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Retention supports and geochemical interactions of Trace Elements in two soils irrigated by sewage (Meknes, Morocco)

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ABSTRACT: The Ourzirha area located in the north-western of the Meknes City is an important agricultural region. This region is one of the principal suppliers of agricultural products to the Meknes citizens. However, the cultivated areas in the Ourzirha region are irrigated by a raw wastewater in major part. To explain and to predict the principal supports of the Trace Elements retention in these soils, two profiles subject to a sewage spreading are taken, a calcareous soil and a vertisol.
Based on the vertical evolution of different studied parameters and the selective affinities of Trace Elements to the active soil fractions present in our profiles, we are tried to determine the various interactions between the considered Trace Elements and the clay, calcite and organic matter contents in studied profiles. The results of this study showed the importance of clay and organic matter as a dominant supports of these pollutants, especially in surface soil. In the calcareous soil, the calcite content influences strongly the distribution of Trace Elements along this profile.
The mechanisms of the Trace Elements retention on studied profiles are considered as a selective adsorption on organic matter, clay and on calcite essentially. In fact, the possibility of a weak co-precipitation with calcite and organic matter in the calcareous soil isn't excluding. Also, in the vertisol probably, the Trace Elements contents are strongly influenced by the particular entering, favoured by a macro-porosity of this profile.

KEYWORDS: Sewage, Trace Elements, soil, phase retention, Morocco.

1 INTRODUCTION

The agricultural activity is a principal sector of moroccan economic by their important contribution in Gross National Product (15 to 20%) and as a premiere employer sector (>35% of employment). This activity based on the fertile soils and a favourite climate of country [1]. However, these important resources are subject to different anthropic pressures. In general, the different degradation forms of soil quality are a result of excessive use of fertilizers and an overexploitation, especially in urban agriculture [2]. The protection and a best management of these resources is a principal objective of the actors in agricultural domain.

In this study, we try to do an identification of various site of Trace Elements retention in two studied profiles. These different geochemical interactions of the Trace Elements with various soil fractions are very important to identified different behaviours and bioavailability of these pollutants in the soils. This knowledge is very significant for the management of the quality and the setting of the culture of the soils, and also to be able to determine and set the standards on the limit of the contents of these pollutants. These Trace Elements in the soils have a different origins, geogenic origins (Parental material), or an exogenic origins due to the anthropic effects [3] , [4] , [5] et [6].

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In the past, the effect of the local remobilization [6] by the changes of physicochemical conditions in the soil mass [3] , [4] et [5]. In the soil, the exogenous Trace Elements are gown to be associated to the different soil components with various paths. These various associations are based on the affinities of these pollutants to the presence of active soil fractions. In general, these different information is an important factor to the determination of the mobility and biodisponibility of pollutant in soil [7] , [8] et [6].

Our study is carried out on two soils developed on rocks rich naturally in Trace Elements (Table 5), and which is subjected to a spreading by sewage. To study and evaluate the variation of the geochemical interactions with the principal components of the soil implied in their retentions, a profound interpretation of vertical variation of various studied parameters and correlations matrix for an explication of retention and fixed mechanism of these pollutants on two studied profiles [9].

2 MATERIALS AND METHODS

2.1 SITE DESCRIPTION

The Ourzirha area is closed to Meknes City (Fig.1). It is known by its agricultural activity. Indeed, cultivated are subjected to spreading by raw wastewater. Two profiles of soils were taken, a vertisol and a calcareous soil “French Classification of soil: CPCS, 1967” [10].

The calcareous soil is developed on quaternary limestone. It presents on the surface an Ap horizon, thick of 25cm, black colour and a Silty-sand texture, overcoming a structural horizon (B), thick of 45cm, and in bottom a Bca horizon, thick of 50cm, rich in Fe-Al oxyhydroxydes and limestone concretions (Table 1).

The vertisol developed on Miocene marl is characterized by a profile made up of a cultivated horizon Ap, thick of 15 cm, of brown colour and a Silty-clay-sandy texture, overcoming an A1 horizon, thick of 15cm, which differs from the Ap horizon by its clearer colour. The whole of the profile is dominated in its bottom by a (B)ca horizon, thick of 70cm very rich in clays (25%), (Table 2).

2.2 SAMPLING & ANALYSES

The samples are taken in pits of 1.2 m and 1 m depths for the calcareous soil and the vertisol respectively. 17 samples are taken on two profiles of soils irrigated by a raw wastewater. The samples after air drying and crushing were subjected to an analysis by ICP-AES for the determination of TEs (As, Cd, Cr, Cu, Ni, Pb and Zn).

The clay fraction is calculated after drying with the drying oven at 105°C and weighed solid load contained in the sample with the pipette of Robinson [11]. The organic matter was determined by the loss on the ignition [12], [6]. The percentage of calcite was determined by the calcimetry, using a Bernard calcimeter [13]. The rock-mothers show important contents of Trace Elements (Table 5).

3 RESULTS & DISCUSSIONS

Based in the vertical evolutions of Trace Elements contents on the studied profiles, and their different affinities to the various soil fractions, we can explain the principal geochemical interactions between the considered Trace Elements and clay, calcite and organic matter, as principal components of soils implied in their retentions [3] , [8] , [4] , [14] et [5]. However, the correlation matrixes are considered to explain a similarity of Trace Elements comportments along the studied profiles by the analysis of their significant correlations.

The retention mechanism type with active soil fractions is predict by the distribution of different studied parameters along studied profiles based on the literature data. These correlations can provide significant information on the sources and become Trace Elements in soils [9]. On the other hand, the different correlation between the considered Trace Elements and clay, calcite and organic matter are insignificant due to no linear relation between these parameters most likely.

3.1 ON CALCAREOUS SOIL PROFILE

The As and Cu are strongly correlated positively between them (Table 3) and this is an index of the same mechanism which controls their behaviours in the profile [12] et [5]. Figure 2, illustrate the vertical evolutions of different parameters along the calcareous profile. In this figure, the contents of the two Trace Elements follow the evolution of organic matter and clay, particularly in surface respectively. This comportment can be interpreted by the retention of these pollutants on the

profile by these soil fractions. The affinity of these pollutants with respect to these two active components of soil is very known [3], [8], [4] et [5]. The mechanism which controls the retention of these two Trace Elements on this profile is probably selective adsorption on the organic matter and clay in surface and on the calcite in the rest of profile.

Ni and Cd are slightly correlated, but its have a similar comportment in this profile, especially in the (B) horizon (Fig.2). Based in the vertical evolutions of the contents of the Ni and Cd in this profile, we can explain that these Trace Elements are retained with slightly contents on organic matter and clay, in surface, and principally on calcite along the profile. These Trace Elements are strongly fixed in the (B) and Bca horizons by the calcite probably.

The Cu, Pb, and Zn show a similar comportment along this profile. These Trace Elements are strongly correlated between them (Table 3). The vertical evolution of their contents in profile enables to say that the mechanism which controls the distribution of these Trace Elements in the profile is probably primarily adsorption on clay and organic matter in surface horizon and the calcite along the profile.

On this profile, the importance of calcite as support dominating in the retention of the Trace Elements in this calcareous soil is well marked [3] et [5]. But the retention of Trace Elements in surface horizon by the clay and organic matter constituents are dominated [8].

3.2 ON VERTISOL PROFILE

The Cd, Cu, Pb, and Zn are strongly correlated (Table 4) as an indication of this similar comportment along this profile. The vertical evolution of these Trace Elements on profile (Fig. 3), well show their important accumulations in surface, influenced by the organic matter and clay contents probably. In fact, these affinities are much known in soil surfaces [3], [8], [4], [14] et [5]. The mechanism of this retention in the profile can be interpreted as an adsorption organic matter and clay in surface and secondary on calcite in down layers [8], [14] et [15].

The As, Ni, and Cr show a good correlations between them (Table 4). Their contents are low along the profile with a small accumulation in surface (Table 3). Thus, the contents of the three Trace Elements in surface profile are influenced by the sewage application in soil [16]. The vertical evolutions of these Trace Elements in profile (Fig. 3) show a small variation, with weak accumulations in up soil. These accumulations are influencing essentially by organic matter and clay contents. And on the remainder of profiles the principal support is a calcite and clay fraction.

The two Trace Elements, Cr and Ni are small correlated on the profile (Table 3) indicate the difference of their principal retention mechanism along profile. The Ni is fixed essentially by the calcite in A1 and (B)ca horizons. On the other hand, the Cr is fixed by the organic matter in surface and the clay in the (B)ca horizons (Fig. 3).

4 TABLES AND FIGURES

4.1 TABLES

Table 1. Contents of various studied parameters on the calcareous soil

Depth (m)	Samples	OM %	Clays %	CaCO3 %	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Zn (mg/kg)	Ni (mg/kg)
0	Cp2-8	17,34	14	13,9	5,1087	0,2425	26,1329	10,2174	19,6488	57,7675	18,4699
-0,25	Cp2-7	16,95	7	15,51	10,5565	0,1478	56,4541	9,868	11,0154	48,6515	29,145
-0,4	Cp2-6	11,44	9	18,72	6,5729	0,1846	24,4989	6,7721	6,3737	31,6693	17,1293
-0,55	Cp2-5	12,53	6	21,92	6,6082	0,3622	24,7808	6,6082	8,4668	30,15	17,1401
-0,7	Cp2-4	11,84	8	6,06	7,491	0,3754	33,8167	8,1331	11,1295	37,0271	51,153
-0,85	Cp2-3	11,91	4	13,19	9,5862	0,3821	45,3165	10,2398	11,547	46,1353	28,7586
-1,1	Cp2-2	11,62	4	8,56	13,6614	0,3928	47,703	10,526	11,6558	46,1353	29,7864
-1,2	Cp2-1	11,43	2	2,35	17,6948	0,1986	47,4638	16,8612	20,4011	54,3335	33,7243

OM : organic matter

Table 2. Contents of various studied parameters on the vertisol

Depth (m)	Samples	OM %	Clays %	CaCO3 %	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
0	Vp2-9	26.63	19	40,64	3,4049	0,3513	29,4421	10,4149	24,8355	12,4178	41,4534
-0.05	Vp2-8	26,13	20	40,64	2,2945	0,3659	33,5827	7,7178	16,687	7,092	44,0121
-0.1	Vp2-7	25.72	19	40,64	2,1219	0,3722	27,7974	7,0024	14,4292	7,8512	36,9217
-0.15	Vp2-6	25.43	18	40,64	1,0251	1,1835	28,8649	12,3707	16,4942	24,7414	294,8345
-0.2	Vp2-5	26,10	18	40,64	1,5965	0,35	27,5402	7,5835	17,3623	8,1822	38,1172
-0.25	Vp2-4	28,77	19	51,87	1,7187	0,3768	22,5583	7,3046	27,7145	6,4452	35,8784
-0.5	Vp2-3	29,23	18	59,89	5,41	0,163	27,8564	4,9221	24,3982	4,4978	30,2113
-0.7	Vp2-2	23,96	48	48,13	4,8714	0,2783	33,5449	7,4613	27,4608	7,2352	47,9331
-1	Vp2-1	22,79	19	41,71	5,8485	0,2222	34,4884	7,5144	21,2495	8,8436	41,4534

OM : organic matter

Table 3. Correlations Matrix of the Trace Elements on calcareous soil profile

	As	Cd	Cr	Cu	Pb	Zn	Ni
As	1	-0,11	0,74	0,84	0,41	0,43	0,34
Cd		1	-0,13	-0,26	-0,22	-0,29	0,29
Cr			1	0,58	0,20	0,49	0,41
Cu				1	0,81	0,76	0,26
Pb					1	0,88	0,13
Zn						1	0,08
Ni							1

The values in fat are significant

Table 4. Correlation Matrix of the Trace Elements on vertisol profile

	As	Cd	Cr	Cu	Ni	Pb	Zn
As	1	-0,63	0,53	-0,48	0,50	-0,44	-0,43
Cd		1	-0,14	0,83	-0,41	0,94	0,96
Cr			1	0,06	-0,14	0,01	-0,02
Cu				1	-0,23	0,93	0,72
Ni					1	-0,34	-0,36
Pb						1	0,91
Zn							1

The values in fat are significant

Table 5. Contents of Trace Elements (litho-geochemical Funds) of the rock-mothers of studied soils (Saïs Basin)

	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Quaternary Calcareous	41.283	4.836	0.345	7.255	10.191	18.828	7.600
Miocene Marls	68.572	4.6145	50.7995	17.707	23.0265	78.6255	53.3745

4.2 FIGURES

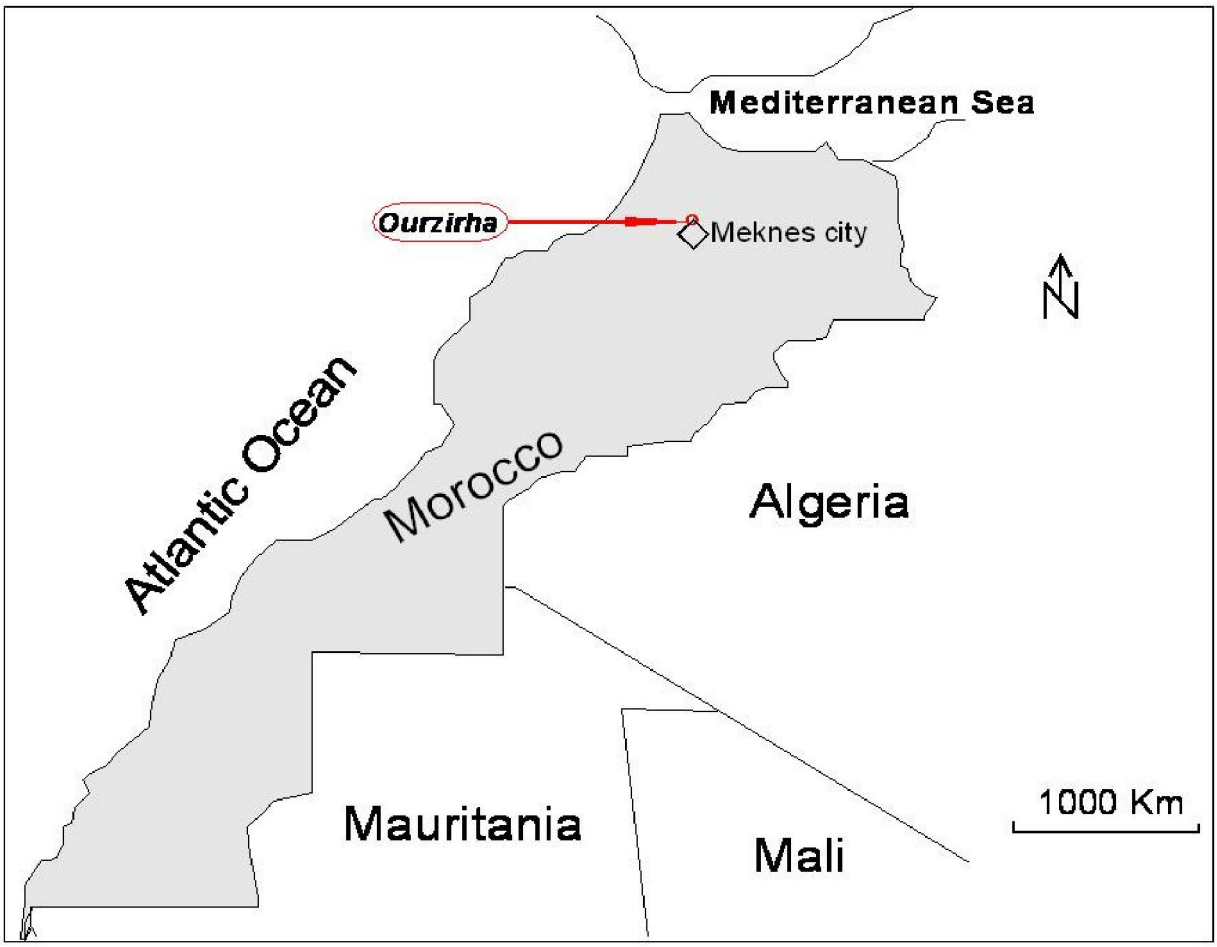

Fig. 1. Localization of the site of study

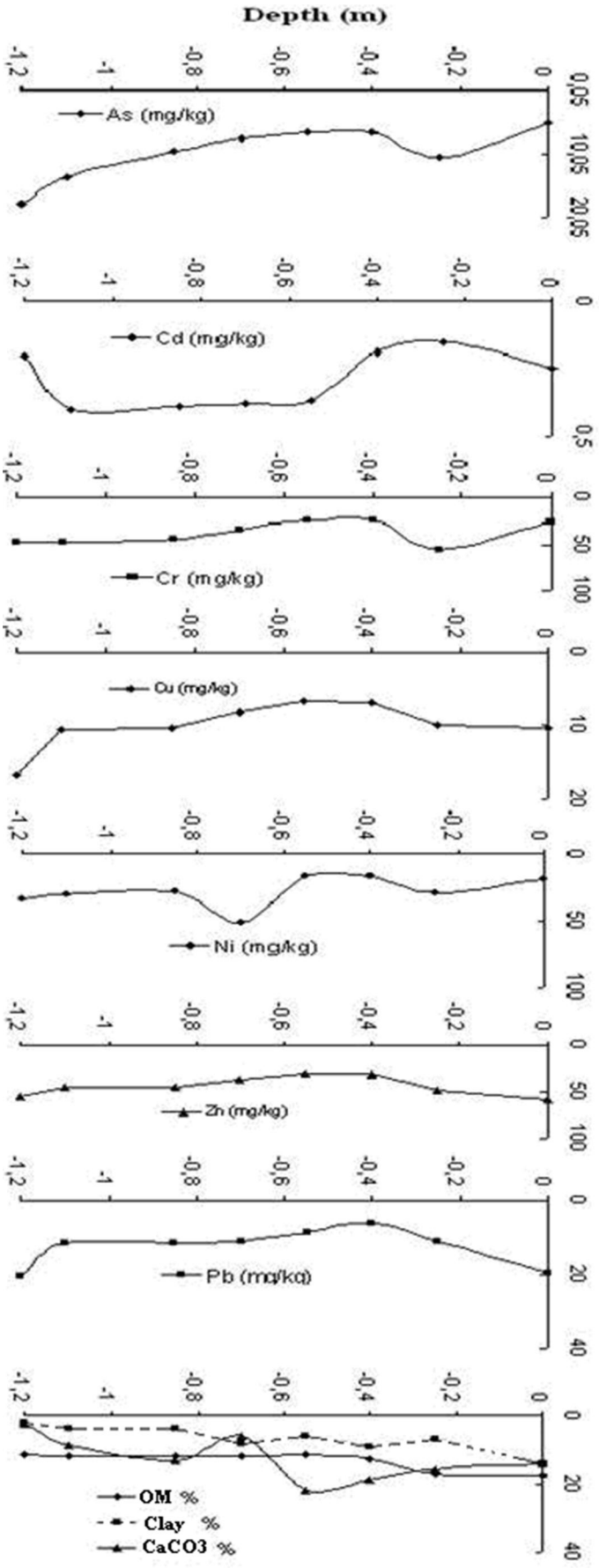

Fig. 2. Vertical variations of different parameters on calcareous soil profile; OM : organic matter.

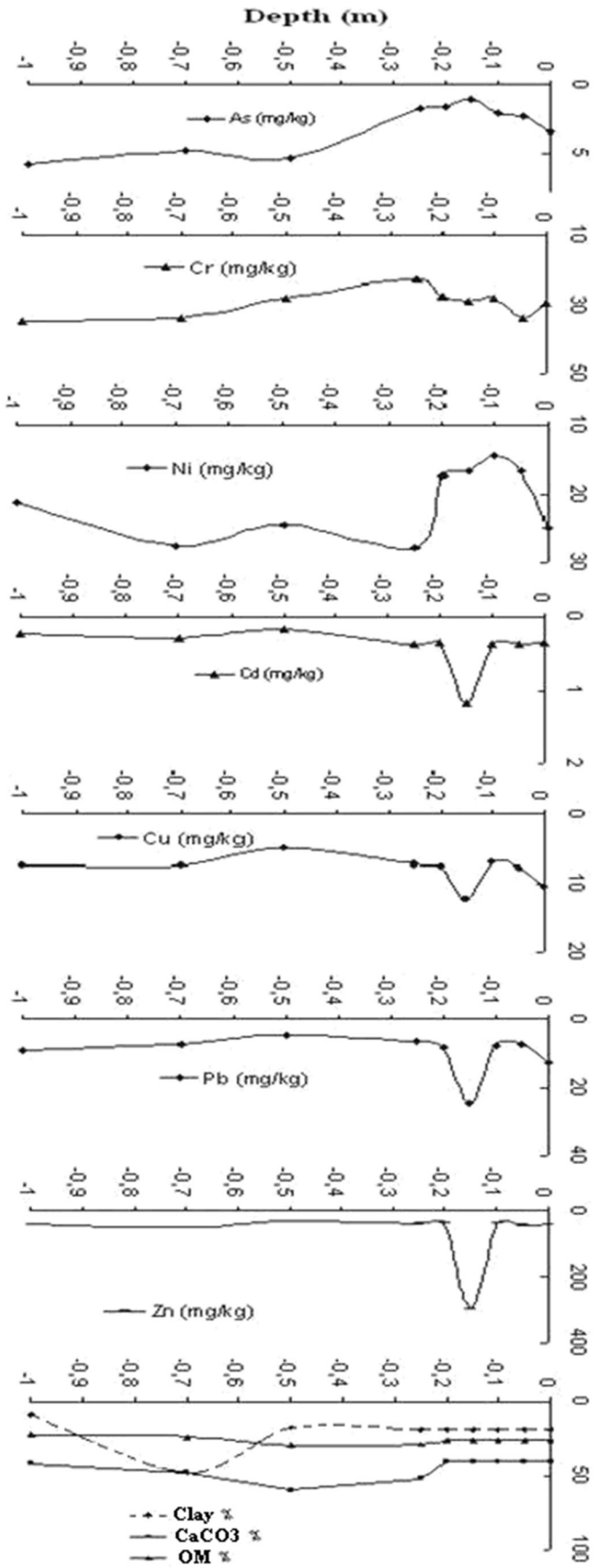

Fig. 3. Vertical variations of different parameters on vertisol profile; OM : organic matter

5 CONCLUSION

In this study the preliminary results show the major importance of active soil fraction, i.e., clay, organic matter and calcite in the Trace Elements retention in the two studied profiles. The contents of Trace Elements are fixed in majority in surface and in based profiles. After our analysis and different interpretations the more contents of organic matter in up-soil is a principal cause of this retention of trace elements in these layers on two profiles. The contents in bottom horizons are related to parental materials.

The dilution effect of calcite, - e.g., by a co-precipitation -, on pollutant contents is a major factor of the absence of positive anomalies in the calcareous profile. But, the importance Trace Elements contents in this profile, their different horizons haven't an abnormal accumulation. On the other hand, the vertisol profile showed an importance accumulation in surface soil, especially for Zn, Pb, Cd and Cu influenced by the exogenic contributions. And an important lixiviation on this profile through the macroporosity by particular transport with clay and organic matter essentially.

Finally, in the two profiles, the major role of calcite in the retention of the Trace Elements is quite illustrated, in particular on the calcareous soil, and also, the dominant importance of adsorption on the organic matter and clay in the upsoil.

These different results can be verified by the sequential extractions and/or a numerical models used for geochemical simulations with a specific software.

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