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Hazard Assessment For Wastes using Multicriterial Methods Considering European And International Harmonized Legislation

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Abstract

The objective of the study is to offer methodological instruments using multiple criteria for hazard waste assessment that will allow reproducibility of value judgments made by experts/specialists in the field when making such decisions based on harmonized national, European, and international legislation. In the hazard waste assessment world practice exist different methods.

We will present the practice of decisional logical schemes and decisional rules derivation using multiple criteria in order to make transparent the decisional act of assessment/classification in each jurisdiction to harmonize the waste management and eventually to make possible some actions to be automated for speeding up the final decision. The proposed methodologies developed by INCD-ECOIND respond to the current legislation requirements and address the needs of scientific waste assessment and management with intend to valorize the results in the form of advanced environmental services. The proposed methodologies are based on relevant criteria like hazardous properties by waste's origin (i.e. waste existing on relevant waste lists - coming from different specific technological processes etc.) and hazardous properties by waste's composition (i.e. based on results of relevant performed tests revealing hazardous properties for certain components of the analyzed waste from beneficiaries). Information about the analyzed waste has been obtained from beneficiaries, from literature and from INCD-ECOIND performed analytical determinations (over 12 relevant indicators). The classification results are finally presented.

The proposed multiple criteria type of methodologies offer efficient, short, logic, and mathematical algorithms for data reduction and discovery of relevant decision rules within the available data information. They offer easy interpretation of the obtained results, revealing the quality of classification, allowing the automation of some actions but also manual (pre)processing of data depending on situation, in order to support the final classification decision.

Key words: hazardous, waste assessment, management, methodologies

1. Aims

The objective of the paper is to present two methodological approaches used by INCD-ECOIND Bucharest for hazardous waste assessment. They are based on multiple-criteria analysis used within decisional logic schemes for decisional rules derivation considering the harmonized national, European and international legislation. Through their results they offer transparency for the decisional process making possible the reproducibility of experts' value judgments.

2. Background

First methodological approach has been dedicated for the use of both experts and waste producers or holders. It can help producers/holders to fulfill the legal requirements regarding the registration/classification of generated wastes according to existing lists when there is no doubt for such a classification. The second methodological approach has been dedicated for the use of experts/specialists when decision based on specific analytical tests should be considered in order to decide the correct classification. It is based on Pawlak's[1] RST (English acronym for Rough Set Theory) and is dedicated for both manually or automated environmental use with special dedicated software. Both proposed methodologies involve an extensive documentary endeavor and expertise from different scientific areas (chemistry, physics, biology, biochemistry, toxicology, chemical engineering, environmental risk assessment etc.) in order to make a correct characterization and classification of the waste. In this respect, the use of RST based methodological approach seems to be especially appropriate taking advantage from its capabilities in information synthesis from different data-bases. According to the current harmonized legislation in assessing waste hazardous properties, Romanian laws consider[2,3,4,5,6] three distinct aspects to be taken into account: a) defining the criteria for establishing their hazardous character and code assignment; b) establishing the storage category for waste based on well defined criteria and procedures; c) conditions imposed for the waste transportation.

In Romania, European Union and on international scale the character of hazardous waste is based mainly on the risk phrases associated to the waste composition. The assessment should state if there is a positive probability that hazardous properties, hazardous situations involving those substances or both might materialize in uncertain conditions. The significance of the used risk phrase in the proposed methodologies is in accordance with Governmental Decision 1408 of November 4th 2008 regarding the classification, packaging and labeling of dangerous substances. In the idea of a good harmonized waste management in relation to the classification, packaging and labeling of substances some changes are prepared. Within a global harmonized system, starting from June 1st, 2015, CE/1272/2008 Regulation known as CLP Regulation (English abbreviation for Classification, Labeling and Packaging) will be introduced and the CHIP Regulations (Chemicals) Hazard Information & Packaging for Supply Regulations 2002 will become obsolete. The new system is expected to facilitate the international trade and the harmonized communication of the information linked to the hazardous character of the chemical substances. It will complement The REACH Regulation (CE 1907/2006).

3. Experimental

The hazardous character of a waste sample has been determined. The sample noted is represented by a mixed tonner waste from tonner reprocessing.

The *first applied methodological approach* that was designated for the use of both the waste producer/holder and expert/specialist has the following essential steps: 1) Collection of relevant existing data about the waste sample. Such data might be from available data sources such as waste producer/holder raw materials and process technical documentation, literature in the field, national and international technical organization's reports. It is referring to waste

type identification waste's origin process, obvious characteristics of waste (aspect, physical state) etc. 2) Matching a waste industrial flow to a waste code from the Governmental Decision nr. 856/2002 waste list, if such a waste industrial flow can be identified in order to classify the waste without additional analytical tests. When there is a doubt regarding the classification of the waste, then additional relevant tests should be performed and the process continues with step three; 3) Establishing of possible constituents matrix and relevant analytic tests (indicators) to be performed in order to have well documented results; 4) Performing the established analytic tests (indicators); 5)The identification of risk phrases for the constituents' matrix based on available reliable data and information including analytic tests results and assignment on those bases of the hazardous properties (described in Annex 4 -Law 211/2011) for the analyzed waste; 6) Quantifying the level of hazardous properties; 7) Comparison of the determined level of the hazardous/dangerous properties with the limits covered by Government Decision no. 856/2002

The second applied methodological RST based approach that was designated for the use of experts has the following essential steps: 1) data acquisition, attributes selection, creation of information table; 2) creating a table with the significance of used attribute values; 3) reduction of data/information and obtaining the information/decision table;4) decision rules derivation; 5) validation on the same type of data set or on new data set by adding new objects to the already existing reference. It allows the manually or automated data (pre)processing in order to derive decision rules for the correct waste classification as hazardous or non-hazardous ones. Essentially, the RST based methodological approach uses the available data and put them into a so called information table. This table is functioning like a reference table for classification of different general waste found in practical situations. In this information table the rows are objects (in present case they represent type of wastes) that can be characterized by attributes from columns. A table where characterization attributes are divided in conditional attributes and decisional attributes is named decision table. Based on the values of those characterization attributes rules of "if ...then" type for classification of different waste can be derived. In the present methodological approach the information table contains six general types of wastes ($d_1 \div d_6$). The RST uses the indiscernability relation "I" among objects with reference to subsets of attributes in order to group indiscernible ones and ease the classification. All wastes that have the same conditions attributes should be classified under the same decision attribute to maintain consistency for a classification. To be used for waste classification we should decide about the value of decision attributes (i.e. "yes" - the waste is hazardous; "no" - the waste is non-hazardous) based on the value of condition attributes. Different attributes can be initially chosen to represent existing data information in relation with the decision attributes (hazardous/non-hazardous). Not all the available data might be relevant from the point of view of hazardous waste characterization and RST algorithm offers the possibility to select only those data that can help with a correct classification. By applying a specific processing algorithm the total number of attributes can be reduced keeping only those that are relevant for the classification concepts of hazardous/non-hazardous waste. This way decision table is based on the so-called informational reduct and from this information decision rules can be derived. In the present methodology the reduct has three attributes two conditional attributes named A1 and A3 and one decisional attribute named A4 defined in the following Table 1 that was obtained by reducing the initial informational table that it is not presented here and was made of four attributes (three decision attributes A1, A2, A3 and one condition attribute A4). The final set attributes for the present methodology are formulated as follows:

Attribute A1: "The waste presents hazardous/non-hazardous properties considering the origin (art. 9 Law 211/2011)" i.e. exists either in accepted lists for hazardous/non-hazardous wastes at national/international level either considering the technological process and other

documents such as Material Safety Data Sheets (English acronym MSDS) of the waste matrix constituents offered by the waste producer/holder when the corresponding constituents are identified.

Attribute A3: "The waste presents hazardous properties considering the composition (art.9 – L 211/2011)" i.e. considering the relevant tests for relevant hazardous properties of the identified constituents waste matrix type from the available information about the waste according to the standards and legislation.

Attribute A4: "The waste is hazardous"

Table 1 – Reference table example for the hazardous RST waste classification

Object to be classified	Conditional Attributes		Decision Attribute
d_n	A 1	A 3	A 4
(0)	(1)	(2)	(3)
d_1	1	0	No
d_2	1	1	Yes
d_3	1	2	Yes
d_4	0	0	No
d_5	0	1	No
d_6	0	2	Yes

The used attributes values have the following significance given in the Table 2

Table 2 – Significance of the attributes values

Attribute Value	Significance for assigning the value from column "0"
0	1
A1=1	When the waste presents documented hazardous/non-hazardous properties upon origin (either from MSDS /other documentation for essential components or from the accepted existing lists/catalogs of waste type etc);
A1=0	When the waste does not present documented hazardous/non-hazardous properties upon origin (there are no documents such MSDS /other documentation for essential components and the type of waste is not on any accepted lists/catalogs of waste type etc);
A3=0	When the waste does not present hazardous properties upon composition i.e. the analysis of relevant tests results for the hazardous properties according to the legal rules document the absence of hazardous properties;
A3=1	When the waste presents hazardous properties upon composition i.e. the analysis of the values of the relevant tests results for the hazardous properties shows that the values are equal to those legally established when those limits exist, otherwise they are equal to the values limits established based on experts advise;
A3=2	When the waste presents hazardous properties upon composition i.e. the analysis of the values of the relevant tests results for the hazardous properties shows that the values are greater than those legally established when those limits exist, otherwise they are greater than the values limits established based on experts advise;
A4= "No"	When the waste is non-hazardous;
A4= "Yes"	When the waste is hazardous;

RST proposed methodology can be used both manually and also in a computerized environment. Using an adequate conceived soft-ware, a Decision Support System (English acronym DSS) can be created having the following components: A) inputs – factors/parameters, numbers and characteristics to be analyzed in relation with waste; B) knowledge and expertise of the users in waste assessment - addressing the issues of manually analyzing the inputs data by the user; C) outputs - the transformed data from which the DSS based on RST conceptual model generates decisions; D) DSS generated results based on user criteria defined in the obtained RST reduct. The methodology can be used by experts involved in hazardous waste assessments when classification made by waste holder is uncertain.

4. Results and discussions

In the chosen case study the waste holders had doubts in classifying the wastes under certain codes available under current legislation and they asked for expert evaluations requiring for additional composition tests information for waste characterizations. The waste

relevant indicators to be determined and the used analytic test methods have been established in consultation between waste producers/holders and a group of INCD-ECOIND Bucharest experts. The obtained results are in Table 3. The waste characterizations have been done by INCD-ECOIND Bucharest through both methodological approaches determining the waste compositions and identifying the risk phrases for the waste components.

Table 3 - Analytical tests results for the sample S

Nr. crt.	Sample Name	Indicator Type	Measurement Units	Test results	The used analytic test methods
(0)	(1)	(2)	(3)	(4)	(5)
1	S	pH	pH units	7,4	SR ISO 10390/2005
2		dry solids (d.s)	%	99,72	SR ISO 11465-98
3		Pb	mg/kg d.s.	27,28	SR EN ISO 11885:2009
4		Mo	mg/kg d.s.	0,3	SR EN ISO 11885:2009
5		Cr (VI)	mg/kg d.s.	<0,05*	SR ISO 11083-98
6		Co	mg/kg d.s.	7,2	SR ISO 11047:1999
7		Ni	mg/kg d.s.	49,92	SR ISO 11047:1999
8		Cu	mg/kg d.s.	71,78	SR ISO 11047:1999
9		Fe	mg/kg d.s.	72748	SR EN ISO 11885:2009
10		Mn	mg/kg d.s.	658,46	SR ISO 11047:1999
11		Zn	mg/kg d.s.	815,12	SR EN ISO 11885:2009
12		Ti	mg/kg d.s.	823,04	SR EN ISO 11885:2009

*) LOD – English acronym for Limit of Detection

The identification of risk phrases were determined based on Material Safety Data Sheets provided by the waste producers/holders for certain known components or were found in other official international accepted databases sources special dedicated to hazardous properties. It should be noted that for both methodological approaches, hazardous character of waste is determined according to the regulated risk phrases for its components. A hazardous property/character is given by one or more risk phrases. The level of hazardous property/character is given by the level of concentrations of its components characterized by the corresponding risk phrases that define that hazardous property/character. Depending on specific situations, waste components' levels of concentration refer to the individual component or a sum of components imparting the hazardous character. According to both methodologies and to Governmental Decision 856/2002, if at least one hazardous property is equal or exceeds the stated regulatory limit under the corresponding property computed as presented above according to the corresponding waste components' risk phrases, then the waste is hazardous; if the level of any hazardous property does not reach the stated regulatory limit then the waste is non-hazardous. Applying the two methodological approaches the results were as follows: 1) first methodology: analysis of documentation concerning the used sample and analytical tests results going through the presented methodological step found that the waste is non-hazardous; it was classified under the code 08.03.18; 2) second RST based methodology: waste sample presents documented no-hazardous properties in safety material data sheets so according to the Table 1 the attribute A1=1; analytical tests showed non-hazardous properties by composition so according to the Table 1 the attribute A3=0; decision rule corresponding to the observation type d_1 in the Decision Table 1 shows A4 = No, i.e. the waste is non-hazardous; it was classified under the code 08.03.18 the same as in the first methodology.

5. Conclusions

The two methodological approaches are meant to help the hazardous classification waste according to the legal requirements and they reached the same conclusions. In addition, the RST methodology allows the automation of a set of actions that can improve the personal efficiency, speed up the decisional process, generates new documented evidences in

supporting decision at the level of authorities and experts involved in such decisions being a useful transparent tool for assessment. As Pawlak mentions[1] "it offers efficient algorithms to find hidden patterns in data, find minimal data sets so reduces data, assesses the significance of data, generates decision rules from data, is easy to be understand and to directly comment the obtained results."

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