ENVIRONMENTAL IMPACT OF ANIMAL PRODUCTION SYSTEMS BASED ON GRAZING

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Introduction: Grazing represents the most relevant alternative of animal production in certain parts of the globe, where climate and soil conditions contribute to an adequate pasture production. Even though these systems are more animal-friendly and have a lower cost in relation to animal feed supply, they can have an important impact on the environment.In developed countries the environmental impact of livestock systems has been widely studied, because of the important role of this activity on water, soil and air pollution. As an example, it has been estimated that in countries of occidental Europe agriculture contributes with 37 to 82% of the nitrogen (N) and with 27 to 38% of the phosphorus (P) input into surface waters (Isermann 1990).Despite the importance of livestock production in Latin-American countries and that N and P are strategic for grassland production, the potential effect of grazing systems on water and air pollution in the area has not been studied in detail. This paper aims to give an overview of the main processes involved in the transfer and losses of nutrients from grazing systems.

Role of water movement on nutrient transport and loss: The main water pathways relevant for nutrient losses in grazing areas are surface runoff and leaching. Surface runoff is the water moving along the surface of the soil, in favor of the slope; while leaching, is the water moving down the soil profile after infiltration has occurred. In freely drained soils, leaching can account for more than 70% of the total water moving in the soil profile. On the other hand, in clay soils, surface runoff can represent an important water pathway during saturation stages. Different experiments have showed that leaching is the most important pathway for nutrient transfer and loss in grazing systems (Alfaro *et al* 2008[a], Ledgard *et al* 1999). Surface runoff will have a strong effect on nutrients losses only at critical times during the year such as those with heavy rainfall occurring after fertilizer application or when the soil is dry, i.e. the first rainfall of autumn or in summer, when a pool of available nutrients, particularly N, has accumulated in the soil because of favorable conditions for mineralization.

Mechanisms for nitrogen and phosphorus losses in grazing systems: The main mechanism associated to N losses in grazing areas is nitrate leaching, which a mobile ion commonly is found in soil solution. Also, studies carried out in the United Kingdom (Hawkins and Scholefield 2000, Murphy *et al* 2000) have shown that dissolved organic N (DON) can represent up to 30% of the total N lost from high yield pastures managed under grazing (89-272 kg N ha-1). In non-intensively managed grasslands, DON can represent up to 50% of the total N losses (Jarvis, 2002).Total N lost in runoff is usually low (even less than 0.5 kg N ha-1 yr-1), and from the total N lost by this pathway, ammonium and nitrate losses represent on average about 24% each, as the result of urine lost in runoff immediately after excretion in each grazing and N lost after nitrate fertilizer application in spring time (Alfaro *et al* 2008[b]). Dissolved organic N (DON) can represent 50% of total N lost in runoff (Figure 1), probably because the high soil organic matter content in the topsoil of grazing soils and the expected high soil biomass activity registered at the site. Nitrogen leaching losses are variable considering different years, soil conditions, stocking rates and N inputs. They can range from 3 to more than 120 kg ha-1 yr-1. A high proportion (70%) of the N is leached as nitrate with ammonium averaging less than 10% of the total inorganic N losses. Dissolved organic N can vary from 8 to 22.5 kg ha-1 yr-1, which represents 25% of total leaching losses. According to this, DON is the most important N form in N leaching losses after nitrate. This represents a challenge for future determinations of N losses from grazing systems. Phosphorus losses are related to particulated P losses and not to phosphate leaching losses. Particulated P is associated to soil particles, organic and minerals, lost by erosion or preferential flow through cracks in clay soils. In grazing experiments carried out in low input systems, average P concentrations measured in runoff (reactive P-RP- and organic P-OP-) were much greater than the 50 and 25 µg total P L-1 established as eutrophication limit caused by anthropogenic influence for rivers and lakes, respectively (Leinweber *et al* 2002). Peaks of RP concentration have been associated to autumn or spring P fertilizer application, because of the direct transport of fertilizers granules in runoff after the application. Peaks of OP concentration have been measured during spring and they are probably related to the flush of organic matter mineralization produced at that time of the year. The main parameter affecting P losses in surface runoff is the field slope, so that P losses on a 4% slope field can be three times lower than those on a 12% slope field (3.5 and 15 g P ha-1 yr-1) (Alfaro and Salazar 2008). Overall P losses measured in volcanic soils of low input are lower than the results reported for P transfer from grazed land in Europe and New Zealand, probably because of the greater soil P concentration in the European and New Zealander soil systems. Total losses are mainly produced as RP (70% on average), and organic P losses represent only 30% of the total P lost in runoff.

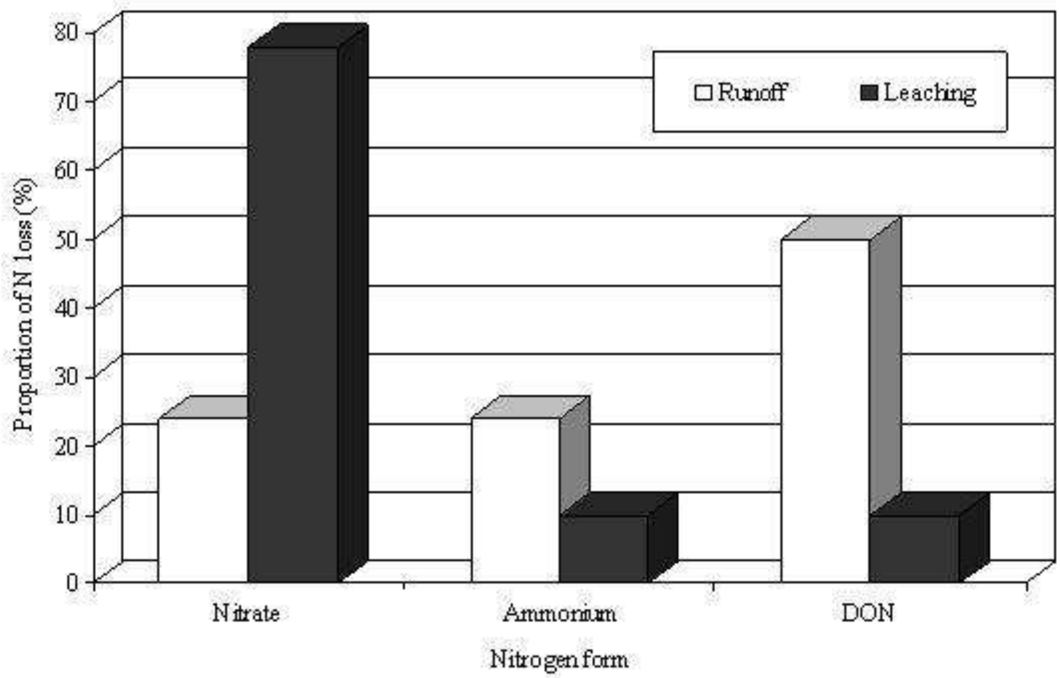

Figure 1. An example of the nitrogen form contribution to total nitrogen losses according to the water pathway.

The effect of grazing management: Winter grazing results in increasing amounts of bare soil at that time of the year. The recovery of the pasture observed in spring and summer showed that the estimated damage is only the production of mud that covers plants and that it is not related to the destruction of plant tillers. Nevertheless, intensive winter grazing should be avoided to reduce soil erosion, as this can be relevant for the loss of particulated P, as discussed previously. In areas with rotational grazing over winter, to increase the area used by animals represents an alternative to avoid over grazing and sediment production.

Gas contribution of grazing systems: Global warming has become a relevant issue worldwide, at the political, research and productive level. Agricultural production has been syndicated as one of the main contributors of greenhouse gases (GHG). Within agriculture, livestock production can represent everything between 30 to 75% of the global emissions depending on the relevance of this sector in the local economy. The main GHG are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). The abundance of these gases in the atmosphere follows the given order, while the impact on global warming follows the relationship 1: 23:300.Grazing is associated with both, a direct and an indirect contribution to GHG production. Thus, N losses in a gaseous form after fertilizer addition to grasslands represent a direct source of N2O production, while the production of this gas from nitrate that previously had been lost by leaching and has reached water sources represents an indirect source. It has been estimated that in grazing areas, losses after fertilizer application can vary between 12-25% of the N applied as mineral fertilizer depending on soil characteristics, pasture production, type of grazing animals and N rate. Enteric methane production by ruminants is the main source of methane generation, while the generation of this gas from soils and manure storage units are less known. As part of Kyoto protocol, countries must account for the internal production of GHG and establish goals for the reduction. These estimations are base on a default system generated by the Intergovernmental Panel for Climate Change (IPCC), which does not account for local differences. Thus, the generation of local emission factors increases the demand for research. On this, little has been done for grazing systems with the exception of New Zealand, where there has been a strong and organized effort to match policy demands and research priorities. This resulted in the creation of a national Institute for Climate Change at the end of the year 2009. Also, this contributed to the recent creation of the Global Alliance at the globe level. Ammonia losses (NH3) after fertilizer application to grazing soils (both organic and inorganic) can also be relevant for N use efficiency in grazing systems. It has been estimated that they can be as low as 1% of the N applied, but also as high as 35% of the N applied when soil and climate conditions are adequate for the losses. When using organic fertilizers, overcast application or spreading with irrigation systems, increase losses significantly.

Conclusions: Because of the potentially high available N and P losses from grazing systems, best management practices (BMP) in relation to the timing of N and P fertilizer application should be adopted in a grazing area. This might be more relevant in grazed systems than the role of animal pouching on erosion and sediment production, as has been described for different soils. These stress the importance of best management practices for fertilizer application, because they represent a risk for incidental surface water pollution in areas located closed by grazing paddocks, with potential negative effects on other activities such as aquaculture and tourism. This is valid for both organic and inorganic nutrient supply. The increasing relevance of livestock production and grazing systems on global warming has resulted in the development of new technologies to reduce GHG production at the farm level. Examples of these are controlled release fertilizers, new alternatives for manure storage and application to grazing land, and improved diets, to reduce enteric methane production. It is important to keep in mind that most of GHG generation of animal products is produced within the farm (75-85%), so that BMP and improved systems can play an important role on the reduction of these emissions. There is still much to be done in relation to the understanding and improvement of animal production based on grazing. Policy makers will be paying more attention to the development of this sector as, so far, little normative has been implemented for its regulation. The most relevant challenge of this generation will be to increase animal production worldwide, while considering farmers profitability and the impact of this activity on the wider environment.

Key words: nitrogen losses, phosphorus losses, stocking rate, greenhouse gases.

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