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COMPARISON OF CU, PB AND ZN MOBILITY IN THE UNSATURATED ZONE AT TWO SITES OF DIFFERENT LITHOLOGIES UNDER TROPICAL CLIMATE (STATE OF SÃO PAULO, BRAZIL)

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The aim of this paper is to compare the mobility of Cu, Pb, and Zn under tropical climate, between "*in situ*" results (terrains of weathered preCambrian schists, where grapevines are cultivated - Site 1) and results from experiments carried out on undisturbed column samples taken from an Experimental Station (representing different levels of the same lithological layer of a Tertiary sedimentary basin, consisting of already weathered ferruginous and clayey material - Site 2).

At Site 1, monitoring wells were drilled, reaching the groundwater at 5.34m depth; porous cups and tensiometers were installed at 0.50m intervals, and a rainwater collector was placed. At this site the concentrations of Cu, Pb, and Zn of the weathered profile have been analyzed and the content of organic matter, spread out on the surface, was determined. The waters of the unsaturated zone and of the aquifer were analyzed during the period of one year. On this profile, where the concentrations of iron were found between 3.03 - 11.23 (WT%), pesticide solutions were applied annually with 8.59 mg/l Cu, 0.001 mg/l Pb and 0.12 mg/l Zn contents.

At Site 2, since 1985, monitoring wells, porous cups and tensiometers (installed at 0.50m intervals, of a profile of 12m thickness) have furnished data on hydrodynamics and geochemistry of water of the unsaturated zone. The experiments were realized on undisturbed columns of material, collected from a depth between 2.0 and 3.0m. Organic matter was practically absent in this material, and the iron contents were between 1.88 and 4.24 (WT%). On the columns, solutions with 100, 500, and 1000mg/l of Cu, Pb, and Zn were applied. On these columns and on two blanks, two rainwater types were simulated. During one year the leached out percolating waters were collected and analyzed. After one year, the columns were opened and the solid materials also analyzed.

At both sites, kaolinite is the most abundant clay mineral, outside of iron hydroxides.

The results showed that at Site 1, Cu was the most retained metal, concentrating on the upper part of the weathered profile and also at depth of 5.30m, where the iron content was found to be 516.8ppm. The Pb content increased with depth being 131.6ppm, concentrating also at levels where the iron content was high. Zn showed the greatest mobility and the retention was related with the clay content.

In the experiment, it can be pointed out that Zn was the most retained metal, in a general way, and mainly in the most ferruginous levels. For all the metals, the retention has been more important in the first ten centimetres (top) with less retention in the median and basal parts of each column. The different rainwater types did not influence the mobility of Cu and Zn; however, Pb was more leached out with the more intense rain type.

From the obtained results, it can be concluded that the original lithologies do not have any influence on the mobility of these metals; this being related to the secondary minerals -- kaolinite and iron hydroxides -- which are responsible for the retention of the studied metals. In these cases, organic matter does not play an important role in metal retention, because, under tropical climatic conditions, its decomposition and subsequent mineralization occur quite quickly.

16—5—2 00866 0765

PROTECTION OF GROUNDWATER RESOURCES FROM POLLUTION

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The safest resource of water supply for human use is still groundwater.

However, the increasing industrial use of modern technologies, which need water for discharge of affluents, is resulting in pollution of groundwater and is limiting the volume of this resource.

Thus, depending on the character of industry, affluents reaching aquifers may carry heavy metals, aromatic substances, phenols, fats, resins, fat acids, and many other deleterious materials which contaminate aquifers for a long time. Percolation of polutants into alluvial aquifers is provided by porous water-bearing deposits (gravel-sand), characterized by high permeability, on one hand, and good communication between river and subsurface flows, especially where rivers have cut their beds in water-bearing deposits, on the other. Aware of these circumstances, certain investigations and laboratory tests have been carried out in areas characteristic for this "vulnerable" environment. The tests included pollutant tracing to an aquifer and its emergence at the nearest pumping point. The tests and the obtained data indicate easy penetration of pollutants into the water resource and consequently into the sumping area.

A clear conclusion, based on the tests which will be described in this contribution, is that possibilities of groundwater pollution are very high, and that certain preventive protection is necessary, primarily for alluvial aquifers.

16—5—3 00871 0771

GEOPHYSICAL EVALUATION VERIFICATION OF AN AQUIFER SYSTEM VULNERABILITY TO POLLUTION (DEGREE OF NATURAL PROTECTABILITY) BY AVAILABLE GEOLOGICAL AND HYDROGEOLOGICAL DATA

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Groundwater for drinking purposes presents the most important and perspective part of the water resources. In many parts of the planet, it is the only source of water supply for population, industry and agricultural irrigation. Untill recently, water-bearing horizon exploration were the main subject of geophysics (in order to provide drinking water). However, the most interesting topic now is analysis of a hanging-wall in order to protect the water-bearing horizon against surface polluters.

Geophysical methods have a very important role in solving numerous practical tasks within domain of groundwater protection. On the other side, alluvial aquifer discussions are of significant importance because of several reasons: 1. the aquifer contains a very large quantity of restorable low-mineralized groundwater, so, in a great number of countries alluvial aquifers are in the first place; 2. water utilization from river valley sandy-gravel horizons is very great; 3. the aquifers are endangered by many sources of surface pollution (associated with the use of agricultural production - pesticides and fertilizers).

In the paper, foreign and Yugoslav contemporary knowledge, acquired not only in the field of hydrogeological research in domain of groundwater protection (accumulated within formations with intergranular porosity), but also in the field of alluvial water-bearing medium investigated by geophysical methods (particularly in determination of hanging-wall and its role in groundwater protection against pollution from the terrain surface) is synthesized.

As a study area, we analyzed risk of pollution of the aquifer system in the Velika Morava river alluvial plain (Serbia, Yugoslavia), as the central valley of the northern part of Balkan peninsula (about 60 km long, 10-13 km wide). The aquifer system represents not only the primary source of drinking water for a numerically substantial community, but it is also exploited for industrial purposes and for irrigation (although on a local scale). The study area also presents a high concentration of civil, industrial and agricultural activities which is a potential source of pollution for the groundwater resources through land occupation and use as well as the disposal of solid and liquid wastes.

According to unique features of the terrain (composition, gravel deposits thickness, stream position), the study area was separated into four exploratory sites: 1. coast near Brzan and Lapovo settlements; 2. Milošević I and II irrigation test fields (near Lozovik); 3. Trnovče - Lozovik rayon and 4. Šalinac field (near Smederevo town).

Vulnerability to pollution for the alluvial plain was estimated by geophysical methods through following factors:

- thickness of a low-permeable hanging-wall $d(m)$;
- groundwater level (in other words, thickness of aeration zone $h(m)$);
- grain-size distribution of hanging-wall;
- filtration coefficients of rocks within hanging-wall $K(m/s)$.

On the basis of cited criteria, *the three main categories of water-bearing horizons according to its self-protectability against pollution* are distinguished:

1. **A category - water-bearing horizon protected**: aquifer covered by impermeable clayey layer, over than 5 m thick; thickness of aeration zone in max GWL: over than 4.0 m; K for hanging-wall sediments: $K<5.0 \cdot 10^{-8}$ m/s.
2. **B category - water-bearing horizon conditionally protected**: aquifer covered by low-permeable layer (silty sand, silty clay, 3.5-5.0 m thick; aeration zone in max GWL: 3.0-4.0 m thick; $K=5.0 \cdot 10^{-6}$ to $1.0 \cdot 10^{-7}$ m/s.
3. **C category - water-bearing horizon unprotected**: aquifer covered by fine-grained clayey sands less than 3.5 m thick; aeration zone: <3.0 m thick; $K>1.0 \cdot 10^{-5}$ m/s.

Geophysical data obtained for gravel-sandy sediments of the Velika Morava alluvion are in satisfactory agreement with available geological and hydrogeological data.

With the more complex tasks existing within the past few-years period and in the future in the field of groundwater protection, further development of geophysical methods and methodological procedures is unavoidable, particularly in domain of environmental geology. That also means further advanced study of mathematical modeling techniques, with contemporary use of graphical and mathematical methods for data processing.