Empirical modelling of the oxidoreduction potential variations in a hydromorphic organic soil

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Hydromorphic soils develop characteristic features due to an excess of water. The microorganisms consume very rapidly the available dissolved oxygen. As the diffusion of oxygen is very slow at the water interface, the stock is rapidly depleted. Then the microflora evolves from an aerobic to a facultative anaerobic population and use other electron acceptors than oxygen (nitrate, iron oxide...). The Eh is decreasing very rapidly in submerged soils preserved from any recharge by fresh water (Berthelin, 1982). But in experimental field, in soils saturated with water, alternation of anoxic and oxic periods is frequently observed during the period of saturation (Maître, 1991). One of the parameters to differentiate these two states is the measurement of the oxidoreduction potential (Eh). Gambrell and Patrick (1978) report that the measure of Eh becomes a pertinent measure of the degree of reduction of hydromorphic soils when oxygen disappears: values of Eh range then from -400 to +400 mV. When oxygen is present, Eh may range from +400 to +700 mV. The Eh was recorded in situ during three years (1993-1996) in the soil solution in the organomineral horizon of a hydromorphic area located in a small catchment in Brittany. These three years were different from an hydrological point of view, and the temporal dynamics of the variation of Eh in the soil also. The more important the precipitation was, the higher the oxidoreduction potential was (Fig. 1). This physico-chemical factor seemed to be directly influenced by the supply of dissolved oxygen issued from recent rain event.

Elaboration of the model

The model is a two components model. One term accounts for the decrease of Eh in a confined area, the second one accounts for the increase of Eh after a rain event.

In soils saturated with water and placed in a confined environment (such as a soil column), the oxidoreduction potential decreases in a few days to very low values. The decreasing can be modelized by an exponential equation. The lowest limiting values evolve according to the supply of easily mineralisable organic matter, presence of electron accep-

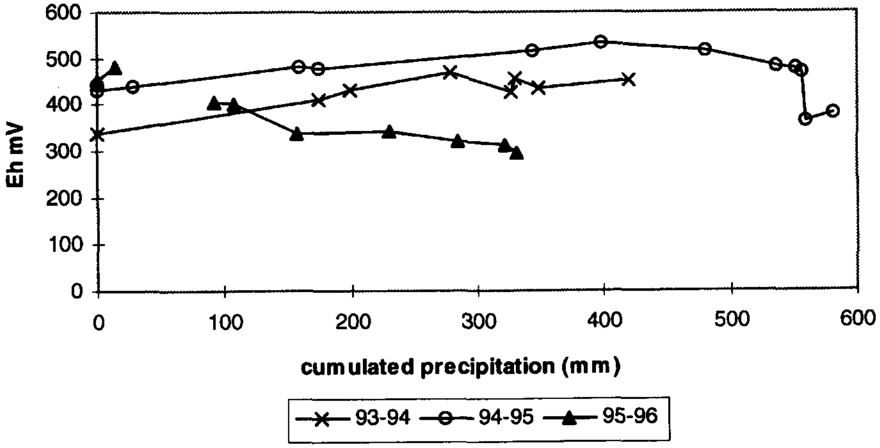

FIG. 1. Cumulated precipitation *vs* Eh.

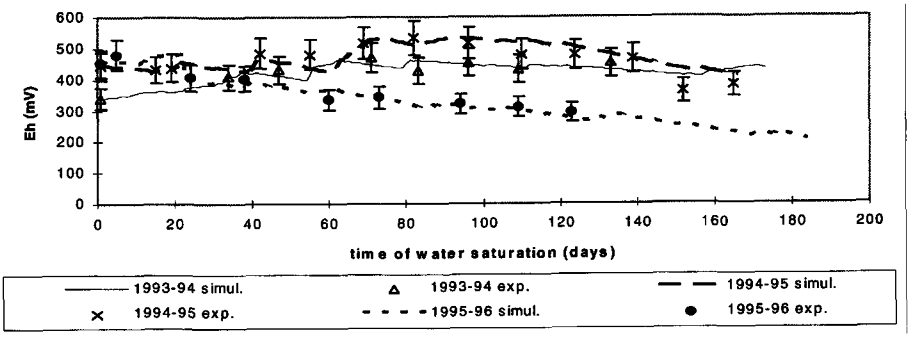

FIG. 2. Simulated and experimental values of the Eh.

tors. The term in exponential is weighted with a factor integrating the time to account for the fact that the more the soil is confined the more the Eh decreases. The second component represents the increase of Eh in the soil solution after the rainfall. It is directly dependent on the recharge of the soil solution with dissolved oxygen and must include the rainfall and the evapotranspiration. The model is an iterating model. The Eh at the j day is calculated by the formula:

$$Eh(j) = Eh(j-1) + a(p-etp) -j/b*\exp(-c*j)$$

j: cumulated days since the saturation of the area by water
etp: evapotranspiration
p: rainfall

The value of the Eh at the first day of saturation must be known. This model is validated by experimental data. Every 15 days, the Eh is measured in situ in the soil solution. The parameters a, b, and c are adjusted on the three first experimental points of the year 1993-1994.

Validation of the model

The two years of measures 1994-1995 and 1995-1996 validate the model. The uncertainty is 15%. This error is acceptable since the error on the Eh measurement on field is about 10%. Figure 2 reports the simulated and the experimental data.

Conclusion

The temporal evolution of the oxidoreduction potential is modelized during three different hydrological years. This model confirms that two major components contributing to the values of Eh in soil exist: the intrinsic decreasing due to the microflora activity and the increasing by the supply of dissolved oxygen by rainfall. The alternation of oxic and anoxic period is confirmed. Therefore transient anoxia occurs in the surface horizon of soil. This alternation can have a great importance on the geochemical processes (Jaffrezic, 1997).

References

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