# Nitrate accumulation in an intensive small agricultural catchment: challenges and solutions

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**Abstract**

Nitrogen (N) fertilization in the intensive horticultural systems is usually high, especially in China during past decades. We have studied nitrate accumulation in soil profiles and nitrate in groundwater of a small catchment dominated by kiwifruit orchard at northern sloping region of Qinling Mountains in Shaanxi. We found that long-term N fertilization resulted in high nitrate accumulation in 4 m profile. The averaged $NO_3^-$-N concentrations and $\delta^{15}N$-$NO_3^-$ values of groundwater increased from natural forest to arable land and to the orchards; on the contrary, the $\delta^{18}O$-$NO_3^-$ decreased. The nitrate sources in the groundwater at different regions were identified.

Keywords: Nitrate accumulation, soil profile, orchards,

## 1. Introduction

The long term application of nitrogen (N) fertilizer has changed the global N biogeochemical cycle (Erisman et al, 2008). Understanding the fate of N fertilizer in soil and plant system (crop uptake, residual in soil, and loss) is important to increase N use efficiency and decrease its loss. Nitrification is very fast in upland soil. Therefore, the accumulation of nitrate in soil profile is one of important fate of N fertilizer after application. China has consumed about one thirds of the global N fertiliser now. Fruits and vegetables together in China have consumed at least 30% of N fertilizers. However, there are limited researches to study nitrate accumulation in soil profiles both at field and catchment scales, to evaluate their potential risk to the groundwater quality.

## 2. Study methods

The study site was located at the kiwifruit belt of northern sloping region of Qinling Mountains, Shaanxi, where produces about 30% kiwifruit in the world. Over-input of N in orchards is very common (Lu et al, 2016). We have studied N apparent balances and nitrate accumulation in soil profiles of a small catchment at the belt (Fig. 1), and the spatial variation of nitrate accumulation in soil profiles at the field and catchment scales. The nitrate concentration and isotopes of nitrate ($\delta^{15}N$–$NO_3^-$ and $\delta^{18}O$–$NO_3^-$) in groundwater at the different land uses (natural forest, arable land and kiwifruit orchards) at the catchment were also compared.

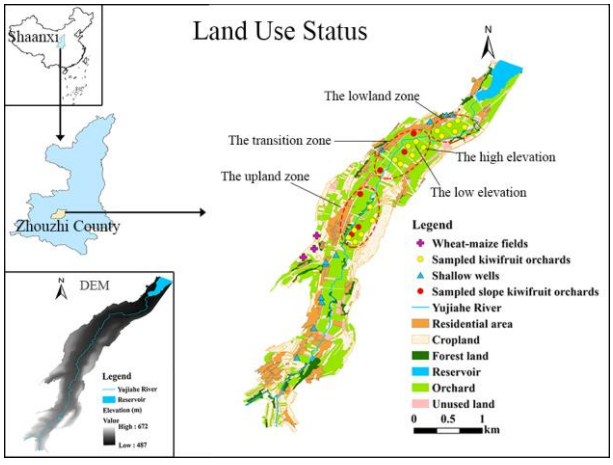


Fig.1 study sites and land use maps of the catchment

**3. Results**

Excessive N fertilisation resulted in high N apparent surplus (1133 kg N $ha^{-1}yr^{-1}$) in kiwifruit orchards (8 times higher than in cereal fields). More than 77.5% of nitrate in soil profile (0–4 m) of the orchards was below 1 m soil depth. The average nitrate accumulation within 0–4 m profile of orchards was 3288 kg N $ha^{-1}$, which was16 times higher than cereal fields.

The nitrate accumulation in soil profiles in the same sloping orchards at different sites was different; and nitrate accumulation in soil profiles at downslope (5960 kg N $ha^{-1}$) was around 2 times higher than the upslope. The nitrate accumulation in soil profiles at the lowland zone of the catchment was higher than that of the upland zone. The total nitrate storage in 0-4 m soil profiles in the catchment was 464.8 Mg N while 94.8% (440.8 Mg N) of them were in the orchards.

The averaged $NO_3^-$-N concentrations of natural forest, arable land and kiwifruit orchards were 7.35, 7.87, 12.50 mg/L, respectively. The $\delta^{15}N\text{-}NO_3^-$ values was increased from natural forest (1.48‰) to kiwifruit orchard (5.76‰); on the contrary, the $\delta^{18}O\text{-}NO_3^-$ values decreased.

Our five years' field experiment indicates reducing N fertilization decreased nitrate accumulation in soil without compromising kiwifruit production (Lu et al, 2018). Other strategies include fertigation, substituting of mineral N fertilizer with manures, recycling of crop residues, and education of farmers, etc.

**4. Conclusions**

Long-term over-application of N fertilizer resulted in high nitrate accumulation in soil profiles of the small catchment. It has increased the risk of groundwater pollution. It is urgent to take measures to solve the problems.

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