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Methodological Approach of Decision Support for the Development Choices of an Abandoned Quarry (The Landfill of Mohammedia-Morocco)

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ABSTRACT

The principal component analysis of the landfill of Mohammedia, was carried out by monitoring and spatiotemporal analysis of a number of physical and chemical tracers (temperature, pH, salinity, conductivity, dissolved oxygen, suspended solids, TOC and metal) of superficial waters during the years 2010-2012. It has, on the one hand, to evaluate several options in situations where no possibility is perfect, and secondly, to visualize the distribution of different individuals (wells), which gave an idea of their similarity relative the measured variables revealed two major groups: The group I is close to the proximal region of the river and landfill and submitted to direct influences of the latter and the group II, with transitional character between wells in Group I, which is characterized by a relatively high TOC showing a deteriorated water quality. And for the potential damage caused by the landfill of the waters of river El Maleh, the identification of suitable rehabilitation plan for this landfill becomes a necessity.

Keywords: Landfill; Wells; Analyse in Major Composantes; River El Maleh; Correlation

1. Introduction

The analysis multicriterion is a decision-making tool developed to solve complex problems which include qualitative and/or quantitative aspects in a decision-making. The choice of a site of arrangement of a quarry requires the use of an analysis of the spatial decision multicriterion [1].

The potential advantage of an approach based on Analyse in major composantes AMC for choosing type of rehabilitation approach is explained by the fact that it not only reduces the time and cost of the selection of the models of rehabilitation, but allows to evaluate several options in situations where no opportunity is perfect.

So, the AMC can also explore a set of observations collected in the form of a data table showing for each statistical unit observed values of a number of quantitative variables [2].

In addition, it allows to combine the economic, technological, environmental and social design for the importance of various criteria.

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2. Materiels and Methods

2.1. Study Site

The quarry of clay is situated near the river el Maleh, in the city of Mohammedia (33˚33"N; 7˚23"W), city of Moroccan Atlantic coast 65 km south of Rabat and 20 km north of Casablanca [3].

2.2. Choice of Stations

Five stations of sampling are distributed on the landfill were chosen so that they are representative, accessible, witnesses of the actual characteristics of these waters taken from wells at the various sites explored and to determine their overall physical and chemical processes defining the problem of contamination by the leaden and chromium [2,4]. Les échantillons d" eau de surface ont été prélevés à l" aide de flacons en polyéthylène de 250 ml, previously washed in the distilled water and transported in portable ice boxes (+ 4˚C).

The physico-chemical determinism water of the landfill and river el Maleh has been made by the analysis of 16 physical and chemical parameters of the water at the five stations. Five of these variables were measured in the ground: temperature, pH, salinity, conductivity and dissolved oxygen. The biological oxygen demand, chimical oxygen demande, nitrates, metallic Cr, Fe, Zn, Cd, Cu and Pb analysis, material suspended and the total organic carbon (TOC), were measured in the laboratory. The spatial evolution of the average values of the three years 2010, 2011 and 2012 of these parameters are shown in **Tables 1** and **2**.

2.3. Analyse in Major Composantes AMC

The methodology adopted for the realization of this analysis passed by the following stages [5,6]:

- A preliminary analysis concerning the modalities of the decision and the consequences which it will be necessary to take into account to guide the choice [7,8];
- An interpretation of how effectively the problem of decision support and the choice of an appropriate method to inform the decision;
- Implementation of this method, that is to say the collection of definitive data, performing calculations and interpretation of results [9].

3. Results and Discussion

The principal component analysis allowed us to perform linear transformations of a large number of inter-correla-

Table 1. Spatial Evolution of average values of the three years 2010, 2011 and 2012 for these parameters.

Sampling station	Te	PH	Ce	Sa	NO_3	COD	OD	MES	TOC	BOD5	Fe	Zn	Cu	Pb	Cr	Cd
Station (S1)	23.17	3.52	41.19	26	5.63	23.29	1.49	71.58	14.46	7.73	28.52	129.36	14.63	70.13	64.24	0.91
Station (S2)	23	3.90	43.49	30	4.54	20.87	2.33	65.52	8.67	7.51	28.51	130.13	14.04	50.78	63.18	1.09
Station (S3)	23.5	3.80	28.35	8	3.83	18.42	3.48	50.29	7.43	7.05	23.07	109.78	13.50	21.87	59.37	1.08
Station (S4)	22.05	5.89	3.11	3	2.46	16.19	6.52	29.57	9.76	5.47	26.61	102.00	9.07	30.23	77.23	0.28
Station (S5)	21.09	7.16	4.60	5	2.58	16.13	9.02	18.55	12.45	5.68	20.29	105.80	11.03	25.88	45.29	1.18

Te: temperature, pH: hydrogen potential, Sa: salinity, Ce: conductivity, OD: dissolved oxygen, BOD5: biological oxygen demand, COD: chimical oxygen demande, MES: material suspended, TOC: total organic carbon, Cr: Chrome, Fe: Fer, Zn: Zinc, Cd: Cadimium, Cu: Cuivre and Pb: Plomb.

Table 2. Descriptive statistics of the analyzed parametres.

Variable	Observations	Obs. with missing data	Obs. without missing	Minimum	Maximum	Average	Standard deviation
Te (˚C)	5	0	5	21.090	23.500	22.562	0.984
Hydrogen potential	5	0	5	3.519	7.161	4.855	1.597
Conductivity mS/cm	5	0	5	3.105	43.494	24.150	19.412
Salinity g/l	5	0	5	3.105	29.825	14.182	12.574
NO_3 mg/l	5	0	5	2.456	5.629	3.806	1.340
COD mg/l	5	0	5	16.133	23.289	18.979	3.097
OD mg/l	5	0	5	1.488	9.022	4.568	3.136
MES (mg/l)	5	0	5	18.547	71.580	47.101	22.755
TOC mg/l	5	0	5	7.430	14.459	10.553	2.863
BOD5 mg/l	5	0	5	5.469	7.732	6.688	1.047
Fe	5	0	5	20.290	28.520	25.400	3.620
Zn	5	0	5	102.000	130.130	115.414	13.371
Cu	5	0	5	9.070	14.630	12.454	2.336
Pb	5	0	5	21.870	70.130	39.778	20.293
Cr	5	0	5	45.290	77.230	61.862	11.450
Cd	5	0	5	0.280	1.180	0.908	0.364

Te: temperature, pH: hydrogen potential, Sa: salinity, Ce: conductivity, OD: dissolved oxygen, BOD5: biological oxygen demand, COD: chimical oxygen demande, MES: material suspended, TOC: total organic carbon, Cr: Chrome, Fe: Fer, Zn: Zinc, Cd: Cadimium, Cu: Cuivre and Pb: Plomb.

ted variables in order to obtain a relatively small number of uncorrelated components [10,11].

This approach has facilitated our analysis by grouping the data into smaller sets and to eliminate the problems of multicollinearity between variables [12,13]. Projections of physico-chemical parameters and wells obtained are presented in **Figures 1** and **2**.

The contribution to the total variability in the first three axes from the AMC performed on the values of the sixteen parameters obtained for the five wells is 97%, 69% for axis 1, 16% for the axis 2 and 11% for Axis 3.

Axis 1 is essentially characterized in the positive direction by three parameters that are strongly correlated: COD, Ce, Te, Sa, Mes, TOC, BOD5, Fe, Zn, Cu, Pb, Cr and Cd This axis defines an increasing gradient of the content of these elements on the left of the axis towards the right side. It can be called as an area of mineralization and rich in organic matter. By against axis 2 in the negative direction opposes the variables mentioned above PH and dissolve oxygen [14,15].

The projection of individuals on both factorial F1-F2 and F2-F3 shows a wide dispersion of wells showing their quite varied composition. However, two groups are identified:

Group I: it is made by the well P1, P2, P4 and P5. This group is characterized in part by a relatively high content of organic matter and the other by a high mineralization expressed in very high values of electrical conductivity depends on the concentration of the major elements groundwater characteristics. All of these wells are loca-

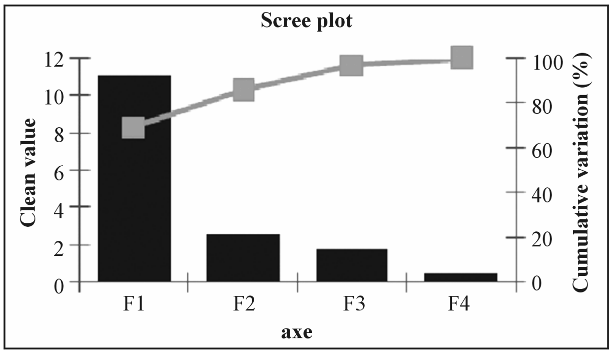

Figure 1. Individualized settings in four areas.

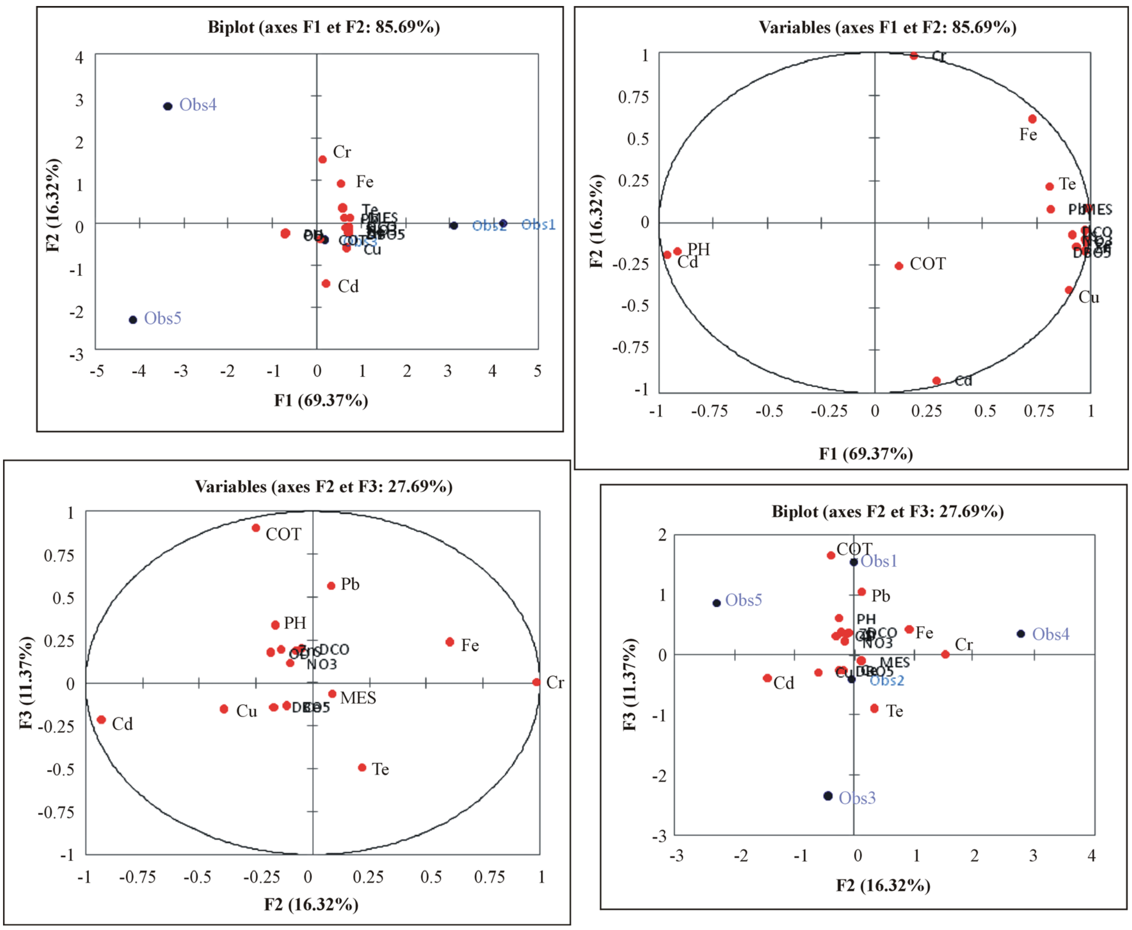

Figure 2. Projections of the physico-chemical parameters and well on the 1-2 plane and the 2-3 plane (during the companions of samples).

ted in the proximal of the landfill and the river.

Group II: it consists of a single well P3, which is characterized by a relatively high TOC showing water quality deteriorated. This well is located between wells in Group I, it can be regarded as a sink transition.

And for the potential damage of this discharge on the environment and near the site of the dam Oued el Maleh, identifying rehabilitation plan for the latter becomes a necessity [16].

4. Conclusions

The examination of the factorial plans will allow to visualize the correlations between variables and to identify the groups of individuals having taken the close values on certain variables. In our study, the variables which contribute most to the axis are also the ones which are the best represented, here we have thirteen parameters which are representative quoting: COD, Ce, Te, Sa, SS, TOC, BOD5, Fe, Zn , Cu, Pb, Cd and Cr.

The analysis allowed us to individualize two major Groups I and II from which we could see the potential damage caused by the discharge of the waters of Wadi el Maleh hence the need to identify a plan adaptable rehabilitation for this landfill.

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