International Journal of Agricultural and Environmental Information Systems
Volume 7 • Issue 3 • July-September 2016

Potential Nitrogen Load from Crop-Livestock Systems:
A Spatial Database for a Multi-Scale Assessment and Mapping

Marco Vizzari, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Sara Antognelli, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Mariano Pauselli, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Paolo Benincasa, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Michela Farneselli, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Luciano Morbidini, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Piero Borghi, Department of Agricultural, Food, and Environmental Sciences, University of Perugia, Perugia, Italy
Giacomo Bodo, ARPA (Agenzia Regionale Protezione Ambientale), Perugia, Italy
Alessandra Santucci, ARPA (Agenzia Regionale Protezione Ambientale), Perugia, Italy

ABSTRACT

The EU "Water" Directive establishes a common European framework for the environmental protection of inland, coastal and marine waters. One of the major environmental concerns about water quality is certainly the N loads from agro-livestock systems. In this study, carried out in Umbria region, Italy, a novel spatial database for a multi-scale and multi-level analysis was designed and implemented integrating different agricultural and livestock farming datasets related to agro-livestock system. This database allows the calculation of different descriptive indicators about agricultural and livestock farming systems at different scales of investigation (NVZ, sub-basins, bodies of ground water, cadastral sheets, municipalities, provinces, entire region). Moreover, three relevant spatial indicators (potential nitrogen crop supply, potential nitrogen availability from livestock manure, and total potential nitrogen loads) were calculated applying an assessment model developed in the study. All this information appears very significant to support decision making at the various administrative levels and to pursue the environmental objectives established by EU and national regulations.

KEYWORDS

Geodatabase, Livestock Manure Management, Multi-Scale Assessment, Nitrogen Management, Sewage Sludge Management, Water Protection

INTRODUCTION

The environmental impact of high crop-livestock concentrations appears particularly significant where it coincides with weaker policy standards and poor manure management strategies (European Environment Agency, 2007). Livestock sludge, in accordance with best agricultural practices, can be used successfully as an organic fertilizer for crops, ensuring its optimal disposal (Martinez et al., 2009). In many cases, however, agronomic and environmental damage can result from the improper use of sludge, such as damage to the soil (Steinfeld et al., 2006), degradation of the soil structure due

DOI: 10.4018/IJAEIS.2016070102

to the levels of certain cations (K^+, Na^+), salinization (Mantovi et al., 2005), alterations in soil pH, alteration of the soil microbial population, and accumulation of heavy metals (Bonazzi et al., 2003; European Environment Agency, 2009).These processes tend to lead to degradation of the agronomic potential of agricultural lands (Halberg et al., 2005), and to the pollution of ground and surface water (Burton & Martinez, 2008; Steinfeld et al., 2010) through Nitrogen leaching (Sutton et al., 2011).

The element causing the greatest number of environmental management problems with regard to impact on near-surface and deep aquifers is nitrogen (N) (European Environment Agency, 2005, 2009; Teira-Esmatges & Flotats, 2003). Nitrogen pollution is mainly due to fertilization as different studies have highlighted (see e.g. Brouwer, 1998; Oenema et al., 2003; Parris, 1998), but its importance may change with the cultivation technique and the cropping system. In particular, for a given environment, the fertilizer-N rate is the main factor affecting N leaching: increasing the N rate, it reduces the N uptake efficiency and increases the amount of residual N in the soil which is exposed to leaching risks (Tei et al., 1999). Also the fertilizer spreading technique may play an important role: the crop N uptake is low with all-at-once broadcast spreading at crop sowing while it is much increased with split and localized fertilization as in the case of drip fertigation (Benincasa et al., 2011; Tei et al., 2015). The fertilizer-N source (i.e. mineral or organic, including livestock manure and sewage sludge) may affect the spreading technique and the synchronization between N availability and crop N demand, which also affects N uptake efficiency and leaching risks as pointed out by different authors (see e.g. Benincasa et al., 2011; Halberg et al., 2005; Oenema et al., 2003; Parris, 1998; Vizzari & Modica, 2013). Finally, N pollution could be limited by an appropriate design of the cropping system, e.g. by rotating crops differing for N requirements, growing season and root architecture, in particular by using deep-rooted cover crops in fall-winter; Farneselli et al., 2013; Tosti, Benincasa, Farneselli, Tei, & Guiducci, 2014). Nonetheless, all these aspects are seldom taken into consideration by farmers and, indeed, N pollution continues to represent a significant problem, especially in regions of intensive livestock farming, in all European Union Member States (European Environment Agency, 2009; Ju & DeAngelis, 2010).

The EU Water Framework Directive (WFD) - integrated river basin management for Europe - establishes a common framework at European level for the protection of inland (surface and groundwater), coastal and marine waters. The main objective is to improve water quality (also preventing further deteriorations), through a gradual reduction of pollution, promoting a sustainable water use (APAT, 2005). The Directive obliges Member States to protect, enhance and restore the environmental quality of water bodies and to achieve ecological chemical and quantitative objectives of those water bodies not significantly disturbed by human activities. In Italian law, the Legislative Decree (LD) n. 152/2006 transposes the EU directive and requires all the Italian Regions to implement a local Water Protection Plan (WPP) that constitutes a sectorial plan within the wider River Basin Management Plan defined by same WFD. WPP represents the planning tool that contains measures and programs aimed to water quality protection and environmental objectives achievement as required by the WFD. To this aim, knowledge of human pressures on water bodies is critical in almost all key stages of the WPP implementation and application process (Kesner & Meentemeyer, 1989; Öborn et al., 2003; Provolo, Riva, & Serù, 2007).

In this context, the characterization of an updated picture about the pressures due to human activities on water (including those generated by crop-livestock systems) seems essential for supporting water sector planning both at regional and district levels. The analysis of pressures must be obviously consistent with the criteria of the WFD and its Italian transposition, which require the assessment of pressures at body of surface and ground water scale. Article 2.10 of WFD defines "Body of surface water" as a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water. The application of this definition required the sub-division of river basins into 'discrete and significant elements' by the regional environmental agencies.

Related Content

Realization of Agricultural Machinery Equipment Management Information System Based on Network

Ling Ma, Mohammad Ikbaland Korhan Cengiz (2021). *International Journal of Agricultural and Environmental Information Systems (pp. 13-25).*

www.irma-international.org/article/realization-of-agricultural-machinery-equipment-management-information-system-based-on-network/280116