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TOWARDS SUSTAINABLE HAZARDOUS WASTE MANAGEMENT IN LITHUANIA

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Abstract

Growing consumption of goods, production and usage of various chemicals influence the amount of different hazardous waste (HW) flows. Society is increasingly facing the problem how to treat and where to dispose of waste in environmentally sound, and economically efficient way, also taking into account a social aspect.

Waste management is one of the principal pollution problems in many countries, and its control has so far not been addressed in a sustainable analysis. Each year in the European Union alone people throw away 1.3 billion tons of waste, 40 million tons of which being hazardous. HW generally constitutes about 1% of the total waste amount generated in Europe; nevertheless, it presents a serious risk to the ecosystem and human health if not managed and treated properly. Several EU countries report HW treatment rates over 40%, the others export a large of portion of HW. Recently, lots of efforts having been put into proper HW identification, treatment, recycling, storage, transportation and/or disposal, this issue is still hot among the governments of the EU.

In spite of the fact that all European Union legal requirements concerning HW management are transferred to Member States legal framework, there are still a number of problems concerning inefficiency of an HW management system and Lithuania is not the exception. The total amount of waste generated in 2008 in Lithuania is about 7.8 million tons; about 145 thousand tons are considered as HW. While the incineration plant and landfill for HW is not built, HW is temporarily stored, processed, exported or managed in the companies which have the Integrated Pollution Prevention and Control (IPPC) permits. It aims to manage HW in a more environmentally friendly way. However, the current HW management is not developed on an integrated approach, which allows to evaluate the environmental impact throughout the life cycle and to use cost-effective HW management processes, and all available technical and technological capabilities. The legal system determines the main HW management objectives, but compliance with them is often more formal than real.

Despite of the fact that waste has to be managed in accordance with the waste hierarchy principles, the hierarchy has some limitations. The latter restrictions motivate interested parties to look for the possibilities of more efficient HW management. An integrated waste management concept is considered as a tool for sustainable HW management. Environmental system analysis, integrated approach and tools for HW management system assessment are discussed and brief analysis of HW management in Lithuania is introduced in the paper.

The aim of this paper is to analyze HW management system in Lithuania and propose the tools for more efficient HW management in the context of sustainable development.

Keywords:

Sustainable development, HW management, integrated approach, environmental assessment tools.

Introduction

Recently, environmentally sound, economically efficient and socially acceptable management of various waste flows has become one of the most pressing issues of the World community pursuing all-round sustainability for current and future generations. The Treaty of Amsterdam has placed the principle of sustainable development and high level of environmental protection on the top of priorities. The EU community generates around 2000 million tons of waste each year, over 40 million tons of which are classified as hazardous. In spite of the fact that HW generally constitutes about 1–2 % of the whole waste depending on the country; nevertheless, HW presents a serious risk to the ecosystem and human health if not managed and treated safely.

During the last decades all over the world, considerable work has been done in waste management and waste generation sectors trying to promote prevention and achieve more sustainable waste management.

Lithuania is also trying to be in step with the global trends. In accordance with the requirements of the EU, by 2012 Lithuania is expected to close about 300 existing landfills, which do not comply with the environmental requirements, and to build up eleven regional landfills for municipal waste. It is prohibited to dispose of HW in new regional municipal waste landfills; it is important to manage them without harming the environment and human health, while even having an economic benefit. It is planned to build up one landfill especially for hazardous waste (HW) disposal and an incineration plant for HW treatment. They are expected to be installed until the end of 2010.

Environmentally sound and cost-based HW management poses many challenges at various management levels not only in Lithuania but also in other EU countries.

EU environmental and waste legislation results from the policy decisions laid out in the sequential series of the Environmental Action Programs (EAP) and the Waste Management Strategies. These Directives represent the legal obligations required for the Member States and are to be transposed into national legislation. The Waste Framework Directive (WFD) 2006/12/EC establishes the basis for the EU waste management. The HW Directive (HWD) 91/689/EEC develops legislation further with regard to HW only, specifying the properties that render waste hazardous and therefore applicable to the management structures outlined in the WFD. In the future, changes to waste legislation may see the measures of HWD integrated into WFD. A list of the wastes falling within the scope of the WFD and HWD is provided in separate legislation, the European Waste Catalogue (EWC) 2000/532/EC. Integrating the expanded HW List 94/904/EC, EWC is subject to the articles of HWD.

The other EU Directives focus on technical aspects of waste management (e.g. the Landfill Directive 99/31/EC), or on particular waste flows through the application of producer's responsibility (e.g. the Waste Electrical and Electronic Equipment Directive 2002/96/EC, the End-of-Life Vehicles Directive 2000/53/EC, and the Batteries and Accumulators Directive 2006/66/EC, etc.). European legislation regarding waste has considerably increased since 1975, reflecting the waste policy of EAPs. The amount of legislation has led to varied rates of transposition into the national law of the Member States, and certain Directives are still in the process of full implementation.

In spite of the fact that all EU legal requirements concerning HW management are transferred to Lithuanian legal framework, there are still a number of problems concerning inefficiency of an HW management system such as: not finely tuned HW records throughout the product life cycle and individual HW flows, lack of technological regulations, inaccurate National Waste accounting data reflection of HW generation and recycling rates, whereas the records are often just a formality. The lack of strict control of records and public servants' responsibility for the control process creates the conditions for unqualified HW management. The above-mentioned problems determine unsustainable HW management and require application of tools for more sustainable HW management.

The aim of this paper is to analyze HW management system in Lithuania and propose the tools for more efficient HW management in the context of sustainable development.

Analysis of HW management situation in Lithuania and problem formulation

A stronger focus on the waste including HW management started to contribute to the environment after Lithuania's accession to the EU, i. e. since 2004, and thus a more comprehensive scientific research into the waste management sphere is relatively new compared to that in the old EU Member States. The earlier researches were associated with the development of technologies for waste management or analysis of different waste flows. The biggest part of waste was not handled; industrial wastes were often stored at the company's territory. Gradually, changes in consumers' attitudes to products and waste instigated manufacturers to choose more environmentally sound processes and products and award more economically acceptable solutions. The latter decisions lead to more favourable societal aspects and at the same time all these aspects lead to sustainable waste management. Increasingly used waste prevention and minimization practices in the production serve as a tool how to generate less waste.

According to the EU Environmental Protection Agency data for the year 2007, despite of all efforts the biggest part of the waste (368 kg/inhabitant from 400 kg/inhabitant) still go to the landfill in Lithuania. One of the reasons for the choice of processing is a minimum of waste management costs compared to the other waste management options. HW formation in comparison to that of municipal waste is much lower. The total amount of waste generated in 2008 is about 7.8 million tons; about 145 thousand tons of them are HW. The generation of HW in Lithuania is presented in Fig. 2

Fig. 2 indicates a decreased amount of industrial waste in the period of 2000-2002. The introduction of a new data collection system and the change of waste classifications in the year of 2000 caused a break time series. The generated amount dropped and increased again in 2003. These fluctuations are apparently due to the introduction of a new data collection system and the economic crisis in Lithuania in 1998-1999.

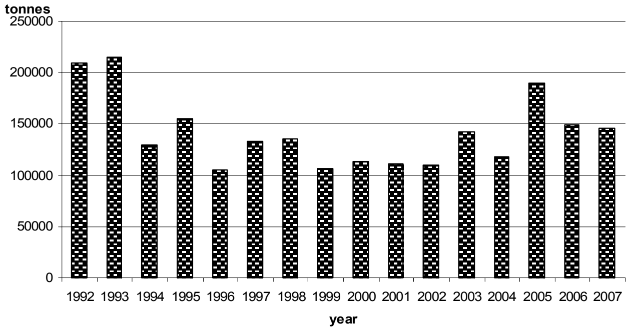

Fig. 2 Development of HW generation in Lithuania (National waste accounting database, Environmental Protection Agency of the Republic of Lithuania)

As it was mentioned above, identification and classification of HW in Lithuania are performed according to the EU requirements. But it should be stressed that classification and identification of the waste started in 1992, when Lithuania became an independent country. Until 2000, the data on waste generation were collected from waste generators and waste management companies. Therefore, the amount and composition of HW varied. For example, in 2000 and 2001, reporting the data to the Eurostat Lithuania distinguished two types of waste - municipal waste and waste of the other origin. The latter referred to industrial waste, though the originating sectors were not specified. However, mining and quarrying were the only industrial activities for which the generated waste amount was specified. It has to be pointed out that Lithuania reports no figures on the total waste generation in Lithuania because the available data are considered to be incomplete (Ulinskaite et al., 2006).

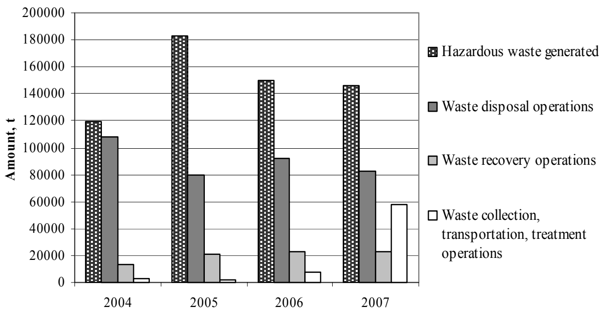

Fig. 3 The amount of hazardous waste generated and managed by different operations (National waste accounting database, Environmental Protection Agency of the Republic of Lithuania)

The main HW management methods in Lithuania are: disposal, recovery and other treatment (including collection and transportation) (see Fig. 3). HW related activities are classified as recovery (R-codes) or disposal (D-codes) as defined in WFD. The other treatment covers HW collection, transportation, import, export and treatment, when some sources of HW (e.g. WEEE, end-of-life vehicles, accumulators, etc.) are cut, pulverized, etc., separating the parts which cause potential risk to the environment.

While the incineration plant and landfill for HW is not built, HW is temporarily stored, processed, exported or managed in the companies which have the Integrated Pollution Prevention and Control (IPPC) permits. It aims to manage HW in a more environmentally friendly way. However, the current HW management is not developed on an integrated approach, which allows to evaluate the environmental impact throughout the life cycle and to use cost-effective HW management processes, and all available technical and technological capabilities. The legal system determines the main HW management objectives, but compliance with them is often more formal than real. This problem is clearly seen in a municipal HW management sector. The amount of household HW is extremely small. As the actual amount of municipal HW is indeterminate, a lot of difficulties arise in planning the activities of a municipal HW system.

Designing new HW management facilities, environmental impact assessment is carried out, but this assessment does not reflect the impact of a HW management system on the environment throughout its all life cycle. To perform a comprehensive assessment, the tools mentioned above in the paper or their combinations can be applied. Sustainable HW management can be achieved by integrating different measures, assessing relevant aspects and optimizing the system.

The existing problems in the HW management system can not be solved without scientific knowledge. HW generation and management problems, methods for solving them as a research object are analyzed by a series of environmental engineering studies and the majority of them are based on "end-of-pipe" approaches.

Different properties of waste flows, decontamination technologies, management and treatment studies have been carried out for some decades in Lithuania (Lapinskas and Jaskelevičius, 2000; Baltrėnas et al., 2004; Čepanko et al., 2008). Considerable scientific research was done analyzing the following: planning and optimization of non-hazardous municipal waste management, its generation and forecasting (Denafas et al., 2004; Denafas and Rimaitytė, 2005), economic and social aspects of municipal waste management studies in the field of sustainable development (Žičkienė, 2004), assessment of an impact on the environment of municipal waste management systems development, and life-cycle assessment of municipal waste management scenarios (Denafas and Rimaitytė, 2005; Miliūtė, 2009). An integrated waste management approach and some waste minimization results achieved in Lithuania industrial enterprises are presented by Stani kis (Stani kis, 2005), whereas application of an integrated approach to HW management has not been analyzed yet.

Globally, most of the integrated waste management research is carried out into municipal waste (McDougall et al., 2000; Najm et al., 2002; Morrisey and Browne, 2004; Erickson et al., 2005), less – into construction and demolition of waste (Klang et al., 2005) and only a few - into different kinds of HW (Najm and El-Fadel, 2004; Zografos and Androutsopoulos, 2008; Ahluwalia and Nema, 2007; Zhang and Roberts, 2007). Here comes the need and importance of application of an integrated approach to the HW management system.

For a long time it has been considered that waste management in environmentally acceptable way is based on the principles of the waste hierarchy. Lately, more and more often the fact has been broached that the waste management hierarchy has several major drawbacks and because of them its application is limited. According to the waste management hierarchy, the most preferable waste management option is prevention, after it goes waste reduction or minimization lowering the amount of produced waste, after it – reuse and recycling where materials are used repeatedly or for making new products, then – recovery of energy from waste. At the end of the waste hierarchy pyramid there is the least preferable option of waste management – landfilling.

For a long time waste hierarchy was considered as the main direction for management of all kinds of waste, including various HW flows. However, the waste hierarchy does not guarantee the cost-effective and sustainable HW management.

McDougall (2001) was one of the first scientists who summarized the shortcomings of waste management hierarchy in his scientific papers. Main drawbacks of waste management hierarchy include the lack of scientific validity, complex application using different combinations of waste management, economic weaknesses. The above-listed deficiencies have led to the appearance of an integrated waste management concept and implementation in waste management activities as a tool for sustainable waste management. An integrated approach to waste management first of all includes waste management hierarchy (Turner and Powell, 1991) taking into account direct effects (transportation, collection, processing and disposal) and indirect impacts (usage of energy and materials from the waste off-site the waste management system) (Korhonen et al. 2004). An integrated approach allows optimizing the existing systems, creating and implementing new ones of waste management and covers waste in physical conditions (solid, liquid and gaseous).

One of the first integrated waste management (IWM) definitions was proposed by the United Nations Economic Commission for Europe (UNECE) in 1991, where an integrated waste management was defined as a "process of change in which the concept of waste management is gradually broadened to eventually include the necessary control of gaseous, liquid, and solid material flows in human environment" (McDougall, 2001). Recently, integrated waste management concept combines waste flows, waste collection, treatment and disposal methods with an intention to achieve environmental benefit, economic optimization, and social acceptance (Coleman et al. 2003). The main principle of IWM concept is to integrate "all available waste management options into the existing geographic, environmental, and socio-economic waste management options that exist under certain geographical, environmental and socio-economic conditions and to manage the generated waste better" (Najm and El-Fadel, 2003).

The application of IWM principles in Lithuania is a new departure and focuses on waste minimization at the generation source and provides specific examples of waste minimization practices at industrial enterprises in Lithuania (Stani kis, 2005). The application of the IWM concept to a municipal waste management sector in Lithuania is widely analyzed by Miliūtė and Staniškis (Miliūtė and Staniškis, 2009).

Analysis of the literature concerned with the subject and the experience of the other EU states has highlighted the need for an integrated waste management concept and application of its principles to the HW management system in Lithuania as a tool for seeking the sustainable HW management.

Methodology

A single method of waste management could not be applied to all waste materials to be treated in an environmentally sustainable, economically efficient and socially acceptable way. Systematic examination of HW management system is needed because practically each waste management system is built on closely related integrated processes.

One of the aspects why integrated waste management is pre-eminent against waste management hierarchy is the fact that waste management is seen as a system, i.e. a systematic approach is applied. The systematic approach is often used in many scientific fields when environmental systems analysis studies focus on human activities' impact on the environment and on the interaction between technical, economic, social and ecological systems using a variety of environmental assessment tools (Finnaveden et al. 2007).

The system can be viewed as a certain number of components interlinked in a totality. The components and relations between them from the rest of the world (environment) are isolated by system boundaries, which indicate which components belong to the analyzed system, which do not. All systems are influenced by the factors which are outside the system boundaries and at the same time can influence their environment. The interaction between the system and its environment is characterized by the input and output parameters (Fig. 1).

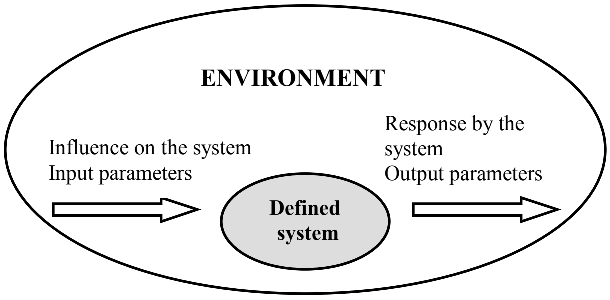

Fig. 1. System interaction with the environment. Adapted (from Klang, 2005)

Every individual system may have different system boundaries (e.g. physical, social, economic, time, etc.), depending on the complexity of the analyzed system. In pursuance of solution of the existing problems in the system, various models are developed. A model is a simplified representation of the real system omitting everything that is of little importance to the system response (output parameters) (Klang, 2005). The prerequisite for an accurate system analysis is that the elements of the system have to be well known and described. The elements of a waste system may be: different processing methods, waste collection vehicle efficiency, factors affecting waste separation efficiency at its source and the others.

In environmental system analysis a variety of tools are used either to measure its impact on the environment or to transform it into monetary units. Frequently, these tools are used for decision-making on waste management activities planning or determination which waste management option or their combination is more environmentally friendly and economically efficient. The selected tools do not point out which alternative should be chosen, but give the information about the economic and environmental impacts of waste management activities.

Tools of the environmental systems analysis can be categorized into analytical or procedural ones (Table 1). Procedural tools are focused on guiding the process to reach and implement environmental decisions, while analytical tools model the systems to provide technical information for decision making (Wrisberg et al., 2002). It should be noted that analytical instruments can be used as a part of the procedural tools for accurate evaluation of technical information about the decision to be taken.

Analytical tools can be used for accounting or change-orienting, for example, they describe the state or the consequences of that choice (Tillman 2000).

All the tools given in Table 1 and a number of the other less common instruments possess differences, similarities, advantages and disadvantages. Depending on the objectives (e.g. to assess the impact on the environment or to transform it into the monetary units, to calculate waste management costs, to make a decision concerning the waste management plan, program, project; to use it for region, nation or organization (including company), etc.) and on the desired result (e.g. natural resources, environmental impacts, natural resources and environmental impacts, economic aspects including natural resources and environmental impacts), on available resources (financial, human, time, available data, expertise, etc.), the stakeholders can choose different tools or their combination for assessment of the selected waste management system. Also there are a number of characteristics for consideration when tools are to be used in combination. These are as follows: type of comparison, degree of quantification, degree of site specifically or time specifically, system boundaries, type of impacts and effects considered, information provided by different tools (Moberg, 2006).

Table 1. The most commonly used tools for waste management systems assessment

Tools	Type
Cost-benefit analysis (CBA)	Analytical
Environmental impact assessment (EIA)	Procedural
Environmental management systems (EMS)	Procedural
Input-output analysis (IOA)	Analytical
Life cycle assessment (LCA)	Analytical
Life cycle costing (LCC)	Analytical
Material flow analysis (MFA)	Analytical
Risk assessment (RA)	Analytical
Strategic environmental assessment (SEA)	Procedural
Material input per unit service (MIPS)	Analytical

All instruments of waste management system assessment presented in Table 1 help managing waste not only in accordance with the waste management hierarchy principles, but also with economic, technical aspects taken into account. It is also obvious that the reduced impact on the environment has not so serious social impact.

Selected tools for environmental system analysis

As the name suggests, the system analysis is analysis of a system. Hence, instead of considering separate parts of a large system, a more holistic approach has to be taken. There is always a larger system whose part forms the studied system, but still the systems analysis approach aims at widening the perspective and thereby avoids sub-optimization and unwanted effects.

All tools of environmental system analysis presented in Table 1 could be applied to the HW management system. Depending on the purpose of research, the interested parties can choose any individual tool or combine some of them.

A very popular analytical tool is life cycle assessment (LCA). LCA is particularly used for assessment of environmental aspects of a municipal waste management system, but it could also be used for different flows of HW.

LCA evaluates the potential impact on the environment of waste management systems throughout all life cycle, from "cradle to grave" (Coleman 2003). In contradistinction to products, life cycle boundaries of waste (including HW) begins at the waste generation and covers the collection, sorting, transporting, processing and final disposal. The results of LCA lead to waste management system optimization.

LCC can be used to assess the costs of HW services using the life cycle perspective. Social and environmental costs may be included.

RA is a broad term and includes risk assessment of both chemical substances and accidents. The latter concerns unplanned incidents, whereas the former concerns the dispersion of chemicals, which is often a part of the use of chemicals. RA of chemicals includes exposure assessment and effect assessment, while RA of accidents includes the analysis of probability and possible consequences. As to HW, RA can be used for selection the waste management and disposal sites, transportation routes with the aim to reduce the impact on the environment and society (Nema, Gupta 2003).

SEA is a procedural tool for handling environmental (and sustainability) aspects in strategic decision-making (policies, programs and plans). It is required by law for certain programs and plans.

Concerning the factors described in the methodology section of this paper, choice of the tools for HW management assessment is a complex process and requires practice and scientific knowledge. The suggested tools for the system management or the planning process of each HW flow are to be analyzed in detail in future research.

Conclusions

The issue related to both HW management and environmental pollution caused by HW having already been not a new one, the need for reasonable and sustainable waste management is still one of the most common complaints. HW management is an important part of corporate management because it is directly linked to urban infrastructure, human health, and industrial environment. Many products contain substances that are harmful to human health and the environment. It is of primary importance that such HW is sorted out and handled separately prior to disposal by recycling, incineration or land-filling. Disposal itself is to be monitored so as to avoid the release of hazardous substances into the environment, like poorly controlled recycling.

Even though there are a number of laws related to HW management; they do not address HW management in its entire spectrum in some countries which have become the EU Members together with Lithuania. Specific government agencies are mandated to manage different waste sectors, but their roles and responsibilities are not clearly defined. In addition, lack of resources, financing, technologies, capacity and skills for HW management are bringing the impact of waste to the forefront.

Economic feasibility is one of the most important considerations in the choice of one option to another. Therefore in the indicators' system, economics of the activities is considered by paying special attention to HW impact on GDP.

The waste management planning system is based solely on economic aspects. To ensure the sustainable HW management, environmental and social aspects have to be integrated.

Analysis has shown that the application of waste management hierarchy does not always ensure sustainable waste management. Effective HW management can be achieved only by applying a systematic approach and integrating various systems assessment tools. More comprehensive analysis of different tools or tools combination for HW system assessment is needed when going towards sustainable HW management in Lithuania.

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