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ASSESSMENT OF ATMOSPHERIC LEAD CONTAMINATION OF BANKS SOILS USING SOILS TAMARISK GROVE. CASE STUDY OF THE KEBIR-RHUMEL (ALGERIA)

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Abstract: In order to know the role of the tamarisk grove in the soil contamination by lead (Pb) fallout, ten stations were randomly selected along the Kebir-Rhumel wadi which skirts a heavy traffic road. In each site, the sampling stations were chosen so as to contain a vegetation plot nearby a bare plot. All the stations were localized on the road side. Two soil's samples were taken in the middle, the road and wadi side of each plot. Tamarisk leaves were the object of an average sampling. Pb concentration was measured, by (ICP-OES) in washed (0.53 $\mu g.g^{-1}$) and unwashed leaves (1.23 $\mu g.g^{-1}$), and in total extracts of soils (18.0 $\mu g.g^{-1}$), which were also the object of organic matter (OM), pH, electrical conductivity (EC), total $CaCO_3$, cation exchange capacity (CEC) and particle sizes analysis. Significant differences were noted between washed and unwashed Pb leaves contents, suggesting an atmospheric contamination source, apparently from the road traffic. Pearson correlation coefficients indicate that total Pb soil contents were significantly and positively related to OM (3.30 %) and clay (10.20 %) in vegetation plots, and to pH (7.82), CEC (17.60 $cmol^+.kg^{-1}$) and silt (30.90 %) in the bare plots. Analysis of variance (ANOVA) and Scheffe's test reveals Pb, OM and clay contents in vegetation plots (especially in the middle of tamarisk grove) are significantly greater than in bare plots. The results show that the tamarisk grove, through the generated OM rates and the clay catching, would allow the retention of Pb in the soils, thus its mobility will decrease towards the stream water.

Keywords: lead, soil banks, tamarisk, Kebir-Rhumel wadi, atmospheric contamination

1. INTRODUCTION

The contribution of cars and road transport to the global emission of atmospheric pollutants is regularly increasing. These pollutants have an impact on the environment: road transports, contaminate the atmosphere, water and soil near the highway via atmospheric fallout. Traffic pollutants include potentially toxic metals for health like lead (Caussy et al., 2003). It is a nonessential element whose biogeochemical cycle is significantly affected by man (Nriagu, 1978).

Lead is a potentially toxic metal that occurs naturally in soils (its natural occurrence is related to the composition of the bedrock), in concentrations ranging from 1 to 200 mg $Pb.kg^{-1}$ soil with a mean of 15 $mg.kg^{-1}$ (Alloway, 1995). It can also enter the soil through numerous anthropogenic activities such as traffic road (Alkorta et al., 2004). Indeed, many studies have indicated that the soils and plants of roadsides are generally contaminated with heavy metals, particularly Pb (Singh et al., 1997; Liu et al., 2007).

One of the most significant wadi of Algeria, the Kebir-Rhumel, skirts a heavy traffic road in the northeast of Algeria. It crosses two different bioclimatic zones: the semiarid on upstream of Constantine and the sub humid in its downstream. This significant wadi crosses various lithological formations and has a great topographic variation: an altitude of more than 400 m separates its upstream section from its downstream one. It comprises in its middle, one of the biggest dam of Algeria.

The Kebir-Rhumel wadi is bordered by a degraded riparian, intersected at several places by large land pieces completely stripped. The tamarisk grove is among the most frequent vegetation formations of the Kebir-Rhumel wadi riparian. The tamarisks are considered by many authors (Grubb et al., 2002; Ellis, 1995; Di Tomaso, 1998; Zavaleta, 2000; Imada et al., 2012) as very harmful trees to their ecosystem involving in particular the salinization of the soils. However, the soils salinization can help the leaching of heavy metals and reduce their retention within the soils (Acosta et al., 2012). However, other authors (Lesica & De Luca, 2004; Yin et al., 2010) have shown a low salinization of tamarisk and an increase in their levels of soil organic matter.

The assessment of atmospheric lead contamination of banks soils of kebir-rhumel wadi has been understudied. In addition, the role of Tamarisk grove on lead interception by this plant has not been investigated. This study aims to determine lead level in soil from the banks of kebir-rhumel wadi, the ability of *Tamarix gallica* to accumulate such metal from soil and hence it's potential for phytoremediation.

2. MATERIALS AND METHODS

2.1. Study area and sampling

The study area for the determination of assessment of atmospheric lead contamination of banks soils is located in the Kebir-Rhumel watershed (East of Algeria) (Fig. 1). It covers an area of 8795 Km^2. The climate of the region is Mediterranean, with considerable seasonal fluctuations in temperature and less humidity.

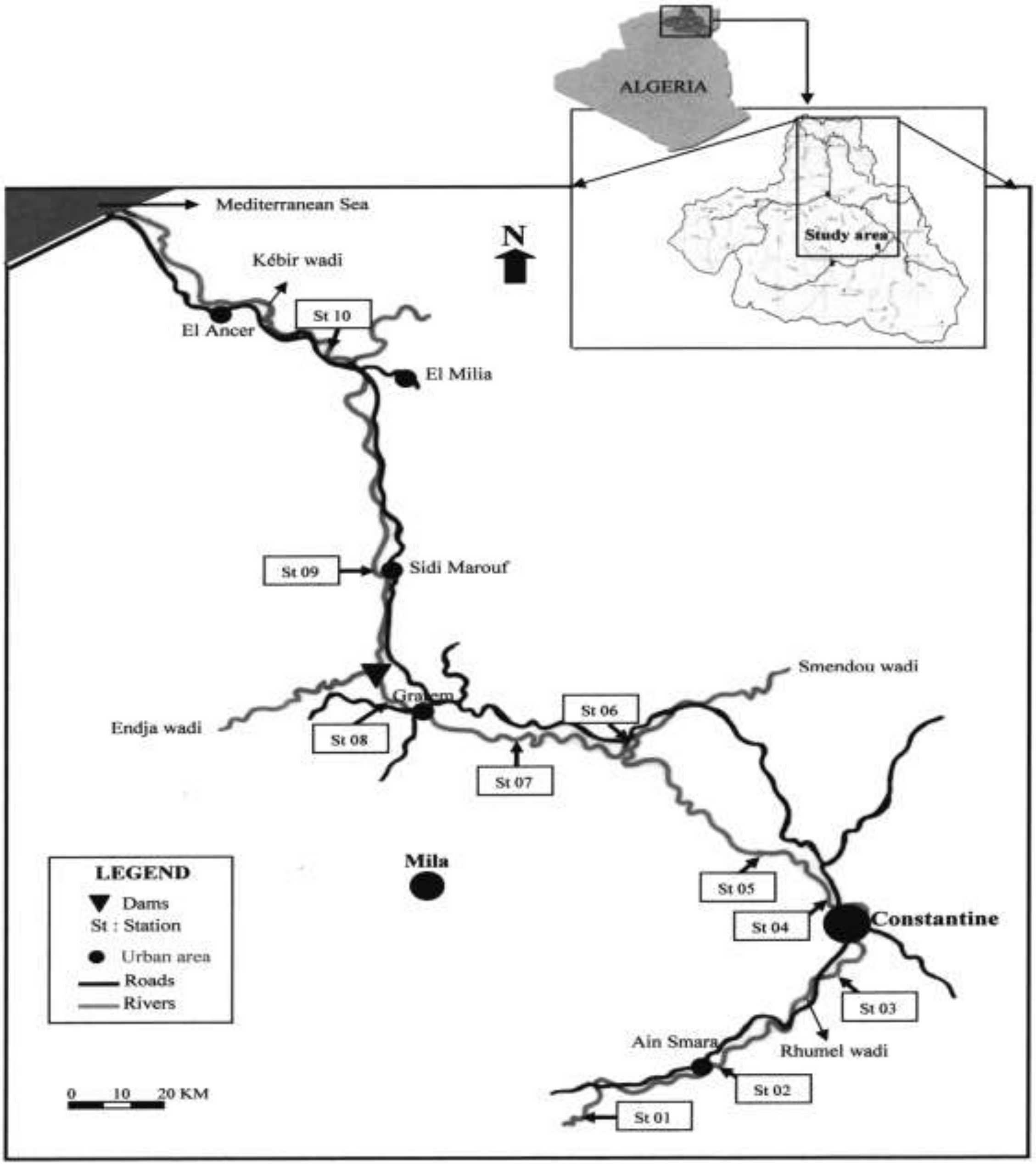

Figure 1. Location of the sampling stations.

Precipitation is low (mean annual rainfall: 528 mm).it is highly irregular and usually absent in July and August, hence during the dry season the hydric balance is clearly negative. Ten stations were randomly selected along the Kebir-Rhumel wadi (Fig. 1) in order to have a vegetation plot next to bare plot. All the stations were localized on the side of the road which is skirting the Kebir-Rhumel wadi. They were, approximately, 500 m distant from the road.

The soils sampling were carried out with a drill at two depths (0-20 cm and 20-40 cm) with two repetitions, in three positions of each type of plot: side of the road (RS), middle (MS) and side of the wadi (WS) (Fig. 2). In the vegetation plot, the middle corresponds to the tamarisk grove.

2.2. Analysis of soil parameters

Samples were collected, air dried and sieved at 2 mm. Organic matter (OM) was analysed by dichromate oxidation and titration with ferrous ammonium sulphate (Walkley &Black, 1974). The $CaCO_3$ equivalent was determined using a Bernard calcimeter. Electrical conductivity was measured in a 1:5 soil/ water suspension. Soil pH (H_2O) was determined in a 1: 2.5 soil water suspension (with glass-electrode W/V), the pH meter was calibrated with three buffer solution (pH=4.0; 7. 0; and 11), and cation exchange capacity (CEC) using a NH_4 oxalate displacement (AFNOR, 1994). Particle size analyses were conducted following oxidation of organic matter with hydrogen peroxide, dispersion with sodium hexametaphosphate and stirring for 16 h. Sand was separated by sieving, silt and clay fractions were determined using the Robinson pipette method (ISRIC, 1984).

2.3. Digestion of Pb soil

0.5 g of soils were placed inside Teflon vessels with 7.5 ml HNO_3, and 2.5ml HCl. The samples were digested in a microwave digestion system (Berghof-speedwave MWS-2).

2.4. Digestion of Pb leaves

Leaves samples were divided in two parts: one unwashed and the second washed with deionized water. The two parts were dried at 105°C for 48 h, milled to pass through a 2 mm mesh sieve. Then, 0.5 g of dried leaves was placed inside Teflon vessels with mixture of hydrogen peroxide (H_2O_2) and nitric acid (HNO_3). The samples were digested in a microwave digestion system (Berghof-speedwave MWS-2).

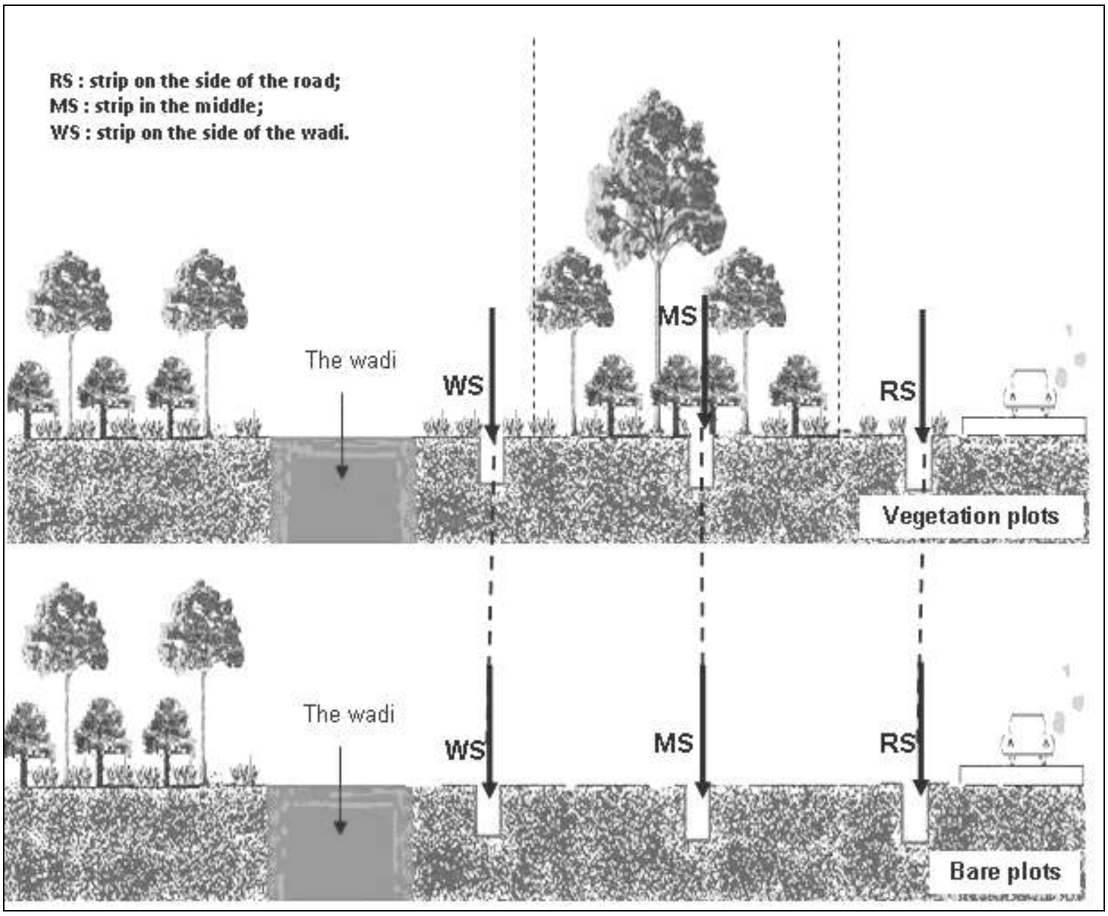

Figure 2. Experimental design.

2.5. Analytical methods

The composition of digested samples (soils and leaves) was determined by inductively coupled plasma optical emission spectrometer (ICP-OES MPX CCD from Varian) in Laboratory of Analytical Chemistry and Applied Ecochemistry, University of Gent (Belgium).

Standard reference samples used in leaves analysis was Olea europea leaves 62- BCR; and, in soil analyses, Calcareous loam soil 141-CRM. The samples were analyzed in three repeats.

2.6. Statistical analysis

Statistical analysis was carried out using the STATISTICA (version 6.0) software package. Basic statistics were used to calculate the mean values and standard deviations for n=240 samples collected in the study area. ANOVA was used to detect significant differences between sampling sites ($p<0.05$). The Scheffé's multiple mean comparison test was also used in the ANOVA. The relationship between metal concentration in plants and soils was tested by the Pearson correlation coefficients (r).

3. RESULTS AND DISCUSSION

3.1. Lead concentrations of leaves

The average concentrations of lead measured in washed and unwashed tamarisk's leaves are shown in table 1.

The average Pb concentrations of unwashed leaves were definitely higher than those of the washed ones (Table 1). The ANOVA analyses showed that there is a significant variation of Pb concentrations between the two leaves categories. Hence, Pb concentrations determined in this part of the plant come essentially from an atmospheric deposit. Indeed, Birbaum et al., (2010) have reported that smaller particles of lead may be incorporated into leaves, whereas large agglomerates are trapped on the surface wax. According to Kabata-Pendias (2001), atmospheric lead can be taken directly through the leaves and very little amount was taken directly from the soil.

The confidence interval of the average concentration of the washed leaves has significant amplitude, which indicates a great Pb dispersion and thus, heterogeneity in its distribution in the studied area. Such heterogeneity could be explained by the variability of the distance between the road and the wadi (Fig. 1) and by the differences in the traffic road concentration according to the road sections. Indeed, Bakirdere & Yaman, (2008); Morton-Bermea et al., (2009); Khan et al., (2011) reported that, in areas where traffic volumes are heavy, the potential for contamination of the roadside ecosystem is significant, particularly in terms of the deposition and uptake of Pb. Moreover, Jaradat & Momani (1999) have reported that the most of the locations in Amman showed a significant correlation between airborne Pb and vehicular traffic density, indicating that automobile exhaust emissions could be the source of atmospheric lead in the city.

Table 1. Pb contents ($\mu g.g^{-1}$ dry weight) in washed and unwashed leaves, with confidence limits at 95%, extreme values (in brakets), and Anova results.

	Washed leaves (n = 20)	Unwashed leaves (n = 20)	Washing effect $F_{1,20}$	Station effect $F_{9,20}$
Pb	0.53 ± 0.03 (0.00-1.25)	1.23 ± 0.37 (0.15-3.55)	20.02***	2.71*

** p <0.01 ; *** p <0.001 ; Pb : lead.

Table 2. Descriptive basic statistics of lead contents and principal properties of soils.

	Mean	95% confidence limits	Minimum	Maximum	SD	CV
pH	7.82	7.79-7.86	7.10	8.35	0.24	3.12
EC ($\mu s.cm^{-1}$)	410.5	388.7-432.2	172	915	171	41.6
OM%	3.3	3.2-3.4	0.92	5.2	0.83	25.4
$CaCO_3$ (%)	37.6	36.7-38.5	12.1	54.1	7.16	19.0
CEC($cmol^{+}.kg^{-1}$)	17.6	17.2-18	8.7	25.5	3.04	17.3
Clay (%)	10.2	10-10.6	5.3	19.3	2.73	26.7
Silt (%)	30.9	30-31.8	16.20	47.6	6.93	22.4
Sand (%)	58.4	57.3-59.5	35.6	75.3	8.46	14.47
Pb ($\mu g.g^{-1}$)	18.0	16.6-19.3	05.50	69.20	10.30	57.30

EC : Electrical conductivity; OM : organic matter; CEC : cation exchange capacity; Pb : lead ; CV: coefficient of variation.

3.2. Physico-chemical characteristics of soils

Table 2 provides some general characteristics of the soils examined in this study; clay content, pH, electrical conductivity (EC), organic matter (OM), cation exchange capacity (CEC) and total Pb concentrations. The soils OM content was 3.3%, medium to average silt content (30.90%). Samples are sandy soil poor in clay (5.3-19.3 %). All soils were characterised by alkaline pH and by low EC values (410.50 µs/cm). CEC varied from 8.7 to 25.5 $cmol^{+}.kg^{-1}$. Soils presents very high carbonate levels (37.6%).

The total concentrations of Pb (Table 2) were included in the interval of total concentrations determined in surface soils no-contaminated given by Kabata-Pendias (2001). Such low values can be explained by the fact that the Algerian car fleet has really gained in importance only for the five last years. Moreover, the sampling stations, randomly selected, were far from 500m to one kilometer from the road (Fig. 1) received a small portion of Pb emitted from this one. The low concentrations may also be explained by the fact that the layer of soil on the surface is in reality formed primarily from newly deposited sediment by major floods due to torrential rainfall favoring the leaching of particles of lead newly deposited.

The high coefficient of variation (Table 2) determined for Pb concentrations in the samples soils may be due to the variation in the distance between the wadi and the road, which would be the main source of contamination, also to the difference density of road traffic between the sections.

The ANOVA analysis (Table 3) for the other soil parameters revealed a highly significant station effect. Other soil parameters have also significant coefficients of variation. Such a variation is verified by analysis of variance, for the total of variables. This can be explained by the extent of the study area ($8795Km^2$), which passes through various lithologic formations and presents a great topographical variation: an elevation of more than 400 m separates the station 01 to the station 10.

3.3. Relationships between lead concentrations of soils and those of leaves

Regression analysis based on Pearson correlation coefficient, indicated that the concentrations of Pb in the layers surface (0-20cm) under tamarisk grove soils, were correlated negatively, almost significantly, with the unwashed leaves ($r = -0.33$, n=20) and very weakly with those of the washed ones ($r = -0.18$, n=20) (data not shown). In this depth of soils, Pb concentrations determined come, therefore, from the rainfall leaching of lead particles deposited on the tamarisk's leaves, hence the correlation with the unwashed leaves (Kabata-Pendias, 2001 ; Bakirdere & Yaman, 2008). Indeed, Olowoyo et al., (2010) have reported that rainfall has the ability to wash off the particles deposited on leaf surfaces thereby reducing the quantity of the particles present on the leaf.

As layers surface, the depth horizons presented a negative and not significative correlations between concentrations of lead and those of unwashed ($r = -0.06$, n= 20) and washed leaves ($r = -0.04$, n= 20) (data not shown). This can be explained by the fact that Pb concentrations determined in down horizons are emitted from the geochemical sources. Indeed, Semlali et al., (2004) have reported that lead is considered as a low- or non-mobile element, strongly accumulating at the soil's surface due to complexation with organic matter.

3.4. Distribution of Pb and principal soil properties according to the positions and the plot types

Table 3 shows non significant depth effect for lead i.e. lead concentrations did not differ significantly of the two depths regardless of the positions, the soil types and the stations. The absence of the depth effect indicates a uniform distribution of Pb through the soil horizons. Also, non significant interaction between depth and the other effects was determined. Therefore, the discussion of the variation of the other parameters depending on the depth does not appear to be useful in this case.

Figure 3 shows that Pb and soil parameters (except CEC) values, in the vegetation plot, were definitely higher than in the bare plots. The ANOVA analysis (Table 3) confirmed a very significant plot effect for the evoked parameters ($p<0.001$).

This effect reproduced in the whole stations for Pb, OM and $CaCO_3$, hence the interaction plot × station was not significant for these parameters. However, this interaction being slightly significant for clay, this one presented significant difference between the two plots for the majority of the stations.

Otherwise, (Fig. 3) indicated that the position effect for Pb, EC, OM, $CaCO_3$, CEC and clay did not reproduce in the same way in the two types of plots. Thus, Pb concentrations and clay rates of tamarisk grove (middle of the vegetation plots) were clearly higher than those of the two other bands. Whereas, in the bare plots, Pb and OM distributions appeared almost uniform.

On the other hand, the ANOVA analysis (Table 3) confirms a very significant interaction plots×positions for the parameters cited above. However, this model reproduced in the whole of the stations for Pb, OM, $CaCO_3$ and clay, hence the interaction positions×plots×stations is not significant.

Table 3. Effect of station, position and plot on Pb contents and principal properties of soils (ANOVA) (n = 240).

	df	**Pb**	**pH**	**EC**	**OM**	**$CaCO_3$**	**CEC**	**Clay**	**Silt**	**Sand**
Station	9	13.75***	5.4***	14.86***	9.33***	14.4***	4.00***	12.59***	11.40***	14.80***
Depth	1	2.63	0.4	0.44	13.89***	3.03	49.53***	204.18***	33.37	72.09***
Position	2	9.39***	5.7**	84.74***	2.66	1.3	2.85	44.04***	1.27	5.69**
Plot	1	13.89***	121.2***	97***	33.85***	11.58***	3.18	88.43***	45.91***	57.88***
Station × depth $F_{9, 230}$	9	0.67	0.61	1.48	1.24	0.99	1.25	3.00**	1.18	1.76
Station × position $F_{18, 230}$	18	1.01	2.01*	3.18***	1.29	0.96	1.04	0.78	2.13**	1.92*
Station × plot $F_{9, 230}$	9	0.83	25.6***	2.99**	1.93	0.66	2.74 **	2.18*	6.19***	5.53***
Depth × position $F_{2, 230}$	2	1.24	0.52	9.45***	2.73	7.01**	0.14	3.78*	0.22	1.23
Depth × plot $F_{1, 230}$	1	0.01	2.21	4.89*	1.44	15.47***	0.0004	1.74	0.05	0.09
Position × plot $F_{2, 230}$	2	12.87***	0.31	6.78**	8.95***	9.73***	33.15***	4.62*	0.64	0.58
Station × depth × position $F_{18, 230}$	18	0.50	0.59	2.05*	0.74	0.76	1.08	0.92	0.55	0.62
Station × depth × plot $F_{9, 230}$	9	0.35	1.57	1.83	0.58	1.20	0.60	1.72	1.23	1.14
Station × position ×plot $F_{18, 230}$	18	1.29	1.46	3.18***	0.72	0.61	1.71*	0.79	2.68***	2.25**
Depth × position × plot $F_{2, 230}$	2	0.27	0.31	0.21	19.01***	6.99**	0.14	1.32	0.07	0.67
Station × depth × position × plot $F_{18, 230}$	18	0.50	0.85	1.12	0.67	1.06	2.13**	1.24	0.66	0.78

df : degree of freedom ; Pb : lead ; OM : organic matter ; CEC : cation exchange capacity ; EC : electrical conductivity ; *$p < 0.05$; **$p < 10^{-2}$; ***$p < 10^{-3}$.

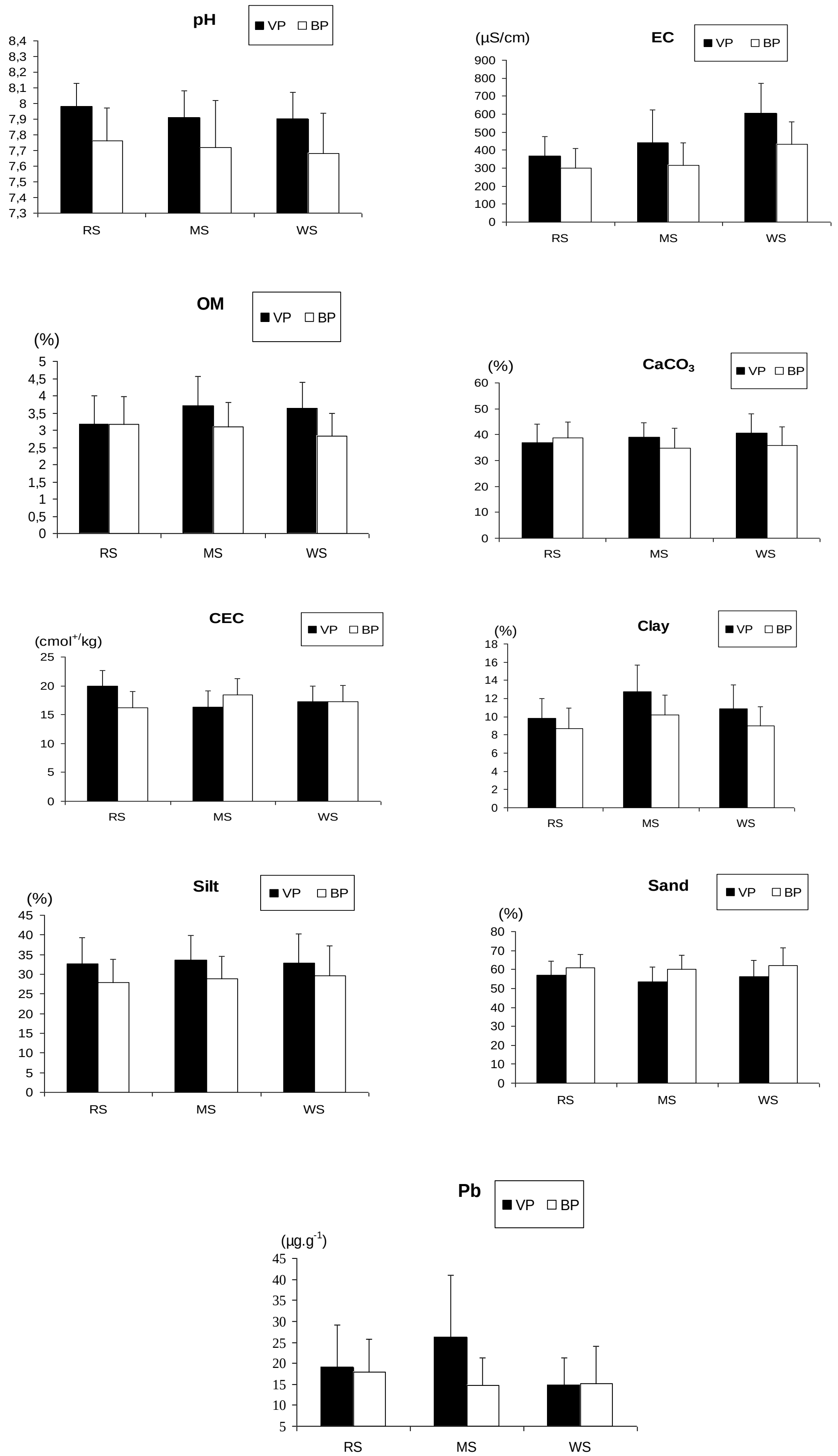

Figure 3. Distribution of lead and principal properties according to positions and the plot types. EC : electrical conductivity; OM : organic matter; CEC : cation exchange capacity; Pb: lead; BP : bare plot; VP: vegetation plot; RS : strip on the side of the road; MS : strip in the middle (tamarisk grove in the vegetation plot); WS : strip on the side of the wadi

For CEC parameter, the model reproduced in the majority of the stations, hence the interaction is slightly significant. The Scheffé's test (Table 4), showed for the cited parameter, a very significant differences between the positions of the vegetation plots and similarities between those of the bare plots.

For pH, silt and sand, uniform distributions according to the positions were determined for both plots. This is confirmed by the ANOVA analysis which emphasizes, for these parameters, a non significant interaction positions×plots.

Regression analysis bases on Pearson correlation coefficient, calculated depending on the different positions of the two types of plots (Table 5), indicated that, in the central band of vegetation plots (under tamarisk), Pb concentrations increased significantly with the rate of organic matter. In the other positions, non-parameters were significantly correlated with metal concentrations. In bare plots, in the side of the road, the Pb concentrations increased significantly at the same time with CEC. In the middle of these plots, the Pb concentrations increased significantly when the rate of $CaCO_3$, silt and clay increased and that of sand decreased. In the side of the wadi, in the same plots, Pb concentrations increased significantly with pH.

3.5. Relationships between the soil Pb concentrations and the principal soil properties

According to table 5, the correlations determined from the regression analysis bases on Pearson correlation coefficient, for the whole soils showed that Pb soil concentrations were correlated positively and significantly with pH, $CaCO_3$, OM, clay and silt, but negatively with the sand. Indeed, these results are similar to those of other authors who have showed that pH, OM, clay and $CaCO_3$ can be considered as the most important factors responsible for the adsorption capacity of soils for Pb (Gomes et al., 2001; Adhikari & Singh, 2003; Aguilar et al., 2004).

However, any significant correlations were determined between metal, EC and CEC. These results are similar to those determined by several other authors (Fytianos et al., 2001; Du Laing et al., 2006).

On the other hand, in the vegetation plots, table 5 indicated also that organic matter was the most important fraction involved in the retention of lead than clay fraction (r=0.28 n=120 vs. r=0.21 n=120). These results are in agreement with those of Sipos et al., (2005), which have showed that the organic matter adsorbs more lead than clay minerals.

Table 4. Probabilities of position differences for Pb content and principal properties of soils, according to Scheffe's test (n = 240).

Soil variables	Positions	VPM	VPW	BPR	BPM	BPW
Pb	VPR	0.045*	0.5735	0.999	0.600	0.721
	VPM		$<10^{-4}$***	0.014*	$<10^{-4}$***	$<10^{-3}$***
	VPW			0.799	1.000	0.999
	BPR				0.820	0.901
	BPM					0.999
OM	VPR	0.116	0.263	1.000	0.998	0.499
	VPM		0.999	0.116	0.035*	$<.10^{-3}$***
	VPW			0.262	0.099	$<.10^{-3}$***
	BPR				0.998	0.500
	BPM					0.776
Clay	VPR	$<10^{-4}$***	0.512	0.541	0.990	0.798
	VPM		0.043*	$<10^{-6}$***	$<10^{-3}$***	$<10^{-6}$***
	VPW			$<10^{-2}$**	0.881	0.026*
	BPR				0.183	0.998
	BPM					0.397
$CaCO_3$	VPR	0.859	0.296	0.899	0.879	0.993
	VPM		0.945	0.999	0.198	0.513
	VPW			0.916	0.014*	0.080
	BPR				0.243	0.579
	BPM					0.994
CEC	VPR	$<10^{-4}$***	$<10^{-2}$**	$<10^{-5}$***	0.350	$<10^{-2}$**
	VPM		0.854	0.999	0.056	0.819
	VPW			0.753	0.604	1.000
	BPR				0.031*	0.710
	BPM					0.651

VP: vegetation plot, BP: bare plot, R: road side, M: middle, W: wadi side (for the vegetation plot M is in the *Tamarix* grove, R and W are outside the *Tamarix* grove), Pb: lead, OM: organic matter, CEC: Cation Exchange Capacity.

Table 5. Pearson correlation coefficients between soil total lead contents and their principal properties.

	EC	pH	OM	$CaCO_3$	CEC	Clay	Silt	Sand
ASPb (n=240)	0.08	0,16*	0,26***	0,16*	0,04	0,22**	0,17**	-0,18**
VPSPb (n=120)	0.01	0.03	0.28**	0.11	0.09	0.21*	0.07	-0.09
BPSPb (n=120)	0.07	0.23*	0.12	0.17	0.19*	0.09	0.20*	-0.22*
VPSRPb(n=40)	0.20	-0.26	0.01	0.26	-0.21	0.15	0.10	-0.09
TGSPb(n=40)	0.12	0.15	0.48**	0.24	0.11	0.11	0.04	-0.00
VPSWPb(n=40)	0.15	-0.14	0.27	-0.07	0.00	0.04	0.03	-0.04
BPSRPb(n=40)	-0.03	0.07	0.06	0.08	0.34*	0.11	0.19	-0.19
BPSMPb(n=40)	0.18	0.18	0.17	0.38*	0.19	0.30	0.39*	-0.42**
BPSWPb(n=40)	0.18	0.37*	0.08	-0.00	0.25	0.04	0.16	-0.18

AS: all soils, VPS: vegetation plot soils, BPS: bare plot soils, TGS: Tamarix grove soils, R: road, W: wadi, M: middle OM: organic matter CEC: cation exchange capacity, EC: electrical conductivity, $^{*}p<0.05$; $^{**}p<10^{-2}$, $^{***}p<10^{-3}$

In addition, several studies have suggested that addition of organic matter would immobilize Pb by forming strong complexes with soil Pb (Bassuk, 1986; Nelson & Campbell, 1991; Wang et al., 1995; Geebelen et al., 2002). Indeed, Lee et al., (1998) have showed that the maximum of lead sorption generally increased with the organic matter content of the soil. According to Kabata-Pendias & Pendias (1992); Fujikawa et al., (2001), the highest concentrations of lead are always found in the upper horizons of uncultivated soils associated with the organic matter accumulation in these horizons, which may be enhanced by anthropogenic contamination.

However, in the bare plots, Pb concentrations were correlated positively and significantly with pH, CEC and silt, negatively and significantly with sand. Indeed, several studies have suggested that lead mobility in soils is affected by pH and CEC (Basta et al., 1993; Dragun, 1998). Lee et al., (1998) have showed that the amount of Pb adsorbed by soil samples increased sharply with pH, up to 5 or 6 and reached a maximum at pH 8. The high dependence of Pb adsorption on pH can be explained by the fact that pH affects the surface charge of the adsorbent and the degree of ionization and the speciation of metal cation (Elliot & Huang, 1981).

4. CONCLUSION

The present work was designed to investigate the assessment of atmospheric lead contamination of banks soils of kebir-rhumel wadi using tamarisk grove. Significant differences were noted between Pb washed leaves contents, and those of unwashed leaves, suggesting an atmospheric contamination source, apparently related to traffic density. Study area was characterized by a sandy soil poor in clay with basic pH and high content of organic matter.

Pb concentrations determined in surface horizons come partly from rainfall leaching of the Pb particles deposited on tamarisk leaves. However, the Pb concentrations determined in dawn horizons have geochemical origin.

High Pb concentrations were determined in the vegetation plot soils. This might partially attribute to accumulation of organic matter. Moreover, we found that the accumulation of organic matter play more important role on enhancing lead complexation. The results of this study show the very important role of the presence of tamarisk grove in the wadi banks, for the reduction of soil contamination by atmospheric lead.

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