Mitigating indirect N_2O emission from Japanese agricultural soils by reducing nitrogen leaching and runoff

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Abstract
Indirect nitrous oxide (N_2O) emission from Japanese agricultural soils is accounted as comparable to direct N_2O emission derived from inorganic or organic nitrogen (N) fertilizers in Japan. This paper tries to evaluate the mitigation potential of indirect N_2O emission by reducing N leaching and runoff in different land uses at different prefectures in Japan. We used the national scale agricultural activity data of different prefectures from 1985 to 2005 and the N leaching and runoff monitoring data in Japan published after 1980. The N leaching and runoff values in vegetable and tea fields under various improved agricultural practices such as organic fertilizer application, slow release fertilizer application with reduced N application rate, cover cropping for green manure, etc., showed about 25% to 30% lower values from those under conventional practices, suggesting that such improved practices are similarly effective to mitigate indirect N_2O emission from agricultural fields.

Key Words
N leaching and runoff database, organic fertilizer, livestock manure, cover crop, slow release fertilizer, chemical fertilizer

Introduction
Indirect N_2O emission from Japanese agricultural soils due to N leaching and runoff is reported as 4.4 kt-CO_2 eq. (GIO, CGER, NIES 2016), of which value is comparable to direct N_2O emission due to inorganic N fertilizers (4.2 kt-CO_2 eq.) and also to organic N fertilizers (4.7 kt-CO_2 eq.) in Japan.

This paper focuses on the mitigation of indirect N_2O emission from Japanese agricultural soils by reducing N leaching and runoff. This approach should be surely effective not only for mitigating total N_2O emission from agricultural fields but also for mitigating effluent N loads to surface water and groundwater bodies; however, it has not been evaluated yet at the national scale.

Methods
National scale agricultural activity data in Japan from 1985 to 2005 (Mishima and Kohyama 2010) were used to obtain the values of chemical and organic fertilizer N applications, crop harvest N, livestock manure N production, etc., in all the 47 prefectures. The N leaching and runoff database for rice paddy fields (Haruta et al 2015) and other crops fields (Eguchi et al 2012) in Japan, based on the literature values published after 1980, were used to obtain the mean N leaching and runoff values in different agricultural land-uses.

Results
Figure 1 shows the annual leached and runoff N from vegetable and tea fields in Japan as affected by ‘conventional’ and ‘improved’ agricultural practices. The ‘improved’ agricultural practices include the use of organic N fertilizers instead of chemical N fertilizers, the use of slow release N fertilizers with reduced N application rate compared to the conventional one, the introduction of cover cropping for green manure, etc. The results clearly indicate that the introduction of ‘improved’ agricultural practices will be effective to mitigate the indirect N_2O emission by about 25% to 30% in vegetable and tea fields.

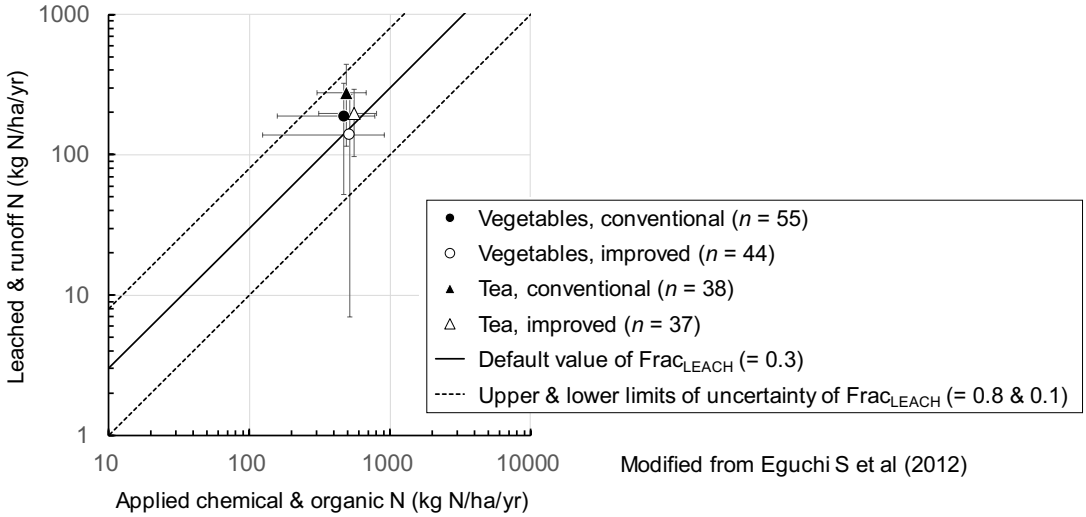

Figure 1. Leached and runoff N from vegetable and tea fields in Japan as affected by 'conventional' and 'improved' agricultural practices. Each plot and error bar indicate the mean and standard deviation, respectively. The leaching fraction ($Frac_{LEACH}$) values refer to IPCC (2006).

Conclusion

About 25% to 30% reduction of N leaching and runoff in N-rich agricultural fields, i.e., vegetable and tea fields, in Japan can be achieved by introducing 'improved' agricultural practices; this approach will be one of the most effective ways to mitigate total N_2O emission from Japanese agricultural soils. Further study for different agricultural land-uses and calculation of national scale mitigation potential of indirect N_2O emission in Japan should be required; therefore, it is currently going on by collecting much larger number of literature data for N leaching and runoff in Japanese agricultural fields.

References

Eguchi S, Sudo M, Okubo T, Kuroda H, Takeda I, Haruta S, Fujiwara T, Yamamoto T, Shima E, Hitomi T, Shiratani E, Yokota K, Inoue T (2012) Effluent load from agricultural fields other than paddy fields and from agricultural watersheds in Japan: A critical review. Proceedings of the 15th Symposium of Japan Society on Water Environmentum, Saga, pp. 61.

Greenhouse Gas Inventory Office of Japan (GIO), Center for Global Environmental Research (CGER), National Institute for Environmental Studies (NIES) (2016). National Greenhouse Gas Inventory Report of Japan. NIES, Tsukuba.

Haruta S, Sudo M, Eguchi S, Okubo T, Kuroda H, Takeda I, Fujiwara T, Yamamoto T, Hitomi T, Shiratani E, Yokota K, Inoue T (2015). Effluent N, P and COD loads from paddy fields in Japan: A critical review. Journal of Japan Society on Water Environment 38(4), 81-91.

Mishima S-I, Kohyama K (2010). The database and the methodologies to estimate recent trend of nitrogen (N) and phosphate (P) flows and residual N and P in Japanese national prefectural scales and examples their application. Bulletin of National Institute for Agro-Environmental Sciences (NIAES) 27, 117-139.

The Intergovernmental Panel on Climate Change (IPCC) (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Agriculture, Forestry and Other Land Use. IPCC National Greenhouse Gas Inventories Programme, Institute for Global Environmental Strategies (IGES), Hayama.