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Developing a Waste Management Plan: A case study of Hajdú-Bihar County in Hungary

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ABSTRACT

The integrated approach towards the waste management system brings us closer to sustainable waste handling. The last few decades indicate a prominent development in the field of waste treatment facilities concerning the "eco-society".

The overall target of this thesis was to analyse the waste management practice in Hungary and to develop a waste management plan for Hajdú-Bihar County by assisting the competent authorities in their future tasks. Moreover, suggesting recommendations to implement an integrated waste management system.

The study expressed the current Hungarian waste management by situation investigating one specific area: Hajdú-Bihar County. The author of this paper presented the available municipal solid waste treatment facilities and examined their environmental consequences. Through this evaluation suggestions are formulated for the competent authorities to help guide the establishment of an integrated waste management plan. To implement the recommended waste treatment technologies legal, economic and social factors are taken into consideration. The paper concludes with the most important points of the study and suggests urgent recommendations for creating a waste management plan and introducing an integrated waste management system.

Keywords: waste management, landfilling, incineration, anaerobic digestion, sustainability, Hajdú-Bihar County

TABLE OF CONTENTS

ABSTRACT ..... **i**

ACKNOWLEDGEMENTS ..... **iii**

1. INTRODUCTION **1**

1.1. PROBLEM DEFINITION 2
1.2. OBJECTIVES 2
1.3. SCOPE AND LIMITATIONS 3
1.4. MATERIALS AND METHODOLOGY 3

2. EXPLANATORY MODEL – CASUAL LOOP DIAGRAM (CLD) **4**

3. THEORY AND BACKGROUND MATERIALS **5**

3.1. INTEGRATED WASTE MANAGEMENT 5
3.2. WASTE MANAGEMENT PLAN 6
3.3. EU POLICY ON WASTE MANAGEMENT 8
3.3.1. General guidelines *8*
3.3.2. Requirements in accordance with the Community Directives and Regulations concerned *8*

4. PROBLEM ANALYSIS **10**

4.1. WASTE MANAGEMENT SITUATION IN HUNGARY 10
4.1.1. Legislative background *11*
4.1.2. National goals and strategies for waste *12*
4.2. THE CURRENT WASTE MANAGEMENT PRACTICE IN HAJDÚ-BIHAR COUNTY 12
4.2.1. Introduction of the county *12*
4.2.2. Present waste disposal method in the county *13*
4.2.3. ISPA Project on Establishing a selective waste collection, utilisation and community waste management system in Hajdú-Bihar County *15*

5. DEVELOPING A WASTE MANAGEMENT PLAN **17**

5.1. AVAILABLE TECHNIQUES 17
5.1.1. Landfilling *17*
5.1.2. Incineration *18*
5.1.3. Fermentation – Anaerobic Digestion *19*
5.2. ENVIRONMENTAL CONCERNS 20
5.2.1. Impacts of uncontrolled landfill sites *22*
5.2.2. Impacts of incineration plants *22*
5.2.3. Impacts of anaerobic fermentation *23*
5.3. SELECTED COMBINATION OF TECHNIQUES 23
5.4. ASSESSMENT OF POSSIBILITIES CONCERNING THE SELECTED TECHNIQUES 25
5.4.1. Biogas utilisation *25*
5.4.2. Nutrient recovery *26*

6. STRATEGIES SUPPORTING THE WASTE MANAGEMENT PLAN **27**

6.1. LEGAL INSTRUMENTS 27
6.2. ECONOMIC INCENTIVES 28
6.3. SOCIAL FACTORS 29

7. CONCLUSIONS **30**

7.1. RECOMMENDATIONS FOR FUTURE RESEARCH AND DEVELOPMENT 30

8. LIST OF REFERENCES **31**

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1. INTRODUCTION

Recently, it has become better known that the Earth faces several environmental challenges such as acid rain, ozone depletion, climate change, loss of biodiversity, toxic and hazardous waste, and pollution of water to name a few. These problems lead to a more limited accessibility of natural resources, which support human activities and economies. Therefore, it is not surprising that in recent years the environmental concerns have become economic concerns as well. However, looking at the current economic and market conditions and attitude such as the rapid exploitation and inefficient utilisation of resources, there are only few signs of hope to change the present attitude towards a more sustainable one. Nevertheless, the local and global crises of the society and the economy underscore the importance of shifting towards sustainable development.

The concept of sustainable development was drawn up in the Brundtland Report in 1987 defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The interdependency of the environment and development was highlighted, and it is also well-known fact that without comprehensive action, further development cannot be reached. Thus, the concept of sustainability forces us to look at the environmental problems in conjunction with the existing economic and social orders and problems.

The UN Conference in Rio in 1992 addressed among other issues, the reduction and elimination of unsustainable patterns of production and consumption since it is no longer possible to deplete non-renewable resources or to dispose of waste at such a rapid rate as is done at present (Nilsson, 1997). However, the creation of wastes has been one of the distinguishing characteristics of every human society as Ponting (1991) pointed out. Waste generation is also an indicator of how efficiently a society uses raw materials, since waste represents the loss of both material and energy resources (European Environmental Agency, 2000). It is therefore crucial to reduce the load on the environment and to develop a closed-loop handling of materials in order to attain long-term sustainability (Nilsson, 1997).

The first step towards a more sustainable waste management system is to break up the linear material flow and to close the cycle. Connelly and Smith (1999) also remarked this emphasising that the linear capitalist economies – characterised by resource depletion, mass production and consumerism – need to become more circular and reduced in size. They further argue that "products should be more durable and when their initial use is over, they should not be disposed of, but rather repaired or recycled – utilised as resources for other production processes."

The creation of integrated waste management systems is a new trend brought about by past environmental damage from landfills, scarcity of land near urban areas, and growing public opposition to landfills and incineration plants. The integrated waste management systems depend on a combination of different waste treatment methods to minimise the dominance of the landfill sites (Barlishen–Baetz, 1996). Therefore, the integrated waste management system can, to a large extent, contribute to achieving sustainable waste management.

1.1. Problem definition

Since Hungary has already proceeded in its negotiations for EU membership and since the proposed goal is to close the negotiations process by the end of 2002. The national legislation has to be adjusted and the institutional requirements have to be met as soon as possible and an implementation of the changes has to be started. This is particularly relevant to the waste management issue within the environmental field since waste generation and treatment options have in the past received less attention and only recently became prioritised.

In order to accelerate the accession process, and to meet not only the national goals but also the EU requirements in close relation with the principles of sustainable development, there is a need for efficient and effective implementation. While the legislative and institutional frameworks seem to keep pace with the international and EU policy, the real actions and practices are far behind the desired outcome. Consequently, every opportunity has to be used to change the current situation. New methods have to be considered and it is necessary to look for new, promising treatment facilities, which minimise both the short-term and long-term environmental risks.

1.2. Objectives

The overall purpose of this study is to show the existing potential and ability to change the current Hungarian waste management system by adopting and implementing the international and the EU requirements and expectations. Furthermore, this thesis demonstrates that it is possible to introduce an integrated waste management system, which fulfils the targets of sustainable development. In order to prove this, a case study is performed showing and analysing the current changes in Hajdú-Bihar County, and additionally further steps towards a prospective development are suggested.

The aim of this paper is:

1. To analyse the current Hungarian waste situation and management system as well as to identify the existing, potential problems and tasks relating to the municipal solid waste issues.

2. To present and evaluate the situation in Hajdú-Bihar County using as a case study to express the possibilities for far-reaching changes.

3. To evaluate one of the ISPA[1] (Instruments for Structural Policies for the Pre-Accession) projects, which has already been submitted for the assistance to the European Commission.

4. To suggest recommendations through a waste management plan to the Hungarian governmental authorities at regional and local level in order to improve the existing waste management systems and to encourage the regional municipalities to apply for assistance to speed up solving the waste treatment issue.

[1] ISPA is a new, EU granting assistance providing financial aid to the candidate countries. Within the framework of ISPA Programmes investments aiming at the development of the infrastructure and the environment will be financed between the period 2000 to 2006.

1.3. Scope and Limitations

The municipal solid waste management issue, even if it is concentrated on one specific area, is a broad but complex subject. Since the extent of this paper is limited, certain aspects such as deep analysis of different waste management techniques, cost-effective analysis, consumer behaviour and so on are not possible to include in it. Therefore, this study focuses more on different waste treatment facilities highlighting the legislative and institutional questions instead of the economic part or the social approach of the issue.

Evaluation of a case study could give a better overview of the whole system and make it easily understandable. Through the analysis, recommendations are formulated in order to encourage the competent authorities to push the issue further and to raise awareness in accordance with the importance of integrated and holistic perspectives. Thus, this paper evaluates the specific problems and opportunities in one of the Hungarian counties as an example, and elaborates on possible, municipal waste disposal methods to introduce an integrated system.

Although, the study highlights the possible options only for the chosen county, they can be converted and applied to other counties and some aspects can be used at the national level as well.

1.4. Materials and Methodology

An extensive literature survey and statistical data analysis are the primary source of this thesis. The basic approach was to review the relevant literature relating to the integrated solid waste management system. It was necessary to show the connection between sustainability and the new waste management principles. Consequently, the background material supports the actual analysis of the Hungarian waste situation in the scope of sustainability and it also provides a holistic approach towards a future waste management systems.

The primary data was gathered by personal communications and workshops with professionals in the waste management field. A visit to the biggest local waste management company in Debrecen, Hungary and a continuous working relation with the regional environmental inspectorate provided valuable data and information about the waste management situation in Hajdú-Bihar County, Hungary and its future perspectives. The secondary information source was published literature such as articles, academic books, laws and regulations in force. These publications are considered as the basis of the study.

Moreover, a case study was used to present and analyse the current waste management system in Hajdú-Bihar County and to suggest further steps to improve the development of the waste issue. This paper also introduced and evaluated the ISPA Project on “Establishing a selective waste collection, utilisation and community waste management system in Hajdú-Bihar County”. This project is already submitted to the Commission of the European Communities for financial aid to implement it.

2. EXPLANATORY MODEL – CASUAL LOOP DIAGRAM (CLD)

This study analyses the issue of waste management and disposal technologies using a systems thinking approach. The focus is on integrated waste management system (IWMS) including the three main elements of sustainability. The causal loop diagram[2] presented in Figure 1 depicts the relationships between different actors and influencing factors. An important issue is that the generated municipal solid waste (MSW) treated in an inappropriate way cause environmental effects, which in turn have to be minimised by applying an integrated waste management system.

The environmental effects have a strong influence on the three main factors: legal, economic and social patterns. Following the legislative line, goals and standards are set up to regulate the impacts of the different treatment technologies. Thus, goals and standards contribute to the establishment of integrated waste management systems through waste management plans. Secondly, the environmental effects lead to an economic burden for companies, governments and indirectly for the general public as well. In order to decrease further environmental impacts and to create a fund for clearing the polluted areas, a tax system is introduced. This also stimulates the integrated waste management systems by promoting the appropriate treatment methods. In addition, increasing public awareness facilitates to a change of the basic behavioural patters, thus reinfocing the IWM systems.

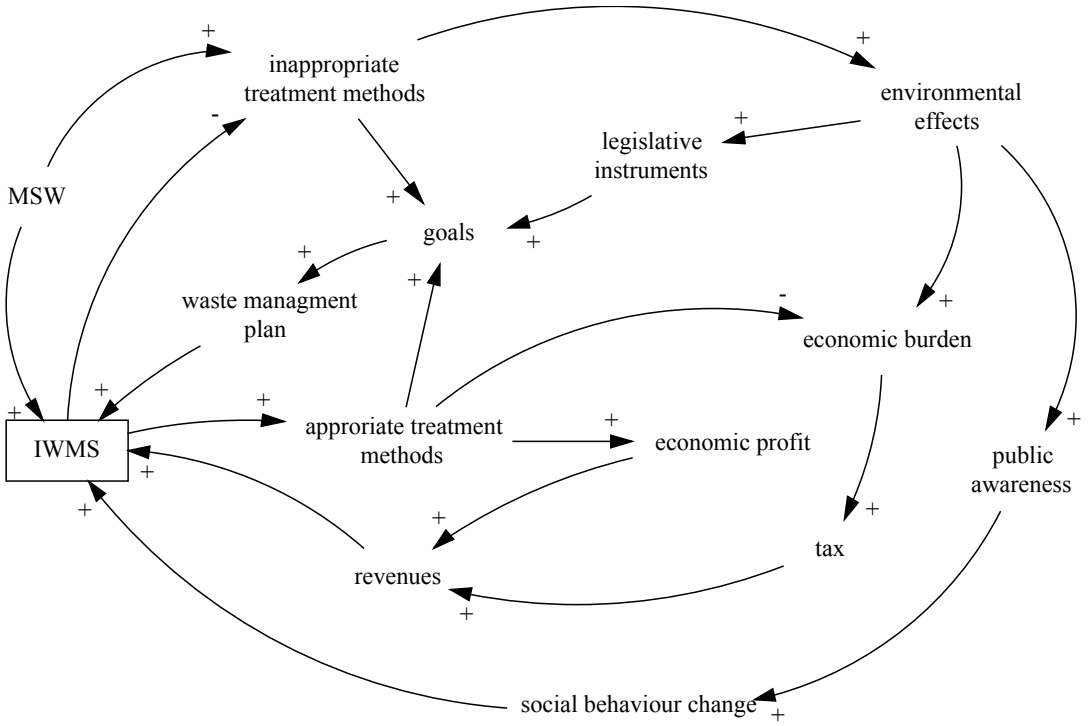

Figure 1. Casual Loop Diagram of waste management system

[2] A causal loop diagram is an effective tool to visualise a problem and the interrelating factors of the system clarifying causes and effects between the main actors.

3. THEORY AND BACKGROUND MATERIALS

3.1. Integrated waste management

It is of great importance to look for improved methods to decrease the growing waste production. Over the last six years the total amount of waste generated in the EU has grown by 10 percent a year (European Union, 1999). A similar expansion prevails all over the world. Thus, there is no doubt that this trend has to be reversed. Meanwhile, sustainable waste management must involve more than efficient waste management and recycling (European Environmental Agency, 1999).

The principles of sustainability emphasise the efficient use of raw materials and the necessity to close the natural cycles. This is valid to a great extent concerning the production and consumption process, since both have negative side effects – one of them is being waste generation. This was already shown in the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992.

While in the past understanding the consequences of waste generation and disposal has had low priority (Ponting, 1991) recently, there has been a trend considering waste production as an antisocial activity rather than necessary and inevitable consequence. Moreover, there is a growing awareness to make efforts to eliminate the further impacts and to create strategies to avoid being overloaded by waste.

The concept of waste prevention has been viewed as two divisions: primary pollution prevention affecting the waste producing source – source reduction – and secondary pollution prevention making use of a potential waste – recycling (van Berkel, 1996; Miller 1999). According to Conn (1988) the source reduction is defined as the prevention of waste at its source by redesigning products or changing patterns of production and consumption. On the other hand, the secondary pollution prevention can be considered as waste minimisation including those activities, which reduce the amount of waste, but do not diminish the amount of waste initially generated (Lober, 1996). Thus, two various approaches considering the avoidance and minimisation of waste generation exist.

New generation of waste management systems has emerged with a focus on waste minimisation, recovery and reuse of materials, the energy recovery from waste and responsible disposal of unavoidable waste (Petts–Eduljee, 1994). These were formulated in the waste hierarchy, which is an early approach towards a sustainable waste management. This is also the main goal of the integrated waste management system (IWM), which can be defined "as the selection and application of suitable techniques, technologies, and management programs to achieve specific waste management objectives and goals" (Tchobanoglous et al., 1993). However, the IWM systems do not consider the waste management hierarchy as a binding priority succession, but rather the elements of the hierarchy are interrelated and are selected to complement each other (Tchobanoglous et al., 1993; Mirza, 1998).

Nevertheless, the first and most important priority is the source reduction since it is the most effective method to avoid the further management issues and the environmental impacts (Mirza, 1998; European Union, 1999; European Environmental Agency, 2000). Only the last solution should be the landfilling for those unavoidable wastes, which cannot be recycled or used for

material and/or energy recovery because there is no available, present treatment facility to utilise this waste (Tchobanoglous et al., 1993; Petts–Eduljee, 1994). Between the first and the last level in the waste management hierarchy the accepted application in the IWM system is the combination of two or more waste management practices, which are adjusted to the specific area taking into consideration the environmental, energy, economic and socio-political aspects (Mirza, 1998). This since sustainable development has three main pillars: the ecological, economic and social dimension. Thus, establishing an integrated and sustainable waste management system should combine all of them.

Creating and applying an IWM system involves the appropriate selection of waste management alternatives and technologies focusing on the specific conditions of a region in order to meet the legal requirements. Furthermore, the established system should be able to adapt new facilities according to changing conditions and developing technologies. Therefore, one of the cornerstones of a successful IWM system is its flexibility. Moreover, the continuous monitoring and evaluation is of great importance as well, since an ongoing comparison with the original objectives and goals can modify the system to meet the changed market conditions.

3.2. Waste management plan

In order to elaborate a comprehensive waste management system, it is necessary to apply several tools. One of them is the waste management plan, which the entire system should be built upon. Meanwhile, such a plan can only contribute to the development if it is well structured, considers different aspects and functions as more than a new, bare policy measure focusing on exclusively solving the existing problems.

The EU Directive on Waste (91/156/EEC) requires the competent authorities to draw up waste management plans. It also determines the most important requirements concerning the content. According to the directive such a plan should contain the following elements:

- the type, quantity and origin of waste to be recovered or disposed of,
- general technical requirements,
- any special arrangements for particular wastes,
- suitable disposal sites or installations.

The waste management plan should be based upon the EU general and specific guidelines and furthermore, it should incorporate the EU guidelines concerning the waste management.

Waste management plans are key elements in the EU organisational structure and intended to help achieve the objectives of waste prevention or reduction, waste recovery, environmentally safe disposal and the establishment of an integrated and adequate network. Therefore, one of the basic aspects is to involve as many stakeholders on whom the success of the actual work depends (Ljunggren, 1997).

The establishment of a waste management plan imposes several new questions concerning the adequate size of the region involved, the ownership of the facilities, necessary legislative steps, inspection and enforcement tasks and the choice of the different treatment facilities. These questions are significant from a comprehensive point of view and they also determine the sustainability of the waste management plan. Furthermore, it has to be noted that the time aspect

needs to obtain a paramount status during the planning process. The preference for short-term fixes is inconsistent with the principles of sustainability.

Analysing some already established waste management plans, it can be said that the first step is to evaluate the existing situation. Then, the deficiencies can be formulated and the goals to be achieved can be set up. The decision process is determined by EU and national standards, the legal enforcement situation and economic pressures as well as the availability of new waste treatment technologies. It is important to stress that optimising the existing system or supplementing it with new elements is not always enough and it does not necessarily make the old system more effective (European Commission, 1994). In order to create an integrated waste management system for a certain area the connections and the interrelated functions have to be

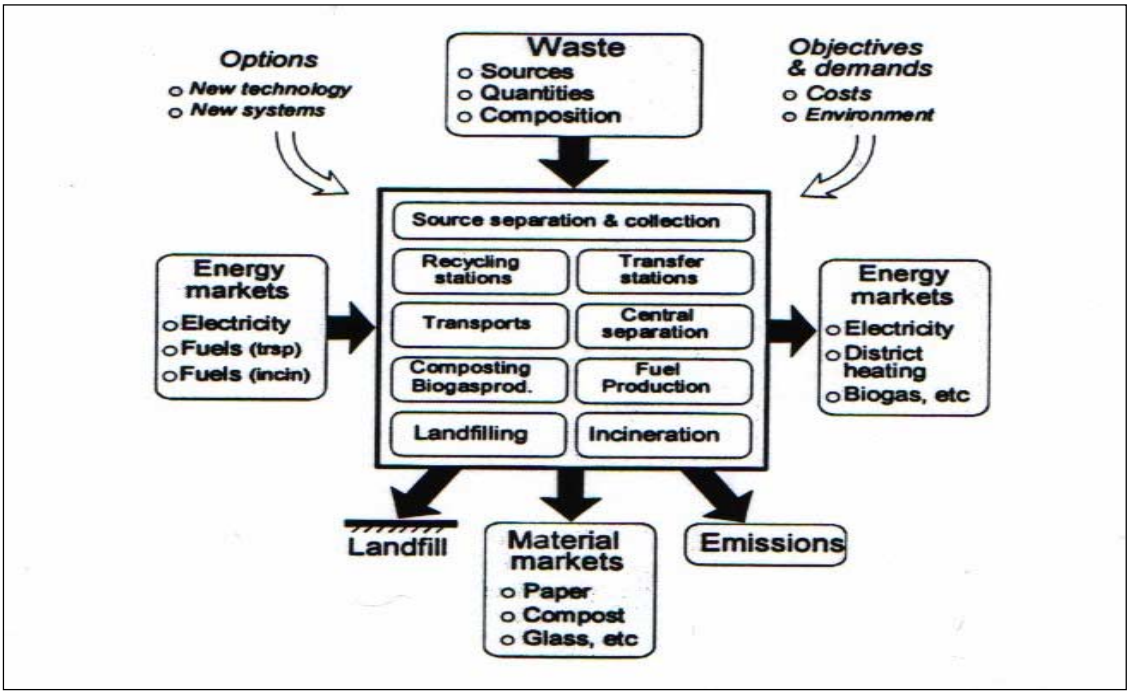

Figure 2. Influencing factors and the boundary of the waste management system (Adapted from Sundberg, 1998)

evaluated. According to Sundberg et al. (1994) the Figure 2 illustrates the boundaries of the system, which promotes an understanding and analysis of how the related factors are influencing the waste management system (in Ljunggren, 1997). The model shows the inputs and the outputs of the system and the influencing elements. The purpose is to create a sustainable system integrating the different treatment facilities whereas the influencing factors are taken into consideration.

During the planning process several economic, social and political aspects are determinative in addition to the environmental factors. Since the economy is the engine/inducement towards development the demand and the prices for recycled materials and compost, the demand and prices for bio-energy, and the availability and cost of new waste treatment technologies affect

the decision to a great extent. In regards to the political aspects, the prospective environmental goals and restrictions should be taken into consideration during the planning process. The social consequences are quite often underplayed and underestimated. However, public participation should receive much attention in the future.

3.3. EU Policy on Waste Management

3.3.1. General guidelines

The European Union, as the only supranational organisation, has started to deal with environmental matters since the early seventies. In 1973 the First Environmental Action Programme was created and explicitly stated the environmental policy of the EU (Connelly–Smith, 1999). During the last three decades a comprehensive environmental policy taking into consideration sustainability was developed relating to different areas and sectors within society. However, some specific areas for instance waste management are highlighted due to the recognition of environmental impacts caused by waste generation and treatment.

Thus, the EU has recognised and formulated five over-arching principles for waste management:

- Prevention principle
- Producer Responsibility and Polluter Pays Principle
- Precautionary Principle
- Proximity Principle
- Best Available Technique Not Entailing Excessive Cost (BATNEEC)

Source: European Union, 1999; Connelly–Smith, 1999.

In addition to these main principles there are also several other objectives – such as the encouragement of clean products, the use of economic instruments, the regulation of the shipment of waste and so on – in the EU waste management policies to be achieved.

Considering the above-mentioned principles, the Framework Directive on Waste (75/442/EEC, modified by the 91/156/EEC) and the EU General Strategy on Waste (1996) concentrate on the waste hierarchy giving top priority to the prevention of waste generation, followed by re-use and recycling of waste materials, energy recovery and final disposal of waste. Furthermore, the strategy emphasises among other tasks the need for new and better management tools such as regulatory and economic instruments, waste management plans and proper enforcement of legislation (European Union, 1999; European Environmental Agency, 1999).

3.3.2. Requirements in accordance with the Community Directives and Regulations concerned

The general requirements formulate the main guidelines, which support the specific tasks. The basic principle is to protect the human health and the environment against harmful effects caused by the waste and the related activities (Council Directive 75/442/EEC). The primary objective of waste management is formulated in the waste hierarchy and what has to be considered is the minimisation of the extent of natural resources used. The Council Resolution of 24 February 1997 on a Community Strategy for Waste Management emphasises the importance of

appropriate waste management planning at all competent levels. Furthermore, a Commission proposal COM (99)31 on Waste Management Statistics calls for regular, comparable, current and representative data on waste.

The specific rules determine certain areas and they integrate the basic principles. According to the Council Directive 94/62/EC on Packaging and Packaging Waste, by the year 2001 at least 50 percent, but at most 65 percent of packaging waste should be re-utilised and 20 to 45 percent of packaging waste should be recycled. Moreover, as a minimum 15 percent of each packaging material should be recycled. According to the Council Directive 99/31/EC on the Landfill of Waste a reduction of the production of methane from landfills is requested through the reduction of the landfill of biodegradable waste. Therefore, the biodegradable municipal waste going to landfills should be reduced to 75 percent of the total amount by weight of biodegradable municipal waste produced in 1995.

Taking into consideration the goals of the EU directive, the current landfill sites in Hungary have to be converted into efficient waste "processing plants", which stabilise the waste, eliminate the methane emissions and provide an optimised collection and utilisation for biogas and nutrients.

Since Hungary is on the way to become a member country in the EU these guidelines and particularly the requirements have to be integrated and implemented into the Hungarian practice.

4. PROBLEM ANALYSIS

4.1. Waste management situation in Hungary

In Hungary, in 1990 the amount of manufacturing and municipal solid waste generated was 106 million tons. Due to a sharp decline of the industrial production, the generated waste fell back with a considerable amount at the beginning of the nineties. According to the estimates based upon technical calculations, presently the waste generated annually ranks from 70 to 80 million tonnes. 20 million tonnes per year of the total amount is treated municipal liquid waste. The annual amount of the municipal solid waste is between 4 and 5 million tonnes. The rest, which is about 45-55 million tonnes per year, is coming from the industrial, agricultural and other production activities (Szabó–Pomázi, 2000; World Bank, 1999). These numbers, however, are not exact and every source shows different numbers relating to the amount of the waste generated yearly, since there is no available data concerning the generated amount due to the lack of an obligatory supplying of data. Furthermore, specific legislative and economic regulations are missing in order to establish a comprehensive information system relating to the waste generation and treatment.

Table 1. General data concerning the solid waste in Hungary

Waste generated **annually**, out of which: - Municipal solid waste - treated municipal liquid waste - industrial, agricultural and other economic activities	70-80 million tons 4-5 million tons 20 million tons 45-55 million tons
Hazardous waste	3-4 million tons/year
Population included in an organised waste collection network	85 percent
Amount of solid waste generated annually Volume weight	1.395 m^3/capita/year 0.192 ton/m^3
Number of landfill sites	2700

Source: World Bank 1999

According to surveys 91 percent of the municipal solid waste generated is deposited in traditional landfill sites without any sorting or recycling. At the beginning of the nineties there were 2700 landfill sites in Hungary (NEPP 1997). Currently, the number of dumpsites both the legal and the illegal ones is between 2500 and 2600. However, it has to be mentioned that the number of the illegal landfill sites is decreasing during the last few years owing to the joint efforts of the different competent authorities (Szabó–Pomázi, 2000). The other remarkable point to highlight is the increasing number of landfill sites with proper technical protection fulfilling

both the national and the EU requirements. However, the ratio of the properly managed landfill sites is still only 30 percent of the total number of landfill sites (Szabó–Pomázi, 2000).

When the present landfill sites were created the principle of regionalism was not taken into consideration and so each municipality established its own landfill site. The dominant phenomenon and practice was the "one settlement – one landfill site" principle. From the beginning of the nineties the regional waste treatment system came to the front owing to the economic interest, the operational costs per unit and the intensification of the market competition. Thus, the strategic goal from the 1990s onwards is to establish regional landfill sites to solve the waste issue in larger areas and to change the less efficient local solutions.

Besides landfilling, an operating incineration plant in Budapest is the only other waste treatment option in Hungary. Its capacity is 350 000 tonnes per year, which is 60 percent of the total amount of waste generated in the capital (Szabó–Pomázi, 2000). The selective waste collection system only exists in a scattered way. Attempts were taken in several big cities and towns to introduce a selective waste collection system, but three basic hindrances – the incomplete legal and economic regulations, the lack of a processing industry and the lack of citizen concern – impeded the successful implementation (MTA, 1998).

4.1.1. Legislative background

In order to establish an integrated waste management system emphasising the sustainable manner comprehensive legislative regulations are essential. Last year the Hungarian Government adopted a framework law on Waste Management, which came into force on 1st January 2001 (XLIII/2000 Act on Waste Management). However, specific regulations such as regulations relating to the existing landfills and the landfill sites having reached their capacity, the regulations concerning the establishment of new landfill sites, etc. ensuring the implementation are still missing from the system and should be created as soon as possible. Therefore, in the near future several other laws and regulations should be enacted concerning the specific areas of the waste disposal such as regulation on specific wastes, processes and facilities of waste disposal to complete and to cover the waste issue. Otherwise, an effective regulation is not likely to be organised since the adopted law is a framework law.

According to the new act several management and controlling tasks will become easier. The new act is based upon mostly the EU directives and regulations, and thus, it facilitates the EU accession requirements. It determines the basic principles such as the prevention, precautionary, polluter pays, and BATNEEC principles, in order to achieve the goals concerning the waste issue set up in the National Environmental Protection Programme adopted by the Parliament in 1997. Furthermore, the law regulates the competencies, obligations and restraints of the producers, vendors, consumers and the different authorities. The section of the law defines that by 1 July 2004 the bio-degradable component of the waste disposed of on municipal landfills should reduce to 75 percent compared to the current surveyed situation. Furthermore, by 1 July 2005 at least 50 percent of the packaging waste should be re-utilised. The law also sets up goals for the long-term period.

4.1.2. National goals and strategies for waste

The general objectives of the Hungarian Government concerning the waste management issue based on the EU directives and the Hungarian laws are the following:

- to avoid the generation of waste
- to decrease the amount and the hazardous features of the generated waste
- to recycle and reuse to a great extent the waste generated
- to handle in an environmentally friendly way the non-recyclable part of it.

National Environmental Protection Programme (NEPP) summarises the environmental protection objectives, which represent the main efforts in the period from 1997 to 2002. The waste management objectives set down in the NEPP with regard to municipal solid waste are as follows:

Waste-1. The amount of waste should not exceed the current level (4 million tonnes/year), and the organic content of the waste deposited has to be reduced gradually until the final value of 5 percent.
Waste-2. The organised waste collection should be increased to 90 percent.
Waste-3. At least 10-15 regional landfill sites should be established annually with a 2-million m^3 annual total capacity on average. Regional landfills should be built with the appropriate technical protection. The number of the illegal landfill sites should be reduced and the landfills without permission or proper technical protection should be closed.
Waste-4. The proportion of waste utilisation should be increased to 25-30 percent by recycling or using waste as secondary material.

Source: NEPP, 1997

One can say that the national goals are clearly defined and they support a firm basis to implement an integrated waste management system encouraging the sustainable aspects. However, examining the actual situation presented in the following sections of this study shows that certain incentives and constraints are necessary to direct the waste management issue towards a more sustainable way.

4.2. The current waste management practice in Hajdú-Bihar County

4.2.1. Introduction of the county

Hungary, with its territory of 93 053 km^2 and roughly 10 million inhabitants, has 19 counties and one of them is Hajdú-Bihar County, which lies in the eastern–northeastern part of Hungary, right at the border of Romania (Figure 3). The territory of the county is 6211 km^2, which ranks it as the fourth largest county of Hungary. The number of inhabitants is 543 720 (CSO, 1999). There are 16 towns and 66 settlements in the county. Three quarters of the total population live in towns and cities (CSO, 1999). The administrative centre of the county is Debrecen city with county status and the second most populated city of Hungary (Süli-Zakar, 1998). The total population of the county city Debrecen is 205 032, which is 38 percent of the total county population (CSO, 1999).

Figure 3. Map showing Hungary with the surrounding countries (Source: Zentai)

The characteristic plain landscape is poor in mineral resources, and it does not have a peculiar advantageous position from the aspect of other natural resources either. The only valuable, natural endowments are the fertile soil and the underground thermal waters, which provide good conditions for both the agriculture and the tourism (Süli-Zakar, 1998).

The economic situation stems from the geographical and natural conditions. This region is primarily an agricultural area. The agriculture is the dominant sector in Hajdú-Bihar County despite political and economic changes, privatisation, market problems, inflation, loss of trade partners and natural disasters such as severe droughts and floods that resulted in roughly 35 percent decrease in agricultural production (European Environmental Campus, 1994; Süli-Zakar, 1998). The GDP per capita in the county is only about 80 percent of the national average (CSO, 1999).

The population is more strongly concentrated in the towns and cities partly due to historical reasons. Although officially 75 percent of the inhabitants live in towns and cities, they do not have access to a well-developed urban infrastructure. The city Debrecen has a prevailing role in the county. In regards to the employment issue, the unemployment rate (considers only the registered unemployed) is high ranging from 10 to 12 percent, higher than the national figure (CSO, 1999).

4.2.2. Present waste disposal method in the county

The main problems of the county relating to the solid waste management are complex and they are not solely specific features of this county. Most of the difficulties are general throughout the country and stem mostly from the lack of comprehensive legal regulations. Besides the missing laws several economic and administrative problems have pushed the waste issue into the background.

According to surveys, 500-550,000 m^3 municipal waste – including the households, institutional and service sectors – is generated a year in Hajdú-Bihar County. In addition, 100-150,000 m^3 industrial and agricultural waste is generated annually (ISPA Project, 1999).

The current and the dominant treatment method for municipal solid waste in the county is the landfilling. Presently the municipal solid waste from the households has not been separated. The mixed waste is collected and transported directly to the landfill sites to be disposed of. It should be mentioned that efforts were taken to introduce a selective waste management system, but economic conditions were not integrated into implementation policy. However in the service sector partial selective waste collection system was introduced (Simon, 2000 personal comm.).

In most cases the excavated pits, which were clay or sand mines, serve as recipient for the municipal solid waste. The other method used for landfill is the hill building (area method). These landfill sites have been created during the sixties and the seventies according to the conditions of that time (Ungváry, 2000 personal comm.). Therefore, these landfill sites lack proper technical protection and constitute environmental hazards. For instance, some have direct contact with the groundwater while some are within or close to nature conservation areas. Half of the landfills do not have an environmental license for the operation because at the time of their establishment the environmental licensing procedure did not exist (ISPA Project, 1999; Ungváry, 2000 personal comm.). Since there was no preliminary environmental impact assessment study before building the landfill sites in some cases it occurred that the disposal is on the area with high water level.

Since a selective waste management system is missing the reusable and recyclable materials together with the hazardous waste from the households are also dumped. The mechanical compression of waste on the dumpsite is unsolved in the majority of the landfill sites. In addition, a monitoring system is not built up. Thus, there is no available updated information concerning the contamination.

The current rate of waste collection is about 85 percent as a county average. It is almost 100 percent in the towns and cities but it is quite low in the villages (ISPA Project, 1999). It is mostly due to the fact that the small local municipalities have less financial possibilities and less technical and management knowledge because of the lack of experts. However, the municipalities should change this approach and find some external financial support. Therefore, it is of great importance to encourage the establishment of regional landfill sites. From both national and regional points of view the strategic goals emphasise the regional aspects and the more environmentally friendly waste disposal systems.

The present situation in the county illustrates that there are nearly 70 landfill sites operating in almost every settlement. They meet neither the national environmental standards, nor the EU ones (Ungváry, 2000 personal comm.). As a consequence, these outdated landfill sites are potential sources of harmful effects on the surroundings and the environment. Furthermore, the old landfill sites can be found everywhere causing scattered potential risk zones all over the county and they occupy large areas in total. Waste generation and handling processes cause severe pressure on the environment through leaching nutrients, heavy metals and other toxic components from the landfills, and emission of greenhouse gases.

There is one modern landfill site – operated by the AKSD City Management Ltd.[3] – with appropriate technical protection operating in the county city Debrecen. It meets both the national and the EU standards and it was created in 1992 to serve as a regional landfill site. The total area of this new landfill site is 28 ha and its capacity is 4.2-million m^3 solid waste (Lakatos, 1998). The yearly amount of the dumped waste from 1994 is shown in the Table 2 below.

Table 2. The amount of waste disposed of the landfill between 1994 and 1999

Year	The amount of waste		
	m^3	tons	t/m^{3*}
1994	96 980	148 934	1,54
1995	75 980	87 744	1,37
1996	57 670	107 293	1,49
1997	67 858	99 285	1,49
1998	101 173	143 021	1,47
1999	101 456	197 228	1,56

Source: AKSD City Management Ltd., 2000

*The reason behind the numbers showing high density is that the construction and demolition wastes are also calculated as part of the municipal waste.

The dumpsite has a combined insulation system as a bottom sealing containing three clay layers and one HDPE foil layer. The continuous top covering together with the re-cultivation is ensured. The extraction and utilisation of biogas that originates from the biological decomposition of the deposited waste is solved and operated. There are two furnaces with 20 kW capacity each utilising the biogas and providing heat for the service building at the dumpsite. Further plans for the utilisation is to provide heat for the central office building and for the horticultural greenhouses. The surplus biogas will be sold to the wastewater treatment company nearby (Simon, 2001 personal comm.).

The contaminated leachate is collected with a drainage system and treated. Similarly to the leachate collection the runoff is also collected with ditches. The collected and treated leachate is sprayed back to irrigate the open surface of the landfill site, thus the proper moisture content can be provided with it (Simon, 2000 personal comm.).

4.2.3. ISPA Project on Establishing a selective waste collection, utilisation and community waste management system in Hajdú-Bihar County

The Section 4.2.2. presented the existing waste management situation in the county. Efforts were and are made to develop a more environmentally sound, waste management system in the county considering the EU requirements and the principles of sustainable development. Thus, in 1999 the Municipality of Debrecen applied for financial help under the ISPA Financial

[3] In 1991, the AKSD City Management Ltd. was founded by the **A**.S.A. **K**röpel **S**preitzer GmbH and the Municipality of **D**ebrecen. The Austrian partner owns 51 percent and 49 percent belongs to the Municipality of Debrecen.

instruments provided by the Commission of the European Communities. The submitted ISPA Project aims at introducing a selective waste management system in the county.

The main objective of the project is to find a solution for the outlined, current problems avoiding a further endangering of the environment. Therefore, a hundred percent waste collections and waste separation system according to their future use should be organised and reached (ISPA Project, 1999).

The ISPA Project is designed to establish three, new, high capacity regional landfill sites with proper technical protection. Secondly, six main components such as paper, plastic, metal, glass, bio-degradable and hazardous parts are planned to be collected separately. The mixed waste collected will be post-sorted at the three regional landfill sites. Thirdly, the transportation routes will be reorganised rationally. The old, non-standard and environmentally hazardous landfill sites will be surveyed, closed down and re-cultivated/remedied. Finally, one of the important goals of these measures is the contribution to decrease the unemployment rate and to increase the public awareness and positive attitude towards the necessity of the integrated waste management (ISPA Project, 1999).

Evaluating the project in general one can say that the indicated goals are the key elements of the waste management system. However, the primary and fundamental inadequacy of the project is the lack of the integral approach. It can originate from the fact that the county has no waste management plan. Thus, the project more emphasises the importance of the introduction of the selective waste collection system more than a focus on the complex waste management system including the different waste treatment facilities/options.

Analysing the outlined possibilities of the selected waste collection system, one of the deficiencies is a lack of indicators for further perspectives of the secondary raw materials. It is likely that detailed assessment concerning the market possibilities has not been done. There is no exact plan, which companies are willing to use the sorted and prepared reusable waste as a secondary raw material. This question is crucial not only from the economic but also from the environmental aspect. Without finding an appropriate solution for the utilisation of reusable waste, the loop remains open. However, the final goal is to close the circle decreasing the need for additional natural resources.

Another important deficiency is the presentation of the biogas utilisation system. The project designs to establish double-lined landfill sites with gas collection and utilisation opportunities. However, the feasibility of this system is not presented.

Although the implementation of the ISPA Project and the targeted programme represents a step forward, it does not serve as a final solution for the generated municipal solid waste. The introduction of a selective waste collection and utilisation system should only be one part of a comprehensive system and therefore, an integrated waste management system should be established and implemented. Nevertheless, neither national standards nor EU expectations drawn up in the NEPP and defined in the laws are likely to be achieved without introducing further disposal methods.

5. DEVELOPING A WASTE MANAGEMENT PLAN

The purpose of this paper is to support the competent authorities in their planning process and to facilitate their decisions. Chapter 3 highlighted the importance of a holistic view of the waste management systems and it also showed the prevailing European Union trends, which are essential to implement in Hungary in the near future. As presented in chapter 4 the current Hungarian situation is paradoxical. The commonly used waste treatment method is landfilling. Most of the dumpsites are uncontrolled without appropriate technical protection and with small capacities. However, the potential to change the existing system was pointed out since the legislative background and the national goals are designed to provide a more environmentally sound waste management system.

Since the scope of the study is limited, is not possible to present a comprehensive planning process. Therefore, this paper only focuses on different techniques and technologies for Hajdú-Bihar County. In addition, it addresses the importance of the integrated management views to the authorities.

5.1. Available techniques

After realising the major environmental problems concerning the conventional waste treatment facilities, more and more new techniques have emerged focusing particularly on energy and material recovery. In the following sections, three main groups – landfilling, incineration and anaerobic fermentation – are discussed and assessed based on their environmental impacts.

5.1.1. Landfilling

In the past, landfilling was the most inexpensive and environmentally acceptable method for waste disposal. In spite of the fact that this trend has been changing and the landfilling is now the least desirable alternative in the waste hierarchy, landfill sites remain an important part of the integrated waste management system. However, the landfilling methods need to shift direction toward more minimisation of both short-term and long-term environmental impacts.

There are three main types of landfill sites operating nowadays: non-controlled, controlled and highly managed landfill sites. The non-controlled landfills follow the dilute and attenuate principle. These have neither bottom lining nor top cover and they contain all kinds of waste mixed together (Westlake, 1997). Consequently and because of these inadequacies landfill gas and leachates migrate into the surrounding environment. This type of landfill site is predominant in Hungary all over the country. The actual number of landfills including both the legal and the illegal ones is between 2500 and 2600 out of which 70 can be found in Hajdú-Bihar County.

During the last few decades, because of more environmental concerns, developed countries have switched to more controlled landfilling, which is based on the containment principle. These landfills require a high degree of site design and engineering management. They have a specific bottom and top liner, which minimise leachate infiltration into the groundwater and gas emissions to the atmosphere (Westlake, 1997). Therefore, this type of landfilling has a lower impact on the surrounding environment. On the other hand, these modern, double-lined landfill sites only delay ecological disturbances, since in the long run, they will eventually leak –

passing contamination, health risks and other problems on to future generations. Careful planning relating to the location of the landfill site can diminish the long-term environmental effect because a thick clay soil layer under the landfill site performs a self-buffering system.

In Hungary, the trend shows the establishment of an increasing number of double-lined landfill sites with high capacity to dump the collected waste of more than one settlement. One of these controlled landfill sites is situated in Debrecen as presented in Section 4.2.2. and utilising the generated methane gas is the further development plan of the company.

The new and third type of landfilling is the highly managed landfill site with gas extraction. The goal of establishing highly managed landfills, or landfill bioreactor cells, is to utilise the nutrients and the energy. The key factors of the system are the recirculation of leachate and the collection of gas for energy recovery (Nilsson, 1997; Bramryd, 1998). Therefore, a fast and complete stabilisation has to be achieved. The landfill consists of reactor cells; each one has a separate gas and leachate collection system. The bottom is covered with a specific liner system avoiding emissions into the surrounding soils and the open surface area, thus preventing the release of methane into the atmosphere (Bramryd, 1998). The production of biogas, which can be extracted, is about 15-20 m^3 per ton of waste annually. Calculating over a period of 10-15 years 200-250 m^3 biogas production is estimated as a total yield per ton dumped waste (Bramryd, 1997, 1998). The biogas can be used as fuel or converted into electricity. The residual waste left in the landfill bioreactor cell is a stabilised form, which decreases the risk for further environmental disturbances. Comparing the controlled dumpsites with the landfill bioreactor cells one can say that the former one only aims at decreasing the negative environmental effects while the latter option concentrates on a more sustainable handling approach by utilising the energy and nutrients stored in the waste.

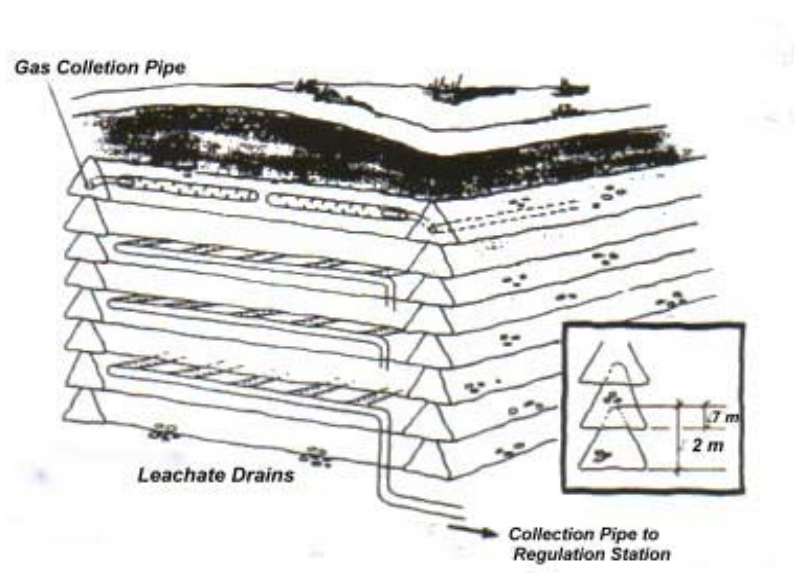

Figure 4: Structure of a bioreactor cell (Source: Bramryd, 1998)

5.1.2. Incineration

Historically, incineration was introduced to reduce the quantity of waste and thus, to prolong the lifetime of the landfill sites. As a consequence, the number of incinerators has increased considerably especially in the areas with high population density because of land scarcity. Burning municipal solid waste seems likely to be a preferred treatment possibility in certain countries. However, the incineration as an accepted waste treatment method is based on the misconception that burning the waste assists in removing the difficulties of generated waste.

Therefore, it has to be emphasised that the incineration process is not a final waste treatment solution but it can be a determining part of the integrated waste management system within limits. For instance, incineration can be used for dry and clean organic matter such as non-painted wood chips or straw. Otherwise, burning mixed waste creates further environmental problems such as toxification through air pollution and contaminated ashes.

During the combustion process the organic matter is rapidly oxidised to carbon dioxide (CO_2) and water vapour (H_2O) and the non-combustible part is the residue or ash. Consequently, the volume of the waste is reduced by approximately 75-80 percent (RVF, 1998). Incineration is also considered as an efficient energy recovery system. However, this type of solid waste treatment facility has several side effects both on the environment and on the human health. The latest incinerators attempt to minimise the pressure on all media although, the ash and certain pollutants can never be eliminated because of the thermal processes. Another important factor is that the incineration techniques do not recover any nutrients and burning of waste containing fossil carbon such as plastics contributes to the global warming effects.

5.1.3. Fermentation – Anaerobic Digestion

Anaerobic waste digestion techniques are rather new and less applied methods compared to the above mentioned techniques. Originally anaerobic digestion was designed for treating agricultural waste and today it is used for handling the organic portion of waste in a controlled environment. The anaerobic fermentation as a waste treatment technique is a simulation of the natural mineralisation process occurring in wetlands. The organic matter is converted into methane and carbon dioxide. The essential difference is that the operation is regulated and controlled. The methane produced by this system is collected and can be utilised as an energy source (Bramryd, 1998). The important benefits of the anaerobic fermentation are the nutrient and energy recycling, waste treatment and odour control.

There are three main types of anaerobic treatment methods: steel reactor, reactor cell fermentation and bioreactor cell. All of them have the same basic/operating principle: it is necessary to cover the place with an impermeable layer to ensure the anaerobic conditions. The major difference between them is the fermentation time: in the steel reactor the process is faster compared to the bioreactor cell (Bramryd, 1998). The fermentation plant consists of a pre-treatment equipment to mix the waste, a digester tank, a system for using the biogas and a system for distributing the remaining digested material (U.S. Department of Energy, 2000; Scottish Executive, 1997).

The oxygen-free process can be managed in a digester, which is an airtight tank or in a covered lagoon. Two main types of digesters can be distinguished: the batch- and the continuous-type digesters. The former one is the simple type: it is loaded with the material and after completing the digestion, the tank is emptied to refill it again. The continuous digester as the name expresses perfectly enables to feed constantly (U.S. Department of Energy, 2000; Scottish Executive, 1997). The digester can be made of concrete, steel or plastic. According to the material of the digester the different anaerobic treatment methods can be created.

5.2. Environmental concerns

Waste is also considered as a second-generation pollution problem since it creates further pressure on the environment through different treatment methods. On the other hand, it is apparent that the characteristics and the extent of the environmental effects correlate to the amount and composition of the waste and to the treatment facilities.

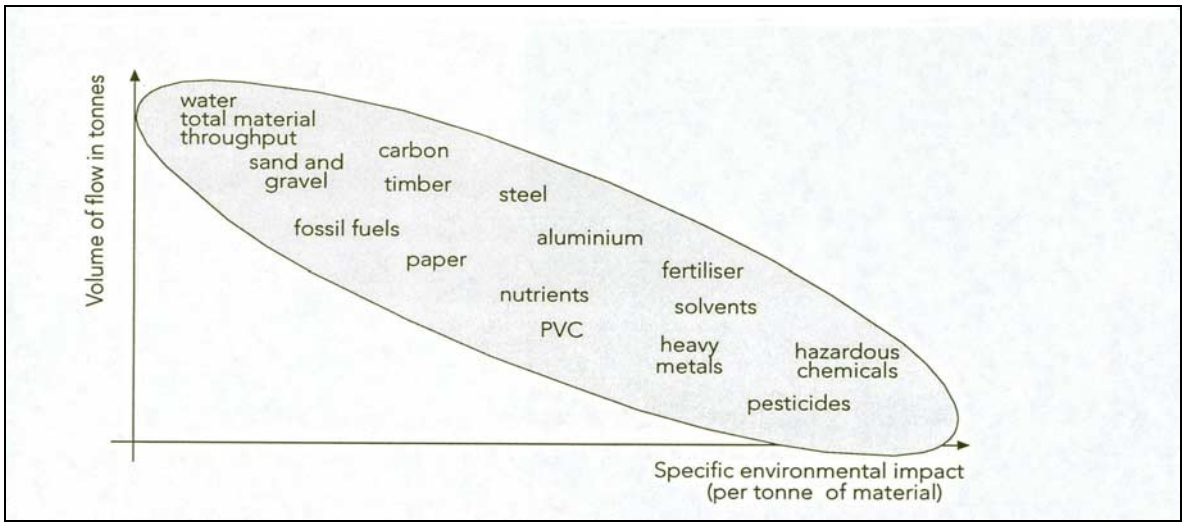

Figure 5. Relation between the waste flow and the environmental impact (Adapted from Steurer, 1996)

Steurer (1996) has already presented the qualitative and quantitative aspects of waste, which can be seen in the Figure 5. It illustrates the relative environmental effects according to the volume of the waste flow. The model highlights the importance of the generated amount and the degree of the hazard of waste.

Nevertheless, the pressure of the various disposal techniques on the environment is as crucial as the characteristics of the waste produced. An overall assessment of the waste management facilities supports the competent authorities to choose the suitable methods as part of their integrated waste management system. Therefore, the Table 3 outlines the relation between the different solid waste disposal techniques and the environmental impacts.

The emissions to the air are divided into three main groups. The first group includes the air pollutants such as heavy metals, dust and organic compounds. The second one consists of nitrous oxides, sulphur dioxide and other acid gases, which result in acidification. The three major greenhouse gases such as carbon dioxide, dinitrogen oxide[4] and methane compose the third group contributing to the global warming. The leachate containing heavy metals, organic and inorganic – mostly nitrogen – compounds contaminate both the ground and the surface water if it is not collected and treated properly.

[4] N_2O is a very strong greenhouse gas, which is emitted during the incineration process.

Table 3. Connection between the different municipal solid waste treatment techniques and their environmental impacts

Treatment methods	LANDFILLING			INCINERATION	ANAEROBIC FERMENTATION	
Environmental effects	Uncontrolled dumpsite with open burning	Traditional controlled landfill	Highly managed landfill	Latest technique (ashes included)	Reactor fermentation	Bioreactor cells
Air pollution Caused by heavy metals, dust and organic compounds	+ +	–	–	+ + +	–	–
Air pollution Caused by acid gases	+ + +	–	–	+ +	–	–
Global warming Caused by green-house gases (CO_2 and CH_4)	+ +	+	–	+ +	–	–[1]
Water pollution Caused by leachate	+ + +	+	– (+)[2]	+ + +	–	–
Odour	+ + +	+ / –[3]	–	+	+[4]	–
Noise (transportation included)	+	+	+	+	+	+
Social acceptance	+ +	+	+[5]	+ + +	–	–

+ + + high impact
+ + medium impact
+ low impact
– no effect

[1] counteracting global warming: net sinks for organic carbon
[2] long-term aspect: when the liner starts to leak
[3] depending upon the actual open surface
[4] depending upon the type of the digester
[5] further land demand after closing

The odour problem, in general, occurs in the vicinity of the treatment plants. However, the question of smell is solved by the new treatment technologies. The noise emission is closely related to the transportation of the collected waste: predominant sources of noise are the delivery vehicles and the equipment used by the various technologies. The consequences of noise and transportation seem a hard task to eliminate. Both odour and noise are inevitable side effects of every waste disposal method since they originate from the characteristics of the waste.

Finally, the last row of the Table 3 deals with the social acceptance, as vital key has to be taken into consideration during the planning and decision process. Informing the public particularly the neighbours of such a plant and the general communication should be as important as every other part of the process. Several examples can be presented where public opposition was able to shatter/defeat the official decision.

5.2.1. Impacts of uncontrolled landfill sites

Landfill methane, which might enter to the atmosphere mostly from the uncontrolled dumpsites act as greenhouse gases. These gases trap solar radiation and inhibit its release into space, thus contributing to global warming. The methane concentration in the atmosphere generates 18 percent of the global greenhouse effect while carbon dioxide accounts for 66 percent (Belgian Federal Department of Environment, 1996). A more significant fact is reported by EU inventories from 1990, that the second largest anthropogenic methane emission sources are the landfill sites with 31.5 percent of total anthropogenic methane emissions (Belgian Federal Department of Environment, 1996). On the other hand, the methane oxidisation process prevents the methane emission and thus, it is a counteracting factor of global warming. Furthermore, mostly the non-controlled, old dumpsites release various acid gases, dust, and other pollutants particularly during open fires. Thus, it is clear that one of the threatening influences of the landfills is the air pollution, which also influences the odour problems.

The other significant factor is the leachate pollution by affecting the drinking water and contributing to the eutrophication. In a controlled condition such as appropriate bottom lining and system for collecting and treating the leachate the nutrients and the pollutants are monitored. The re-circulation of the leachate keeps up the adequate moisture content of the landfill, the equilibrium of the nutrients and inoculating the proper micro-organisms. Therefore, it enhances the gas production in the landfill. Moreover, the leachate re-circulation decreases most of the organic compounds and stabilises the heavy metals in the form of insoluble sulphides (Bramryd, 1998; Pacey, 1999). In addition, the highly managed landfills utilise the elements of the leachate in biofilters producing biomass (Bramryd, 1998). Concentrating on sustainable society the biggest advantage of the landfill bioreactor cells is closing the loop, since the landfill bioreactor cells do not only control and monitor the process but they also bring back the nutrients and the energy into the ecological circle.

5.2.2. Impacts of incineration plants

During the incineration process several components are emitted into the air. The main contaminants are acid gases (NO_X, SO_2, HF and HCl), polyaromatic hydrocarbons (PAH), chlorinated organic compounds such as dioxins and furans, dust and heavy metals (Bramryd, 1985; Sundqvist, 1999; European Environmental Agency, 1999). These unwanted emissions

contribute significantly to the impact on the environment generating further tasks to tackle. The acid gases, mostly NO_X because of the difficulties to separate them from the flue gases, cause acidification (Bramryd, 1985). Dioxins and furans originate from burning PVC plastics, bleached paper, food residues and other chlorine containing compounds (Gandy, 1994; Bramryd, 1985). The Dutch Government (1989) claimed that dioxins and furans from the incineration plants contribute 30 per cent of these emissions. These pollutants lead to adverse health problems besides the ecological deterioration.

The primary solid waste of the thermal process is ash. This end product needs further treatment facilities, which are usually landfills due to their toxic compounds. Westlake (1997) questioned how the incineration ash should be landfilled. In his paper, a reassuring solution was not presented rather the difficulties of the by-products from incinerators are emphasised. Very soluble heavy metals and organic compounds in the incineration ash are potential contaminants in the leachate. Hence, the danger of the incinerator ash is high. However, the negative assessment of incineration can be diminished by reducing the quantity of toxic elements in the ash and by improving the efficiency of the combustion process. Even if the efforts to decrease the threat to the environment are promising the zero emission can never be reached and the ash as a by-product also remains to take care of.

5.2.3. Impacts of anaerobic fermentation

Since the anaerobic fermentation process takes place in a closed system – because of the oxygen-free requisites – neither the gas emissions nor the leachate are able to leave the equipment and to enter into the surrounding environment assuming the proper operation of the facilities. Therefore, both the gaseous contaminants and the compound of the leachate can be controlled and utilised in an environmentally sound way. The biggest advantage of the anaerobic digestion is that the energy content of the waste is almost completely converted into methane gas, which is further used as energy source.

The product of the anaerobic fermentation is the digestate or residue, which is a valuable organic fertiliser if the initial waste was not polluted.

The odour problems and the pre-treatment process as nuisance factors seem of great importance up to the present time (Nordberg et al., 1999). Despite of the existing difficulties associated with this treatment facility it has low impact on the environment.

5.3. Selected combination of techniques

Because the waste stream consists of a mixture wastes, an effective waste management plan should find the best options for treating this assortment. In order to be able to elaborate this, a preliminary assessment, which is not part of this study, is necessary in order to survey the composition of the waste stream. Otherwise, the treatment technologies cannot be selected properly.

As presented earlier, the only waste treatment method in Hajdú-Bihar County is landfilling. Since current economic and market conditions still favour landfilling as the cheapest waste disposal technique, this practice is likely to remain the dominant treatment method in the near

future. However, landfilling practice needs to be directed towards a sustainable way by encouraging both energy and nutrient recovery from the landfill. On the other hand, it needs to be supplemented with other technologies to meet the regulations and to handle the solid waste in a more environmentally friendly way. The central question is which combination of treatment techniques should be implemented.

Both EU targets and national goals are aiming to reduce the amount of easily bio-degradable components deposited in landfill sites. The precondition for this goal is the separation of the organic part from the rest of the waste. In Hajdú-Bihar County, implementing the presented ISPA Project will solve the waste separation problem. Then, the question is how to handle the bio-degradable part of the waste stream in order to avoid environmental damage and to save and utilise the nutrients and energy accumulated in the waste. According to the ISPA Project (1999) the organic waste should be composted. Composting is a proper treatment method for organic waste; however, the energy stored in the waste is usually not recovered during the process. Dalemo et al. (1996) using systems analysis and computer based simulation model argue that energy conversion is much higher during the anaerobic digestion than in the composting process. Therefore, in the context of Hajdú-Bihar County the anaerobic fermentation as a more effective treatment technology for the organic part of the waste is suggested to be employed at a large scale in the near future.

On the small scale, considering local conditions domestic composting is recommended. It has a great importance particularly in residential communities, where the kitchen and garden waste can be composted on site and the compost also can be utilised in the garden.

Non-recyclable plastics and synthetic rubber containing organic carbon can contribute to the increasing atmospheric CO_2 concentration without an appropriate treatment method. Burning of these materials has a high impact on global warming through the CO_2 releases; whereas landfilling minimises their negative environmental effect through long-term accumulation of organic carbon (Bramryd, 1998). Thus, these components of waste together with the rest of the waste are recommended to be deposited in landfills after source separation. Recently, there have been developed more promising anaerobic landfill techniques called bioreactor cells provide a more sustainable method of landfilling. This, since the generated biogas is collected and the nutrients from the leachate have the potential to be directed back to the ecosystem. The fermentation residue containing the heavy metals and other pollutants remains in the landfill. Bramryd (1998) argues that the landfill bioreactor cells should be considered as biological waste treatment technology. This approach has already being discussed by the EU as a possible new pre-treatment method.

Another remarkable point has to be stressed in regards to the highly managed landfill sites that this type of treatment technology is an effective volume reduction method. Whereas the traditional landfill sites that have reached their capacity have to be closed, the landfill bioreactor cells give an opportunity to construct a new cell on top of the old ones. Therefore, additional land requirements can be saved using this technology.

An incineration plant requires a large capital investment and it can only be cost-effective if a continuous waste flow is ensured. According to the Hungarian Waste Management Act, the municipalities, as governmental authorities, are responsible for waste management. Their budgets are financed by the central budget and are fairly limited. Massive investments such as

incineration facilities are not likely to be feasible options. On the other hand, based upon the evaluation of the available waste treatment techniques, it can be said that from an ecological viewpoint, incineration places high impacts on the environment (see Table 3). Mass-burn incineration is not a suitable waste management technology under the present and near future circumstances in Hajdú-Bihar County.

A significant positive feature of incineration is the volume reduction: an additional advantage of modern incineration plants is the energy recovery system. However, these positive features do not necessarily provide enough of a benefit to introduce waste incineration. Incineration discourages both the waste minimisation and enhanced recycling. Therefore, incineration is not suggested option for treating mixed municipal solid waste.

The recommended combination of technologies can be an effective solution for employing an integrated waste management system based upon sustainable waste management. The implementation of the suggested waste management plan depends mostly upon the authorities' attitudes and willingness to change.

5.4. Assessment of possibilities concerning the selected techniques

Before employing the selected combination of the different waste management techniques there are a number of important aspects that have to be discussed and evaluated. Two of them are the utilisation of the generated biogas and the utilisation of nutrients.

5.4.1. Biogas utilisation

The biogas from the anaerobic fermentation process can be converted into heat and electricity. The heat production is the most common way to use biogas. It is also relevant to be considered in Hajdú-Bihar County as potential heat source for district heating. The municipality has to encourage the local district heating company to use the biogas instead of natural gas for heat generation. A special programme should be developed to facilitate this idea. The other option is to convert the biogas into electricity. The management of the operating landfill site in Debrecen has already planned to sell surplus biogas to the sewage treatment plan to generate electricity. In the near future this plan needs to be implemented. The produced electricity can contribute to the energy demand of the city. Further studies to research the feasibility of this proposal should be undertaken.

Another possibility is that this storable biogas can also be used as a vehicle fuel. The Municipality of Debrecen has already started to use more environmentally friendly public buses that run on natural gas engines. It is therefore essential to use the biogas as fuel for the public transportation buses. Alternative options for the biogas utilisation as a fuel source is to also increase the number of vehicles run by natural gas engines, for example using the biogas as fuel to operate the waste collection lorries, which collect the waste from the households and enterprises.

5.4.2. Nutrient recovery

In regards to the system nutrients two main part can be distinguished. One of them is the residue after the fermentation process and the other one is the leachate containing nutrients. The residue or compost left after the digestion process should be restored. This compost can be recycled in the agricultural fields supplementing or replacing the artificial fertiliser. Furthermore, the compost mixed with soil can be used in greenhouses to produce vegetables or flowers and plants.

The leachate originating during the fermentation process is necessary to be treated. Presently, the leachate in the landfill site of Debrecen is recirculated to irrigate the top of the landfill. However, there is a better utilisation of the leachate. Establishing an energy crop field close to the landfill area can be an advantage to utilise the nutrients in the ecosystem.

6. STRATEGIES SUPPORTING THE WASTE MANAGEMENT PLAN

As pointed out earlier in this study the waste management plan is a prominent part of an overall waste strategy. Evaluation of the environmental concerns of the presented waste treatment methods can provide a holistic view and facilitate the decision process during waste management planning. Since the adopted regulatory measures concerning the waste management plan pursue the general and the specific principles, they do not suggest practical guidelines for creating a waste management plan. Overall knowledge about the various facilities and technologies, which can be adapted, is a prerequisite for a realistic and achievable plan. Therefore, the comprehensive assessment of the possible treatment methods supports the selection of the final options for a certain area. Additionally, several other tools such as legislative, economic and social aspects influence the planning process.

6.1. Legal instruments

The legislative measures such as laws and ordinances including the goals elaborate the political will and principles. They determine the various standards, restrictions and control mechanisms. This study has presented the EU requirements and targets concerning certain waste and waste treatment methods. In addition, the Hungarian legislative basis and the targets set up in the NEPP are designed to implement a more sustainable waste management system in accordance with the accession process.

Examining the attitude in the EU countries, there is an escalating trend to finally ban landfilling of certain types of waste. Some of the regulations on landfills are already fairly strict in many places in order to foster the desired priorities of the waste hierarchy and to decrease the negative environmental impacts caused by landfilling. Besides restrictions, licences and permits are effective legislative tools in the implementation process. The licensing procedure also limits the applicability of different treatment facilities. The system may be supplemented with standards and control mechanisms as well.

In the Hungarian context, the laws and regulations already adopted aim at reducing both the primary and secondary pollution caused by waste production. However, it can be said that further laws and regulations need to be created to facilitate the waste management system and especially the planning requirements. The adopted framework law on waste management should be supplemented with the following necessary regulations:

- ordinances concerning the different treatment technologies
- standards for establishing new landfill sites
- standards for closing and aftercare of the old, existing landfill sites
- the list of specific waste, which cannot be dumped
- standards for incineration plants.

Furthermore, not only the existing EU directives and standards have to be taken into consideration but also the trends and the approach toward the entire waste issue. Therefore, the legislation procedure should seek far-reaching trends and build them into the new regulations.

On the other hand, the National Environmental Protection Programme has to be realistic and take into consideration the economic and social circumstances as well. The presented NEPP

objectives presented in Section 4.1.2. are not likely to be fulfilled by the year 2002 as was the aim of the programme. The reason behind it is complex: it can be interpreted by the lack of capital in the case of establishing regional landfill sites or by the lack of proper enforcement concerning the collection rate. Another remarkable point is to mention that the target to decrease the organic content of the waste to 5 percent might be a risk for introducing an integrated system, since this goal could only be fulfilled by applying incineration. Therefore, it is recommended to carefully set up the targets, which are not only ambitious but also achievable, in the next programme.

Beyond the national legislation procedure, the regional and local authorities are responsible for the implementation. As illustrated in Chapter 4.2., there is no comprehensive waste management system or waste management plan in Hajdú-Bihar County. In order to meet the present national targets and the future requirements, an integrated waste management plan with achievable targets and timetable should be set up/elaborated.

6.2. Economic incentives

The economic incentives reflect the legislative decisions and often they become as an efficient part of the implementation. The economic incentives influence the companies and the consumers through their budget. One of the generally applied incentives is the tax system. However, it is important to stress that the original intention could only be effective if it is part of an integrated system since these tools interfere with the open market mechanisms.

Several European countries have already introduced a landfill tax in order to promote the alternative waste treatment methods. However, in few cases, for instance in Finland, the result has altered from the original intention. Presently, there is no landfill tax in operation in Hungary, although it can be considered as a possible effective tool. Introducing a proper tax system can foster other waste treatment options and in effect a more real price of landfilling can be achieved. If Hungary decides to propose a tax system on landfill the revenue from the levy should be directly transferred to support implementing sustainable treatment technologies.

The other commonly applied economic incentives are subsidies. The purpose behind the subsidies is to encourage and to financially support the waste reduction facilities and the environmentally sound treatment technologies. These economic incentives help to start a new programme and make stakeholders interested in it. In Hungary there is an operating subsidy system managed and controlled by the Ministry for the Environment to finance different environmental investments, for instance waste disposal methods. This aid support system should be further extended and a special fund for waste management systems should be set up to foster the change. For example, applying the tax system on landfills mentioned above could contribute to the available financial aid.

European Union also provides financial support for Central and Eastern European countries such as Hungary. A new aid programme is the ISPA Programme offering financial instruments for environmental projects. Therefore, the Ministry for Environment should take actions encouraging the regional and local authorities applying for ISPA funds. On the other hand, the competent authorities should receive suitable assistance from the Ministry and experts to elaborate projects acceptable by the EU Commission.

On the other hand, the before-mentioned incentives – tax system and subsidies – are end-of-pipe solutions. These tools focus on the waste disposal methods promoting secondary pollution prevention facilities and they do not facilitate avoiding the waste generation, which should be emphasised more. Therefore, the price of the products or rather the raw material should include the treatment cost as well.

6.3. Social factors

Awareness and willingness to change are the key factors in the social part of the waste management system. In order to reduce the quantity of waste, fundamental behavioural change is required both on the production and the consumption sides. Thus, communication, information exchange and educational programmes are needed in order to provide positive attitudes and to facilitate the official decision making process.

For the successful implementation of the integrated waste management plan, intensive information campaigns are the first and most important factors. The ecological and economic pressures of the waste streams and the consequences of the various treatment technologies should be illustrated to the general public. It is also essential to present the past experiences with each treatment method and the recent development of the techniques.

The public is always concerned with the neighbourhood. Therefore, a demonstration programme such as a field visit to the landfill sites or an incineration plant showing and explaining the technologies and the process in the language of public helps to convince them to accept and participate in the system.

7. CONCLUSIONS

Waste and its consequences have become a significant issue. It is obvious that waste creation needs to be prevented and minimised because of its potential source of pollution and because of the value of the energy and material stored in the waste. Since awareness has recently turned towards sustainability, new policies and regulations are applied to establish the integrated waste management system. Meanwhile, several new treatment facilities have emerged mostly due to legislative instruments and constraints.

The integrated waste management system in practice focuses on the different waste treatment facilities and the actual waste reduction at the source receives less attention because of its complexity. This paper also looked at the available treatment methods in the framework of sustainable waste management. Further development is necessary how to introduce and integrate primary prevention pollution into a waste management plan.

In accordance with the objectives, this study has illustrated the present situation in Hungary relating to the waste issue. It was shown that the legislative basis supports establishing an integrated waste management system, however some suggested laws and regulations are necessary to complete the legal background.

A case study of Hajdú-Bihar County pointed out the necessity of developing an integrated waste management system. The evaluated ISPA Project demonstrated that an initial step was taken to rearrange the existing waste management practice. However, the project does not suggest a comprehensive solution for the municipal waste. Therefore, an overall waste management plan is suggested for urgent employment.

This paper has presented a possible waste management plan for Hajdú-Bihar County. The selected combination of treatment technologies includes small-scale composting and large-scale anaerobic fermentation technique for organic waste. During the digestion process biogas should be collected and utilised and the nutrients after the fermentation process should also be reintroduced into the ecosystem. Finally, a new landfilling method such as the landfill bioreactor cells are suggested as an efficient waste treatment technology for the non-recyclable, mixed municipal solid waste.

The notion of an inevitable shift towards the sustainable waste management and the holistic approach are necessary to keep in mind during both planning and implementation.

7.1. Recommendations for future research and development

In order to elaborate an integrated waste management plan and to implement a sustainable waste management system for Hajdú-Bihar County further research is necessary. The following areas are suggested for investigation:

- Further assessment of the feasibility of the recommended waste treatment options
- Survey and evaluate the old landfill sites in Hajdú-Bihar County
- Establish a strategy programme to close the old landfill sites
- Search for other financial support programmes
- Investigate the social factors of the system.

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