Quantification and modeling of ammonia volatilization from irrigated and non-irrigated winter wheat plots in the North China Plain

Widdig, M.[1]*, Roelcke, M.[1,2]*, Tong, B.X.[3], Xin, S.Y.[3], Zhou, Y.Y.[3], Gao, Z.L.[3], Ma, W.Q.[3], Michalczyk, A.[4], Kersebaum, C.[4], Nieder, R.[1]

[1]Technische Universität Braunschweig, Institute of Geoecology, Langer Kamp 19c, 38106 Braunschweig, Germany
Tel. (+49)-(0)531-391 5917, Fax: (+49)-(0)531-391 5637,
E-mail: m.widdig@tu-braunschweig.de m.roelcke@tu-braunschweig.de
[2]German-Chinese Agricultural Center (DCZ), 55 Nongzhan Beilu, 100125 Beijing, China
[3]Agricultural University of Hebei (AUH), College of Resources and Environmental Science, 071001 Baoding, China
[4]Leibniz Centre for Agricultural Landscape Research (ZALF), Institute of Landscape Systems Analysis, 15374Müncheberg, Germany

Abstract:
China's growing population has led to a drastic intensification of agriculture and livestock production in the last 50 years. Excessive mineral nitrogen (N) fertilizer application and intensive livestock production cause high N losses to the environment. Pathways of N losses from soils may include gaseous N emissions via nitrification/denitrification (N_2O, N_2), ammonia (NH_3) volatilization, nitrate leaching and surface run-off. Ammonia emissions are one of the most important N loss pathways in the North China Plain (NCP) contributing to soil acidification, eutrophication of ecosystems and causing human health problems through combining with particles in the atmosphere which also impair visibility.

For developing mitigation measures in a winter wheat-summer maize double-cropping system, systematic measurements of NH_3 volatilization were conducted in the NCP in Zhengding, Hebei Province, 260 km southwest of Beijing. Ammonia emissions were measured with the calibrated Dräger-Tube Method (DTM) during the main growing season of winter wheat from April to June 2016. Treatments included urea surface-broadcast and urea followed by immediate irrigation. Soil samples were taken from three depth increments (0-20, 20-60 and 60-90 cm) before and after fertilization. Additionally, NH_3 volatilization was simulated with the HERMES model.

Urea applied to winter wheat showed a total NH_3 loss equal to 22% the of applied N. Application of urea to winter wheat followed by irrigation yielded a reduction of the NH_3 volatilization to 0.1% of the applied N. The soils showed highest mineral nitrogen

(N_{min}) contents of up to 340 kg ha^{-1} (0-90 cm) after fertilization. An observed decrease in calcium carbonate content and soil pH in topsoils (0-20 cm) (pH: 6.7) compared to subsoil horizons (pH: 7.7) was attributed to the long-term application of ammonium-based fertilizers as well as to high atmospheric deposition rates of ammonium and sulfuric compounds.

An improved N management based on the soil N_{min} content is recommended to improve nitrogen use efficiency and to reduce N losses to the environment. For reduction of NH_3 volatilization, irrigation after fertilization can be recommended; however, leaching losses should be avoided. The NH_3 volatilization sub-module of the HERMES model enabled to simulate ammonia volatilization in the NCP satisfactorily. It is suggested to validate the model with further data sets from the NCP or from regions with comparable conditions.

Acknowledgements:
The study was supported by the German Academic Exchange Service (DAAD) and the China Scholarship Council (CSC) (PPP project no. 57217922), and by the National Natural Science Foundation of China (NSFC), grant no. 31272247.