From ADEME's perspectives:
Overview of actions promoting phytomanagement of contaminated sites

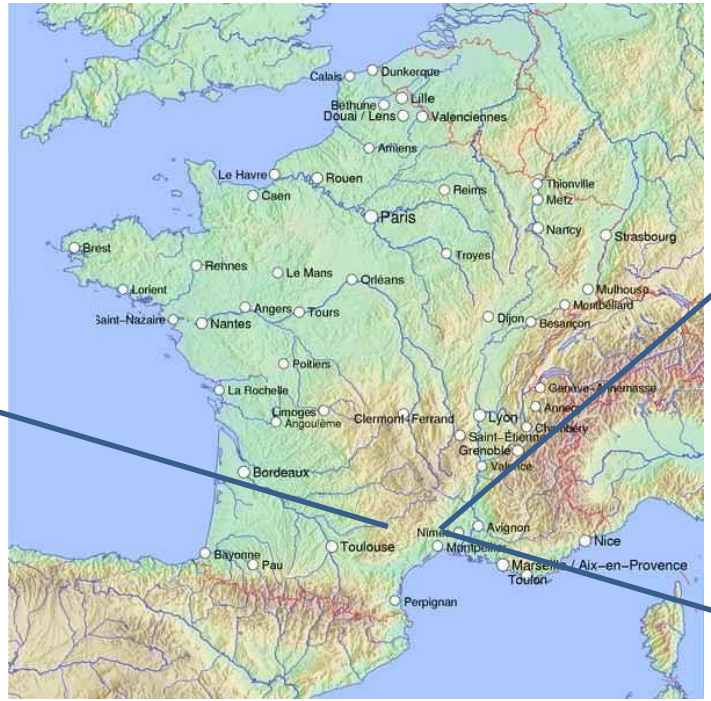
research programmes, implementations and perspectives

French Environment and Energy Management Agency

Patrick Jacquemin / Frédérique Cadière

Bordeaux – April 27th 2017

3 ADEME examples



Salsigne Mine (Gold)

Carnoules Mine (Silver, Lead)

Avinières Mine (Zinc)

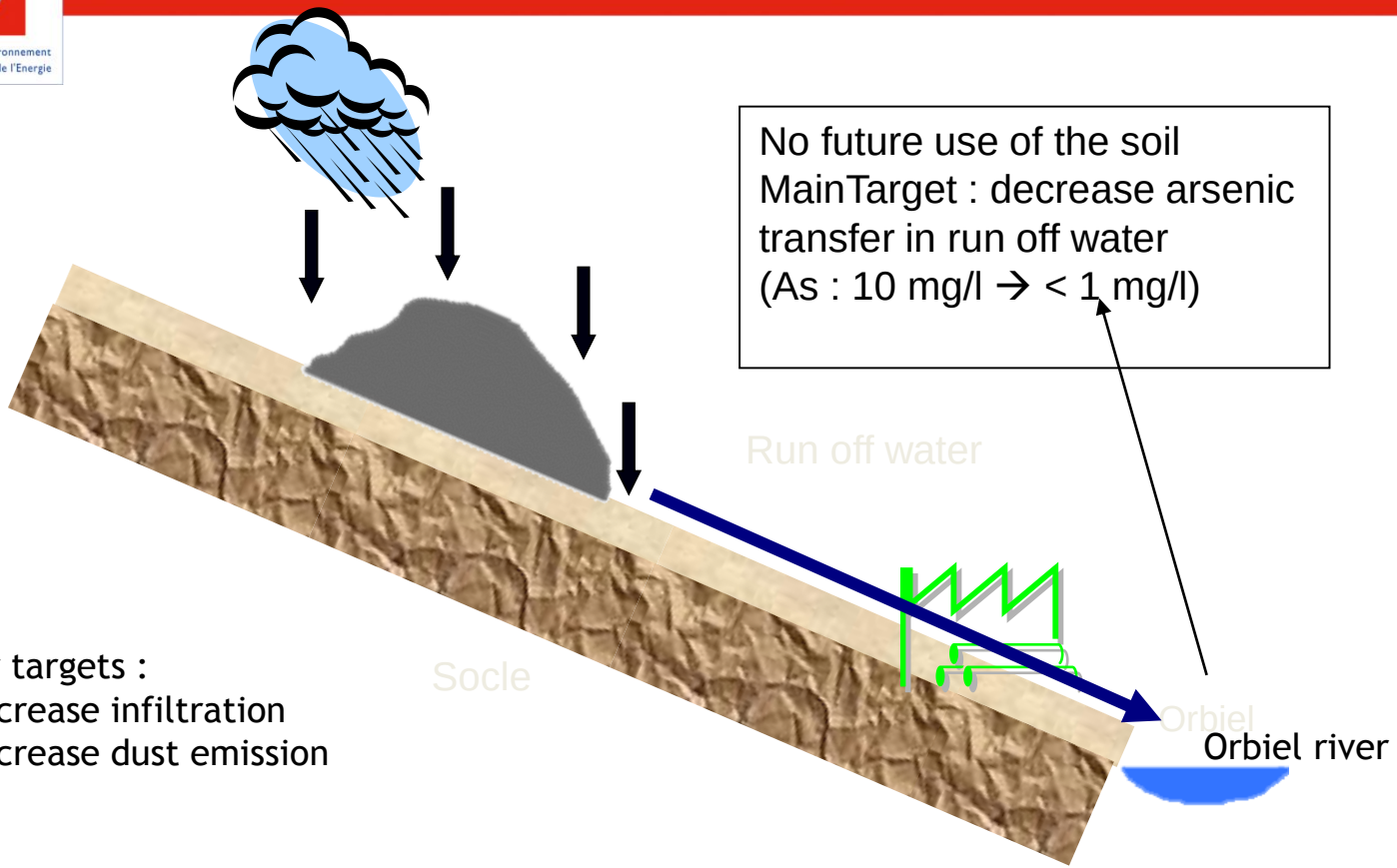
Salsigne Mine (La Combe du Saut) : example 1

- Gold mine
- 1924 to 2004
- Pyrometallurgy
- Cyanide treatment
- 15 million tons of ore
- 110 tons of gold
- 200 000 tons of arsenic trioxyde
- Soil were highly contaminated
  - Arsenic (up to 10 % in top soil)
- Remediation actions :

- excavation
- confinement
- phytostabilisation (10 ha)

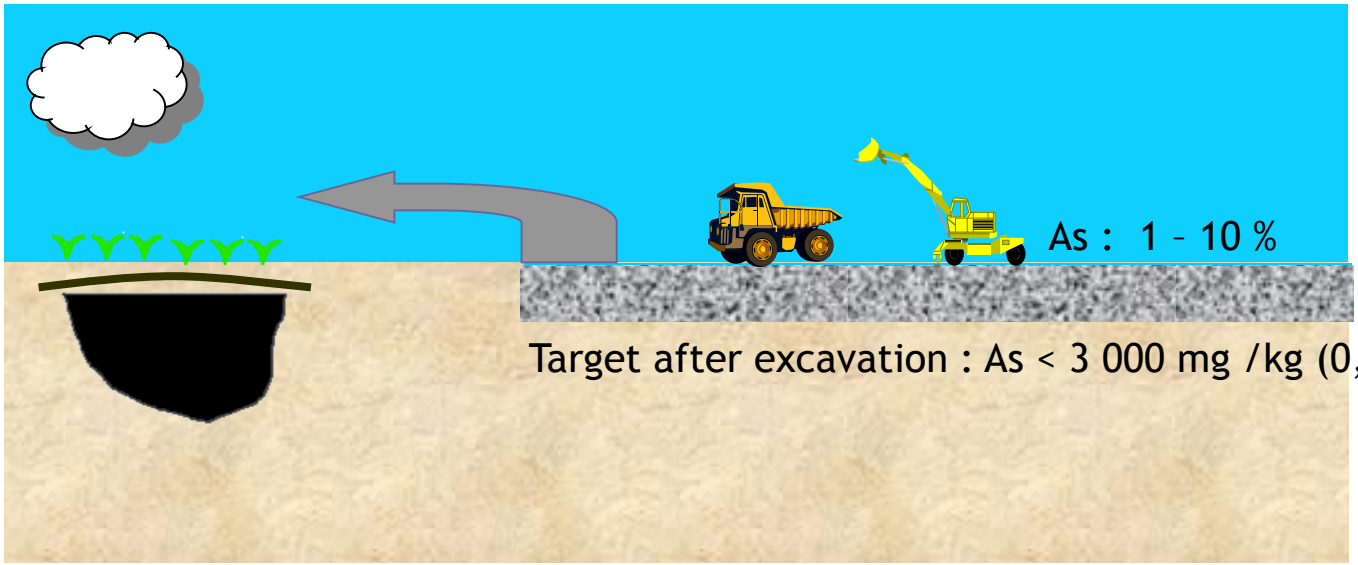
2001

2017
google



Other targets :

- Decrease infiltration
- Decrease dust emission


As : 1 – 10 %
Target after excavation : As < 3 000 mg /kg (0,3 %)

2002 Life Environment projet : Difpolmine
(IRH Environment,Hasselt University)

Phytostabilisation schedule

Without steel shots

2004

2006

Laboratory experiments

Selection amendment and seeds

Field plots 100 m^2

Large scale phytostabilisation

10 ha

With steel shots :

- Reduction of arsenic transfer by water
- Decrease of phytotoxicity

2005

Picture of the field plots in this area

2005

04 2017

Tools for full scale implementation

Spreading of steel shots

Mixing of steel shots

End 2005 :
after excavation

2008 : two years after seeding

2007 : one year after seeding
(Very low density of plants)

PHYTOPERF EVALUATION :

- Follow up the performance of the phytostabilisation technique applied in la Combe du Saut
- Understand the limitation factors

Phytoperf conclusions in 2012

- **Vegetal cover is badly developed and progresses very slowly.**
- It is **not due to arsenic phytotoxicity** of the soil, climatic conditions or the choice of the seeds.
- The principal responsible factor**: the micro-structure of the soil induced by the way the soil was handled** (The crushing of the soil)
- Induced very **strong resistance to penetration of water and plants**
- Illustrate the importance of the **soil preparation** prior to seeding in a phytostabilisation project

Recommendations :

- **Conduct very carefully lab experiments and in situ experiments**
- **At large scale, surface soil are often very poor (no farmland)**

➢ **Be careful of soil preparation**

➢ **Integrate an agronomical engineer**

10 years after implementation

2014 :
9 years
after seeding

2017 :
12 years
after seeding

2017 :
12 years
after seeding

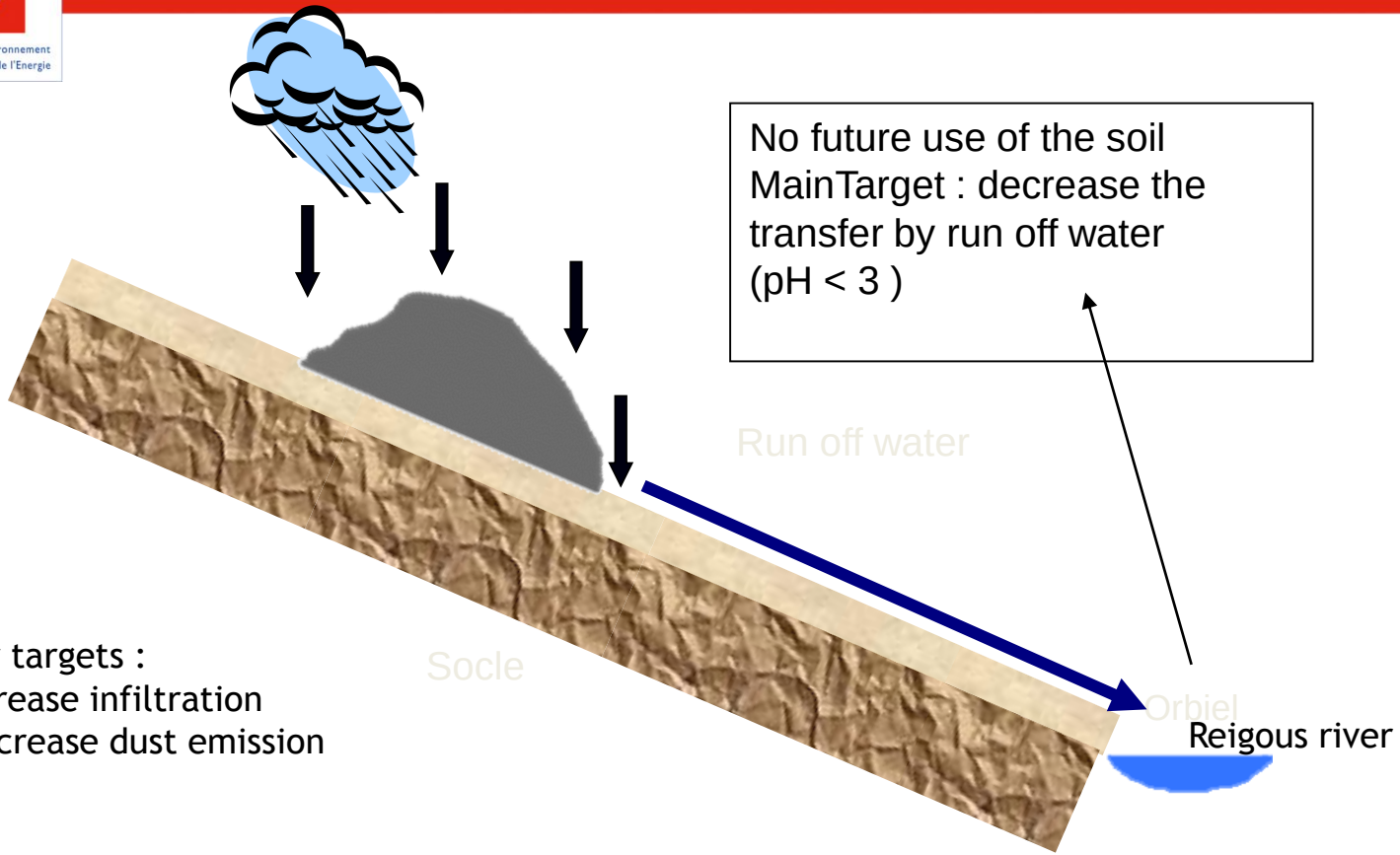
- Progressively, the density of plants is increasing
- There is a need for a new evaluation

Recommandation :
- You need time
- Be patient !

Carnoulès mine : example 2

- Silver and Lead production
- 1833 to 1963
- 1,2 million tons of ore
- Surface : 50 ha
- Soil are highly contaminated
  - Arsenic : 1000-2000 mg/kg
  - Lead : 30000-110000 mg/kg
- Acid Mine Drainage
- 3 years study (3 years 2016-2018)
  - TESORA/EAUGEO
    - Target : propose a global remediation program in 2019 (water and soil management)
  - LSTM/INRA/BPMP
    - Target : propose a phytostabilisation protocol
    - Lab and in situ experiments

Picture during the mine activity

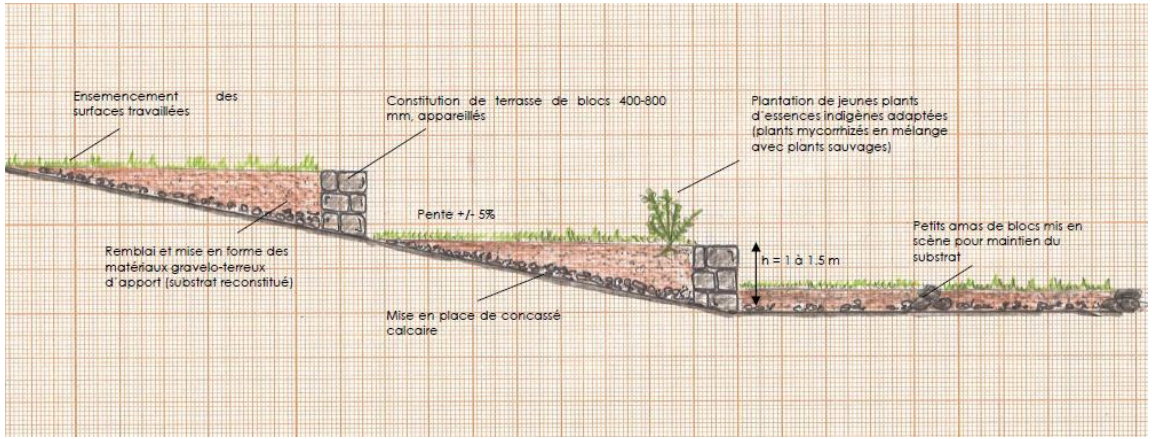


Other targets :

- Dcrease infiltration
- Decrease dust emission

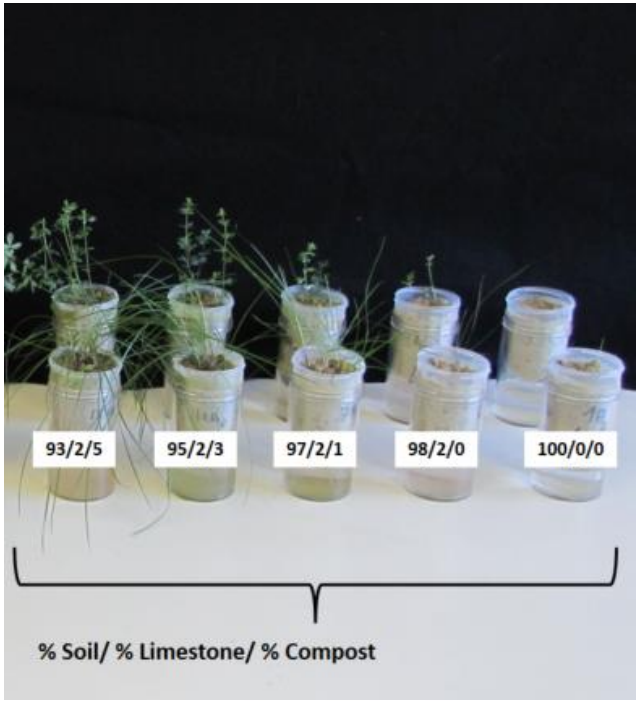
Project

- Create a new top soil + vegetation
  - limit acid mine drainage
  - reduce erosion
  - reduce transfer



BIOTEC (TESORA/EAUGEO)

Laboratory experiments



2016

Field experiments

04/2017

Les Avinières : example 3

- Zinc production
- 1875 to 1920
- Soil contamination (TESORA/EAUGEO)
  - Arsenic : mean = 1800 mg/kg
  - Lead : mean = 29600 mg/kg
  - Zinc : mean = 45 300 mg/kg
- Surface 3 ha

Target :

- Phytostabilisation of Avinière area in order to reduce dust emission and water erosion.
- Protocol : INRA/SUPAGRO research (2008-2015)

2017