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Microbial disintegration of pollutants in carbonate aquifers of the Franconian Alb. Potentials and limitations according to results from laboratory and field investigations

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Under special sedimentologic and hydraulic as well as nutrient and energy supply conditions karts aquifers may develop within short runs of time a significant microbial disintegration potential in both the saturated and unsaturated karst zones. – Systematic tracer and environmental isotope studies proved for the Franconian Alb that only bi- or poly-porous carbonates, which are wide spread, have the potential to dilute and microbially disintegrate contaminants e.g. from agriculture. If only dilution prevailed, pollutants may accumulate on a long run of time and endanger the quality of karst groundwater in a far future; this accumulation, however, is difficult to monitor, hence remains on long runs of times undetected. As far as micro-organisms came into game, accumulated pollutants become disintegrated if two basic conditions are fulfilled:

1. There exists a habitat large enough to host micro-organisms and their bio-films and to allow water to flow through, but simultaneously small enough to guarantee sufficient long turn-over-times for the disintegration process and
2. A nutrient and energy supply, which keeps metabolism of micro-organisms running; nutrient supply depends from POM or DOC in groundwater, which are abundantly available in weathering karst zone, but occur only in small quantities in karst groundwater.

Laboratory experiments showed that microbial disintegration in water (DOC $<$ 2mgC/L) is quasi negligible under anaerobic conditions; it can be stimulated adding

nutrients to the water or rock pieces, which have been incubated during 5 to 11 months in karst groundwater. Such rock pieces are covered with bio-films of 10 to 30μm thickness and need no anaerobic water for disintegration because the bio-film itself creates anaerobic conditions despite an aerobic environment. Under field conditions this can also be observed using isotope fractionation signals from reduction processes in karst groundwater with an Eh of +400mV. – Exposing quartz, granite, white and black carbonate rock pieces to karst groundwater of different agriculture impact and using the exposed rock pieces for disintegration experiments resulted in the following observations.

1. Under agricultural areas more living strains occur than under forest areas; obviously micro-organisms adapt to the nutrient supply; in contrast, in old groundwater (5000years), the microbial numbers are very small;
2. All rocks are covered with bio-films after incubation, but thick bio-films develop only on black limestones and
3. Only bio-films on black limestones have a significant disintegration potential.

These findings are interpreted in terms of

1. Bio-film interaction with water and rocks if the nutrient supply from water is limited and
2. Inorganic carbon in carbonates can not replace organic carbon or under the experimental conditions no auto-lithotrophic disintegration came into game.

In conclusion, microbial disintegration takes place in carbonate rocks if the residence times of groundwater are high, bio-films develop at the rock surface, the nutrient and energy supply becomes sufficient.