



ELSEVIER

Contents lists available at ScienceDirect

## Journal of Environmental Management

journal homepage: [www.elsevier.com/locate/jenvman](http://www.elsevier.com/locate/jenvman)

## Research article

## Chromium and fluoride sorption/desorption on un-amended and waste-amended forest and vineyard soils and pyritic material



Aurora Romar-Gasalla<sup>a</sup>, Vanesa Santás-Miguel<sup>b</sup>, Juan Carlos Nóvoa-Muñoz<sup>b</sup>, Manuel Arias-Estévez<sup>b</sup>, Esperanza Álvarez-Rodríguez<sup>a</sup>, Avelino Núñez-Delgado<sup>a,\*</sup>, María J. Fernández-Sanjurjo<sup>a</sup>

<sup>a</sup> Department of Soil Science and Agricultural Chemistry, Engineering Polytechnic School, Universidade de Santiago de Compostela, Lugo 27002, Spain

<sup>b</sup> Department of Plant Biology and Soil Science, Faculty of Sciences, Campus Ourense, Universidade de Vigo, 32004 Ourense, Spain

## ARTICLE INFO

## Keywords:

By-products  
Cr(VI) pollution  
F<sup>-</sup> pollution  
Retention  
Release

## ABSTRACT

Using batch-type experiments, chromium (Cr(VI)) and fluoride (F<sup>-</sup>) sorption/desorption were studied in forest and vineyard soil samples, pyritic material, pine bark, oak ash, hemp waste and mussel shell, as well as on samples of forest and vineyard soil, and of pyritic material, individually treated with 48 t ha<sup>-1</sup> of pine bark, oak ash, and mussel shell. Pine bark showed the highest Cr(VI) sorption (always > 97% of the concentration added) and low desorption (< 1.5%). Pyritic material sorbed between 55 and 98%, and desorbed between 0.6 and 9%. Forest and vineyard soils, oak ash, mussel shell and hemp waste showed Cr(VI) sorption always < 32%, and desorption between 22 and 100%. Pine bark also showed the highest F<sup>-</sup> retention (sorption between 62 and 73%, desorption between 10 and 15%), followed by oak ash (sorption 60–69%, desorption 11–14%), forest soil (sorption 60–73%, desorption 19–36%), and pyritic material (sorption 60–67%, desorption 13–15%), whereas in vineyard sorption was 49–64%, and desorption 24–27%, and in hemp waste sorption was 26–36%, and desorption 41–59%. Sorption data showed better fitting to the Freundlich than to the Langmuir model, especially in the case of Cr(VI), indicating that multilayer sorption dominated. The addition of by-products to the forest and vineyard soils, and to the pyritic material, caused an overall increase in F<sup>-</sup> sorption, and decreased desorption. Furthermore, the pine bark amendment resulted in increases in Cr(VI) retention by both soils and the pyritic material. These results could be useful to favor the recycling of the by-products studied, aiding in the management of soils and degraded areas affected by Cr(VI) and F<sup>-</sup> pollution, and in the removal of both anions from polluted waters.

## 1. Introduction

Hexavalent chromium (Cr(VI)) and fluoride (F<sup>-</sup>) are substances related to environmental and public health concerns, as detailed in different studies (for example, Choubisa, 2017; Shahid et al., 2017; Yesilnacar et al., 2016; Zhang et al., 2017). To prevent or fight related risks, a variety of methods could be used in order to remove Cr(VI) and F<sup>-</sup> from polluted media, but many of them imply high operating costs, also generating sludge with high heavy metals concentrations (Demiral et al., 2008; Gode and Pehlivan, 2005; Mohapatra et al., 2009; Raichur and Basu, 2001; Reardon and Ewang, 2000).

As alternative, sorption and bio-sorption have deserved increasing interest in the last years. In fact, different works have dealt with Cr(VI) and/or F<sup>-</sup> sorption, showing promising results (for example, Akram et al., 2017; Bhatnagar et al., 2011; Gupta et al., 2013; Jadhav et al.,

2015; Ravulapalli and Kunta, 2017; Zhang et al., 2018). In this way, we have previously performed studies dealing with retention/release of anionic pollutants on soils and by-products, some of them focusing on Cr(VI) (Fernández-Pazos et al., 2013; Núñez-Delgado et al., 2015; Otero et al., 2015; Paradelo et al., 2017; Quintáns-Fondo et al., 2016a; Rivas-Pérez et al., 2017; Seco-Reigosa et al., 2013a,b, 2014), while other focused on F<sup>-</sup> (Quintáns-Fondo et al., 2016b; c). However, as far as we know, no previous study has been carried out investigating simultaneously Cr(VI) and F<sup>-</sup> sorption/desorption on forest and vineyard soil samples, pyritic material, mussel shell, oak ash, pine bark and hemp waste, as well as on the soils and pyritic material amended with the by-products mussel shell, oak ash and pine bark.

In view of that, in this work we studied Cr(VI) and F<sup>-</sup> retention/release on forest soil, vineyard soil, pyritic material, mussel shell, oak ash, pine bark and hemp waste samples, as well as on the soils and

\* Corresponding author.

E-mail address: [avelino.nunez@usc.es](mailto:avelino.nunez@usc.es) (A. Núñez-Delgado).

pyritic material amended with  $48 \text{ t ha}^{-1}$  of each of the three by-products that showed the best results regarding Cr(VI) and  $\text{F}^-$  retention (mussel shell, oak ash, and pine bark). The results of the study could aid to appropriately manage soils, degraded areas and waters affected by Cr(VI) and  $\text{F}^-$  pollution, as well as to promote the recycling of the by-products studied.

## 2. Materials and methods

### 2.1. Materials

Two different soils (forest and vineyard), together with pyritic material and various by-products (fine mussel shell, pine bark, oak ash and hemp waste) were used in this study. Detailed descriptions are included in Supplementary Material. In addition, representative samples of forest soil, vineyard soil and pyritic material were individually amended in the laboratory with  $48 \text{ t ha}^{-1}$  of the three by-products that showed the highest Cr(VI) and  $\text{F}^-$  sorbent efficiency (oak ash, pine bark, and fine shell). These mixtures were stirred for 48 h to homogenize. Thus, apart from the 7 individual materials, there were 9 additional binary mixtures including the forest and vineyard soils and the pyritic material, combined with three of the by-products.

### 2.2. Methods

#### 2.2.1. Characterization of the materials

Supplementary Material shows details regarding methods used to characterize each of the soils and by-products investigated, as well as the results of such characterization procedures. Specifically, determined parameters were: total C and N contents, pH in distilled water, pH of the point of zero charge ( $\text{pH}_{\text{pzc}}$ ), exchangeable Na, K, Ca, Mg and Al, effective cationic exchange capacity (eCEC), total P, total concentrations of Na, K, Ca, Mg, Al, Fe, Mn, as well as As, Cd, Cr, Cu, Ni, Pb, and Zn, non-crystalline Al and Fe ( $\text{Al}_o$ ,  $\text{Fe}_o$ ), and particle-size distribution of forest and vineyard soils. In addition, the main functional groups present in each material were determined by infrared spectroscopy.

#### 2.2.2. Cr(VI) and $\text{F}^-$ sorption/desorption experiments

Similarly to that indicated in Coelho et al. (2016), to perform individual sorption experiments, 3.0 g of each material (both individual materials and the amended soils and pyritic material) were weighed and added with 30 mL of a 0.01 M  $\text{NaNO}_3$  solution, with increasing concentrations (0, 0.5, 1.5, 3.0 and  $6.0 \text{ mmol L}^{-1}$ ) of Cr(VI) and  $\text{F}^-$ , respectively, prepared from analytical grade  $\text{K}_2\text{Cr}_2\text{O}_7$  (Panreac, Spain) and KF (Panreac, Spain), respectively. These suspensions were stirred for 24 h, centrifuged for 15 min ( $6167 \times g$ ), and filtered through acid washed paper (Whatman, Spain). Cr,  $\text{F}^-$ , dissolved organic carbon (DOC), and pH values were quantified in the filtrated liquid using ICP Mass (Varian 820-NS, USA) for Cr, an ion-selective electrode and TISAB IV (Orion Research, Cambridge, USA) for  $\text{F}^-$ , visible-UV spectroscopy (UV-1201, Shimadzu, Japan) for DOC, and pH meter (model 2001 Crison, Spain) equipment.

To determine desorption, after ending sorption experiments each sample was added with 30 mL of 0.01 M  $\text{NaNO}_3$ , then stirred, centrifuged, and filtered as above. Cr,  $\text{F}^-$ , DOC, and pH were quantified in the filtrated liquid as indicated above. Percentage desorption was calculated after determining concentrations released to the equilibrium solution, referring to those previously retained by sorption. All determinations were performed by triplicate.

### 2.3. Data analyses

SPSS 21 (IBM, USA) was employed to carry out basic statistical treatment (descriptive statistics, stepwise linear regression, and Pearson correlation analysis) and fitting to sorption models, as well as testing for normality (we used the Kolmogorov-Smirnov test), when applicable.

Data from sorption experiments were adjusted to the Langmuir and Freundlich models.

In the Langmuir model, a maximum sorption value ( $Q_m$ ) can be calculated from Equation (1):

$$Q_{\text{eq}} = Q_m K_L C_e / (1 + K_L C_e) \quad (1)$$

where  $Q_{\text{eq}}$  is the quantity of Cr(VI) or  $\text{F}^-$  sorbed ( $\text{mmol kg}^{-1}$ ),  $Q_m$  is the maximum sorption capacity ( $\text{mmol kg}^{-1}$ ),  $K_L$  is the Langmuir constant related to the sorption energy ( $\text{L mmol}^{-1}$ ), and  $C_e$  is the concentration of Cr(VI) or  $\text{F}^-$  in the equilibrium solution ( $\text{mmol L}^{-1}$ ).

The Freundlich model is expressed by means of Equation (2):

$$Q_{\text{eq}} = K_F C_e^{1/n} \quad (2)$$

where  $Q_{\text{eq}}$  is the quantity of Cr(VI) or  $\text{F}^-$  sorbed ( $\text{mmol kg}^{-1}$ ),  $K_F$  is the Freundlich constant related to the energy of sorption ( $\text{L}^n \text{ kg}^{-1} \text{ mmol}^{(1-n)}$ ),  $C_e$  is the Cr(VI) or  $\text{F}^-$  concentration in the equilibrium ( $\text{mmol L}^{-1}$ ), and  $n$  is a constant related to the sorption intensity.

## 3. Results and discussion

### 3.1. Cr(VI) sorption on the individual materials

As shown in Fig. 1a, when the highest Cr(VI) concentration ( $6 \text{ mmol L}^{-1}$ ) was added, pyritic material sorbed  $33.3 \text{ mmol kg}^{-1}$  of Cr(VI), which represents 55.4% sorption referred to the concentration added. In this material, Cr(VI) sorption reached up to 97.9%, but just when the lowest Cr(VI) concentration ( $0.5 \text{ mmol L}^{-1}$ ) was added. Previous studies showed Cr(VI) sorption close to 90% on pyritic material when  $100 \text{ mg L}^{-1}$  of Cr(VI) (approximately  $2 \text{ mmol L}^{-1}$ ) were added (Fernández-Pazos et al., 2013; Otero et al., 2015), while in the present study percentage sorption decreased considerably when clearly higher concentrations (up to  $6 \text{ mmol L}^{-1}$ ) were used. Forest and vineyard soils

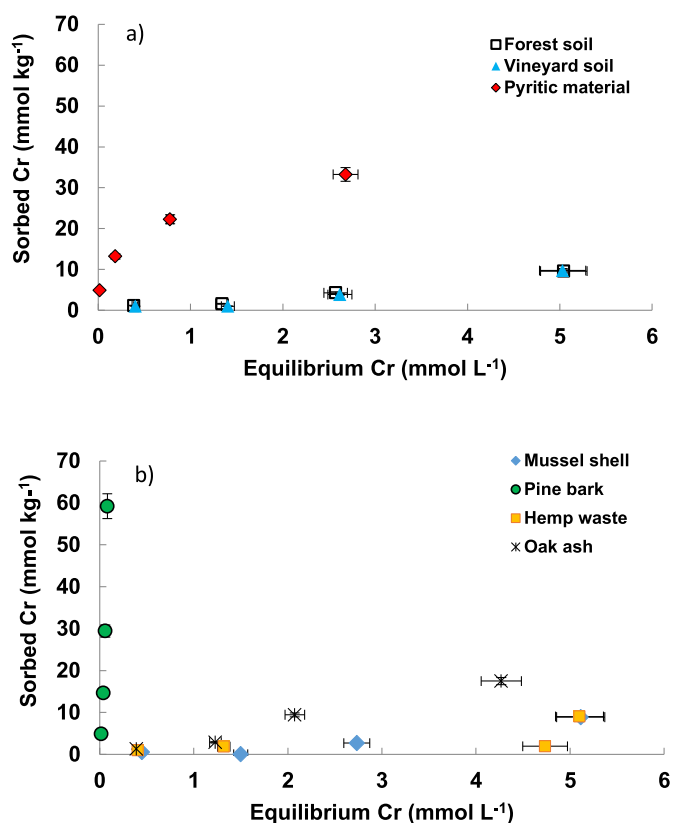


Fig. 1. Cr(VI) sorption curves for forest soil, vineyard soil, and pyritic material (a), and for the by-products studied (b). Mean values (with error bars) for 3 replicates, with coefficients of variation always < 5%.

Download English Version:

<https://daneshyari.com/en/article/7475855>

Download Persian Version:

<https://daneshyari.com/article/7475855>

[Daneshyari.com](https://daneshyari.com)