A NEW WASTE CLASSIFYING MODEL: HOW WASTE CLASSIFICATION CAN BECOME MORE OBJECTIVE?

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Abstract: *The waste management specialist must be able to identify and analyze waste generation sources and to propose proper solutions to prevent the waste generation and encurage the waste minimisation. In certain situations like implementing an integrated waste management sustem and configure the waste collection methods and capacities, practitioners can face the challenge to classify the generated waste. This will tend to be the more demanding as the literature does not provide a coherent system of criteria required for an objective waste classification process. The waste incineration will determine no doubt a different waste classification than waste composting or mechanical and biological treatment. In this case the main question is what are the proper classification criteria witch can be used to realise an objective waste classification? The article provide a short critical literature review of the existing waste classification criteria and suggests the conclusion that the literature can not provide unitary waste classification system which is unanimously accepted and assumed by ideologists and practitioners. There are various classification criteria and more interesting perspectives in the literature regarding the waste classification, but the most common criteria based on which specialists classify waste into several classes, categories and types are the generation source, physical and chemical features, aggregation state, origin or derivation, hazardous degree etc. The traditional classification criteria divided waste into various categories, subcategories and types; such an approach is a conjectural one because is inevitable that according to the context in which the waste classification is required the used criteria to differ significantly; hence the need to uniformizating the waste classification systems. For the first part of the article it has been used indirect observation research method by analyzing the literature and the various documents available in the virtual space, on the websites of certain international organizations involved in the wide and complex issue of waste management. The second part of the paper contains a proposal classification model with four main criteria in order to make waste classification a more objective process. The new classification model has the main role of transforming the traditional patterns of waste classification into an objective waste classification system and a second role of eliminating the strong contextuality of the actual waste classification models.*

Keywords: waste management, waste classification, waste classification models, waste classification criteria.

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1. Introduction

Waste classification has a special meaning for the design, planning, implementation and operation of an adequate waste management system. In spite of the underlined importance, the literature handles waste classification in a quite evasive manner; there are several approaches and isolated points of view related to the waste classification models and criteria, but most of them have a strong contextual nature.

It can certainly state that due to the physical and chemical composition heterogeneity of waste, due to the bio-chemical features, diversity of component elements and various level of recycling potential indicated by the materials found in the waste mass, the literature can not provide unitary waste classification system which is unanimously accepted and assumed by ideologists and practitioners. The attempt to identify a few criteria based on which to achieve the typological classification of waste is doomed to fail, especially due to the powerful contextual character of the action, due to its nature. We insist on the fact that regarded in general, waste must and can be classified according to a set of criteria.
The waste management specialist must be able to identify and analyze waste generation sources and to propose actual solutions to prevent and / or fight the generation of such waste. In certain situations, practitioners can face the challenge to classify the generated waste, which will be all the more demanding as the specialty literature does not provide a coherent system of criteria required for an objective waste classification system. The attempt to identify unitary criteria based on which to achieve the typological classification of waste shows a powerful contextual nature, determined by the conditions and specifics considered by the practitioners in the various situations they are faced with.

2. A critical literature review of the existing waste classification models

Official documents of various international organisations provide different waste classification models. In the European space, for example, wastes are classified according to the European Waste Catalogue. It contains more than 700 items grouped into waste types and subcategories within 16 categories. The catalogue does not provide a unitary perspective on waste classification, its role being to provide general support for considering an object / material / substance as waste or non-waste. We consider that this is the reason for which within the 16 waste classes, random classification of waste can be found according to several viewpoints: according to the threat degree of the included substances, according to the materials in the components thereof, according to the type of damaged products or goods found in the waste mass etc. Thus, in our opinion, the inventory of more than 700 waste types and categories, the encoding within a catalogue and the attempt to regulate an objective classification of waste in the European space is meant to equalize the identification procedures and methodologies regarding what is and what is not classified as waste and less to classify what is regarded as being part of the waste scope. On the other hand, in our opinion, there is a risk for any material / substance of the European Waste Catalogue to not be regarded as waste, in certain time and space conditions.
The Organization of Economic Cooperation and Development (O.E.C.D.) perspective related to the waste classification is similar to the one of the European Union. In the same manner, waste are classified in 16 classes presented in the already famous Table 1 (annex to the OECD Decision C(88)90, representing in fact 16 reasons due to which various goods, materials or substances become waste. As in the case of the European Waste Catalogue, we note that Table 1 actually provides a list allowing the consideration of a material as waste or non-waste and, as a result, it can be more likely used to define the concept of waste, than to classify it. But, unlike the European Union, O.E.C.D. has a more pragmatic perspective, based on the objectivity and systematization of various waste classes or categories.
The most interesting approach of the waste classification is without any doubt the one of the United Nations Environment Programme (U.N.E.P). The official documents of U.N.E.P. include a unitary classification of waste using four general criteria: origin, composition, toxicity and management (U.N.E.P., 2004). The 'origin' criterion considers the economic - social activities classified on the main economy sectors, from micro to macro level; according to this criterion, the generated waste cover a wide range of activities, from

domestic waste and garden waste within households to pesticide waste in agriculture, military equipment waste generated by the army, medical waste generated in hospitals and health institutes or nuclear waste generated by the power generation plants, etc. The 'composition' criteria considers the materials usually found in the waste mass structure and the waste is classified as plastic waste, glass waste, ashes and dust, textiles, metal waste, packaging waste, paper waste, food waste, wood waste etc. From the 'toxicity' viewpoint of the hazardous degree to the environment and human health, waste is classified into infectious waste, inert waste, poisonous waste, flammable waste, corrosive waste, radioactive waste, special waste etc. The criterion considering 'the manner in which the waste is managed', actually regards the succession of stages the waste goes through, from the moment it is generated until they are disposed of and which form the so-called 'life cycle of waste'; according to this criterion there are collected waste, transported waste, sorted waste, stored waste, recycled waste, composted waste, incinerated waste and landfilled waste.

The resourcefulness of the perspective provided by U.N.E.P. on the waste classification comes from the fact that new sub-criteria and waste sub-categories result from overlapping the main four typological classification criteria. For example, by associating the 'origin' and 'toxicity' criteria, it stands out that there can exist hazardous household waste, that is the waste generated on the level of households and which are relatively toxic for the environment, such as used batteries and accumulators, cathodic tubes which are TV components or refrigerating agent included in the refrigerating devices. That is why, in our opinion, the U.N.E.P. classification of waste is extremely effective from the viewpoint of waste type diversity, which can be identified by the independent approach of four essential waste classification criteria.

The waste classification provided by the Basel Convention puts a special emphasis on the threat degree of waste, which can be explained through the nature and subject of the convention - specific regulations for dangerous substances included in the waste management. According to the document, waste are classify into dangerous waste (waste from organic solvents, wood processing waste, medical waste, radioactive waste etc.), dangerous substances into waste streams (arsenic waste, cadmium waste, cyanide waste, phenols waste etc.) and waste requiring specific regulations (household waste, waste generated from the incineration process or individual composting within households etc.). We note that the classification system from the Basel Convention grants the main threat role to the waste and substances included in the mass thereof, according to this criterion and the waste and urban waste in general can be regarded as non-dangerous, but requiring specific regulations. We consider that such a classification underlines the fact that the dangerous nature of the waste must consider an increase attention to the toxicity degree of the substances found in the chemical composition of the waste. The conclusion is that the waste is first of all dangerous due to the toxicity of the substances included in them and then due to the large volume in which are generated and the critical manner in which they are managed.

The Environmental Protection Agency of the United States of America (U.S. E.P.A.) uses two major criteria for the waste classification; both are related to the elements witch can be found in waste streams: used materials and products (U.S. E.P.A., 2011). According to the type of waste materials, waste are classified into paper and cardboard waste, glass waste, metal waste, plastic waste, leather waste, textile waste, wood waste and others. From the used products point of view can exist waste generated by goods for long-term use (deteriorated electrical appliances, old furniture, used tires, etc.), waste generated from consumer goods (papers and magazines, bags, apparel and footwear etc.), waste generated by packaging (bottles, aluminum cans, cardboard boxes) and other waste (waste from courtyards and gardens, waste from food leftovers, anorganic waste etc.). We note that the classification system provided by the American agency is strongly oriented

towards the physical components of waste, which can indeed be regarded as either materials or goods or products. In our opinion, in spite of obvious limitations, such a waste classification approach surprises the diversity of the types of materials and products which can be recycled and capitalized. Thus, the waste classification perspective according to the contained materials and products provides the possibility to raise awareness on the enormous economic potential of waste, by waste materials recovery and damaged products and goods re-use or recycling.

An extremely interesting approach is found in the Environmental Association of Universities and Colleges point of view, a professional association including more than 280 universities and colleges from United Kingdom. The specialists here draw the attention on the fact that certain waste categories are not clearly defined and regulated, while other types of waste, such as dangerous waste, although clearly defined and strictly regulated from the legal point of view, are often interpreted in a wider sense. The association members consider that a correct classification of waste must take into consideration the inclusion or not in the waste management system. They basically suggest that one of the main criteria that must be used to classify waste is weather or not they are taken over and assimilated by the formal waste collection systems. According to this criterion, waste is controllable and non-controllable, but the control does not regard here the legal regulation, but the possibility to manage certain waste quantities outside the formal waste management system. Thus, we can consider that, in fact, the difference between the generated and collected waste is translated into uncontrollable waste, which are not assimilated and managed within the officially established and regulated formal collection system. Such a waste classification criteria draw the attention on the fact that there are waste quantities left outside the waste management system. This reflects the reduced capacity of waste collection systems or the insufficient accessibility of waste producers to the waste collection services.

The most frequent criteria used for the waste classification is the waste generation sources, the waste materials or the hazardous degree posed by the waste. Most classification models found in the official reports and statistics are based on the waste components, mainly used in the physical (reuse and recycling), biological (composting) and chemical processing of waste. That is why we consider that the typological waste classification into various categories, subcategories and types is a conjectural process. It seems inevitable that according to the context in which the waste classification is required, the used criteria differ significantly.

There are various classification criteria and more interesting perspectives in the literature regarding the waste classification. The most common criteria based on which specialists classify waste into several classes, categories and types are the generation source, physical - chemical features, aggregation state, origin or derivation, hazardous degree etc. Also, waste classification is approached considering the types of materials found in the waste structure, the size/dimension of component elements or from the valorification potential point of view. It is certain that the waste classification need comes from the diversity of components and materials generally making-up waste and it is proven by the multitude of models presented in the specialty literature.

Wastes are present in various states of aggregation: solid, liquid or gaseous, and in William's opinion (2005) can be generated within various processes, from agriculture activities up to the technological industry processes, commercial activities or household activities. William establishes the generation source as a typological classification criterion, just like Pichtel (2005) and Lemann (2008), the difference being that in case of the latter, the waste categories classified according to the origin criterion are much more detailed and varied. Pichtel (2005) considers that there can be municipal waste, dangerous waste, industrial waste, waste generated from medical activities, universal waste, construction and demolition waste, radioactive waste, waste generated by mining activities and

agriculture waste; about the same approach has Franchetti (2009) regarding the waste classification criteria.
Specialists such as Siegel, Robertson and Anderson (1990) or Uriarte (2008) classify waste according to the materials included in the components thereof, while Grisolia, Napoleoni and Tancredi (1995) use certain physical and chemical waste properties, such as stability, ductility and biodegradability as criteria for the typological classification of waste. In his Ph.D. thesis, Kolsch (1996) classifies waste according to the size of materials witch waste contains, while a group of researchers (Thomas et al, 1999) use criteria referencing to the bi- or three-dimensionality of waste components to classify waste. Among the numerous perspectives found in the literature, such as Dixon's and Langer's (2006), the most extensive one from the viewpoint of classifying waste according to their physical properties can be regarded as the most extensive one. The two authors classify waste according to several criteria, among which specific weight, size, shape etc.
One of the most interesting waste classification methods belongs to the specialists Landva and Clark (1990). In their opinion, waste is classified into two major categories: organic and anorganic, each of them divided into degradable and non-degradable. According to the classification system drafted by the two authors organic waste is classified into degradable and non-degradable, from viewpoint of resistance to external factors of polymers in the waste composition. Thus, degradable organic waste include polymers whose form and structure modifies in a relatively short time, under the environmental factors action, such as waste generated by leftovers, waste from parks and gardens, animal waste and any other materials contaminated by them. The organic non-degradable waste includes waste containing long-term stable polymers, such as paper, wood, textiles, leather, plastic, paint, oils, chemical products waste, etc., whose form and structure does not radically change under the action of external factors. The other category, the one of anorganic waste is also divided into degradable and non-degradable waste, but from the viewpoint of the physical - chemical properties and not from the perspective of bio-chemical properties. The specialists included metals in the category of degradable anorganic waste, which are more or less corrosive, while glass, ceramics, mineral oils, ashes, debris etc. were regarded as non-degradable anorganic waste. We consider that such a waste classification model is limited, in spite of the large inclusion area it reflects on the first view. The model proposed by Landva and Clark underlines bio-physical-chemical properties, such as the biodegradability and compressibility of waste components, but does not emphasize the energy potential represented by waste. Such a waste classification can be successfully used in the context of waste composting processes.

3. A new criteria system for waste classifying: how to transform the waste classification model in an objective one?

We regard as pertinent a waste classification model according to four essential criteria: the level which waste is generated on, the potential risk and hazardousness the waste poses for the environment and human health, the origin and waste generation source and the stability of waste components and materials.
An overview of the material flow used in economic activities indicates that waste is generated both on the production as well as on the consumption level. Thus, according to the level which wastes are generated on, waste can be either municipal or industrial. Municipal waste is represented by the waste generated due and in the context of services and goods consumption, while industrial waste is generated as a result of technological processes required for the manufacture and supply of goods and services to the consumers. Considered in the context of such a waste classification criterion, waste management must facilitate not only the fight against, but also the prevention of waste generation. Even though apparently the industrial waste management has a strong

preventive character and the municipal waste management has an important combative nature, this must not be translated into a limitation / restriction of waste management prevention measures during the entire resource / materials management flow into the economy. We consider that the importance of preventing and minimizing waste is absolute, no matter the waste category brought up or the extend of the impact thereof, and we argue this opinion through the fact that waste has a negative impact on the environment, not just due to their toxicity, but due to the enormous quantity which they are generated in.

The waste toxicity degree must be included in the waste classification criteria, because through their nature and structure, certain types of waste are more toxic / dangerous than others. The potential risk to the environment and health increases directly proportional to the level of toxicity of the components included in the generated and collected waste. Thus, from hazardous waste potential point of view it can exist hazardous waste, inert waste and semi-hazardous waste. Hazardous waste is represented by those types of waste with a strong negative impact on environmental factors, causing accentuated pollution. This category includes flammable, corrosive, reactive or toxic waste, representing a real contamination potential for the proximity. The opposite pole is represented by inert waste, which due to the physical and chemical features and properties does not pose a risk for the environment and human health, since they do not suffer transformation of shapes or structure, under the incidence of external factors. The typical examples of inert waste are glass, broken bottles, ceramic waste etc. Waste posing an average threat potential for the environment are regarded as semi-hazardous waste. This category can includes the waste which in theory poses a reduced risk of toxicity, which may increase as an effect of non-compliant management. The category of semi-hazardous waste includes waste which is not part of the hazardous waste category or inert waste category, such as waste with combustion potential or biodegradable waste.

The origin or waste generation source is another very important criterion according to which waste can be classified, and its relevance is justified by the fact that the waste properties and features are decisively influenced by the place and moment when waste were generated. According to the origin, waste can be classified in household waste, street waste, commercial waste, institutional waste, production waste and special waste. Any material, substances, objects, damaged goods etc. generated on household level as a result of individual or household activities are considered to be household waste. The same logic is followed for street, commercial and institutional waste. The production waste includes any type of waste generated as a result of related technological processes or as an effect of natural resources extraction and processing. Special waste refers to waste which due to their specific nature require special collection, recycling and treatment installations and which is usually collected from the generation source, through separate collection; the special waste category includes waste electric and electronic equipment, bulky waste, construction and demolition waste, waste generated within the health system etc.

Due to the fact that under the influence of external factors, waste can change its shape and structure, it can be considered that waste can be classify acording to the stability of components into biodegradable waste, waste with combustion potential and structurally stable waste. Biodegradable waste is not stable due to the temperature factor influence, which at a certain point triggers the organic fermentation process. Leftovers and organic waste of animal or vegetal nature are biodegradable waste suitable for composting. Waste with a combustion potential do not change form and shape by itself, but may suffer such transformations as an effect of external factors; even in this situation combustible waste is much more stable than biodegradable waste. Structurally stable wastes hardly change its shape and structure, even under the influence of external factors, since they are either biodegradable or subject to incineration process. The category of stable waste includes glass waste, metal waste, soil, sand, dust, ashes etc. If the first two waste categories can

not be directed towards specific facilities for the purpose of adequate treatment and recovery, the recycling possibilities for stable waste are limited.

4. Conclusion

The proposed waste classification criteria have the role of making the waste classification process more objective and set up as solution for eliminating the contextuality of waste classification. We consider that the four proposed criteria is a good start for providing an unitary and general classification model of all existing types of waste and underline the premises for understanding the essential importance of the waste classification in the context of designing and implementing an integrated waste management system. We also insist on the fact that in addition to the four generally proposed criteria, other criteria may exist, which are perfectly adjustable and usable in that context. The waste incineration will definitely determine a different waste classification than waste composting or mechanical and biological treatment, but the fact that there are a few objective criteria considered to be universally valid and applicable in any context related to the waste management issues is essential.

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