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Application of Neutron Stimulated Gamma Spectroscopy for Soil Elemental Analysis and Mapping

Authors : Aleksandr Kavetskiy, Galina Yakubova, Nikolay Sargsyan, Stephen A. Prior, H. Allen Torbert

Abstract : Determining soil elemental content and distribution (mapping) within a field are key features of modern agricultural practice. While traditional chemical analysis is a time consuming and labor-intensive multi-step process (e.g., sample collections, transport to laboratory, physical preparations, and chemical analysis), neutron-gamma soil analysis can be performed in-situ. This analysis is based on the registration of gamma rays issued from nuclei upon interaction with neutrons. Soil elements such as Si, C, Fe, O, Al, K, and H (moisture) can be assessed with this method. Data received from analysis can be directly used for creating soil elemental distribution maps (based on ArcGIS software) suitable for agricultural purposes. The neutron-gamma analysis system developed for field application consisted of an MP320 Neutron Generator (Thermo Fisher Scientific, Inc.), 3 sodium iodide gamma detectors (SCIONIX, Inc.) with a total volume of 7 liters, 'split electronics' (XIA, LLC), a power system, and an operational computer. Paired with GPS, this system can be used in the scanning mode to acquire gamma spectra while traversing a field. Using acquired spectra, soil elemental content can be calculated. These data can be combined with geographical coordinates in a geographical information system (i.e., ArcGIS) to produce elemental distribution maps suitable for agricultural purposes. Special software has been developed that will acquire gamma spectra, process and sort data, calculate soil elemental content, and combine these data with measured geographic coordinates to create soil elemental distribution maps. For example, 5.5 hours was needed to acquire necessary data for creating a carbon distribution map of an 8.5 ha field. This paper will briefly describe the physics behind the neutron gamma analysis method, physical construction the measurement system, and main characteristics and modes of work when conducting field surveys. Soil elemental distribution maps resulting from field surveys will be presented. and discussed. Comparison of these maps with maps created on the bases of chemical analysis and soil moisture measurements determined by soil electrical conductivity was similar. The maps created by neutron-gamma analysis were reproducible, as well. Based on these facts, it can be asserted that neutron stimulated soil gamma spectroscopy paired with GPS system is fully applicable for soil elemental agricultural field mapping.

Keywords : ArcGIS mapping, neutron gamma analysis, soil elemental content, soil gamma spectroscopy
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