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title: **Identification of nitrogen long term trends at regional scale in Seine-Normandie groundwater (France) linked to CFC-age determination, water table variations and agricultural practices**

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INTRODUCTION

The European Union (EU) has adopted directives requiring that Member States take measures to reach a "good" chemical status of water resources by the year 2015 (Water Framework Directive: WFD 2000/60/CE). In order to achieve the environmental objectives for the Seine-Normandie groundwater, or to justify the non achievement of these objectives, a large body of water table time-series and nitrate data (available from 1945 to 2009) is analysed. Coupled with CFC-age determination (Baran et al., 2007; Cook and Solomon, 1997), recent geostatistical treatment applications are performed on water table and nitrogen time-series to identify hydrodynamic behaviours and nitrate trends at regional scale.

HYDRODYNAMIC AND NITROGEN BEHAVIOURS

The detailed dataset available for the whole superficial aquifers of Seine-Normandie basin is used to evaluate tools and to propose efficient methodologies for identifying and quantifying past and current trends. The temporal piezometric behaviour of each aquifer is defined using geostatistical analyse of water table time-series. This method requires the calculation of an experimental temporal variogram that can be fitted by a theoretical model valid for a large time range. The identification of contrasted behaviours (short term, annual or pluriannual water table fluctuations) allows a systematic classification of the superficial aquifers. The same treatments are performed on the nitrate time-series after filtrate them. This approach allows the identification of different behaviours in response of agricultural diffuse pollution at regional scale.

TREND ANALYSIS

Trends are determined based on nitrate time-series. But the dataset shows too many irregularities to justify traditional time-series approaches such as linear regression or Pearson regression. The non-parametric Mann-Kendall (MK) test is a robust statistical trend detection test that does not require verification of the normality of the dataset (Aguilar et al., 2007). Moreover, this test seems adequate as it is less sensitive to missing or outlier data than a simple linear regression test (Stuart et al., 2007). The trend analyses are decadely partitioned in order to detect possible trend reversals along the studied period.

The trend identification is also spatialized by the use of the Kendall Regional (KR) test on homogenous zones characterized by their geology, their agricultural practices and their hydrodynamic behaviour. The KR test, quite similar to de MK test, consists of a creation of a virtual global borehole constituted with all the boreholes located in the homogenous zone (Broers and Van Der Grift, 2004). This test allows the identification of regional trends, even in the zones in which nitrate time-series are too small to detect punctual trend.

To complete the study, CFC measurements have been carried out in 2009 throughout the Seine-Normandie basin in order to estimate the pollutant transfer time in each aquifer. The CFC apparent ages give information on the possible lags between the changes in agricultural practices and the appearance of effects in groundwater quality. Causes of trend reversals are not determined with the statistical analyse, but nitrate and water table time-series cross analyses give a brief replies on the possible positive correlation between these two variables. The evolution of

the concentrations in nitrate in superficial aquifers may depend on a combine effect of the change in agricultural practice and the evolution of the water table.

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