

Chapter 21

Mining Spatial Patterns of Distribution of Uranium in Surface and Ground Waters in Ukraine

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ABSTRACT

A variety of geovisualization and spatial statistical methods can reveal spatial patterns in the distribution of chemical elements in surface and groundwater, and also identify major factors which define those patterns. This chapter describes a combination of modeling techniques to enhance understanding of large-scale spatial distribution of uranium in groundwater in Ukraine, by linking spatial patterns of several indicators and predictors. Factor, correlation, and regression analysis, including their spatial implementations, were used to describe the impacts of several environmental variables on spatial distribution of uranium. Local factor analysis (or Geographically Weighted Factor Analysis, GWFA) was proposed to identify major environmental factors which define the distribution of uranium, and to discover and map their spatial relationships. The study resulted in a series of maps to help visualize and explore the relationships between uranium and several environmental indicators.

INTRODUCTION

Surface and ground waters are important resources for drinking water supplies. Ukraine river flow is 1,000 m³ per capita, which is one of the lowest indicators in Europe, so availability of quality drinking water is a very important issue for the country. Drinking water quality is determined by chemical and biological content of the water and depends on several factors, including radioactivity of surface and groundwater associated with various natural and anthropogenic processes.

Natural radioactivity and groundwater contamination is often studied in areas of the extraction and processing of minerals, including uranium and oil. Natural radioactivity of oil and gas was first registered in 1904 in Canada, and later found in many places worldwide (Schneider, 1990; Makarenko, 2000). Several areas in Ukraine have high concentrations of uranium, so surface and groundwater in these areas can be potentially unsafe as a source of drinking water. Concentrations of uranium of 0.08 Mg/L and higher are potentially dangerous to human health, therefore, investigation of the impacts of uranium on groundwater (and thus, on the quality of drinking water) is an important scientific problem (Canadian soil quality, 2007; Nacional'nij atlas, 2007; Uranium in Drinking-water, 2011).

Multiple studies suggest that geological structure is the main natural factor which determines the content of natural radionuclides in ground and surface waters (Hakonson-Hayes et. al., 2002; Myers et. al., 1982; Sami & Druzynski, 2003; Skeppstrom & Olofsson, 2007). There is a wide body of research on this topic, but the most relevant to Ukraine are studies implemented in Sweden, Finland, and Canada, as geological structures in these countries are similar to those in Ukraine; they are all located on Pre-cambrian crystalline shields, Baltic and Canadian.

Ukraine is located in the central and southeast regions of Central Europe, with a population of about 47 million people. It spreads from the southwest of the Eastern European Plain, through the Ukrainian Carpathians and the Crimean Mountains, with its shores in the south washed by the Black and Azov Seas. About 95% of the country is relatively flat (with an average elevation of about 170m), and the Carpathians and Crimean Mountains occupy about 5% of its territory.

Ukraine is located within two major tectonic structures: the East European platform and the Alpine geosynclinal (folded) region. The plateau part of Ukraine is a rigid, slightly shifting tectonic structure with ancient crystalline rock covered by sediments (sand, clay, limestone, etc.). The Alpine geosynclinal region is dominated by sedimentary rocks. The system is relatively young (25-100 million years), and exhibits intense tectonic movements.

Ukraine has a complicated geological structure, comprising the following genetically related geo-structural regions: the Ukrainian Shield, Volyn-Podolsk Upland, Dnieper-Donetsk Basin, Donetsk folded structure within the East European Platform, and Carpathian and Crimean folded systems and Scythian Platform within the Alpine geosynclinal region. An interesting geological structure, the Black Sea Depression, stands out in the entire system. The structure lies in the merging areas of the old East European and younger Scythian Platform.

Apart from radioactive elements in rocks, concentration of radioactive elements in natural waters is defined by hydrogeological and climatic conditions, physical properties of rocks, chemical composition and electrochemical properties of natural waters, migration of radioactive isotopes during their transition from rocks into the water and further transportation with water, as occurs mostly in faults or other permeable surfaces. On average, river water has less total natural radioactivity than the sea and underground waters, except for rivers in regions with highly radioactive rocks (Uranium in Drinking-water, 2011). Levels of radioactivity in rivers vary depending on seasonal changes; levels reduce in spring and rise

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