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An integrated approach for assessing influence of agricultural activities on pesticides in a shallow aquifer in south-eastern Norway

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HIGHLIGHTS

- Eight pesticides and metabolites were detected in groundwater in fluvial deposits.
- The results indicated groundwater pollution from normal pesticide use on fields.
- The highest pesticide concentrations occurred in wells close to washing sites.
- In Nordic areas pesticide pollution of fluvial deposits should be given attention.
- An integrated approach is recommended for pesticide investigations in groundwater.

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ABSTRACT

The study examines the influence of agricultural activities on pesticides in groundwater in an area with fluvial deposits of sand with a top layer of sandy silt and silt, intensive cultivation of potatoes and cereals, and drinking water supplies of households from local groundwater wells. Information about local agricultural practice and washing sites for pesticide spraying equipment, properties of soils and deeper deposits, hydrogeology and groundwater flow, simulations of pesticide leaching, and contents of pesticides and nitrate in groundwater samples from drinking water wells was used to explore extension and reasons of pesticide contamination of groundwater. Pesticides were found in a majority of the sampled wells. Eight different pesticides and metabolites were detected in groundwater samples. The results demonstrate that on fluvial deposits diffuse pollution from spraying of fields with pesticides can result in groundwater contamination in Nordic climate. Higher concentrations of pesticides in some wells can be explained by point source contamination from washing sites. The occurrence of pesticides in drinking water wells touches up the question whether pesticides should be given general approvals, or approvals should include restrictions or recommendations regarding use on areas with high risk of groundwater contamination. Combination of washing sites for pesticide spraying equipment and groundwater wells for drinking water requires attention, proper equipment and practice, and knowledge about pesticides, soil and water to avoid contamination. Samples from wells adjacent to washing sites for pesticide equipment might overestimate average pesticide concentrations in groundwater bodies. In Nordic areas attention should be given to pesticide pollution of shallow groundwater in fluvial deposits. To provide basis for interpretation of results and planning of mitigation measures against pesticide contamination, an integrated approach using information about agronomical practice and point sources, soil properties, hydrogeology and simulations of pesticide leaching is recommended for future surveys and monitoring of pesticides in groundwater.

1. Introduction

Leaching of pesticides and nitrate from agricultural fields is a problem in several countries, but little research has been done on pesticide dissipation in cold climate (Stenrød et al., 2008). Point sources may also contribute to pesticide contamination of groundwater (Leterme et al., 2006). Groundwater is an important source of drinking water, and contamination of drinking water wells by pesticides represents a major concern in several countries (Malaguerra et al., 2012), e.g. United States (Gilliom et al., 2007), Portugal (Gonçalves et al., 2007), Netherlands (Schipper et al., 2008) and United Kingdom (Reid et al., 2003).

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In Norway data for pesticides in groundwater are very limited. Screening sampling has revealed occurrence of pesticides in local drinking water wells in shallow groundwater beneath agricultural areas (Roseth, 2013), but sample programs have usually comprised only a single or a few wells for each aquifer that do neither show the spatial variation of pesticide contamination in the aquifers nor provide possibilities of assessing the importance of different pollution sources.

Alluvial plains along the rivers in Norway are often used for agricultural purposes, and shallow groundwater beneath such areas is used for drinking water. Pesticide residues from the agricultural activity might represent a possible risk for contamination of local drinking water wells. The study area in Grue represents permeable fluvial deposits with intensive cultivation of potatoes and cereals, combined with drinking water supplies of households from local groundwater wells. In a pilot investigation in this district in 1995/1996 8 μg/L and 19 μg/L of metribuzin and metalaxyl, respectively, were detected in groundwater (Eklo, 1997). In addition the substance ethylenethiourea (ETU), a metabolite from mancozeb, was found in two samples (0.4 and 2.0 μg/L).

It was therefore decided to examine the influence of agricultural activities on pesticides in groundwater in this area by an integrated approach, with collection of information about agricultural practice and washing sites for pesticide equipment, soil properties, hydrogeology, pesticide leaching simulations and pesticide contents in drinking water wells.

The objectives of the study have been i) to explore the pesticide contamination of groundwater wells and risk of pesticide leaching in an area with fluvial deposits and intensive cropping under Nordic climate, ii) to discuss the importance of diffuse sources and point sources for groundwater contamination in such areas and iii) to point out consequences for mitigation and monitoring of pesticides in groundwater.

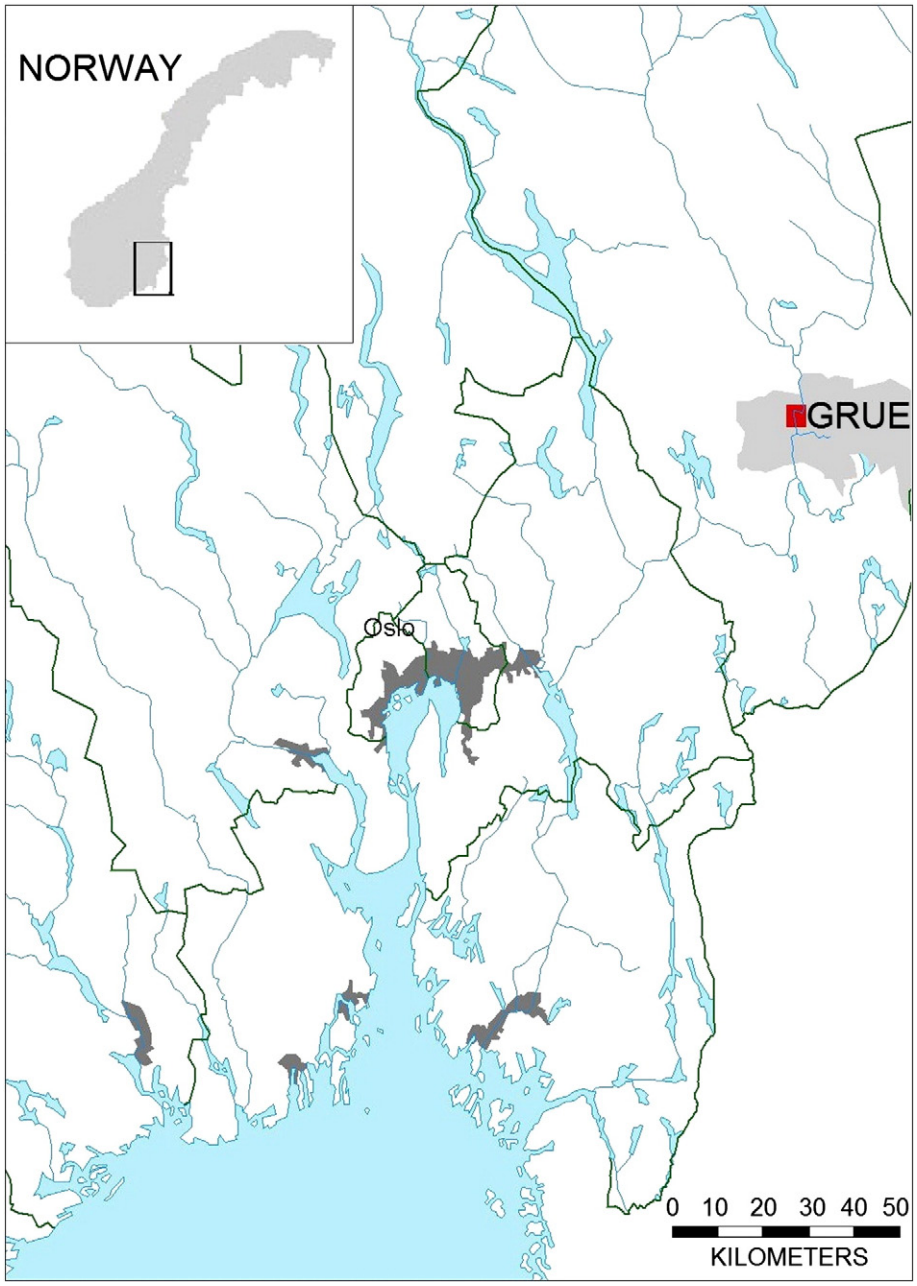

Fig. 1. Location of the study area.