CONSTRUCT PONDING SYSTEMS / INCREASE SOIL LEVELS ALONG DITCHES

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Description

Phosphorus (P) is mainly transported to surface water by water transport. During rainfall events water flows over soil. As a result the water will detach soil particles and transport these sediments. Since nutrients are often attached to sediments P losses can occur. Furthermore, phosphorus can desorb from the soil and be transported in runoff water. The particle P in runoff water is highly correlated to the amount of sediments transported and particle size of the transported material, because the smaller particles (clay particles versus sand particles) often contains more P. The soluble mineral P components in runoff water depends highly on the soil P status of the plough layer, while the soluble organic P components depends on the organic matter content, physical and chemical type of organic material and the pH of the top soil. Depending of the main pathway of P losses (e.g. overland, subsurface, artificial drains etc) and the main P component in soil solution (particulate P material, colloids, inorganic soluble P, organic soluble P) specific measures will reduce P losses. E.g. by changing the length of the pathway of the water and reducing the water flow phosphorus rich components in solution will be reduced. In this fact sheet the impact of constructing ponding systems on overland flow will be discussed in more detail.

Rationale, mechanism of action

Changing of blocking the pathway of the water flow in such a way that

- The pathway length of water located nearby trenches or ditches is increased (fast subsurface flow will be reduced)
- and/or the flow rate is reduced (sufficient reaction time for sorption to the soil) will reduce the amount P loss to surface water.

One option to realize this effect is by blocking the water flow by increasing the soil level along the ditches (also known as ponding). The first option is visualized in figure 1

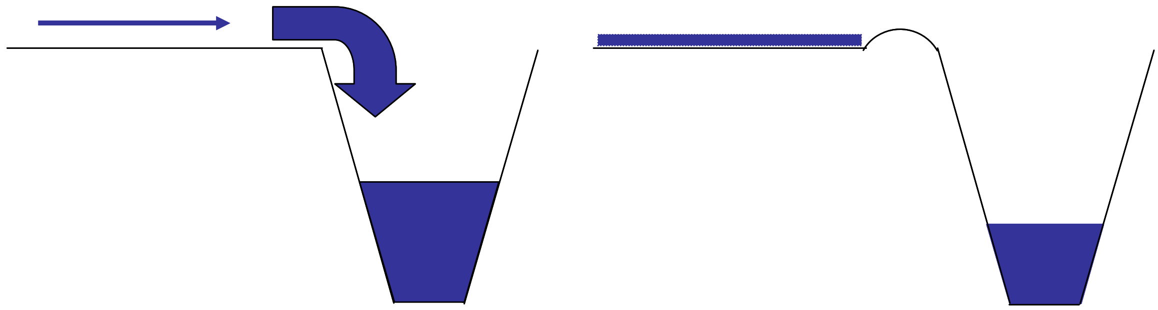

Figure 1. Schematic visualization of the impact of "ponding" on the water flow

As the water moves across the field, the flow rate decreases. Soil detachment reduces and sediments deposit takes places in lower portions of the field. Lowering the water flow rate and increasing the pathway length, reduces the P losses. In the lower parts also the dissolved P can sorb to the soil because of the infiltration of water into the soil.

Good conservation tillage, to reduce the erodibility of the soils, or creating vegetative filter strips at the end of the field are often used management practices to reduce P losses. Both options are described in other factsheets. However, also creating sediment ponds at the end of the field can reduce suspended material and nutrient losses to surface waters. Those sediment ponds remove suspended material from the water by reducing the water flow rate allowing particles to settle. Sediment ponds also remove nutrients associated with sediment particles.

a) Particle P / colloidal P

The P losses caused by transport of detached soil particles in soil solution will particularly be reduced by the measure. The effectiveness of measures which increase the travel time will depend on the physical and chemical composition of the transported solution. Important physical factors are the distribution of the weight and size of the particles in solution. The most important chemical aspect is the amount of P allocated to those particles. Most of the time the total amount of transported P increases with decreasing particle size, because small particles have a higher specific area and more P is bound to these particles. The measure will be more effective in situations where most of the material will settle.

b) Soluble P components

The impact of the measure on the P losses in soil solution is less known. Soluble components are defined as material that is still in solution after filtering by 0.45 μm.
In this case the P loss to surface water will be reduced if during the transport process there is interaction with the surface layer with a lower P status. Especially reactive inorganic P components will react with the soil and the P concentration in runoff water will decrease. Reduction of the amount of soluble organic compounds will probably hardly take place, because those particles are most of the time not reactive.

However, the measure also leads to a change of the water flow from overland flow to subsurface flow or downward seepage in the flat parts of the field (ponding area). Because of the infiltration also the P loss of overland flow by soluble P components will be reduced. On the other hand the P losses by subsurface pathways can increase because of the increase of water flow by this pathway. The overall effect will highly depend on the hydrological situation and physical and chemical (P) status of the soil in relation to the decrease of overland P losses.

Applicability

The measure will be most effective when applied under field conditions where transport of particulate P components by overland flow causes the main P loss to surface water (erosion): hilly areas in combination with high rainfall intensities. However, the practical applicability will also depend on the landscape of the fields. Low parts within the field, especially at the edges of the field nearby the ditch or brook, should be present. Furthermore, the practical applicability depends on the management issues at the farm scale, because the farmer wants to cultivate the field and wet conditions (for a long time) are not preferred, especially not in early spring time.

Effectiveness, including certainty

If the slope of the field (hill) is too high and flat parts are hardly available, the effectiveness is low, because the water can hardly be blocked. The general idea is that the measure will be applicable at slopes less then a few percent and substantial possibilities for creating ponds.

Since the distribution of the rainfall (amount, frequency, intensity) highly determines the amount of P losses by overland flow, and the elevation of the landscape varies tremendously, it is rather difficult to give overall figures with respect to the effectiveness.

However, the principle of reducing P losses by means of blocking overland flow, and the physical and chemical processes behind, can be described scientifically and technically. However, parameterization of such water management measure will be different for each specific situation, and is not often studied or determined and hardly to generalize.

Most experience with ponding measure was obtained during research on irrigation [1,2,3,4]. Well-constructed ponds can potentially remove 65-75 percent of the sediment and 25-33 percent of total P entering the pond. Total P reduction will depend on the relative amounts of dissolved and particulate P in the pond inflow [2,5]. Some caution is necessary, because often relative high reductions are found in situations with low P losses.

Time frame

Increasing the length of the pathway or reducing the velocity of the water flow will have an impact on the travel time and therefore on the timeframe. However, the impact of the measure will turn out at the short term (within a year).

Environmental side-effects / pollution swapping

The risk of environmental side-effects and pollution swapping are minimal. However it has been discussed before that shift of water flow from overland through the (sub)soil can increase the P losses of another pathway (subsurface losses). The main negative effects are related to agricultural practices and crop production because the soils can stay wet for a long time. The longer an area remains ponded, the higher the risk of plant death. Soil oxygen is depleted within about 48 hours of soil saturation. Without oxygen, plants cannot perform critical life sustaining functions; e.g. nutrient and water uptake is impaired and root growth is inhibited. Secondly, dense surface crusts can be formed as the soil dries again, increasing the risk of emergence failure for recently planted crops. Finally, long term wet soil conditions favor the development of diseases caused by fungi.

Relevance, potential for targeting, administrative handling, control

The option can be relevant for fields that cause diffuse P losses by overland flow at local scale. Selection of such fields by modeling approaches or by local experiences are highly recommended.

Costs: investment, labor

The main costs are caused by labor in order to increasing the soil level along the ditches (ponding). No investments are necessary to build specific mechanical equipment.

References

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