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A rating system for determination of hazardous wastes

İlhan Talınlı [a,*], Rana Yamantürk [a], Egemen Aydın [a], Sibel Başakçılardan-Kabakçı [b]

[a] *Istanbul Technical University, Faculty of Civil Engineering, Department of Environmental Engineering, 34469 Maslak, Istanbul, Turkey*

[b] *Istanbul Technical University, Faculty of Chemical and Metallurgical Engineering, Department of Chemical Engineering, 34469 Maslak, Istanbul, Turkey*

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Abstract

Although hazardous waste lists and their classification methodologies are nearly the same in most of the countries, there are some gaps and subjectiveness in determining the waste as hazardous waste. A rating system for the determination of waste as a hazardous waste is presented in this study which aims to overcome the problems resulted from the existing methodologies. Overall rating value (ORV) calculates and quantifies the waste as regular, non-regular or hazardous waste in an "hourglass" scale. "ORV" as a cumulative-linear formulation in proposed model consists of components such as ecological effects of the waste (Ee) in terms of four main hazard criteria: ignitability, reactivity, corrosivity and toxicity; combined potential risk (CPR) including carcinogenic effect, toxic, infectious and persistence characteristics; existing lists and their methodology (*L*) and decision factor (*D*) to separate regular and non-regular waste. Physical form (*f*) and quantity (*Q*) of the waste are considered as factors of these components. Seventeen waste samples from different sources are evaluated to demonstrate the simulation of the proposed model by using "hourglass" scale. The major benefit of the presented rating system is to ease the works of decision makers in managing the wastes.

Keywords: Hazardous waste determination; Rating system; Hazard criteria; Combined potential risk; Listing

1. Introduction

Hazardous wastes, the main drawbacks of industrialized world, are still keeping their importance because of their potential hazard to human health and environment when improperly treated, stored, transported and/or disposed. These kinds of wastes must be managed and controlled from the point of generation to ultimate disposal.

The legislators of each country should create regulations enforcing the safe management of the hazardous waste. These regulations should appoint the hazardous waste generator as a legal entity who must ensure that the waste is managed in accordance with its regulatory standards [1]. But a generator who will comply a regulatory program demands a far more precise definition of the term "hazardous waste".

The term "hazardous waste", originated from US Environmental Protection Agency, does not have a unique and universally accepted definition but the identification of hazardous waste in each country is based on the four characteristics: (1) ignitability, (2) corrosivity, (3) reactivity and (4) toxicity [2].

Although every country has its own regulatory program, the most common violation of the rules, whether willful or inadvertent, is because of the definition of the waste as hazardous waste [3]. In most of the countries, the board responsible for the hazardous waste management defines the hazardous waste by using two different mechanisms: (1) by listing and (2) by identifying characteristics. These definitions are commonly based on the Subtitle C of Resource Conservation and Recovery Act (RCRA) which is the most extensive study done about hazardous waste management.

* Corresponding author. Tel.: +90 212 285 65 46; fax: +90 212 285 65 87.
E-mail address: italinli@ins.itu.edu.tr (İ. Talınlı).

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Using lists to define hazardous wastes presents certain advantages and disadvantages. The main advantage is that lists make the hazardous waste identification easier for waste producers, but hazardous waste lists simply cannot include all hazardous wastes. Another disadvantage is their lack of flexibility. Lists determine a waste as hazardous, if it falls within a particular category or class. The actual composition of the waste is not considered as long as the waste is listed. Thus, the lists can regulate some wastes that do not pose a significant health threat or a really hazardous waste may not be found in the lists [4].

Designation of hazardous waste by determining the characteristics of the waste is another method which needs proper analyses to define the waste as a hazardous waste. Although phytotoxicity, teratogenicity, bioaccumulation, mutagenicity are the characteristics of the hazardous waste because of the difficulties in testing protocols of these characteristics mentioned above, EPA decided to use four common characteristics to identify the hazardous waste: (1) ignitability, (2) corrosivity, (3) reactivity and (4) toxicity.

Although EPA introduces the test protocols for ignitability, corrosivity, reactivity and toxicity, there are still gaps which enable to determine a hazardous waste as conventional waste. The main gap is seen in toxicity testing, which only 43 of the toxic chemicals are subject to the TCLP test [5]. Thus, if a waste does not bear any of the 43 chemicals, the waste is not considered as hazardous, although in reality it is hazardous. The other example is ignitability which does not have a test method for non-liquid wastes. The gaps for the determination of the hazard potential of hazardous waste mixtures are also noticed and an index is prepared to serve as a guide for people who produce, store, transport, dispose, recycle and/or regulate hazardous waste [6].

Although lists and analyses of characteristics are nearly the same in all countries, the differences in regulations make the determination subjective which creates a serious problem in management of these wastes. In order to eliminate the subjectiveness of lists and characteristics tests, a quantitative determination system is stated in this study. Overall rating value (ORV) calculates and quantifies the waste as regular (conventional) waste, non-regular (solid) waste or hazardous waste by using variables, such as ecological effect (Ee) (ignitability, reactivity, corrosivity, toxicity), combined potential risk (CPR) (carcinogenic effect, toxic characteristics, infectious characteristics, persistency), listing (L), physical form (f) of the waste and quantity (Q) of the waste.

2. Rating system

Conceptual framework of proposed quantitative system in order to determine the waste as hazardous waste is shown in Fig. 1. Mainly, two components take place in this approach: (1) hazard criteria of the hazardous waste in terms of ecological effects and (2) their combined potential risk.

To formulate the rating system, following assumptions are postulated:

1. When the discarded material is defined as a waste, it should be classified if the waste is conventional waste, such as wastewater, municipal solid waste, air emission or not. The term “non-regular waste” has been considered as intermediate waste which is obviously not conventional but probably hazardous. The waste must be determined as hazardous or non-hazardous if it is identified as non-regular waste.
2. In Eq. (1), the component “D” represents the boundary of the non-regular waste in the scale. Hospital and radioactive wastes are neglected in this inquiry. Because they have their own control regulations and these wastes have already been identified as non-regular wastes.
3. Listing methodology of the hazardous waste and their lists published in different countries cannot be neglected. Thus, the component “L” is added in formulations.
4. Ecological effects (Ee) includes primarily impacts of waste regarding with its hazard characteristics, such as toxicity, ignitability, corrosivity and reactivity. Physical form of the waste is another factor that affects the hazard characteristics.
5. Accumulative and synergistic effects and uncertain potential risks are included in combined potential risk parameter. Components of this parameter are human health toxicity, carcinogenetic effects, infectious risks and persistency associated with biodegradability, solubility and bioaccumulation. Physical forms of the waste and exposure mode are also taken into account during the evaluation of these risks.
6. Four critical components (D, L, Ee and CPR) are considered as cumulative functions of “overall rating value”. Because higher values of D, L, Ee and CPR must increase the ORV. Obviously, the amount of the waste (Q) is a basic component in this rating system, so it should be a multiplier of the other components.

The formula of the rating system is shown in Eq. (1) which is composed of a cumulative-linear function coupled with eight sub-equations. The values for each parameter in the equations are obtained from ranking tables for each parameter. Mathematical formulations are given below, and the notations are listed in Appendix A.

$$\mathrm{ORV} = D + L + [\mathrm{Ee} + (\mathrm{CPR}) \times f] \times Q \tag{1}$$

$$\mathrm{Ee} = I + C + R + T \tag{2}$$

$$I = i^n \tag{3}$$

$$C = c^n \tag{4}$$

$$R = r^n \tag{5}$$

$$T = t^n \tag{6}$$