1. Introduction

Chromium, is a significant environmental pressure in soils and groundwater since the World War II. Its industrial use in engines’ parts as stainless hard steel alloy has created plumes of contamination in localities around the world (Jacobs and Testa 2005). The last 20 years there is increasing concern on the geogenic origin of Cr(VI) in soils and groundwater (Morrison et al. 2010, Moraetis et al. 2012 and references therein). Aluminosilicates such as serpentinites, chlorite and amphiboles could be a source of Cr(III) which potentially is converted to Cr(VI) through oxidation by Mn(IV) (Kazakis et al. 2015). On the other hand, the presence of Fe-oxides and organic matter in soils can immobilize Cr(VI) by adsorption and/or reduction to Cr(III) (Kozuh et al. 2000).

2. Study area

The Sultanate of Oman has the most extensive outcrop of an ophiolite sequence in the world (Rajendran et al. 2012). The presence of serpentine and amphibole are very common in most of the alluvial aquifers and soils like in Barka (Fig. 1 and Fig. 3). In addition, there are chromite mines scattered in areas of harzburgite outcrops (Rajendran et al. 2012). Further more recent studies have indicated aquifers where Cr(VI) is either higher or close to the drinking water standard (50 μg/l) WHO (Ali-Riyami, 2017).

3. Scope

The main aim of the project was to enhance the understanding of Cr geochemistry in one of the most extensive outcrops of Cr-bearing rocks. The aim of this project was to characterize the geochemical and mineralogical content of Cr-bearing soils in Sultanate of Oman. We tested the Cr(VI) release of different fractions of soil (magnetic and non-magnetic). We also investigated the capacity of the different fractions of soil to absorb Cr(VI) in the presence of glucose exposed in sunlight and dark.

4. Materials and Methods

4.1. Sample characterisation

We have analysed 3 soil samples (W12, Barka-2, Barka-5) from Barka coastal area (Fig. 3) and one soil (NS8) from the bottom of a chromeite mine in Nakhal area (Fig. 2). The samples were analysed with Niton™ XL3iT (TermoFischer) for bulk chemical composition with X-ray Fluorescence (XRF). Mineralogical analysis was performed with an Aurora M90 instrument from BRUKER Company.

4.2. Magnetic separation and Cr(VI) extraction

The magnetic separation was performed with an electrical magnet in two different voltages 5V and 20V in wet sample. Non-magnetic (Non) fraction was left after the separation. Two samples were selected for further processing (W12 and NS8) that included different extraction solutions such as water and phosphate (KHPo4/Na2HPO4:2H2O) (Kozuh et al. 2000).

4.3. Glucose treatment in sunlight and dark

Phosphate extraction was applied in the same samples (W12 and NS8) after the addition of glucose and 100 and 300 mg/l Cr(VI) (potassium dichromate). Glucose was added in the soil in a percentage of 3%. The mixture of glucose and Cr(VI) were preserved in the sunlight (OUT) and in dark (IN) in cycles of dryness and wetness for 10 days.

6. References


5. Results

5.1. Mineralogy

The magnetic separation showed in average 88% was not magnetic material, 8% was collected with 20V and 3% was collected with 5V. The mineralogical analysis showed that serpentine (lizardite/chromite) was mainly accumulated in the magnetic fraction of the samples along with other minerals such as quartz, calcite and magnetite (Table 1).

5.2. Geochemistry

The XRF results showed a strong correlation between Fe, Mn, Mg and Cr content in the magnetic fraction (Fig. 4). The total Cr concentration was higher in the magnetic fraction for all soil samples from Barka alluvial fan except the sample from the chromeite mine (NS8) where magnetic had lower Cr content (9,893 mg/kg) compare to the non-magnetic (13,114 mg/kg).

5.3. Extraction with distilled water and phosphate:

The extraction with distilled water showed no significant variation between bulk and magnetic fractions, while the extraction with phosphate showed higher Cr extraction (9-13 mg/l) for the non-magnetic fraction (Fig. 5). The IN and OUT treatment in W12 showed that the organic matter oxidation under sunlight had no effect on Cr(VI) (Fig. 6). The IN and OUT treatment in NS8 showed statistically sound evidence of sunlight influence in the Cr(VI) release. Overall Cr(VI) was much higher in the alluvial fan soil sample instead the mine soil (Fig. 6).

6. Discussion

Large amount of exchangeable Cr(VI) is closely related to the non-magnetic fraction (e.g. calcite) contrary to the high Cr concentration in the serpentine and the magnetic (Kazakis et al. 2015) as XRF analysis showed. We suggest that the photochemically catalysed reaction of organic matter oxidation (Hug et al. 1997) in Oman has an effect on Cr(VI) immobilization only in areas of ophiolite rocks. In alluvial fan soils, other reactions apart the photochemically catalyzed oxidation are regulating the high capacity of Cr(VI) immobilization.