THE POLLUTION CAUSED BY VETERINARY ANTIBIOTICS WITHIN FRESHWATER

AN ASSESSMENT OF THE PATHWAYS AND THE EFFECTIVITY OF REDUCTION MEASURES USING VANTOM

The use of veterinary antibiotics is a common practice within livestock agriculture. Because of its popularity it potentially pollutes freshwater entities. Globally, high concentrations of veterinary pharmaceuticals have been detected, which can have significant ecotoxicological effects. The goal of this research is to improve the understanding of this pollution, by modelling the pathways of 8 types of antibiotics between the application on the field and inflow into freshwater. With help of the model VANTOM (Bailey, 2015) and the Grey Water Footprint (GWF) concept (Hoekstra et al., 2011), the pollution is quantified so that different scenarios and reduction measures can be compared. This is done for a case study of the Vecht catchment.

After administration to the animal, residues of antibiotics are excreted into manure, which is used for fertilizing soil. Following the application of this polluted manure, antibiotics can spread through different paths: 1) through runoff or 2) through erosion into surface water. Other possibilities are that antibiotics 3) degrade within the soil, 4) leach through the soil into groundwater or 5) accumulate through sorption to soil particles and persist within the soil. Leaching, erosion and runoff determine how severe antibiotics pollute freshwater.

Considering a period of one year, the largest part of antibiotics degrades within the soil, namely between 90% and 100%. Between 4 and 8% accumulates within the soil. The rest is transported through erosion, runoff and leaching. Loads to surface water are sensitive to different parameters: 1) degradation and adsorption, which depend on the soil and antibiotic type, 2) the soil characteristics, such as porosity and density of the soil, 3) the slope of the field and 4) the moment of application. The largest load is caused by tetracycline, while the largest GWF is caused by chlortetracycline. The GWF of chlortetracycline within the Vecht area is around 38,000 m^3, while the GWF of tylosin is around 5,800 m^3. These numbers are significantly smaller than the average discharge of the river, which lies between 1.4 and 2.6 billion m^3 $year^{-1}$. This means that the maximum acceptable concentrations of the antibiotics is not reached.

Different measures can potentially reduce the pollution. These can be split into 1) reduction of input, by a reduction in antibiotic use or composting or anaerobic digestion of manure, and 2) mitigation measures, by injecting or mixing manure into the soil and the implementation of vegetation buffer strips. The reduction of input is the most efficient measure (see Table 1), because less antibiotics reach the environment. Within this category, the reduction of antibiotic use has the largest potential. Composting of manure is a reliable measure, although it costs space and time. Anaerobic digestion is very effective and has the production of biogas as an extra asset, but requires a large financial investment. Vegetation buffer strips and injection or mixing into the soil can reduce the load through runoff and erosion to surface water but increases the fraction of antibiotics that accumulates in the soil, which can form a danger on the long term.

This research has sought a methodology to establish the fate of antibiotics and the effectivity of reduction measures. While this has given some new insights, the results still contain many uncertainties. It is therefore recommended to 1) do more research on the behavior of antibiotics in soil and water, 2) collect data on the total use of antibiotics and 3) improve the awareness on the effects of antibiotic use.

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Graduation Date:
27 March 2020

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Table 1. The annual GWF of chlortetracycline and tylosin for different scenarios within the Vecht catchment.

Antibiotic	Normal application	99% Input reduction	Composting	Anaerobic digestion	Manure injection	Buffer strip
Chlortetracycline	38190	382 (-99%)	3400 (-91%)	764 (-98%)	1200 (-97%)	37000 (-3%)
Tylosin	5790	58 (-99%)	1100 (-81%)	6 (-99%)	200 (-97%)	5700(-2%)

Bailey, C. (2015). *The overland transport of veterinary antibiotics*. Rheinisch-Westfälischen Technischen Hochschule Aachen.

Hoekstra, A.Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). *The Water Footprint Assessment Manual: setting the global standard* (1st ed.). London: Earthscan.

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