Summary

The main goal of this study was to examine whether water entering the post-reaction area after underground coal gasification (UCG) leaches metals from the post-processing waste in the cavity to such a degree that it can pose a threat to the water environment.

After the completion of UCG process, a portion of solid products such as char, ash and slag remains in the cavern where the quenching occurred, and the complete removal of these solid products is impossible. In the post-operational phase of *in situ* gasification of coal groundwater may flow into the post-UCG area and have contact with the post-process residues, eluting impurities from waste and carrying them into the surrounding aquifers (on the principle of circulation of groundwater). Because geo-reactors are situated in the vicinity of natural geological formations of varying structure and properties, there is always a risk that, despite proper prior hydrogeological examination, the thermal and mechanical factors accompanying the process of UCG significantly alter rock mass parameters and thus enable the migration of eluted substances into the environment. Tests carried out within the framework of this study have been proposed primarily in terms of the safety of the natural aquatic environment, particularly ground water.

The subjects of tests were the residues obtained from seven different coal and lignite gasification experiments (two *in situ* experiments and five experimental simulations of UCG in an *ex situ* laboratory installations). Two types of solid waste were collected: ash residue and char residue. The experimental research part was divided into three sections, the short description of which is given in section 2.2.1.

To estimate the qualitative and quantitative profiles of metals and nonmetals leaching to the aquatic environment in the vicinity of the UCG cavity, an elution method for solid waste remaining in the cavern after the exploitation phase of the process was proposed. Deionized water was used as a medium in the leaching tests, which in principle allowed to release the most probable load of analyzed inorganic pollutants from the tested waste. In addition, natural mine waters of different mineralization were used. Such a method of carrying out the leaching test allowed to simulate the natural hydrological conditions characteristic for different depths of geo-location of the UCG georeactor. Carrying out the leaching tests allowed to estimate the charge of substances entering the aquatic environment and to assess their toxicity in relation to the normative values given in the relevant legislation in the field of water management.

Based on the proximate and ultimate analysis of solid materials and the physicochemical analysis of obtained water extracts, the behavior of the elements during the *in-situ* gasification process was investigated and the individual groups of elements were identified for their affinity for the aqueous phase. Comparative analyzes of UCG ash residue and furnace ashes from raw coal combustion were conducted to illustrate how the type of thermal conversion of coal affects the leaching ability of particular elements in the aquatic environment. It has been found that the majority of tested elements tends to be leached to a stronger degree from ash residues than from chars. A higher relation to the water phase is shown by the residue of gasified lignite compared to residues from hard coal. However, more exceedances relative to the limits of the hydro-geochemical background are characteristic for hard coal eluates. The presence of Cr, Pb or Cd in the extracts may suggest that toxic metals are able to leach to water from the residues of the gasification process and that there might occur a non-negligible risk of environment contamination.

The sorption characteristics of solid waste from UCG cavern treated as geosorbents allowed to verify the self-purifying capacity of groundwater from toxic metals in the area affected by the quenched UCG reactor. The knowledge about inorganic contaminations and its leaching by water together with sorption characteristics of tested metal-geosorbent systems was incorporated into hydrogeochemical model of the spread of pollutants in the time period in the area of UCG.

Based on the results of this study, it can be assumed that the major and trace metals present in coal after the completion of the UCG process may be eluted after gasification by incoming groundwater and may migrate to the geo-surrounding water-ground environment of consequences cause groundwater pollution. It has been also proven that both the type of gasification as well as the degree of coal thermal conversion and the physicochemical changes occurring during the ucg process have a significant effect on the intensity of the spread of inorganic pollutants in the aquatic environment.