greenhouse gas emissions (Zhang et al., 2021), in the method of burying the waste in the sanitary landfill, two modes are considered, including no extraction and purification of gas and extraction and purification of gas in the sanitary landfill. In this paper the new method callled plasma was intorudced. A plasma incinerator begins by removing any future elements in municipal waste that are traditionally non-recyclable. The remaining waste is then fed into a gasifier, which uses a multi-burner burner and recycled heat from different sections of the incinerator to gasify the waste.

3. Results

The amount of emission produced in each of the management systems by disposal method is shown in Table 3.

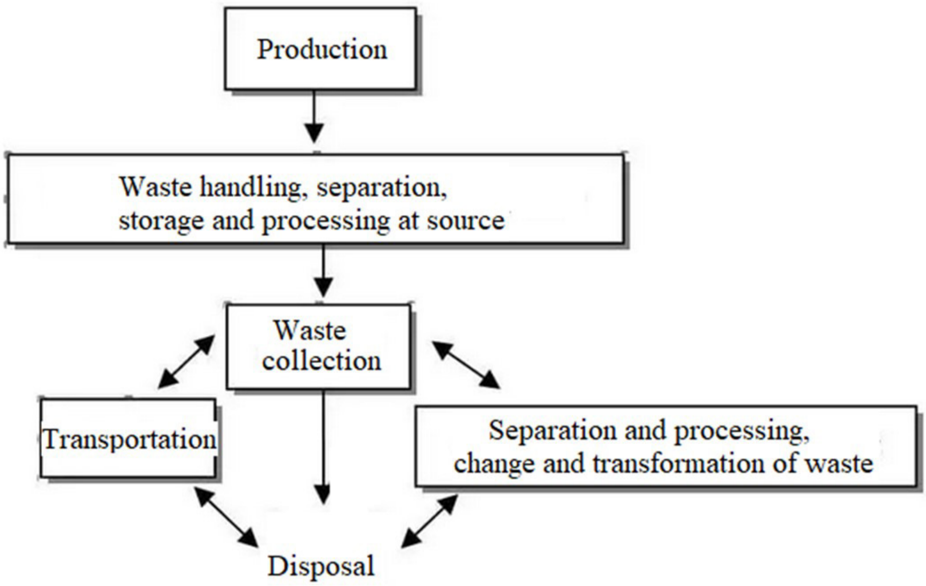

Figure 2. Flowchart of waste management.

Table 3. The EMISSION produced in each management procedures regarding waste disposal process.

Waste management processes	EMISSION($kgCO_2$)				
	P1	P2	P3	P4	P5
Collection and transportation of MSW	0.052	0.035	0.041	0.035	0.035
Garbage Incineration	-	171	225	161	161
Incineration waste		36	44	32	3.9
Disposing of waste in a sanitary landfill (without gas extraction)	860	565	475	433	433
Recycle	-	84-	-	84-	84-
Anaerobic decomposition	-	-	36-	36-	36-
Polution	860	688	708	506	478

In all four management systems, the amount of emission caused by the waste collection and transportation system is insignificant compared to the waste disposal systems. In the existing management system (P1 system), disposal in sanitary landfill is the only method of waste disposal. There is no gas extraction and purification system in this landfill. Therefore, assuming the oxidation of 10% of the methane produced in the sanitary waste landfill, 90% of the methane produced in the sanitary landfill is discharged into the atmosphere. The results show that in the comprehensive waste management system 1 (system P1), the amount of net emission per ton of waste is equivalent to 860 kgCO_2. P1 management system has the highest amount of emission compared to other management systems. This high emission is due to the direct release of CH_4 gas (the heating effect of each kilogram of CH_4 is equivalent to 21 kilograms of CO_2) from the landfill site.

In comprehensive management system 2 (P2 system), the major share of organic waste (kitchen and yard waste) has been treated in waste incinerators instead of being buried in sanitary landfills, and paper waste has been disposed of through waste incineration. According to the analysis (Table 3), burning MSW in the incinerator causes the production of emission in the amount of 221 kg CO_2. The largest share in the production of greenhouse gas in the waste incineration process is related to plastic waste. In this study, it is assumed that the energy obtained from the waste incinerator is used to produce electricity. Therefore, compared to the electricity produced in the waste incinerator, the electricity production in the power plant is reduced. This decrease in electricity production in power plants causes a decrease in greenhouse gas output from power plants (equivalent to 50 kg CO_2). By reducing the amount of greenhouse gas production (50 kg CO_2) in power plants, from the greenhouse gas produced in the waste incinerator, the amount of net emission in the waste incinerator is equal to 171 kg CO_2.

In the waste incineration process, the important factor in the production of CO_2 gas and the increase of emission is plastic waste. Increasing the separation of plastic waste from waste entering the incinerator will reduce emission. However, due to this separation and reduction of fuel sources, the recycled energy from waste incinerators is reduced. Evaluating the impact of plastic waste separation is not one of the objectives of this study. The impact of plastic waste treatment through the processes of burying in sanitary landfills and recycling instead of incineration can be investigated in other studies.

One of the disposal processes considered in this study is the recycling process. The goods resulting from the recycling process can replace the goods produced from raw sources. Therefore, the environmental impact caused by the production of goods from raw resources is reduced. For example, in aluminum recycling, recycled aluminum ingots can replace aluminum ingots produced from a raw source (bauxite). Therefore, the environmental effects caused by the raw aluminum ingot production process (bauxite extraction, aluminum oxide production, electrolysis, ingot casting and transportation) are reduced (Luo et al., 2019). In the comprehensive management systems presented in this study, the reduction of greenhouse gas emissions is considered due to the reduction in the processes of producing goods from raw resources. For this purpose, this reduction in GHG emission is deducted from the amount of greenhouse gas produced in the recycling process. In management system 2 (P2 system), the reduction of greenhouse gas emissions due to the reduction of production of goods from raw sources is more than the amount of greenhouse gas emissions caused by the recycling process. Therefore, the amount of emission in the recycling process is negative and equal to 84 kg CO_2. In this system, the amount of net emission per ton of waste is equivalent to 652 kg CO_2 and about 78% of the S1 system.

In comprehensive management system 3 (P3 system), due to the lack of organic waste burial in sanitary landfill, the amount of emission produced in sanitary landfill is lower than in P2 system. Failure to bury organic waste in the sanitary waste landfill will reduce the decomposition of this type of waste and reduce the production of CH_4 in the sanitary waste landfill. Considering that CH_4 has a major impact on global warming (each kilogram of CH_4 is equivalent to 21 kilograms of CO_2), reducing the production of this gas will significantly reduce the emission output from the landfill. Also, the production of organic fertilizer in the process of anaerobic decomposition of waste reduces the production of chemical fertilizer. Therefore, the amount of emission in the process of anaerobic decomposition is negative and equal to 36 kg of CO_2. Also, due to directing a larger amount of plastic waste to the incinerator, the amount of emission output from this process increases in the P3 system compared to the P2 system. Net emission in P3 system per ton of waste is equivalent to 664 kg CO_2 and about 79% of P1 system.

Comprehensive management system 4 (P4 system) is a combination of management system 2 and 3. The recycling process from system 2 and the anaerobic decomposition process from system 3 are included in this management system. Therefore, in the P4 system, both anaerobic decomposition and recycling processes are effective in reducing emission. Also, due to the reduction in the amount of waste input to the processes of waste burning and disposal in the landfill, the amount of GHG output from these processes is reduced. The P4 management system has the lowest emission (equivalent to 474 kg CO_2) compared to other management systems. Therefore, if the amount of global warming is considered in the evaluation, the P4 system is the best management method. Also, the P2 system has better performance than the P3 and P1 systems. Finally the P4 system with Plasma burning technology improve the Incineration waste procedure by high temprature and reduce the emission up to 6% in comparison to P4 system.

Burial of urban waste in sanitary landfill without recycling system is the most common method of waste disposal in Iran. According to the results of this study, among the different methods of waste disposal, burial in a sanitary landfill has the greatest impact on global warming (Table 3). Due to the presence of methane, the greenhouse gases coming out of the landfill have a high heating effect. Therefore, collecting methane gas in sanitary landfill and converting it into energy or CO_2 gas (through burning in a burner) reduces the heating effects of sanitary landfill.

Table 4. The impact of landfill gas extraction and refining of waste in the production of emission and cost.

Waste management processes	Emission($kgCO_2$) – Operational Cost (usd per ton)				
	P1	P2	P3	P4	P5
Disposing of waste in a sanitary landfill (with gas extraction and refining)	540-330	360-410	305-450	227-490	255-580
Disposing of waste in a sanitary landfill (without gas extraction)	860-380	565-440	475-460	433-490	420-590
Net EMISSION (with gas extraction and refining)	540-410	447-460	494-480	318-510	220-620
Net EMISSION (without gas extraction)	860-470	688-500	708-510	506-540	477-630

In this part, the impact of the gas collection of landfill gas and the production of electricity from extracted gas on the production emission in each of the management system states (P1-P5) is examined.

In this study, it is assumed that energy recovery in the refining system is only related to methane gas. The calorific value of methane is between 50-55 MJ/kg, which in this study is considered to be 50 MJ/kg. It is also assumed that 75% of the methane produced in the sanitary landfill is collected and electricity is produced by a power plant with an efficiency of 35%, and 10% of the uncollected methane gas is oxidized in the covering layer of the sanitary landfill and turns into carbon dioxide. (These assumptions are considered based on the standards and guidelines of the environmental organization) (Cudjoe and Acquah, 2021; Chen et al., 2022; Belikov and Prokuronov, 2023; Godinho et al., 2022). Therefore, only 22.5% of the methane produced in the landfill is directly discharged into the atmosphere. The results of emissions calculation in sanitary landfill with recycling system and sanitary landfill without recycling system for all four management systems (Incineration waste) are shown in Table 4. According to Table 4, as a result of recycling 75% of the waste sanitary landfill gas, the amount of emissions of the sanitary waste landfill is reduced by about 36%. This reduction is due to the reduction of methane output from the sanitary landfill and also the production of electricity from recycled gas.

Plasma gas production is a process that is used in the conversion of organic and carbon complex molecules in both liquid and solid states and produces simple gas. Most of the produced gases are flammable and are finally used as a fuel in processes or applications that require flammable gases. This method is one of the most advanced and expensive methods and is used for all types of waste, especially for special waste such as hospital waste. This technology is capable of turning all types of waste into usable and environmentally friendly materials, regardless of their type. One of the advantages of the plasma method compared to waste incinerators is the reduction of the volume of radioactive waste. Plasma gas production is different from the types of gas production and pyrolysis. In this method, heavy metals and carbon ash, which need to be disposed of in other methods, are not produced. In addition to this, ordinary waste incinerators, which are like fireplaces, burn waste at a low temperature, but new plasma type waste incinerators keep the temperature high and burn waste at this temperature. Therefore, the waste disposal process is carried out with higher efficiency. Plasma incinerators, which are used to burn some dangerous hospital materials, raise the temperature above 4000 degrees and do not allow the production of dioxins and eruptions, so the use of plasma method is more favorable than conventional incinerators and pyrolysis.

According to Table 4, refining and using sanitary waste landfill gas in electricity production improves the potential of global warming in all management systems. Considering the gas purification system in the sanitary landfill, the P5 system is still the best management option due to the production of the lowest emission in high temprature burning by plasma method. In general, after adding the extraction and refining process of landfill gas to management systems (P1-P5), the ranking of these four systems in terms of impact on global warming does not change.

In the traditional and common method of burning, the wastes are burned with a maximum temperature of 800 to 900 degrees Celsius, which can cause the production of dangerous secondary gases in the absence of complete combustion. Plasma technology produces a very high temperature (2000 thousand degrees and more) and decomposes the waste into its components and produces a very small amount of gas (syngas). Unlike burning, plasma does not require a mixture of fuel and air to generate heat and therefore produces a much smaller volume of exhaust gases. The above table shows the operational comparison between fossil fuel incinerators and plasma reactors for waste disposal. Contact us for more information.

4. Conclusion

The evaluation of the effects of the existing management system (system P1) shows that the amount of emission caused by one ton of waste is equivalent to 860 kg CO_2. As one of the options of waste management, the disposal process in the landfill has the greatest impact on increasing the potential of global warming. This effect is due to the release of CH_4 gas from the waste decomposition process in the landfill.

The results of this study showed that by reducing the disposal of waste in waste incineration and sanitary landfill processes, and also increasing disposal in the processes of recycling and anaerobic decomposition, the amount of emission decreases. Separation from the source of waste and separate disposal of waste in the processes of anaerobic decomposition, recycling, and waste incineration and burial in sanitary landfill (P4 and P5 system) is the best method among other management systems investigated in this study. While the existing management system (P1 system) is the worst management method in terms of GHG production. Also, the comprehensive management method 2 (including the processes of burial in a sanitary landfill, waste incineration and recycling) has a better performance than the comprehensive management method 3 (including the processes of burial in a sanitary landfill, waste incineration and anaerobic decomposition). Assuming that 75% of the landfill gas is extracted and used in electricity production, the amount of emission caused by the burial process in the landfill will decrease by about 36%. Plasma procedure is most usefal, however its initial and operational cost are higher than the other procedures, so it is needed to do the tradeoff of waste, costs and emissions based on waste volume and compostion to propose the most appropriate procedure.

According to the results of the study, it is suggested to increase the separation from the origin of waste and the disposal of segregated waste through the processes of recycling and anaerobic decomposition in the country's waste management systems. According to the results obtained in the study, recycling is the best management option to reduce emission. Therefore, in cases where the simultaneous use of recycling and anaerobic decomposition processes is not possible, it is recommended to use the recycling process. Reducing the entry of plastic waste into the incinerator will significantly reduce the GHG output from the incinerator. Considering the simplicity of plastic waste separation, plastic separation is suggested as the first management option in the waste incineration process to increase the environmental efficiency of the incinerator. This evaluation method can be useful for making decisions in other waste management projects.

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