

International Conference on Inventions & Innovations for Sustainable Agriculture 2016, ICIISA 2016

Agricultural Land Use Systems and Groundwater Quality: Impact Assessment Using Nutrient Balances for Evaluation, Monitoring and Conservation of Natural Resources

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Abstract

This review presents the methods used to assess soil, pore water and groundwater nutrient levels on farms and agricultural fields. The purpose of this catalog of methods is to provide a basis for evaluating the efficiency of measures for the control of water catchment areas. A Zone monitoring model (ZMM) which is a basis for appropriate monitoring schemes in view of risks for the groundwater coming from agricultural lands has been developed. Based on this scheme, various methods to monitor nitrate concentrations at different unit levels, from the farm to the soil zone and on to the groundwater are described. At farm level, nutrient balances are mandatory to identify the potentially remaining concentrations of nutrients in the soil. Nutrient balances are incorporated in the latest information and communication technology (ICT) and farm management information systems (FMIS). The methods at groundwater-level described here are groundwater sampling by means of a suction lance, soil sampling beneath the groundwater table, groundwater sampling using the direct-push method, sampling from observation wells, from multi-level observation wells and from production wells. These practices are the early-warning systems which can prevent the surface and/or underground drinking water from contaminating with unwanted chemicals.

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Peer-review under responsibility of the Faculty of Animal Sciences and Agricultural Technology, Silpakorn University

Keywords: agriculture; groundwater conservation; nutrient balance; groundwater quality; monitoring; farm management; information systems

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1. Introduction

The importance of fresh water resources for the well-being in Europe's industrialized societies and the protection of groundwater are the main topics of the environmental concerns in the European Union. The European Water Framework Directive, which entered into force in December, 2000 (EU WFD 2000) should highlight its significance and urgency. The Groundwater Directive (EU GWD 2006) was subsequently developed in response to the requirements of Article 17 of the EU WFD, formulating the EU policy on groundwater protection. By the end of 2015, the EU WFD aimed to achieve a good quantitative and qualitative state of all European surface water and groundwater bodies.

The presented methods are based on a large number of scientific papers, which are summarized in an operating manual (DWA M-911 (2013)). The methods described are now standard in Central Europe. In addition, the methods were also scientifically tested and tested in practice (Eulenstein et al. 2008).

This review describes methods that have been presented (Eulenstein et al. 2014; Dannowski et al. 2014). The current review includes up-to-date information with respect to the tools used for optimizing nutrient cycles in managing farm for sensible environmental conservation.

2. Monitoring nutrient cycles to protect water resources

2.1 The zone monitoring model (ZMM)

The zone model of monitoring of nutrient cycles was shown (Fig. 1). The model consists of different vertical compartments: the soil surface (farm zone) where nutrients are applied, the root zone, the drain zone, and the groundwater zone. It refers to a typical geo-hydrological situation in Europe, but could be modified and refined to suit other geo-hydrological situations as well.

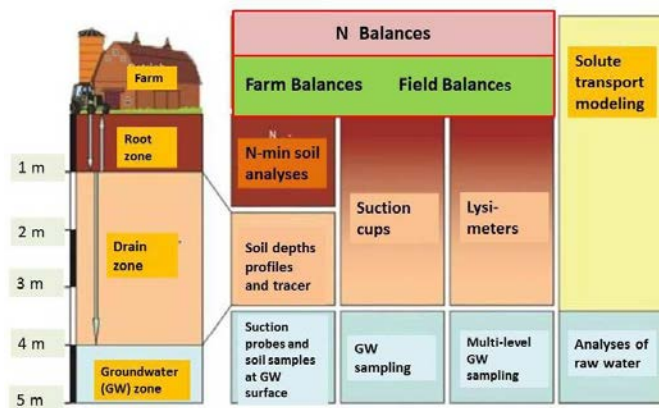


Fig. 1. Zone model of acknowledged methods for estimating agricultural nutrient surpluses for the purpose of groundwater protection, example of nitrogen. It demonstrates different monitoring levels and appropriate tools: the farm zone, the root and drain zone, and the groundwater zone (DWA M-911 (2013), modified)

Each zone is characterized by proven monitoring methods using analytical measurements and balancing calculations. Solute transport models enable an operator to analyze and predict nutrient flows over all these zones or even considering fluxes in all directions (Natkhin et al. 2013; Merz et al. 2009).

The following sub-sections of this chapter will focus on the farm zone above the soil, evaluating the performance of balances at field and farm level, and on sampling methods in the groundwater zone for monitoring purposes. These are not samples or repetitions, but are rather extensive surveys of individual areas and entire farms.

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