Nitrate accumulation in an intensive small agricultural catchment: Challenges and solutions

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Introduction

The long term application of nitrogen (N) fertilizer has changed the global N biogeochemical cycle. 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.

Methods

The study site was located at the kiwifruit belt of northern sloping region of Qinling Mountains, Shaanxi, where produces near 30% kiwifruit in the world. 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.

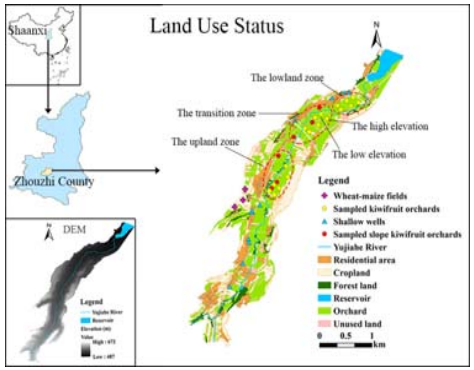


Fig.1 study sites and land use maps of the catchment

Results

High N apparent surplus in kiwifruit orchards relative to cereal lands

Total N inputs of kiwifruit orchards were significantly higher than wheat and maize cropland, resulted in high surplus N.

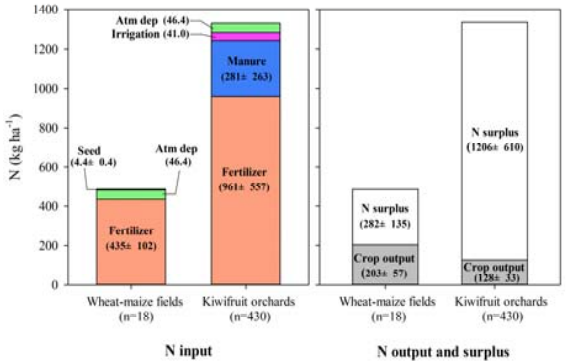
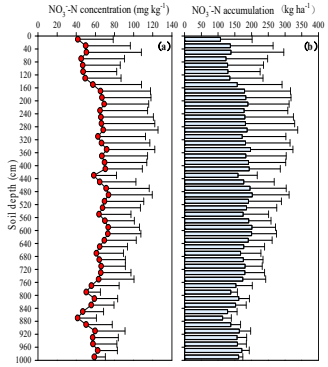


Fig.2 Comparisons of annual N balance inputs, outputs and surplus in kiwifruit orchards and wheat–maize fields (kg ha^{-1} yr^{-1}).

High nitrate accumulated in soil profiles of orchards



The average NO_3-N concentration ranged from 40 to 72 mg kg^{-1}, and the average nitrate accumulation0-10 m soil profiles in kiwifruit orchard was higher than 8000 kg N ha^{-1}.

Fig. 3 Nitrate content and accumulation in 0-10 m soil profiles in the kiwifruit orchards (n=13)

Nitrate concentration and $\delta^{15}N$-NO_3^- of groundwater increased from natural forest to kiwifruit production region; on the contrary, $\delta^{18}O$-NO_3^- of groundwater decreased

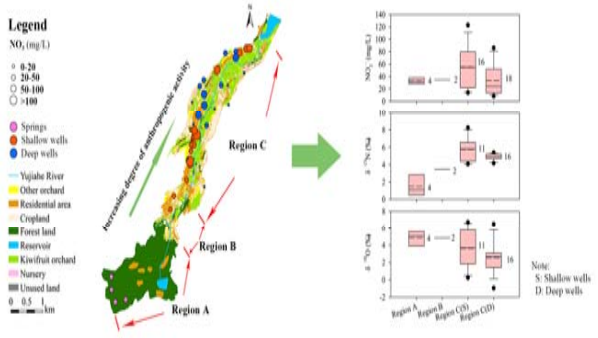
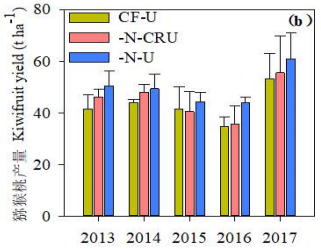


Fig. 4. Box plot of NO_3^--N (a), $\delta^{15}N$-NO_3^- (b) and $\delta^{18}O$-NO_3^- (c) in groundwater.

Reducing N fertilizer without compromising of kiwifruit yields



CF-U = Farmers' N rate
-N-CRU = Reduced N rate by >25%
-N-U = Reduced N rate by >25%

Fig 5 Kiwifruit yields of different N treatments from 2013 to 2017

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. The effect of legacy N in vadose zone on groundwater quality deserves to be studied.

Acknowledgement

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