Geoderma 247–248 (2015) 1–11

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

# Short-term impact of de-vegetation on organic/inorganic interactions and cation transfers in uppermost soil horizons

Khadija Semhi [a], Norbert Clauer [b,*], Sam Chaudhuri [c]

[a] Department of Earth Sciences, College of Science, Sultan Qaboos University, Al-Khod 123, Muscat, Oman
[b] Laboratoire d'Hydrologie et de Géochimie de Strasbourg, CNRS/UdS, 1 Rue Blessig, 67084 Strasbourg, France
[c] Department of Geology, Thompson Hall, Kansas State University, Manhattan, KS 66502, USA

ARTICLE INFO

*Article history:*
Received 10 September 2014
Received in revised form 3 January 2015
Accepted 13 January 2015
Available online 21 February 2015

*Keywords:*
Grass
De-vegetation
Meadow sandy soil
Soil solutions
Leaching minerals
Elementary chemistry

ABSTRACT

The soil solutions of a natural soil covered by grass and of the same soil after grass removal were collected and analyzed after each rainfall and percolation through the two soils during a fifteen-month experiment. To identify and quantify the water–mineral–plant interactions during this period of time, plastic tubes containing calcite and smectite particles were inserted into the two soils, some powder of both being recovered after three and fifteen months, water leached and the leachates analyzed. The contents of various elements including the rare-earth elements were measured in the soil solutions and the water leachates, to identify the extent of the interactions and evaluate the contribution of the plants. The immediate impact of de-vegetation was recorded in the soil solutions that exported systematically more Si and Ca, and often more Mg from de-vegetated soil. The supplement of exported Si was probably released by altering microorganisms as a response to de-vegetation, whereas that of Mg resulted probably from dissolution of oxy-hydroxides and that of Ca from partial dissolution of the calcite reference mineral. The removed elements were about 50 times higher in the soil solutions than in the plain rainwater before percolation through the soils. The contents of the dissolved organic carbon and ammonia of the soil solutions from de-vegetated soil were about one third higher than in those of the vegetated soil.

On the basis of the elemental contents of the soil solutions that percolated through the two soils, removal of plants did not significantly affect adsorption of the nutrient K on the inserted smectite and calcite during the initial three months. However, less K was adsorbed on smectite and calcite of the de-vegetated soil than on the same minerals of the same soil covered with grass during the following twelve months, indicating in turn that more K was removed from de-vegetated soil within a one-year time.

## 1. Introduction

Plants are known to modify the chemical and physical properties of soils in which they grow, mainly by releasing organic components that lower the soil pH and, therefore, affect the weathering process of the constitutive minerals. For instance, Cochran and Berner (1996) noticed that a basalt rock is more intensively altered below a vegetated soil than below a non-vegetated soil. The cation nutrients (e.g., Ca and Mg) released by weathered minerals and atmospheric dust can be retained in soil-exchange complexes and picked up variably from soil solutions by the vegetation. In fact, Drever (1994) focused on the complex interaction between organics and inorganics in soils, as plants can either increase mineral weathering rates in areas of high physical erosion, or decrease chemical weathering in binding secondary products that isolate fresh minerals from meteoric water during long-term interactions. Huang and Keller (1972) and Ochs et al. (1993) identified also varied behaviors of organic matter in soils by examining experimental systems, since humic substances can either enhance or inhibit mineral dissolution. In turn, humic compounds appear to decrease the dissolution rate of minerals by forming bi- or poly-nuclear surface complexes that protect the mineral grains from dissolution (Ochs, 1996). Since plants and their associated microbiota affect directly mineral weathering, vegetated soils should yield other chemical compositions and microbial populations than the same soils after de-vegetation. Conversely, Zhao et al. (2011) reported that vegetation removal has no significant effect on soil physico-chemical properties such as water content, pH, total nitrogen and organic carbon content.

The present work was designed to elaborate on the short-term impact of a de-vegetation action on the uppermost horizon of a natural soil covered by grass, in examining the behavior of usual chemical tracers. The challenge was to identify and quantify a short-term impact on the organic/inorganic interaction of a de-vegetated soil relative to that of its unaffected reference. The vegetated soil and its intentionally de-vegetated equivalent were collected next to each other in a meadow; they were, therefore, considered as strictly identical at the start of the survey. The study was based on the comparison of the chemical composition of solutions (labeled "soil solutions" hereafter) that were

---

* Corresponding author at: Laboratoire d'Hydrologie et de Géochimie de Strasbourg, CNRS/UdS, 1 Rue Blessig, 67084 Strasbourg, France.
*E-mail address:* nclauer@unistra.fr (N. Clauer).

http://dx.doi.org/10.1016/j.geoderma.2015.01.011

recovered during a fifteen-month period after rainwater migrated through two 50-cm thick soil blocks stored next to each other in field conditions similar to those in nature. Also, as the discrete, combined mineral/organic interactions of soils are often difficult to identify and the variations difficult to attribute precisely, especially during the period following immediate de-vegetation, two reference minerals, namely calcite and smectite, were inserted in both soils at the beginning of the experiment and analyzed periodically. These reference materials were leached gently after recovery with de-ionized water to remove and quantify the cations that were adsorbed on their surfaces during the experiment, in order to evaluate their potential adsorption/desorption and dissolution properties depending on the organic/inorganic interactions and elemental transfers in each soil.

## 2. Material and methods

The contents of major-, trace- and rare-earth elements (REEs), as well as of the dissolved organic carbon (DOC) and ammonia ($NH_4$), were measured in the soil solutions of both the vegetated soil covered by grass (labeled VGS hereafter) and the non-vegetated equivalent soil (labeled NVGS hereafter) after each rain episode. The same chemical elements were also analyzed in the bulk soils and in the leachates by de-ionized water of the two reference minerals (smectite and calcite) that were inserted in both soils, after three and fifteen months, to determine the source of the nutrients picked up by the soil solutions, and investigate the extent of the potential interactions between organic and inorganic components in each soil.

### 2.1. Experimental and sampling aspects

Two blocks of soil from a meadow located on the alluvium of the Rhine River about 20 km to the south of Strasbourg city, in eastern France, were collected next to each other. The two strictly identical soil blocks had a length of 0.50 m, a width of 0.35 m, and a thickness of 0.45 m. They were stored in opaque plastic boxes, and installed in the backyard of the Geology building during fifteen months, in similar conditions than previously in nature. The grass leaves and roots of one soil block were carefully removed at the beginning of the experiment, and the de-vegetated soil was watched afterwards to avoid growth of any plant at its surface. The grass species belongs to the so-called Ray grass (*Lolium perenne* L.).

As explained above, pure calcite and smectite minerals were used as tracers of the interactions between the minerals, organic matter and soil solutions of the two soil blocks, and of the associated elemental transfers. They were stored in plastic tubes of 1.5 cm in diameter with pore holes of 1 mm in diameter all over the tubes to maintain a close contact between the mineral crystals in the tubes and the soil solutions. The tubes were installed horizontally in the two soil blocks at a depth of about 10 cm. During fifteen months, the soil solutions were collected after each rain event in containers below the plastic boxes containing the soils. Some powder of the two reference minerals was sampled from each soil for analysis after three and fifteen months.

### 2.2. Analytical aspects

The purity of the two reference minerals and the mineral composition of the soil samples were checked by X-ray diffraction (XRD) before the experiment. The percolating soil solutions from the VGS and NVGS were collected in polyethylene bottles. These soil solutions and the water leachates of the reference minerals were pressure filtered through a Millipore HAWP 047–00 filter of 0.45 mm pore size, consisting in an ester of cellulose (nitrate + acetate).

The major elements (Al, Na, Ca, K, Fe and Mg) were analyzed in the soil solutions and water leachates by atomic absorption on a spectrometer (Z 8200 Hitachi) with an air–$C_2H_2$ gas mixture, whereas the $SiO_2$ concentrations were determined by colorimetry. The detection limit was 1 μmol/L and the total analytical precision was at ±2% (2σ). The trace and rare-earth elements (REEs) were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS; VG Plasmaquad PQ2+), the overall analytical precision ranging from ±5% for the trace elements to ±10% for the REEs, on the basis of the procedure by Samuel et al. (1985).

## 3. Results

The temperature and precipitation were measured during fifteen months in addition to the elemental concentrations of the soil solutions, and of the water leachates of the inserted reference minerals (Table A available upon request): the precipitations averaged 8.45 mm/month and the air temperature 12.9 °C. The pictured monthly averages of both outline some abnormally heavy rain events, especially during May 2000, whereas the temperatures were especially high during July and August 1999, as well as June 2000 (Fig. 1).

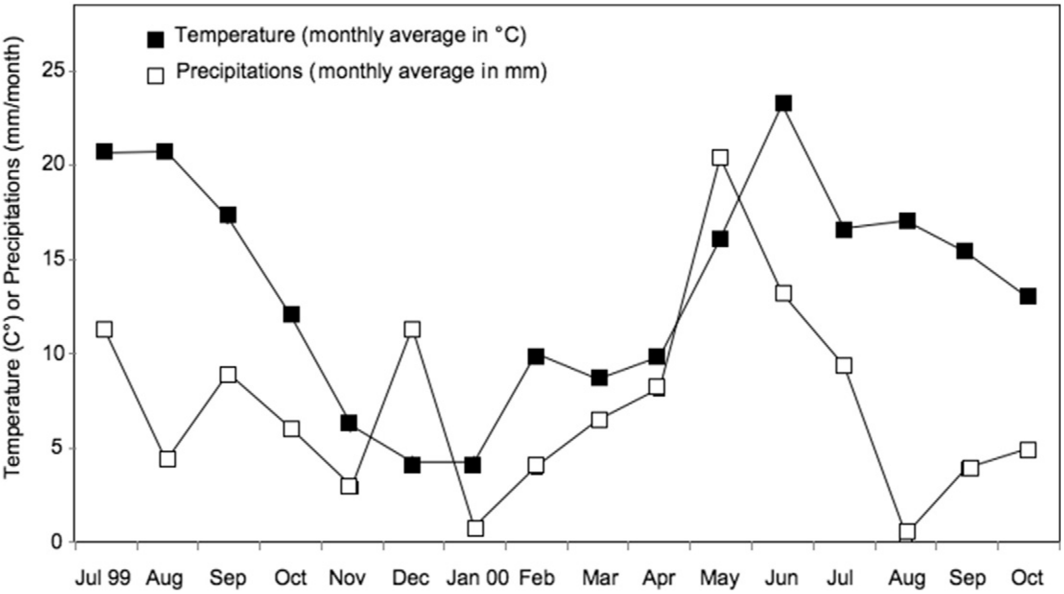

**Fig. 1.** Monthly variations of rain precipitation and air temperature during the 15-months experiment starting in July 1999. Jul, Aug, Sept, Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, and Jun stand for July, August, September, October, November, December, January, February, March, April, May and June, respectively.