
Co²⁺ sorption capacity indicators of La Plata region's soils: insights and correlations with soil properties

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Abstract: Notwithstanding that the soil act as a pollutant sink, its Co sorption capacity presents still controversial results. Here, Co^{2+} sorption on soil samples from La Plata (Argentina) was analysed. Four sorption indicators were used: K_{dis} (estimated from the entire sorption isotherm), K_{Fl} (estimated from the lineal part of the sorption isotherm), K_{ds} (solid-solution distribution coefficient) and K_r , a dimensionless parameter recently developed. Pearson correlation coefficients between the parameters and soil properties were calculated. Significant and negative correlations with silt were obtained, whereas significant and positive correlations were established with clay and smectite content. Soil clay fractions were isolated and Co^{2+} sorption was evaluated, observing relatively high removal. The correlations with kaolinite, magnetite and Mn and Fe oxides showed debatable results: K_{dis} could be more sensitive than K_r to magnetite variations whereas K_r seems to be more sensitive to Mn changes. K_{Fl} presented similar behaviour to K_r . The studied soils presented a high Co^{2+} sorption capacity, making them an effective barrier of this pollutant, avoiding its passage to groundwater and crops.

Keywords: cobalt sorption; soil/clay; isotherms; distribution coefficients; correlations; soil properties.

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1 Introduction

At present, the rapid industrial development of urban areas made necessary to determine the impacts of heavy metals pollution on environmental soil quality as well as human health (Cachada et al., 2012; Praveena et al., 2015). In particular, cobalt is a toxic heavy metal that can affect the environment and that also can provoke human health problems (Manohar et al., 2006). It is essential for both human and animal health but in relatively high concentrations it could cause health effects as vomits, heart and thyroid problems, paralysis, low blood pressure, lung irritations and bone defects among others, and harmful impact for crop production as well (Jalali and Majeri, 2016; Manohar et al., 2006).

It is known that soils are one of the ultimate sinks for pollutants discharged into the environment. Therefore, the knowledge of the interactions between them is crucial to

predict contaminants distribution and the potential transfer to animals, crops and the human alimentary chain.

Despite the great variety of industries that release cobalt into the environment and the potential risk to human health and environmental quality, controversial results about cobalt interactions with soils and soil components still remain, assigned mainly to the variations on the key components (organic matter, clays and Fe oxides) of the soils, coming from different world regions.

Regarding soils organic matter content, a significant role was found in Co^{2+} sorption for a sandy soil from Korea (Chon et al., 2012) and also in Scotland soils, with clay content between 10% and 30% (McLaren et al., 1986). Moreover, a significant high Co^{2+} sorption was obtained for a Japanese soil with 36% of clay and 17% of total carbon (Abd Elfattah and Wada, 1981), although the opposite statement was observed for Iran soils with clay range that included the previous (15.0 and 43.2%), presenting relatively lower organic matter content, between 0.7 and 3.5% (Jalali and Majeri, 2016). In addition, after analysing in situ 70 polluted soils in a Wales, Great Britain, industrial area, a weak but negative correlation between Co^{2+} concentration and organic matter content was determined (Davies, 1997).

Considering clay mineral content, a relatively high Co^{2+} sorption capacity was determined for Indian, US and Egypt soils (El-Sofany et al., 2009; Gutierrez and Fuentes, 1991; Rawat et al., 1996), but on Scotland and Iran soils it was stated that minerals probably had not a significant influence on Co^{2+} sorption (Jalali and Majeri, 2016; McLaren et al., 1986).

In relation to Fe oxides content, for Japanese soils it is highlighted the higher selectivity coefficient obtained for Fe oxides than those obtained for clays and organic matter (Abd Elfattah and Wada, 1981). Moreover, Co^{2+} bounds to Fe and Mn oxides and carbonates was observed for a Serbian soil composed principally by quartz, kyanite and muscovite (Smičiklas et al., 2015). In addition, a direct correlation between solid-solution distribution coefficient values and Mn and Fe oxide contents was reported for Amazonian soils (de Souza Braz et al., 2013). Conversely, low affinity between Co^{2+} and amorphous Fe oxides, goethite and haematite (Gunnarsson et al., 2000; Han, 2007) and non-significant correlation between Fe and Co^{2+} sorption for calcareous Iranian soils were reported (Jalali and Majeri, 2016).

Summing up, the results show that Co^{2+} interaction with soils and its main components is a complex process that can be influenced by the different combinations of soil composition.

The presence of cobalt and other heavy metals in sediments collected around the most important petrochemical pole of South America located in La Plata, Argentina, evidenced the generated pollution (Labunska et al., 2000). Thus, concern was originated about the ability of metals soil retention and the transfer of this pollution to groundwater, rivers and crops.

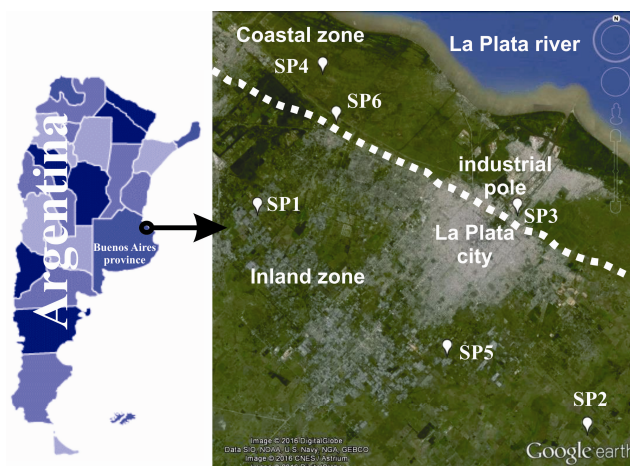
The aim of this study was to analyse the influence of soils and soil components from La Plata region, Argentina, on Co^{2+} sorption capacity. A deep characterisation of soils properties has been performed by a variety of techniques and three main distribution coefficients used in soil interaction studies were determined (distribution coefficient K_{dis} , the solid-solution distribution coefficient K_{dx} and the indicator of sorption capacity K_r) and the correlation between them was presented.

2 Materials and methods

2.1 Soil samples

In La Plata region (Figure 1), two principal geomorphological units are identified: the coastal and inland zones. Inland region is covered by loessic Pampean deposits and the soils are developed from wind and fluvial sediments whereas the coastal zone is covered by marine and fluvial deposits coming from La Plata River and the fluvial transport, with soils developed from sediments carried by marine incursions (Hurtado et al., 2006). Soil samples were collected from six unperturbed soils: SP1, SP2 and SP5 (inland region) and SP3, SP4 and SP6 (coastal zone). Samples were collected from soil pits (0–50 cm depth) and three subsamples of each profile were selected: surface, medium deep and the deepest one; labelled with a, b and c letters, respectively, along with the soil profile number (i.e., 1a, 2c, etc.). The clay fraction of some medium depth soil samples (1b, 2b, 5b, 3b, 4b and 6b) was isolated using the methodology proposed by Carver (1971) and then they were dried at 90°C, crushed and sieved. These samples were labelled adding c1 to the end of the soil sample name, i.e., 1bc1 corresponds to the clay fraction of the 1b soil sample.

Figure 1 Sampling point locations. Dash line indicates the border between coastal and inland soils. SP1, SP2 and SP5 belong to the inland soils, whereas SP3, SP4 and SP6 to the coastal region (see online version for colours)



2.2 Soil samples characterisation

The textural and carbon content determinations for SP1–SP4 soils were previously published (Montes et al., 2013). SP5 and SP6 samples were characterised following the same procedure utilised for SP1–SP4 soils. The results are presented in Figure 2. Haematite content of all soil samples was previously reported (Montes et al., 2016).

2.2.1 Mineral content

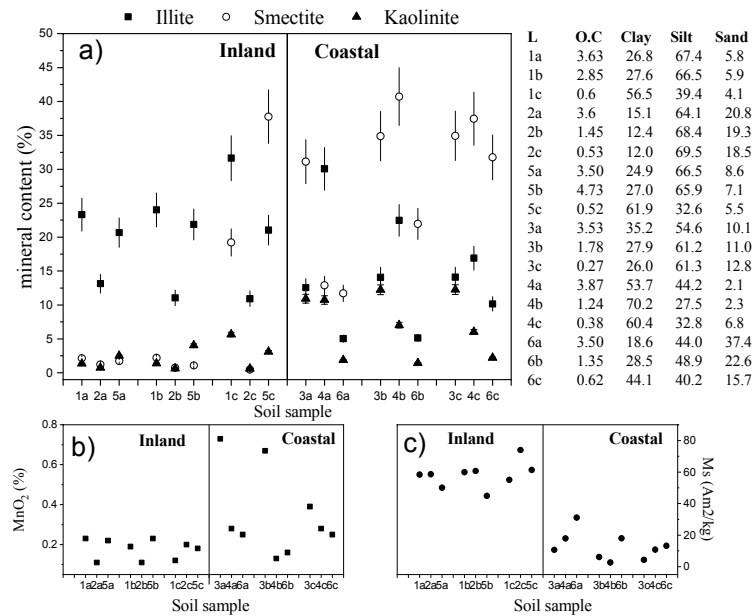
Clay mineral content was determined from diffraction patterns (Mg- and glycol-saturated samples and annealed samples) according to Carver (1971). X-ray diffractograms were

obtained by a PANalytical, X'Pert PRO high-resolution diffractometer (CuK α radiation) from 3° to 32°, with a step mode collection of 0.02°, 0.02 s by step. The illite (I), smectite (Sm) and kaolinite (Ka) content were obtained by a semi-quantitative analysis (Foscolos et al., 1976).

2.2.2 Mn determination

MnO₂ determinations were carried out by wavelength dispersive XRF using a Philips MagiX apparatus (PANalytical) on soil samples pellets. The pellets (200 mg) were prepared using 5 tn pressure. Uncertainties in the analysis were 5%.

Figure 2 Content for the indicated soils (a) Illite, smectite and kaolinite, (b) MnO₂ and (c) Ms value related with Magnetite. The table inset indicates the determined organic content (OC) and the clay, silt and sand percentages (data for 1, 2, 3 and 4 profiles were previously reported (Montes et al., 2013))



2.2.3 Saturation magnetisation

The saturation magnetisation (Ms) was obtained from the hysteresis loops measured by a VSM spectrometer LakeShore 7404 with external magnetic fields between -1.2 T and 1.2 T, after subtracting the paramagnetic contribution. Soil samples were supported in a diamagnetic sample holder with negligible magnetic response. In environmental samples, the Ms value was directly related to the type and concentration of the presence of magnetic minerals (Evans et al., 2003).

2.3 Sorption experiments

The Co²⁺ sorption experiments were performed during 24 h in batch conditions (25 mL) at 20°C, pH = 6 and soil/solution ratio 1 : 1, varying the initial Co²⁺ concentration C_i

(0.17, 0.34, 0.51, 0.68, 0.85, 1.02, 1.19, 1.44 and 1.70 mmol/L). Milli-Q water and CoCl₂·6H₂O (99%), supplied by Fluka-Sigma-Aldrich, was used to prepare the Co²⁺ solutions. All sorption experiments were done by duplicate. Co²⁺ sorption was also investigated on the clay fraction of selected soils, using C_i = 0.51 and 0.85 mmol/L and same conditions as indicated earlier.

After each sorption experiment, solid and liquid phases were isolated by centrifugation (15 min, 15,000 rpm). Supernatant was collected and properly stored for Co²⁺ concentration determination. Solid phase was dried at 90°C and kept into a desiccator for further analysis. Supernatants Co²⁺ concentration was determined by colorimetric method (Sandell, 1944) using a Hewlett-Packard 8453 UV-visible spectrophotometer ($\lambda = 620$ nm).

2.4 Data analysis

Several parameters are used for metal sorption studies on soils as the solid-solution distribution coefficients (K_{dx}), parameters extracted from sorption isotherms and a more recently developed parameter K_r .

The solid-solution distribution coefficient, K_{dx} (in L/g), for a specific metal concentration, is defined as:

$$K_{dx} = \frac{(C_i - C_e) V}{C_e m} \quad (1)$$

where C_i and C_e represent the Co²⁺ concentration in solution before and after sorption experiments and m and V the soil mass and the solution volume, respectively. X denotes the used metal initial concentration. This coefficient considers the net result of the several transfer processes between the metal and soil and it is useful to compare the sorption of a determinate cation on different soil samples under equal conditions (Vega et al., 2008).

The extracted parameters from the complete sorption isotherms and the recently developed parameter K_r (see here) are determined using the entire range of the used metal concentrations.

The Freundlich can be defined by the following equation:

$$(C_i - C_e) \frac{V}{m} = K_F C_e^{1/n} \quad (2)$$

Equation (2) allowed obtaining the K_F (mmol^{1-1/n} L^{1/n} g⁻¹) and n parameters and, complementary, the K_{F1} parameter (L/g), if only the lineal part of the curve (lower concentrations, $n = 1$) is considered:

$$(C_i - C_e) \frac{V}{m} = K_{F1} C_e \quad (3)$$

The K_F parameter could introduce some interpretation problems owing to, depending on the used units, the achieved results can be contradictory. This is related to the presence of the n parameter in the unit change process. Therefore, instead of using K_F , here were used K_{F1} and K_{dis} (mmol^(n-1/n) L^(1-n+1/n) g⁻¹), defined as:

$$K_{dis} = K_F C^{n-1} \quad (4)$$

where the used Co^{2+} concentration was $C = 0.017$ mmol/L as previously proposed by Shaheen (2009).

Another parameter used to analyse metal sorption in soil is the K_r indicator (Vega et al., 2008). To obtain the parameter, two plots must be constructed and fitted by a lineal model:

C_e vs. C_i , obtaining K_{r1} as the slope of the obtained straight line

$C_i - C_e$ vs. C_i , being K_{r2} the slope of the fitted curve

Then, the obtained fittings must be compared; K_r will be equal to K_{r1} if the coefficient of determination in the first fitting is better than that obtained in the second fit process. Contrarily, K_r is equal to $1 - K_{r2}$. This parameter is useful when Langmuir and Freundlich equations are not adequate to fit sorption isotherms (Vega et al., 2008), as it frequently occurs with soil samples. In cases where the Langmuir and Freundlich models can be used, K_r is an extra used parameter than can also provide complementary information.

Finally, once obtained the above-mentioned parameters, the correlations between the K values (soil sorption capacity) and soil properties were assessed by the Pearson correlation coefficients, considering 95% of confidence level.

3 Results and discussion

3.1 Samples characterisation

The organic carbon content (OC), resumed in table inset Figure 2, decreases with soil depth, contrarily to the clay content behaviour. Different textural classes were determined for the soils (Montes et al., 2013) whereas haematite content resulted, in general, lower for coastal than inland soils (Montes et al., 2016).

The illite, smectite and kaolinite content of soil samples (Figure 2(a)) indicated significant variations among mineral content in the different evaluated profiles. Illite and smectite were the major minerals for inland and coastal zone soils, respectively, whereas kaolinite was the minor mineral in both regions. MnO_2 content did not exceed 1% in none of the soil profiles (Figure 2(b)), being 0.7% the highest concentration, attained in the coastal region.

Soils from inland area presented higher M_s values than those from coastal zone (Figure 2(c)). The only two components present in the studied soils with ferrimagnetic or ferromagnetic behaviour were haematite and magnetite with $M_s = 0.4$ and 92 mAm^2/kg , respectively (Montes et al., 2012). The relatively lower M_s value of haematite with respect to magnetite allowed to associate directly the M_s value with magnetite content.

3.2 Cobalt sorption: effect of soil properties

Table 1 summarises n , K_{dis} , K_{F1} and K_r values. An example of K_{dx} distribution coefficient obtained for Co^{2+} initial concentration = 1.19 mmol/L, $K_{d1.19}$ (L/g) was also added. As it can be seen from Table 1, K_{dis} varied from 2.8 $\text{mmol}^{(n-1/n)} \text{L}^{(1-n+1/n)} \text{g}^{-1}$ to 10.2 $\text{mmol}^{(n-1/n)} \text{L}^{(1-n+1/n)} \text{g}^{-1}$, K_{F1} between 2.6 and 5.4 L/g, $K_{d1.19}$ from 3.29 L/g to 4.06 L/g and K_r from 0.741 to 0.780 .

Table 1 n , K_{dis} , $K_{dl,19}$ and K_r obtained values

	$K_{dis}^{(n-1/m)} L^{(1-n+1/m)} / g$	n	$K_{FI} (L/g)$	$K_{dl,19} (L/g)$	K_r	$K_{dis}^{(n-1/m)} L^{(1-n+1/m)} / g$	n	$K_{FI} (L/g)$	$K_{dl,19} (L/g)$	K_r
1a	5.8 ± 0.2	1.23 ± 0.02	3.5 ± 0.2	3.51 ± 0.05	0.743 ± 0.008	9.4 ± 0.6	1.33 ± 0.05	4.4 ± 0.2	3.98 ± 0.09	0.778 ± 0.008
1b	4.3 ± 0.2	1.11 ± 0.02	3.3 ± 0.1	3.50 ± 0.05	0.770 ± 0.008	10.2 ± 0.2	1.52 ± 0.03	5.4 ± 0.3	4.06 ± 0.09	0.761 ± 0.007
1c	4.5 ± 0.1	1.08 ± 0.02	3.7 ± 0.2	3.71 ± 0.06	0.773 ± 0.008	6.1 ± 0.2	1.19 ± 0.03	5.0 ± 0.2	4.03 ± 0.09	0.776 ± 0.008
2a	2.8 ± 0.2	1.03 ± 0.05	2.6 ± 0.2	3.29 ± 0.05	0.741 ± 0.009	5.4 ± 0.2	1.17 ± 0.04	3.5 ± 0.2	3.57 ± 0.08	0.767 ± 0.006
2b	4.7 ± 0.1	1.10 ± 0.04	3.1 ± 0.2	3.48 ± 0.05	0.769 ± 0.007	7.2 ± 0.5	1.26 ± 0.06	4.8 ± 0.3	4.24 ± 0.09	0.777 ± 0.005
2c	5.3 ± 0.1	1.19 ± 0.04	3.5 ± 0.2	3.50 ± 0.05	0.757 ± 0.009	6.3 ± 0.2	1.20 ± 0.04	4.4 ± 0.2	4.31 ± 0.09	0.777 ± 0.006
5a	6.1 ± 0.2	1.08 ± 0.03	3.5 ± 0.1	3.75 ± 0.07	0.773 ± 0.008	3.9 ± 0.4	1.05 ± 0.05	3.0 ± 0.2	3.33 ± 0.07	0.764 ± 0.005
5b	6.5 ± 0.4	1.21 ± 0.04	3.9 ± 0.1	3.70 ± 0.06	0.764 ± 0.008	7.7 ± 0.3	1.30 ± 0.04	4.3 ± 0.1	3.82 ± 0.08	0.774 ± 0.008
5c	9.9 ± 1.0	1.30 ± 0.02	3.9 ± 0.2	3.91 ± 0.07	0.770 ± 0.006	5.6 ± 0.1	1.25 ± 0.05	4.2 ± 0.2	4.05 ± 0.09	0.780 ± 0.007

The n values, related with the sorption sites heterogeneity, ranged from 1 to 1.52. This parameter was positively correlated with the clay and smectite content (Table 2), i.e., the inhomogeneous sorption sites for Co^{2+} sorption in soils could be associated to the presence of smectite in the samples, in agreement with results reported for different montmorillonite samples (Hashemian et al., 2015; Ma et al., 2011; Shawabkeh et al., 2007).

Pearson correlation coefficients between distribution coefficients (K_{dis} , K_{Fl} , K_r , $K_{d0.51}$, $K_{d0.85}$, $K_{d1.19}$, $K_{d1.44}$ and $K_{d1.70}$) and soil properties are shown in Table 2. Organic carbon, sand, illite and haematite contents did not present significant correlation with any of the distribution coefficients evaluated and, consequently, they were not included in Table 2.

Table 2 Pearson correlation coefficients between soil properties and n , K_{dis} , k_{dx} and K_r ; ns: no significant correlation. Subscripts indicate the correlation significance

	<i>Clay</i>	<i>Silt</i>	<i>Sm</i>	<i>Ka</i>	<i>Ms</i>	<i>Fe</i>	<i>Mn</i>
<i>Parameters depending on the entire/partial concentration range</i>							
N	0.52 _{0.03}	-0.47 _{0.04}	0.50 _{0.04}	ns	ns	ns	ns
K_{dis}	0.59 _{0.01}	-0.54 _{0.02}	0.51 _{0.03}	ns	ns	ns	0.67 _{0.003}
K_{Fl}	0.76 _{0.0003}	-0.75 _{0.0004}	0.73 _{0.0005}	0.57 _{0.02}	-0.63 _{0.005}	0.63 _{0.007}	0.65 _{0.005}
K_r	0.53 _{0.02}	-0.54 _{0.02}	0.53 _{0.02}	0.47 _{0.049}	-0.50 _{0.03}	0.51 _{0.03}	ns
<i>Parameters depending on the specific concentration</i>							
$K_{ds0.51}$	0.71 _{0.001}	-0.71 _{0.001}	0.72 _{0.0008}	ns	ns	0.51 _{0.03}	0.64 _{0.006}
$K_{ds0.85}$	0.57 _{0.01}	-0.51 _{0.03}	0.53 _{0.02}	ns	ns	ns	0.64 _{0.005}
$K_{ds1.19}$	0.81 _{0.00004}	-0.75 _{0.0003}	0.78 _{0.0002}	0.68 _{0.002}	-0.63 _{0.005}	0.65 _{0.004}	0.49 _{0.04}
$K_{ds1.44}$	0.67 _{0.002}	-0.55 _{0.02}	0.55 _{0.02}	0.61 _{0.006}	-0.50 _{0.04}	ns	ns
$K_{ds1.70}$	0.64 _{0.004}	-0.63 _{0.005}	0.66 _{0.003}	0.64 _{0.004}	-0.64 _{0.004}	0.54 _{0.03}	ns

The absence of correlation between Co^{2+} sorption and OC content was in agreement with results obtained for soils with OC values below 26 g/kg (Anderson and Christensen, 1988; de Souza Braz et al., 2013; Jalali and Majeri, 2016; Rawat et al., 1996).

For sand content, the absence of correlation with Co^{2+} sorption was expected owing to the deedless of sand fraction.

The significance and correlation type (positive or negative) obtained between the sorption capacity indicators and clay, silt and smectite were similar. However, differences in the correlation significances were obtained for kaolinite, saturation magnetisation and Mn and Fe content, depending on the observed sorption parameter.

Focused on K_{dx} coefficients, it seems that kaolinite affects significantly and positively the Co^{2+} sorption on soils for C_i equal or higher than 1.19 mmol/L, being not significant for the lower Co^{2+} concentrations. In addition, K_{Fl} and K_r also revealed a significant correlation, contrary to the obtained results with K_{dis} . Therefore, it seems to indicate that K_{Fl} and K_r parameters are more sensitive to kaolinite amount changes than K_{dis} coefficient. The significant correlations between kaolinite and K_{dx} for the highest Co^{2+} concentrations could be indicating that kaolinite presence becomes important for relatively high Co^{2+} concentration, probably owing to the smectite sorption sites, which

has a higher efficiency for Co²⁺ sorption than kaolinite (Bhattacharyya and Gupta, 2008), which were already saturated.

The obtained correlations between Ms and the evaluated *K* parameters followed the same behaviour than those found for kaolinite amount, although the sign of the correlations was negative. Then, it seems that for a *C_i* value higher than 1.19 mmol/L, the magnetite content affected negatively the Co²⁺ sorption on the studied soils.

Concerning the Mn oxide amount, despite the determined low content, *K_{dx}* showed a significant and positive correlation for Co²⁺ concentration values lower than 1.19 mmol/L, whereas *K_r* did not reveal any kind of correlation. Moreover, it seems that *K_{F1}* and *K_{dis}* are more sensitive to disclose changes in Mn concentration than *K_r*, contrarily to that indicated for kaolinite contents.

Regarding Fe content, debatable correlation results were observed (Table 2). Again, *K_r*, *K_{F1}* and *K_{dis}* did not indicate the same tendency; in this case, Fe content and *K_r* and *K_{F1}* correlation resulted significant and positive, whereas the correlation with *K_{dis}* resulted not significant. In addition, *K_{dx}* did not present a defined behaviour with the Co²⁺ concentration. Therefore, not conclusive observation can be done for Fe amounts influence on Co²⁺ sorption for La Plata region soils.

Pearson correlation coefficients between silt fraction and *K_{dis}*, *K_{F1}*, *K_r* and *K_{dx}* were significant and negative, indicating that this fraction influenced negatively the Co²⁺ sorption. This behaviour could be assigned to the aggregation of silt fraction by organic matter, producing a decrease of the reactive surface sites for Co²⁺ sorption.

The significant correlation between the evaluated *K* parameters and smectite content and the no significant correlations with illite concentrations can be understood considering the sorption studies of Co²⁺ on these different clay minerals. In general, when comparing Freundlich and Langmuir parameters, it could be concluded that the retention capacity of Co²⁺ by smectite was larger than for illite clays (Kubilay et al., 2007; Ozsoy and Bekbolet, 2018).

The Pearson coefficients determined between the *K* coefficients and clay content of La Plata soils were significant and positive, in agreement with results from Denmark (Anderson and Christensen, 1988) and Indian soils (Rawat et al., 1996) and corroborated by the higher *K_d* values obtained when clay content, in soil contaminated with radionuclides, increases (Gil-García et al., 2009).

Table 3 Co²⁺ sorption percentage for indicated clay fractions, and relation of sorption percentage from bulk soil and clay fraction (As/Acl)

Sample	0.51 mmol/L		0.85 mmol/L	
	Sorption (%)	As/Acl	Sorption (%)	As/Acl
1bcl	90 ± 1	0.90 ± 0.03	88 ± 1	0.90 ± 0.03
2bcl	79 ± 1	1.00 ± 0.03	84 ± 1	0.93 ± 0.03
5bcl	82 ± 1	1.00 ± 0.03	79 ± 1	1.00 ± 0.03
3bcl	84 ± 1	1.04 ± 0.03	86 ± 1	0.97 ± 0.03
4bcl	86 ± 1	0.99 ± 0.03	87 ± 1	0.91 ± 0.03
6bcl	79 ± 1	1.01 ± 0.03	81 ± 1	1.03 ± 0.03

To go deeper on the later *K* correlations, several clay fractions of some medium depth soil samples were used as Co²⁺ sorbents and the results of the sorption experiments are

indicated in Table 3, where As/Acl represents the rate between sorption percentage on soils and clay fraction.

The obtained As/Acl values (Table 3) were lower or equal to 1, which means that these clay fractions played a main role in Co^{2+} sorption on the evaluated soils. This behaviour also pointed out that organic carbon and sand fraction did not participate significantly in the Co^{2+} sorption, which support correlation results discussed previously.

4 Conclusions

The Co^{2+} sorption on 18 soils (belonging to six unperturbed soils from La Plata region) with different characteristics was investigated. The influence of soil parameters on Co^{2+} sorption was analysed by the Pearson correlation coefficient between four sorption indicator parameters (K_{dis} , K_{F1} , K_{dx} and K_r) and the principal soil properties.

The analysed coefficients showed no correlation with organic carbon, sand, illite and haematite content of soils. Debatable correlations with kaolinite, magnetite and Mn and Fe oxides contents were determined. The results seem to indicate that K_{F1} and K_r were more sensitive than K_{dis} to kaolinite and magnetite changes, whereas K_{F1} and K_{dis} seem to be more sensitive to manganese oxides variations than K_r .

A significant correlation between clay, silt and smectite content and K_{dis} , K_{F1} , K_{dx} and K_r was established. Silt fraction seems to affect negatively Co^{2+} sorption, whereas clay and smectite content seems to affect it positively.

Regarding clay, the Co^{2+} sorption percentage determined in clay fraction of some soils resulted equal or higher than the sorption percentage observed in the corresponding soil samples, supporting the previously determined correlation. The positive correlation with smectite content reveals its importance on Co^{2+} sorption as reported for sorption Co^{2+} experiments on this mineral alone. This also supports the no correlation observed with illite (mineral with a lower Co^{2+} sorption efficiency than smectite) and the positive correlation determined for K_{dx} and kaolinite for relatively high Co^{2+} concentrations, where, possibly, the smectite sorption sites were already saturated. These results indicate that the higher the smectite content, the better the soil Co^{2+} sorption capacity.

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