Agricultural contamination in soil-groundwater-surface water systems in the North China Plain - DTU Orbit (29/05/2019)

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The North China Plain is one of China’s major economic zones and one of the most densely populated areas in the country. It covers a broad expanse of eastern China, extending from just below Beijing in the north down towards the Yangtze River in the south. This alluvial plain region is also one of China’s main agricultural production zones, accounting for about one third of the national grain output. The dominant crop system is a winter wheat and summer maize rotation. Beginning in the 1980s, in an effort to increase agricultural productivity, China’s government heavily promoted the use of fertilizers and pesticides. Unfortunately, the lack of regulation or oversight has led to the overuse of these agrochemicals: current application rates (in kg/ha) are two- to threefold higher than in most developed countries, and this is taking its toll on the environment. Problems include severe surface water and groundwater pollution by nitrogen and pesticides, soil degradation, bioaccumulation of toxic compounds, and more. It is crucial for China to do improve the safeguarding of its water resources in order to sustain the livelihoods of its people and ensure safe supply of drinking water.

Recently, the Chinese government and the scientific research community have acknowledged the need for more sustainable production techniques, and increasing quantities of money and effort are being directed toward achieving this goal. There has already been a great deal of improvement in determining the appropriate amounts of agricultural inputs, such as irrigation and fertilizers, as well as the ideal times to apply them. In terms of pesticides, most studies have focused on pesticide residues, crop resistances, and on the efficient treatment of specific pests. Despite this groundwork, however, statistical records show that the application of agrochemicals per hectare continues to increase, and the water quality within the river basins of the North China Plain remains substantially worse than in other parts of the country.

Taking this background into consideration, this PhD study focused on four different objectives: (a) to quantify the nutrient loading in groundwater and surface water at a sample field site in order to understand their exchange and removal pathways; (b) to review the current use and monitoring of pesticides (and especially herbicides) in the NCP; (c) to assess the occurrence of selected herbicides at a sample field site in the NCP; and (d) to provide a new basis for discussion and guidance on how to address the issue of water pollution caused by the improper use of agrochemicals in China. For the field investigation, a study site located within the NCP with river water-groundwater interaction was chosen, and field work was performed between October 2012 and March 2014.

Results from the field study showed that fertilizer inputs were excessive, and could be reduced substantially. Contaminated river water was infiltrating – and carrying ammonium pollution – into the shallow groundwater. Additionally, nitrate was infiltrating from the surface of the field into the aquifer. Anammox, denitrification, and cation exchange were the suggested dominant removal processes in the soil-surface water-groundwater system examined in this study, which showed a very high nitrogen removal capacity. However, if the composition of the river water were to change (if, for instance, the ammonium concentration were to decrease) the removal processes in the system would also be altered. Consequently, further monitoring of nitrate pollution is suggested.

Regarding pesticides, a literature review and data assessment revealed that the most commonly applied herbicides in the North China Plain wheat-maize cropping system are 2,4-D, acetochlor, and atrazine. Although 2,4-D and atrazine are listed in the Chinese Drinking Water Guideline, there is currently no systematic monitoring of these compounds taking place, and most research studies have focused on the monitoring of legacy pesticides such as hexachlorocyclohexanes (HCHs) and dichlorodiphenyltrichloroethanes (DDTs).

In the river water and groundwater samples drawn during this study, mainly 2,4-D and atrazine residues, were discovered in concentrations of several µg/l (these results were consistent across all four sampling campaigns). Most of the pollution seemed to have been caused by the river water carrying pesticides into the groundwater system. This indicates that it may be important to pay more attention to the investigation of currently-used pesticides, especially in areas where surface water infiltrates into shallow aquifers.

The overall observation on agricultural activities in the North China plain was that much improvement is needed in educating farmers on sustainable production techniques and the proper application of agrochemicals. One way to increase farmers’ understanding and knowledge of the environmental impact of agriculture would be to shift to a more formal training regime, for example vocational education. One possible side effect of such a change could be to raise the status and income opportunities enjoyed by agricultural workers, thereby giving the younger generation an incentive to choose farming as a profession.

In conclusion, this PhD study gave insights into a more systemic understanding of nutrient degradation and the occurrence of particular herbicides at a specific field site. The research into the use and monitoring of pesticides in the North China Plain was reviewed and new recommendations were developed to enhance the dissemination of knowledge from environmental researchers to farmers.