BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI

Tomul LVIII (LXII)

Fasc. 1

CHIMIE şi INGINERIE CHIMICĂ

2012 **Editura POLITEHNIUM**

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
PUBLISHED BY
"GHEORGHE ASACHI" TECHNICAL UNIVERSITY OF IAŞI
Editorial Office: Bd. D. Mangeron 63, 700050, Iaşi, ROMÂNIA
Tel. 40-232-278683; Fax: 40-232-237666; e-mail: polytech@mail.tuiasi.ro

Editorial Board

President: Prof. dr. eng. **Ion Giurma**, Member of the Academy of Agricultural Sciences and Forest, *Rector* of the "Gheorghe Asachi" Technical University of Iaşi

Editor-in-Chief: Prof. dr. eng. **Carmen Teodosiu**, *Vice-Rector* of the "Gheorghe Asachi" Technical University of Iaşi

Honorary Editors of the Bulletin: Prof. dr. eng. **Alfred Braier**,
Prof. dr. eng. **Hugo Rosman**,
Prof. dr. eng. **Mihail Voicu**, Corresponding Member of the Romanian Academy, *President* of the "Gheorghe Asachi" Technical University of Iaşi

Editor in Chief of the* CHEMISTRY and CHEMICAL ENGINEERING *Section
Prof. dr. eng. **Teodor Măluţan**

Associated Editor: Assist. dr. chem. **Gabriela Apostolescu**

Editorial Advisory Board

Prof.dr.eng. **Dan Caşcaval**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Gabriela Cârjă**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Silvia Curteanu**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr. **Jurek Duszczyk**, Delft University of Technology, Netherlands
Prof.dr.eng. **Anca Galaction**, University "Gr.T.Popa", Iaşi
Prof.dr.eng. **Maria Gavrilescu**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Dan Gavrilescu**, "Gheorghe Asachi" Technical University of Iaşi
Assoc.prof.dr.eng. **Doina Horoba**, "Gheorghe Asachi" Technical University of Iaşi
Assoc.prof.dr.eng. **Eugen Horoba**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr. eng**. Vasile Hulea**, Institut Charles Gerhardt, Franţa
Prof.dr.eng. **Nicolae Hurduc**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Florin Dan Irimie**, University Babeş-Bolyai, Cluj- Napoca
Assoc.prof.dr.eng. **Gabriela Lisă**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Matei Macoveanu**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Ion Mangalagiu**, "Al.I.Cuza" University, Iaşi
Prof.dr.eng. **Ioan Mămăligă**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr. **Shin'ichi Nakatsuji**, University of Hyogo, Japonia
Prof.dr.eng. **Ionel Marcel Popa**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Marcel Popa**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Valentin I. Popa**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Aurel Pui**, "Al.I.Cuza" University, Iaşi
Prof.dr. **Nicolas Sbirrazzuoli**, Université de Nice Sophia Antipolis, Franţa
Prof.dr.eng. **Dan Scutaru**, "Gheorghe Asachi" Technical University of Iaşi
Academician prof.dr.eng. **Bogdan Simionescu**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Dan Sutiman**, "Gheorghe Asachi" Technical University of Iaşi
Lecturer dr.eng. **Dana Şuteu**, "Gheorghe Asachi" Technical University of Iaşi
Prof.dr.eng. **Mihai Vâţă**, "Gheorghe Asachi" Technical University of Iaşi

B U L E T I N U L   I N S T I T U T U L U I   P O L I T E H N I C   D I N   I A Ş I
B U L L E T I N   O F   T H E   P O L Y T E C H N I C   I N S T I T U T E   O F   I A Ş I
Tomul LVIII (LXII), Fasc. 1 2012

CHIMIE şi INGINERIE CHIMICĂ

S U M A R

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tomul LVIII (LXII), Fasc. 1 2012

CHEMISTRY and CHEMICAL ENGINEERING

CONTENTS

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVIII (LXII), Fasc. 1, 2012
Secţia
CHIMIE şi INGINERIE CHIMICĂ

ENVIRONMENTAL COMPARISON OF SOLID WASTE MANAGEMENT SYSTEMS: A CASE STUDY OF THE CITIES OF IAŞI, ROMÂNIA AND ENSCHEDE, NETHERLANDS

BY

CRISTINA GHINEA[1*], MĂDĂLINA PETRARU[1], HANS BRESSERS[2] and MARIA GAVRILESCU[1]

[1]“Gheorghe Asachi” Technical University of Iaşi,
Faculty of Chemical Engineering and Environmental Protection
[2]University of Twente, Enschede, The Netherlands,
Twente Centre for Studies in Technology and Sustainable Development

Received: January 12, 2012
Accepted for publication: January 24, 2012

Abstract. Sustainable approach to solid waste management in any region can be achieved by integrated waste management systems. The waste management systems differ in developed and developing countries. The Netherlands has a unique waste management system, the Dutch approach to waste consist in “avoid waste as much as possible, recover the valuable raw materials from any waste that is created, try to generate energy by incinerating the residual waste, and only then dump what is left”. Netherlands is today among the leading countries in terms of waste management and especially in recycling solid waste. Compared with the waste situation from Netherlands the waste management in România is far behind. Landfilling of municipal solid waste is still the most used method to disposal of waste in Romania. The solid waste management sector in România is expected to develop in the coming years. In this paper environmental impact evaluation of these two different systems was realized with GaBi4 software.

Key words: environmental impact, life cycle assessment, municipal solid waste.

*Corresponding author; *e-mail*: cbghinea@yahoo.com

1. Introduction

Waste management represents an important issue for all countries. The manner in which the growing amount of solid waste is handled influences the human health and environment (Giusti, 2009; Ngoc & Schnitzer, 2009). The solid waste should be managed according to the hierarchy of waste (or Lansink's Ladder in The Netherlands) which comprises the most and less favourable options for waste management (Fig.1) (Ahluwalia & Nema, 2007; Banar *et al*., 2009; de Jong, 2011). There are big differences regarding waste collection and processing between the countries from European Union (EU). In 2006 the recycling rate was higher in West of Europe and lower in countries from East of Europe. The landfilling rate was lowest in countries such as Germany 1%, Netherlands 2%, Belgium and Denmark 6% and highest in East European countries: 85% in România, 80% in Hungary and Bulgaria (EVD, 2008; Eurostat, 2010). The Netherlands has a unique waste management system. Using policy to discourage landfilling and improve safety such as landfill decree (technical requirements and standards; financial covering of post-closure costs), landfill ban (no dumping for 32 types of wastes), landfill tax (extra tax for combustible waste) and reorganisation of the landfill sector and policy to encourage prevention, reuse and recycling and also by developing of a professional waste market Netherlands is today among the leading countries in terms of waste management and recycling of solid waste especially (SenterNovem, 2006; SenterNovem, 2009).

Compared with the waste situation from Netherlands the waste management in România is very far behind. In 2008 in Iaşi the municipal solid waste was only collected and transported to landfill. The waste management sector in România is expected to develop in the coming years because as part of European Union, România has to meet some targets related to waste management (Agentschap NL, 2011; ANPM, 2009).

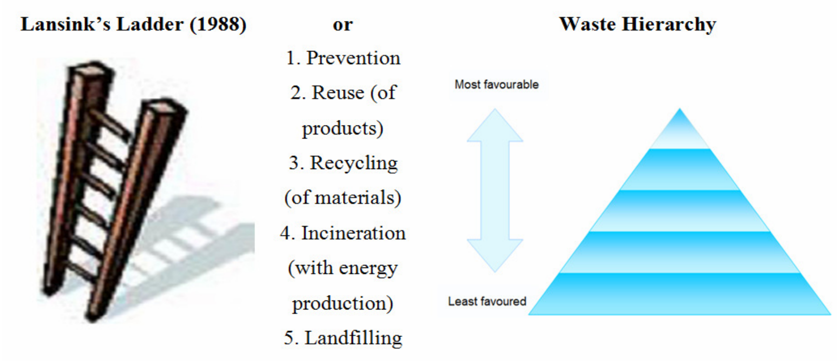


Fig. 1 − Lansink's Ladder.

Environmental pressures from generation, collection and processing of waste including emissions to air, soil and water has different impacts on the human health and the environment. To evaluate the environmental issues connected with solid waste management systems can be used many models (Ghinea & Gavrilescu, 2010a; Ghinea & Gavrilescu, 2010b; Morrissey & Browne, 2004). One of the most useful methodologies for evaluation of solid waste management is life cycle assessment (LCA).

In this paper LCA was used to evaluate the existing solid waste management systems in 2008 in Iaşi, România and Enschede, Netherlands from environmental point of view.

2. Methodology

2.1. Life Cycle Assessment Methodology

Life cycle assessment comprises four major stages according to ISO standard (14040:2006): goal and scope definition, inventory analysis, impact assessment and interpretation. LCA can be used to evaluate the environmental impacts of different processes, systems. In recent years various models were developed based on LCA methodology and can be very useful in helping users to interpret the results of an LCA study (Ness *et al*., 2007; Winkler & Bilitewski, 2007). GaBi software is one of the models that support every stage of an LCA from data collection and organization to presentation of results (PE International, 2009). GaBi calculates the potential environmental impacts as well as other important quantities of a product system based on plans. The plan includes the system studied which is made up of processes and flows (PE International, 2009). In LCA terms, "a plan represents the system with its boundaries, processes represent the actual processes taking place, and flows represent all the inputs and outputs related to the system" (PE International, 2009). Gabi software includes LCA methodologies such as: CML 2001, CML 1996, Eco-Indicator 95, EDIP 1997, EDIP 2003 etc.

CML 2001 methodology was developed by Center of Environmental Science of Leiden University and succeeds the CML 1996 methodology. CML 2001 methodology includes a set of impact categories: obligatory impact categories, additional impact categories, other impact categories (Frischknecht *et al*., 2007; Goedkoop *et al*., 2008; JRC European Commission, 2010). For waste management systems the most important and relevant impact categories are abiotic depletion potential (ADP), acidification potential (AP), eutrophication potential (EP), global warming potential (GWP), human toxicity potential (HTP) and photochemical ozone creation potential (POCP) (Table 1).

Eco-Indicator 95 (EI 95) considers "the environmental effects (greenhouse effect, ozone layer depletion, acidification, eutrophication, smog and toxic substances) that damage ecosystems or human health on European scale"

(Goedkoop *et al*., 1996). Heavy metals, winter smog and carcinogenic substances are the specific impact categories for this methodology (Goedkoop, 1995).

Environmental Design of Industrial Products (EDIP 1997) is a Danish LCA methodology which covers the most of the emission-related impacts, resource use and working environment impacts (Wenzel *et al*., 1997). Three different steps are included in this method: environmental impact potentials, normalization with a common reference, weighting of the normalized impact potentials (Frischknecht *et al*., 2007).

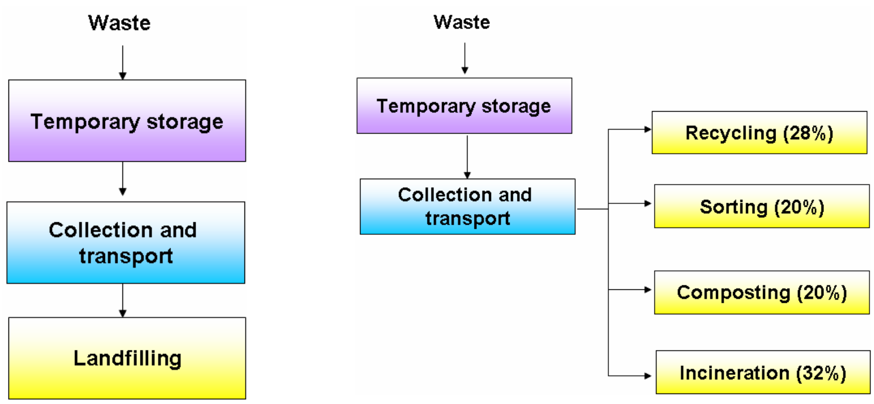
Table 1
Description of the Most Relevant Impact Categories for Waste Management
(den Boer *et al*., 2005a; Ghinea & Gavrilescu, 2010b)

Environmental indicators	Description of the impact category	Substances contributing to the impact category
Global warming potential (GWP)	Represent the effect of increasing temperature in the lower atmosphere.	CO_2, CH_4, N_2O, CFCs, HCFCs, HFCs, Halons, CCl_4, CCl_3CH_3, CO
Photochemical ozone formation (POCP)	Ozone is formed in the troposphere under the influence of sunlight when nitrogen oxides are present.	NOx, VOCs including CH_4, CO
Acidification potential (AP)	A number of emissions are either acid or they are converted to acid by processes in the air.	SO_2, SO_3, NOx, HCl, HNO_3, H_2SO_4, HF, H_2S, NH_3
Eutrophication potential (EP)	Include all potential impacts of excessively high environmental levels of macronutrients.	NO_2, NH_3, PO_4^{3-}- P, N
Human toxicity potential (HTP)	Negative effects on human health of toxic substances emitted to the environment.	VOC, particles, heavy metals, POPs, NO_x, SO_2 etc.
Abiotic depletion potential (ADP)	Abiotic resources are natural resources such as iron ore, crude oil.	

EDIP 2003 is an update of the EDIP 1997 methodology. Both methodologies show many similarities: accordance with the requirements of ISO 14042 and precede the same steps characterisation, normalisation and weighting (Hauschild & Potting, 2005). The main difference between EDIP 1997 and EDIP2003 lies in the choice of impact category (Hauschild & Potting, 2005).

2.2. Scope, Functional Unit, System Boundaries, Scenarios

The purpose of this study is to evaluate the environmental impacts of two different municipal solid waste management systems (MSWMS) from two cities: Iaşi, România and Enschede, Netherlands and to highlight the difference between these systems. Two scenarios representing the MSWMS were developed based on the amounts of waste generated in 2008 in the cities of Iaşi and Enschede (Fig. 2) and analysed with GaBi software. The functional unit has been defined for: the first scenario (noted Sc_Is) as the amount of solid waste generated in Iaşi City and for the second scenario (noted Sc_En) as the quantity of solid waste generated in Enschede City. The systems boundaries include: temporary storage of waste in containers, collection and transport and treatment, elimination processes of solid waste. Municipal solid waste management existent in Iaşi, România in 2008 included only temporary storage of mixed waste (residual) from household in various containers, collection and transport of solid waste to a non-compliant landfill (Fig. 2 *a*). In 2008 the separate collection of waste by fraction was implemented only in some locations from the city just for collection of paper and PET waste (pilot projects).



a *b*

Fig. 2 − Waste management systems in 2008, *a* − in Iaşi, România, *b* − Enschede, Netherlands.

Enschede has a well organized separate collection system for various waste fractions. The separation of household waste is realized at source and each fraction is temporarily stored in special containers. From these containers the solid waste are collected and transported by various private companies for processing/treatment. Municipal solid waste management system in Enschede included in 2008 the following methods for processing solid waste: recycling, sorting, composting and incineration (Fig. 2 *b*).

2.3. Inventory Analysis

All the inputs and outputs were established for the processes included in waste management systems evaluated. The amounts of waste generated in Iaşi in 2008 were taken from Iaşi County Council (2009). The number of containers, annual quantity of material required for containers fabrication were calculated according to den Boer *et al*., (2005b) for the evaluation of temporary storage process.

Number of vehicle and loading capacity, transport distance, fuel consumption and emissions from fuel consumption are the main necessary data for the inventory of inputs and outputs of collection and transport processes. The municipality Iasi has 30 vehicles with total loading capacity of 1881 m^3 (Doba *et al*., 2008), the fuel consumption was estimated to 30 L/100 km (den Boer *et al*., 2005b) and the density of diesel are 0.845 kg/L (Recycled Organics Unit, 2003). Fuel consumption emissions were calculated based on the quantity of emission (CO_2, CO, NO_x, N_2O, PM10, CH_4, SO_2 and hydrocarbons) resulted from burning of 1 kg of diesel (Recycled Organics Unit, 2003).

For landfilling process the inputs and outputs consist in amount of waste landfilled, fuel consumption, emissions from fuel consumption, landfill gas and leachate. The biogas potential was calculated, the content of pollutants in the gas flow was estimated according to den Boer *et al*. (2005b) and also the quantity of leachate was calculated based on area of landfill and annual average rainfall.

The amount of waste generated in 2008 in Enschede was taken from CBS (2011) statistics. Most of the necessary data for inventory analysis were collected from the Dutch Waste Management Association and Twence Company. Also most of the inputs and outputs for modeling of waste management system were calculated according with these data because the Twence Company is processing the waste collected not only from the Enschede but from the entire Twente Region. **Twence's** waste activities are: incineration, composting, separation, landfilling of solid waste (de Jong, 2011). The Twence Company produces besides energy compost and raw materials for reuse (metals, bottom ash).

3. Results

Both municipal solid waste management systems existent in 2008 in Iaşi, România and Enschede, Netherlands were analysed with GaBi software. Only the normalised values of the environmental impacts for different methodologies included in Gabi software are illustrated in Figs. 3,…,7.

For MSWMS from Iaşi (Sc_Is) the value of all impact categories from all methodologies analysed are positive this means a negative impacts on the environment. Global warming potential (GWP) for Sc_Is has high values because of the higher content of organic waste that was landfilled. The organic wastes are degraded through a series of consecutive reactions which are taking place in the body of landfill so that large molecules are broken down into simpler molecules, then these molecules are degraded in intermediate compounds such as fatty acids, ketones, aldehydes, alcohols and in third phase the intermediate compounds are degraded under anaerobic conditions first in acetates and hydrogen which will then form CH_4 and CO_2 (Sundqvist, 1999). CH_4 and CO_2 are the main constituents of the biogas and because the biogas is not collected the emissions will reach in atmosphere as contributors to global warming potential.

The eutrophication potential (EP) for MSWMS from Iaşi has high values because the leachate resulted after landfilling of waste is not collected and can easily reach in the soil and groundwater. The average values of N-NH_3 and PO_4^{3-} are 2358.82 mg/L respectively 7.13 mg/L (Şchiopu *et al*., 2009).

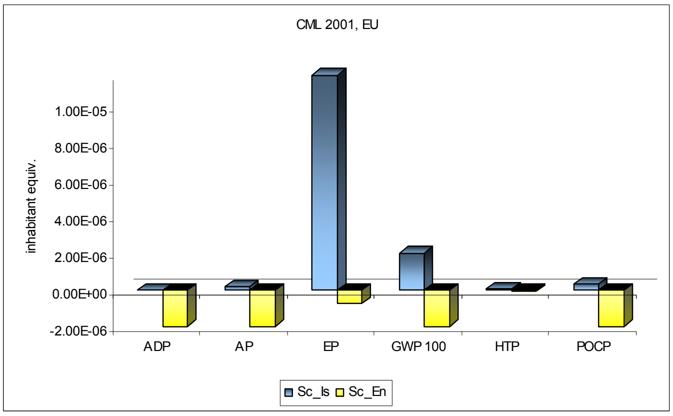


Fig. 3 − Environmental impacts of waste management systems in Iaşi (Is) and Enschede (En) – CML 2001 methodology.

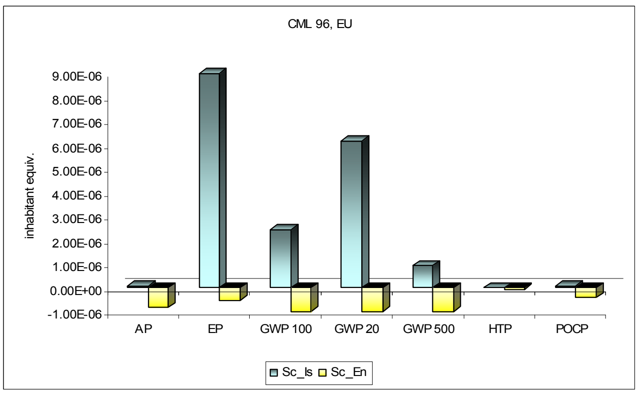


Fig. 4 − Environmental impacts of waste management systems in Iaşi (Is) and Enschede (En) – CML 96 methodology.

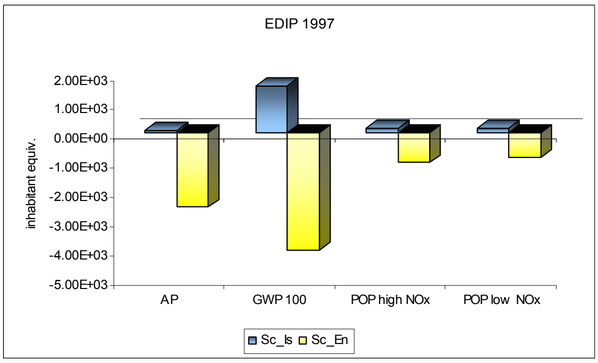


Fig. 5 − Environmental impacts of waste management systems in Iaşi (Is) and Enschede (En) – EDIP 97 methodology.

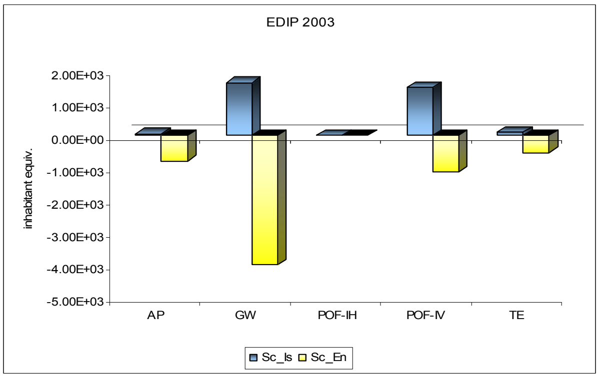


Fig. 6 − Environmental impacts of waste management systems in Iaşi (Is) and Enschede (En) – EDIP 2003 methodology.

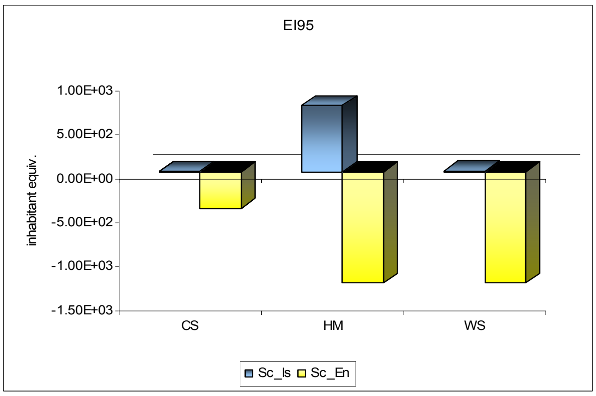


Fig. 7 − Environmental impacts of waste management systems in Iaşi (Is) and Enschede (En) – EI95 methodology.

For the existing system in Enschede (Sc_En) in 2008 are recorded environmental benefits, all impact categories had negative values (Figs. 3,…,7). It can be said that the existing system in Enschede in 2008 is more favorable in terms of environment than the system from Iaşi in the same year. The differences between the two systems are starting from temporary storage because in Enschede were containers for each type of waste but in Iaşi the separate collection was still in phases of pilot projects form and some containers were located in several places in Iaşi city in 2008. Also, in the same year, in Enschede landfilling of municipal waste was 0% but for Iaşi was the most used method for disposal of waste fractions.

4. Conclusions

In this study GaBi software was used to evaluate from environmental point of view two different municipal solid waste management systems from Iaşi, România and Enschede, Netherlands. Results showed that the waste management systems existent in Iaşi, România has to be improved.

Implementation of treatment/elimination methods such as: recycling of materials, composting of biowaste, incineration of residual waste can achieve environmental benefits. The model of waste management of leaders like Netherlands can be very helpful in choosing the way for a sustainable waste management.

Acknowledgements. This work was supported by EURODOC "Doctoral Scholarships for research performance at European level" project, financed by the European Social Found and Romanian Government; GaBi 4: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH; University of Twente, Twente Centre for Studies in Technology and Sustainable Development (CSTM) and by a grant of the Romanian National Authority for Scientific Research, CNCS – UEFISCDI, project number PN-II-ID-PCE-2011-3-0559 IDEI Project, contract 265/2011.

REFERENCES

*** Agentschap NL, *Waste Management and Research*. Ministerie van Economische ZAken Landbouw en Innovatie, The Netherlands (2011).

*** ANPM, *Annual Report on the State of the Environment in România in 2008*, *Waste* (2009), on line at: http://www.anpm.ro/Files/Capitolul%207%20-%20Deseuri_20091227450.pdf.

*** CBS, *Statistics Netherlands.* Centraal Bureau voor de Statistiek (2011) on line at: http://www.cbs.nl/en-GB/menu/cijfers/default.htm.

*** Eurostat, *Waste Statistics* (2010) on line at: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Waste_statistic.

*** EVD, *Made in Holland. Waste a Valuable Resource*. Agency for International Business and Cooperation (2008) on line at: http://www.hollandtrade.com/publications/made-in-holland/mih.asp?bron=waste.

*** Iaşi County Council, *Long-term Investment Plan for the Period 2008-2038 on Integrated Waste Management* (2009) on line at: http://www.icc.ro/activitate/mediu/MasterP/MasterPlan.pdf.

*** ISO, *Environmental Management – Life Cycle Assessment – Principles and Framework* (ISO 14040:2006). European Standard EN ISO 14040. The International Organization for Standardization, Geneva, Switzerland (2006).

*** JRC European Commission, *Analysing of Existing Environmental Impact Assessment Methodologies for Use in Life Cycle Assessment*. Joint Research Centre Institute for Environment and Sustainability, ILCD Handbook (2010).

*** PE International, *Handbook for Life Cycle Assessment (LCA) Using the GaBi Education Software Package*. Germany (2009).

*** Recycled Organics Unit, *Life Cycle Inventory and Life Cycle Assessment for Windrow Composting Systems.* Report prepared for NSW Department of Environment and Conservation (Sustainability Programs Division), Published by Recycled Organics Unit, the University of New South Wales, Sydney (2003).

*** SenterNovem, *Progress in Dutch Waste Management: 1990-2005*. Twinning Domestic Waste Management Project (2009) on line at: http://www.twinning-waste-bacau.ro.

*** SenterNovem, *The Dutch Waste Profile 1990-2005* (2006), on line at: http://www.senternovem.nl.

Ahluwalia P.K., Nema A.K., *A Life Cycle Based Multi-Objective Optimization Model for the Management of Computer Waste*. Resources, Conservation and Recycling, **51**, 792–826 (2007).

Banar M., Cokaygil Z., Ozkan A., *Life Cycle Assessment of Solid Waste Management Options for Eskisehir, Turkey*. Waste Manag., **29**, 54–62 (2009).

de Jong W., *Twence from Waste to Energy*. Visit Romanian Ph. D. Student from Twente University Presentation, Twence Company, Hengelo, The Netherlands (2011).

den Boer E., den Boer J., Jager J., *Waste Management Planning and Optimization, Handbook for Municipal Waste Prognosis and Sustainability Assessment of Waste Management Systems*. ibidem-Verlag Stuttgart, Germany (2005a).

den Boer E., den Boer J., Jager J., Rodrigo J., Meneses M., Castells F., Schanne L., *The Use of Life Cycle Assessment Tool for the Development of Integrated Waste Management Strategies for Cities and Regions with Rapid Growing Economies LCA-IWM*. Deliverable report on D3.1 and D3.2: Environmental Sustainability Criteria and Indicators for Waste Management (Work Package 3), Technische Universitaet Darmstadt (TUD), Darmstadt (2005b).

Doba A., Nistorescu M., Păstrăvanu L., Petruc I., Simionescu I., *Strategic Plan for Integrated Waste Management in Iaşi County* (2008) on line at: http://www.scribd.com/doc/13769639/Planul-Judetean-de-Gestionare-al-Deseurilor.

Frischknecht R., Jungbluth N., Althaus H.-J., Bauer C., Doka G., Dones R., Hischier R., Hellweg S., Humbert S., Köllner T., Loerincik Y., Margni M., Nemecek T., *Implementation of Life Cycle Impact Assessment Methods*. Ecoinvent Report no. 3, v2.0. Swiss Centre for Life Cycle Inventories, Dübendorf (2007).

Ghinea C., Gavrilescu M., *Models for Sustainable Waste Management*. Bul. Inst. Polit. Iaşi, s. Chemistry and Chemical Engineering, **56**, 2, 21−36 (2010a).

Ghinea C., Gavrilescu M., *Decision Support Models for Solid Waste Management – an Overview*. Environmental Engineering and Management Journal, **9**, 869−880 (2010b).

Giusti L., *A Review of Waste Management Practices and their Impact on Human Health*. Waste Manag., **29**, 2227–2239 (2009).

Goedkoop M., Demmers M., Collignon M., *Eco-Indicator 95*. Manual for Designers, The Netherlands (1996).

Goedkoop M., *Eco-Indicator 95*. Final Report, The Netherlands (1995).

Goedkoop M., Oele M., Schryver A., Vieira M., *SimaPro Database Manual*. Methods Library, PRé Consultants, The Netherlands (2008).

Hauschild M., Potting J., *Spatial Differentiation in Life Cycle Impact Assessment - The EDIP2003 Methodology.* Environmental news no. 80 (2005).

Morrissey A., Browne J., *Waste Management Models and their Application to Sustainable Waste Management*. Waste Manag., **24**, 297−308 (2004).

Ness B., Urbel-Piirsalua E., Anderbergd S., Olssona L., *Categorising Tools for Sustainability Assessment*. Ecological Economics, **60**, 498−508 (2007).

Ngoc U.N., Schnitzer H., *Sustainable Solutions for Solid Waste Management in Southeast Asian Countries*. Waste Manag., **29**, 1982–1995 (2009).

Şchiopu A.M., Robu B.M., Apostol I., Gavrilescu M., *Impact of Landfill Leachate on Soil Quality in Iaşi County.* Environmental Engineering and Management Journal, **8**, 1155−1164 (2009).

Sundqvist J.O., *Life Cycles Assessments and Solid Waste – Guidelines for Solid Waste Treatment and Disposal in LCA*. Final Report, Swedish Environmental Protection Agency (1999).

Wenzel H., Hauschild M., Alting L., *Environmental Assessment of Products: Methodology, Tools and Case Study in Product Development.* Vol. I, Kluwer Academic Publisher (1997).

Winkler J., Bilitewski B., *Comparative Evaluation of Life Cycle Assessment Models for Solid Waste Management.* Waste Manag., **27**, 1021–1031 (2007).

ANALIZĂ COMPARATIVĂ A SISTEMELOR DE MANAGEMENT AL DEŞEURILOR SOLIDE: STUDIU DE CAZ IAŞI, ROMÂNIA ŞI ENSCHEDE, OLANDA

(Rezumat)

Abordarea durabilă a managementului deşeurilor solide din orice regiune poate fi realizată prin sisteme integrate de management al deşeurilor. Sistemele de management al deşeurilor diferă atât în țările dezvoltate cât şi în cele în curs de dezvoltare. Olanda are un sistem unic de management al deşeurilor, abordarea olandeză constă în „evitarea generării deşeurilor pe cât este posibil, recuperarea materialelor din orice tip de deşeu creat, generarea energiei prin incinerarea deşeurilor residuale şi depozitarea deşeurilor rămase”. Olanda este astăzi printre țările lider în ceea ce priveşte managementul deşeurilor şi în special reciclarea deşeurilor solide. Comparativ cu situația din Olanda managementul deşeurilor din România este cu mult în urmă.

Depozitarea deşeurilor solide municipale reprezintă cea mai utilizată metodă de eliminare a deşeurilor din România. O dezvoltare a sectorului de management al deşeurilor solide din România este preconizată pentru următorii ani. În această lucrare evaluarea impacturilor asupra mediului a celor două sisteme a fost realizată cu softul GaBi4.