# GROUNDWATER POLLUTION: DISPERSED

extract from pages 403-404 of:

Gunn, J., (editor) *Encyclopedia of Caves and Karst Science*, Fitzroy Dearborn, NY.

Dispersed pollution, also known as nonpoint source pollution, comes from a wide variety of sources rather than from a single point source such as a pipe or injection well. As rainwater or snowmelt runs across the surface and percolates through the soil it picks up and carries away natural and man-made contaminants. The list of contaminants and sources is long, but can be categorized into some generalized groupings. Dispersed pollutants may include fertilizers, herbicides, and insecticides from agricultural and residential areas; oil, grease, and toxic chemicals from urban and highway runoff; sediment from crop and forest lands and construction sites; salt from irrigation and highway runoff; pathogens and nutrients from livestock, pet wastes, and faulty septic systems; and atmospheric deposition.

Contaminants from dispersed sources enter karst groundwater systems by allogenic or autogenic recharge. Allogenic recharge originates from nonkarst areas; surface streams flowing onto the karst land sink into the karst bedrock carrying any contaminants with the sinking water. Allogenic recharge undergoes very little or no natural filtration and contaminants in the sinking water directly contaminate the groundwater. Autogenic recharge originates from rain falling directly on the karst landscape. The recharge may be dispersed, infiltrating through the soil and percolating through the rock mass, or concentrated by overland flow and throughflow and entering at a point, often at the bottom of a doline (Gunn, 1983). Autogenic recharge waters pick up contaminants from the surface and during percolation through soil. Gibert (1990) describes the various forms of filtration and filtration interactions in karstic and porous aquifers. Autogenic recharge water percolating through soil undergoes natural filtration, but thin, karst soils with highly developed secondary porosity via macropores are limited in their filtration ability. Furthermore, solutionally enlarged joints at the soil–bedrock interface can rapidly transport draining water and contaminants to the groundwater system.

Although not the sole source of dispersed contaminants in groundwater, agriculture is often viewed as a major source of nutrients, organic chemicals, and pathogens. Nitrate is the primary nutrient of concern in groundwater because of its potential health risks such as methemoglobinemia (blue body syndrome), some cancers, and teratogenic effects. Agricultural sources of nitrate include inorganic fertilizers and animal wastes. A linear relationship has been shown between nitrate concentrations in karst springs and percent of land in agricultural land use in the Appalachian region of the United States (Kastrinos & White, 1986; Boyer & Pasquarell, 1995). Nitrate is an anion (negatively charged ion) and is not readily adsorbed to soil particles. Quickly percolating water on karst landscapes reduces the opportunity for denitrification processes to convert nitrate to the more stable ammonium cation and it quickly leaches to the groundwater system. Drinking water standard limits for nitrate nitrogen are set at 10 mg $L^{-1}$ in the United States and 11.3 mg $L^{-1}$ in Europe. Boyer and Pasquarell (1996) found nitrate concentrations in karst groundwater below animal grazing systems in the Appalachian region of the United States exceeded the drinking water standard on numerous occasions.

Pathogens have received an increasing amount of attention in recent years as a groundwater contaminant. Recent research emphasis has been placed on the human pathogens *Cryptosporidium panium* protozoa and *Escherichia coli* O157:H7 bacteria, but there are potentially hundreds of pathogens that might be present in groundwater. Tests for faecal coliform bacteria are usually used to indicate the presence of faecal contamination and the possible presence of enteric pathogens. The lack of suitable natural filtration in karst systems has resulted in significant numbers of faecal coliform bacteria contaminating karst ground water as a result of agricultural activity (Pasquarell & Boyer, 1995; Gunn et al., 1998). Water in the United States and Europe does not meet drinking water standards if any total or faecal coliform bacteria are found.

Herbicides and pesticides have been found in some karst groundwaters (Hallberg, 1986; Pasquarell & Boyer, 1996). The appearance of herbicides in the karst groundwater of the intensively cropped Midwestern United States (Hallberg, 1986) is not surprising, but Pasquarell and Boyer (1996) routinely found atrazine in karst groundwater of the central Appalachian karst in the United States, even though the use of agricultural chemicals in that region is minimal because of the lack of widespread cropland. The results led the researchers to conclude that changes in agricultural management practices in that area that would even slightly increase reliance on agricultural chemicals could have dramatic effects on the karst groundwater quality. Drinking water quality standards in the United States place an upper limit of 0.003 $\mu g\ L^{-1}$ for atrazine; the limit on pesticides in Europe is generally 0.1 $\mu g\ L^{-1}$. Once karst groundwater resources are contaminated there may not be any quick remediation. Researchers in Slovenia found atrazine and alachlor still present in that country's groundwater seven years after their use was no longer permitted (Zgarjnar-Gotvajn, Zagorc-Koncan & Tisler, 2001).

Regulations for controlling dispersed pollution of groundwater in the United States are covered under Section 319 of the nation's Clean Water Act. Recent regulation requires the determination of the total maximum daily load (TMDL) of contaminants that individual surface streams can accommodate without exceeding water quality standards. TMDL regulations will only indirectly affect groundwater. In Europe the European Union Parliament and Council have agreed to a proposal by the European Commission for a Water Framework Directive. One objective of the legislation is the protection of all waters, surface and groundwater, and includes strict new standards for the use of fertilizers, manures, and pesticides. Economic incentives and voluntary programs are often used to attempt reduction of pollution from various sources. Best management practices to control diffuse pollution are commonly used. Practices such as nutrient budgeting to reduce the use of fertilizers and manures, composting of manures, storm water management, precision agriculture, and buffer strips are common. Such practices have not necessarily been developed for the special problems associated with karst terrain and may not be effective for protecting karst groundwater quality. Rapid percolation and lack of surface water on karst land means that source areas are expansive and little time is available for arresting contaminant movement to groundwater. Protection of karst groundwater from dispersed pollutants requires a holistic approach with a broad spectrum of treatments and practices (see Groundwater Protection).

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**Useful Websites**

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UK Department for Environment, Food & Rural Affairs,
http://www.defra.gov.uk/environment/water/index.htm

US Environmental Protection Agency,
http://www.epa.gov/OWOW/NPS/index.html