Contaminated land

Grave concerns

Health risks from human burials

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Many cemeteries in the United Kingdom are becoming full and additional land is required to accommodate the estimated 160 000 burials that take place each year. The impact of cemeteries on groundwater is a little researched subject, despite historical accounts of microbial pollution of groundwater in adjacent wells. Moreover, a review carried out by the BGS on behalf of the Environment Agency in 1998, noted that there is a paucity of knowledge of microbiological contaminants in groundwater, even for major sources such as septic tanks, treatment plants, and sewage irrigation schemes, while the impact of cemeteries is virtually unknown.

Researchers at the BGS and the Robens Institute (University of Surrey) in collaboration with the Environment Agency are investigating a cemetery in the West Midlands in order to assess the impact on groundwater of current burial practices and provide guidelines for the siting of new cemeteries.

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The cemetery is located on an area of thin glacial till on the Bromsgrove Sandstone Formation, the second most important drinking-water aquifer in England. The graves are dug to two metres depth to the sandstone–till interface. Groundwater levels are generally five metres beneath surface and the site investigation has involved drilling ten boreholes which have been used to measure the hydraulic conductivity of the sandstone and provide groundwater samples for analysis. The saturated vertical conductivity of the overlying drift deposits was determined from a number of infiltration tests. The groundwater has been analysed for major, minor, and trace element composition, and GC-MS techniques have been used to identify any organic compounds present. The Robens Institute was responsible for detecting and identifying bacteria and viruses.

The results show that groundwater down hydraulic gradient from the cemetery has slightly elevated concentrations of chloride and sulphate, consistent with compounds released from a decaying body. Microbiological tests show that the water contains thermo-tolerant coliforms and faecal streptococci at concentrations that the World Health Organisation classes as 'heavily contaminated'. The ratio of thermo-tolerant coliforms to faecal streptococci indicates a human source and, in addition, the groundwater contains *Staphylococcus aureus*, which is found on human skin and mucous membranes, but is otherwise a very rare groundwater contaminant. This bacterium is responsible for most hospital-acquired infections. Roto- and enteroviruses, which are found in the intestine and are stable in the environment, were not detected.

There is now good evidence that bacteria which decompose corpses can reach the water table. Modelling bacteria movement through the unsaturated zone below the graves suggests that they would break through a three-metre thick unsaturated zone and enter the groundwater within five years of burial. However, these times are well in excess of the life expectancy of these bacteria. The conclusion to be drawn, which is supported by hydraulic test results, is that groundwater flow through fractures is allowing rapid transit to the water table. Further work is under way to evaluate how the microbiological population changes over time and to understand transport pathways and the survival of bacteria through various geological settings.

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Vicarage rendered unhealthy by infiltration from churchyard. Based on plate LX in: Pridgin Teale, T. 1881, Dangers to Health: A Pictorial Guide to Domestic and Sanitary Defects.