Field-Scale Evaluation of Water Fluxes and Manure Solution Leaching in Feedlot Pen Soils

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Accumulation of beef cattle manure on feedlot pen surfaces generates large amounts of dissolved solutes that can be mobilized by water fluxes, affecting surface and groundwater quality. Our objective was to examine the long-term impacts of a beef cattle feeding operation on water fluxes and manure leaching in feedlot pens located on sandy loam soils of the subhumid Sandy Pampa region in Argentina. Bulk density, gravimetric moisture content, and chloride concentration were quantified. Rain simulation trials were performed to estimate infiltration and runoff rates. Using chloride ion as a tracer, profile analysis techniques were applied to estimate the soil moisture flux and manure conservative chemical components leaching rates. An organic stratum was found over the surface of the pen soil, separated from the underlying soil by a highly compacted thin layer (the manure–soil interface). The soil beneath the organic layer showed greater bulk density in the A horizon than in the control soil and had greater moisture content. Greater concentrations of chloride were found as a consequence of the partial sealing of the manure–soil interface. Surface runoff was the dominant process in the feedlot pen soil, whereas infiltration was the main process in control soil. Soil moisture flux beneath pens decreased substantially after 15 yr of activity. The estimated minimum leaching rate of chloride was 13 times faster than the estimated soil moisture flux. This difference suggests that chloride ions are not exclusively transported by advective flow under our conditions but also by solute diffusion and preferential flow.

BEEF CATTLE feeding operations or feedlots may affect the environment due to the accumulation of manure and transport of contaminants to surrounding areas. Cattle manure solutions are composed of dissolved organic matter, including microorganisms and other remaining dissolved materials, such as nutrients, salts, steroidal hormones, antibiotics, ectoparasiticides, mycotoxins, heavy metals, and dioxins. Due to high levels of potential pollutants being released toward surface water or groundwater (García et al., 2006; García and de Iorio, 2003), the feedlots were specifically defined as “point sources” of water pollution (USEPA, 1972).

In feedlot pens, rain, animal trampling, and feedlot operations promote manure interactions with the soil and the lower atmosphere, which results in the generation of an organic stratum on the surface of the pen soil. This organic stratum consists of a manure pack, a manure–soil interface layer, and underlying native soil (Mielke et al., 1974). Published evidence shows that the manure–soil interface results in self-sealing of the feedlot floor, which substantially reduces the soil moisture flux and manure solution leaching (Mielke and Mazurak, 1976; Barrington and Madramootoo, 1989; Maule and Fönstad, 2000). This interface is formed by a mixture of manure and soil, involving physical processes (compaction by cattle and physical plugging of pores by manure), chemical processes (dispersion of clay by Na or K), and/or biological mechanisms (e.g., gleying, whereby slime or gums from anaerobic decomposition clog soil pores) (Mielke and Mazurak, 1976; Rowsell et al., 1985; Barrington et al. 1987a,b).

Feedlot pens do not sustain vegetation; therefore, plant roots play no role in the soil moisture flux. Mielke et al. (1974) reported that pen soil profiles generally present more uniform moisture content than cropped land profiles. The water infiltrating the organic layer can evaporate or pass through the interface and travel within the underlying soil. Mielke et al. (1974) also stated that the texture of soil under feedlots appeared to have little effect on water movement into the profile or runoff characteristics. Consequently, the amount of accumulated water in the organic layer could be expected to be directly related to soil moisture flux and manure solution leaching levels.