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Priority Estimation of Quality Indicators in Hazardous Wastes Management

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ABSTRACT

Hazardous Waste Management is a complex task involving multiple target parameters. Each one of them has a certain meaning, but it is not sufficient to determine the optimal management of hazardous waste. The optimal values of the different target parameters are obtained at different values of the plurality of control parameters. Some approaches reduce the task to one main target parameter, and others are presented as regional constraints, but this is not always possible. Optimal decisions in multicriteria optimization problems in quality control greatly depend on priorities and weight coefficients W_j*, adopted for the various quality characteristics. There are no strictly formalized methods for estimation of importance, priority and weight coefficients.*

Two questionnaires with 10 quantitative indicators are developed. Priorities and weighting factors are determined by ranking the quality indicators. Coefficients of concordance have been calculated and their significance has been estimated.

Keywords: hazardous waste management, weight coefficients, coefficient of consent.

INTRODUCTION

Technological development of the human society leads to the creation of opportunities for utilization of natural raw materials (ores, minerals, energy carriers, etc.), containing ever lower concentrations of useful components [1]. This trend is deepening and definitely leads to increasing the mass of industrial wastes both after each technological operation and as a result of the overall production process. In many industries in the industrial solid wastes remain significant amounts of useful components due to physico-chemical limitations for complete extraction.

In the metallurgical and chemical industry, the quantitative and qualitative characteristics of generated industrial waste are identifiers for the efficiency of the raw materials utilization and the degree of extraction of useful components in a technological process. The most preferred method for industrial solid waste management from technically and ecologically point of view is to reduce the quantities generated at the source [2] by using all the technical and technological opportunities.

Many hazardous wastes contain toxic materials, which can be classed in more than one

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category. In this case the waste will be grouped in the category of major significance. The dangers of toxic wastes being released to the environment are real and originated of three sources [3, 4]:

Generation of toxic chemical;

Use of toxic chemical in subsequent process;

Release of toxic product/chemical from the use or wastage of the product.

In general hazardous wastes can be classified in four groups [3]:

- Chemically and/or thermally destructible compounds, including all organic and some inorganic compounds (cyanides, nitrates, etc.);
- Toxic compounds, especially heavy metals;
- Inorganic salts;
- Inorganic inert materials containing iron, aluminum, alkaline and earth alkaline metals, silicon, etc.

The first step in minimizing the negative effects of the hazardous wastes is to reduce the volume of the wastes [3].

This can be achieved by:

- Classification of wastes;
- Changing production (technology) to decrease the wastes;
- Reusing and recycling the wastes.

The quantity of the hazardous wastes could be minimized by:

- Process changes;
- Equipment modification;
- Segregation and/or equalization of wastes;
- By-product recovery;
- Monitoring of wastes streams;
- All treatment technologies have involved important technical, environmental and/or economic limitations. The scales of these limitations is connected more with the quantity, the character and the composition of the waste, than to the choice of the treatment technology. These technologies can be grouped on the basis of the scientific and engineering principles involved, or, on the basis of how and where technology is implemented [3, 4].

The choice of technologies for hazardous wastes treatment is heavily influenced by physico-chemical and thermal properties, geomorphological properties of wastes, cost and public opinions.

EXPERIMENTAL

Hazardous Waste Management is a complex task involving multiple target parameters. Each one of them has a certain meaning, but it is not sufficient to determine the optimal management of hazardous waste. The optimal values of the different target parameters are obtained at different values of the plurality of control parameters. Some approaches reduce the task to one main target parameter, and others are presented as regional constraints, but this is not always possible.

In most industrial process optimization, environmental impacts are considered final external effect at the output to be mitigated by recycling and treatment, rather the intrinsic internal parts of total system. In additional optimization, of a sub system or a process component does not necessarily yield a system that is optimized overall. This raised very difficult question – how large the optimization domain should be, and the potential conflict between optimization from a mass or thermodynamic sense, and optimization from an economic or environmental sense.

From an environmental impact aspect, the emission of very small amounts of waste material flows from industrial processes is a very difficult for assess and/or predict. Internal economic incentives usually do not exist for manufacturer to capture these waste flows to make them environmentally neutral. Process optimization to minimize waste flow would go a long way toward improving the present system.

Optimal decisions in multicriteria optimization problems in quality control greatly depend on priorities and weight coefficients W_j, adopted for the various quality characteristics [5, 6]. There are no strictly formalized methods for estimation of importance, priority and weight coefficients.

Creation of an inquiry card for evaluation of quality indicators priority of the indicators on "Indicators of Hazardous Wastes" and "Hazardous Waste Management"

On the basis of a thorough study and analysis of the hazardous waste generated in Bulgaria, their main properties, the possible problems that exist in their optimal management, two questionnaires were developed for defining the priorities of the

Table 1. Questionnaire on "Hazardous Waste Indicators".

Hazardous Waste Indicators	Rank (priority indicator)
Quantity of the generated hazardous waste, t/y	
Specific heat of incineration in generated hazardous waste	
Possibility of utilization of the energy resource of hazardous waste	
Presence of valuable components in generated hazardous waste	
Possibilities for recycling hazardous waste	
Degree of influence on air pollution	
Degree of Impact on Water Pollution	
Degree of influence on soil contamination	
Degree of harmfulness of waste to the environment	
Toxicity of waste for human health	

Table 2. Questionnaire on "Hazardous Waste Management".

Hazardous Waste Management	Rank (priority indicator)
Recycling of the hazardous waste in the same manufacturing / technological process	
Recycling of the hazardous waste in other technological processes	
Thermal treatment (recovery) of the hazardous waste within the same production facility	
Thermal treatment (recovery) of the hazardous waste in other technological processes	
Recycling of the hazardous waste with subsequent disposal of the non-recycled fraction (components)	
Direct disposal in landfill of the hazardous without recycling	
Reducing the negative impact on atmospheric air	
Reducing the negative impact on surface water	
Reducing the negative impact on soil and groundwater	
Reducing the negative impact on human health	

Table 3. Table of ranks for questionnaire card: „Indicators of hazardous wastes".

Indicator / Expert	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
E_1	1	6	2	3	3	5	5	5	4	4
E_2	1	4	3	1	2	7	7	7	7	6
E_3	2	7	8	2	1	3	4	5	2	3
E_4	1	7	2	1	1	2	2	2	2	1
E_5	5	8	9	3	4	4	8	3	3	5
E_6	2	1	3	3	4	7	9	8	6	5
E_7	3	1	2	3	4	5	8	8	6	7
E_8	2	4	3	2	1	3	6	6	6	5
E_9	2	3	3	1	1	3	5	6	7	3
E_{10}	3	5	4	2	1	6	8	10	9	7
E_{11}	1	4	3	2	1	5	5	5	5	5
E_{12}	1	4	2	1	2	3	5	5	5	3
E_{13}	1	3	2	2	3	4	5	5	5	4
E_{14}	1	2	2	3	3	4	5	5	5	4
E_{15}	2	5	2	1	1	3	4	4	4	3
E_{16}	1	5	2	2	1	3	6	7	3	4
E_{17}	1	2	1	2	1	3	4	4	3	3
E_{18}	1	3	2	2	3	5	5	5	5	4
E_{19}	5	7	6	3	2	1	4	4	4	1
E_{20}	1	4	4	2	1	3	5	5	3	3
E_{21}	1	4	1	1	1	3	3	3	2	2
E_{22}	1	8	2	1	1	3	3	3	2	1
E_{23}	1	8	3	1	1	3	3	3	2	1
E_{24}	1	5	2	1	1	3	3	3	2	1
E_{25}	1	6	1	1	2	3	4	5	1	1
E_{26}	1	8	2	1	1	3	3	3	2	1
E_{27}	1	8	2	1	1	3	3	3	4	1

indicators (the target parameters) in order to create a strategy for optimal management of hazardous waste indicators:

- Questionnaire on "Indicators of Hazardous Wastes";
- Questionnaire on "Hazardous Waste Management".

Two questionnaires with 10 quantitative indicators are developed, given in Table 1 and Table 2.

The choice of people to be included in a representative sample for inquiry is important. The choice depends on the information expected to come out as a result of the investigation. A group of 27 expert in the field of hazardous wastes management are chosen.

Priority assessment and weight coefficients estimation by ranking the quality indicators

Optimal decisions in multicriteria optimization problems in quality control strongly depend on priorities and weight coefficients, adopted for the various quality characteristics. The weight coefficients are quantitative expression of the importance of quality characteristics.

Table 4. Table of ranks for questionnaire card: „Hazardous wastes management”.

Indicator / Expert	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
E_1	2	3	1	1	5	6	4	4	4	4
E_2	1	1	1	1	6	7	3	4	5	2
E_3	2	3	2	3	1	4	2	5	6	3
E_4	1	1	1	2	4	9	1	1	1	1
E_5	9	4	8	10	3	5	7	6	4	4
E_6	1	1	2	2	3	8	5	6	7	4
E_7	1	2	1	1	5	6	4	4	4	3
E_8	1	2	1	3	8	10	6	6	6	5
E_9	1	1	2	3	6	10	4	5	5	4
E_{10}	1	2	3	4	5	9	6	7	8	6
E_{11}	2	2	1	1	5	10	3	3	3	3
E_{12}	1	2	1	2	6	9	3	4	4	3
E_{13}	1	3	2	4	5	10	6	6	6	5
E_{14}	1	2	1	2	6	10	3	4	5	3
E_{15}	1	2	1	2	6	8	3	4	4	3
E_{16}	1	2	1	2	7	8	3	4	5	3
E_{17}	1	2	3	3	7	8	3	5	6	4
E_{18}	2	3	1	1	6	9	4	7	8	5
E_{19}	1	1	1	2	6	7	3	4	5	3
E_{20}	1	1	1	1	5	6	2	3	4	2
E_{21}	1	2	1	2	7	8	4	5	6	3
E_{22}	1	1	1	2	4	10	1	1	1	1
E_{23}	1	2	3	2	4	10	1	2	2	1
E_{24}	1	1	1	2	5	10	1	1	1	1
E_{25}	1	2	3	4	6	10	5	6	7	1
E_{26}	1	1	1	2	4	10	1	1	1	1
E_{27}	1	1	1	2	4	10	1	1	1	1

Ranks tables creation

All information from the questionnaire cards are recorded in a rank table (Table 3 and Table 4). Rank tables have been created, including the results of the two inquiry cards. Each number in the weight matrix a_{ij} determines the weight (rank) that the expert „i“, i = 1, 2, ..., 27 gives the qualifying indicator (target parameter) “j”, j = 1, 2, ..., 10. In the tables are given also the determined weight coefficients for each indicator W_j and the respective “Ranks” of the indicators.

Ranks matrix normalization with equal ranks

In case of equal ranks appear, i.e. two or several characteristics have same ranks, the rank matrix has to be normalized according to the method presented in [7]. To compare repeated with non-repetitive ranks given by the 27 experts qualified target parameters with consecutive numbers from 1 to 10, it is necessary that the rows of the Table 3 and Table 4 to normalize so that for each expert i the condition is fulfilled:

$$\sum_{i=1}^{m} \alpha_{ij} = S_p = \frac{m(m+1)}{2} = \frac{10(10+1)}{2} = 55 \qquad (1)$$

Evaluation of coefficient of consent of the inquired experts

The measure of relative agreement which represents experts' opinion consent is evaluated by the coefficient of consent (the Kendall's coefficient of concordance) k_w, using the rank correlation method in the presence of repeated ranks [7].

Rank matrixes of quality indicators are given in Table 5 (Indicators of hazardous wastes) and in Table 6 (Hazardous wastes management).

Evaluation of the coefficient of consent w_k in the presence of repeated ranks using formula suggested by Maurice Kendall [7]:

$$w_k = \frac{12\sum_{j=1}^{m}\delta_j^2}{R^2\left(m^3-m\right)-12R\sum_i T_i} \tag{2}$$

where, Ti - correcting value;
δ_j - deviation between the sum of all ranks for each characteristic and the average sum of ranks;
R - number of the experts (R = 27);
m - number of the quality indicators (m = 10).

The deviation between the sum of all ranks for each characteristic and the average sum of ranks is calculated by the followed equation:

$$\delta_j = \sum_{i=1}^{R} a_{ij} - S_{av} \tag{3}$$

Calculation of correcting value:

$$T_i = \frac{1}{12}\sum_{t_i}\left(t_i^3 - t_i\right) \tag{4}$$

where t_i is the number of repeated ranks (tied ranks), set separately for each expert i.

The estimated coefficient of concordance w_k for "Indicators of Hazardous Wastes" is **0.5426** and for "Hazardous Wastes Management" is **0.57614.**

Verification of the coefficient of consent significance

The coefficient of consent (coefficient of concordance) *wk* can vary from 0 (for total disagreement in opinions) to +1 when there is a total agreement. For verification of the significance of the evaluated coefficient k_w one can use χ^2 criterion when $m \geq 7$ [10, 11].

Indicators of Hazardous Wastes:

$$\chi^2 = R\left(m-1\right)w_k = 27\left(10-1\right).0,5426 = 131,8497$$

Hazardous Wastes Management:

$$\chi^2 = R\left(m-1\right)w_k = 27\left(10-1\right).0.57614 = 140,0016$$

For a significant level **α = 0.01** (confidential probability **β = 0.99**) and for a degree of freedom **ν = 10 − 1 = 9**, the table value is $\chi^2_{table} = 21.666$ [….].

$$\chi^2_{calc} = 131,8497 > \chi^2_{table} = 21.666$$

$$\chi^2_{calc} = 140,0016 > \chi^2_{table} = 21.666$$

RESULTS AND DISCUSSION

For Indicators of hazardous wastes survey, the concordance coefficient w_k is significant. With a probability not less then 99 % (the significant level α = 0.01) the agreement of opinions of inquired experts exists and weight coefficients of the quality indicators of Indicators of hazardous wastes can be estimated. The coefficients W_j are shown in Table 5 and graphically represented on Fig. 1. The highest levels of importance are:

Quantity of generated hazardous waste, t/y (W_1 = **0.16502**), Presence of valuable components in generated hazardous waste (W_4 = **0.16173**) and Possibilities for recycling hazardous waste (W_5 = **0.15885**). Followed by the Possibility of utilization of the energy resource of hazardous waste (W_3 = **0.11728**), Toxicity of waste for human health (W_{10} = **0.10782**), Degree of influence on air pollution (W_6 = **0.07695**) and Degree of harmfulness of waste to the environment (W_9 = **0.07243**). The lowest level of importance have the following indicators: Specific heat of incineration in generated hazardous waste (W_2 = **0.06214**), Degree of influence on soil contamination (W_8 = **0.03951**) and Degree of Impact on Water Pollution (W_7 = **0.03827**).

Table 5. Rank matrix of quality indicators for questionnaire card: „Indicators of hazardous wastes”.

Indicator / Expert	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}	t_i	T_i
x_1	1	10	2	3.5	3.5	8	8	8	5.5	5.5	**2+3+2**	**3**
x_2	1.5	5	4	1.5	3	8.5	8.5	8.5	8.5	6	**2+4**	**5.5**
x_3	3	9	10	3	1	5.5	7	8	3	5.5	**3+2**	**2.5**
x_4	2.5	10	7	2.5	2.5	7	7	7	7	2.5	**4+5**	**15**
x_5	6.5	8.5	10	2	4.5	4.5	8.5	2	2	6.5	**3+2+2+2**	**3.5**
x_6	2	1	3.5	3.5	5	8	10	9	7	6	**2**	**0.5**
x_7	3.5	1	2	3.5	5	6	9.5	9.5	7	8	**2+2**	**1**
x_8	3	6	4.5	2	1	4.5	9	9	9	7	**2+3**	**2.5**
x_9	3	5.5	5.5	1.5	1.5	5.5	8	9	10	5.5	**2+4**	**5.5**
x_{10}	3	5	4	2	1	6	8	10	9	7	**0**	**0**
x_{11}	1.5	5	4	3	1.5	8	8	8	8	8	**2+5**	**10.5**
x_{12}	1.5	7	3.5	1.5	3.5	5.5	9	9	9	5.5	**2+2+2+3**	**3.5**
x_{13}	1	4.5	2.5	2.5	4.5	6.5	9	9	9	6.5	**2+2+2+3**	**3.5**
x_{14}	1	2.5	2.5	4.5	4.5	6.5	9	9	9	6.5	**2+2+2+3**	**3.5**
x_{15}	3.5	10	3.5	1.5	1.5	5.5	8	8	8	5.5	**2+2+2+3**	**3.5**
x_{16}	1.5	8	3.5	3.5	1.5	5.5	9	10	5.5	7	**2+2+2**	**1.5**
x_{17}	2	4.5	2	4.5	2	7	9.5	9.5	7	7	**3+2+3+2**	**5**
x_{18}	1	4.5	2.5	2.5	4.5	8.5	8.5	8.5	8.5	6	**2+2+4**	**6**
x_{19}	8	10	9	4	3	1.5	6	6	6	1.5	**2+3**	**2.5**
x_{20}	1.5	7.5	7.5	3	1.5	5	9.5	9.5	5	5	**2+2+2+3**	**3.5**
x_{21}	2.5	10	2.5	2.5	2.5	8	8	8	5.5	5.5	**4+2+3**	**7.5**
x_{22}	2.5	10	5.5	2.5	2.5	8	8	8	5.5	2.5	**4+2+3**	**7.5**
x_{23}	2.5	10	7.5	2.5	2.5	7.5	7.5	7.5	5	2.5	**4+4**	**10**
x_{24}	2.5	10	5.5	2.5	2.5	8	8	8	5.5	2.5	**3+2+3**	**4.5**
x_{25}	3	10	3	3	6	7	8	9	3	3	**5**	**10**
x_{26}	2.5	10	5.5	2.5	2.5	8	8	8	5.5	2.5	**4+2+3**	**7.5**
x_{27}	2.5	10	5	2.5	2.5	7	7	7	9	2.5	**4+3**	**7**
$\sum_{i=1}^{10} \alpha_{ij}$	**69.5**	**194.5**	**127.5**	**73.5**	**77**	**176.5**	**223.5**	**222**	**182**	**139**	$\sum_{i=1}^{21} T_i = 136$	
δ_j	**-79**	**46**	**-21**	**-75**	**-71.5**	**28**	**75**	**73.5**	**33.5**	**-9.5**	$\sum_{j=1}^{10} \delta_j^2 = 32559,00$	
V_j	**0.8251**	**0.3107**	**0.58642**	**0.80864**	**0.79424**	**0.38477**	**0.19136**	**0.19753**	**0.36214**	**0.53909**	$\sum_{j=1}^{10} V_j = 5$	
W_j	**0.16502**	**0.06214**	**0.11728**	**0.16173**	**0.15885**	**0.07695**	**0.03827**	**0.03951**	**0.07243**	**0.10782**	$\sum_{j=1}^{10} W_j = 1,00$	
Ранг	**1**	**8**	**4**	**2**	**3**	**6**	**10**	**9**	**7**	**5**		

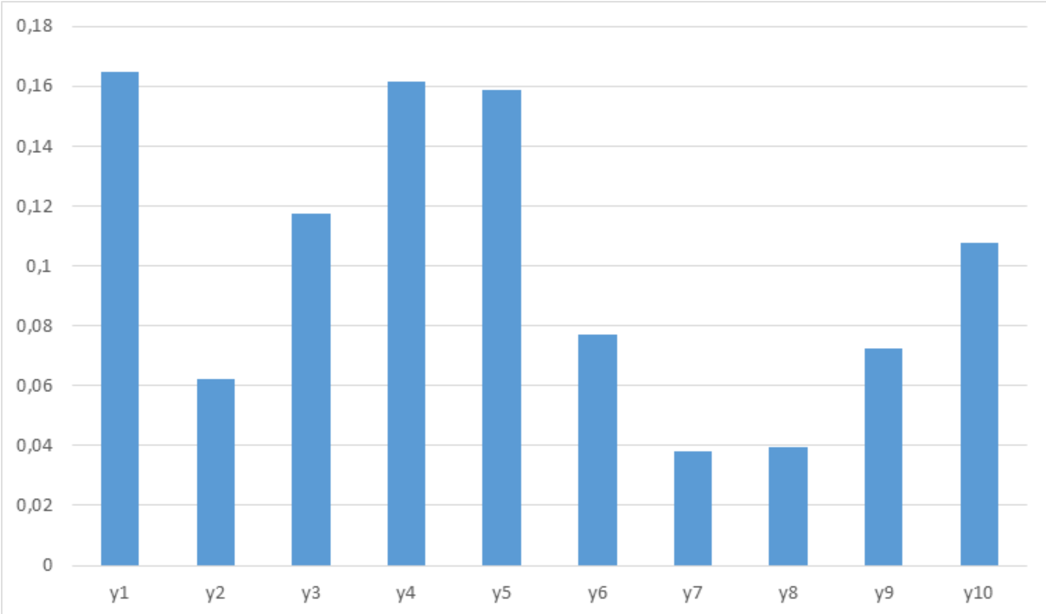

Fig. 1. Quality indicators weight coefficients of the „Indicators of hazardous wastes".

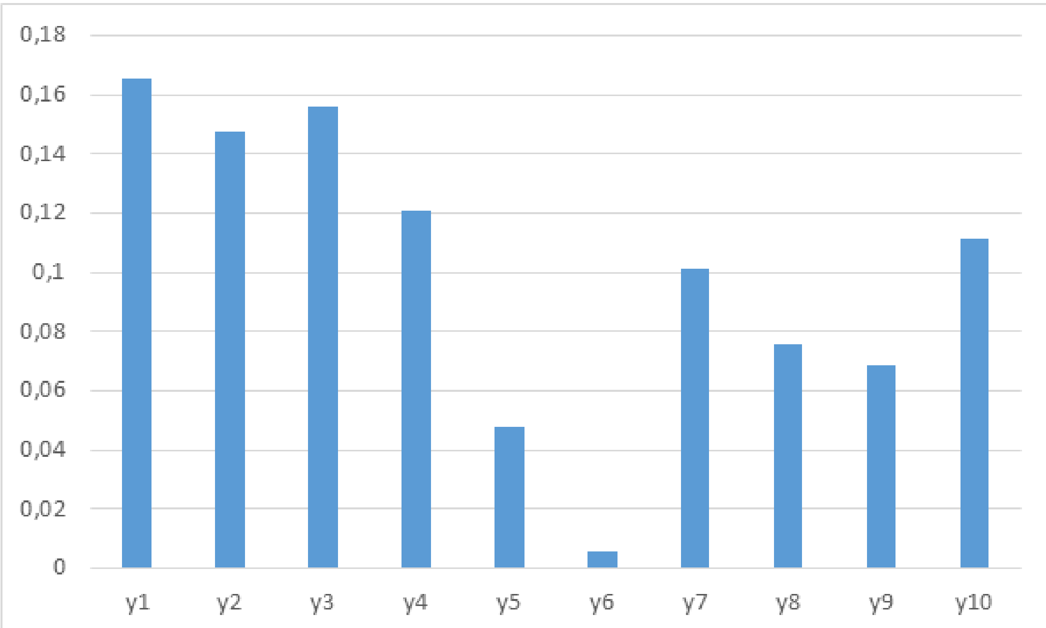

Fig. 2. Quality indicators weight coefficients of the „Hazardous wastes management".

The coefficient of consent for Hazardous Wastes Management is significant. With a probability not less than 99 % (the significant level $\alpha = 0.01$) the agreement of opinions of inquired experts exists and weight coefficients of the quality indicators of Hazardous wastes management can be estimated. The coefficients W_j are shown in Table 6 and graphically represented on Fig. 2.

Highest levels of importance have the following indicators: Recycling of the hazardous waste in the same manufacturing/technological process (W_1 = **0.165**), Thermal treatment (recovery) of the hazardous waste within the same production facility (W_3 = **0.156**) and Recycling of the hazardous waste in other technological processes (W_2 = **0.148**). The next significant are Thermal treatment

Table 6. Rank matrix of quality indicators for questionnaire card: „Hazardous wastes management”.

	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}	t_i	T_i
x_1	3	4	1.5	1.5	9	10	6.5	6.5	6.5	6.5	2+4	5.5
x_2	2.5	2.5	2.5	2.5	9	10	6	7	8	5	4	5
x_3	3	6	3	6	1	8	3	9	10	6	3+3	4
x_4	4	4	4	8	9	10	4	4	4	4	7	28
x_5	9	3	8	10	1	5	7	6	3	3	3	2
x_6	1.5	1.5	3.5	3.5	5	10	7	8	9	6	2+2	1
x_7	2	4	2	2	9	10	7	7	7	5	3+3	4
x_8	1.5	3	1.5	4	9	10	7	7	7	5	2+3	2.5
x_9	1.5	1.5	3	4	9	10	5.5	7.5	7.5	5.5	2+2+2	1.5
x_{10}	1	2	3	4	5	10	6.5	8	9	6.5	2	0.5
x_{11}	3.5	3.5	1.5	1.5	9	10	6.5	6.5	6.5	6.5	2+2+4	6
x_{12}	1.5	3.5	1.5	3.5	9	10	5.5	7.5	7.5	5.5	2+2+2+2	2
x_{13}	1	3	2	4	5.5	10	8	8	8	5.5	2+3	2.5
x_{14}	1.5	3.5	1.5	3.5	9	10	5.5	7	8	5.5	2+2+2	1.5
x_{15}	1.5	3.5	1.5	3.5	9	10	5.5	7.5	7.5	5.5	2+2+2+2	2
x_{16}	1.5	3.5	1.5	3.5	9	10	6.5	6.5	6.5	6.5	2+2+4	6
x_{17}	1	2	4	4	9	10	4	7	8	6	3	2
x_{18}	3	4	1.5	1.5	7	10	5	8	9	6	2	0.5
x_{19}	2	2	2	4	9	10	5.5	7	8	5.5	3+2	2.5
x_{20}	2.5	2.5	2.5	2.5	9	10	5.5	7	8	5.5	4+2	5.5
x_{21}	1.5	3.5	1.5	3.5	9	10	6	7	8	5	2+2	1
x_{22}	4	4	4	8	9	10	4	4	4	4	7	28
x_{23}	2	5.5	8	5.5	9	10	2	5.5	5.5	2	3+4	7
x_{24}	4	4	4	8	9	10	4	4	4	4	7	28
x_{25}	1.5	3	4	5	7.5	10	6	7.5	9	1.5	2+2	1
x_{26}	4	4	4	8	9	10	4	4	4	4	7	28
x_{27}	4	4	4	8	9	10	4	4	4	4	7	28
$\sum_{i=1}^{21} \alpha_{ij}$	69	90.5	81	123	212	263	147	178	186.5	135	$\sum_{i=1}^{21} T_i = 205,5$	
δ_j	-79.5	-58	-67.5	-25.5	63.5	114.5	-1.5	29.5	38	-13.5	$\sum_{j=1}^{10} \delta_j^2 = 34532,00$	
V_j	0.827	0.739	0.778	0.605	0.239	0.029	0.506	0.379	0.344	0.556	$\sum_{j=1}^{10} V_j = 5,00$	
W_j	0.165	0.148	0.156	0.121	0.048	0.006	0.101	0.076	0.069	0.111	$\sum_{j=1}^{10} W_j = 1,00$	
Rang	1	3	2	4	9	10	6	7	8	5		

(recovery) of the hazardous waste in other technological processes (W_4 = **0.121**), Reducing the negative impact on human health (W_{10} = **0.111**), Reducing the negative impact on atmospheric air (W_7 = **0.101**), Reducing the negative impact on surface water (W_8 = **0.076**) and Reducing the negative impact on soil and groundwater (W_9 = **0.069**). The lowest level of importance have the following indicators: Recycling of the hazardous waste with subsequent disposal of the non-recycled fraction (components) (W_5 = **0.048**) and Direct disposal in landfill of the hazardous without recycling (W_6 = **0.006**).

CONCLUSIONS

A quantitative assessment of priorities has been prepared by weighting coefficients of quality indicators for "Hazardous Waste Indicators" and "Hazardous Waste Management" determined in the opinion of experts, by examining the consistency of experts opinions.

The collected information from the experts' opinions was processed and statistically analyzed.

The priorities and weights of the indicators are determined. A normalized grading matrix with quality indicators was compiled. The kendal alignment coefficients were determined and their significance checked. The weighting coefficients of the respective indicators have been calculated and their ranks have been determined.

Highest levels of importance for "Hazardous Waste Indicators" have the following indicators: Quantity of generated hazardous waste, t/y, Presence of valuable components in generated hazardous waste and Possibilities for recycling hazardous waste.

Highest levels of importance for "Hazardous Waste Management" have the following indicators: Recycling of the hazardous waste in the same manufacturing/technological process, Thermal treatment (recovery) of the hazardous waste within the same production facility and Recycling of the hazardous waste in other technological processes.

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