# Environmental Impacts of Grazing Grassland



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| 著者 | HOJITO Masayuki |
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# Environmental Impacts of Grazing Grassland

**Masayuki HOJITO**

**National Institute of Livestock and Grassland Science, Nasushiobara, Tochigi, Japan**

This study is intends to assess the use of grasslands for grazing and nitrogen pollution in order to determine the environmental impact of the utilization of grasslands for grazing.

## *1. Characteristics of grazing grassland and water nitrogen pollution*

There are specific characteristics of grasslands used for grazing such as heterogeneously-distributed nutrient input and tread pressure, which are the direct results of cattle grazing on the grassland. Since the pollution of water with nitrogen occurs when the amount of excess nitrogen in an area exceeds a certain level, the presence and intensity of the pollutant depends on the amount of nitrogen being applied in the area. This is true for grasslands being used for grazing or cutting. In the case of grazing grasslands, since the amount of nitrogen application depends on the amount of chemical fertilizers being used and cattle density or intensity, cattle density control is obviously an essential factor in nitrogen pollution prevention.

Grassland utilization methods of grazing and cutting were compared in terms of grass yield and the soil's chemical composition (Figs 1 and 2). The results of the grassland utilization experiment that compared grazing grassland and cutting grassland under the same application rate of chemical fertilizers were as follows: 1) Grass yield was higher in grazing grasslands than in cutting grasslands, 2) Soil nutrient accumulation was also higher in grazing grasslands than in cutting grasslands. These results are due to the extra nutrients the soil receives with the additional application of the grazing cattle's manure. The results establish that grass productivity increases under conditions of grazing as a result of the additional nutrient enriched manure being applied to the grasslands. Similar data are being published in "Nature" (Ryden et al. 1984). Under the same conditions of nitrogen application (420 kgNha$^{-1}$), perennial ryegrass grassland was used as cutting grassland or grazing grassland. Obviously higher concentrations of nitrate nitrogen in the soil solutions were observed in the grazing grassland (Fig. 3). Owens et al. (2004) and Cuttle et al. (1998) also reported the relations between grazing and water pollution.

However, this does not necessarily mean that there is a higher risk of nitrogen pollution in grazing grasslands compared to cutting grassland. There is no difference between them in terms of risk if the nutrient enriched manure applied by grazing cattle is taken into consideration when determining the amount of chemical fertilizer that is to be applied. Recent unpublished IGER data shows interesting results; the nitrate concentration of the leachate was higher in plots that had been grazed except for those using tactical treatment. This result indicates not only the occurrence of water nitrogen pollution in grazed plots but also the potential for avoiding nitrogen pollution through the proper management of the soil nitrogen level.

The amount of nitrogen runoff or leaching in grazing grasslands and cutting grasslands was compared in Konsen AES (Table 1) (Kouda 1999). Calculations were based on farm records and other relevant documentation. The comparative study displayed that the potential for water pollution through leaching and surface runoff is higher in grazing grasslands than cutting grasslands. The nitrogen concentration in shallow ground water in different methods of land use was as follows: forests< cutting grasslands< grazing grasslands< crop fields (Table 2) (Hayakawa et al. 1997). From these results, it is undeniable that the risk of water nitrogen pollution by grazing utilization of grassland increase.

Primal cause of this is of course on manure of the grazing cattle, but it is not deniable that the intake-rate (water permeability) of the surface layer can be increased due to the influence of heterogeneous tread pressure and water pollution caused by unevenly distributed nutrients. However, it was also shown that the risk of water nitrogen pollution can be avoided by adjusting the amount of nitrogen application through

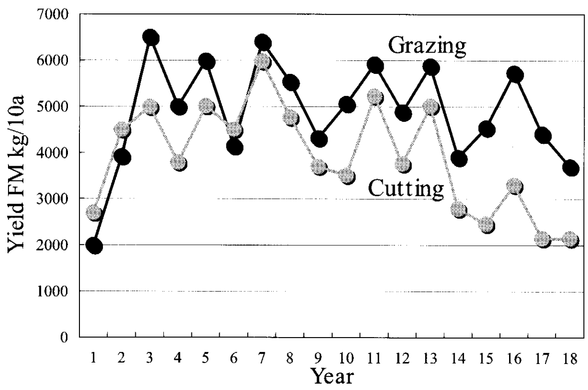


**Fig. 1.** Yield comparison between cutting and grazing grassland.Orchardgrass (*Dactylis*) + Perennial ryegrass (*Lolium*), 100kgNha$^{-1}$yr$^{-1}$, 5-6 cuts or graze yr$^{-1}$

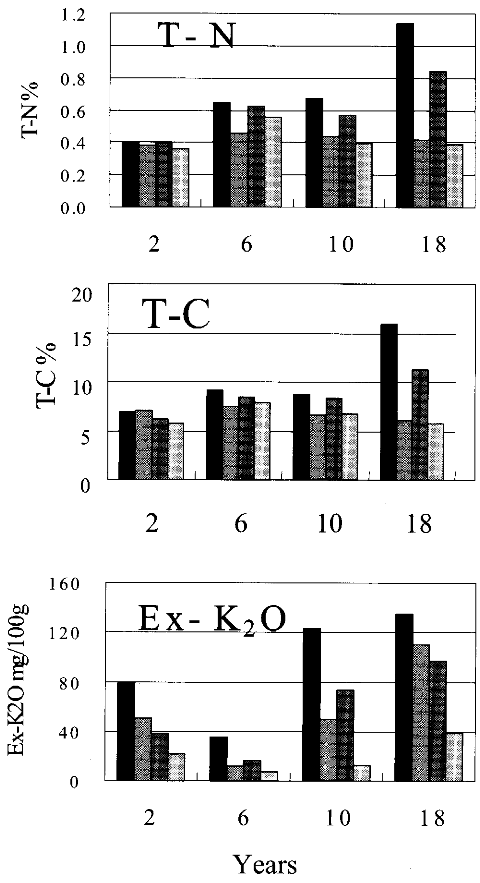


**Fig. 2.** Differences in soil nutrition accumulation by grazing or cutting

chemical fertilizer control.

## *2. Environmentally advantageous aspects of grazed grasslands*

However, it can be stated that the use of grazing contributes to environmental conservation in that it decreases the amount of manure that needs to be treated. The amount of manure produced in the barn decreases in accordance with increases in the amount of time spent grazing (Bando 1996) (Fig. 4). This is definitely advantageous for environmental conservation because it can reduce the time and labor dedicated to manure treatment. However, the amount of manure that needs to be treated is not reduced to zero and manure is naturally spread over the grassland.

In other words, allowing livestock to graze on grasslands reduces the amount of manure being generated in barns, therefore reducing the time and energy that word otherwise be spent treating manure, which, in turn, enables farmers to dedicate more time and attention to environmental concerns and, consequently, works to further environmental conservation. In this way, from an environmentalist standpoint, the use of grasslands as grazing lands is advantageous.

**Table 1** Nitrogen loading on the water in Konsen AES (Estimation)

| Water category | Land utilization | Loading kgN/yr | Area ha | Loading/ha kgN/ha/yr |
|---|---|---|---|---|
| Surface runnoff | Cutting grassland | 218 | 68 | 3 |
| | Grazing pasture | 252 | 60 | 8 |
| | Both | 101 | 17 | 6 |
| | Total | 571 | 125 | 5 |
| Percolating | Cutting grassland | 461 | 68 | 7 |
| | Grazing pasture | 403 | 30 | 14 |
| | Both | 174 | 17 | 10 |
| | Facilities | 1160 | 9 | 129 |
| | Total | 2199 | 125 | 18 |
| Sum | Cutting grassland | 679 | 68 | 10 |
| | Grazing pasture | 655 | 30 | 22 |
| | Both | 275 | 17 | 16 |
| | Facilities | 1160 | 9 | 129 |
| | | 2769 | 125 | 22 |

Kouda et al.,

**Table 2** Nitrate concentration of shallow ground water

| Land utilization | NO3-N mg/L |
|---|---|
| Forest | 0.000 |
| Cutting grassland 1 | 1.453 |
| Cutting grassland 2 | 1.571 |
| Grazing pasture | 4.142 |
| Arable crop 1 | 3.890 |
| Arable crop 2 | 21.433 |

Hayakawa 1997, average of 17 sampling

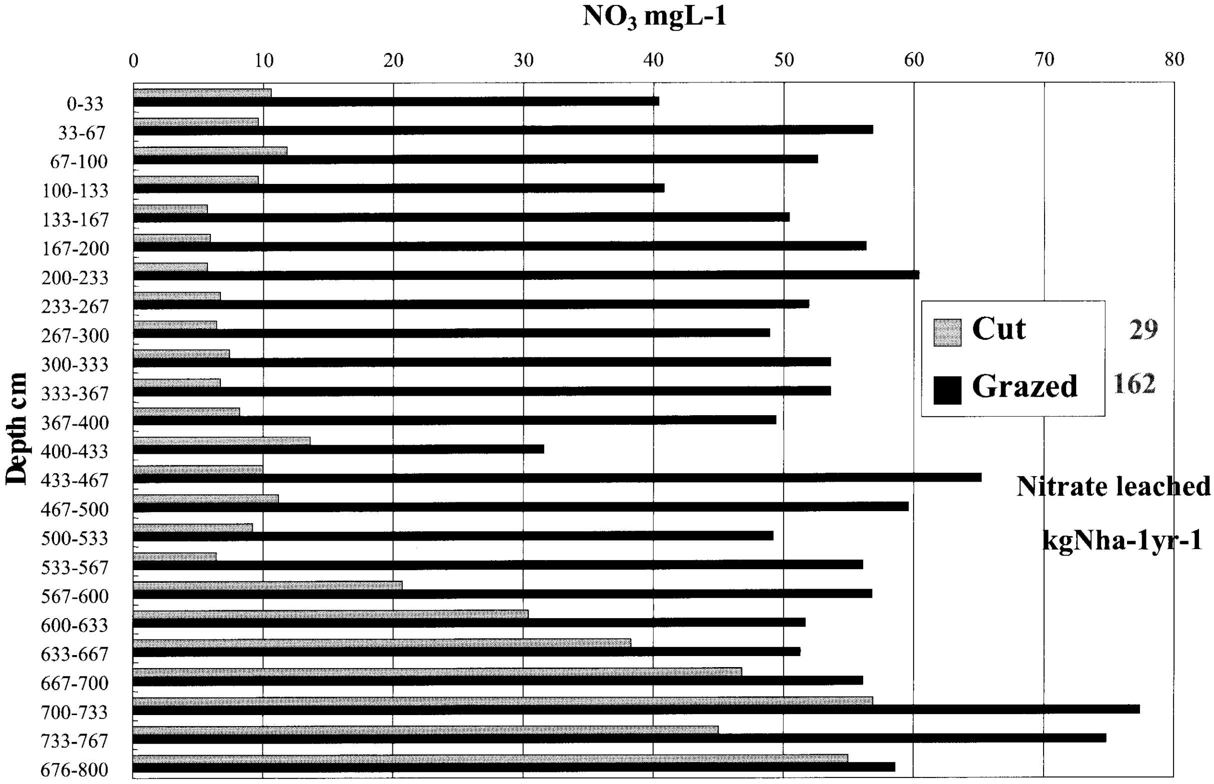


**Fig. 3.** Nitrate concentration of soil solutions from successive depth below cut and grazed ryegrass sward, after 5 years treatment (420kgNha$^{-1}$ + 9.3headha$^{-1}$)
J.C Ryden *et al.*, Nature 331 (1984)

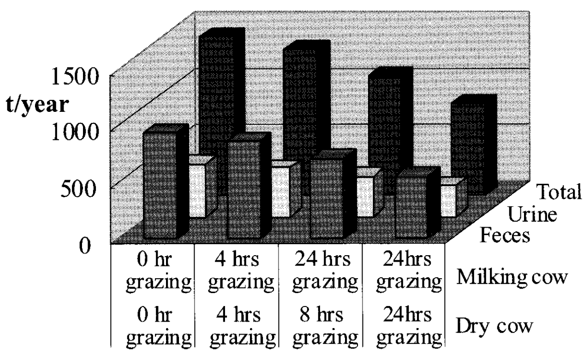


**Fig. 4.** Effects of grazing hour on manure production in barn (estimation) Bando 1996

### *3. Difficulties in analyzing the environmental impacts of grazing grassland in sloped areas*

Since Japan is limited in terms of arable land, grazing grasslands have primarily been limited to hilly or sloped areas. Therefore, it is necessary to differentiate the impact of maintaining grasslands through gazing from factors resulting form an area' s sloped conditions. Heterogeneously-distributed soil nutrients exist in sloped areas for a variety reasons. According to the data for sloped areas and valleys, nutrient accumulation often occurred at the bottom of the valley (Sakai and Hojito 2001). However, there were few cases that were contrary to this. Comparing soil nutrients at the time of seeding time and one month later showed that the movement of nutrients in the soil is caused by precipitation that occurs just after the seeding. This means that grasslands maintained through grazing in sloped areas have risk of nutrients escaping due to surface runoff during periods of precipitation shortly after seeding.

Creating a buffer zone is an effective way to address this problem. Establishing 5 m-wide at lower part of a sloping grassland resulted in decreases in nutrient loss (Sakai and Hojito 2001). On the other hand, the nutrient distribution pattern in the sloping grazed grassland highly corresponded to the location of the grazing cattle's feces (Yamada 2000). Since the nutrient accumulation is more pronounced at areas in which the cattle gather, risks of nutrient leaching increase there. Although soil diagnosis and fertilizer management is said to counteract these risks, actually conducting them is somewhat difficult.

In this way, factor analysis of heterogeneously-distributed soil nutrients in grazed grasslands is

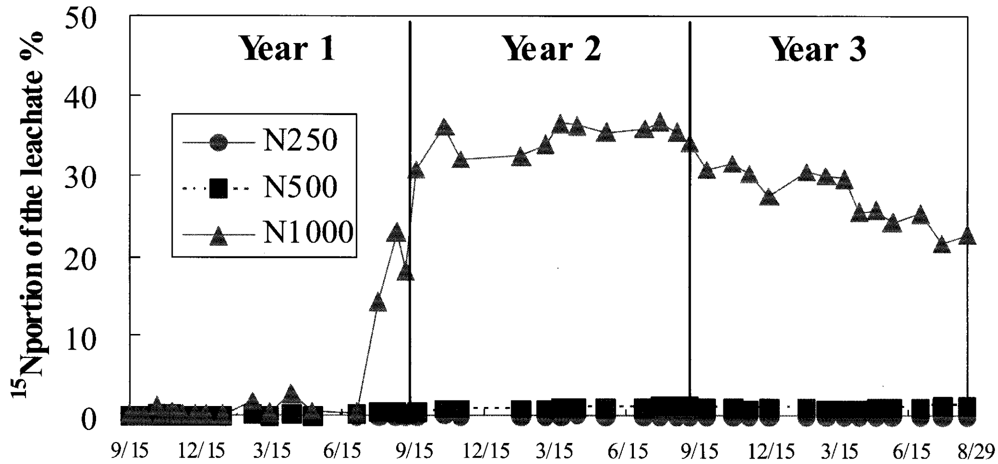


**Fig. 5.** 15N proportion in the leachate after N application-Lysimeter experiment- (Matsunami and Hojito 2005)

complicated since factors associated with cattle behavior overlap with those connected to sloping.

### *4. Difficulties in verifying water pollution*

Even though the risks of water pollution from grazing grasslands exist, providing sufficient data to verify them is not easy. For instance, a case of the investigation of shallow ground water quality when grazing is introduced to fallow paddy field is discussed. Most sites failed to show increases in nitrogen concentration during grazing, but displayed decreases as a result of the water management techniques being applied to the surrounding paddy fields. However, despite being at very low levels, the tendency of ammonium nitrogen to increase during grazing was recognizable. This phenomenon is representative of the actual conditions of grazed grasslands. One major reason for the difficulties in tracing nitrogen pollution in grazed grasslands is that a considerable amount of time lapses between the excretion of feces and the dissolving of leachate. For example, with conditions of 240 cm deep lysimeter, it took almost one year to get nitrogen from the fertilizer applied even in 1000 kgha$^{-1}$ level to the leaching water (Fig. 5) (Matsunami et al. 2005). In addition, results have yet to be obtained in 250 and 500 kgNha$^{-1}$ levels in three years of experiments. This results show that it is necessary to consider the time lag associated with how grazing effects leachate in order to accurately analyze its influences. Therefore, demonstrative data regarding practical grazing grassland and the resulting levels of water pollution are limited in certain cases. The reason for this limitation is that it is difficult to take water samples and identify and separate influences that directly result from grazing and those of other possible variables. It is only possible to identify direct result and influences of grazing in areas where shallow ground water can be taken or where very effective impermeable soil layers exist making it possible to collect whole leachate through the fields. In the absence of such conditions, it is difficult to collect and analyze data in terms of the direct effects of grazing on leachate on a practical scale.

A capillary lysimeter can be installed in soil layer as a means to achieve this (Fig. 6). This is a 40cm diameter and 100 cm long polyvinyl chloride tube, used to collect water permeating 40-100cm into the soil layer. This device sets the capillary to have a very weak negative pressure for water suction. This technique is useful and inexpensive however, setting it up is labor intensive and needs to be replicated a number of times because of the variations in the collected water quantity. The 'grazing lysimeter'

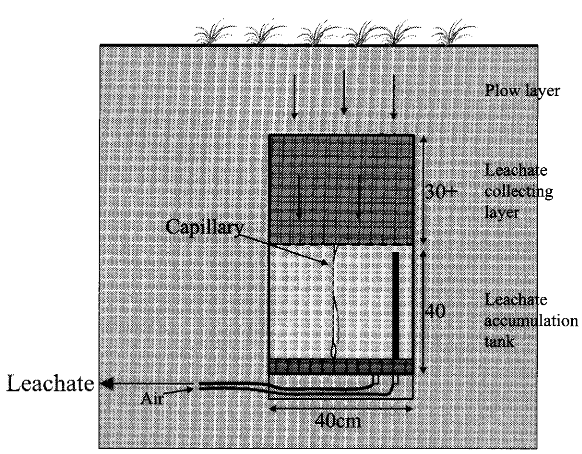


**Fig. 6.** Capillary lysimeter

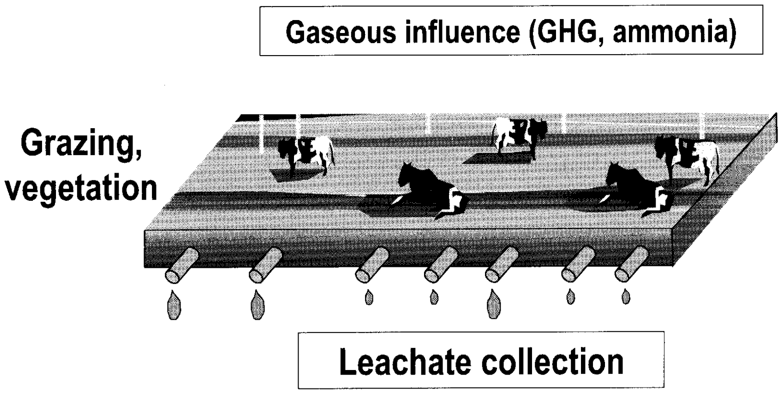


**Fig. 7.** Grazing lysimeter

should be regarded as a useful piece of equipment (Fig. 7). It can be used to develop a practical scale model of a grazed grassland with a pool made of concrete that traps leaching water which can then be collected from bottom of the pool. This method is of course costly, but it is nevertheless useful for collecting leaching water. There is a good grazing lysimeter in IGER NorthWyke, Rowden Moor, UK, where the top soil is very argillaceous and impermeable to water (Scholefield et al.). Consequently most of the drainage water can be collected by artificially draining it with a mole drain. The drainage water volume was measured using weir chambers and 14 plots, each 1ha in area. (Unfortunately, no data the effects of maintaining grasslands through grazing has been taken as of yet.)

### *5. Other environmental impacts of maintaining grassland through grazing*

In terms of global greenhouse gasses ($GHG_s$), grazing grasslands have negative relationships to nitrous oxide ($N_2O$) and methane ($CH_4$) (Flessa et al. 1996, 2002). Grasslands are primarily considered to be methane absorption sites. However, due to the accumulation of cattle manure, grazed grasslands are generally regarded as a source of methane release. On the other hand, ammonia ($NH_3$) emissions are also regarded as a concern causing characteristic of manure. However, recent data concerning air ammonia concentration attained through the passive sampler method showed no difference of emissions between cut and grazed grassland. The effects of chemical fertilizer application were alternatively observed noticeable. In addition to this, the potential for pathogenic microbe pollution was reported in the study.

Consequently, grazing is a reasonable and rational method of cattle production. In order to perform grazing in the absence of risks of environmental pollution, it is important to develop a proper understanding of the characteristics of grazing grasslands and the measures required to counter its negative effects. Features of grazing grasslands include heterogeneously-distributed soil nutrient, problem associated with sloped areas, tread pressures and unstable vegetation, which was unaddressed here. Each characteristic has its own corresponding environmental pollution problem. Hence, in solving these issues, from a scientific perspective, separating the impact of factors directly related to cattle from variables and effect associated sloping is important. In addition to the effectiveness of orthodox grassland management, controlling cattle density and grazing intensity is important in terms of nitrogen loading control.

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