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Mineral Emission of Austrian Agriculture: Research and Policies

Markus F. Hofreither, Klaus Pardeller,
Erwin Schmid, and Franz Sinabell*) *)

Abstract

Some of the changes in environmental policy to be expected after Austria's accession to the EU are presented. General statistics on the Austrian agricultural sector form the background of a review of research focusing on mineral emission of agriculture which covers the following substances: nitrogen compounds, phosphate, methane, and heavy metals. The analysis of policy shows that the predominant command and control approach failed to reach a major goal of Austrian environmental policy, the protection of groundwater resources. A short analysis of the levy on mineral fertilisers which was in force during the period 1986-1994 points out that political economy issues seem to be decisive whether such an instrument is effective or not. Finally an extensive list of research relevant for the topics is presented as well as a list of institutions carrying out research in this field.

Keywords: Austria, agriculture, mineral emission, nitrogen balance, environmental policy

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Introduction and General Background

Introduction

Since January 1, 1995 Austria is, together with Finland and Sweden, a full member of the European Union (EU). For Austrian agriculture, as well as most parts of the upstream and downstream sectors, this EU accession brought about the most dramatic incision in the post-war history from an economic point of view. As far as environmental regulations are concerned some aspects have to be considered:

- Austria is among the countries with an elaborated set of environmental legislation which implies that the EU accession will not bring about fundamental changes in environmental policy;
- in some fields Austrian production standards were or are stricter than other EU member states which raises competitiveness issues;
- the Common Agricultural Policy (CAP) is in some important aspects distinctively different from the agricultural policies in Austria up to 1994; environmental legislation which was adapted to the environmental outcomes of this set of policies certainly has to change otherwise it will become obsolete in some fields;
- environmental policy in Austria with respect to agriculture therefore must be seen as "under construction" because several important programmes and environmental regulations have been implemented only a short time ago or did not yet pass the parliament;
- Austria is a federal state of nine *Bundesländer* (provinces) with their own legislation and environmental policy is an integrated concern of nearly all ministries and administrative bodies; therefore different approaches are being taken in different places in order to cope with the same problems and monitoring data are not always available or compatible on a national level.

Having in mind these arguments the following survey is intended to render only some general and basic insights how mineral emission of the agricultural sector is regulated, and to survey selected research which was carried out in this field. Readers who are interested in a general survey of linkages between the natural environment and agriculture in Austria which goes beyond mineral emissions should refer to Wytrzens & Reichsthaler (1990), and Hofreither & Sinabell (1994).

The paper will proceed as follows: in the next chapter basic statistics of the Austrian farm sector will be presented, then a short description of the level of pollution due to mineral emission by agriculture follows. In the following chapters the Austrian environmental policy with respect to these issues is summarised in short and policy relevant research is reviewed. Some paragraphs are devoted to the description of the effects of the levy on mineral fertilisers in Austria which was abolished when Austria became an EU member state because such a levy is still being debated in Austria. The papers ends with a list of institutions carrying out related research and some further readings.

Basic Statistics of Austrian Agriculture

In *Table 1* basic statistics of the Austrian agricultural sector are summarised. Generally farms are small and a great share of them are ran by part time farmers who earn most of their living in other professions. Since most of the country is part of the Alps a big share of farms is classified as mountain farms which are supported by a specific program designed for compensating farmers directly for disadvantages. The great number of farmers complying with the rules of organic farmers is remarkable. Most of these farms are situated in mountainous areas specialised in cattle production. However among them there are only few crop farms which contribute substantively to mineral emission under conventional farming practices.

Tab. 1: Production Related Statistics of the Agricultural Sector

category	value	units	percent	base	year	source
share of GDP	64.7	billion ATS[1)]	2.3	GDP Austria	1994	BMLF 1995
work force	182.2	1000 persons	4.9	Austrian work f.	1994	BMLF 1995
plant production	21.6	billions ATS	33.3	agr. production	1994	BMLF 1995
livestock production	43.1	billions ATS	66.7	agr. production	1994	BMLF 1995
agric. trade balance	-18.6	billions ATS	56	consumption	1994	BMLF 1995
total PSE	37.4	billions ATS	62[2)]		1994	OECD 1995
farms	267	1,000	100	Austrian farms	1993	PRÄKO 1995
farms < 5 ha	93	1,000	35	Austrian farms	1993	PRÄKO 1995
farms > 50 ha	17	1,000	6.4	Austrian farms	1993	PRÄKO 1995
mountain farms	108	1,000	41	Austrian farms	1994	BMLF 1995
biofarms	23	1,000	8.5	Austrian farms	1994	BMLF 1995
farms ran by full-time farmers	78	1,000	29	Austrian farms	1994	BMLF 1995
agricultural land	3.4	million ha	46	Austrian area	1994	PRÄKO 1995
arable land	1.4	million ha	40	agric. land	1994	PRÄKO 1995
intensive grassland	0.8	million ha	25	agric. land	1994	PRÄKO 1995
extensive and alpine grassland	1.1	million ha	31	agric. land	1994	PRÄKO 1995
N from fertiliser	126	1000 tons	101	year before	1994	PRÄKO1995
P_2O_5 from fertiliser	62	1000 tons	95	year before	1994	PRÄKO 1995
K_2O from fertiliser	76	1000 tons	97	year before	1994	PRÄKO 1995
livestock intensity	0.9	LU/ha		agric. land	1994	own estimates

[1)] 1 ATS equals about 0.077 ECU; [2)] percentage PSE

Pollution

Nitrogen

Balances for nitrogen clearly show that agriculture is contributing substantially to the Austrian nitrogen emission. A balance for the agricultural sector is given in *table 2*. The data show that the amount of mineral fertilisers spread in Austria is exceeding the amount of nitrogen which is accumulated in agricultural products. A map (see *figure 1*) visualises the regional differences. For most of the Austrian area (the mountainous region in the Alps) nitrate levels are balanced or even negative.

Tab. 2: Nitrogen Balance of Austrian Agricultural Sector

Category	sub category	1,000 t N	share in percent
Input	mineral fertiliser	141.0	47.0
	feed stuff imports	38.0	12.7
	atmospheric deposition	71.0	23.7
	biological N-fixation	44.0	14.7
	other emissions (e.g. urban)	5.9	2.0
Output	livestock production	47.4	15.8
	plant production	38.2	12.7
Total surplus		214.4	71.5
	leaching	47.9	16.0
	surface runoff	5 - 10	1.7 - 3.3
	denitrification	75 - 90	25 - 30
	accumulation	5 - 9	1.7 - 3.0
	NH_3-LOSSES	81.5 - 57.5	27.2 - 19.2

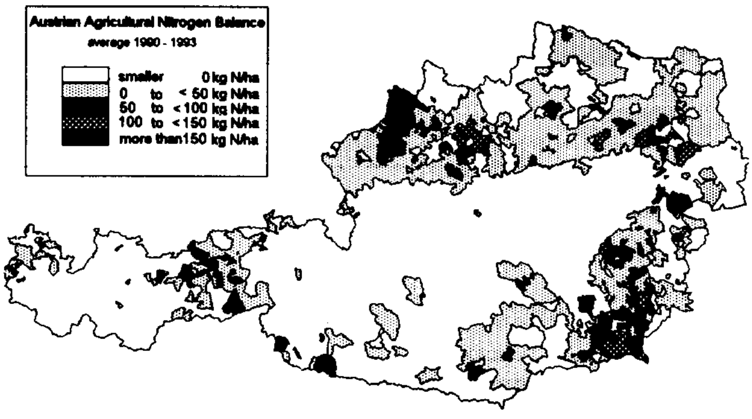
Source: Knoflacher et. al. (1993)

Such data are helpful for general purposes, for the implementation of specific programs regional data are required which cover all potential polluters. An example of such studies which focus on water pollution due to agriculture in comparison with other polluters is given in *table 3* for the *Bundesland Oberösterreich*.

Tab. 3: Regional Nitrogen Emission in Kremstal, Oberösterreich

resource	source of pollution	category	share in percent
ground water	agriculture	fertilisers runoff	50-70
		volatilisation	20-30
	traffic		< 1
	industry and households	thermal processes	1-2
		other processes	5-15
		waste water	0
surface water	agriculture	fertilisers runoff	40-50
		volatilisation	15-25
		leaching	8-12
	industry and households	thermal processes	0
		other processes	5-10
		waste water	10-12

Source: Amt der oö. Landesregierung (1995)



Source: based on data from Hofreither & Rauchenberger, 1995

Fig. 1: Austrian agricultural Nitrogen Balance on community level (average 1990-1993)

Nitrate

Public in Austria is considerably aware of the nitrate problem. This is due to the fact that ground water is (besides spring water) the major source of drinking water. Agricultural enterprises which use ground water as a sink for their nitrogen wastes are therefore in direct conflict with the other users of this resource.

Tab. 4:Average values of Nitrate in Groundwater in mg/l on regional level

Bundesland	**sample plots [1)]**	**1992/93**	**1993/94**
Burgenland	121	52.53	54.44
Kärnten	173	23.08	19.70
Niederösterreich	238	35.97	35.42
Oberösterreich	259	26.98	24.40
Salzburg	70	13.32	10.64
Steiermark	234	30.49	26.05
Tirol	115	9.10	6.37
Vorarlberg	61	5.34	4.11
Wien	45	52.62	50.71
Austria	1,316	29.75	26.82

[1)] the number of sample plots is slightly different among the years

Source: adopted from BMLF & BJUF 1995

A monitoring program has been established under which over 1,300 samples are drawn four times a year. Some of the aggregated data are given in *table 4*. The average values suggest that except for *Burgenland* (a region in the east bordering to Hungary where precipitation is low and intensive crop production prevails) no dramatic problems exist. However, if the data are looked upon on a regional basis (see *table 7*) it turns out that in a significant share of the area of some of the *Bundesländer* ground water nitrate content exceeds the threshold value (currently 45 mg/l).

Ammonia Volatilisation, nitrous oxides

Two main sources of **ammonia** are identified in Austria:

- *Natural nitrogen cycle:* due to natural processes ammonia is emitted. Knoflacher et al. (1993) estimate that 3 kg NH_3 are produced per ha arable land (this totals to about 4,200 t NH_3);
- *Human activities* in the agricultural and other production process: Total ammonia emission in Austria is estimated to be between 77,000 and 123,000 t per annum, the share of agriculture is estimated to be 80%.

This share is due to volatilisation which occurs when mineral and organic fertilisers are spread or stored. NH_3-emission from mineral sources are estimated to lie in the bandwidth of 8,600 - 17,200 t; emission due to livestock production is estimated to be 67,300 t. The shares among the products are: 76% beef, veal, and milk, 17% pork, and 3% chickens and eggs.

According to model-based estimates NH_3-emission from agriculture is contributing 25% to acid rain in Austria. The costs to reduce emission by 30% until the year 2000 were estimated to be as high as 700 Mil ATS per year (Klaasen, 1994, 224pp).

Generally Austria is a net importer of **NO_x** so abatement strategies were not as successful as e.g. with respect to SO_2. NO_X emission amounted to 245,000 t in 1991 (this is a 12% reduction compared to 1985), the greatest single source is road-traffic (65%; BMJUF, 1993). Combustion engines and heated glass houses with the potential of NO_x emission are the major sources of this substance which can be attributed to agricultural production. Estimates for this single sector are not available.

As in the case of ammonia **N_2O emission** is due to natural processes which hardly can be influenced by agricultural practices. In general clear cutting (not relevant in Austria), burning of fossil and biomass fuels, and the application of fertilisers are the major anthropogenic sources. On a global scale one third of the increase in atmospheric concentration is considered to be due to fertilisation and N-accumulation in soils due to legume crops. Krapfenbauer (1994, 4) estimates that agriculture's share of total N_2O emission is 35%, however for Austria detailed empirical time series data do not exist up to now though several field experiments were carried out (see Holtermann, 1994).

Methane

The first estimate of methane emission in Austria dates back to 1989 (Forschungszentrum Seibersdorf, as quoted in BMJUF, 1993). Anthropogenic methane emission was estimated to be 600,000 t per annum. Agriculture was seen to be the most important single sector (56% of total emission) mainly due to livestock production, in particular beef and milk production. An amount of 3,700 t per annum was estimated to be due to burning straw after harvest (Orthofer, 1991) which is forbidden now. More recent estimates are much lower. The *Austrian CO_2-Commission* estimates that 221,000 t methane are emitted per annum, the share of agriculture is 38% according to this estimate. This figure equals 63 kg CH_4/ha arable land per annum (AUE, 1994).

Phosphorous

Eutrophication of lakes was a major environmental concern during the 60s in Austria because tourist industry was negatively effected by it. Heavy investments in sewage treatment plants were made to cope successfully with the problem of municipal emission. This reduction of a major source led to a relative increase of the impact due to agriculture with the effect that in some regions agriculture is the most important anthropogenic source of phosphate pollution (see table 5).

Tab. 5: Sources and Loads of Phosphate of Selected Lakes (in mg/m^2 per annum)

lake	precipitation	background	agriculture	run off water	other
Wörthersee	25	51	57	239	15
Mondsee	40	80	90	303	815
Neusiedler See	25	39	152	284	3

Source: adopted from Sampl, 1993

Actually the input of phosphate from mineral fertiliser has been reduced at a 1.9 percentage point level per annum during the last decade. This reduction of potential emission was outweighed by an increase of manure due to intensification of livestock production (e.g. production of pigs increased by 2.1 percentage points in the same period). Consequently it can be observed that some rivers in intensive agricultural regions carry a load of over 1 mg/l phosphate (river *Thaya* and *March*). It is estimated that 35% of total emission (6,150 t per annum) into the river *Danube* are due to agricultural non-point emission sources. A phosporous balance is a available for a region in *Oberösterreich* (see Glenk et. al. 1995).

Heavy Metals

The situation of soils with respect to heavy metal contamination was studied by Blum (1993). Relative small areas of soils with critical loads can be identified around some industrial sites. Special regulations forbid cultivation for nutritional purposes in these areas. Agriculture is not seen to be a prominent source of emissions of that kind because heavy metal content of fertilisers is limited by regulations and pesticides which are based on arsenic or mercury compounds are forbidden.

Sewage sludge which is used as a fertiliser has attracted some public awareness and rather often farmers refrain from spreading it even it was a bargain because they fear to reduce land values if they did. Therefore only 25% of sewage sludge (total production in Austria are 200,000 t dry substance) are spread on agricultural land (Aichberger, 1990).

Agriculture may be seen as a victim of heavy metal contamination in some regions. In *Tirol* in 10% of the samples of agricultural soils Pb-content exceeded the threshold value (100 mg Pb/kg DS; Amt der Tiroler Landesregierung, 1989).[1]

Pollution

No other minerals emitted by agriculture are of major relevance. Of course minerals are part of "normal" wastes. Studies carried out by Reisner (1989) and Blum et al. (1993)

1 *Tirol* is a special case because it is located around a major North-South transit route and exhibited to heavy impact of road traffic.

identified several compounds which may be seen as a potential threat but according to the authors these substances (e.g. used in wine-production) are subject to general legislation with respect to wastes and are not seen to require special care.

CO_2 is a major input of agriculture and part of the emission of the production process. Up to now no estimate with respect to the agricultural sector exists. Currently a sector-based balance sheet of the Austrian economy is being calculated for CO_2 which will include agriculture (Jonas, 1995).

Estimates of a damage function of agricultural emissions in general and an identification of an intensity level of "optimal pollution" are not available for Austria. Environmental damages due to agriculture are documented mostly in physical terms, monetary evaluations only were made in the case of nitrate pollution. Investments in purification plants by suppliers of drinking water amount to two billions ATS for the period from 1993 to 2000 (Gerhold, 1993). These investments mainly become necessary because the maximum allowable dose of pollutants in drinking water is being stepwise reduced. Agriculture is the major source of the relevant pollutants (most prominently nitrate and pesticide residues), however in this study no distinction was made between organic and inorganic substances.

The release of nutrients into ecosystems is seen to be an important cause of plant species decline which causes a fauna decline as well because the natural balance among species gets biased towards plants being able to utilise abundant nutrients. The decline of species however is due to other sources as well, like changes in land use, dehydration, air and soil pollution. In the "Red List" the decline of species is being documented. Causal connections are difficult to find in that context which may be the reason that there is no study available which quantifies the impact of mineral emission of agriculture.

Policies in Austria

History, objectives, and approaches

The Austrian way to protect the environment is generally dominated by the command and control approach. However, some other instruments like deposit-refund-systems (implemented for some consumer products), eco-labelling (such a scheme is implemented for organically produced farm products), and cost-sharing measures are implemented on a small scale. The causal relationship between agricultural policies and the indirect negative impact on the environment was noticed only recently. Policy makers relied on the validity of to the so-called *Kielwassertheorie* (*wake theory;* see Mannert, 1991) which arguments in short "supporting farmers is beneficial for rural society and the environment as well". Holzer & Reischauer (1991, 14) conclude that legislation with respect to agriculture "is dealing with the protection of the agricultural sector not with the protection of the environment from the impact of agricultural production".

However, an elaborated set of legislation was put into force in order to prevent damages from heavy metal, pesticides, ozone and hazardous wastes, both on national as well as regional level. All these measures follow the command and control approach. Depending on the pollutant marketing of products not registered or products with substances exceeding certain threshold values is prohibited or requires special licenses, respectively. These measures are surveyed and evaluated from the legal sciences (see e.g. Onz, 1987, Kind, 1995, Welan & Kind, 1995, Holzer & Reischauer, 1991, Wegscheider, 1994). Federal research institutions are giving expert opinion on specific regulations based on findings of natural sciences and carry out the control. Economic risk assessments and cost-benefit analysis of measures do not play a role at all.

Ground water protection can be seen as an exception. In this field of environmental policy various instruments are employed: cost sharing measures (for investments in bigger storage facilities for manure), education and moral suasion (with respect to the application of chemicals), various prohibitions and mandatory regulations (concerning organic and mineral fertilisers), and environmentally motivated subsidies (for farmers complying with special management practices). A monitoring program has been established in order to evaluate the outcome of these measures and to be able to adapt specific measures to regional requirements (see *table 6*). This program covers several substances besides nitrate (among them pesticides and their residuals, ammonium, phosphate, chloride, and potassium). These data will serve as the basis of designating *ground water rehabilitation zones* (see next chapter) in the next few years and constitute the empirical basis for research devoted to evaluating these policies (see last chapter).

Tab. 6: Groundwater Zones Planned for Designation as Rehabilitation Zones

Bundesland	**agricultural N-input**[1]		**monitoring area**	**threshold value is exceeded by**			
	mineral	**organic**		**at least one substance**		**by nitrate**	
	kg N/ha	kg N/ha	km²	km²	%	km²	%
Burgenland	59	26	1,685	1,685	100	1,442	85
Kärnten	37	93	898	571	63	100	11
Niederösterreich	69	51	3,039	2,025	66	1,909	62
Oberösterreich	59	101	2,379	2,032	85	1352	56
Salzburg	16	115	171				
Steiermark	49	102	753	559	74	518	68
Tirol	9	126	414	101	24		
Vorarlberg	16	113	261	216	82		
Wien	69	51	318	318	100	318	100
Austria	55	78	9,918	7,507	75	5,639[2]	56

[1] base year: 1989/1990; [2] 5,639 km^2 equal 6.7% of the total Austrian area and amount to 40% of arable land

Source: adopted from BMLF & BMJUF 1995 and Holzer & Reischauer, 1991

Policy Measures to Prevent Nitrate Pollution

Current Legal Framework

The *Water Act* (*WRG, BGBl 215/1959 idF 252/1990*) is regulating almost all aspects concerning the use of water resources in Austria (for details see Rossman, 1993, Stalzer, 1995, and Tomek, 1995). According to this act ground water is in principle private property of the land owner. He or she may use it without permission to cover the *necessary* demand for household or enterprise. For extraction which exceeds this amount (e.g. for irrigation by a farmer or for a water supplier) a license is required.

The concept of "good agricultural practices" with respect to ground water is defined in that act and focuses on the maximum amount of mineral fertilisers which may be spread and livestock units per hectare. According to this act at most 175 kg N/ha (without a cover crop) or 210 kg N/ha may be spread without permission. A permission is also required if more than 3.5 *DGVE*/ha are kept on a farm.[2]

According to the *water act* the quality of ground water shall meet the same requirements as drinking water (the quality parameters are currently 50mg NO_3/l, from July 1999 on 30mg NO_3/l). This implies that for *all* national ground water sources very strict standards apply. Three instruments are provided to reach this ambitious quality aim:

- **Groundwater protection zones**: these are small zones surrounding a well. The water supplier has to pay foregone profits to a farmer if he has to comply with certain management practices or to change land use. Several thousand zones of this category are designated by the heads of the sub national governments. In some of these zones problems arise if the water supplier should ask for stricter regulations but refrains from doing so because he might be obliged to pay compensation payments to the land owner. Due to regional differences in soil and climatic conditions the particular regulations vary across the different *Bundesländer*. They have in common that spreading of manure is limited to certain periods, that manure storage facilities have to be big enough to allow for storage of at least five month, that the use of some pesticides is prohibited, and the like.
- **Groundwater preservation zones**: these areas should be as big as a closed aquifer around a well. Compensation for land owners are like reported above. Regulations are not so strict in that case. Again different regulations apply contingent upon the sub national government and the implementation by local authorities. Currently 130 regulations exist which designate *preservation zones* which cover about 6.7% of total Austrian area.
- **Groundwater rehabilitation zones**: In regions where nitrate content (or some other pollutant) exceeds the threshold value not only temporarily (currently 45 mg NO_3/l) a rehabilitation program has to be installed by the local authorities. Agricultural practices may be regulated in detail in these zones. If these regulations have economic effects farmers may get at most 80% of profits foregone in form of compensation payments. Such payments are contingent upon the allocation of budgets for such programs by local and federal governments. Because no decision was made yet whether compensation payments for farmers will be available or not *groundwater rehabilitation zones* have not yet been designated.

Regulation 91/676 EEC will be implemented in Austria in the near future. There is a strong preference from policy makers to designate the whole country as a *nitrate vulnerable zone*. Although this regulation is focused on nitrate the level of emission of other minerals will be effected as well.

Farmer organisations and government authorities are currently drafting a code of good agricultural practices (*Ehrenkodex*). Compliance with this code will be on a voluntary basis for the next few years but it will serve as the base level of minimum standards later on. The details are not yet agreed upon but they will not be very different from the regulations which are relevant for *ground water preservation areas* already. Experts who bring forward the idea of a re-implementation of an input tax on mineral fertilisers have to face the opposition of farmers who argue that such a tax only would make sense if it was implemented on an EU-wide level.

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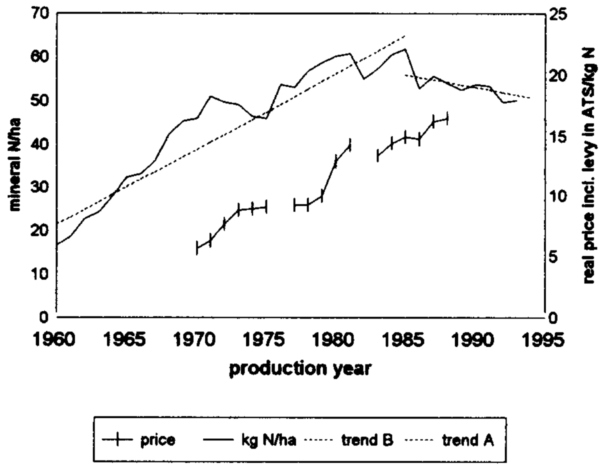
2 *DGVE* is the Austrian definition of livestock units

Austrian Experiences with a Levy on Fertilisers

During the period from 1986-1994 a levy was imposed on mineral fertilisers[3]. This environmentally motivated tax was abolished 1995 when Austria became an EU member state because of competitiveness considerations. When the tax was introduced a marked fall in consumption could be observed (-15.5%) which could not be explained by a slight *decrease* of costs (-1%) compared to the year before. This happened because fertiliser industries reduced their prices simultaneously by 24.6% and therefore compensated farmers for the tax (23.7 %).

Price elasticities of nitrogen fertiliser were estimated to be -0.35 for maize and -0.15 for grains (Schneeberger, 1990, 109) which means that large quantitative effects are to be expected only by sharp price changes. Austrian farmers obviously took the introduction of the levy as an opportunity to rethink their production plans and as average yield data suggest the reduction of N fertiliser had no negative effect on crop yields.

Since all farmers benefited from the reduction of pre-tax costs the opposition against the fertiliser levy was rather weak. The levy had a second positive effects for a specific group of farmers because the money collected was used for expanding export-subsidies of agricultural products (the distributional consequences were that grain producers among farmers actually profited). This transfer from all farmers using fertilisers to grain farmers would not have been possible after the Austrian accession to the EU which seems to be the real argument for abolishing the levy.[4] A third reason for a weak opposition of farmers may be that farmers could present themselves in environmental debates as a good example of producers who accepted green-taxes in order to reduce the environmental impact of farming. However, no analysis was made with respect to the environmental effects of this levy which could verify or falsify this argument.



Source: PRÄKO (1995, 1975,1972) and Schneider (1990)

Fig. 2: Mineral Nitrogen Use per ha Agricultural Land (excluding range land and alpine grassland) and Real Prices Including Levy in ATS/kg N (the levy was introduced in 1986)

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3 The levy amounted to 6.50 ATS per kg N (about 0.5 ECU), 3.50 ATS per kg P_2O_5, and 1.90 ATS per kg K_2O; a total of 1.178 billions ATS were collected in the plant period 1993/1994; in 1986 the levy was 3.5 ATS/kg N, in 1987 it was 5.0 ATS/kg N (PRÄKO, 1995, 61, Schneider, 1990, 166pp).

4 Hofreither & Salhofer & Sinabell (1995) analyse political economy aspects of grain production in Austria.

Research

Policy Oriented Research

It was only recently that the connection between agricultural policies and the intensity of farm production became apparent and therefore only few projects deal with the evaluation of policy measures in the context of mineral emission of agriculture. These research projects which focus on nitrate pollution (see list below) make use of the data collected under the *Ground Water Monitoring Program* which was mainly established for the designation of nitrate vulnerable zones. Data collected under this program and data of the *Soil Monitoring Program* will also be used to control the success of measures which will be taken under the Austrian *National Environmental Plan* (Österreichische Bundesregierung, 1995). The *Austrian Program of Environmental Friendly Agricultural Production* (*ÖPUL*) is expected to have a major influence on agricultural emission levels, however a research program for evaluating measures under this program has not been established so far. Some minor contributions to the issue of emission of agriculture are to be expected from the *Research Initiative Cultural Landscapes* which was launched in 1995. The *Federal Ministry of Agriculture and Forestry* plays a co-ordinating role in all of these programmes.

General research on agri-environmental policy was carried out by Wytrzens & Reichsthaler (1990) and Hofreither & Sinabell (1994). The authors pleaded for better integrating environmental concerns into agricultural policy after extensively enumerating the environmental problems due to agricultural production. One of their major concerns is that command and control measures tend to be inefficient and a potentially beneficial reduction of product prices (which actually happened in 1995) should be accompanied by the adoption of environmental policy instruments which create economic incentives for reducing pollution.

The effects of the levies on fertilisers on farm production and the tax system were investigated by Pfingstner (1986 and 1987), Schneeberger (1990), and Schneider (1990). Schneider concludes that the administration of the tax was very simple and cheap and yielded the expected amount whereas some producers of crops which did not receive protection definitely had to face losses because their competitiveness was negatively effected. Further research is required to analyse the environmental benefits of this levy.

In an econometric analysis data from the groundwater-monitoring-program were used to estimate the inter linkage between agricultural policy variables and the environmental outcome measured as nitrate content in groundwater on a community basis (Hofreither & Rauchenberger, 1995). Although the statistical properties of the estimated functions do not allow for simulating the effects of agricultural policies on a regional basis, the data significantly show that part of the variance of nitrate content in groundwater can be explained by observing agricultural policies. Better results are to be expected when data of several years will be used in a pooled data analysis. The results of this study constitute the empirical basis of an analysis which deals with the implementation of *economic instruments* versus the *command and control approach* which proofed its non-effectiveness (Hofreither & Sinabell, forthcoming).

Institutions Carrying Out Related Research

Federal Research Institutes

Bundesamt und Forschungszentrum für Land- und Forstwirtschaft; Spargelfeldg. 191;1220 Wien

Bundesamt für Agrarbiologie, Wieningerstraße 8, A-4020 Linz

Bundesanstalt für Agrarwirtschaft; Schweizertalstraße 36;1130 Wien

Umweltbundesamt; Spittelauer Lände 5, A-1090 Wien

University Departments

Institut für Bodenforschung und Baugeologie; Universität für Bodenkultur, Gregor-Mendel-Str. 33,A-1180 Wien

Institut für Land-, Umwelt und Energietechnik; Universität für Bodenkultur, Peter Jordanstr. 72, A-1180 Wien

Institut für Wirtschaft, Politik und Recht; Universität für Bodenkultur, Gregor-Mendel-Str. 33, A-1180 Wien

Institut für Wassergüte und Abfallwirtschaft, Technische Universität Wien, Karlsplatz 12, A-1040 Wien

Other Institutions

Koordinierungsstelle des Forschungskonzepts Kulturlandschaftsforschung; Gregor Mendel-Str. 12-14/II/3, A-1180 Wien

ÖVAF - Österreichische Vereinigung für Agrarwissenschaftliche Forschung; Kleine Sperlg. 3, A-1020 Wien

Joanneum Research; Steyrergasse 17, 8010 Graz

Wenzel, Pollak, Alge Technisches Büro; Laudong. 34a/2/8, A-1080 Wien

Research Documentation on the Internet

Literature in Austria: *http://bibgate.univie.ac.at/*

University of Resource Sciences; *http://www.boku.ac.at:2080/Cfodoke*

Technical University Vienna: *http://info.tuwien.ac.at:4324/histu/fodoksuchen.html*

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