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Self-purification capability of underground water courses in the humid tropics: results of a tracing experiment at the Gran Caverna de Santo Tomas, Cuba

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The “Gran Caverna de Santo Tomas”, located some 210 km west of the city of Havana, capital of Cuba, is the biggest cave system in the country, with almost 47 km of communicated underground galleries and several dozens of non connected caves. In addition to remarkable size and length of the underground system, the “Gran Caverna de Santo Tomas” represents one of the most famous karst caves in Cuba, that has been studied since the ‘50s by the Cuban explorer and caver Antonio Nunez Jimenez. The karst system develops in the Sierra de Quemado, a “mogotes” karst area in the Pinar del Rìo province where five catchment basins converge (respectively, Santo Tomas, Bolo, Peñate, Arroyo de La Tierra, and Los Cerritos). Water courses from these catchments enter the hills through individual caves in the eastern slope of the carbonate mountains. The town of El Moncada is located just upstream these basins and discharges its untreated wastewaters to the rivers before they reach the underground cave system. The “Gran Caverna de Santo Tomas” develops in seven levels at different elevations, the lowest of which corresponds to the present course of the Arroyo Santo Tomas. Speleological activities, caving, researches and explorations are considered of great importance in Cuba, and particularly in the Pinar del Rio province, as the foundation of the Escuela Nacional de Espeleologia in 1984, dedicated to Antonio Nunez Jimenez and sited nearby two of the main cave entrances of the Santo Tomas karst system, shows. Groundwater pollution is a topic of crucial importance all over the world, from developing to industrialized countries. Especially in developing countries, scarcity of groundwater and severe pollution of the available resources may have dramatic effects on the local populations: difficulty in keeping up with sinking ground-

water levels, or problems in finding alternative sources once the groundwater resource has become polluted are quite common. In karst, infiltration is fast and the degree of natural purification is low. Additionally, self-purification is limited because of fast, turbulent underground flow through well-developed karst conduits. Direct consequences of the high velocities of flow are very short residence times and the spreading of contamination at great distances from the original point of entry. There is therefore a strong need to deepen the knowledge on karst groundwater, and to protect it adequately. In this sense, a very important contribution might come from water-tracing experiments, that have repeatedly proved to be very useful tools for the acquisition of information on the extent of recharge zones, characteristics of groundwater flow and transport of contaminants. Tracer tests are often considered essential if carbonate aquifers are to be adequately protected from pollution. Starting from these considerations, water retention and groundwater velocity and mixing were evaluated at the "Gran Caverna de Santo Tomas" karst system by carrying out a tracer test conducted by one of the authors of this contribution. Water sampling in several input-output stations allowed the determination of the self-purification degree and the coefficient of oxygen consumption in this unconfined conduit flow system. The eco-hydrological vulnerability and the anthropogenic hazards to human health of the communities living at the discharge slope of the Sierra de Quemado have been evaluated after this experiment. The hydrological behavior of a system where flash floods linked to heavy and/or hurricane rains can modify groundwater flow and hence the retention and self-purification capability of the system is also discussed in the paper.