

Chemical environmental impact of geothermal resource utilization

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High-temperature geothermal resources are being increasingly exploited for power generation and low-temperature resources for direct use. In 1999 the installed capacity of geothermal power plants in the world was ~8000 MW (energy use = 49,000 GWh). The corresponding numbers for direct use were 11,000 MW and 53,000 GWh. The environmental impact of geothermal power plants includes chemical pollution from gaseous components in steam and dissolved solids in water, scenery spoliation, land erosion, noise and sometimes subsidence. In the last 20 years, or so, the environmental impact has been reduced by injecting into wells waste water and condensate. At some geothermal power plants, the H₂S in the steam is removed before disposal to reduce atmospheric pollution. Generally cooling towers have been used for steam condensation, the purpose of condensation being to improve the efficiency of steam exploitation. A notable exception is the Nesjavellir power plant, Iceland where the steam is condensed in heat exchangers. With this layout, and the injection of waste water and condensate into wells, surface installations are effectively a closed loop between production and injection wells, thus minimizing the environmental impact of the utilization of the geothermal resource. The environmental impact of direct use of low-temperature geothermal resources is much less than that of high-temperature ones and generally very insignificant with respect to chemical pollution.

Geothermal fluids show very wide ranges in chemical composition ranging from <1000 ppm dissolved solids in systems hosted by basaltic rocks to >30% in systems in sedimentary rocks containing evaporites. Correspondingly large variations occur in the concentrations of air- and water-borne poisons in these fluids. Water-borne poisons include As, B, Hg, H₂S, NH₃, sometimes Al and various heavy metals in addition to high salt content. Air-borne poisons include As, Hg and H₂S in addition to the greenhouse gases, CH₄ and CO₂. The concentrations of environmentally harmful chemical constituents in geo-thermal fluids are related to their geological setting, the rock types that host them and aquifer temperature.

The activities of reactive components in >100°C geothermal fluids are controlled by temperature dependent secondary mineral-solution equilibria. By contrast, the concentrations of conservative components (e.g. Cl, B, As) are determined by their supply to the geothermal fluid which may come from the rock with which the fluid has reacted, the magma heat source or the parent fluid. Because of this, geothermal fluid compositions are to some extent predictable, including poisons compounds, in terms of aquifer temperature, salinity and geological environment.

Carbon Cycling in a Continental Margin Sediment: Contrasts Between Organic Matter Characteristics and Remineralization Rates and Pathways

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In Skagerrak, chemical characterization suggested that sedimentary organic matter was similar at 3 stations, with high C/N, just 12% of TOC characterizable at a molecular level, and little downcore variation in total organic carbon, total hydrolysable amino acids, or total hydrolysable carbohydrates. All of these parameters are characteristic of 'low quality' and not particularly reactive organic matter. Measurements of the terminal steps in the carbon remineralization pathway, however, presented a different picture. Net carbon oxidation rates at all three stations were relatively high, and differences in terminal remineralization processes (sulfate, iron, and manganese reduction) implied differences among the microbial communities active in these sediments. Measurements of enzymatic hydrolysis rates also demonstrated depth-, substrate, and site-related differences in potential enzyme activities. A comparison of dissolved organic carbon (DOC) inventories with enzymatic hydrolysis and terminal remineralization rates demonstrated that turnover of at least a portion of the DOC pool must be rapid, hence conversion of POC to DOC must also be sufficiently fast to maintain the DOC pool. Standard methods of bulk chemical characterization of sedimentary organic matter are clearly insufficient in this case to reveal variabilities in organic matter reactivity that are important at a microbial scale.