" Phosphorus transfer and farming systems in the Lake Leman watershed, France"

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ABSTRACT

In the Lake Léman area, two main surface runoff processes determine total phosphorus emissions from cultivated fields: hortonian runoffs (generated by low soil surface infiltration capacities) and water saturated surface runoff (variable source area hydrology).These processes are dependant on fixed (geomorphology, soil conditions) and seasonal (hydrology, soil use...) factors and appear to be generally dissociated in space (variations from one cultivated field to another) and in time (seasonal changes). Saturated surface runoff contains a high proportion of dissolved-P and bioavailable-P. This type of non erosive runoffs generates noticeable total-P loads during some events (which often take place when the surface water's sensitivity to nutrients inputs of the lake is potentially maximum). Hortonian runoffs are often associated with erosion and characterized by high content in particulate P. They occur mainly during winter and spring (which may diminish the impact on the receiving lake) and represent generally a major component of total-P export on an annual basis.

We monitored the occurrence of surface runoff generation and of total-P mobilisation and transfer, in various fields representative of the diversity of regional farming systems and landscape organisation. The objective was to understand the phenomena's involved in P transfer, to determine the risk factors and to find a strategy for a better management of phosphorus from the field to the watershed and to the farm scale.

Saturated surface runoff depends mainly on soil saturation of bottom slopes in relationship with rainfall inputs. However in the studied area and under certain circumstances, saturation was associated with some tillage practices operated on moist soils (harvesting, soil ploughing ....). Such conditions tended to generate strongly compacted sub-superficial soil layers, limiting for water infiltration. These situations was significantly more frequent in fields managed by traditional dairy farming systems (or mid intensive dairy systems) which were characterized by their badly adapted labour organisation and management (several seasonal peaks of farm work).

We determined that hortonian runoff and related total-P transfer, were strongly linked to structural degradation of soil surface by impacts of rain drops (soil crusting). The extent of this phenomena was controlled by meteorological conditions (cumulated rainfall) and by some agricultural practices depending on farm machinery, crop rotations, management of crop residues during inter-crop seasons, frequency of corn in crop rotations...and finally depending on the type of farming system. For example, in the cultivated fields managed by the traditional dairy systems, tillage practices tended to increase soil crusting susceptibility and consequently to increase the frequency of surface runoff and erosion. The risk was significantly lower for the fields cultivated by more intensive farms equipped with a better machinery leading to a more adapted cropping system. Finally unlike as was believed, in the studied area, the way the farmers managed their crops and organized their rotations mainly determine the occurrence of surface runoff and total-P transfer from cultivated fields.

We used these results to evaluate critical areas for phosphorus losses at the regional scale and to developed a set of indicators including, risk factor for surface runoff, spatial organization of crops, fertilization regimes and the general structure of the rural landscape.