Regional scale evaluation of nitrate fluctuations in groundwater using cluster analysis and standardised hydrometeorological indices

Ascott, M.J., Gooddy, D.C., Marchant, B, Kieboom, N., Bray, H. and Gomes, S.

Temporal fluctuations in nitrate in groundwater can result in concentrations temporarily exceeding drinking water standards, resulting in costly water treatment or blending. The extent and potential controls on these fluctuations are poorly understood, particularly at regional to national scales. Applied to southeast England (UK), we develop the first application of cluster analysis and standardised hydrometeorological indices to evaluate nitrate fluctuations in groundwater. Cluster analysis of 96 groundwater nitrate time series showed that nitrate time series can be divided into 4 clusters: (1) long term increasing trends (n = 23, mean trend = 0.26 mg NO_3/l/a), (2) long term decreasing trends (n = 19, mean trend = - 0.65 mg NO_3/l/a), (3) long term increasing trends with seasonal fluctuations (n = 24, mean trend = 0.29 mg NO_3/l/a) and (4) long term increasing trends superimposed on near-decadal scale fluctuations (n = 30, mean trend = 0.22 mg NO_3/l/a). There is weak spatial coherence in the clustering, with clusters 3 and 4 present in the South and North Downs respectively. Cross-correlation analysis between groundwater nitrate time series with precipitation and groundwater level indices showed that rapid seasonal fluctuations in nitrate concentrations in cluster 3 in the South Downs are associated with rapidly responding groundwater level fluctuation. This is likely due to the highly fractured and faulted nature of the Chalk aquifer in this area. The strongest correlations between groundwater levels and nitrate concentrations in cluster 3 occurred when cross-correlating at a lag of zero months, which suggests that matrix diffusion is unlikely to be a significant control on seasonality. Seasonal fluctuations in nitrate concentrations are likely to be associated with piston displacement and changing groundwater flow paths. The

methodology developed here is generic and can be applied wherever there is a large body of groundwater nitrate time series data.