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Effects of Soil Neutron Irradiation in Soil Carbon Neutron Gamma Analysis

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Abstract : The carbon sequestration question of modern times requires the development of an in-situ method of measuring soil carbon over large landmasses. Traditional chemical analytical methods used to evaluate large land areas require extensive soil sampling prior to processing for laboratory analysis; collectively, this is labor-intensive and time-consuming. An alternative method is to apply nuclear physics analysis, primarily in the form of pulsed fast-thermal neutron-gamma soil carbon analysis. This method is based on measuring the gamma-ray response that appears upon neutron irradiation of soil. Specific gamma lines with energies of 4.438 MeV appearing from neutron irradiation can be attributed to soil carbon nuclei. Based on measuring gamma line intensity, assessments of soil carbon concentration can be made. This method can be done directly in the field using a specially developed pulsed fast-thermal neutron-gamma system (PFTNA system). This system conducts in-situ analysis in a scanning mode coupled with GPS, which provides soil carbon concentration and distribution over large fields. The system has radiation shielding to minimize the dose rate (within radiation safety guidelines) for safe operator usage. Questions concerning the effect of neutron irradiation on soil health will be addressed. Information regarding absorbed neutron and gamma dose received by soil and its distribution with depth will be discussed in this study. This information was generated based on Monte-Carlo simulations (MCNP6.2 code) of neutron and gamma propagation in soil. Received data were used for the analysis of possible induced irradiation effects. The physical, chemical and biological effects of neutron soil irradiation were considered. From a physical aspect, we considered neutron (produced by the PFTNA system) induction of new isotopes and estimated the possibility of increasing the post-irradiation gamma background by comparisons to the natural background. An insignificant increase in gamma background appeared immediately after irradiation but returned to original values after several minutes due to the decay of short-lived new isotopes. From a chemical aspect, possible radiolysis of water (presented in soil) was considered. Based on stimulations of radiolysis of water, we concluded that the gamma dose rate used cannot produce gamma rays of notable rates. Possible effects of neutron irradiation (by the PFTNA system) on soil biota were also assessed experimentally. No notable changes were noted at the taxonomic level, nor was functional soil diversity affected. Our assessment suggested that the use of a PFTNA system with a neutron flux of 1e7 n/s for soil carbon analysis does not notably affect soil properties or soil health.

Keywords : carbon sequestration, neutron gamma analysis, radiation effect on soil, Monte-Carlo simulation
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