

NATURAL CHEMISTRY OF SHALLOW GROUND WATER IN UNCONSOLIDATED, SURFICIAL AQUIFERS

Shallow ground water in the BMA is young (recently recharged) and is not fully chemically evolved because the predominant minerals in the aquifer sediments, quartz and feldspar, are not easily dissolved. Typical characteristics include relatively high concentrations of dissolved oxygen (median of 3.7 mg/L), low pH (less than 6.5), low specific conductance (median of 290 $\mu\text{s}/\text{cm}$) and low concentrations of dissolved ions (median of 166 mg/L) (table 1). These characteristics reflect the chemistry of precipitation, which is the dominant source of recharge to shallow ground water. In general, concentrations of major ions and other inorganic compounds were comparable to those reported in previous investigations of water quality in surficial aquifers in eastern Massachusetts (Klinger, 1996, and Lapham, 1988).

COMMON SOURCES OF CONTAMINANTS TO SHALLOW GROUND WATER

Land-use practices in residential and commercial areas include the use and disposal of fertilizers, treated wastewater, pesticides, solvents, and other chemicals. Elevated nutrient (nitrogen and phosphorus) concentrations in ground water (more than 3 mg/L for nitrogen) usually are the result of human activities. Common sources of nutrients in urban areas are septic system and sanitary-sewer effluents, domestic animal wastes, infiltration of runoff from streets and parking lots, home and farm usage of fertilizers, and atmospheric deposition. Nitrogen is present in water primarily as the nitrate (NO_3^-) anion, but under reducing conditions, can be present as the ammonium (NH_4^+) cation. Phosphorus is present in water primarily as the phosphate (PO_3^-) anion. Nitrate and phosphate are an environmental concern as potential sources of nutrient enrichment in rivers, lakes, wetlands, and coastal embayments. The USEPA's Maximum Contaminant Level (MCL) drinking-water standard for nitrate is 10 mg/L (U.S. Environmental Protection Agency, 2000).

Historically, pesticides, which include insecticides, herbicides, and fungicides, have been used in agricultural areas to control weeds and insects. Pesticide usage in urban areas, once limited primarily to home insect and weed control, has increased as a result of the growth of the commercial lawn care business and the development and use of new herbicides and insecticides. In the BMA, pesticides are applied to lawns, gardens, small farms, golf courses, busi-

ness parks, and cemeteries. Herbicides are used to control vegetation along roadways, fence lines, and utility rights-of-way. These uses are potential sources of pesticide contamination to ground water.

VOCs are components of petroleum-based products, such as solvents, degreasers, refrigerants, and fuels. Direct industrial and wastewater discharges, exhaust from fuel combustion, accidental fuel and oil spills, storm-water runoff, and chlorinated public-drinking-water supplies are potential sources of VOCs in ground water. Relations between land use and the detection of specific VOCs in ground water often are impossible to determine because of the varied and widespread uses of VOCs and atmospheric deposition of these compounds from vehicle and industrial emissions. VOC contamination of drinking-water supplies is a human health concern because many are toxic and are known or suspected human carcinogens (U.S. Environmental Protection Agency, 2000).

Table 1. Statistical summary of selected water-quality data at 29 shallow wells in surficial aquifers in the Boston metropolitan area

[MCL, Maximum Contaminate Level; SDWR, Secondary Drinking Water Regulation; mg/L, milligrams per liter (parts per million); --, no value; <, less than the laboratory reporting level; >, greater than; ntu, nephelometric turbidity units; E, estimated value; µg/L, micrograms per liter (parts per billion); Some of the values in the maximum column correspond to monitoring wells with degraded water quality.]

Constituent (percent detected)	Laboratory reporting level	Minimum	Median	Maximum	MCL ¹	SDWR ²
Field parameters						
Alkalinity, filtered, as calcium carbonate (CaCO ₃), in mg/L (100)	--	1	10	106	--	--
Dissolved oxygen (100)	--	0.2	3.7	13	--	--
Specific conductance (100)	--	88	290	2,630	--	--
pH (100)	--	4.5	5.5	6.5	--	6.5 - 8.5
Iron, ferrous, in mg/L (66)	0.01	<0.01	.01	>3.3	--	--
Sulfide, as S, in mg/L	0.001	<0.001	0.004	0.2	--	--
Turbidity (ntu) (100)	--	0.04	2.5	970	--	--
Dissolved gases						
Carbon dioxide, as CO ₂ , in mg/L (100)	--	21	52	390	--	--
Methane, as CH ₄ , in mg/L	--	0	0	9	--	--
Nitrogen, as N ₂ , in mg/L (100)	--	9.5	21	25	--	--
Argon, as A, in mg/L	--	0.5	0.7	0.8	--	--
Major ions						
Bromide, in mg/L (97)	0.01	<0.01	0.04	0.5	--	--
Calcium, in mg/L (100)	0.02	1.3	12.4	70.3	--	--
Chloride, in mg/L (97)	0.1	10	60.2	728	--	250
Fluoride, in mg/L (7)	0.1	< 0.1	0.1	0.4	4	2
Iron, total, in µg/L(50)	10	E 5	< 10	38,000	--	300
Magnesium, in mg/L (100)	0.12	1.07	2.7	20	--	--
Manganese, in µg/L (100)	2.2	1.4	63.4	28,200	--	50
Nitrate, as N, in mg/L (83)	0.05	< 0.05	1.1	10.9	10	--
Ammonium, as N, in mg/L (17)	0.02	< 0.02	< 0.02	3.7	--	--
Phosphorus, in mg/L (62)	0.004	<0.004	0.005	0.02	--	--
Potassium, in mg/L (100)	0.24	0.68	1.7	9.0	--	--
Silica, in mg/L (100)	0.09	6.5	11	19	--	--
Sodium, in mg/L (100)	0.09	5.0	28.8	377	--	--
Sulfate, in mg/L (97)	0.01	< 0.01	14	75	--	250
Total dissolved solids, in mg/L (100)	--	52	166	1,460	--	500
Trace elements						
Aluminum, in µg/L (97)	1	< 1	24	819	--	--
Arsenic, in µg/L (7)	1	< 1	< 1	2	³ 10	--
Barium, in µg/L (100)	1	8	39	214	2,000	--
Cobalt, in µg/L (28)	1	< 1	< 1	95	--	--
Copper, in µg/L (24)	1	< 1	< 1	17	--	--
Strontium, in µg/L (100)	0.2	13	96	290	--	--

¹Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are enforceable standards set by the U.S. Environmental Protection Agency (2000).

²Secondary Drinking Water Regulations are non-enforceable federal guidelines, regarding cosmetic effects or aesthetic effects of drinking water established by the U.S. Environmental Protection Agency (2000).

³The U.S. Environmental Protection Agency recently (January 2001) passed a final ruling, which lowers the drinking-water MCL for arsenic to be phased in over 5 years (U.S. Environmental Protection Agency, 2001).