High vs. low enthalpies geothermal resources: environmental issues

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The aim of this work is to perform a comparative study of the environmental impacts associated with the operation of geothermal resources, in order to determine its type and possible causes. The promotion of the use of renewable energy resources to the detriment of non-renewable energy resources is ascribed to the reduced environmental impacts caused by the first ones, as well as the fact that their source is subject to constant renewal. The environmental impacts resulting from the use of geothermal resources are diverse and depend on the type of geothermal fluid and the respective type of use. Accordingly, the direct applications, associated with low enthalpy geothermal resources have a lower impact as compared to the exploitation of high enthalpy geothermal resources. Given the nature of the use of low enthalpy geothermal resources and their own characteristics, exploitation has little impact on the environment, which might explain the scarcity of scientific literature on this subject. On the other hand, the exploitation of high enthalpy geothermal resources produces much higher impacts on the environment. Therefore, their use must be sustainable, which implies the resources protection and mitigation of potential environmental impacts of its operations. Some of the major negative impacts resulting from the use of high enthalpy geothermal resources are: reinjection in the geothermal reservoir (at a temperature much lower than the fluid in the reservoir) enhancing the loss of thermophilic biodiversity; visual impact (intense in the preparation, drilling and construction phases due to deforestation, earthmoving and the presence of heavy machinery); noise pollution due to five distinct phases of geothermal power plants development (preparation, drilling, borehole testing, construction of the geothermal power plant and operation; hydrothermal eruptions that occur due to sudden reduction of pressure in the reservoirs located relatively close to the surface; thermal and chemical pollution due to the release into the environment of the effluents from geothermal power plants; induced seismicity ascribed to the injection of a fluid at a temperature lower than the reservoir; subsidence related with reservoir overexploitation. Two case studies of low

enthalpy geothermal systems (Caldas de Moledo and Caldas da Rainha – northern/central Portugal, respectively) will be discussed, in order to present the usefulness of geochemical and isotopic tracers in the assessment of environmental impacts. In the case study of Caldas de Moledo thermal spring waters, the SO_4 and K concentrations found in some thermal spring waters show evidences of mixing between deep geothermal and shallow cold groundwaters collected at low altitude sites (enrichment in $\delta^{18}O$ values). In the Caldas da Rainha case study, the presence of ^{3}H (from 1.1 to 2.8 TU) in some thermomineral boreholes (showing rather similar geochemical signatures) corroborates the existence of different underground flow paths.

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