Baseline hydrogeochemical study of shallow groundwaters in NE England.

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Introduction

The introduction of a groundwater protection policy in the UK has generated increased interest in groundwater quality (National Rivers Authority, 1992). Shallow groundwaters are particularly susceptible to derogation and pollution from anthropogenic activities. In the North East of England limestones and alternating sandstone/mudstone rocks of Carboniferous age form a number of important local aquifers providing water resources in rural regions. Shallow groundwaters also frequently provide baseflow to rivers supplying larger surface water resources in the region. This preliminary study aims to provide a baseline hydrochemical study of shallow groundwater quality in the region and to determine the effects of geology, landuse and local industries on water quality.

Results

Samples were collected in January and March from springs from a variety of stratigraphic horizons of Carboniferous age. Details of sample sites, geology and landuse characteristics are given in Table 1. Groundwaters were analysed using standard procedures described by Cook and Miles (1980) and Rump and Krist (1985). All metal analyses were performed by flame AA.

The major cations Na, K, Mg and Ca generally increase in concentration in the following order of sample sites; RH1, RH2, NS, PHP, SG, GL, TV, TB and BC. Concentrations of Fe are low (0.02 to 0.16 mg/L) for all sample except GL (0.3 mg/L). Samples RH1, RH2, NS and SG show a trend of lower Fe concentrations in March samples in comparison to January samples. Sample PHP shows an opposite trend. The elements Al, Mn, Pb, Cu, and Cr all have concentrations below 0.03 mg/L. Sample BC, GL and RH1 show trace concentrations of Zn. Nickel concentrations in January samples range from 0.05 to 0.1 mg/L and Co concentrations from 0.04 to 0.1 mg/L. The same samples collected in March are below analytical detection levels. All samples have ortho-phosphate concentrations below the detection limit of 0.1 mg/L.

The analytical results may be divided into two groups. Group A contains samples RH1, RH2, NS, PHP and SG and Group B contains samples GL, TV, TB and BC. Group A samples have chloride concentrations which vary from 4 to 16 mg/L and Na:Cl ratios from 0.4 to 1. This variable

TABLE 1. Sample location, landuse, aquifer geology and stratigraphic horizon

Sample	Location	Landuse	Aquifer rock(s)	Stratigraphic horizon
GL	Greenlee Lough	Nature Reserve	Alternating sandstone, mudstone & thin limestones	Lower Carboniferous, Asbian (formerly Lower Limestone Gp)
RH1	Rookhope 1	Moorland	Alternating sandstones and mudstones	Lower Carboniferous, Pendleian (formerly Upper Limestone Gp)
RH2	Rookhope 2	Moorland		
NS	Near Sandyford	Moorland		
PHP	Park Head Plantation	Woodland	Coal Measure sandstone and mudstone	Namurian/Westphalian A Boundary - Quaterburn Marine Band
SG	Salters Gate	Farmland		
TV	Thornley Village	Farm/woodland		
TB	The Birches	Woodland/ Farmland	Coal Measure sandstone	Lower Coal Measures, Westphalian A (Ganister Clay)
BC	Bishops Close	Woodland/ Farmland	Coal Measure sandstone	Middle Coal Measures, Westphalian B (Brass Thill)

trend in Na:Cl ratios is typical of shallow groundwaters and generally reflects variable chloride recharge concentrations (Edmunds, 1986). This is shown by snow samples collected near samples RH1 and PHP (5 and 11.5 mg/L chloride respectively). Group B samples show higher chloride concentrations from 22 to 56 mg/L and lower Na:Cl ratios of between 0.3 and 0.5. Alkalinity (expressed as HCO_3^-) varies from 4 to 17 mg/L with the exception of samples GL and BC (124 and 173 mg/L respectively). Sulphate concentrations vary from 3 to 12 mg/L for Group A and 28 to 63 mg/L for Group B. Nitrate concentrations range from 0.4 to 2.7 mg/L (Group A) and from 12.5 to 35 mg/L (Group B) except for sample GL (2.8 mg/L). Sample temperatures vary from 4.9 to 7.9°C although there is little seasonal variation (± 1°C). Electrical conductivity values for Group A samples vary from 0.03 to 0.09 mS/cm. Group B samples are higher (0.14 to 0.45 mS/cm).

Water quality

Samples from Lower Carboniferous (Pendleian) and Namurian/Westphalian A Boundary aquifers are dominated by $(Na,K)HCO_3$, $(Na,K)SO_4$ and/or $(Na,K)Cl_2$. Westphalian A Coal Measures are $CaSO_4$ or $CaCl_2$ dominated while Westphalian B and Lower Carboniferous (Asbian) aquifers are $Ca(HCO_3)_2$ dominated, the latter probably reflecting higher levels of carbonate dissolution.

In general sample sites with recharge zones overlain by woodland show enhanced levels of chloride, sometimes in excess of EC guidelines for potable waters. These enhanced levels are likely to have resulted from dry deposition of chloride and evapotranspiration (Appello and Postma, 1993). Sample PHP has an excess chloride concentrations of 0.06 mmol/L after correcting the data for evaporation. Up to 13% of the chloride in sample PHP may be contributed by dry deposition.

Sites with recharge zones overlain by farmland with the exception of SG show enhanced levels of anthropogenic sulphate and nitrate in excess of EC guidelines for potable waters. Nitrate levels are generally higher in samples collected in March due to increased biological activity in the soils overlying the aquifers.

Conclusions

The hydrogeochemistry of groundwaters from springs in NE England fall into two groups. Samples from moorland regions with little anthropogenic activity display relatively low major cation, nitrate, sulphate and chloride concentrations. Aquifer geology and limited water:rock interaction control the groundwater chemistry. Samples from Coal Measure sandstone aquifers overlain by farmland and woodland have higher major cation, nitrate, sulphate and chloride concentrations derived largely from anthropogenic sources and which may exceed EC recommended guidelines for potable waters.

References

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