EUTROPHICATION RISK: ASSESSING THE IMPACT OF AGRICULTURAL N AND P PRESSURE AT REGIONAL SCALES

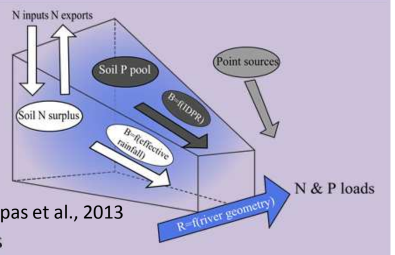
RÉMI DUPAS [1,2*], MAGALIE DELMAS [3], JEAN-MARCEL DORIOZ [4], JOSETTE GARNIER [5], FLORENTINA MOATAR [6], CHANTAL GASCUEL-ODOUX [1,2]

Context - Objectives

- Excessive nutrient loads into freshwater bodies results in increased eutrophication risk worldwide. Managers need tools to assess water quality and evaluate the relative contribution of agriculture to eutrophication at regional scales, such as national level or River Basin Districts. We chose France as a typical western country with a large variability of agricultural and climate conditions
- We present a mass-balance model to estimate N and P loads in unmonitored catchments at regional scales and a novel index to assess the risk of eutrophication resulting from excessive nutrient delivery in freshwater bodies

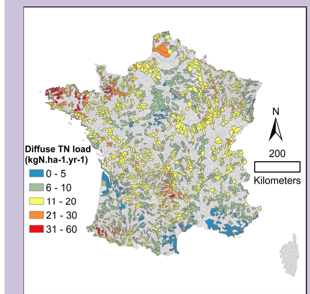
Mass-balance model NUTTING

- Model structure
  - Load=R*(B*Diffuse source + Point source)
  - R= river retention factor=f(river geometry)
  - B=catchment retention factor=f(catchments attributes)
  - Diffuse sources = soil N surplus & soil P content
  - Point sources = Σdomestic & industrial point sources

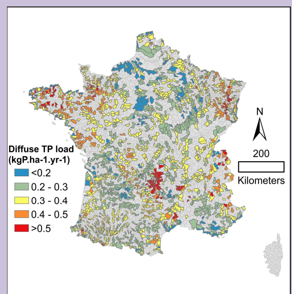


Dupas et al., 2013

- Calibration
  - A database of 160 headwater catchments and their attributes
  - Attributes characterize N & P agricultural pressures and transfer: climate, soil, IDPR connectivity index (Mardhel et al., 2004), river geometry
- Application at national level



N model
- ➢ Diffuse source variable *Soil N surplus*
- ➢ Catchment retention *=f(effective rainfall, % semi-natural areas)*
- ➢ River retention *=f(river residence time, river depth)*



P model
- ➢ Diffuse source variable *Soil P pool*
- ➢ Catchment retention *=f(IDPR connectivity index)*
- ➢ River retention *=f(river residence time, river depth)*

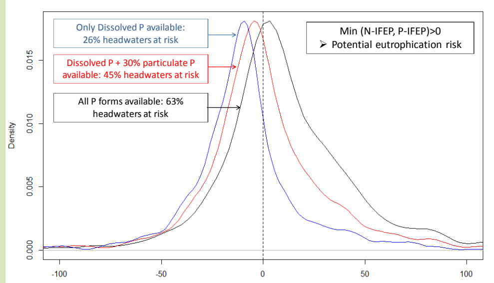
- Model fit (leave-one-out cross validation on 160 calibration catchment)
  - Total-N: R^2=0,59 (specific load) & 0,85 (global load)
  - Total-P: R^2=0,40 (specific load) & 0,70 (global load)
- Agriculture contributes 97% total-N load and 46% total-P load (national mean)

Index of Freshwater Eutrophication Risk IFEP

- The Indicator of Freshwater Eutrophication Potential (IFEP) is an adaptation for freshwater of the Indicator of Coastal Eutrophication Potential (ICEP) by Billen and Garnier (2007)
- Both are based on Redfield's (1963) molar C:N:P:Si ratios for diatoms, i.e. 106:16:1:20 in marine waters and 106:16:1:40 in freshwaters
- The IFEP measures the degree to which N and P concentrations exceed that of Si, assuming that excessive nutrient delivery causes development of undesirable nonsiliceous algae instead of diatoms. The IFEP can assess N and P independently (N-IFEP, P-IFEP), as follows

- $N-IFEP = \left(\frac{TNload}{14*16} - \frac{Siload}{28*40}\right) * 106 * 12$
- $P-IFEP = \left(\frac{TPload}{31} - \frac{Siload}{28*40}\right) * 106 * 12$

- The risk of freshwater eutrophication, expressed in carbon units, is min (N-IFEP, P-IFEP).
- min(N-IFEP, P-IFEP)>0 indicates potential risk
- Estimated eutrophication risk is highly sensitive to assumptions about P bioavailability: the potential range of catchments at risk (France) spans 26-63%



Density function of eutrophication risk min (N-IFEP, P-IFEP) under 3 hypotheses

Conclusion - perspective

- We refined exiting mass-balanced model s (e.g. Smith et al., 1997) by
  - Considering soil N surplus as N pressure variable & soil P content as P pressure variable, instead of traditionnaly used N&P inputs or land-use classes
  - Using novel transfer variable such as the IDPR connectivity index and river geometry database. Climate remains a significant variable, as in previous mass-balanced models
- We developed a simple indicator of freshwater eutrophication but
  - Environmental variables other than N&P load (e.g. temperature, light) are not accounted for
  - Results highly depends on assumptions about P bioavailability
- Therefore we recommend measuring P bioavailability in monitoring programs

Billen G, Garnier J. River basin nutrient delivery to the coastal sea: Assessing its potential to sustain new production of non-siliceous algae. Marine Chemistry 2007; 106: 148-160.
Dupas R et al. Assessing N emissions in surface water at the national level: comparison of country-wide vs. regionalized models. Sci Total Environ 2013; 443: 152-62.
Mardhel V et al. Index of development and persistence of the river networks as a component of regional groundwater vulnerability assessment in Slovenia. Int. Conf. groundwater vulnerability assessment and mapping. Ustron, Poland, 2004.
Smith RA et al. Regional interpretation of water-quality monitoring data. Water Resources Research 1997; 33: 2781-2798.

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[1] Agrocampus Ouest Rennes, France
[2] INRA, UMR1069 Sol Agro et hydrosystème Spatialisation Rennes, France
[3] INRA, UMR LISAH INRA–IRD–SupAgro Montpellier, France
[4] Univ Savoie, CARRTEL, INRA Le Bourget Du Lac, France
[5] Univ Paris 06, CNRS, UMR Sisyphe 7619 Paris, France
[6] Univ Tours, Fac Sci & Tech, EA 6293 Tours, France

*remi.dupas@rennes.inra.fr
http://www7.rennes.inra.fr/umrsas/

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Water quality at the catchment scale: measuring and modeling of nutrients, sediment and eutrophication impacts