Diagnosis and Solutions for Field Erosion and Surface Drainage Problems

Soil erosion and inadequate surface drainage greatly reduce the productivity of agricultural fields and can cause water quality problems downstream from the affected fields.

Source: Mikael Guillou (MAPAQ)

This page presents erosion and surface drainage problems frequently observed in fields as well as the hydro-agricultural installations and cropping practices most appropriate to each situation. Essentially, the proposed solutions are aimed at:

- reducing the volume and flow of runoff water;
- modifying the slope of the land, and intercepting and directing the surface runoff in order to reduce its speed; and
- improving soil structure, and protecting the surface to increase its resistance to erosion.

On this page:

Sheet Erosion

The uniform-or non-concentrated-flow of water on the surface of the soil can rip up and drag fine particles that are then transported towards watercourses. This type of erosion is called sheet erosion. Because of its diffuseness, this type of erosion is difficult to detect, but it can cause significant soil losses. All soil types can, to varying degrees, be affected by sheet erosion. The adoption of preventive measures can to a great extent prevent this problem from appearing.

Sheet erosion
Source: Richard Laroche (MAPAQ)

Diagnosis

The areas affected by sheet erosion can be identified by lower yields and paler soil colour, as well as by eroded-material deposit sites when benches are located downstream. Eroded zones have thinner topsoil than the other parts of the field.

Solutions

Sheet erosion can be prevented with cropping practices such as:

- establishing a good vegetation cover;
- maintaining a significant portion of crop residues in the soil through reduced tillage; and
- adopting balanced rotation (with grasslands or green manure catch crops or intercropping).

These practices limit and slow down surface runoff by increasing the roughness and infiltration potential of the soil. Moreover, they improve soil structure and, in so doing, its resistance to erosion.

Field Gullying

When draining water picks up speed and is concentrated in certain drainage canals, it can erode large quantities of soil in these canals, thereby creating runnels or ravines.

Small gullying
Source: Jacques Goulet (MAPAQ)

Diagnosis

A soil surface examination can help detect the affected areas, particularly after periods of heavy rains or during snow melt. Before appropriate solutions can be selected, the causes of the gullying must be identified. The sudden appearance of a gullying may be the result of, among other things, a change in the way the soil is being used upstream or particular weather conditions. In spring, the low infiltration capacity of frozen soil can promote the appearance of runnels and ravines in the fields.

Solutions

First of all, runnels can be dealt with through normal tillage operations, while ravines are bigger and must be backfilled, with care taken to protect the topsoil.

Significant gullying
Source: Mikael Guillou (MAPAQ)

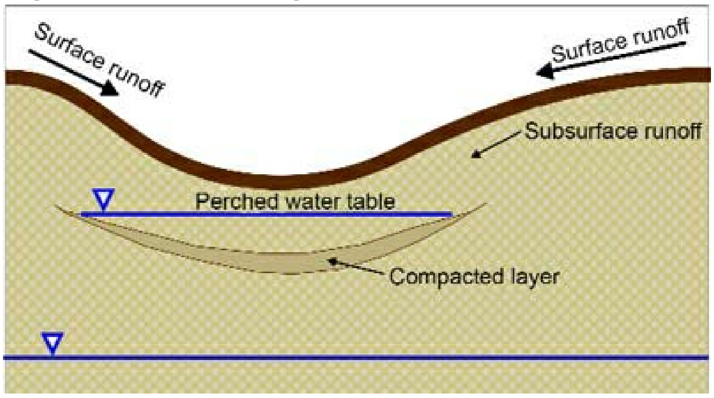
In the case of small gullyings, a change in cropping practices can sometimes resolve the problem. The best practices are the implementation of forage crops, reduced tillage or direct seeding, and cross-slope cropping. If the cause of the surface runoff is located further upstream in the drainage basin, selective reforestation of this area can also be a good solution. Levelling work can help limit the erosive nature of the surface runoff.

When there are significant gullyings, the practices mentioned above are still recommended, but adapted structures must also be put in place in a more targeted manner. In areas of concentrated surface runoff where the water drains away quickly, gullyings can be avoided by installing a grassed (or rip-rapped) watercourse. When gullyings are caused by a sudden and relatively brief increase in the slope of the field, a system with an inlet well and berm can be put in place to create a retention pond and drain away surface runoff through underground piping in order to reduce surface flow in the areas that are more prone to erosion. This type of system also makes it possible to promote sedimentation of the soil particles suspended in the surface runoff before the runoff is drained, but good water storage capacity in the field is required. There is also a risk in using berms, in that a berm failure could cause serious damage downstream.

Poor Drainage of Depressions

The poor drainage of depressions often causes a delay in working the fields. Furthermore, work is often undertaken before the depressions are completely dry, resulting in compaction problems and a worsening of drainage problems in these zones (Figure 1). Lastly, when depressions filled with water drain in an uncontrolled manner, they can cause gullying problems.

Figure 1: Poor drainage of depressions



Adapted from CPVQ (1976)

▶ Description – Figure 1

Diagnosis

A visual examination of the land is performed to identify the eroded depressions and zones, especially after periods of heavy rain or in the spring, after the snow has melted. However, a depression is often much bigger than the portion of the field that is flooded after precipitation. The exact size of the depressions must be determined by a detailed topographical report. An analysis of the drainage plan is also essential to the selection of appropriate solutions.

Poorly drained depression
Source: Mikael Guillou (MAPAQ)

Solutions

If the depression is limited in size, it can be eliminated through levelling (maximum area of the depression based on the topographical report: 0.5 ha; maximum depth: 5 to 10 cm). The work must be done with great precision, because insufficient levelling could result in expanding the area of the depressions. The final slope of the land must be at least 0.15%, so as to avoid any water accumulation above the old depressions. Furthermore, the topsoil must be kept at the surface in all circumstances. Lastly, it is sometimes necessary to undertake corrective work during the first few years following the levelling, in order to eliminate the irregularities that might result from soil compaction following the work.

If the depression is too large to be levelled, there are several possible solutions. An infiltration well or a permeable trench can be used to drain the accumulated water from depressions that are too deep to be backfilled. Infiltration wells are good for small, circular depressions (with a maximum area of approximately 0.5 hectares), while permeable trenches are better suited to elongated depressions. These structures reduce soil losses and are not an obstacle to machinery.

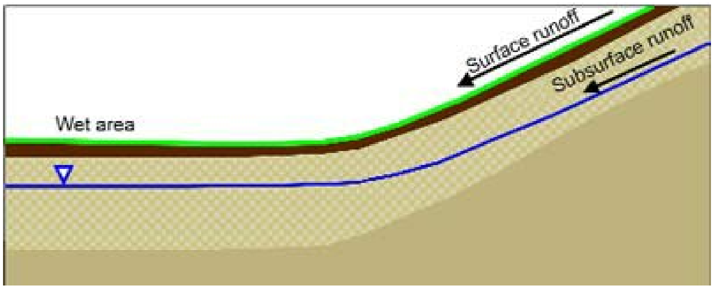
Another solution is the construction of a grassed waterway. This type of structure is easy to construct, but it does lead to a loss of cultivable area in the field and requires frequent maintenance, because the grassed area does not withstand the frequent movement of machinery and the spraying of herbicides well. However, grassed waterways are the only possible option when a deep enough outlet is not available to service a structure that requires the installation of a drain outlet.

Inlet wells make it possible to drain large depressions (up to 20 hectares). However, they are an obstacle to machinery and, when installed in the middle of the field, must be clearly marked so that they can be easily found. Soil losses can be reduced further by limiting the speed at which the water drains; doing so promotes the sedimentation in the field of the soil particles in the surface runoff.

Resurgence of Subsurface Runoff or Unconfined Groundwater

Water can travel at shallow depths under the surface of the soil, in the direction of the field slope. This water is called subsurface runoff, and it sometimes resurfaces at the bottom of depressions (Figure 1), at the bottom of slopes, or in slopes if they are very long or have benches (Figure 2). Unconfined groundwater can also rise to the soil surface (as a spring) when the subsoil is irregular (Figures 3 and 4). These resurgences can lead to compaction and erosion problems if the flow is not controlled.

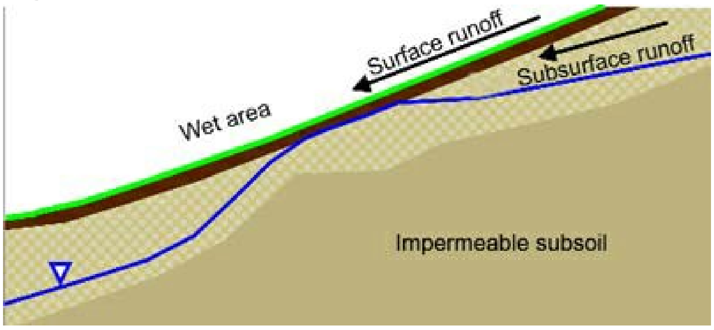
Figure 2: Foot of slope or steep slope followed by a gentler slope



Adapted from CPVQ (1976)

▶ Description – Figure 2

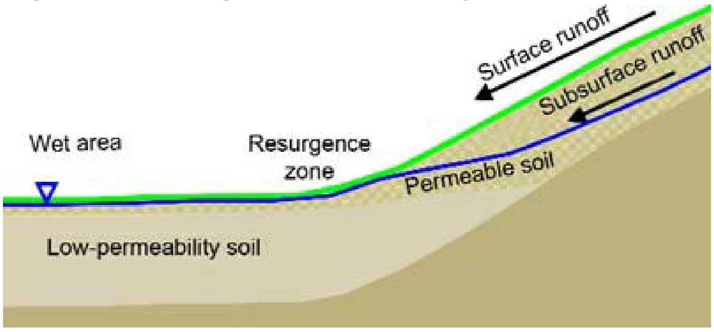
Figure 3: Localized rise in the impermeable subsoil



Adapted from CPVQ (1976)

▶ Description – Figure 3

Figure 4: Meeting of two different types of permeable soils



Adapted from CPVQ (1976)

▶ Description – Figure 4

Diagnosis

Subsurface runoff or unconfined groundwater resurgence zones are characterized by the fact that they are often damp even though they are not located in depressions. This last point is important because, since Quebec fields often have low slopes, resurgence zones can sometimes be difficult to distinguish by the naked eye from depressions. That is why it is important to review the topographical report in detail to make a well-informed diagnosis. Soil profiles can also help identify the precise cause of the resurgences.

Solutions

Grassed waterways are simple, low-cost structures for draining water from the resurgence of subsurface runoff or unconfined ground water. They are used infrequently, because they generate a loss of space, complicate field work and require frequent maintenance. However, grassed waterways are the only possible solution when there is no outlet deep enough to service a structure that requires the installation of a drain outlet.

The most common solution for eliminating resurgences is the installation of an interceptor drain along these zones. This solution works particularly well in permeable soils, such as sandy or well structured clay soils. In less permeable soils, infiltration wells or permeable trenches can complete the system to increase infiltration, depending on whether the resurgences are localized (wells) or linear (trenches).

Erosion at Confluences

The confluences of ditches, runnels and furrows are often prone to erosion, since the runoff volume and flow are significant in those spots. This erosion is accentuated by differences in elevation that can exist between the tributary and the outflow.

Erosion at the confluence of a ditch and a watercourse
Source: Mikael Guillou (MAPAQ)

Diagnosis

The deposition of sediment in the outflow is a good indicator of this type of erosion.

Solutions

Depending on the case, erosion at confluences can be controlled by installing a grassed chute, a rock chute or a drainage ditch.

A grassed chute is created by installing sod at the mouth of the furrow or the runnel to be protected. A grassed chute is the simplest and least costly solution and can be applied in cases where the flow is weak and slow.

A rock chute involves strengthening the confluence using riprap and a geotextile membrane. A rock chute can withstand higher water speeds than a grassed chute. However, a rock chute does not increase sedimentation in the field.

A drainage ditch is constructed by backfilling the mouth of a ditch to create a sedimentation basin with a rip-rapped overflow, from which the water is drained using an inlet well and high-density polyethylene (HDPE) piping. This structure is more complex and more costly to install than a rock chute but has the advantage of promoting sedimentation in the ditch and facilitating the movement of machinery between fields.

Bank Gullying

Like confluences, the banks of watercourses are zones where the risk of erosion is high, because of the concentration of surface runoff and the difference in elevation between fields and watercourses.

Bank gullying
Source: Mikael Guillou (MAPAQ)

Diagnosis

The gullying and sediment deposition zones in watercourses are easily identifiable and make it possible to identify the sections to be stabilized.

Solutions

Systems with rock chutes and berms or inlet wells and berms can be used to protect the banks and concentrate the surface runoff towards a protected drainage point. A rock chute works well in cases where the length and inclination of the banks are limited. An inlet well can be used in cases where sedimentation in the field is to be promoted. As explained in the "Field Gullying" section, the sizing, construction and maintenance of berms must be conducted with particular care, given the damage that the failure of a berm can cause downstream.

Erosion and poor surface drainage can have a significant negative impact on crop productivity and surface water quality. A good diagnosis will make it possible to select the solution that is best suited to the problem observed. Lastly, healthy soil, characterized by good structure and active organic matter, will withstand erosion better. Think about it!

Summary Table

Problem	Solutions	Comments
Sheet erosion	• Good vegetation cover • Reduced tillage • Balanced rotation (with grassland or green-manure catch crops or intercroping)	These practices should be adopted as preventive measures in all fields where they are applicable
Field gullying	Forage crops, reduced tillage or direct seeding, cross slope cropping, selective reforestation upstream from the field, levelling	Use when the surface runoff is significant and the flow is rapid
Field gullying	Grassed (or rip-rapped) watercourse	Use when the surface runoff is significant and the flow is rapid
Field gullying	Inlet well and berm	• Use when the surface runoff is significant and the slopes are short • Increases sedimentation in the field (good for water quality) • Requires good capacity for water storage in the field **Note:** Risk associated with the use of berms (see "Field Gullying" section)
Poor drainage of depressions	If the depression is small: Levelling	For small depressions (maximum area = 0.5 ha; maximum depth = 5-10 cm)
Poor drainage of depressions	If the depression is too large and/or too deep to be levelled: Infiltration well or permeable trench	• Infiltration wells: circular depressions (max: 0.5 ha) • Permeable trench: elongated depressions • Can be connected to an existing drain • Increases sedimentation in the field (good for water quality)

Summary Table

Problem	Solutions	Comments
Poor drainage of depressions	Grassed waterway	• Only system possible if a deep enough outflow is not available to install a structure with a drain outlet • Easy to construct, but causes loss of space, is an obstacle for machinery and requires frequent maintenance
Poor drainage of depressions	Inlet well	• Maximum drained surface area = 20 ha • Possible obstacle for machinery • Requires the installation of a separate drain • Reduced soil loss if the drainage time = 12-24 hours
Resurgence of subsurface runoff or unconfined groundwater	Grassed waterway	• Only system possible if a deep enough outflow is not available for the installation of a structure with a drain outlet • Easy to construct, but causes loss of space, is an obstacle for machinery and requires frequent maintenance
Resurgence of subsurface runoff or unconfined groundwater	Interceptor drain	Particularly effective in permeable soils
Resurgence of subsurface runoff or unconfined groundwater	Infiltration well or permeable trench	• To increase the infiltration and effectiveness of the interceptor drain in low permeability soil • Well: localized resurgence • Trench: linear resurgence
Erosion at confluences	Grassed chute	Simple, adapted to low flow speeds
Erosion at confluences	Rock chute	Simple and resistant, but does not promote sedimentation
Erosion at confluences	Drainage ditch	• More complex than the chute, but promotes sedimentation • Allows the movement of machinery between fields
Bank gullying	Rock chute with berm	• Simple and resistant, but does not promote sedimentation • Adapted to banks with limited

Summary Table

Problem	Solutions	Comments
		slope and length **Note:** Risk associated with the use of berms (see "Field Gullying" section)
Bank gullying	Inlet well with berm	• Adapted to banks with significant slope and length • More complex than the chute, but promotes sedimentation • Requires good capacity for water storage in the field **Note:** Risk associated with the use of berms (see "Field Gullying" section)

References

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