AES BIOFLUX
Advances in Environmental Sciences - International Journal of the Bioflux Society

Alternative decisions for municipal solid waste management in Cluj-Napoca area

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Abstract. The environmental impact of waste is a function of different strategies used for municipal solid waste management. At Cluj-Napoca, the landfill of waste is the predominant strategy used for the municipal solid waste (MSW) management. Considering the environmental impact, landfill is one of the least desirable option, because in terms of limited control possibilities of emissions, it is an "*end-of-pipe*" treatment option. Other options as, recovery, recycling or waste treatment or other methods for waste management can also produce environmental impact, but as different as simple storage, they present some positive aspects, such as: reducing natural resources consumption, reducing emissions of greenhouse gases (GHG), reducing all of emission directly related to the environmental impact, and better land use planning possibilities. To do an accurate analysis of the environmental impacts resulted by the different management strategies of municipal solid waste, the life cycle assessment (LCA) represent a suitable and useful tool. This paper aims is to present an analysis of management options of MSW resulted from Cluj-Napoca area, using a specific program (WARM) based mostly on estimating emissions of GHG in different circumstances of waste management: source reduction, recycling, composting, landfill, and combustion. The WARM program is based on life cycle assessment of different management options for municipal solid waste. The computer program used is an useful and suitable tool for the authorities, for the decision makers, and for the stakeholders, because it represent for them one of the faster method to make the correct decision about management strategies for municipal solid waste, less costly for the environment and suitable for the region. Thus, the waste management decision, at this level, could be based on a quick and easy to use tool, which generates simultaneously optimal results for users.
Key Words: municipal solid waste (MSW), life cycle assessment (LCA), waste management (WM), greenhouse gases (GHG).

Introduction. From waste management point of view, the desired solution is the source reduction of the waste. The waste storage is an expensive solution on the long term, both for the environment and for human community. The main costs of the waste storage are for: the landfill gas monitoring, the leachate treatment, the water treatment plant maintenance and post-closure monitoring of landfill for many years (minimum 30 years, after the landfill is closing). Land use as a result of waste disposal is also a major cost to the environment, even if its quantification is less uniform from accounting point of view, due to related factors to land storage location, usually, outside of the city, especially in the areas with reduced environmental and economic value, therefore the accounting assessment, not always accurately reflect the real environmental costs.

Estimates from the literature give for methane concentrations values between 45% and 60% (% vol.) in the landfill gases (US EPA 2006). Using the methane from the landfill gas to generate steam or electricity can be effective at concentrations exceeding percentages of 35% - 45%. Sometimes, the content of methane in landfill gas is too low (for example at de beginning, but not only), the possibility of use it at acceptable efficiency is, also, too low, and discontinuous. In that case the use of CH_4 from landfill gases is limited to simple controlled combustion processes or only to biological filtration of gas collected (for concentrations of CH_4 in 30-35%, % vol.) (Order 757 2004).

The Romanian legislation, as well as the European Union legislation, has similar requirements for waste management, that focus all stakeholders (producers, processors, government etc.) on recycling and reuse programs, as well as solutions as source reduction and minimization of waste, in the detriment of the expensive previous solutions aimed mainly on the waste storage.

Material and Method

Alternative management options of municipal solid waste. The average composition of municipal solid waste collected in Cluj-Napoca is: 42% biodegradable waste, 21% paper, 22% plastic, 3% wood, 2 to 3% metal, less than 3% glass, 4% electronic waste, 3% other (Figure 1). Of all the products waste, the rate of recovery for metal waste was the most important, the reason being resulted of the existence of an infrastructure for metal waste recycling and that the metal recycling is done relatively easily and without additional cost to existing industries.

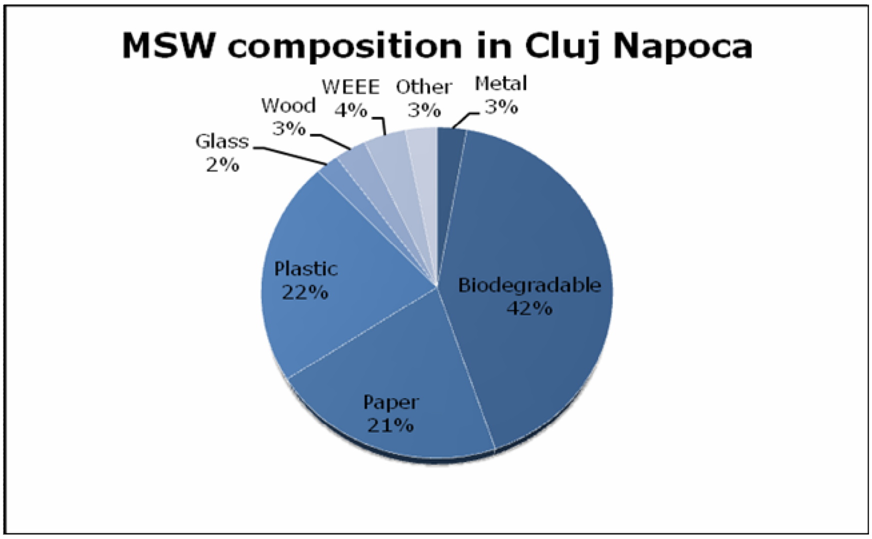

Figure 1. Municipal solid waste composition in Cluj-Napoca area (Source: REPA Cluj 2010).

The municipal solid wastes collected in the city of Cluj-Napoca are managed mainly by storage. In the recent years, some collection centers began to appear in town, but the percentage of recycled waste is insignificant compared to the total amount of municipal waste produced. The city has a stable population of 309,136 inhabitants, according to the National Institute of Statistics (NIS) after the 2011 census and a total number of 57,595 students, in the same year (NIS 2011). Believing that each person in Cluj-Napoca produces on average 1.25 kg waste per day, the average amount of waste produced daily is 386,420 tons, or 440,077 tons/day, if we take into account the students, who spend approximates 9 months in a year in the Cluj-Napoca city. So, the amount of waste produced exclusively by the inhabitants in Cluj-Napoca can reach approx. 155,500 tons annually, an appreciable amount, and at this amount we need to add, the municipal waste produced by companies, institutions, the waste resulted on the street, and the waste resulted from the gardens and parks, too.

Main environmental issues related to waste management by landfilling are related to cover of large areas of land and removing them from the natural circuit, problems with leachate collection and treatment, problems with collection of landfill gas, costs of daily maintenance and cost of environment monitoring etc.

The land occupied by the municipal landfills become unattractive for other activities, including a considerable area in their proximity and this is not only a temporary inconvenience; it is a problem for a long time. The land in the vicinity cannot be used as residential or recreational areas, and nor for the other activities, because the businessmen do not wanting to be in the proximity of a municipal waste landfill.

Regarding the leachate resulted from the landfill, the literature presents its complex and diverse composition, the pollutants being a mixture of organic and inorganic substances that results from aerobic and anaerobic degradation processes occurring in landfills and that pollutants can cause major ecological and ecotoxicological problems (Zhang et al 2009). For this reason, the optimum treatment of the leachate, in order to reduce its negative impact on the environment, is, at the present, a real challenge for researchers (because the complexity of the problem) (Fernandes et al 2012) and for the stockholders because of costs.

The landfill gases are another challenge in terms of their management and their recovery. The recovery of landfill gases cannot be achieved fully; the losses are around of 25 to 80%, if the deposits are conform and fitted with the recovery equipment for the CH_4, and, in the worst case, the losses can be total for the old landfills without CH_4 recovery systems. Oonk (2010) present that landfill gases can be recovered at a rate of 25 - 75%, and the IPCC Guidelines (2006) provides a single global value for landfill gas recovery of 20%. The rest is lost into the atmosphere as fugitive emissions, contributing to increase the emissions of the global greenhouse gases, GHG. Landfill gas consists mainly of CH_4 and CO_2 and small amounts of N_2O, and non-methane volatile organic compounds (NMVOCs), and some traces of NO_x, NH_3, CO, and particulate matter, PM10, PM 2.5 (EMEP/EEA 2009).

The methane from the landfill gases resulting from the anaerobic degradation of the organic matter, according to the equation (1):

$$(CH_2O)_n \rightarrow ½\ n\ CH_4 + ½\ n\ CO_2, \qquad (1)$$

where: $(CH_2O)_n$, means the approximate composition of organic matter in the deposited waste.

The methane production potential is proportional to the amount of waste disposed, respectively with the organic carbon content of the waste. It is known, that not all of organic matter can be degraded at the same rate. Part of the organic matter, such as cellulose, lignin is not degraded under anaerobic conditions, while others may not be degraded for other unfavorable reasons on biodegradation, that may occur in a landfill (Oonk 2010; Oonk & Boom 1995). The fractioned biodegradation of the organic matter generates some oscillations in the resulting methane concentration from the storage, but also extends the biodegradation process after the closure of the landfill.
Sometimes when passing through the surface layer, the methane can be oxidized according to equation (2), but the rate of occurrence of this reaction depends on a number of factors such as homogeneity of surface layer and the methane emission flow, porosity and humidity of surface layer, ambient temperature and the surface layer temperature that can increase or decrease the activity of microorganisms at the surface of the landfill:

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O \qquad (2)$$

Methane emissions from landfill is a worldwide important anthropogenic source of methane (Figure 2) and the recovery of the methane from the resulted landfill gases is achieved only at a rate of approx. 50-75% (Themelis 2008). In the year 1999, the CH4 emissions from municipal solid waste disposal accounted for 37% in USA, and for the year 2020 it is expected to fall below 10% by applying alternative measures of municipal solid waste management (US EPA 2000).

In addition, the landfill must be maintained and monitored, both technologically point of view (ex: stability, integrity, physical condition, including the integrity of the geological membrane) and in terms of emissions into the environment (loss of landfill gases, the leachate concentrations at the entrance of the treatment plant, the quality of treated water parameters resulted from the treatment plant and so on). The landfill monitoring must be done not only during operational phase, but also in the post-closure phase, to prevent any accidental pollution due to its existence, because the biochemical and physical processes in the deposit are not fully stabilized at the moment of closing the landfill.

All the above considerations lead to the conclusion that the choice of the optimal alternative of waste management, with the aim to transform the waste from an unwanted product that harms the environment, to a byproduct that can be used as raw material for various industries, is particularly important. Thus, reuse, recover and reuse of waste, may give certain advantages for the environment, such as: reducing consumption of natural resources, use of waste as an alternative source of energy, for use the bio-composting results as an amendment for degraded and eroded soil, resulting the reduced impacts and environmental risks, unlike the resulted of choosing the unique solution, the landfilling (Figure 3).

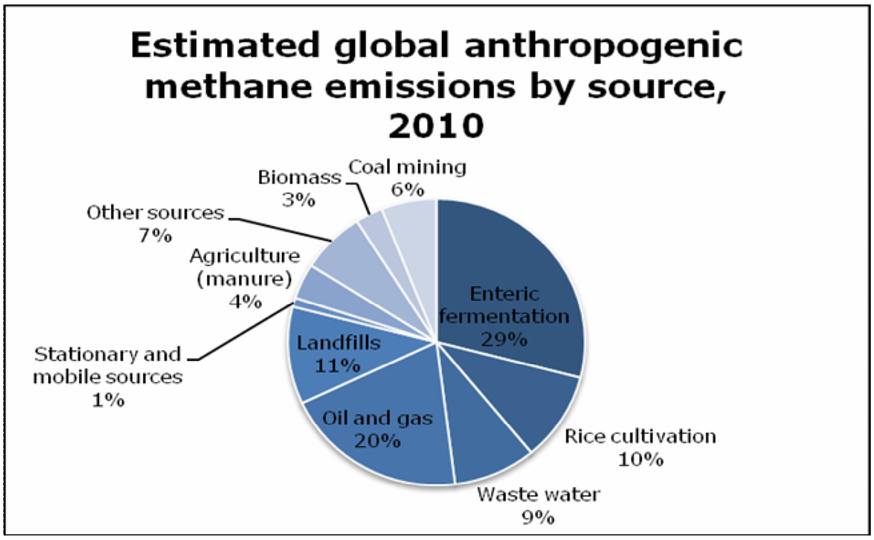

Figure 2. Estimated anthropogenic methane sources in the year 2010
(Source: Global Methane Initiative 2010)

Thus, in terms of waste management, the storage option is the least wanted environmentally solution for the waste management, because of the overall environmental impact. Thus, the options of reduction and waste minimization would be most desirable solutions and can be obtained either by upgrading of industrial processes, either by resizing the packaging, by using the biodegradable packaging and by actions of public awareness about responsible consumption and about to use better the reusable product, than the disposable product (European Commission 2010).

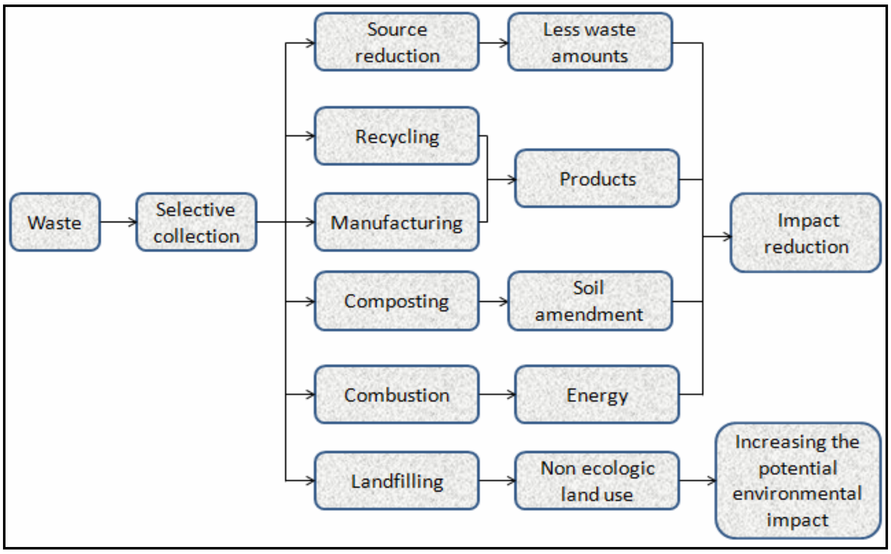

Figure 3. Management options for municipal solid waste, MSW.

Unfortunately, the landfilling is still one of the most common strategies of waste management worldwide. Municipal solid waste landfilling is not only a source of environmental impact, but also an important source of ecotoxicological risk that overwhelms the capacity of the land, resulting in high costs to the community and in terms of the authorities to have only the possibilities to decisions exclusive and unidirectional (Li, et.al, 2007).

From another point of view, many of the municipal solid waste, MSW, contain elements that can be recovered and reused, thus can reduce the natural resources consumption. Thus, from the electric and electronic waste, WEEE (Nnorom et al 2011), X-ray films, photographic solutions and films, as well as thin films of photovoltaic panels (Simon et al 2013) it can recover an important variety of metals, including precious metals. The aluminum cans recycling is a relatively simple, fast and very economical way to recycle metals, reducing the energy consumption required to obtain aluminum from raw material (bauxite and alumina) (BREF 2001). Plastic recycling in the industry can significantly decrease the consumption of raw material (oil) (Pretty 2003), energy consumption and the CO_2 emissions into the environment. Similarly, the paper recycling approach reducing the need for timber that allows the regeneration of forests and their use mainly to the ecosystem benefits. Recycling and reuse actions it obtains, new products, which provide a longer life cycle for natural resources and raw materials, with obvious benefits for the environment.

The construction and demolition wastes, are also resulted from municipalities, and globally are used with good results in the construction of the roads and for other geotechnical works, or as aggregate for the concrete production. Amount of construction and demolition waste arising in Romania is 9.67% of the total municipal waste arising, according to data from the National Statistics Institute (INS) and the National Environmental Protection Agency (NEPA), and 84% from them resulted from urban areas. The most part of the construction and demolition waste are inert waste, they do not produce impact ecotoxicological on the environment, but the main problem that arises is related to the large volumes produced, this means occupy large storage areas, with more waste that should be recovered and reused in other economic branches.

Another important category of municipal wastes is the waste from gardens and parks, from the market, and generally the biodegradable waste. From management of the biodegradable wastes using aerobic and / or anaerobic composting, results soil amendments that can replace peat and mineral fertilizers (Rigamonti et al 2009; Smith et al 2001) and can produce alternative fuel (methane) from anaerobic digesters (Hartmann & Ahring 2005). Greenhouse gases emissions during aerobic composting is less quantitative than the emissions resulted from long-term landfill and final product can be successfully used for the eroded soil or as nutrient for the poor soil. Moreover, by composting waste increase the soil carbon sequestration, so decrease the carbon emissions into the atmosphere, and implicit decrease the greenhouse gases emissions. (US EPA 2012).

Another way of managing the municipal solid waste is the heating treatment, as incineration, gasification, pyrolysis, under controlled conditions (pollutant retention equipment, and incineration at high temperatures), allowing the treatment of hazardous and the non-hazardous waste from MSW, with energy recovery. The result is to reduce the volume of waste by 90% and the major advantage is the use of waste as source of alternative fuel with a thermal efficiency of 87% (Rigamonti et al 2009). European Commission had reported (2010) that primary energy resulting from the incineration of MSW, in the year 2010 has doubled since 1995.

The alternative waste management processes described above are also generating of CO_2 and greenhouse gas emissions, however, of the observed, or the GHG concentration are lower, or it is countered by obtaining some advantages: useful products, including energy, reducing quantities of natural resources used, etc.

From this point of view, is the least wanted solution for the waste management is landfilling, as it brings more damage to the environment, high costs for maintenance and proper monitoring, the only advantage is too modest, and consists in waste collection from households. Furthermore, the landfilling of hazardous waste, as the WEEE category, can increase the ecotoxicological impact to the environmental and population (Kiddee et al 2013), and will create some additional issues for leachate treatment resulted from the landfill.

Using the life cycle assessment to choose the waste management alternative. Using alternative methods of municipal solid waste management is an increasingly important concern for researchers, authorities and governments. It wanted a variety of solutions to choose alternative scenarios of municipal solid waste management, to reduce the impact and potential risks wastes generate on the environment and to the people. Many of the scenarios used are based on the concept of life cycle assessment, LCA. Life cycle assessment is a useful mechanism and relatively easy to use in making decisions. LCA provides data to determine potential operational efficiency by reducing consumption of resources: energy reduction, materials reduction, water consumption reduction, and by reducing the amount of waste generated, and emissions into the environment, therefore, LCA help to increasing the environmental performance. The financial costs are increase, too with the increase of the environmental impact so, by reducing the environmental impact is expected to reduce the total costs involved in the process (Grant 2007).

From the perspective of LCA, integrating the environmental impact of municipal solid waste landfilling, versus time is shown in Figure 4.

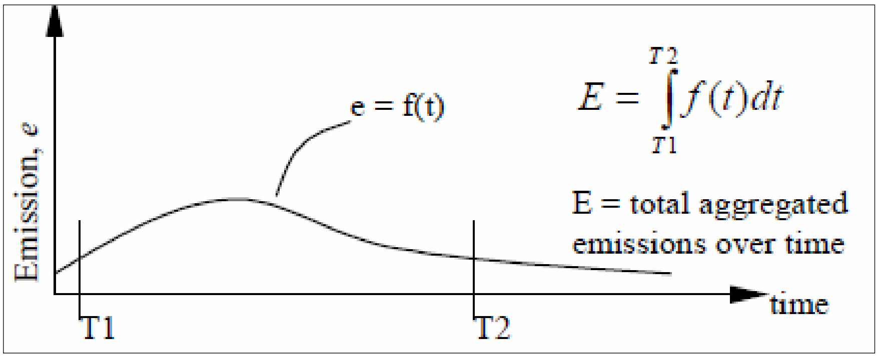

Figure 4. Integration of the Environmental Impacts from Landfill over the time (Source: Bjarnadóttir et al 2002).

The challenge is then to select a time interval T2, as close as it is possible to T1, that means actually the GHG emission period from the landfill. To select this time period should be based on ethical requirement, namely, exposure to emissions from landfills should not affect the future generations.

A report in terms of LCA for landfilling of MSW have to decide the time for the decay processes that occur in the landfill and to provide reasons for choosing that time period, ensuring the validity of the choice made (Bjarnadóttir et al 2002). It is important to highlight that is no evidence of dioxine emissions from the landfill, but it was detected the emission of mercury vapor from the landfills directly into the atmosphere. The dioxine emission can be observed only if there occurs the ignition processes (open burning) in the landfill, intentional or non-intentional (US EPA 2000).

Life cycle analysis in solid waste management is a technique for assessing the environmental impact of "cradle-to-grave" associated with the production, use and abandonment of products and materials. The main impact factors which consider are climate change, and greenhouse gas emissions, population health, or emissions of pollutants hazardous that interact with people and biodiversity, that can be eco-toxics, and are harmful for the environment.

Life cycle assessment for the waste management is associated with the scenario "zero waste" and the fact that waste should be regarded and treated as a resource, not only as a source of discomfort for environment. Recycling and reuse of the waste are actions in accordance with the principles on reducing consumption of natural resources, respectively with their use as source of alternative fuel.

Thus, LCA has become a tool for decision making in alternative waste management strategies, including municipal solid waste (Rigamonti et al 2009; Bjarnadóttir et al 2002; Finnveden 1999) (Figure 5).

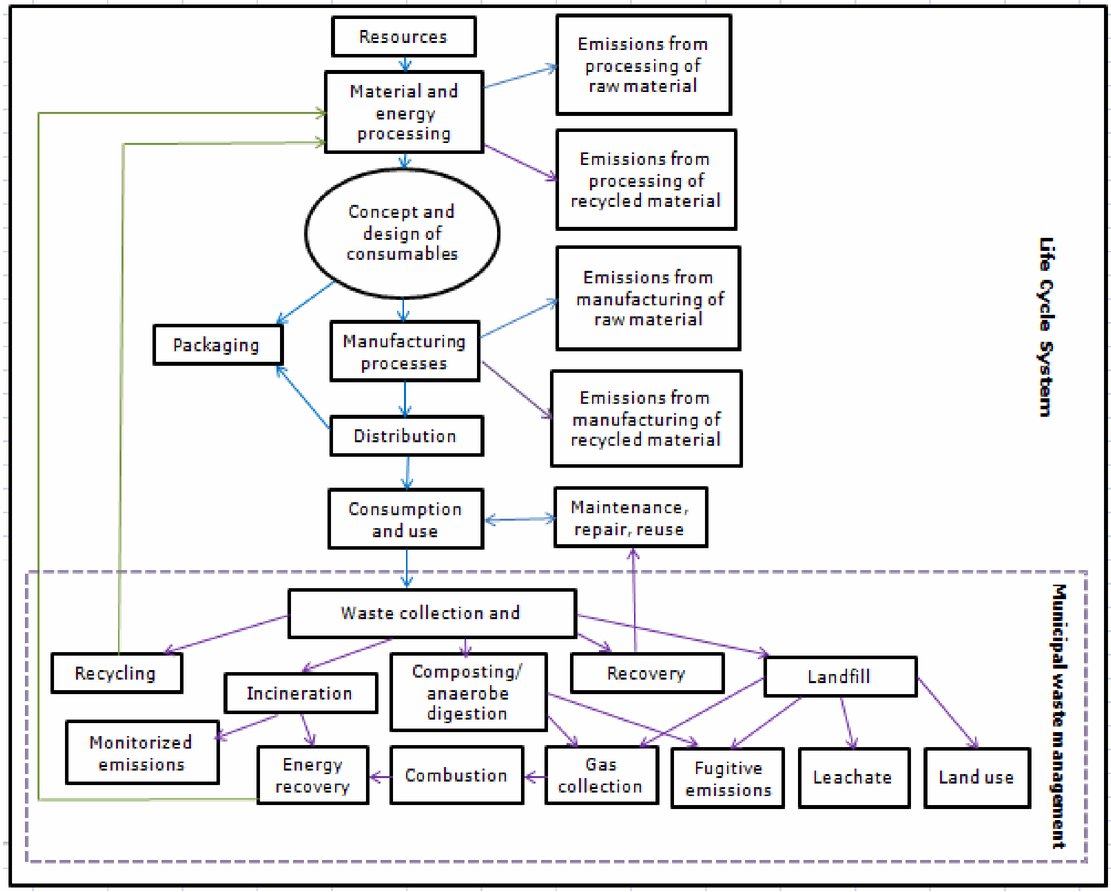

Figure 5. Schematic life cycle and waste management system
(Source: after Bjarnadóttir et al 2002 with completions).

Using the LCA can determine the optimal configuration of the management of municipal solid waste, taking into account all activities that generate environmental impacts from consumption of resources, emissions to the environment and waste flows, taking into account the possibility of replace the natural resources with wastes or energy production using the wastes that can replace the combustible fossil (Rigamonti et al 2009).

In terms of life cycle, the environmental impact of municipal solid waste depends on the following characteristics: design and product design, the amount of recycled material used in the manufacture of the new product, use or consumption pattern that influences the flow waste, reuse, recovery and recycling and management options used for MSW, if the management solution that was used for MSW was the landfilling or other using less demanding environment alternatives for MSW (US EPA 2012; Bjarnadóttir et al 2002).

From another perspective, the application of LCA in the environmental impact assessment is carried out using the energy balance: for any material emissions resulting from processing recycled material decreases in emissions resulting from the processing of natural resources. Thus, LCA approach includes both direct emissions and indirect, resulting from the processing of recycled materials (Figure 5). In this way, the estimation of emissions from processing recycled materials can be negative, which indicates that there is an environmental benefit (Rigamonti et al 2009; US EPA 2012).

LCA can be used to test the waste management hierarchy (source reduction, minimization, recycling, reuse, recovery treatment, including heat treatment and storage) and to identify any situations where this is not true. The results obtained using LCA can be used thus help to making political decisions and strategic choices of municipal solid waste management (Finnveden et al 2000).

Using LCA for waste management can also identify which of the options to improve waste management generates benefits for partial or entire MSW management system. Evaluating environmental performance of MSW management scenario and comparison with other scenarios and their performance can be achieved, all using LCA perspective. In addition, LCA can increase awareness of local organizations responsible for managing flow management (selective collection, treatment, recycling etc.). By emphasizing the optimal management solutions, it helping them to identify the directions in which they could improve environmental performance (Bjarnadóttir et al 2002).

Results and Discussion. The decisions regarding the choice of MSW management systems in the recent years have required usually the cost-benefit analysis, life cycle assessment and multi-criteria analysis (Beigl et al 2008; Morrissey & Browne 2004), because using these, the analyze is done more objective.

The literature and the studies undertaken by the American Environmental Protection Agency (US EPA) or the European Agency for Environmental Protection (EEA) showed that greenhouse gas emissions are more important in case of landfills than using the application of other technologies for MSW management. The greenhouse gas emissions from various waste management techniques decrease from prevention techniques, to techniques the recycling and reuse, and storage is undoubtedly the most important generator of GHG emission.

In this context, the use of the WARM (Waste Reduction Model) developed by the US EPA is a fast and convenient solution for making fast decisions. WARM is a program to aid those involved in making decisions, be they managers, authorities, other stakeholders. WARM program is based on comparing the GHG emission resulting during the life cycle and implications of energy consumptions arising from various waste management options (recycling, source reduction, incineration for energy recovery, landfilling), providing a quick and easy way to interpret results. So, 'WARM' is easy to use to take the best decisions in a shorter time by comparing the different alternatives scenarios with to the waste storage scenario. The general formula used for modeling of emissions of GHG in the 'WARM' is as follows (US EPA 2012):

"Net = Gross GHG Emissions GHG Emissions manufacturing - (Increase in carbon stocks + Avoided Utility GHG Emissions)"

The equation can be used to compare two scenarios of MSW management to determine between them which have the lowest GHG emissions. WARM uses several basic assumptions, such as, for example, it is considered that source reduction do not generate GHG; in most cases by recycling the waste the GHG emission is reduced, as the production of goods from recycled materials requires less energy than the using of natural resources or raw materials; the carbon resulted from organic matter decay in the composting the waste process is sequestrated in the soil and thus reduce the amount of carbonic gases that can be emitted into the atmosphere; the emissions of CH_4 resulting from the landfilling is (partially) captured and used for energy production, and thus are offset emissions from consumption fossil fuels; the combustion of waste can generate electricity also replacing fossil fuels (US EPA 2012).

Thus, for illustration of that assumption it was applied the WARM for assess the GHG resulted from municipal solid waste management in Cluj-Napoca in 2010. The baseline scenario shows emissions of greenhouse gases, GHG, in case that all the resulting wastes are stored (this is the main management option used now in the Cluj-Napoca area). After, it was used other two alternative scenarios for MSW management, as shown in Figures 6 and 7.

Three scenarios were analyzed using WARM. The first is the baseline scenario (landfilling the waste), with we compare the other two scenarios and which presenting two different options for management of MSW. In the second alternative scenario (Figure 6), continue storing mixed organic waste fraction, and in the third alternative scenario (Figure 7), it is proposed the incineration of mixed organic waste in the ecological conditions (with energy recovery, and using temperatures adequate for the incineration process to destroy the hazardous substances resulted from the incineration, and use, for this purpose, a facility which has the advantage of using MSW as combustible, replacing fossil fuels, and thus reducing the amount of waste sent for landfilling).

Baseline scenario						Alternative scenario						Change (Alt - Base) MTCO2E
Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Compos-ted	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Compos-ted	Total MTCO2E	
Glass	0	7,746	0	N/A	301	0	7,746	0	0	N/A	-2,154	**-2,455**
PET	291	20,600	0	N/A	477	0	20,891	0	0	N/A	-23,155	**-23,632**
Newspaper	0	3,023	0	N/A	-3,056	0	0	0	3,023	N/A	-8,409	**-5,352**
Office Paper	0	15,050	0	N/A	17,674	0	15,050	0	0	N/A	-42,941	**-60,363**
Dimen-sional Lumber	1,357	605	0	N/A	-3,774	0	1,357	0	605	N/A	-3,686	**88**
Yard Tri-mmings	N/A	6	0	0	-1	0	N/A	0	0	6	-1	**0**
Leaves	N/A	1	0	0	-1	0	N/A	0	0	1	0	**0**
Mixed Paper (general)	0	32	0	N/A	-2	N/A	0	0	32	N/A	-16	**-13**
Mixed Metals	12,909	0	0	N/A	-51,292	N/A	12,909	0	0	N/A	-51,292	**0**
Mixed Plastics	291	20,710	0	N/A	518	N/A	21,001	0	0	N/A	-20,616	**-21,134**
Mixed Organics	N/A	62,998	0	0	17,396	N/A	N/A	0	0	62,9980	-12,452	**-29,848**
Mixed MSW	N/A	94,497	0	N/A	92,950	N/A	N/A	94,497	0	N/A	92,950	**0**
Carpet	0	455	0	N/A	18	0	455	0	0	N/A	-1,078	**-1,096**
Personal Compu ters	1,310	0	0	N/A	-3,074	0	1,310	0	0	N/A	-3,074	0
Concrete	0	1,765	N/A	N/A	69	N/A	1,765	0	N/A	N/A	-14	**-83**
Wood Flooring	N/A	620	0	N/A	42	0	N/A	0	620	N/A	-472	**-514**
GHG Emissions from Baseline Waste Management Scenario (MTCO2E):					68,241							
GHG Emissions from Alternative Waste Management Scenario (MTCO2E):					-76,434							
Total Change in GHG Emissions: (MTCO2E):					**-144,675**							

Figure 6. Assessment of LCA GHG emissions in terms of alternative 1MSW management in Cluj-Napoca* (Source: US EPA 2012) (*The negatives values in the Figures 6 and 7 indicate the emission reduction; the positive values indicate the emission increase (US EPA 2012)).

Baseline scenario						Alternative scenario						Change (Alt - Base) MTCO2E
Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Compos-ted	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCO2 E	
Glass	0	7,746	0	N/A	301	0	7,746	0	0	N/A	-2,154	**-2,455**
PET	291	20,600	0	N/A	477	0	20,891	0	0	N/A	-23,155	**-23,632**
Newspaper	0	3,023	0	N/A	-3,056	0	0	0	3,023	N/A	-1,676	**1,380**
Office Paper	0	15,050	0	N/A	17,674	0	15,050	0	0	N/A	-42,961	**-60,636**
Dimen-sional Lumber	1,357	605	0	N/A	-3,774	0	0	0	1,962	N/A	-1,141	**2,633**
Yard Tri-mmings	N/A	6	0	0	-1	0	N/A	0	0	6	-1	**0**
Leaves	N/A	1	0	0	-1	0	N/A	0	0	1	0	**0**
Mixed Paper (general)	0	32	0	N/A	-2	N/A	0	0	32	N/A	-16	**-13**
Mixed Metals	12,909	0	0	N/A	-51,292	N/A	12,909	0	0	N/A	-51,292	**0**
Mixed Plastics	291	20,710	0	N/A	518	N/A	21,001	0	0	N/A	-20,616	**-21,134**
Mixed Organics	N/A	62,998	0	0	17,396	N/A	N/A	0	62,998	0	-8,624	**-26,020**
Mixed MSW	N/A	94,497	0	N/A	92,950	N/A	N/A	0	94,497	N/A	-3,653	**-96,603**
Carpet	0	455	0	N/A	18	0	0	0	455	N/A	501	**484**
Personal Computers	1,310	0	0	N/A	-3,074	0	1,310	0	0	N/A	-3,074	**0**
Concrete	0	1,765	N/A	N/A	69	N/A	1,765	0	N/A	N/A	-14	**-83**
Wood Flooring	N/A	620	0	N/A	42	0	N/A	0	620	N/A	-472	**-514**
GHG Emissions from Baseline Waste Management Scenario (MTCO2E):					68,244							
GHG Emissions from Alternative Waste Management Scenario (MTCO2E):					-158,349							
Total Change in GHG Emissions: (MTCO2E):					**-226,593**							

Figure 7. Assessment of LCA GHG emissions in terms of alternative 2 MSW management in Cluj-Napoca* (Source: US EPA 2012) (*The negatives values in the Figures 6 and 7 indicate the emission reduction; the positive values indicate the emission increase (US EPA 2012)).

One should note that the modification of waste management options resulted in different values for GHG emissions. Thus, it is possible to create scenarios that are consistent with existing MSW management opportunities in the region and the requirements to reduce environmental impact.

As was mentioned before, the main way of municipal solid waste management in Cluj-Napoca city is the landfilling option. While the landfilling may seems to be the easiest option, at a thorough evaluation, the landfilling is an expensive option, both in terms of environmental impact and in terms of costs requested, both to short and to long periods of time (for maintenance, and for monitoring, too).

It is true that for the development of the alternative waste management options is necessary to create an appropriate infrastructure for recycling, treatment and so on, but it is also known that, for the build up a new landfill and for their adequate management, in accordance with legislative requirements, is an expensive investment, too. In this context, is better to thinking for the long term, and to invest in the infrastructure that would ensure recycling and / or other MSW management alternatives, including ecological incineration that is certainly more profitable, from the environment point of view, and for the financial point of view.

It is estimated that the WARM (US EPA 2012) can be used as a decision making tool for different alternative waste management scenarios, to providing fast solution, thinking at the lowest environmental impact, from different management options MSW, from the point of view of GHG emissions . It is a useful tool that can be used by all stakeholders in MSW management, including the authorities, to take decisions with a better accuracy, based on the possibility of comparing scenarios using the perspective of GHG emissions, during the life cycle of the product.

From another point of view, a MSW management system can be considered sustainable if it is effective in terms of environmental impacts, if feasible, economically and legally acceptable, legally social (Contreras et al 2008; Petts 2000). To achieve such a consensus must be ensured and local community consultation before adoption options for MSW management, but also the investors who can create necessary infrastructure implementation of these options.

Conclusions. There were compared various alternatives for municipal solid waste management, MSW. The solution mainly used at the present, in Cluj-Napoca is the MSW landfilling. The alternatives that were analyzed targeted other options of MSW management (the source reduction of waste, recycling, composting, combustion of waste). It was emphasized once again that greenhouse gases emissions from MSW management alternatives are lower than if is choose only the option of landfilling for MSW management. In addition, recycling, reuse, composting of waste, can changes the waste perspective, from unwanted objects to the byproducts than can be used in the manufacturing processes. Or other alternative for MSW management, as waste incineration can be used to obtain the energy that can replace the fossil fuels. Thus, the alternative waste management options are preferred and acceptable in comparison with the singular landfilling option, because for the long-term, the landfilling is more expensive and their environmental impact is bigger, than for using others options of waste management.

It is, also, important to be a consensus among the local community wishes, the possibilities of regional development, the interest of the potential investors in the region and the requirement of the authorities, to choose the best MSW management solution, which can reduce the environmental impact, but also to meet social consensus and to be consistent with the economic possibilities of the area.

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Received: 20 February 2013. Accepted: 25 February 2013. Published online: 15 April 2013.
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How to cite this article:
Modoi O.-C., Popiţa G. E., Mihăiescu R., 2013 Alternative decisions for municipal solid waste management in Cluj-Napoca area. AES Bioflux 5(2):166-177.