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ENVIRONMENTAL SERVICES IN MUNICIPAL SOLID WASTE MANAGEMENT – THE CASE STUDY OF WASTE INCINERATION

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ABSTRACT: This paper presents the interactions between municipal solid waste management processes (such as waste incineration) and influences of environment in aspects of the atmosphere, water and space. These environmental components provide people with benefits, which are referred to as "environmental services". In the paper authors attempt to identify environmental services in a process of waste incineration and to describe an approach to services' potential valuation.

KEY WORDS: environmental components, environmental services, municipal solid waste, incineration

Introduction

Production of municipal solid waste by people takes place in their environment of living, everyday activities and working. The waste becomes mostly a burden for the natural environment, which results in the need of appropriate waste management. This belongs to obligations of municipalities. All the stages and methods of waste management take place in the presence of ecosystem services – access to air, place (space), land and all the chemical processes determined by natural environmental principles[1]. The share of environmental factors in waste management processes is referred to using the term "environmental services", which are of a different nature than ecosystem services. Those interactions were indicated particularly in the case of waste incineration process. Subsequently, authors introduce the concept for valuation of the interactions and determine their specificity in relation to already researched services of ecosystems (such as forests, lakes etc.). In currently applied methodology of the ecosystem services description some abiotic environmental components (such as space or the atmosphere) are rarely included or even completely omitted. However, they are crucial to processing and management of waste, especially to waste incineration. The study comprises the original concept of authors, an economist and an environmental engineer.

Specificity of municipal solid waste and waste management

Municipal solid waste is defined as waste material generated by a household or generated by a commercial, industrial, or institutional entity, to the extent that the waste material does not contains hazardous waste and is essentially the same as waste normally generated by a household (Act from 14 December 2012 on waste).

To characterize the municipal solid waste its morphological composition is needed – the percentage of different material groups in the waste stream. The most common division includes such groups as: organic waste, paper and cardboard, glass, plastics, metals, textiles and others.

[1] Authors investigate services of the environment, which they refer to using the term "environmental services". They are not identical to ecosystem services, which predominate currently as a subject of research studies. There is a difficulty in distinguishing both categories linguistically as the term "ecosystem services" is commonly applied to all services of the environment, especially in translations.

The processes for municipal solid waste management include:

- Waste gathering (at households, in the streets, etc.) often together with separation of some waste groups by the producer;
- Waste collecting from households or other producers by specialized firms;
- Waste transportation to waste management facilities;
- Waste processing in one or more stages;
- Utilization of waste (or what was retrieved from waste during its processing) and/or its eventual landfilling.

The first Waste Framework Directive introduced the waste hierarchy and obliged all the EU countries to its application (Directive 75/442/EEC; Directive 2008/98/EC). The hierarchy indicates an order of preference for action to reduce and manage waste – always more preferable is the action which is higher in the hierarchy. The Waste Framework Directive of 2008 refers to 5 steps hierarchy which includes (in order of preference): prevention, reuse and preparation for reuse, recycle, recovery (also recovery of energy in incineration processes), and finally disposal.

The term „incineration" refers to waste combustion which takes place in facilities specially designed to this purpose. Incineration processes allow for (Nemerow, 2007):

1. Energy recovery, which is important in reference to increasing prices of energy derived from fossil fuels.
2. Reducing the waste volume – the volume of solid residues after thermal treatment is far lower than the input waste volume. Moreover, they can be submitted to further processing toward recovery of materials or reuse in building industry.

The main aim of incineration is to transform the waste into a form which does not endanger the environment and humans. The benefits gained during the process (potentially valuable residues, retrieved energy) are its value added.

For municipal solid waste the heating value of 6 MJ/kg is regarded as the minimum which ensures autothermal combustion. Average heating values of municipal solid waste in Poland (7-9 MJ/kg) fulfill this condition (National Waste Management Plan 2022; Wielgosiński and Namiecińska, 2016).

An attempt to identify environmental services in the case of municipal solid waste incineration process

Municipal The ecosystem services classification proposed by R. Costanza (Costanza, 2008) or Common International Classification of Ecosystem Services (CICES) (http://cices.eu) comprising of 48 classes are not fully relevant

to the issue of environmental services in waste management. They do not include e.g. services provided by the atmosphere or related to mineral resources. In principle, processes of phenomena occurring in waste management systems, which basically are technical structures built and designed by humans but strictly within the environmental space, interact deeply with the environment – both directly and indirectly. Without environmental services determining e.g. processes of organic matter decomposition in landfilled waste or the atmosphere's "acceptance" of flue gas flow from an incineration plant's chimney, waste management would not be possible. Identification of those services, their description and classification are different than for the services of individual ecosystems, e.g. lakes or forests. There are more environmental components involved in providing services for waste management processes than just the components of any individual ecosystem. For example – the flue gas mentioned above is "accepted" by a part of the atmosphere which can reach over the area of many ecosystems. The spatial range of the service's influence is relatively wide. Naturally, it is to assume that the impact of the flue gas is stronger within near surrounding of the incineration plant, and becomes weaker with an increasing distance from the emitter. Nevertheless, it is "the atmosphere" which should be the environmental component referred to in identifying and describing the service mentioned above, not "the ecosystem". It is again the question of distinguishing between ecosystem services (as described by R. Costanza and followers) and the environmental services approach. In conclusion, to describe and classify the services identified in waste management (which are not R. Costanza's ecosystem services but are provided by other components of the environment[2]) some other classification than CICES would be more suitable.

For purpose of this study authors defined "environmental services" as benefits people obtain from all the components which constitute the environment (including also abiotic elements, such as the atmosphere). An environmental services classification introduced by A. Michałowski has been applied, since it comprises categories corresponding to the processes in waste management. In the Michałowski's classification there are 5 services

[2] It is not to forget that those components are also constituents of ecosystems and ecosystem services emerge from services provided by the components and by their interactions. Of considerable significance is the role of abiotic components (such as the atmosphere), which, as E.N. van der Meullen et al. emphasize, are not only an integral part of ecosystems but also an indispensable causative factor in their services. L.C. Braat already in the 1970s distinguished functions of the natural environment for society, which later became the foundation for the ecosystem services concept. He emphasized contributions of abiotic components in constituting the functions – e.g. surface and subsurface part of our environment provide storage capacity for water or waste. E.S. van der Meullen and L.C. Braat postulate that abiotic flows should be included in ecosystem services classification to a greater degree (van der Meulen et al., 2016).

categories: material, energetic, informational, spatial, stabilizing (Michałowski, 2012).

The issue of environmental services in waste management is complex, yet hugely important. This study presents an attempt of identifying and describing environmental services in a process of municipal solid waste incineration which is one of the fundamental processes in waste management and is becoming more commonly applied in Poland in recent years.

The significance of environmental services in waste incineration issue can be presented on the example of making a decision, which location for an incineration plant should be chosen. The decision on whether to build or not to build an incineration plant is determined by waste management requirements, need of keeping proper level of cleanliness in municipalities, safety and environment protection regulations as well as financial issues. The subsequent decision on the plant's location (most often the more difficult one) is dependent on series of technical and social aspects, but also on potential environmental services for each proposed location. First of all, to realize the investment a sufficient space is required. This component of the environment seems to be so obvious that it is often neglected, still making it available is one of the fundamental environmental services. Analyzing the stages of an incineration process the fact has to be considered that for waste combustion the air supply is necessary, also the water for steam production and cooling has to be provided. Further on, the process residues in form of flue gas and solid materials (slag and fly ash) have to be removed outside the installation, which occurs by releasing flue gas through the chimney to the atmosphere and by landfilling solid residues on disposal sites or (in some cases) using them as building materials e.g. in roads construction. All the aspects mentioned above constitute some specific environmental services. Some of them (e.g. delivery of the process air for combustion) are characterized by common availability and their realization cannot lead to any noticeable changes in the environment or its degradation. Other, such as access to water in right amounts or services enabling slag disposal are not available frequently – their realization will change the interrelations of environmental components on a certain area. The feasibility to provide those environmental services will be one of the crucial determinants for choosing the location site. Consequently, it is also to assume that the environmental services can be or even ought to be valuated. Table 1 presents main environmental services in municipal solid waste incineration.

Table 1. Authors' identification of the environmental services in municipal solid waste incineration

No.	Key components of the waste incineration process	Services category	Most important environmental services
1	Incineration plant construction	Spatial Material	• making the space for construction and additional investments (roads, heat and electrical networks) available • supplying with natural resources used for production of materials and energy necessary for the construction
2	Waste combustion at the facility	Material Stabilizing	• supplying the air for the process • taking in flue gas emission by the atmosphere • making water for technical purposes available • balancing gases in the atmosphere: the process air and the flue gas • taking in noise emission (resulting from facility functioning and transportation)
3	Process residues management	Spatial Material Stabilizing	• making space for slag and fly ash disposal available • mineralization and other processes occurring in disposed waste residues • biochemical and geochemical processes – transformation of a disposal site into a new component of the environment

The concept for valuation of environmental services in municipal solid waste incineration processes

In research studies it is admitted that ecosystem services bring benefits for human well-being. The value of such services can be estimated using one of many methods presented in literature and research reports [3]. Services of the environment in municipal solid waste management processes, including incineration, do not qualify for monetary valuation described in any of those methods. It results from the specificity of waste management processes. In the case of waste management the services are provided mostly by individual environmental components, such as air, water, land surface, public space, and have not been a subject for valuation to such an extent as in the case of uniform and mappable ecosystem services[4].

[3] Among many publications, worth noticing is the synthesis of methods comprised in (Żylicz, 2010, p. 35).

[4] For purposes of mapping and evaluation the Corine Land Cover classification divides ecosystems in: land ecosystems (here such categories are present as urban areas, open areas, areas deprived of plant cover), inland waster ecosystems, see water ecosystems (Stępniewska, 2014).

The assessment and valuation of waste management benefits ought to be subjects of a the methodology which comprises: defining categories of benefits' values, selection of value measures, implementation of selected valuation techniques (Famielec, 1999; Famielec, 2014). For instance, environmental services in the aspect of waste management can be treated as indirect value in use, measured by value of energy, estimated using a cost-benefit analysis of municipal solid waste management in a given municipality. Such methodology represents only an indirect valuation of environmental services and comes down to providing a closed cycle in municipal solid waste management, including food and biodegradable waste (The European Commission Package on Circular Economy). Typically, there are attempts to evaluate the influence of environmental services on GDP. As the National Waste Management Plan states managing of municipal solid waste according to indicated waste hierarchy is supposed to enable "the separation of increase in weight of waste produced from GDP increase" (National Waste Management Plan 2022).

A successful realization of waste management tasks can be considered as benefits of environmental services in the process of waste management. Fulfilling of those tasks would not be possible without participation of environment's components. Indirectly, the values of those services can be driven down to the production and social values of effects of closed cycle waste management.

Monetary valuation of results mentioned above can be driven down to compensation values (payments and fines for degradation of the environment or lack of fulfilling ecological standards) and/or costs of remediation activities, e.g. reclamation of lands used for waste disposal or devastated through other waste management actions, and/or costs of lost opportunities (opportunity costs) caused by decrease in values of the parcels and properties in which waste is not properly managed.

Authors would like to stress that in spite of changes in waste management technologies aiming at closed cycle systems there will always be a necessity of "cooperation" with environmental components to secure proper functioning of waste management. The environmental services in waste processing may change in time, some may substitute others as the system drifts from landfilling towards incineration or further towards recycling and reuse. Still, as long as humans produce waste environmental services in its processing are inevitable.

Conlcusions

Municipal solid waste management is not a typical field for research in the aspect of life quality on urban areas: waste is generated in the environment of human living and residing – in households, institutions, catering and even in separate municipal waste collection facilities. Already at this stage, there is a demand for services of the environment (e.g. providing with space), which has to "accept" the waste wherever it is produced and rely on a consumer's way of its disposing. Next stages of waste management: collection, transportation, segregation, disposal, utilization (including incineration) require further and other environmental services. Hence, it can be assumed that the value of environmental services in the field of municipals solid waste management is the net effect in life quality, which is described by the difference between levels of living quality in the environment submitted to pressure resulting from lack of any municipal solid waste management system and from achieving the waste management objectives such as ecological, technological and organizational standards[5].

The contribution of the authors

Authors declare that their participation shares are equal (50%).

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