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Abstract to doctoral dissertation

APPLICATION OF GEOELECTRICAL METHODS FOR NEAR SURFACE ZONE RESEARCH IN THE VICINITY OF METALLURGICAL WASTE DISPOSAL SITES

Landfills are an immediate threat to the surrounding hydrogeological environment. Heaps and settling ponds associated with metallurgical plants are some of the examples of such waste sites. Effluents present or generated by such landfills can enter groundwater and further spread within the aquifers. The effluents usually cause increase in water mineralization, which is equivalent to lowering its resistivity. Geophysical methods sensitive to resistivity changes in the centre are geoelectrical methods. Therefore, those methods are predestined to investigate (indirectly) both the degree of contamination of the hydrogeological environment and its spatial extent. Effective use of geoelectrical methods for such issues is not easy due to the difficulty in selecting appropriate measurement methodology and complex interpretation of the results.

The purpose of the presented work is to indicate the possibilities and limitations, as well as the principles of effective use, of DC resistivity methods in the examination of contamination of hydrogeological centre. The work required the author to perform fieldwork, laboratory scale experiments as well as numerical modelling.

In field surveys, electrical resistivity tomography (ERT) and penetrometer based geoelectrical profiling (PBGP) methods were used to investigate the impact of selected metallurgical waste sites (related to the ArcelorMittal steelworks in Kraków) on the surrounding groundwater environment. Combined use of the methods

allowed to assess the degree of contamination of the examined centre on a macro scale. Some important information on the geoelectrical characteristics of the analysed area was provided and allowed determination of the extent of the contamination zone generated by the metallurgical waste sites. For more accurate (micro scale) investigation of the degree and nature of contamination the PBGP method was applied in field and laboratory measurements. The advantage is the ability of performing, in addition to the standard determination of resistivity, measurements of electrical potential along with its dynamics (changing in time) and *electrode effects*. The use of PBGP surveys provides significant opportunities for collecting, correlating and analysing data of different scope. The field variant of such measurements allowed to determine the depth differentiation of settlings in the studied pond, by examining the distribution of electrical potential and resistivity in the centre.

In laboratory work, an original research setup was designed and constructed to simulate a contaminated centre and study it with the use of ERT and PBGP methods. In the laboratory models presented in the work, the contaminant generating effluents was anthropogenic material collected from one of the sediment ponds. The experiments involved PBGP method with the use of a special geoelectrical probe and original variant of the ERT method. The results of laboratory tests have been extended by analysing the chemical and mineralogical composition of the anthropogenic material used in the experiments. Among other things, laboratory research allowed to investigate the *electrode effects* and electrical potential changes for different samples of contaminated material. The results indicated the presence of specific and well measurable electrical effects, however, their genesis (and interpretation) is complex. This requires more research, but the results so far can contribute to the development of an original method for characterizing different types of contaminants already at the field measurement level.

The dissertation presents as well the possibilities and limitations of the ERT method to "trace" the contamination zone in the aquifer. Numerical analysis of the respective 2D and 3D models (based on fieldwork results) was used for this purpose. The obtained interpreted resistivity distributions were used to analyse the differences between the results obtained by 2D and 3D variant of ERT method. In addition, the results of numerical modelling show the possibilities offered by the 3D variant, which, due to many technical limitations, is relatively rarely applied.

Additionally, it has been shown that 3D modelling can be a useful, complementary element in interpreting the results of DC resistivity methods.

The results of conducted geoelectrical studies, both field and laboratory, have provided important information on the contamination of the subsurface zone. In combination with the available geomorphological and hydrogeological information, the results allowed the author to formulate hypotheses regarding the entering of pollutants from metallurgical waste sites into the aquifer. It has also indicated the possible routes of further transportation of the pollutants. Presented examples of numerical modelling, both 2D and 3D, enable the development of an effective field methodology for ERT method. The proposed method of performing laboratory measurements can be used to develop an innovative method for determining the properties of a contaminated centre both *in situ* and on the basis of samples of anthropogenic material.