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Results from long-term fertilizer experiments in China: The risk of groundwater pollution by nitrate

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ABSTRACT

Nitrate–N distribution and accumulation down to 200 or 300 cm in the soil profile of different long-term fertilization regimes were studied in 2002 in the China Long-Term Experiments Network (CLTEN) including eight experimental sites where the experiments were started in 1990 or 1991. In this paper we report on the results from five comparable sites (Beijing, Henan, Hunan, Jilin and Xinjiang) representing a wide range of soils, climates and cropping systems some of them with irrigation. At each site, crops (wheat and/or maize) had been grown with no inorganic fertilizer or manure inputs (as control), and with various combinations of N, P or K fertilizers or with NPK *plus* different levels of manure (M) or straw (S). Fields where N input was from inorganic fertilizers, generally had higher amounts of accumulated NO_3–N in the soil profile than control or long-term fallowed soils, which indicated that the use of inorganic fertilizer–N in agricultural systems increased the risk of pollution of the environment. Long-term application of fertilizer–N without P (N, NK) resulted in low crop yields and low N uptake by the crops, leading to lower cumulative apparent N recovery (ANR) and higher NO_3–N content and accumulation in the soil profile. This increased the risk of groundwater contamination by nitrate. When fertilizer–N was applied along with P (NP) or PK (NPK) the crop yields, N uptake by the crops and ANR increased markedly and the NO_3–N accumulation in the soil profile was much lower than in the N and NK treatments. Adding manure or straw based on equal total N (NPK + M or NPK + S) resulted in similar contents and accumulation of NO_3–N in the soil profile as in NPK treatment under normal conditions. Increasing the N input levels whether through inorganic fertilizer or manure (NPK + 1.5M or 1.5(NPK + M)) further increased the NO_3–N accumulation in the soil profile. The data show that potentially 24–82% of applied inorganic fertilizer–N was lost, mostly through ammonia volatilization. It was estimated that a quarter of the N was lost through leaching beyond the root zone.

1. Introduction

Under aerobic soil conditions, nitrate (NO_3^-) is the final oxidized form of inorganic nitrogen and the main chemical form in which nitrogen is taken up by plants. Nitrate ions are soluble in water and can easily be leached out of the soil to natural waters. Leaching is the main pathway of nitrate loss and increases the risk of groundwater contamination by nitrate [1].

In order to obtain high crop yields, high rates of inorganic-N fertilizers are usually applied. In 2000/2001, 28% of the N and 25% of the NPK fertilizers in the world were used in China [2]. The annual inorganic fertilizer input per hectare of arable land in China in 2000/2001was 2.8 times the world average level. In China, N fertilizer recovery is around 35%, which means that approximately 50% or more of N fertilizers (11.34 Mt) applied are lost via various pathways. Inappropriate use of fertilizers results in severe non-point sources of pollution from agriculture, which means great pressure on the environment in China. Imbalanced application of fertilizers with high rates of N relative to P and K, which both are used in low quantities, makes the situation even worse. According to traditional viewpoints, greater use of organic manure (OM) results in

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