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Nitrate leaching from three afforestation chronosequences on former arable land in Denmark

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Abstract

In regions dominated by agricultural activities, nitrogen (N) is recognized as a major pollutant in aquatic environments. In north-western Europe, afforestation of agricultural land is part of a strategy to improve water quality. In Denmark, former arable land has been afforested during the past 40–50 years. This study evaluated the effect of afforestation of former arable land on nitrate leaching, based on three afforestation chronosequences. Precipitation, canopy throughfall and soil water were collected and soil moisture was monitored at two Danish locations, Vestskoven (nutrient-rich, medium deposition) and Gejlvang (nutrient-poor, high deposition). Afforestation was performed using Norway spruce [Picea abies (Karst.) L.] and common oak (Quercus robur L.) at Vestskoven and Norway spruce at Gejlvang. The results suggest that afforestation of former arable land initially leads to lower nitrate leaching than that occurring under the former agricultural land use, and largely below the standard of 50 mg NO_3^- L^{-1} for groundwater to be utilized as drinking water. Nitrate concentrations became almost negligible in forest stands of 5–20 years of age. However, after canopy closure (> 20 years) nitrate concentrations below the root zone and nitrate leaching tended to increase. This was attributed to increased N deposition with increasing canopy development and decreased N demand once the most N-rich biomass compartments had been built up. Nitrate leaching started to increase at a throughfall deposition level of about 10 kg N ha^{-1} yr^{-1}. Compared with nutrient-poor sandy soils, nutrient-rich clayey soils appeared more vulnerable to disturbance of the N cycle and to increased N deposition, leading to N saturation and enhanced nitrate leaching. In approximately the first 35 years after afforestation, nitrate leaching below the root zone was generally higher below oak than below Norway spruce.

Keywords: afforestation, chronosequence, C/N ratio, common oak, former arable land, hydrological modelling, nitrate leaching, Norway spruce, soil N

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Introduction

In Europe, socioeconomic changes have led to a reduction in agricultural area over the past half century (Mather, 2000). Much of the abandoned cultivated land has been given over to forest, either through plantation or through natural succession. Forest expansion in Europe (excluding the former USSR) occurred at a rate of 0.4million ha^{-1} yr^{-1} (or 0.3% of the forest area) in the 1990s (Mather, 2000). Such land use change is expected to continue in coming decades due to Common Agricultural Policy (CAP) reforms in the European Union (EU) (Rabbinge & van Diepen, 2000). In North America, similar massive land use changes have occurred over the past century (Foster & Motzkin, 2003). The concern over climate change resulting from elevated CO_2 may further increase the interest in afforestation of agricultural land, as the Kyoto Protocol allows for accounting of the biological sinks from afforestation as emission reductions.

In north-western Europe, concern over nitrate pollution of groundwater and surface water from agricultural sources has also led to a new focus on afforestation.

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