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Sanitary protection zoning based on time-dependent vulnerability assessment model – case examples at two different type of aquifers

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Delineation of sanitary protection zones of groundwater source is a comprehensive and multidisciplinary task. Uniform methodology for protection zoning for various type of aquifers is not established. Currently applied methods mostly rely on horizontal groundwater travel time toward the tapping structure. On the other hand, groundwater vulnerability assessment methods evaluate the protective function of unsaturated zone as an important part of groundwater source protection. In some particular cases surface flow might also be important, because of rapid transfer of contaminants toward the zones with intense infiltration. For delineation of sanitary protection zones three major components should be analysed: vertical travel time through unsaturated zone, horizontal travel time through saturated zone and surface water travel time toward intense infiltration zones. Integrating the aforementioned components into one time-dependent model represents a basis of presented method for delineation of groundwater source protection zones in rocks and sediments of different porosity.

The proposed model comprises of travel time components of surface water, as well as groundwater (horizontal and vertical component). The results obtained using the model, represent the groundwater vulnerability as the sum of the surface and groundwater travel time and corresponds to the travel time of potential contaminants from the ground surface to the tapping structure. This vulnerability assessment approach do not consider contaminant properties (intrinsic vulnerability) although it can be easily improved for evaluating the specific groundwater vulnerability.

This concept of the sanitary protection zones was applied at two different type of aquifers: karstic aquifer of catchment area of Bledrija springs and “Beli Timok” source of intergranular shallow aquifer. The first one represents a typical karst hydrogeological system with part of the catchment with allogenic recharge, and the second one, the groundwater source within shallow intergranular alluvial aquifer, dominantly recharged by river bank filtration.

For sanitary protection zones delineation, the applied method has shown the importance of introducing all travel time components equally. In the case of the karstic source, the importance of the surface flow toward ponor zones has been emphasized, as a consequence of rapid travel time of water in relation to diffuse infiltration from autogenic part. When it comes to the shallow intergranular aquifer, the character of the unsaturated zone gets more prominent role in the source protection, as important buffer of the vertical movement downward. The applicability of proposed method has been shown regardless of the type of the aquifer, and at the same time intelligible results of the delineated sanitary protection zones are possible to validate with various methods.

Key words: groundwater protection zoning, time dependent model, karst aquifer, intergranular aquifer, groundwater source protection