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Multi-tracer study of Croatian and Bosnian karst springs: is there a future for the lumped parameter approach?

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During the EU project “Anthropol.prot” the border area between Croatia and Bosnia-Herzegovina was studied in the catchments of the Plitvice Lakes and of the Una River with geochemical, isotope hydrological, geochronological and sedimentological methods. For the National Park Plitvice Lakes and the karst springs used for the drinking water supply of the city of Bihac and Kulen Vakuf any pollution had a high social-economic impact. Potential contaminant sources exist, like an abandoned military airport in the border region, chemical industry in the surroundings of Bihac, industrial and domestic wastewaters, and high tourist activity and a former saw mill in the Plitvice National Park. The whole area is highly karstified and most sensitive to pollution. Hydraulic transboundary connections from Croatian sinkholes to Bosnian springs were known from dye experiments between 1973 and 1983 and are confirmed by the isotope hydrological investigations. For some springs, irregular tritium records exist since the late seventies.

The presentation will first give a very short overview of the project activities ranging from geochemical studies of age-dated sediment records to water balance investigations using classical hydrology and transient (isotope) tracers including GIS-based vulnerability and risk mapping. The presentation will focus then on determinations of mean residence times in karst springs using the lumped parameter approach. Whereas elder studies using well-established model codes like FlowPC mainly focused on one

transient isotopic tracer in a single box model, the dataset in this study can rely on monthly records of stable isotopes and tritium for at least two years together with two single campaigns applying CFC/SF6 species and the isotopes of helium and neon. A special problem here is the inversion of noble gas data to derive the tritiogenic 3He component. For the common interpretation of such a variety of tracers an own model code was developed which is integrated into the open source LabData laboratory database system. The application of this code to this multi-tracer dataset shows that a single box model is not able to explain all data. It further demonstrates how the combination of time series of several tracers during different hydrological conditions can give a deeper insight into the system by at least partly resolving the components. This sheds new light on the strengths and limitations of lumped parameter models applied to karst systems in general. It also points towards developments needed in future, like lumped parameter modelling with unsteady flows and the numerical treatment of noble gas data resulting from water components infiltrated under different conditions (temperature, excess air).