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Application of multicriteria decision analysis to jar-test results for chemicals selection in the physical–chemical treatment of textile wastewater

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ABSTRACT

Jar-test is a well-known tool for chemicals selection for physical–chemical wastewater treatment. Jar-test results show the treatment efficiency in terms of suspended matter and organic matter removal. However, in spite of having all these results, coagulant selection is not an easy task because one coagulant can remove efficiently the suspended solids but at the same time increase the conductivity or increase considerably the sludge production containing chemicals and toxic dyes. This makes the final selection of coagulants very dependent on the relative importance assigned to each measured parameter.

In this paper, the use of multicriteria decision analysis (MCDA) is proposed to help on the selection of the coagulant and its concentration in the physical–chemical wastewater treatment, since textile wastewater contains hazardous substances. Therefore, starting from the parameters fixed by the jar-test results, these techniques will allow to weight these parameters, according to the judgements of wastewater experts, and to establish priorities among coagulants. Two well-known MCDA techniques have been used: analytic hierarchic process (AHP) and preference ranking organization method for enrichment evaluations (PROMETHEEs) and their results were compared.

The method proposed has been applied to the particular case of textile wastewaters. The results obtained show that MCDA techniques are useful tools to select the chemicals for the physical-technical treatment.

1. Introduction

Physical–chemical treatment of wastewaters is widely used in the field of the waste industrial effluents. Its application in textile industries can be performed in combination with a biological treatment or as unique treatment if the final effluent is discharged into a sewer. By means of a physical–chemical treatment, removal efficiencies of both suspended solids and COD can reach values up to 95 and 70%, respectively, [1,2] and colour can also be removed depending on the chemical used [3]. Other authors report about processes combining physical–chemical treatment with hydrolysis/acidification and Fenton oxidation [4] and about biological treatment plus membrane processes [5].

Jar-tests are a valuable tool in wastewater treatment to evaluate the efficiency of a physical–chemical treatment [6]. Chemicals selection and optimum operating conditions (pH and chemicals concentrations) are determined by means of these experiments.

However, selection of the best chemical and the best conditions is not an easy task, since high suspended and organic matter removals are coupled with an increase in conductivity and above all an increase in the sludge production. Besides, the coagulant selection is difficult at first sight since different coagulants show many similar results. Thus, decision has to be made according to different criteria and not only evaluating the pollutants removal efficiency.

In this work, multicriteria decision analysis (MCDA) is proposed as a tool for helping in the design of the physical–chemical wastewater treatment. MCDA "is a term that includes a set of concepts, methods and techniques that seek to help individuals or groups to make decisions, which involve several points of view in conflict and multiple stakeholders" [7]. All these MCDA concepts and methods have been largely studied in the operational research literature [7,8].

Selection of the mathematical model based on MCDA is not easy. According to Bouyssou et al. [9], there are several models that can be used in a decision-making process. There is no best model. In this paper, the use of two well-known MCDA techniques is proposed: analytic hierarchy process (AHP) [10] and PROMETHEE II [11], the results of which will be analysed and compared.

In the field of water management the MCDA techniques have already been used by different authors. AHP has been applied in Refs. [12–14]. On the other hand, PROMETHEE has been used in Refs. [15,16]. Other different MCDA techniques have been used in

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Refs. [17–19]. However, no references related to jar-test coagulant selection have been found.

2. Material and methods

2.1. Wastewater characterization

The parameters analysed were conductivity, pH, COD, colour and turbidity. COD was determined with Spectroquant Nova 60 from Merck and turbidity with D-112 apparatus from DINKO. Both conductivity and pH were measured with CRISON apparatus. Colour was calculated by means of the spectral absorption coefficients at three different wavelengths (436, 525 and 620 nm) according to the following equation [20]:

$$\text{colour} = \frac{A_{436}^2 + A_{525}^2 + A_{620}^2}{A_{436} + A_{525} + A_{620}} \quad (1)$$

Absorption coefficients values were measured by means of a spectrophotometer UV-Visible HP 8453.

2.2. Chemicals

Tests can be divided into four groups depending on the coagulant used. These chemicals were:

- Coagulant A. It is a polymeric liquid chemical based on aluminium.
- $FeCl_3$ combined with an anionic flocculant (anionic polyacrylamide).
- Coagulant B. It is formulated as a combination of inorganic and organic coagulants (mainly ferric sulphate).
- Coagulant C. It is an organic cationic coagulant.

2.3. Jar-tests

Physical–chemical experiments were carried out in a multiple stirrer jar-test apparatus from SELECTA. The procedure consisted in introducing 900 mL of the sample in the jars, then the coagulant was added and rapidly mixed (180 rpm) during 3 min. After that, the paddles velocity was decreased down to 50 rpm and the flocculant was added in the tests in which ferric chloride was used. At last, the paddles were withdrawn so that the particles could settle during 30 min [21].

In all tests COD, turbidity, colour, pH and conductivity of the clarified water and the sludge volume after 30 min sedimentation (V_{30}) were measured.

2.4. Evaluation process

The decision-making process proposed in the present work consists of the following steps (Fig. 1).

For the proper development of the process a group of experts was chosen. The main tasks of the experts were (i) To choose the coagulants to be tested and their concentrations, (ii) to define the jar-test parameters and to carry out the experiments and (iii) to weight the criteria.

The participation of experts in the processes of multicriteria evaluation is widely extended and enhances d_e value of the results obtained. [22]

2.5. Chemicals selection with MCDA: the AHP and PROMETHEE methods

2.5.1. The AHP method

The AHP proposed by Saaty is a measurement theory of intangible criteria [23]. AHP is based on the fact that the inherent complexity of a multiple criteria decision-making problem can be solved through the construction of hierarchic structures consisting of a goal, criteria and alternatives.

In each hierarchical level paired comparisons are made with judgments using numerical values taken from the AHP absolute fundamental scale of 1–9. These comparisons lead to dominance matrices from which ratio scales are derived in the form of principal eigenvectors. These matrices are positive and reciprocal ($a_{ij} = 1/a_{ji}$). The synthesis of AHP combines multidimensional scales of measurement into a single one-dimensional scale of priorities. For mathematical details see Refs. [10,24].

The method has the additional advantage of being easy to explain to the experts that have to assess the different criteria or alternatives in a simple and systematic way. The support software, Expert Choice 2000 (EC 2000), also enables the calculations and presentation of the results to be done easily and quickly.

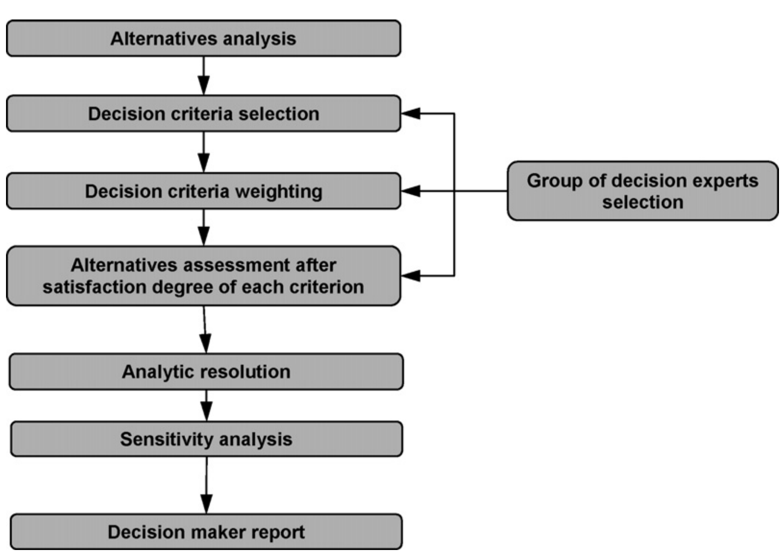

Fig. 1. Decision-making process.

2.5.2. The PROMETHEE methods

The PROMETHEE I and II methods belong to the family of the outranking methods in MCDA [11]. The difference between them is that PROMETHEE I allows the construction of a partial pre-ordering and PROMETHEE II a complete pre-ordering on a finite set of feasible alternatives. In this work PROMETHEE II has been chosen because the objective is to obtain a complete rank order of the different alternatives. For that, the algorithm of the method starting from the evaluation matrix associates a preference function (generalised criterion) to each criterion considering the difference on values between the alternatives for this specific criterion. This preference function takes values between 0 and 1 and allows the establishment of indifference and preference thresholds. The authors of the method propose six types of preference functions. After that, the preference structure is based on pairwise comparisons so that a new matrix of aggregated preference indexes can be created. Each value of this matrix is obtained by multiplying (for each criterion in which alternative A is better than B) the value of its weight by the value of the preference function. From this matrix and for each alternative, a positive flux (Φ^{+}) is calculated which quantifies how much this alternative dominates the others and a negative flux (Φ^{-}) which quantifies how much this alternative is dominated by the others. The support software, DecisionLab, also enables the calculations and presentation of the results to be done easily and quickly.

3. Results

3.1. Wastewater characterization

In Table 1, characterization results of the raw wastewater of a printing, dyeing and finishing textile industry are shown. As expected, for textile wastewaters COD is approximately 2.5 times higher than for domestic wastewaters. Other characteristics to be highlighted are the alkaline pH (10.5), the salt content, given by the conductivity and the brown colour.

3.2. Criteria weights

The criteria weights statement is essential in any MCDA process. The assessment and interpretation of criteria weights have been matters of controversy in the operational research field. The meanings of weights differ according to the models and to the decision contexts [7]. Nowadays one of the most used and recommended technique to assess weights is the AHP. Once the criteria have been established, the AHP method allows establishing a scale of priorities among the criteria by means of binary comparisons.

To this end, a specific questionnaire was designed to obtain the judgements of each expert. After that, the weights were calculated with the aid of the EC2000 software, which allows both individual and combined (mean of individual ones) results. It also enables inconsistencies to be analysed and resolved.

The weights obtained for the different criteria are shown in Table 2. Finally, it has to be pointed out that cost (measured in €/kg) has been added to the six-jar-test criteria.

Table 1
Characterization of textile wastewater samples

Parameter	
Conductivity (mS/cm)	2.09
COD (mg/L)	2560
Colour	1.34
pH	10.5
Turbidity (NTU)	140.9

Table 2
Weights of the different criteria according to the experts committee tests

Criteria	Weights
COD	0.412
Turbidity	0.172
pH	0.140
Conductivity	0.049
Colour	0.085
V_{30}	0.081
Cost	0.061

For all experts COD was the most important factor to be considered, followed by turbidity. Weights of the other criteria were ranged depending on the expert. It was supposed that a physical–chemical treatment did not change dramatically the wastewater characteristics concerning conductivity, colour and pH.

3.3. Jar-tests results

Previous jar-tests showed that the raw wastewater pH was in the appropriate range for the coagulants addition. Thus, jar-tests carried out at different pH values are not included in this work.

Coagulant C did not reduce at all the COD and the turbidity of the wastewater in the jar-test. Thereby, only results with the other three coagulants are detailed. In Table 3, the clarified water characterization after the tests with the three other coagulants can be observed. It must be commented that the coagulants concentration range of the table was the effective range for COD and turbidity reduction.

In Fig. 2 the variation of the COD and turbidity values with the coagulants concentration can be observed.

For more than 700 mg/L of coagulant A, COD of the clarified water was lower than 1500 mg/L, reaching the minimum value for 900 mg/L (the lowest COD). However, the sludge production was high (V_{30} = 240 mL/L) and the high concentration of coagulant could increase the costs significantly.

For the case of combination between ferric chloride and an anionic polyelectrolyte, it can be observed that the process efficiency was very low and the quality of the clarified water was significantly worse than those obtained with the coagulant A.

Concerning the coagulant B, it can be highlighted that a coagulant concentration range between 400 and 600 mg/L yielded the best results in terms of COD of the clarified wastewater. However, very similar turbidity values were also achieved for higher coagulant concentrations. Besides, at the highest concentrations, the pH values of the clarified water are more appropriate for an additional biological treatment due to the acidic character of the coagulant.

In order to evaluate the results, it was decided to apply MCDA to all the alternatives in which COD of the clarified wastewater was <1800 mg/L. It has to be point out that the expert committee indicated that COD was the most important parameter to be considered and this is the reason why the pre-selection of the alternatives has been carried out according to this parameter. Thus, the alternatives to be considered were the following:

- Alt. 1: coagulant A at a concentration of 700 ppm
- Alt. 2: coagulant A at a concentration of 750 ppm
- Alt. 3: coagulant A at a concentration of 800 ppm
- Alt. 4: coagulant A at a concentration of 900 ppm
- Alt. 5: coagulant A at a concentration of 1000 ppm
- Alt. 6: coagulant A at a concentration of 1250 ppm
- Alt. 7: coagulant B at a concentration of 400 ppm
- Alt. 8: coagulant B at a concentration of 500 ppm

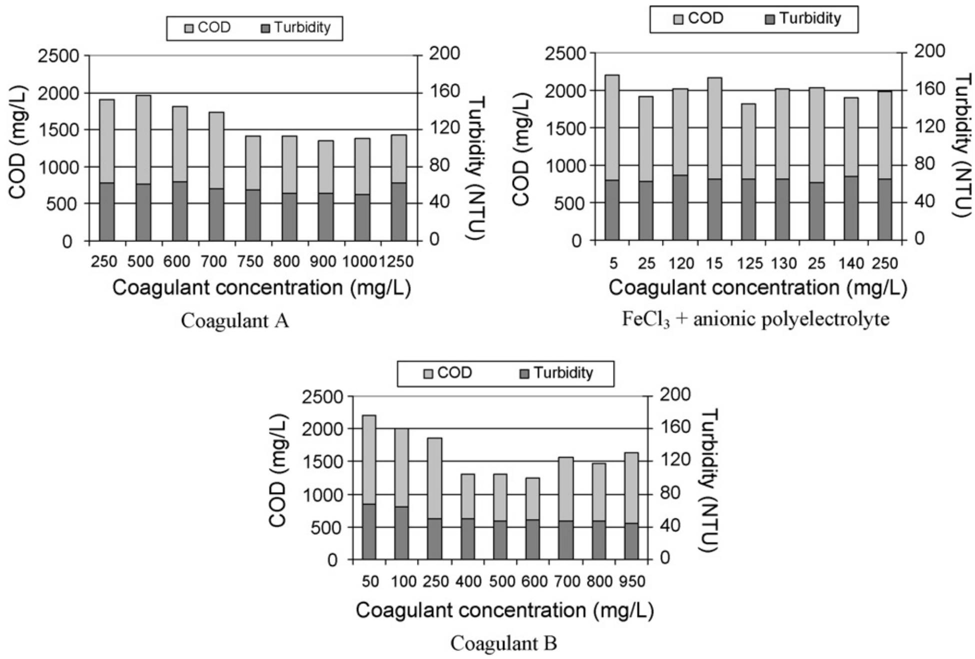

Fig. 2. Influence of coagulants concentration on COD and turbidity.

- Alt. 9: coagulant B at a concentration of 600 ppm
- Alt. 10: coagulant B at a concentration of 700 ppm
- Alt. 11: coagulant B at a concentration of 800 ppm
- Alt. 12: coagulant B at a concentration of 950 ppm

3.4. Evaluation and decision matrix

The decision matrix (Table 4) was made from the results obtained in the previous steps.

Table 3
Water characterization after different jar-tests with the coagulants tested

Coagulant A									
	Concentration (mg/L)								
	250	500	600	700	750	800	900	1000	1250
COD (mg/L)	1908	1965	1815	1740	1405	1415	1350	1375	1420
Turbidity (NTU)	62.0	61.5	63.5	56.5	55.5	52.0	51.0	50.5	63.0
pH	9.8	9.2	9.6	8.9	8.9	8.6	8.4	8.5	7.6
Conductivity (mS/cm)	1.43	1.37	1.71	1.71	1.70	1.69	1.70	1.69	1.26
Colour	1.01	0.91	0.81	0.66	0.64	0.61	0.55	0.49	0.8
V_{30} (mL/L)	40	95	125	160	180	180	240	325	350
Ferric chloride + anionic polyelectrolite									
	Flocculant (mg/L)								
	1			5			10		
	5[a]	25[a]	120[a]	15[a]	125[a]	130[a]	25[a]	140[a]	250[a]
COD (mg/L)	2200	1915	2025	2170	1820	2020	2040	1900	1980
Turbidity (NTU)	64.0	63.0	70.0	66.0	65.0	65.5	62.0	68.0	66.0
pH	10.4	10.4	10.2	10.2	10.2	10.1	10.4	10.2	9.9
Conductivity (mS/cm)	2.09	2.03	1.69	2.01	1.81	1.74	1.99	1.71	1.67
Colour	1.08	1.03	1.31	1.04	1.14	1.33	1.02	1.34	1.46
V_{30} (mL/L)	12	40	40	39	54	40	41	40	58
Coagulant B									
	Concentration (mg/L)								
	50	100	250	400	500	600	700	800	950
COD (mg/L)	2210	2000	1855	1308	1296	1248	1565	1465	1645
Turbidity (NTU)	67.5	65.0	50.5	50.0	46.5	48.5	47.0	46.5	44.5
pH	10.1	10.0	9.8	9.8	9.7	9.6	7.5	7.9	7.8
Conductivity (mS/cm)	1.99	1.90	1.87	1.76	1.71	1.69	2.10	1.94	2.18
Colour	1.07	0.88	0.62	0.56	0.61	0.43	0.64	0.51	0.54
V_{30} (mL/L)	31	61	96	100	110	120	58	60	64

[a] $FeCl_3$ concentration (mg/L).

Table 4
Decision matrix

	COD (mg/L) 0.412[a]	Turbidity (NTU) 0.172[a]	pH 0.140[a]	Conductivity (mS/cm) 0.049[a]	Colour 0.085[a]	V_{30} (mL/L) 0.081[a]	Cost (€/kg) 0.061[a]
ALT.1.A700	1740.00	56.50	8.90	1.71	0.66	160.00	6.70
ALT.2.A750	1405.00	55.50	8.90	1.70	0.64	180.00	7.18
ALT.3.A800	1415.00	52.00	8.60	1.69	0.61	180.00	7.66
ALT.4.A900	1350.00	51.00	8.40	1.70	0.55	240.00	8.62
ALT.5.A1000	1375.00	50.50	8.50	1.69	0.49	325.00	9.58
ALT.6.A1250	1420.00	63.00	7.60	1.26	0.80	350.00	1.97
ALT.7.B400	1308.00	50.00	9.80	1.76	0.56	100.00	7.00
ALT.8.B500	1296.00	46.50	9.70	1.71	0.61	110.00	8.75
ALT.9.B600	1248.00	48.50	9.60	1.69	0.43	120.00	10.50
ALT.10.B700	1565.00	47.00	7.50	2.10	0.64	58.00	12.25
ALT.11.B800	1465.00	46.50	7.90	1.94	0.51	60.00	14.00
ALT.12.B950	1645.00	44.50	7.80	2.18	0.54	64.00	16.63

[a] Weight.

3.5. Evaluation with AHP

The AHP method has been applied to calculate the criteria weights and the final rank of the alternatives. In our case the value of the different alternatives relative to each covering criterion has been given in an objective way. Thus, these values reflect the decision maker preferences (except that of pH). Therefore, these values have been introduced in a *direct* way in the software EC2000 and normalised with the sum.

For criterion pH the following utility function (uf) has been used:

- If pH <5.5 ≤ uf = 0 (pH should be increased if either an additional biological treatment or a discharge to the sewer have to be carried out).
- If pH ≤ [5.5–6.5] ≥ uf = 0.5.
- If pH ≤ [6.5–8.5] ≥ uf = 1 (optimum value for a biological treatment and for a discharge to the sewer).
- If pH ≤ [8.5–9.5] ≥ uf = 0.5.
- If pH > 9.5 ≥ uf = 0 (pH should be decreased if either a biological treatment or a discharge to the sewer have to be carried out).

Fig. 3 presents the final results obtained with EC 2000. The values shown represent the preference ratio associated to each alternative. According to this method the best alternative is coagulant B at a concentration of 800 mg/L because it has a preference ratio of 9.54%. Following in the ranking we can find a group of four coagulants with very similar ratios (B700, B950, B900 and A1000). The worst ranked coagulant is A at a concentration of 700 mg/L.

3.5.1. Sensitivity analysis

The weight of the criteria has a big influence in the rank order of the alternatives. The decision maker must know the degree of reliability of the results in order to be able to make the final decision. Therefore, a sensitivity analysis is recommended to be used once the global order of alternatives has been obtained. This consists in calculating again the rank order of the alternatives but with modifications in the weight of each criterion. With the help of software EC 2000 a complete sensitivity analysis can be performed. The way to do that is to increasingly or decreasingly modify the weight of each criterion little by little while the rest of the criteria weights remain fixed. In that way, the contribution of each criterion to the value of the alternatives may be analysed. After proceeding with the sensitivity analysis, the alternatives ranking may change. The analysis of all the possible changes can be done with the help of Expert Choice 2000, which has a very powerful and user-friendly sensitivity analysis module.

As an example, in Fig. 4 a graphical representation of one of the sensitivity analysis performed is presented. It shows on the left side the criteria weights modified in order to study the influence of the COD criterion weight (the most important one) on the preference ratios for the different alternatives (shown on the right side). For that, the COD weight had to be increased from 41.2% (Table 2) up to 67.5% so that the alternatives B800 and A900 could have the same preference ratio. That means that the weight of criterion COD has to be deeply modified in order to change the rank order of alternative B800, which shows that results are stable in front of weight modifications smaller than 20%.

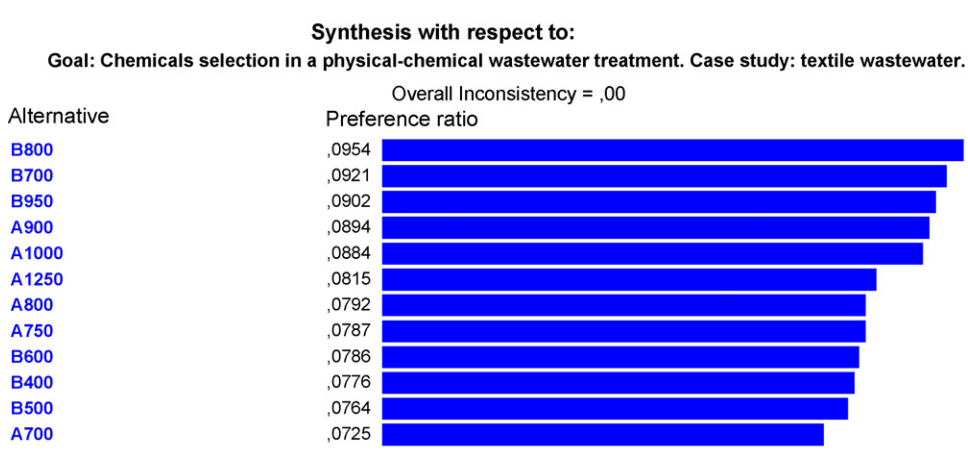

Fig. 3. Evaluation results with AHP.

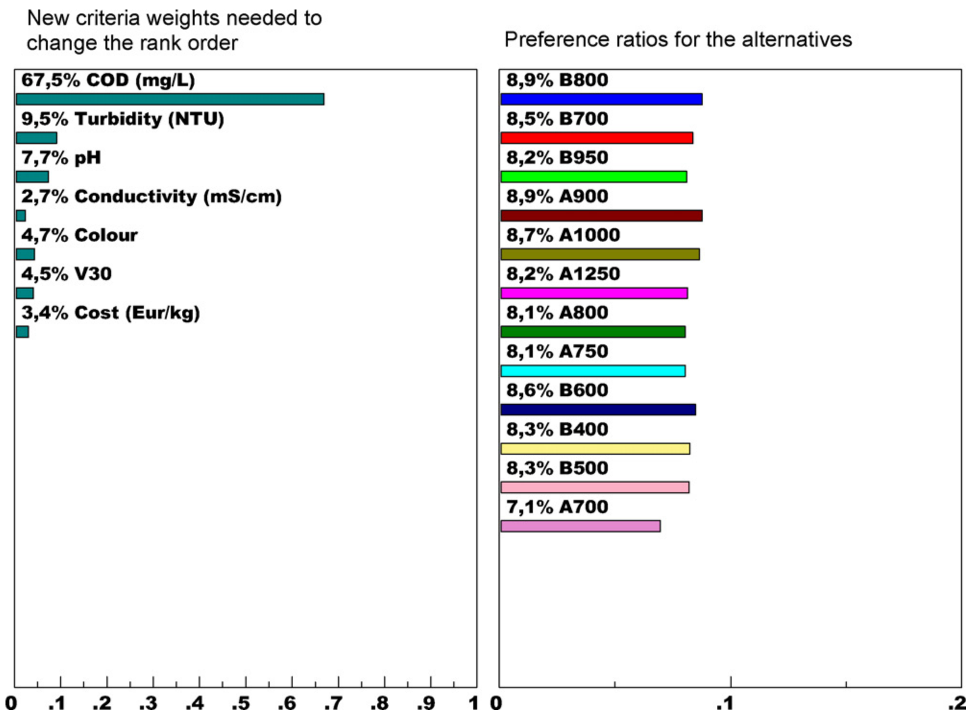

Fig. 4. Sensitivity analysis for COD criterion.

3.6. Evaluation with PROMETHEE II

The PROMETHEE method is sensitive to the type of the preference function chosen for each criterion. PROMETHEE does not propose a particular way of calculating the criteria weightings. In this work, the criteria weightings determined in Section 3.2 (by means of AHP) have been used for the application of the PROMETHEE method, as other authors recommend [25].

In this work four PROMETHEE scenarios have been analysed (Fig. 5):

(i) Scenario 1: in which all the criteria have a *usual* preference function.
(ii) Scenario 2: in which all the criteria (except pH) have a V preference function with a high preference threshold ($p = 50\%$).
(iii) Scenario 3: same as scenario 2 but with a higher preference threshold ($p = 100\%$).
(iv) Scenario 4: in which some criteria (COD, turbidity, conductivity and V30) have a linear preference function, which enables to consider measurement errors due to the measurement devices.

In Fig. 6, results obtained with Software DecisionLab are presented. Φ represents the difference between the positive and the negative flux $\Phi^+ - \Phi^-$ (see Section 2.5.2).

3.6.1. Sensitivity analysis

According to Mareschal [26], stability intervals for each criterion can be calculated for PROMETHEE. These values indicate the percentage within which the weight of one criterion can vary without modifying the original ranking.

Table 5 shows the stability intervals for each criterion.

3.7. Comparison between AHP and PROMETHEE

Table 6 shows all the alternatives ranking obtained with AHP and the four PROMETHEE II scenarios.

It may be observed that alternative B800 has taken first place in four of the five rankings. It is also notable that Scenario 1 of the PROMETHEE method shows a very different ranking since alternative B600 is the best in this scenario. This is due to the application of the usual preference function in PROMETHEE. In this case the entire criteria weighting underpins the best alternative without taking into account the difference between both alternatives. This means that the decision maker does not care whether the value difference is very small or very large, and this has an effect of reducing compensation between criteria.

In this case, it can be observed that alternative B600 is the best ranked for criterion COD, with a weight of 41.2%. For that, in Scenario 1 it is the best ranked one. However, both with AHP and in Scenarios 3 and 4 with PROMETHEE the effect of criteria compen-

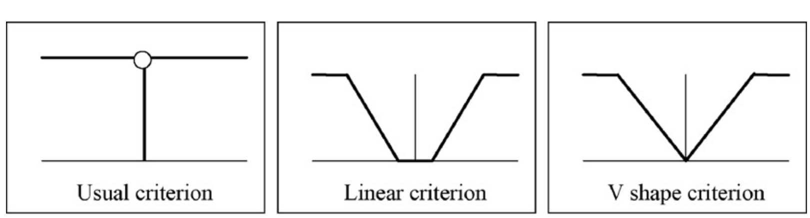

Fig. 5. Preference functions used.

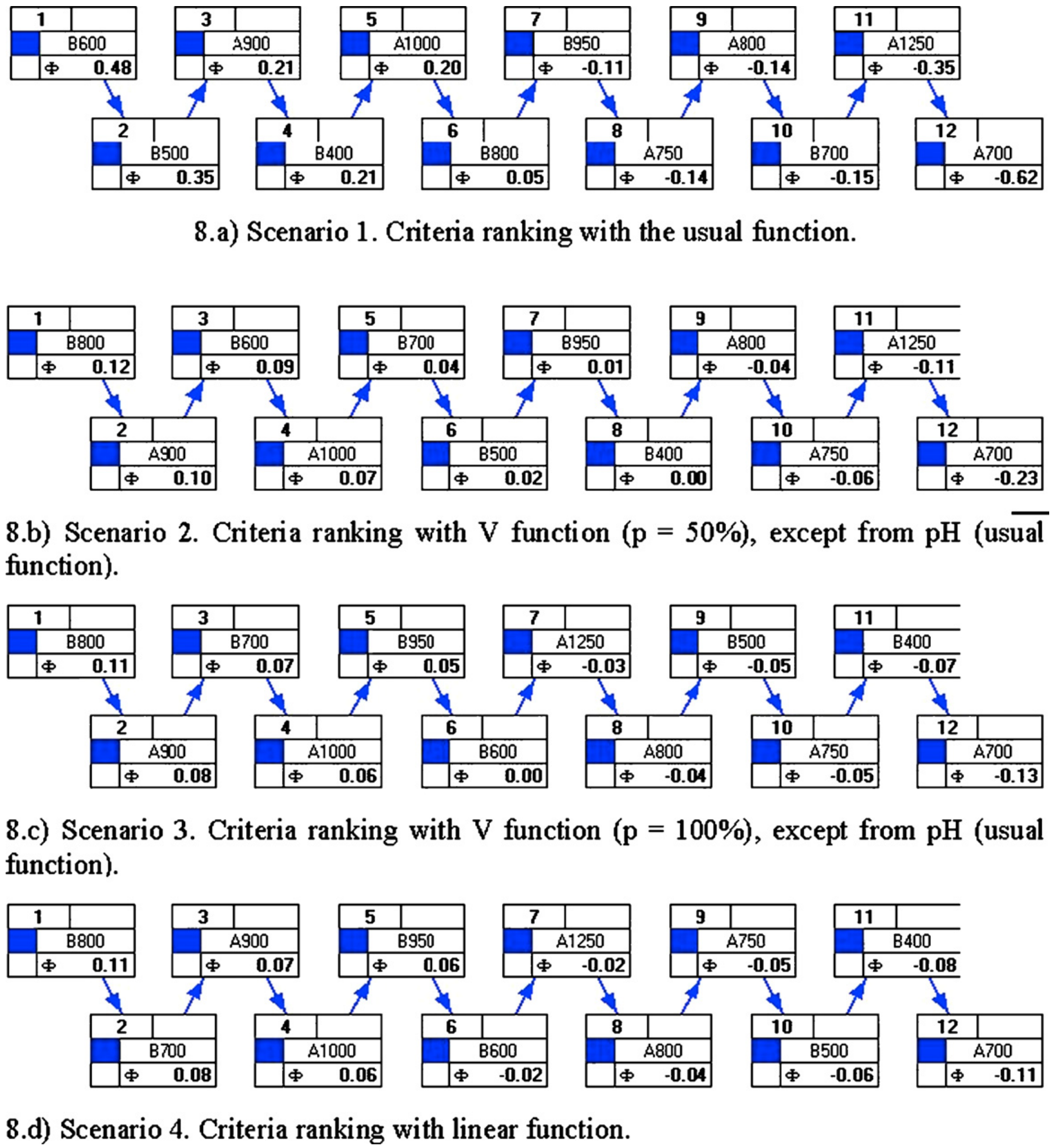

Fig. 6. Preference flows for the different scenarios with PROMETHEE.

sation appears, that means the best ranked alternative is the one that obtains better results for other criteria, although not for COD. In this case, it seems reasonable to think that a coagulant like B at a concentration of 800 mg/L is preferable to the rest of them because it shows acceptable results for the majority of the criteria. On the other hand, although coagulant B at 600 mg/L is the best one for the COD parameter, it has a bad behaviour for pH and a better behaviour for the rest of them.

Table 5
Stability intervals for each criterion

	%Weight	Stability intervals							
		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
		%Interval		%Interval		%Interval		%Interval	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
COD (mg/L)	41.20	40.70	42.44	40.04	42.05	36.22	41.70	41.05	42.65
Turbidity (NTU)	17.20	15.67	17.90	14.75	23.58	14.13	17.76	16.90	17.48
pH	14.00	13.78	14.44	13.63	14.57	13.88	15.29	11.97	14.06
Conductivity (mS/cm)	4.90	4.31	5.22	2.98	6.44	0.00	6.06	4.76	5.19
Colour	8.50	6.49	8.89	1.97	10.23	3.85	9.42	8.37	10.06
V_{30} (mL/L)	8.10	7.52	8.43	6.64	9.17	7.88	8.31	7.99	8.13
Cost (€/kg)	6.10	5.30	6.77	5.21	6.57	5.47	7.26	6.03	6.89

Table 6
Rankings obtained with AHP and PROMETHEE II

AHP	PROMETHEE II			
	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4
ALT.11.B800	ALT.9.B600	**ALT.11.B800**	**ALT.11.B800**	**ALT.11.B800**
ALT.10.B700	ALT.8.B500	ALT.4.A900	ALT.4.A900	ALT.10.B700
ALT.12.B950	ALT.4.A900	ALT.9.B600	ALT.10.B700	ALT.4.A900
ALT.4.A900	ALT.7.B400	ALT.5.A1000	ALT.5.A1000	ALT.5.A1000
ALT.5.A1000	ALT.5.A1000	ALT.10.B700	ALT.12.B950	ALT.12.B950
ALT.6.A1250	**ALT.11.B800**	ALT.8.B500	ALT.9.B600	ALT.9.B600
ALT.3.A800	ALT.12.B950	ALT.12.B950	ALT.6.A1250	ALT.6.A1250
ALT.2.A750	ALT.2.A750	ALT.7.B400	ALT.3.A800	ALT.3.A800
ALT.9.B600	ALT.3.A800	ALT.3.A800	ALT.8.B500	ALT.2.A750
ALT.7.B400	ALT.10.B700	ALT.2.A750	ALT.2.A750	ALT.8.B500
ALT.8.B500	ALT.6.A1250	ALT.6.A1250	ALT.7.B400	ALT.7.B400
ALT.1.A700	ALT.1.A700	ALT.1.A700	ALT.1.A700	ALT.1.A700

Results of PROMETHEE Scenarios 3 and 4 are very near the AHP one. This is due to the way in that the preference functions have been defined. They consider the compensation effect among criteria. It can also be noted that there is a group of almost indifferent alternatives (B700, B950, A900 and A1000). Finally, we also want to stress that alternative A700 is the worst ranked for any of the scenarios studied.

4. Conclusions

The authors of this work conclude that MCDA is a useful tool to choose after the jar-tests the chemicals to be used for a physical–chemical wastewater treatment. The use of MCDA techniques has allowed to aggregate the whole volume of information generated with jar-tests and to select the most suitable coagulant for the specific problem to be solved. The proposed tool has the advantage that it brings much information to the decision process and justifies the selection of the chemicals and their concentrations. The application of multiple criteria decision analysis (MCDA) allows this decision to be done in a serious and rigorous manner. This approach was highly valued by the experts who participated in the process, in the sense that these techniques provided them with a large amount of well-structured information. This fact supports the assertion “MCDA is not about finding the right answer, but is a process which seeks to help decision makers learn about and better understand the problem they face, their own values and priorities, and different perspectives of other stakeholders” [7].

Two of the best known MCDA techniques, AHP and PROMETHEE, have been successfully applied and can therefore be considered as a good complement for the jar-test.

The practical application of these techniques is not difficult but they require a good background comprehension. Both are supported by software, Expert Choice 2000 and DecisionLab, which make the necessary calculation easier. Various stakeholders can steer the process, especially during criteria weighting and evaluation of alternatives, in case the criteria cannot be objectively measured.

For the case studied, AHP and three of the four PROMETHEE scenarios proposed the same alternative (in terms of coagulant type and concentration) as the best one. The application of AHP is easy. The present study does not conclude that one of the techniques studied is the best, but the authors do recommend the use of AHP for weighting calculations because it does not require complex information from the decision maker. Additionally, it has solid theoretical foundations which are widely accepted by the scientific community, albeit correspondent critics.

PROMETHEE offers interesting features such as the reduced compensation effect or the rather direct data treatment which requires no previous normalisation. The use of independent or preference thresholds in order to establish to what degree evaluation differences are significant in constructing the decision makers preferences is a very interesting tool when dealing with imprecise data or measurement errors. However, according to the expertsǐ opinion, this last method was considered complicated to use for people without a MCDA background.

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