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Impact of agricultural pollution on water systems in Austria

Country paper of Austria

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Although Austria is an alpine country and its mean levels of fertiliser and pesticide input are quite low in comparison to other European countries, the quality of water resources is strongly influenced by agricultural practices. The main water quality problems for groundwater as well as surface waters are unevenly distributed over the territory, with focus on the eastern and south-eastern parts of Austria, where high input agriculture is practised. Surface water is affected by enhanced phosphorus loads due to accelerated soil erosion, groundwater quality is strongly influenced of high nitrate concentrations. For a considerable number of sites, pesticide levels (especially Atrazine and Desethylatrazine) above the threshold limit still are present although Atrazine has been banned in 1995.

Basic statistics on agriculture in Austria

Austria is an alpine country. More than 60% of Austria's area of 83,870 km² is covered by the Alps. Austria's geomorphological situation is reflected by the size of the agriculturally used area (43% agriculturally used, 46% forest) and the distribution of its land use pattern (Figure 1). The main areas of intensive agriculture are concentrated in the eastern and south-eastern parts of Austria. Not surprisingly, the main problems of water pollution have been reported out of the same regions.

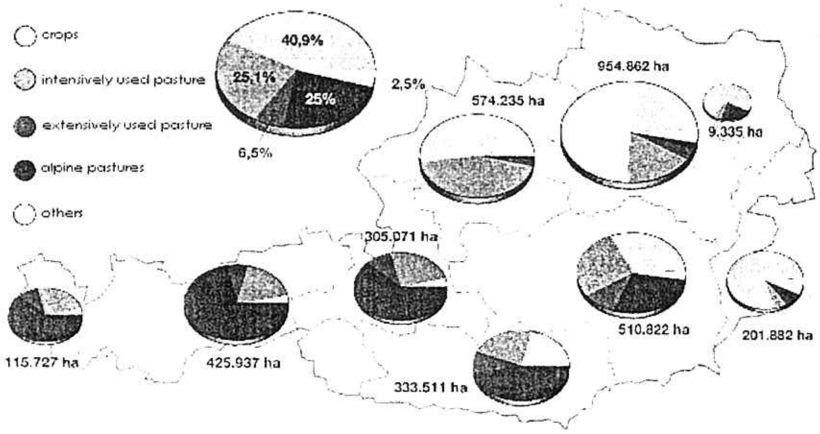

Figure 1. Distribution of cropping systems for the agricultural used land of the nine Austrian federal provinces [1].

Fertilisation

Total amounts of applied fertilisers (Table 1) are relatively low in comparison to the mean European level of fertiliser application rates [2].

Table 1. Mean annual nutrient application rates (kg/ha of used agricultural area) and total amounts of applied nutrients (tons) for 1994 [3].

	N (kg/ha)	N (tons)	P_2O_5 (kg/ha)	K_2O (tons)	K_2O (kg/ha)	K_2O (tons)
Manure	51	167,000	34	85,000	77	190,000
Mineral Fertiliser	47	116,000	22	54,000	25	61,000
total	98	283,000	56	139,000	103	251,000

These numbers are mean values and are therefore not suited to reflect the great variability in application rates within Austria, where the highest amounts of applied fertilisers can be found within the intensively used Marchfeld area (105 kg N/ha/1994). Mean livestock units per hectare agricultural used land are below the mean European level (0.7 LU/ha), but also irregularly distributed over Austria's territory. Increasing environmental problems due to water pollution by agriculture resulted in decreasing application rates since the early 80's (Figure 2).

Figure 2. Development of nutrient application rates for N, P and K since 1986 [1]

Pesticides

According to the decreasing trend of application rates for fertilisers, pesticide application rates also decreased markedly from totals of 4,486 tons (1991) to 3,620 tons in 1994 [4]. This is equal to 1.04 kg/ha agricultural used area respective 2.41 kg/ha for the sum of cropped areas, perennial crops and gardens. Compared to application rates at a European level these numbers are within the lower third of reported amounts of pesticide application.

Nutrient inputs to ground- and surface waters

Kroiß et al. [5] calculated phosphorus and nitrogen fluxes for the Austrian part of the Danube river catchment, which covers about 96% of Austria's total area. Their data (Figures 3 and 4) show that agriculture contributes with considerable amounts (around 40%) to the total nutrient loading for nitrogen as well as phosphorus. While agricultural contribution to nitrogen input is due to groundwater loading, the main source of agricultural input to phosphorus loading is due to erosion and surface run-off. Although these calculations are affected with uncertainty, they give insight into mean quantities of nutrient loading. Given a certain watershed the calculated values as well as the accuracy of their estimation may be completely different according to specific local conditions. Given the varying contribution paths of nitrogen and phosphorus loads, clearly different strategies for their reduction have to be applied.

Main water quality problems

Survey and control of Austria's water quality are termed in the water law (Wasserrechtsgesetz 1959, WRG) with its latest novel in 1997 (BGBl.Nr.74/1997) and the legal ordinance on water quality measurement (Wassergüteerhebungsverordnung, WGEV, BGBl.Nr. 338/91). According to the WGEV, water quality is evaluated four times per year at 2,055 sites for groundwater and six times per year at 244 sites for surface water. For each sampling point a large number of physical, biological, inorganic and organic water quality parameters are measured. Details about these parameters and the respective methods used are termed in the WGEV.

Surface water

Based on the WRG, a legal ordinance with threshold limits for the water quality parameters to be measured is in preparation. The draft version of this legal ordinance distinguishes between alpine and lowland rivers. For selected parameters, Kroiß et al. [5] investigated the water quality, based on the presumable threshold limits of this draft (Table 2).

Table 2. Percentages of parameter values above limits of the draft legal ordinance on threshold limits.

PARAMETER	ALPHINE RIVERS % of measured values > limits	LOWLAND RIVER % of measured values > limits
BOD	29	8
DOC	37	7
NH_4-N	10	6
NO_3-N	0.7	-
NO_2-N	27	11
Total P (filtrated)	53	19
Total P (unfiltrated)	53	19

Table 2 especially reveals that for a considerable number of cases P loads of Austrian rivers are too high in comparison to target levels. Looking at the distribution of the rivers with high loadings it can be seen that the main area of polluted rivers is located in the eastern and south-eastern parts of Austria. Besides local problems due to high input of sewage treatment plants (the rivers Glan, Gurk, Danube Channel in Vienna and some others), diffuse agricultural input acts as a major source of pollution (see also Figures 3 and 4). Summer and Klaghofer [6] evaluated, that soil erosion increased drastically within the last forty years. Because P losses from agriculture mainly occur via superficial transport [7], this constitutes a major path of agricultural contribution to nutrient loading of surface water.

Groundwater

As 98% of drinking water in Austria is taken from groundwater sources, a high quality of this resource is of major concern for the country. Rising nitrate and pesticide concentrations during the last decades have increased the public awareness of the susceptibility of our water resources and forced the government to set legislative measures for the protection of groundwater quality. Drinking water is termed as food in Austria. Therefore, besides the WRG, several legal ordinances within Austria's food laws deal with the quality of drinking water, especially the legal ordinance on nitrate in drinking water (Trinkwassernitratverordnung, BGBl.557/89) and the legal ordinance on pesticides in drinking water (Trinkwasserpestizidverordnung, BGBl. 448/91). These legal ordinances term threshold limits for nitrate (50 ppm NO_3^-) and pesticide concentrations (for almost every pesticide 0.1µg/l) in groundwater. Table 3 lists the nitrate contents of Austria's federal provinces.

Table 3. Nitrate contents in groundwater (time: 1991 - 1995) for the nine federal provinces of Austria [8].

CLASSES	VBG	TYR	SBG	CTA	STA	LOA	VIEN	BGLD	UPA	TOTAL
<10 ppm	644	966	545	846	935	1.083	80	480	626	7,384
10-30 ppm	122	512	22	805	961	1.282	105	293	1,081	5,422
30-45 ppm	1	9	55	241	461	567	69	132	652	2,195
45-50 ppm	0	2	6	43	147	150	22	41	135	546
>50 ppm	1	0	4	188	548	952	301	456	280	2,730
Σ	768	1,489	832	2.123	3,052	4,034	577	1,402	2,774	18,277

Table 3 shows satisfying mean nitrate contents for Austria, but again loading is distributed unevenly and main problems occur in agricultural intensively used areas. These areas often coincide with high amounts of potentially available groundwater as they are located in Austria's great basins or lowland regions, with favourable conditions for agricultural use. The same trends can be observed concerning pesticide loading. Two main products are of major concern, Atrazine and its derivative Desethylatrazine. Although Atrazine has been banned in 1995, it can be detected at a considerable number of sampling sites (Table 4). This gives a good indication for the necessity of the application of long-term strategies for groundwater protection. As a consequence of groundwater pollution, probable groundwater rehabilitation areas have been identified (Table 4). These areas extent to a size of about 72% of the total area of connected groundwater bodies in Austria, 46% of the probable rehabilitation area is caused by only one component - enhanced nitrate loading [8].

Table 4. Number of groundwater areas with probable demand for rehabilitation for the given parameters [8].

TOTAL	SIZE (km^2)	NO_3	NO_2	ATRAZINE	DESETHYLATRAZINE	NH_4	PO_4	Na	Cl	K
55	9060.5	27	21	33	41	24	12	11	11	13

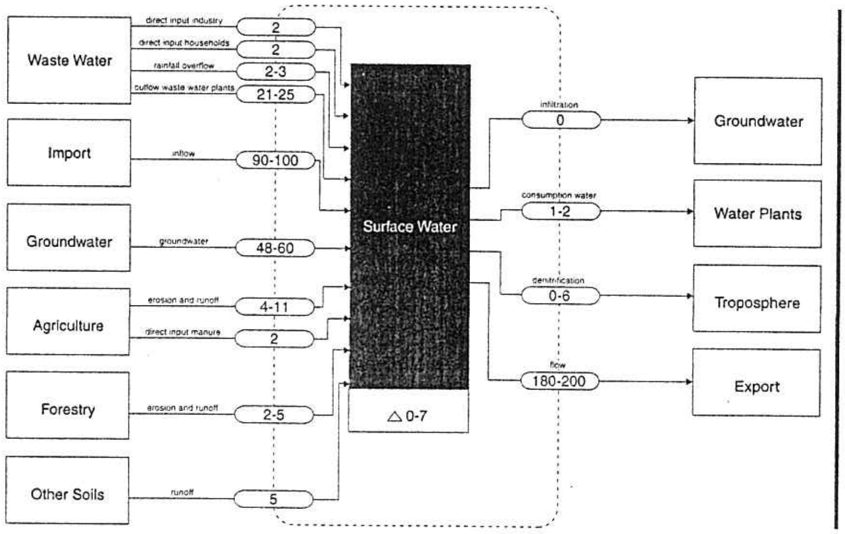

Figure 3. Nitrogen balance (in 1000 t N/a) for Austria in 1992 according to [5], modified.

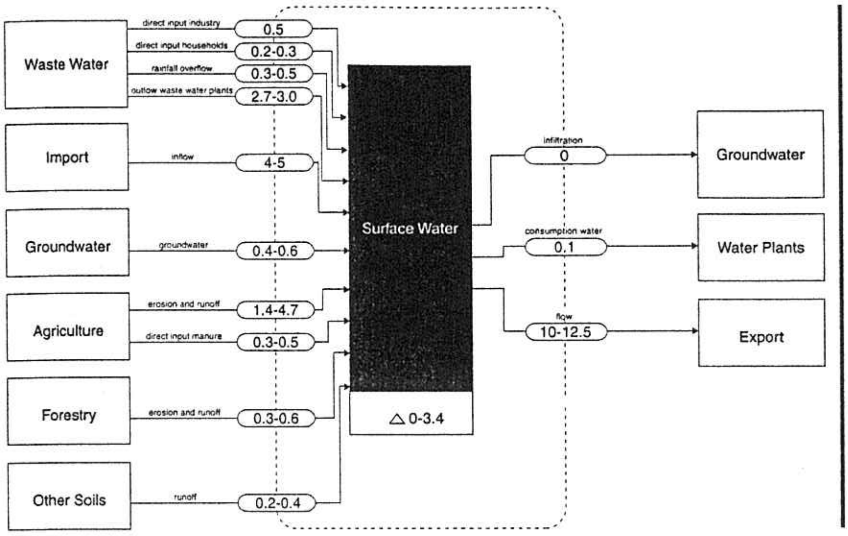

Figure 4. Phosphorus balance (in 1000 t P/a) for Austria in 1992 according to [5], modified.

Simulation tools for nitrate loading of groundwater

Simulation models help to evaluate the effects of varying management practices on groundwater quality. Some of the models used to simulate water and nitrate movement of agriculturally used soils are SIMWASER [9] and STOTRASIM [10]. STOTRASIM is designed to describe the one-dimensional, vertical flow of water and nitrate-nitrogen in a soil profile. Interflow, preferential flow and surface run-off are neglected. It consists of two submodels describing water balance and plant growth (SIMWASER) and nitrogen cycle on a daily basis. It runs under the operating systems Windows95/WindowsNT and is combined with a graphical interface for data input. If the necessary input parameters are not available, the user is provided with possibilities for their estimation. Figures 5 and 6 give the results of a comparison between measured and calculated seepage rates and nitrogen loads applying the models SIMWASER and STOTRASIM for various locations in Eastern Austria.

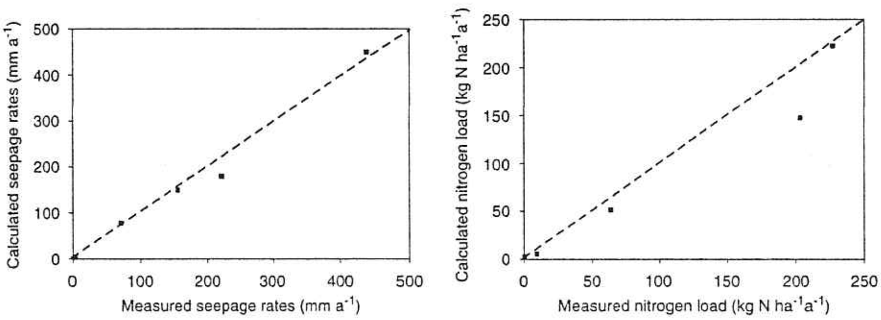

Figure 5. Comparison between calculated and simulated nitrogen loads and seepage rates for various locations in Eastern Austria [11]

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