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The abiotic degradation of soil organic matter to oxalic acid

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The abiotic degradation of soil organic matter to volatile organic compounds was studied intensely over the last years (Keppler et al., 2000; Huber et al., 2009). It was shown that soil organic matter is oxidised due to the presence of iron (III), hydrogen peroxide and chloride and thereby produces diverse alkyl halides, which are emitted into the atmosphere. The formation of polar halogenated compounds like chlorinated acetic acids which are relevant toxic environmental substances was also found in soils and sediments (Kilian et al., 2002).

The investigation of the formation of other polar halogenated and non-halogenated compounds like diverse mono- and dicarboxylic acids is going to attain more and more importance. Due to its high acidity oxalic acid might have impacts on the environment e.g., nutrient leaching, plant diseases and negative influence on microbial growth.

In this study, the abiotic formation of oxalic acid in soil is examined. For a better understanding of natural degradation processes mechanistic studies were conducted using the model compound catechol as representative for structural elements of the humic substances and its reaction with iron (III) and hydrogen peroxide. Iron is one of the most abundant elements on earth and hydrogen peroxide is produced by bacteria or through incomplete reduction of oxygen.

To find suitable parameters for an optimal reaction and a qualitative and quantitative analysis method the following reaction parameters are varied: concentration of iron (III) and hydrogen peroxide, time dependence, pH-value and influence of chloride.

Analysis of oxalic acid was performed employing an ion chromatograph equipped with a conductivity detector.

The time dependent reaction shows a relatively fast formation of oxalic acid, the optimum yield is achieved after 60 minutes. Compared to the concentration of catechol an excess of hydrogen peroxide as well as a low concentration of iron (III) are required. In absence of chloride the degradation of catechol to oxalic acid delivers a maximum yield of approximately 60 %, whereas the presence of chloride reduces the formation of oxalic acid to 30 %. Chloride possibly induces further competing reactions of catechol leading to a lower concentration of oxalic acid.

Freeze-dried soil samples have been tested for production of oxalic acid, where the rate of organic matter seems to play an important role for the formation. By adding iron (III) and/or hydrogen peroxide oxalic acid yields increase, which demonstrates the reaction of soil organic matter with iron (III) and hydrogen peroxide as expected. Thus the natural abiotic formation of oxalic acid is confirmed.

The results of the soil measurements are similar to those obtained with catechol. Therefore, the newly gained insights with model compounds appear to be applicable to soil conditions and these findings increase our understanding of the degradation pathways of soil organic matter.

Furthermore an overview of the rates of oxalic acid formation of a variety of soil samples is shown and discussed in the light of different soil parameter.