# Irrigation and Drainage Engineering

## (Soil Water Regime Management)

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4ETCS, Master option

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Lecture 12-1. Drainage: materials and clogging risk

EPFL

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

# Drain materials

**Earthenware or concrete drains**

(almost in disuse today)

See hydraulic scheme

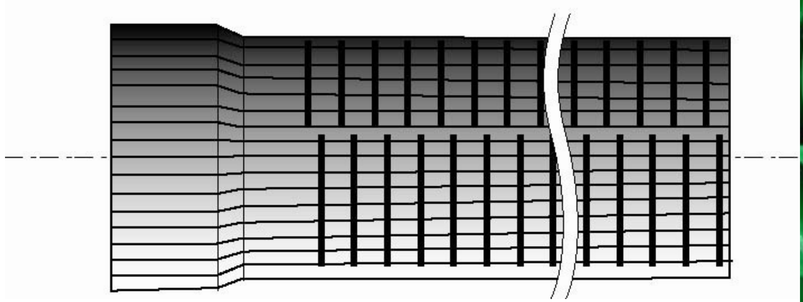
**Plastic drains**

**(PVC ou PE)**

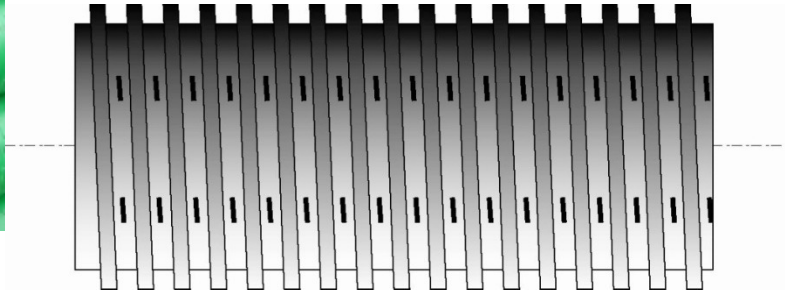
- ✓ **Drains lisses et rigides**
- ✓ **Drains annelés**

**Others**

**Ringed drains with filter and smooth drains rigid**



Smooth and rigid drains



Ringed and flexible drains

# Criteria for choosing drains

- cost;
- local availability
- ease of installation
- resistance to crushing
- hydraulic efficiency
- chemical characteristics of the soil
- durability

Other materials are also used locally for:

- Discharge of drain

- shallow sections

- passages under obstacles

- areas at risk of root clogging

Plastic drains meet most of these
most of these requirements

# Drain clogging

## Tipology

### Type of clogging

external clogging
internal clogging

### Time of occurrence

primary clogging
secondary clogging

### Causes

mineral clogging
physico-chemical clogging
root clogging

***Most frequent case: secondary clogging of mineral or physico-chemical origin***

**Prevention**

- **risk assessment**
- **if necessary, choice of an effective filter**

## Primary mineral clogging

**Causes: laying drains in extreme soil humidity conditions**

- Very high humidity and low structural stability: mud projection or coating with mud
- Laying in very dry conditions in very silty soils: silt coating likely to become clumpy when dampened

## Secondary mineral clogging

**Manifestation progressive dans les années suivant la mise en place**

→ FILTERS

# FILTERS AND RELATED TYPOLOGY

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- Hydraulic function (flow filter); generally thick filter

- Stop function to prevent fine particles from fine and unstable soils (sandy, sandy-silty soils, etc.) from entering the drain or blocking the orifices**. The filter can be either thin or thick.

- Thin filter placed around the drain: covering filter (straw, coconut fibre, felt strip, fibreglass, glass wool, etc.).

- Thick filter (> 10cm) used to fill the trench in place of excavation material: backfill filter (drainage trench or drainage jacket if the filter is very thick); hydraulic and/or stop function

* Material placed around the drain

** A good blocking filter must retain dangerous particles (> 50 mm) and allow the fines likely to clog it to pass through.

# FILTER TYPOLOGY

## Backfill filters *

- uncalibrated gravel (flow filters) or gravel with selected grain size (stop filters)
- expanded synthetic materials (polystyrene, PE, etc.) or synthetic fibre mats
- organic materials (straw, peat, wood shavings, sawdust, etc.)

* used to backfill trenches instead of excavation material; flow and/or stop function

## Coating filters

Organic or synthetic materials put in place during installation or predisposed around the drain.

*Coconut fibres, glass wool, felt strips, nylon, polyester sheets, straw, etc.*

Drains annelés avec filtre

## Filtres spéciaux

Antoc filters to prevent iron hydroxide deposits: fragments of bark from phenol-rich substances (oak, mimosa, etc.) embedded in coconut fibres or straw. The phenol combines with the iron to form soluble complexes and prevent precipitation.

# Sand-gravel filters

- Well-structured soils with good cohesion

Role of the filter: to facilitate the flow of water to the drain

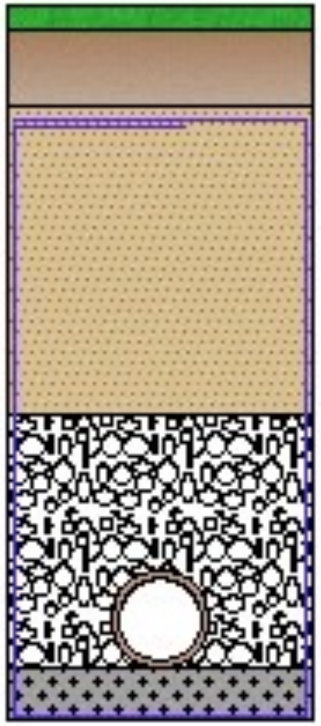
➔ any sufficiently permeable porous material can be used

- Poorly cohesive, powdery soils

The particle size of the filter must be scientifically studied (SNV, SCS standards, etc.).
The filter must be :

- sufficiently coarse (high conductivity)
- fine enough to retain clogging particles

Minimum filter thickness: 10 cm

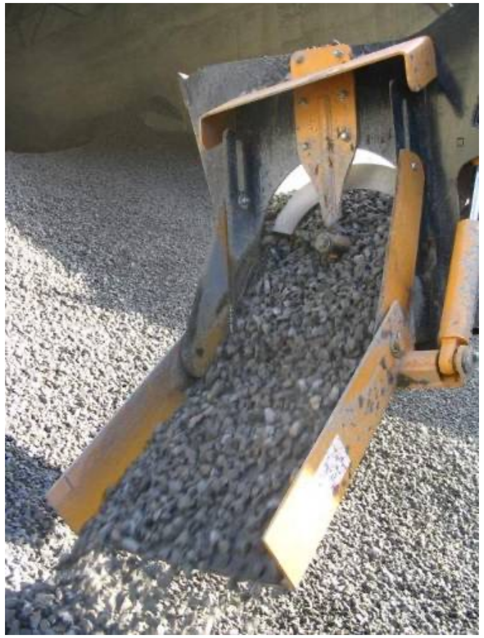


**Gravel filter for groundwater drainage**

# Granulometry of sandy-gravel stop filters

Based on the soil in place around the drain.

Filter selection criteria proposed by the Swiss Standards Association (SNV) and the US Bureau of Reclamation (USBR):



| | SNV* | USBR |
|---|---|---|
| $\frac{D_{15}\ \text{filtre}}{D_{15}\ \text{sol}}$ | > 5 | between 10 and 40 |
| $\frac{D_{50}\ \text{filtre}}{D_{50}\ \text{sol}}$ | < 25 | between 10 and 60 |
| $\frac{D_{15}\ \text{filtre}}{D_{85}\ \text{sol}}$ | < 5 | < 5 |
| $\frac{D_{85}\ \text{filtre}}{\text{Diam. orif.}}$ | > 1 | 100% < 4 cm<br>90% < 2 cm |

* Norme SNV 670 125

$D_{15}$ : equivalent particle diameter corresponding to a weight % of 15

# Assessment of the risk of secondary mineral clogging

## Quality level

Fine soils (A* > 20 to 30%): good structural stability

➡ *filter may be required*

Soils at risk: poorly cohesive soils with low structural stability and low clay content (sandy and/or silty soils).

➡ *stop filter required*

* A : argile; S : sable; Sf : Silt fin (0.002 à 0.02 mm);

U : coefficient d'uniformité

## Quantitative level

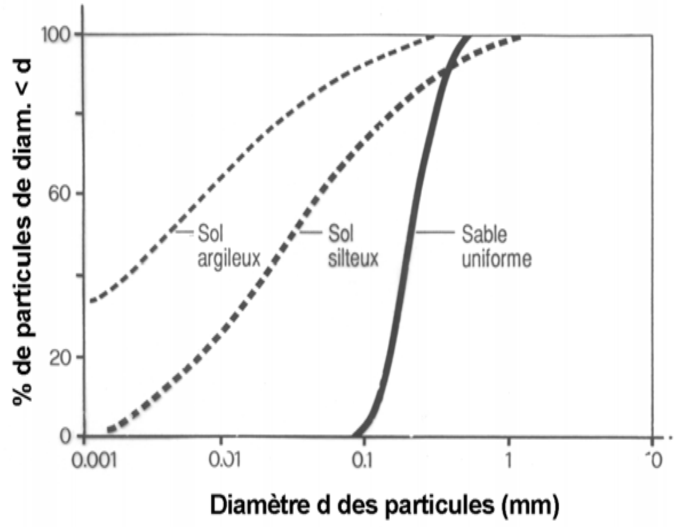
Examples of criteria used to characterise risks:

High-risk soils *:*

- Sandy soil: S* > 50% et A < 15%
- sandy-loam soils : A < 20% et 2A + Sf* > 50%
- U < 5 ($U = D_{60} / D_{10}$)

*Low-risk soils :*

- clay soils : A > 20%
- U > 15




- **Clay : < 0.002 mm**
- **Silt : 0.002 - 0.05 mm**
- **Sand : 0.05 - 2 mm**
- **Gravel : > 2 mm**

# When should a filter be used?

Stop (or coating) filter

- when the clay content is less than 20 %
- generally speaking, when the majority of particles are between 0.05 and 1.0 mm
- the risk is very high when more than half the particles are between 0.05 and 0.12 mm (fine sand)

Flow filter (backfill)

- when the hydraulic conductivity of the soil is poor

A filter must be considered as a sensible prevention measure and not as a curatiuve measure. Therefore, either it is foreseen to be installed since the beginning or later addition may result in essential costs for no real benefits

# Clogging

## Physico-chemical clogging

Represented essentially by iron deposits which may result from :

- a chemical reaction (oxidation of ferrous iron to ferric iron)
- biological processes (oxidation by bacteria)

Very often, the 2 processes act simultaneously

**Colmatage ferrique des orifices d'un drain**

# Origine du Fer

- Allochthonous: risk of permanent clogging
- Native: generally temporary clogging

Soils at risk of iron clogging :

- mineral clay soils, rich in iron
- organic and peaty soils (marshes)
- environments where the concentration of ferrous iron in the soil solution is > 3 mg/l at acid pH and 6 mg/l at basic pH

# Physico-chemical clogging of chemical origin

## Causes

Changes in physico-chemical conditions in the vicinity of drains

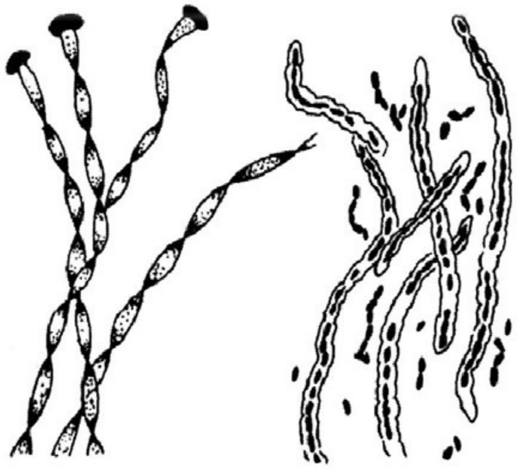
- precipitation of previously dissolved substances:
  - ✓ precipitation of calcium bicarbonate (rare)
  - ✓ precipitation of iron in the form of poorly soluble ferric ions $Fe^{+++}$ (oxides, hydroxides, hydroxide gels) by oxygenation of ferrous iron $Fe^{++}$.

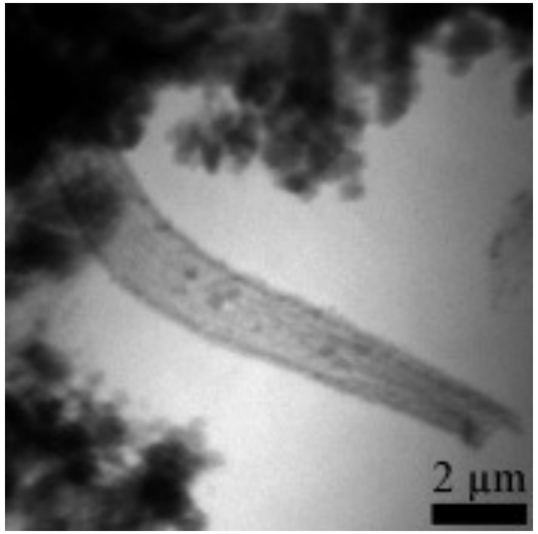
# Physico-chemical clogging linked to biochemical reactions

Iron deposits resulting from the action of bacteria (ferrobacteria) that are part of the microflora of groundwater (Gallionella, Lepthotrix).

They reproduce rapidly in colonies when conditions are favourable and develop inside the drain.

The ferric iron deposit hardens on contact with air.






Ferruginous bacteria

# Deposits inside the drain

## Criteria for assessing the risk of iron clogging

| Fe++ concentration in soil solution (mg/l) | | Clogging risk |
|---|---|---|
| pH < 7 | pH > 7 | |
| < 0.5 | < 1 | Low |
| 0.5 - 1.0 | 1.0 - 3.0 | Low to medium |
| 1.0 - 3.0 | 3.0 - 6.0 | Medium to high |
| 3.0 - 6.0 | 6.0 - 9.0 | High to very high |
| > 6.0 | > 9.0 | Very high |

# Prevention of iron compounds clogging

- measures likely to cause iron precipitation before water enters the drains (installation of a highly macroporous backfill around the drains; repeated subsoiling of the plot; modification of the soil pH by liming, etc.).

- Use of special filterrs (ANTOC)

**Tannin-rich substances: oak, mimosa or acacia bark**

↓

**Phenols**

↓

**Fixing ferrous iron**

**Gravel coating**

***Prior actions :***

- carry out chemical analyses of the soil (pH, iron concentration)

- provide facilities for cleaning drains at the design stage

# Clogging by vegetation roots

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## Plants at risk

Deep-rooted plants (oilseed rape, wheat, maize, beetroot, lucerne, etc.), certain weeds (nettles, thistles, horsetail, etc.) and certain trees (poplar, willow, ash, etc.).

## Measures :

- **preventive**
  - ✓ deep drains
  - ✓ sufficient water velocity (> 0.5 m/s)
  - ✓ avoid high-risk areas; if necessary, cross these areas with non-perforated pipes with watertight joints
- **corrective**
  - ✓ injection of chemical substances (copper sulphate, etc.)
  - ✓ high-pressure purging