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On the Question of Soil Water Balance in the Leibnitz Area (Styria)

SUMMARY: *The Leibnitzer Feld, an area south of Graz that is used intensively for agricultural purposes, is described in its morphological and pedological features, with special emphasis on soil-water balance in respect of groundwater recharge.*

Based on the problem of nitrate it is being shown that, in spite of intensive agricultural use, a solution of the problem and thus rehabilitation is possible by legal provision in cooperation with the farmers concerned.

KEY WORDS: *Leibnitz area, soil moisture regime, strategy against water pollution by nitrate, nitrat content in well waters.*

O pitanju vodnog balansa u području Leibnitza (Štajerska)

SAŽETAK: *Opisane su morfološke i pedološke osobitosti Lajbniškog polja, područja južno od Graza koje se intenzivno koristi za poljoprivredu, s posebnim naglaskom na ravnotežu tlo-voda vezano uz prihranjivanje podzemnih voda.*

Na osnovi problema dušika pokazano je da se usprkos intenzivnom poljoprivrednom korištenju može naći rješenje problema i time postići oporavak tla, uz uvjet da postoje odgovarajuće pravne osnove i u suradnji s poljoprivrednicima.

KLJUČNE RIJEČI: *područje Leibnitza, režim vlažnosti tla, strategija za sprečavanje zagađenja tla dušikom, sadržina dušika na vodocrpilištima*

1. Introduction and problem

In our industrialized societies many of us are nor longer able to understand the role and impact of the activities carried out by farmers. As in the past, farmers still produce biomass on areas cultivated by man, but, via soil, also groundwater. Substances which, knowingly or unknowingly, find their way into precipitation water or soil may be stored, used up by vegetation, accumulate on the surface, or seep into groundwater. This paper describes the path taken by water, from rain via soil (in a biogenic sense) and the unsaturated zone on soil (= seepage water zone: area between land surface and the capillary fringe of the groundwater) to the groundwater. However, the main focus is on processes in the unsaturated zone, which are discussed based on practical work carried out in a selected part of the Leibnitz Area.

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2. Location and geological situation of the area studied (cp. Map 1)

The area in question ("Leibnitzer Feld") has a size of about 105 km2, and extends about 35 km south of the capital city of Graz on both sides of the river Mur from the narrow of the valley near the town of Wildon to the sharp bend of the river at Gabersdorf-Retznei. The area is bordered by rocks that lithologically are greatly varied in their composition, and it owes its today's morphological features to pre-glacial interactions during the last cold-warm period. Above tertiary material, the older terrace (Riss), the low terrace (Würm), and the alluvial plain were molded, with the low terrace giving the area its distinctive shape. (cp. map 2).

While the alluvial plain consists mainly of a basal gravel layer of 3 to 7 m in thickness and sandy and sandy-silty top layers of 0.3 to 2 m thickness, the low terrace lies 1 to 2 m above the alluvial plain, and its gravel layer is covered by a 0.2 to 1 m top layer. On the older terrace the gravel layer is covered mostly by thick layers of loam (M. Eisenhut, 1991).

Although, at first glance, the area appears rather uniform, this geological situation already suggests a most heterogeneous soil cover.

3. Climatic conditions

Due to usually plentiful precipitations of 900 to 1000 mm, with a pronounced maximum in summer (H. Wakonigg, 1978), and a very long vegetation period of 230 to 240 days, this area is most favorable for agricultural production - unfortunately, also with negative consequences.

In soils of medium to high water retention capacity seepage mostly occurs in late autumn, in winter, and in early spring; the quantities taken up range from 50 to 150 mm. At shallow sites with low retention capacity, on the other hand, seepage is possible throughout the year; it is estimated to amount to approx. 250 mm.

Thus, groundwater recharge does not only depend on the total of precipitations over the year including their quantity and distribution, but also on the thickness and the physical properties of soils, especially in the unsaturated zone, as well as on the kind and intensity of agricultural use.

But before these aspects are discussed, the pedological situation of this area shall be described briefly.

4. Soils and their properties

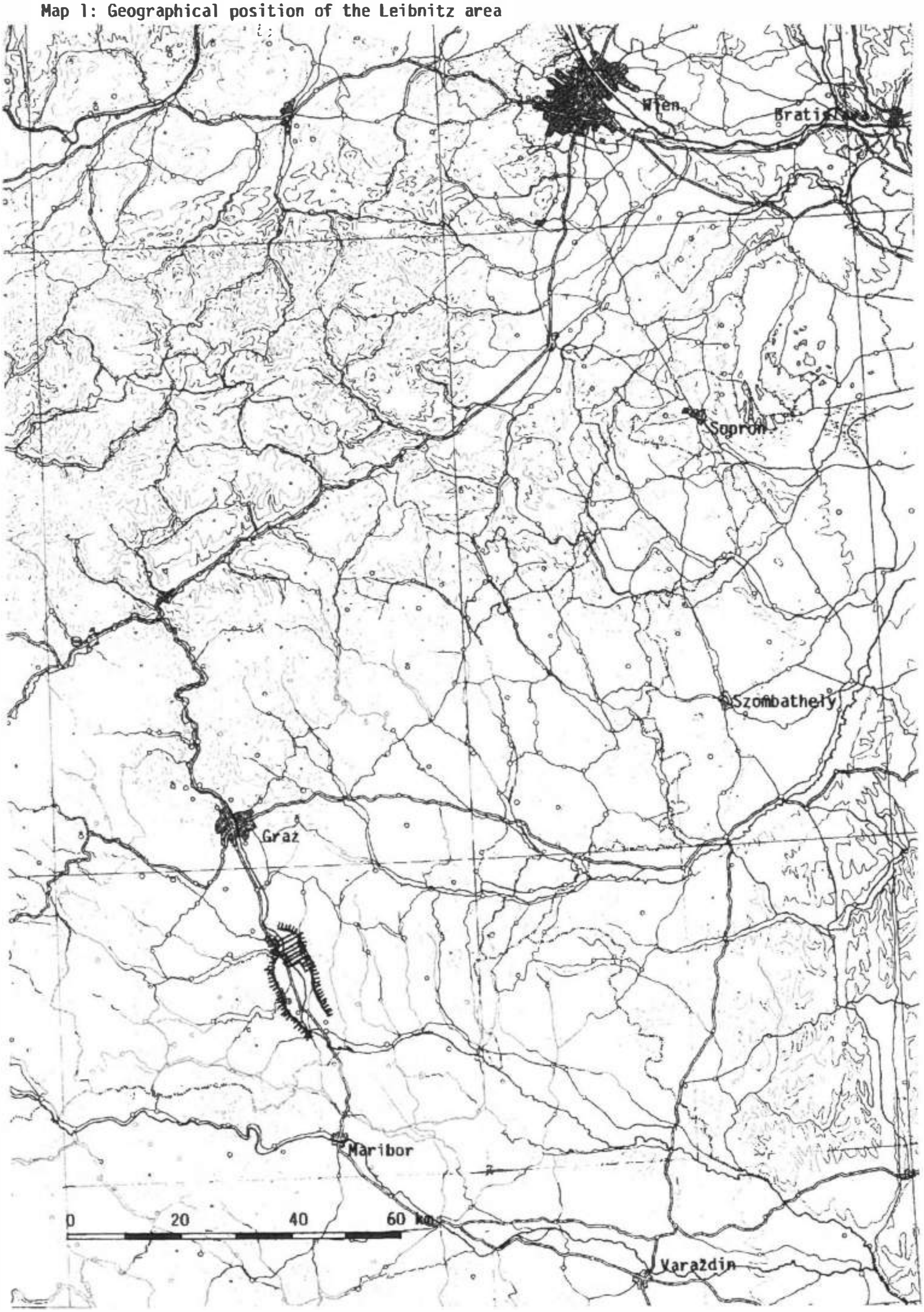
As briefly mentioned in the chapter on geology, the area investigated presents three morphological entities: the alluvial plain, the low terrace and the older terrace.

The alluvial plain is characterized by a water table of 3 to 4 m below ground level and significant seasonal groundwater fluctuations. The soil cover is composed of fluvisols of different maturity[1] and thus also of different filter strength (cp. map 3).

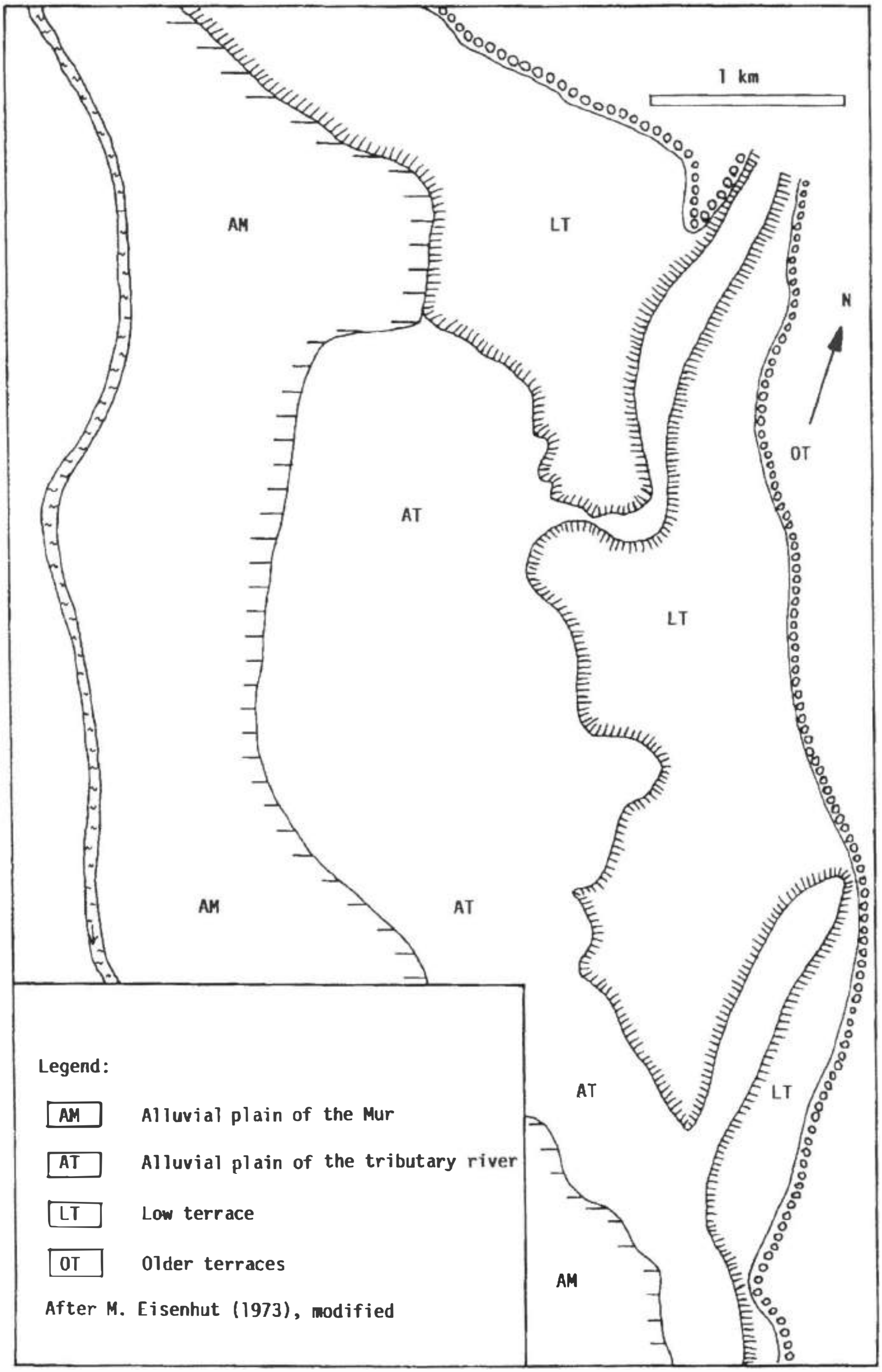
On the low terrace, the top layers of 20 to 80 cm on average have developed primarily acidic cambisols that provide favorable conditions for intensive agricultural use. It is, however, worth mentioning that these top layers, whose mean coefficient of per-

1 The typological classification of the soil was made acc.to P.M. Driessen and R. Dudal, 1991

Map 1: Geographical position of the Leibnitz area



Map 2: Morphological situation in the NE part of the Leibnitz area



meability is 5.10^{-3}, may be problematic as regards the quick discharge of nitrate and pollutants into groundwater. Studies have proved seepage speeds of about 0.5 m/a in these top layers (J. Fank et al., 1989); naturally, in the gravel layer these speeds must be expected to be significantly higher.

On the older terrace, planosols have developed from the above-mentioned thick and hardly permeable dust loam cover, in which silt is the predominant type on soil. Due to their water-logging propensity, planosols are regarded as difficult soils in terms of agriculture. Little groundwater recharge takes place below such sites.

5. Emitters responsible for the discharge of nitrate into soil and groundwater

By way of introduction to this chapter it should be mentioned that there are a number of emitters, and that agriculture is not the only polluter.

It has already been mentioned that large parts of the Leibnitz Area consisv of light and highly permeable soils, whose retention and filter capacity is often overstrained. In the past 30 years, economic necessities have resulted in increasingly intensive agricultural use, which is characterized by the intensified production of corn (in some communities up to 80% of the farmland), increased spreading of liquid manure on areas without hardy vegetation cover and by intensified pig production (hence the large quantities of liquid manure).

But this intensive agricultural production is not the only emitter of nitrate. It must not be forgotten that this area is densely populated (185 inhabitants per km2, the Austrian average is 84) and that leaking cesspits of individual houses and domestic and industrial sewage can also contribute to the nitrate in groundwater.

Another nitrate source are gravel pits which, were recultivated after excavating and then used for agricultural purposes or as landfill for refuse, earth and building debris. Here, too, nitrate may easily seep into groundwater due to the very thin and light filter layer.

Untreated waste waster from traffic areas may further contribute to groundwater contamination.

Last but not least natural mineralization in the soil must be mentioned in this context. Acc.to E. Klaghofer (1991), about 150 kg N are produced per ha in the form of nitrate from nitrogen that is organically bound in humus-containing soils by mineralization; this value does not include mineralization of crop residues.

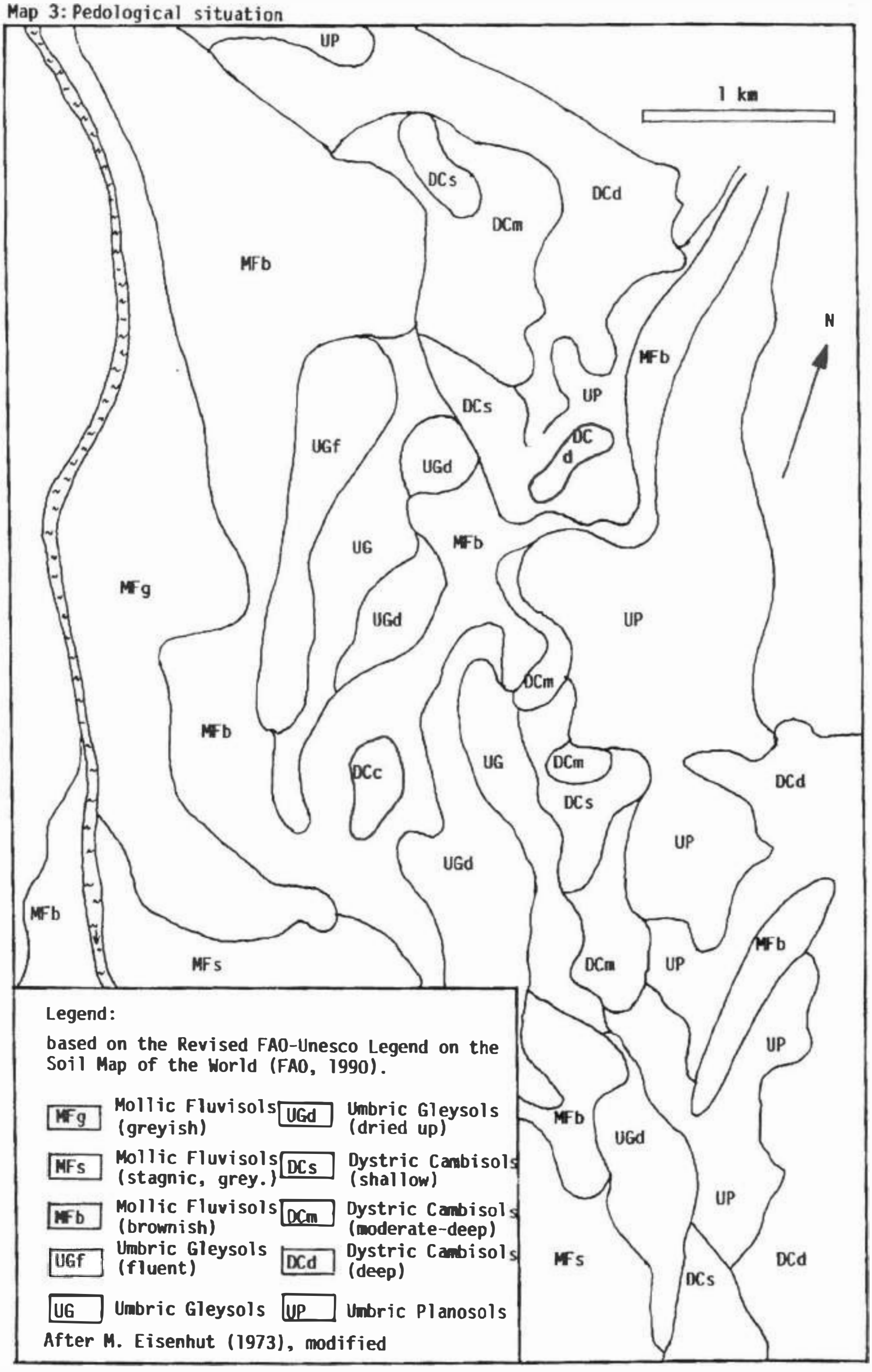
Fig.1 shows the relationship between seepage water quantity and nitrate eluviation based specifically on estimates of seepage water quantity in this particular region.

6. Strategy for rehabilitation

Based on the limits recommended by law of a maximum of 100 mg nitrate per liter as of 1 July 1990, and 50 mg nitrate per liter as of 1 July 1994, - by 1999 this value is to be reduced to 30 mg - a number of measure have been taken to achieve this goal. Whether it will be possible to achieve a reduction to 30 mg appears questionable from a scientific point of view.

What measures have already been taken and resulted in a reduction of nitrate in groundwater (cp. Fig.2)?

Map 3: Pedological situation



Logically and correctly all potential nitrate emitters were examined closely in order to take the proper measures. As of 7 December 1987, all inner and outer well protective areas have been specifically declared, contaminated sites examined and the quarrying of gravel and sand monitored (H. Zetinigg, 1991). It should also be mentioned that 81% of all households have been connected to the sewer system.

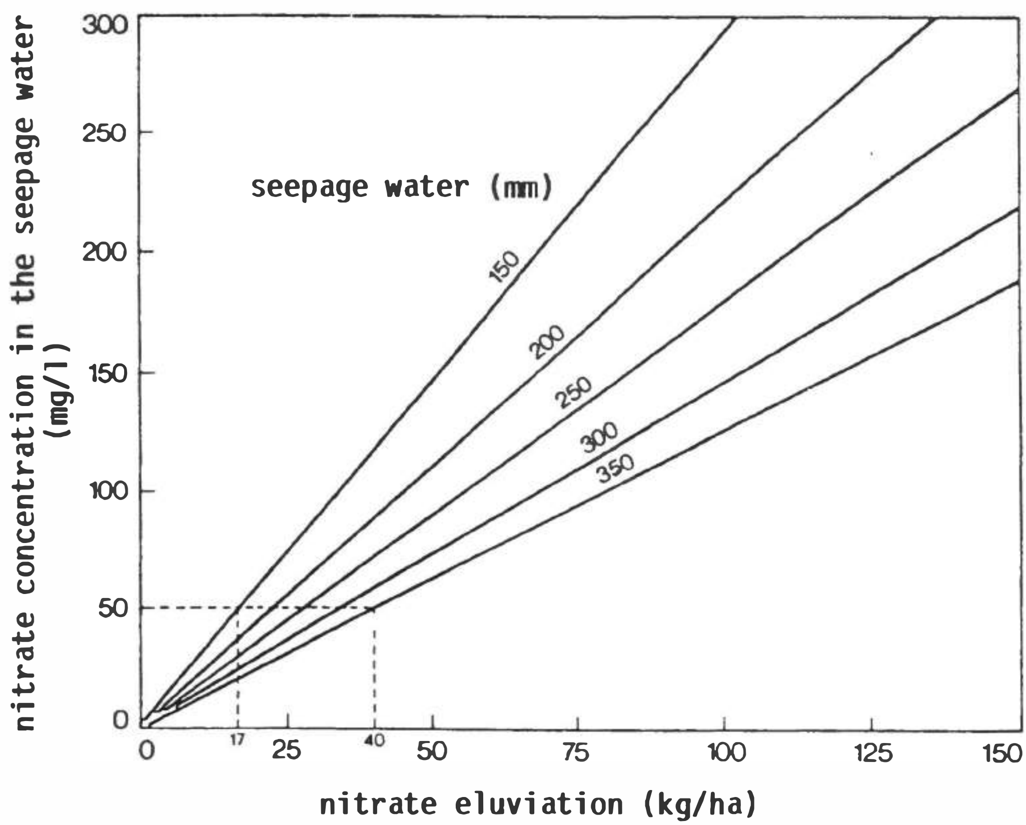
However, the main focus has been on agricultural activities: this is why the strategies in this area are more strongly emphasized.

According to D. Patter (1991), the groundwater situation can be relieved by extensifying farming practices, by introducing crop rotation systems, by reducing the use of fertilizers and herbicides to the actual demand and by adjusting the stocks of animals to the given area used for agricultural purposes.

According to the Water Act, a special approval is required if more than 175 kg of pure nitrogen per culture and with vegetation cover more than 210 kg of pure nitrogen are spread per hectare and year. An approval is equally required for keeping animals producing manure equivalent to more than 3.5 large animal units per hectare.

According to the regulations for outer protective zones as of 1 January 1991, the following measures and activities are prohibited:

- The spreading of slurry and liquid manure on areas without hardy vegetation cover from 15 October until tillage next spring.
- The spreading of herbicides containing the agents atracine, alachlor, cyanacine, dicamba, clopryalid, bromacil, amitrol and propacine.
- The spreading of nitrogen fertilizers on corn fields in fewer than two dosages.



Map 4: Nitrate retention capacity

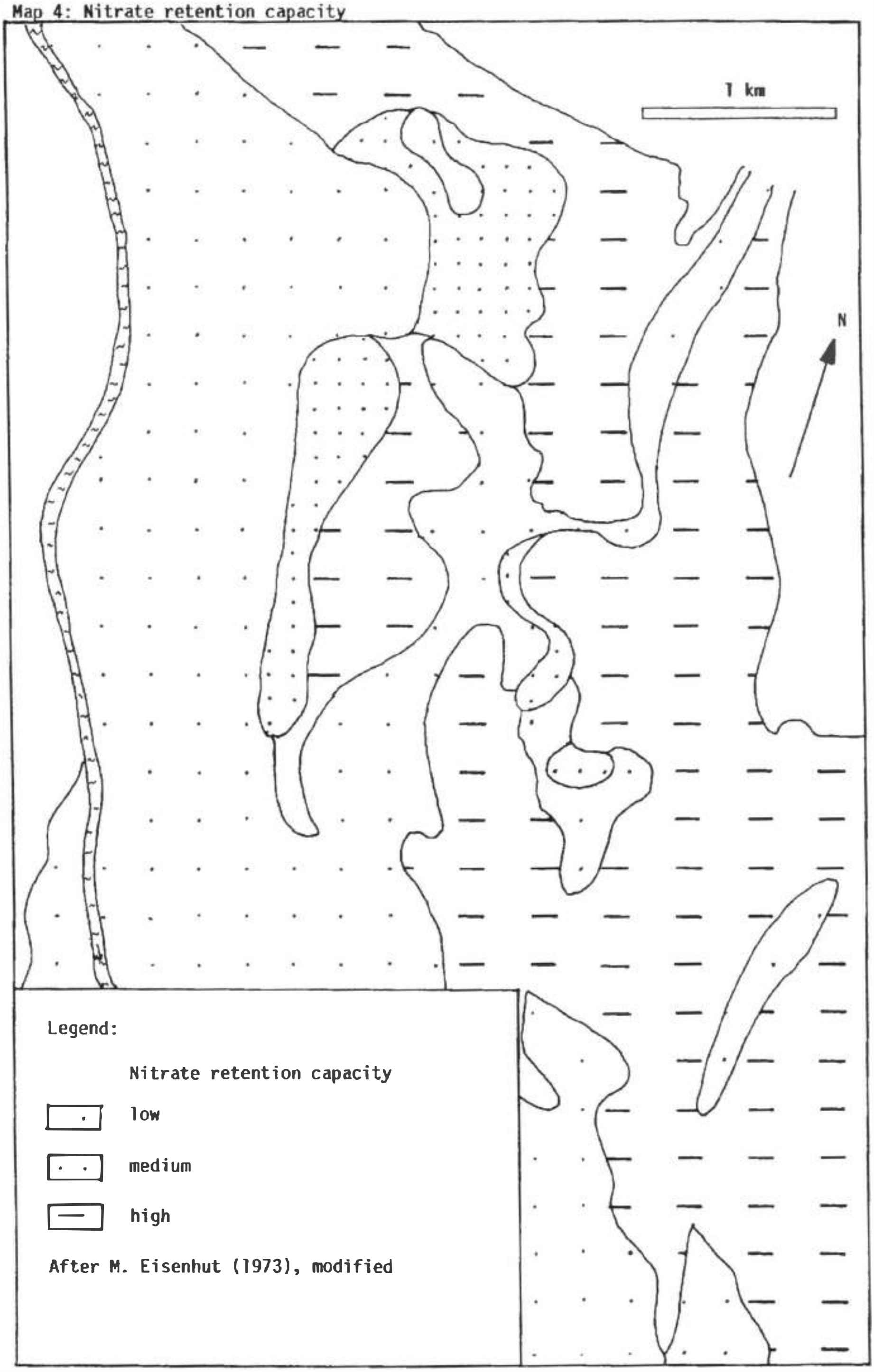
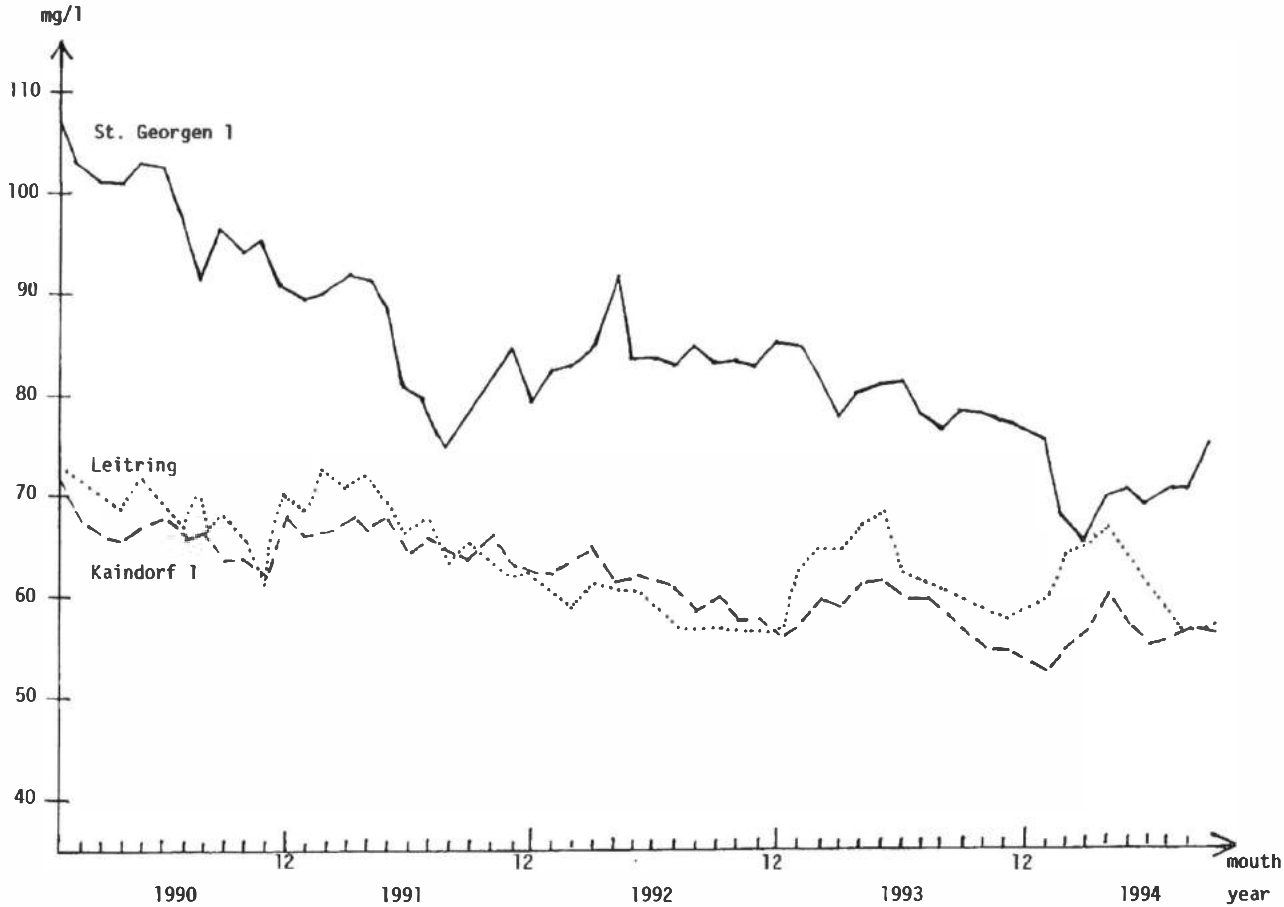


Diagram 2: Nitrate content in well-waters in Leibnitz area (Styria)



After D. Patter, 1995

- The spreading of sewage sludge and refuse compost except compost from bio-composters.
- The keeping of economically useful animals without sufficient farm manure storage capacity.
- The keeping of economically useful animals producing manure equivalent to more than 2.7 large animal units per hectare of land available for agriculture without keeping a liquid manure logbook.

Additional measures are more frequent N_{min} studies, bonuses of AS 4,000 per year and hectare of green fallow and energy grass areas as well as subsidies for hardy vegetation (at least for the period between 1 November and 15 March). In the winter months 1989/90, the latter together with green fallow and energy grass areas already accounted for 89.5% of arable land. (D. Patter, 1991).

To complete this chapter and the whole question of soil-water balance including the possibility of better evaluating the filter effect of a site, a study carried out by M. Eisenhut (9993) shall be briefly referred to.

The potential of nitrate eluviation via soil into groundwater is determined by a combination and weighting of soil structure, coarse fraction, organic matter, structure and stratification. In addition, the water retention capacity of the soil, water conductivity, the thickness of the top layers (distance between groundwater and land surface) and the climatic water balance are used in order to assess and describe, based on existing soil maps, the potential risk of a site. One such description attempted by the author is shown in Map 4, with the mosaic-like structure of the soil cover being clearly visible.

Whether and to what extent the above-cited measures have been effective can be easily seen from Fig.2. Water measurements performed at three wells clearly show a slightly falling tendency. This success should be an encouragement to intensify the measures already taken.

7. Conclusions

The above-mentioned figure in particular proves that basically the policy adopted by us has been correct, and that by fruitful cooperation between practice and science sound groundwater can be produced also in areas of intensive agricultural use. However, farmers should be cautioned to strictly avoid over-fertilization, i.e. not more than is necessary to achieve an adequate yield, to take into account nitrogen mineralization, and they should be requested to provide for a continuous hardy vegetation cover, while scientists are expected to advise them, based on soil assessments and soil maps, in questions of fertilization and crop rotation.

In addition, greater awareness should to be created in the public at large about the value of sound water, something that is not available without sacrifice.

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