Daily Nitrate Losses: Implication on Long-Term River Quality in an Intensive Agricultural Catchment of Southwestern France

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High nitrate concentrations in streams have become a widespread problem throughout Europe in recent decades, damaging surface water and groundwater quality. The European Nitrate Directive fixed a potability threshold of 50 mg L^{-1} for European rivers. The performance of the Soil and Water Assessment Tool model was assessed in the 1110-km^2 Save catchment in southwestern France for predicting water discharge and nitrate loads and concentrations at the catchment outlet, considering observed data set uncertainty. Simulated values were compared with intensive and extensive measurement data sets. Daily discharge fitted observations (Nash-Sutcliffe efficiency coefficient = 0.61, R^2 = 0.7, and PBIAS = −22%). Nitrate simulation (1998–2010) was within the observed range (PBIAS = 10–21%, considering observed data set uncertainty). Annual nitrate load at the catchment outlet was correlated to the annual water yield at the outlet (R^2 = 0.63). Simulated annual catchment nitrate exportation ranged from 21 to 49 kg ha^{-1} depending on annual hydrological conditions (average, 36 kg ha^{-1}). Exportation rates ranged from 3 to 8% of nitrogen inputs. During floods, 34% of the nitrate load was exported, which represented 18% of the 1998–2010 period. Average daily nitrate concentration at the outlet was 29 mg L^{-1} (1998–2010), ranging from 0 to 270 mg L^{-1}. Nitrate concentration exceeded the European 50 mg L^{-1} potability threshold during 244 d between 1998 and 2010. A 20% reduction of nitrogen input reduced crop yield by between 5 and 9% and reduced by 62% the days when the 50 mg L^{-1} threshold was exceeded.

Rising nutrient levels, including nitrates, in streams draining intensively managed agricultural land have become a widespread problem throughout Europe in recent decades (Heathwaite et al., 1996). Excessive loading of nutrients into streams and water bodies accelerates eutrophication and renders water unfit for human consumption (Raffaelli et al., 1989; Vinten and Dunn, 2001). Intensive agriculture is known to have a detrimental effect on surface water and groundwater quality, leading to acute problems such as erosion and diffuse pollution by nutrients (Langan et al., 1997; Zalidis et al., 2002). The Nitrate Directive (European Commission, 1991) was established by the European Commission to prevent water pollution caused by nitrate from agricultural sources and has fixed a potability threshold for European rivers of 50 mg L^{-1}. One of the main objectives of the European Water Framework Directive (European Commission, 2000) is to achieve a good ecological state for water bodies by 2015. The Directive adopted river basins as the territorial management unit, and reliable modeling tools were needed to evaluate N sources' contribution to water pollution, quantify loads, and evaluate alternative water management policies such as the European Water Framework Directive (Dørge and Windolf, 2003; Wasson et al., 2003). Various models to simulate nitrogen transformation and transport have been developed at catchment scale to study nitrogen dynamics and spatial interactions (e.g., Beasley et al., 1980; Styczen and Storm, 1993; Arnold et al., 1998; Beaujouan et al., 2002). The Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) has been used widely to assess hydrology in various catchments, help identify pollution sources (Holvoet et al., 2008), assess impacts of climate change (Singh and Gosain, 2011), and assess agricultural management practices (Moriasi et al., 2011). Some authors focused on nitrate (Santhi et al., 2001; Grizzetti et al., 2003; Jha et al., 2007; Lam et al., 2010). They reported that SWAT was an appropriate tool for assessing nitrate fate from daily to yearly

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Abbreviations: AEAG, Agence de l'Eau Adour-Garonne; CACG, Compagnie d'Aménagement des Coteaux de Gascogne; E_{NS}, Nash-Sutcliffe efficiency coefficient; HRU, hydrological response unit; PBIAS, percentage of bias; SWAT, Soil and Water Assessment Tool.