ASPECTS CONCERNING HEAVY METALS PRESENCE IN MUNICIPAL HOUSEHOLD WASTE

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Abstract:Heavy metals constitutes chemical hazards that are affecting the environment because of their toxic potential of bio-accumulation in food chain through plants and animals and because they have a long time persistence in the human body while causing severe health problems. Many articles that end up as waste contain also different amounts of metals that will contribute to the pollution of the environment from the place of their final deposition: landfills. In order to fulfill European Union's legislation regarding the environment, Romania started to publish reports regarding the quantities of municipal solid waste and implemented separate collection of the electrical and electronic waste that have to be recycled. For this paper, Iasi municipality's waste management system is analyzed in order to highlight the heavy metal pollution risk.

Key words:*Municipal waste, landfill, heavy metals, bioaccumulation, recycling.*

Introduction

Waste management has been the concept of a hierarchy of waste management options, where the most desirable option is not to produce the waste in the first place (waste prevention) and the least desirable option is to dispose waste with no recovery of either materials or energy. Between these extremes there are a wide variety of waste treatment options that may be used as part of a waste management strategy to recover material (reuse, recycle or composting) or generate energy from the wastes during incineration (DEFRA, 2013). In European Union, the Waste Framework Directive (EU, 2008) includes a 50% recycling target for waste from households, to be fulfilled by 2020 (EEA Report, 2013).

Waste can be defined as any material that is considered to be of no further use to the owner and is, hence, discarded (Taylor and Allen, 2006). In the EU's Landfill Directive, municipal solid waste is defined as "waste from households, as well as other waste which, because of its nature or composition, is similar to waste from households" (EU, 1999). It comprises household waste collected by local authorities, some commercial and industrial wastes from, commerce, offices and public institutions (DEFRA, 2013). Solid waste is disposed mainly to landfills because it is the simplest, cheapest and most cost-effective method of disposing it (Barret and Lawler, 2005). Although policies of reduction, reuse and diversion from landfill are strongly promoted in European Union, the majority of countries still landfilled more than half of their own municipal waste in 2010 (EEA Report, 2013). Waste accepted in municipal waste landfills in developed countries would normally consist of municipal solid waste, plus commercial and non-hazardous industrial wastes and construction and demolition waste (Taylor and Allen, 2006).

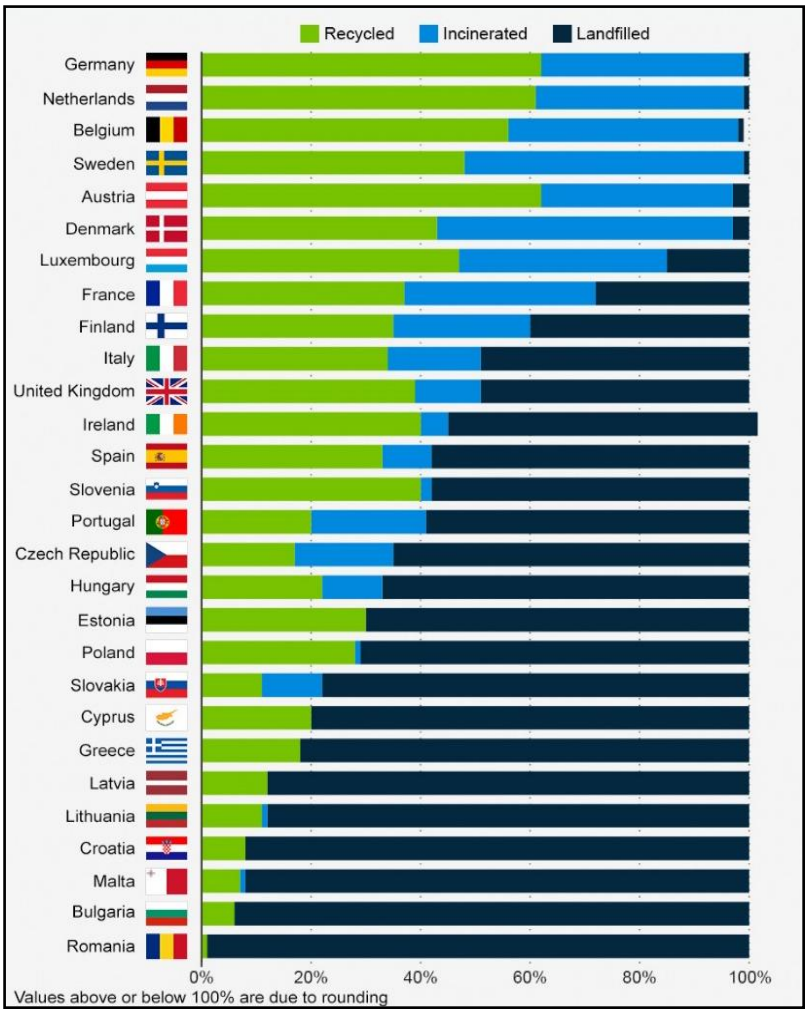
The EU Waste Directives had created obligations to recycle and recover increasing percentages of waste and discourages landfilling. Overall employment related to the recycling of materials in European countries increased by 45% between 2000 and 2007. The situation

differs substantially between Member States: while almost 100% of municipal waste in Romania and Bulgaria end up in landfills, Germany and Netherlands have abandoned this practice (EEA, 2009).

The responsibility of the collection and management of municipal waste belongs to municipalities. By 2009, 63% of the population in Romania benefited from collection services. Separate municipal waste collection practices were adopted in 2006, through the development of several pilot projects. In the period 2007-2017 the municipalities are required to develop a solid infrastructure for this practice, which is expected to boost the recycling levels. The level of recycling is very low, only organic waste is recycled in small amounts by householders for their own purposes (Almasi, 2013).

Many metals and metalloids are present in "trace" amounts in the soil and water. Heavy metals are released into the environment by natural and anthropic sources and as they do not decay and are characterized by latent toxicity, they are continuously present in the environment entering into the biological cycles (Perugini, 2011). Most heavy metals are not biodegradable and are having a long biological half-lives and the potential for accumulation in body organs, leading to major health problems (Khanna Suruchi and Pankaj, 2011).

Figure 1. Municipal waste treatment in European Union by category in 2011



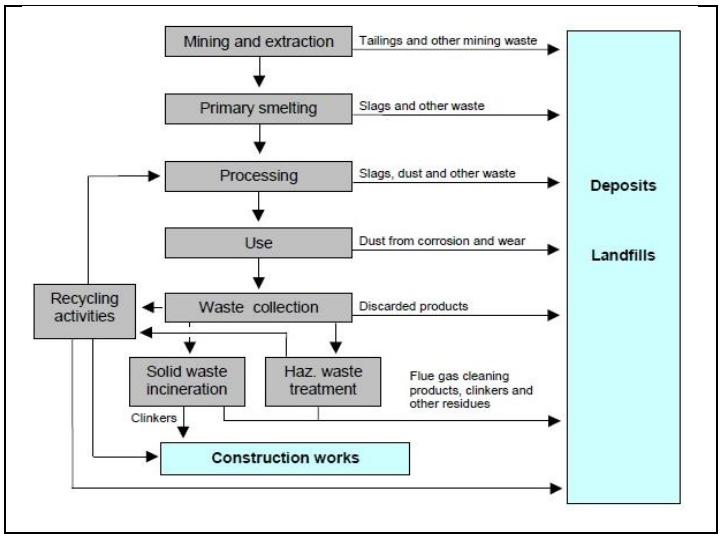
Source: Eurostat, 2012

The presence of heavy metals in waste

The presence of heavy metals in waste is a consequence of the intended use of heavy metals in industrial products. At the end of their useful life, all products that contain metals will end up in waste to the extent they are not attractive for recycling. Dedicated recycling of heavy metals can be carried out efficiently if proper technology is applied. The main problem is to ensure an effective collection of items that can be present in such a quantity and condition that collection is feasible. Reality is that significant quantities of heavy metals will never be collected for recycling by the present waste management systems (Zhang, 2008; EC, 2002).

Except for mercury, the heavy metals do not naturally occur in the environment in metallic form. Heavy metals can exist in a wide variety of physical and chemical forms and several forms will coexist in a certain media. The speciation is important for the transport and the bioavailability of the metals; physical and chemical conditions such as pH, redox potential, alkalinity and the occurrence of organic and inorganic compounds in the media play an important role in the speciation (EC, 2002).

Figure 2. Schematic illustration of the overall flow of heavy metals to waste



Source: EC, 2002

Table 1. The origin of heavy metals in domestic waste

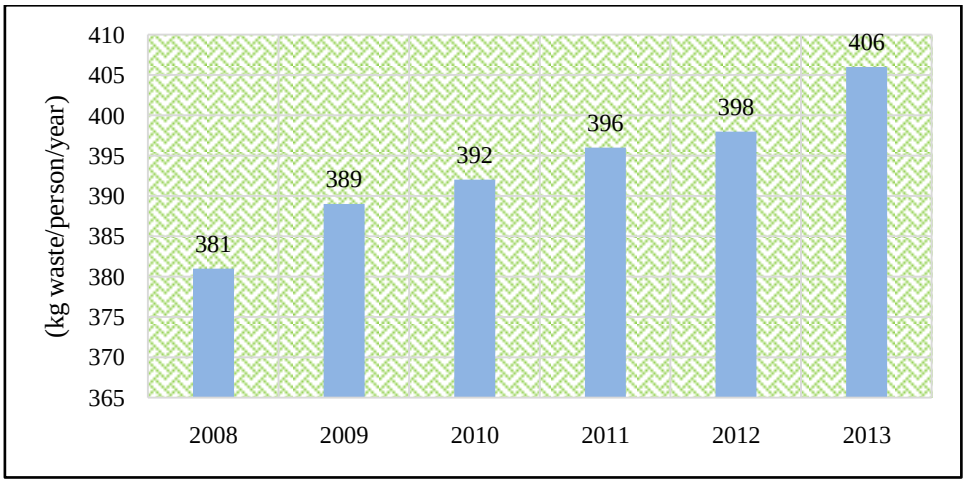
Element	Type of waste
Cadmium	Batteries, ceramic, detergents, pigments, plastic.
Chromium	Metals, textile materials, leather, paints, plastic, glass.
Copper	Electric cables, metals, plastics.
Nickel	With alloys in textile materials, accumulators.
Mercury	Measurement and control devices, paints, light bulbs, incandescent bulbs, wiring devices, batteries.
Lead	Accumulators, batteries, water pipes, building waste.
Zinc	Metals, plastic, paint, paper, textile.

Source: EC, 2002

Common to lead, mercury and cadmium is that neither has any known useful function in biological organisms. Lead influences the nervous system, slowing down nerve response. This influences learning abilities and behavior. Children are exposed to lead from their mother's blood, from dust and contaminated soil by deposition from the atmosphere. Cadmium accumulation leads to dysfunction of the kidneys. Intake of cadmium is generally based on diet, in particular vegetables and corn products. An increase in the content of cadmium in agricultural soil will result in an increase uptake of cadmium by plants (Hutton, 1987). In humans, methylmercury affects the brain and kidneys; in the environment animals placed highly in the food chain and in particular the marine food chain are assumed exposed to mercury poisoning due to the ability of methylmercury to concentrate via the food chain (Satohi, 2000).

In Iași County, municipal waste includes the household waste that is generated and collected and the household waste that is generated but is not collected because of the people's lack of awareness regarding deposition in especially designed places. According to the data from the Iasi Environmental Protection Agency, the amount of waste that was collected increased during 2003-2013 (EPA Iasi, 2013) because of a better collection management system. Basic data regarding the municipal household waste are provided mainly by sanitation operators that relies on estimations and not on precise data obtained through weighting.

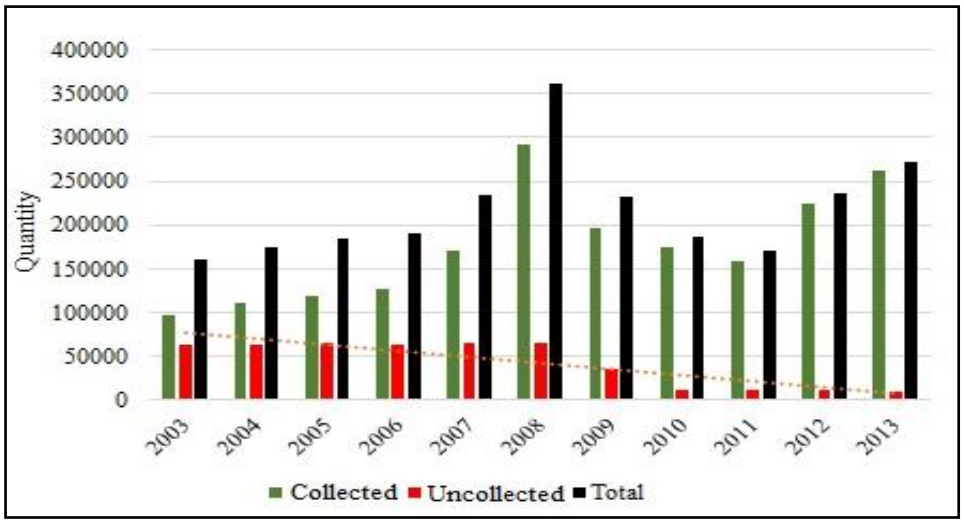
Figure 3. Evolution of household waste quantities generated by the population of Iași County (2008 - 2013)



Source: EPA Iași, 2013

The rate of municipal household collection increased at the same time with the growth of the waste quantity that is generated by person (Figure 3), both in rural and urban areas (Figure 4).

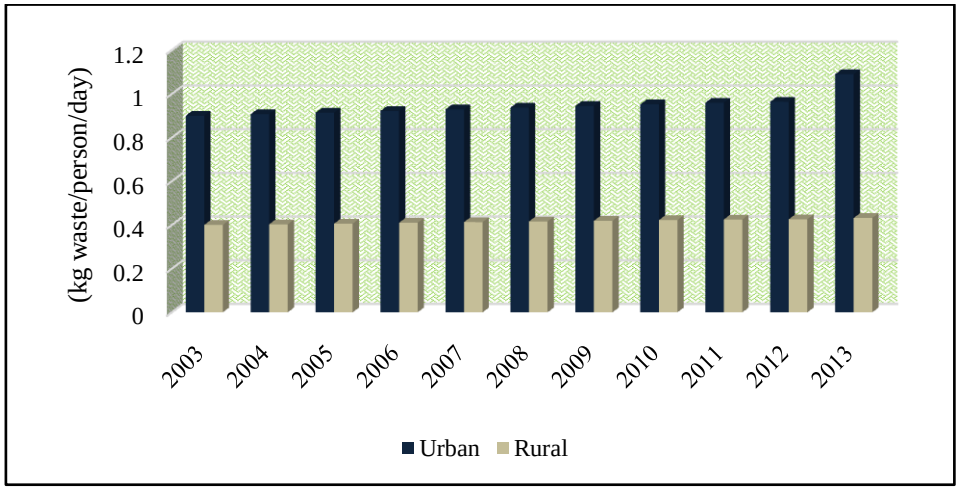
Figure 4. Evolution of collected and uncollected indicators of municipal household waste in Iași County



Source: EPA Iași, 2013

The average composition of municipal household waste of Iasi municipality was estimated using the questioners of annual statistic investigation that were filed by sanitation operators. In the category of hazardous waste are found components that may contain metals from auto repair activities, medical devices, batteries, fluorescent tubes, electric equipment or electronic devices.

Figure 5. Comparison between rural and urban localities of Iași County regarding the waste generation indicator (2003 - 2013)



Source: EPA Iași, 2013

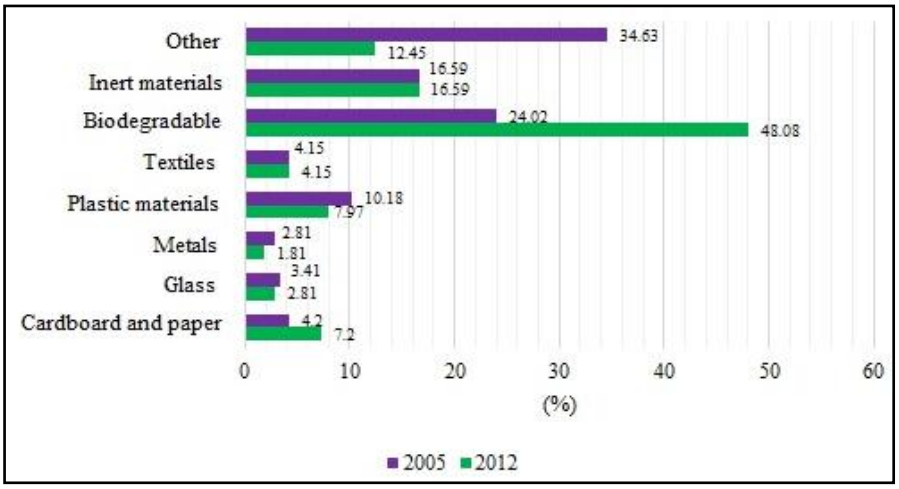
Hazardous waste management in the municipality was not the subject of a separate activity until present, except for electrical and electronic devices, for which a target of 4 kg of waste/year/person was set. For small dimension batteries and used accumulators, collection points in public institutions and supermarkets were created. The waste electrical and electronic equipment includes computers, refrigerators, microwaves ovens, televisions, electrical and electronic tools, old mobile phones or lighting equipment. This type of waste contains very dangerous metals such as lead, mercury, chromium, cadmium and halogenate

substances. If this types of waste would be burned, tones of heavy metals would be released in the environment every year (EPA Iasi, 2013).

As a part of European Union, Romania transposed the Directive 96/CE/2002 on waste electrical and electronic equipment (WEEE) in Government Decision 1037/2010. According to the Govern Decision 1037/2010, only authorized producers can introduce on the market electrical and electronic equipment. This target was not obtained yet because of the economic status of an important part of the population that can't afford to purchase WEEE every year in order to replace the existing WEEE that are used far beyond the duration use. WEEE usually contain approximately 50% ferrous metals, iron and steel, 13% copper, aluminum, lead and precious metals (silver, gold, platinum, palladium), 21% plastic materials while the difference consists in glass and printed circuits (ICPE, 2006).

A comparison of the 2005 and 2012 shows a modification of the composition of household waste, with a significant increase of the biodegradable material that is found in household waste. It can be observed a decrease of the metals quantity that can be attributed to the fact that WEEE that contain metals are collected separately in order to be recycled.

Figure 6. Composition of the household waste in 2005 and 2012



Source: EPA Iași, 2013

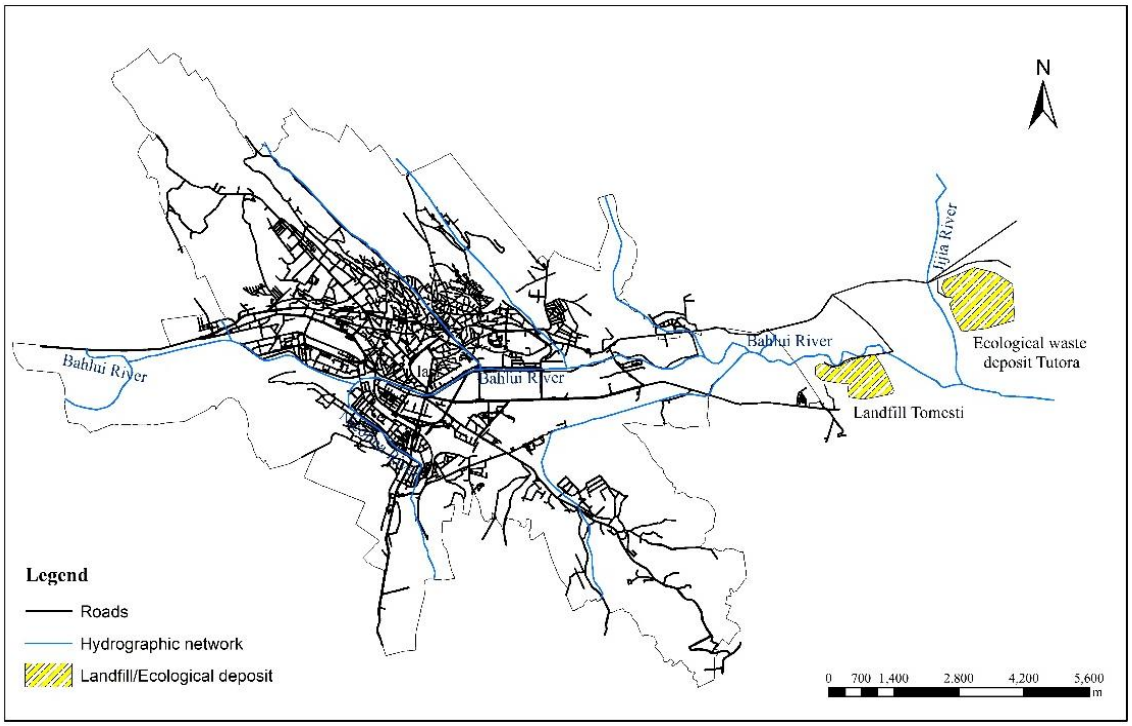
Landfills of Iasi Municipality

Until 2009, Iasi municipality's sanitation system was depositing the municipal household waste at the Tomești landfill located that it is located in the floodplain of river Bahlui, at 6 km distance of the city. Tomești landfill functioned since 1968 until 2009 and it has a surface of 30 ha and a volume of 3.0 million m^3. The large amount of deposited waste during almost 40 years represents a permanent source of air and soil pollution, especially because of the leachate infiltration in the soil. Currently, landfill closure is taking place while the landfill surface is coated with soil in order to minimize the rainfall infiltrations into the waste mass, surface water is drained and gas circulation control systems are installed (Romair Consulting, 2011).

Since 2009, an ecological waste deposit nearby village of Țuțora was put into operation. The deposit has a surface of 50 ha and a capacity of 8.6 million m^3. The new deposit is equipped with a waste sorting system, a compost plant for biological waste, a mechanic treatment facility and a leachate wastewater treatment plant with a capacity of 84 m^3/day.

Țuțora and Tomești are a part of a representative area known for its intense anthropogenic pressure as a result of combined action of pollutants generated by the major sources of pollution located nearby: the thermoelectric power-plant, the wastewater treatment plant, the proximity of the industrial area of the municipality and the waste deposits. In the proximity of Tomești landfill, soil analyses indicated variable concentrations of lead, cadmium and copper (Iancu and Buzgar, 2008).

Figure 7. Landfill locations in the vicinity of Iași Municipality



All landfills produce leachate, caused inevitably by the interaction of garbage with the rainfall. The majority of landfills are not equipped with liners, leachate collection systems or groundwater monitoring systems. Generally, the leachate has high biochemical and chemical oxygen demands and high concentrations of organic carbon, nitrogen, phenols, pesticides, solvent and heavy metals. Considerable metal mobilization may be generated by the variation of ambient parameters such as a consistent lowering of the redox potential of the pH. (Di Palma and Mecozzi, 2010).

Landfills are most readily identified with the pollution of groundwater by waste-derived liquids. The likelihood of disposed wastes polluting groundwater depends on the thickness of the unsaturated zone and the attenuation capacity of the overburden underlying the site, and also on the total and effective precipitation at the site, since the quantity and concentration of leachate generates is a function of the access of water to waste. Degradation of many components of waste including food, paper, and textiles consumes oxygen, thereby changing the redox potential of the liquid present and potentially influencing mobility of the constituents. Plastic, glass and metal compounds tend to be less reactive and degrade slowly. The main stages of anaerobic digestion are acid fermentation, intermediate anaerobiosis and

methanogenic fermentation, all three of which can operate simultaneously in different parts of the landfill (Flyhammar, 1997; Taylor and Allen, 2006).

Conclusions

The disposal of municipal household waste is a problem of real interest because of the potential risk of pollution and the necessity of selective collection in order to recycle the hazardous. As a part of European Union, Romania implemented the selective collection, but the recycling activity counts for less than 1% from the total municipal household waste. Tomești landfill is closed and represents a major source of heavy metal pollution as studies indicated variable concentrations of lead, cadmium and copper because waste was deposited during forty years on this site. Heavy metals from the old landfill represents a threat to the health of living organisms because of the non-biodegradable characteristic and the mobility through the biological cycles. Hazardous waste management in the municipality was not the subject of separate activity until last years when European Directives came into force and sorting systems came as a necessity for contemporary society. Furthermore, a new ecological deposit with modern equipment was put into operation in order to prevent the environment pollution.

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REFERENCES

Almasi A. M., 2013. Municipal waste management in Romania. Raport prepared for European Environmental Agency.

EC, 2002. European Commission, Heavy metals in Waste, Final Report, Project ENV.E3/ETU/2000/0058_http://ec.europa.eu/environment/waste/studies/pdf/heavy_metalsreport.pdf

EEA, 2009. Diverting waste from landfill. Effectiveness of waste-management policies in the European Union Report no. 7 European Environment Agency.

EEA Report, 2013. Managing municipal solid waste – a review of achievements in 32 European countries. Report no. 2 European Environment Agency.

EPA Iasi 2013. Environmental Status Report for Iași County, Local Environmental Protection Agency Iasi.

Eurostat 2012. Internet page: http://www.statista.com/chart/1312/recycling-remains-a-rarity-in-eastern-europe.

DEFRA, 2013. Incineration of Municipal Solid Waste. Department of environmental Food & Rural Affairs, United Kingdom, https://www.gov.uk/government/uploads/system/uploads/attachm entdata/file/221036/pb13889-incineration-municipal-waste.pdf

Di Palma L., Mecozzi R., 2010. Batch and column tests of metal mobilization in soil impacted by landfill leachate, Waste management, 30, 1594-1599.
Flyhammar P., 1997. Estimation of heavy metal transformations in municipal solid waste, The Science of Total Environment, 198, 123-133.
Hutton M. 1987. "Human health concerns of lead, mercury, cadmium and arsenic" In *Lead, mercury, cadmium and arsenic in the environment*, edited by T.C. Hutchinson and K. M. Meema, John Wiley & Sons, Ltd, p. 53-68.
Iancu O. G., Buzgar N., 2008. Atlasul geochimic al metalelor grele din solurile municipiului Iaşi şi împrejurimi, Ed. Universităţii „A.I.Cuza" Iaşi.
ICPE, 2006. Studiu pentru determinarea costurilor privind gestionarea deșeurilor de echipamente electrice și electronice și determinarea numărului necesar de puncte de colectare în România, Institutul de cercetări electrotehnice, București. http://www.deseurielectrice.ro/alte/studiu_ costuri _gestionare_DEEE.pdf
Khanna Suruchi and Pankaj, 2011. Assessment of heavy metal contamination in different vegetables grown in around urban areas, Research Journal of Environmental Toxicology, 5 (3), 162-179.
Perugini M., Manera M., Grotta L., Abete M.C., Tarasco R., Amorena M., 2011. Heavy metal (Hg, Cr, Cd, and Pb) contamination in urban areas and wildlife reserves: honeybees as bioindicators, Biol Trace Elem Res, 140, 170-176.
Romair Consulting, 2011. Sistem de management integrat al deșeurilor in județul Iași. Raport la studiul de evaluare a impactului asupra mediului, https://www.icc.ro/sites/default/files/files /diverse/SMID/RIM.pdf.
Satoh H., 2000. Occupational and environmental toxicology of mercury and its compounds, Industrial Health, 38, 153-164.
Taylor R., Allen A., 2006. Waste disposal and landfill: potential hazards and information needs In Protecting groundwater for health: managing the quality of drinking-water sources, Editors Schmoll O., Howard G., Chilton G., Chorus I., pp. 339-362.
Zhang H., Pin-Jing He, Li-Ming Shao, 2008. Implication of heavy metals distribution for a municipal solid waste management system – case study in Shanghai, Science of Total Environment, 402, 257-267.
***EU 2008. Directive 2008/98/EC on waste (Waste Framework Directive).
*** EU 1999. Directive 1999/31/EC on the landfill of waste.
***Directive 96/CE/2002 on waste electrical and electronic equipment.
***Government Decision 1037/2010 regarding electrical and electronic waste equipment.