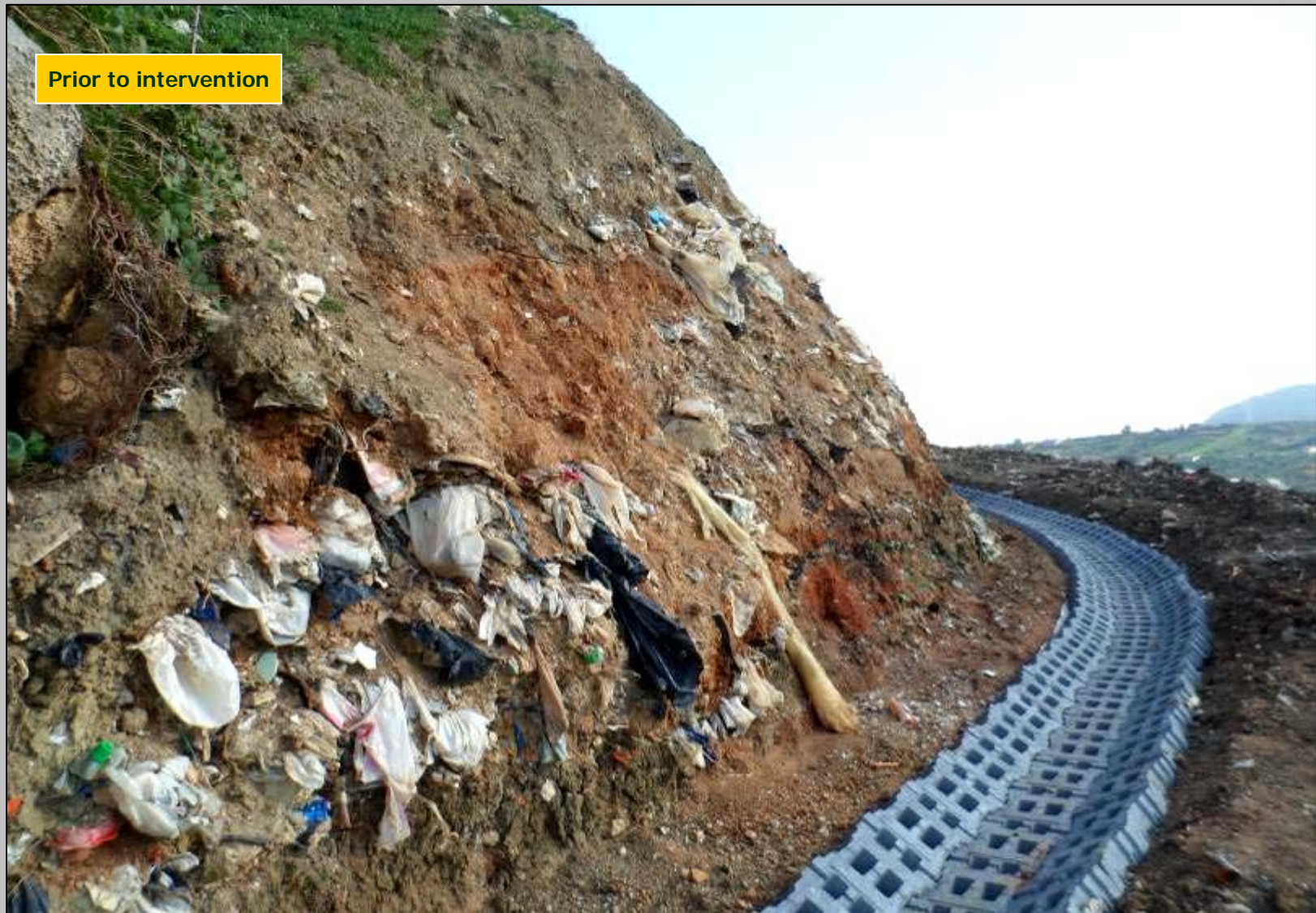


LOCATION	Northwest SICILY
TYPE OF SITE	SLOPE LANDFILL
INTERVENTION GOALS	<ol style="list-style-type: none"> 1. Blockage of water and wind erosion 2. Immobilisation of waste 3. Reduction of leachate production 4. Drastic reduction in costs and intervention time 5. Drastic reduction in intervention energy costs 6. Drastic reduction in pollutant emissions resulting from use of traditional techniques 7. Non-use materials and products in plastic, clay, topsoil, etc. for implementation of safety measures 8. Naturalisation with native species 9. Elimination of all post-plant maintenance
SIZE	Approx. 20,000 sq m
LITHOTYPE	Waste
INTERVENTION DATE	March 2012





"Ground" of landfill before sowing: a mixture of debris, glass bottles, cans, rusted iron, plastic sheets and bags: that which is most difficult for the normal growth of any type of vegetation

SLOPE LANDFILL in Sicily

Prior to intervention



SLOPE LANDFILL in Sicily

Prior to intervention



SLOPE LANDFILL in Sicily



The landfill before sowing. Note the completely sterile and barren ground



12 months later

SLOPE LANDFILL in Sicily

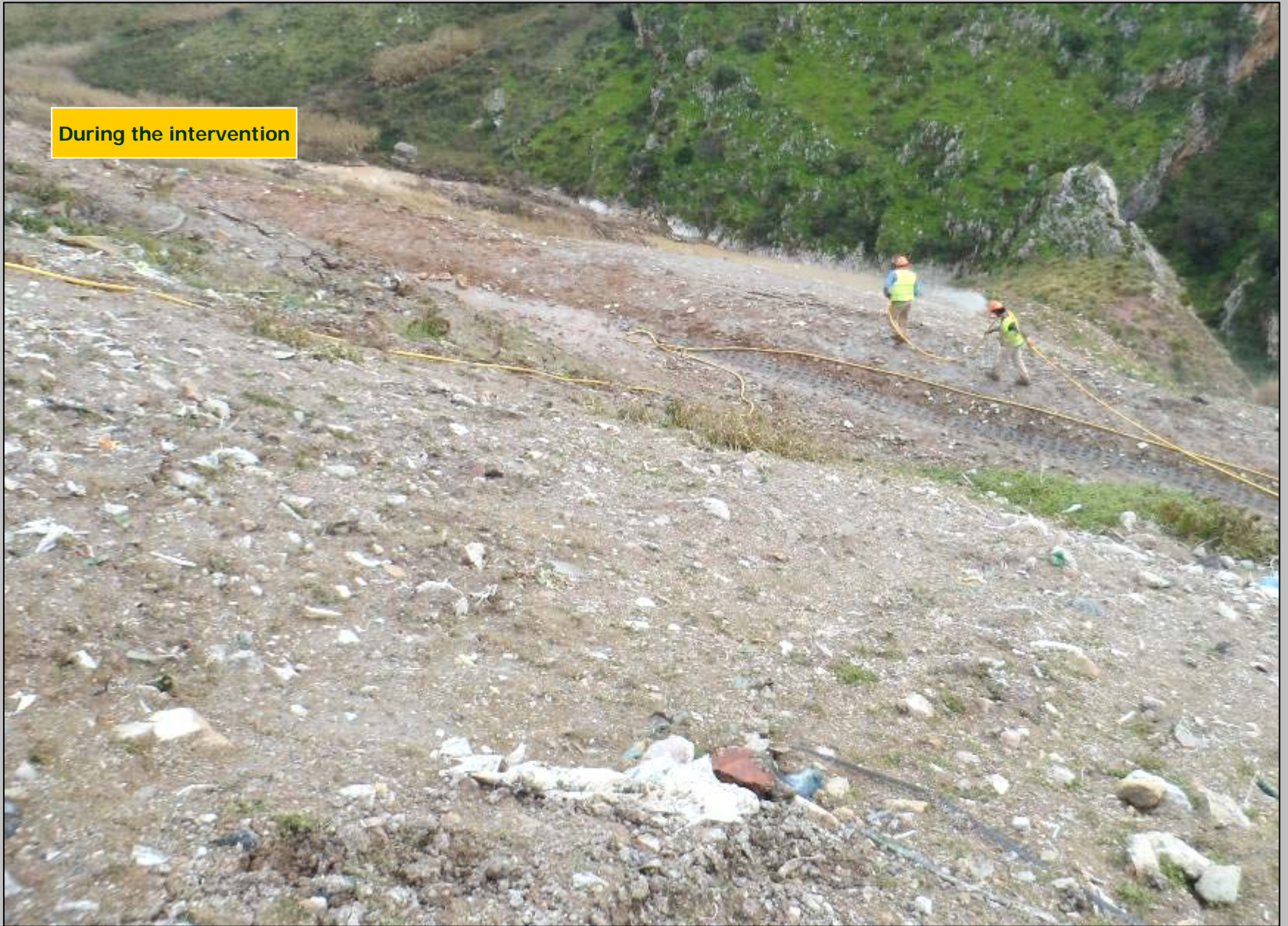
During the intervention





SLOPE LANDFILL in Sicily

During the intervention





12 months later

SLOPE LANDFILL in Sicily

Prior to intervention





12 months later

The excellent revegetation of the landfill about 12 months after the first hydroseeding intervention

A SIMPLE SOLUTION FOR A COMPLEX PROBLEM: DEEP-ROOTING HERBACEOUS PLANTS FOR IMPLEMENTING EMERGENCY SAFETY MEURES ON SLOPE LANDFILLS

Slope landfills are accumulations of waste dumped illegally in valleys or near slopes.

Waste of various types, nature and size, such as special waste, construction waste, excavation soil or polluted soil, MSW, etc., has accumulated over the years with a thickness of even tens of metres.

Given the age that these illegal dumps often have, and considering the old practices of cultivation, the production of biogas is almost nil, while the production of leachate is still active.

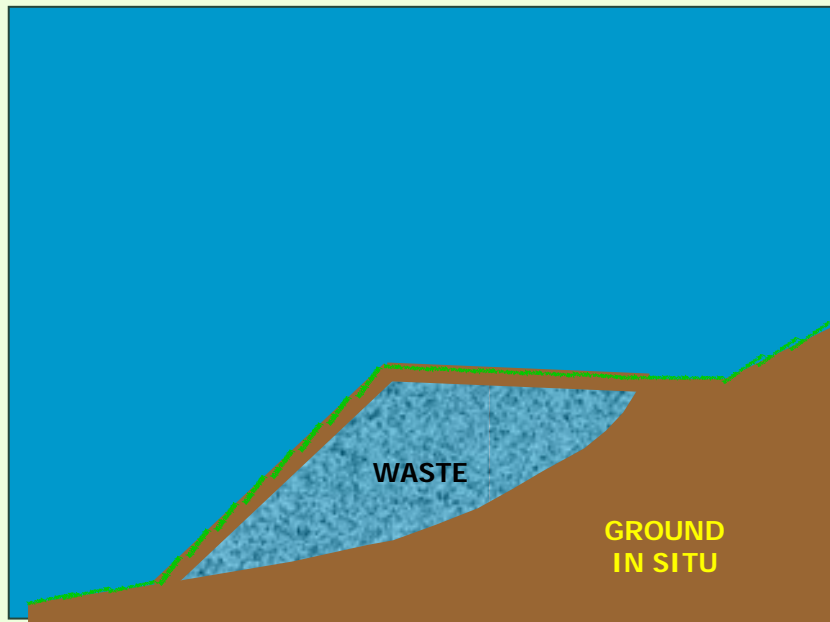


Diagram of slope landfill



Example of slope landfill

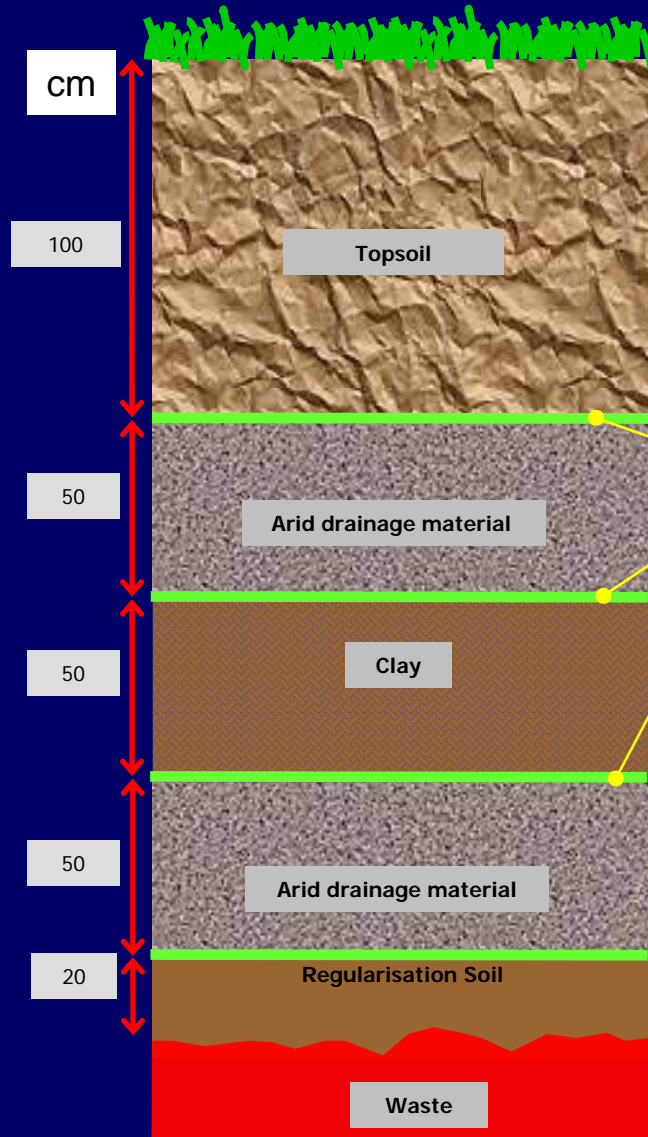
Environmental restoration of these sites is technically complex and expensive from both an economic and energy point of view. Given that full restoration is not possible, there is a trend to implement emergency safety measures with some targeted goals: prevent the addition of new material, isolate waste from the surrounding environment, decrease the production of leachate, mitigate the visual impact.

The most widely used solutions for rendering slope landfills secure so far have been:

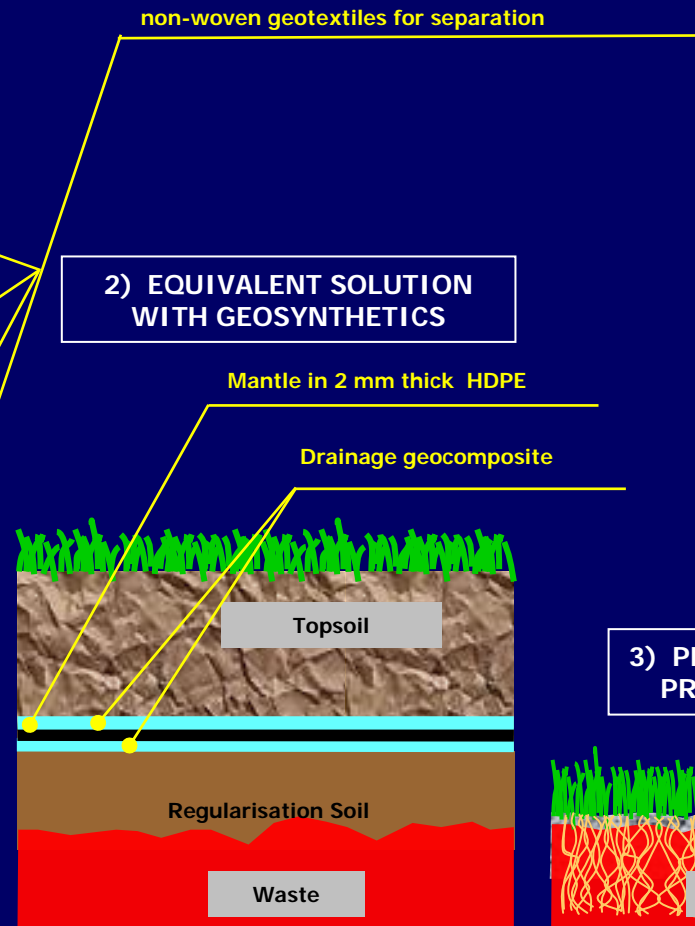
1. mineral waterproofing;
2. waterproofing with geosynthetics;

These have been joined in recent years by a particular plant solution that uses only deep-rooting herbaceous plants: PRATI ARMATI®.

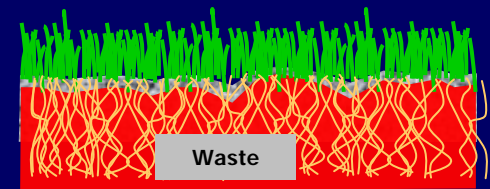
1) MINERAL WATERPROOFING (Legislative Decree No. 36/2003)



2) EQUIVALENT SOLUTION WITH GEOSYNTHETICS



3) PLANT SOLUTION PRATI ARMATI®



Different solutions for the waterproofing of slope landfills (Source: Eng. Ignazio Balsamo)

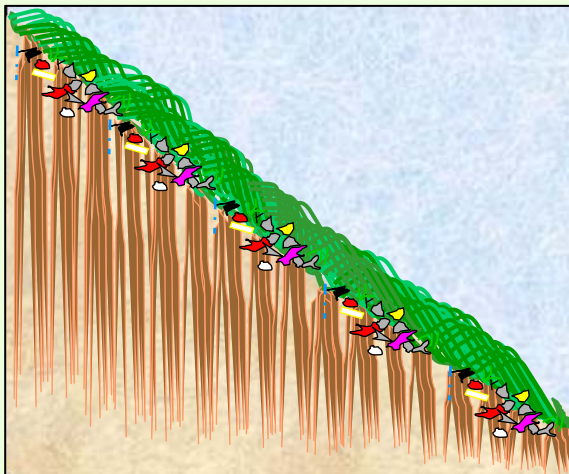
Mineral waterproofing and waterproofing with geosynthetics are often neither convenient nor effective: interventions are lengthy, expensive, dangerous and complex, if not downright impossible to accomplish, especially on steep slopes.

On the other hand, traditional herbaceous, shrubby or arboreal species:

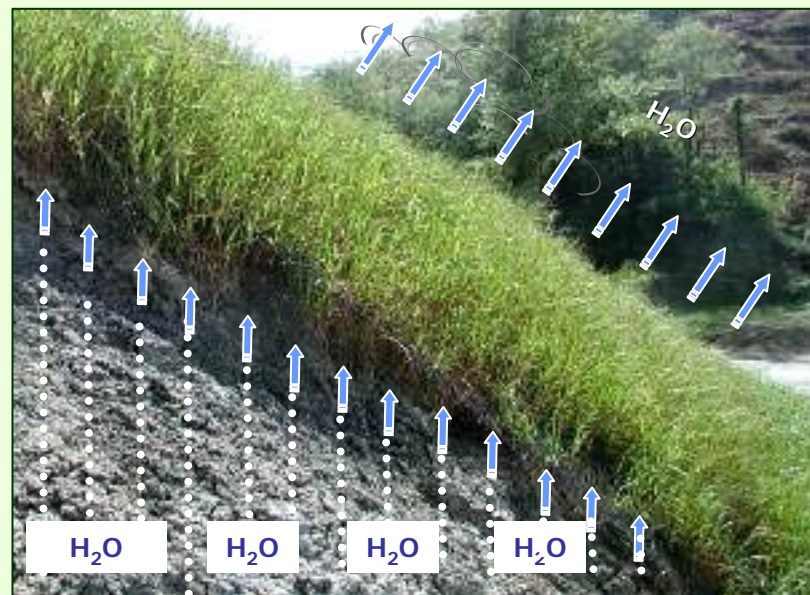
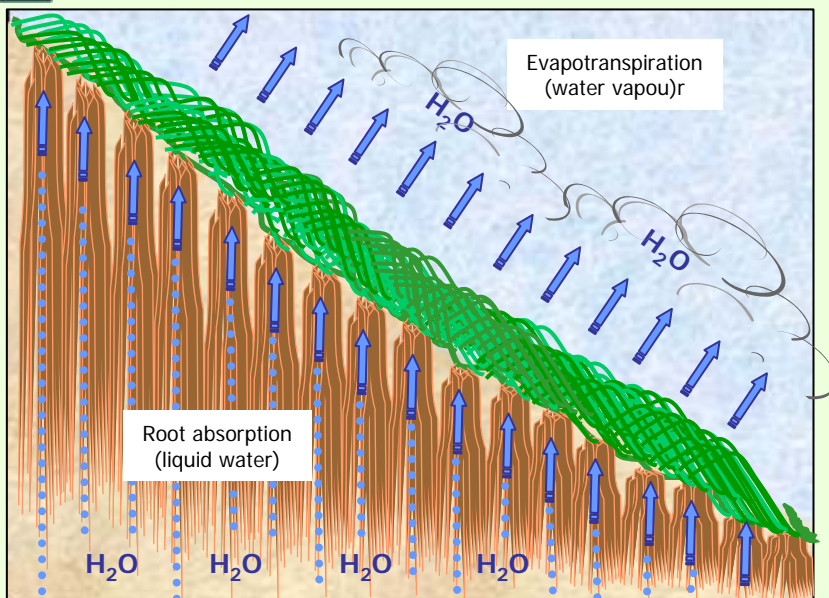
- do not seal the slope: water penetrates deeply, increasing the production of leachate;
- are unable to take root and vegetate in conditions of drought and pollution;
- do not curb waste outcrops.

Deep-Rooting Herbaceous Species (such as those used in PRATI ARMATI®) can, instead, provide a fast, economical and safe solution for implementing emergency safety measures for these landfills. These interventions (see Ministerial Decree No. 471/99) fall into the category of "in situ" techniques, that is, without handling or removal of contaminated soil and waste. In fact, PRATI ARMATI®:

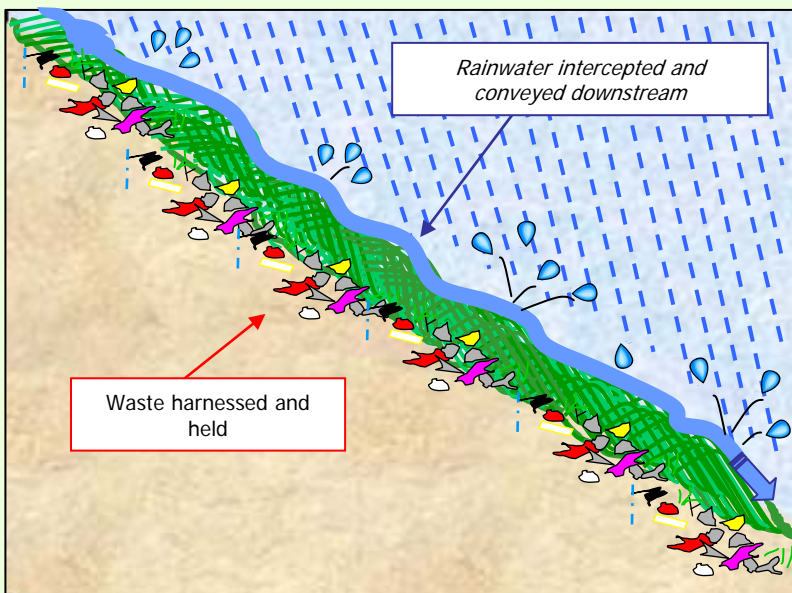
- even grow on sterile soils and those heavily polluted by heavy metals, hydrocarbons and waste;
- increase the shear strength of the soil and its safety factor;
- reduce wind and water erosion and the consequent dispersion of pollutants;
- reduce the drag downstream of waste outcrops, which are incorporated into the vegetation cover: they thus isolate the waste from the external environment;
- they reduce the production of leachate in landfills due to:
 - major reduction of infiltration of stormwater due to runoff above the herbaceous layer folded to the ground;
 - the intense transpiration capacity of these plants;
- giving a green and natural look to the landfill, improving the visual impact.



The deep roots of PRATI ARMATI® harness the soil and retain waste.
Plants are not affected by phytotoxic conditions present in situ.



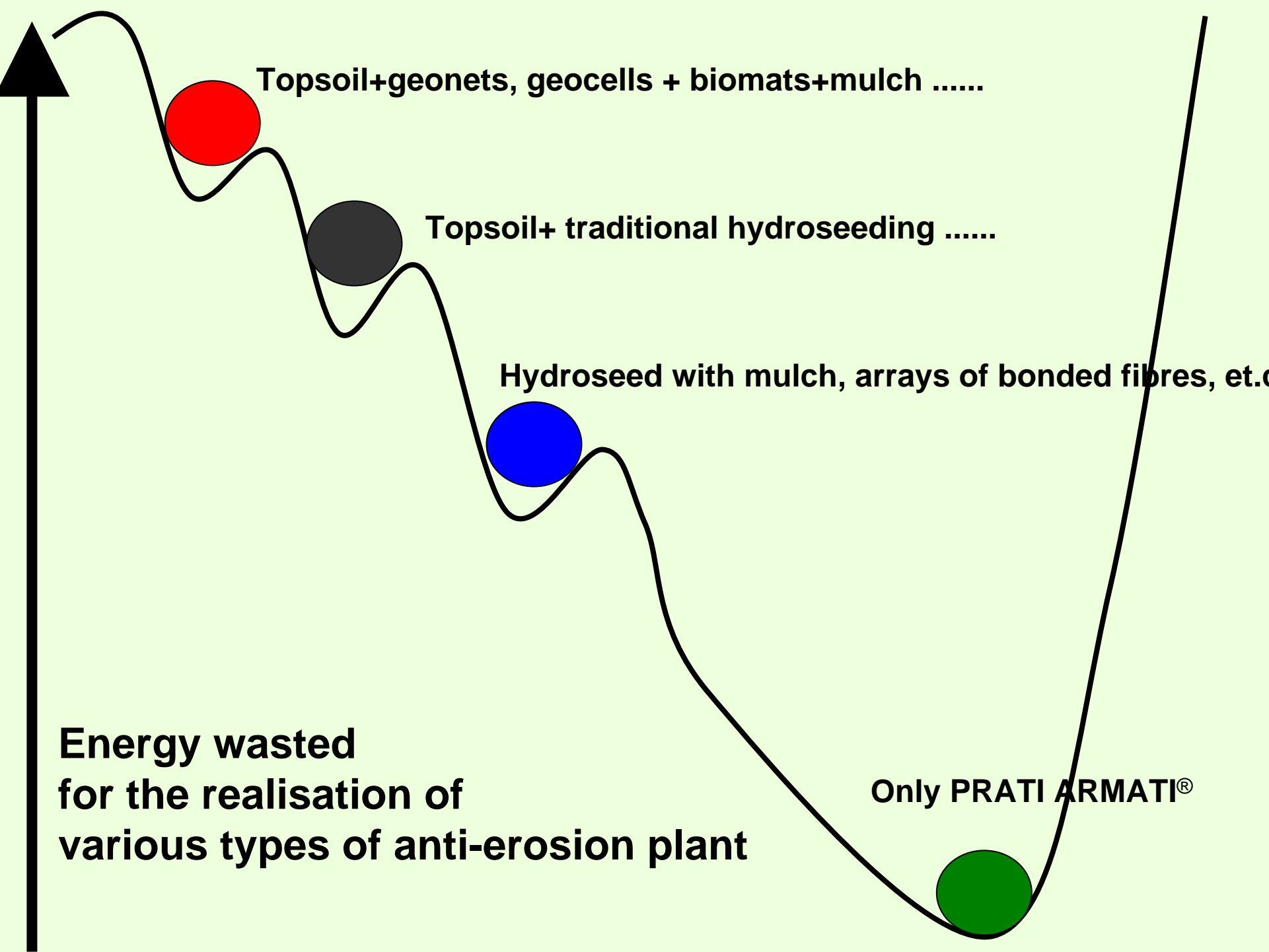
Transpiration: water absorbed by the roots is transferred to the atmosphere through the plant as steam: in this way, the fraction of water that penetrates and feeds the production of leachate decreases.



PRATI ARMATI® on slope landfill: slope sealed, lower leachate production, waste harnessed

COMPARISON OF DIFFERENT WATERPROOFING SOLUTIONS

CHARACTERISTICS	MINERAL SOLUTION	SOLUTION USING GEOSYNTHETICS	PLANT SOLUTION PRATI ARMATI®
Thickness of materials used (plastic, clay, etc.)	Very High	High	Null
Increase in shear resistance	Null	Null	High
Waterproofing	High	High	High
Reduction of water saturation	Null	Null	High
Influence on slope stability	Null	Null	High
Landscape Appearance	Very Negative	Very Negative	Very Positive
Duration of solution	Limited	Average	Long-Unlimited
Environmental value of site after treatment	Null	Null	Very Good
Time Frames	Very Long	Long	Very Short
Resource Consumption	Very High	Very High	Very Limited
Operational status of solution	Difficult or Impossible	Very difficult	Very simple
Production of greenhouse gases and other emissions (CO, NOx, SOx, PM)	Very High	Very High	Very Low
Need for topsoil	Yes	Yes	No
Maintenance costs	High	High	Null
Environmental impact	High negative	High negative	Positive-Improvement
Subtration of CO ₂	Null	Null	Very high (up to 400% more than in traditional grassing)



POLITECNICO of MILANO

energy and pollution analysis for various anti-erosion solutions (reference surface: 1 ha = approx. 10,000 sq m)

7.3 Results of case study: SLOPE LANDFILL

7.3.1 Comparison of energy needs and pollution produced by the rehabilitation of 1 ha of slope landfill

We compared the energy requirements (expressed in GJ) and pollution emissions (CO₂, CO, NO_x, SO_x and PM), analysing the following three solutions:

- mineral solution;
- solution using geocomposite;
- solution using deep-rooting plants by PRATI ARMATI® (RP)

1,000 GJ correspond to the energy contained in 25 tons of oil.

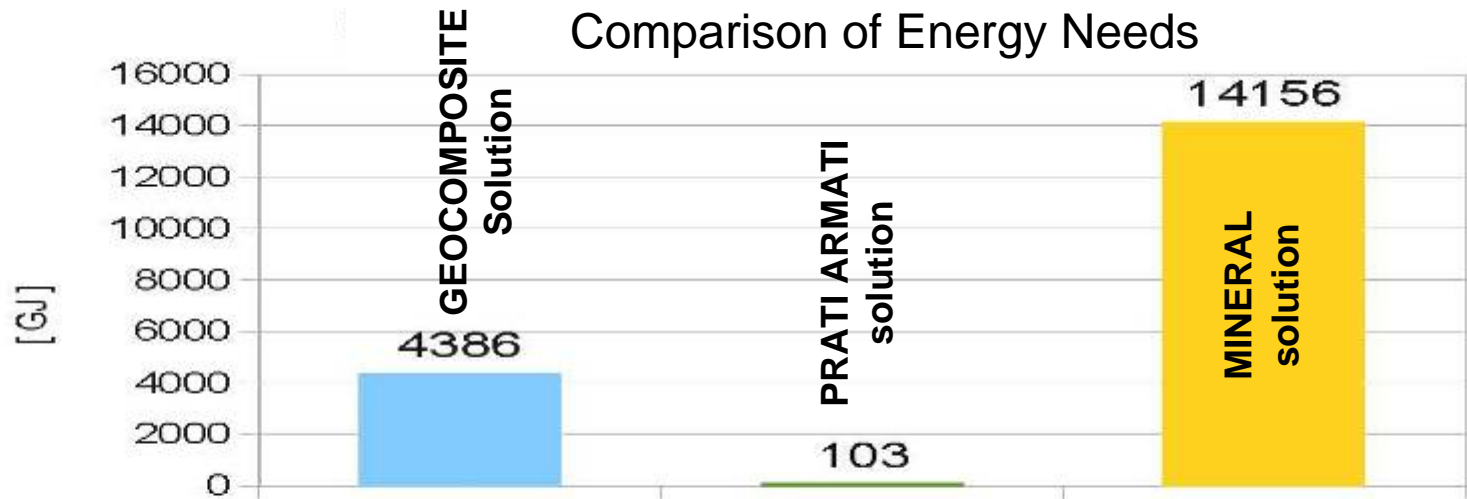


Figure 31: Comparison of energy needs required by the different solutions

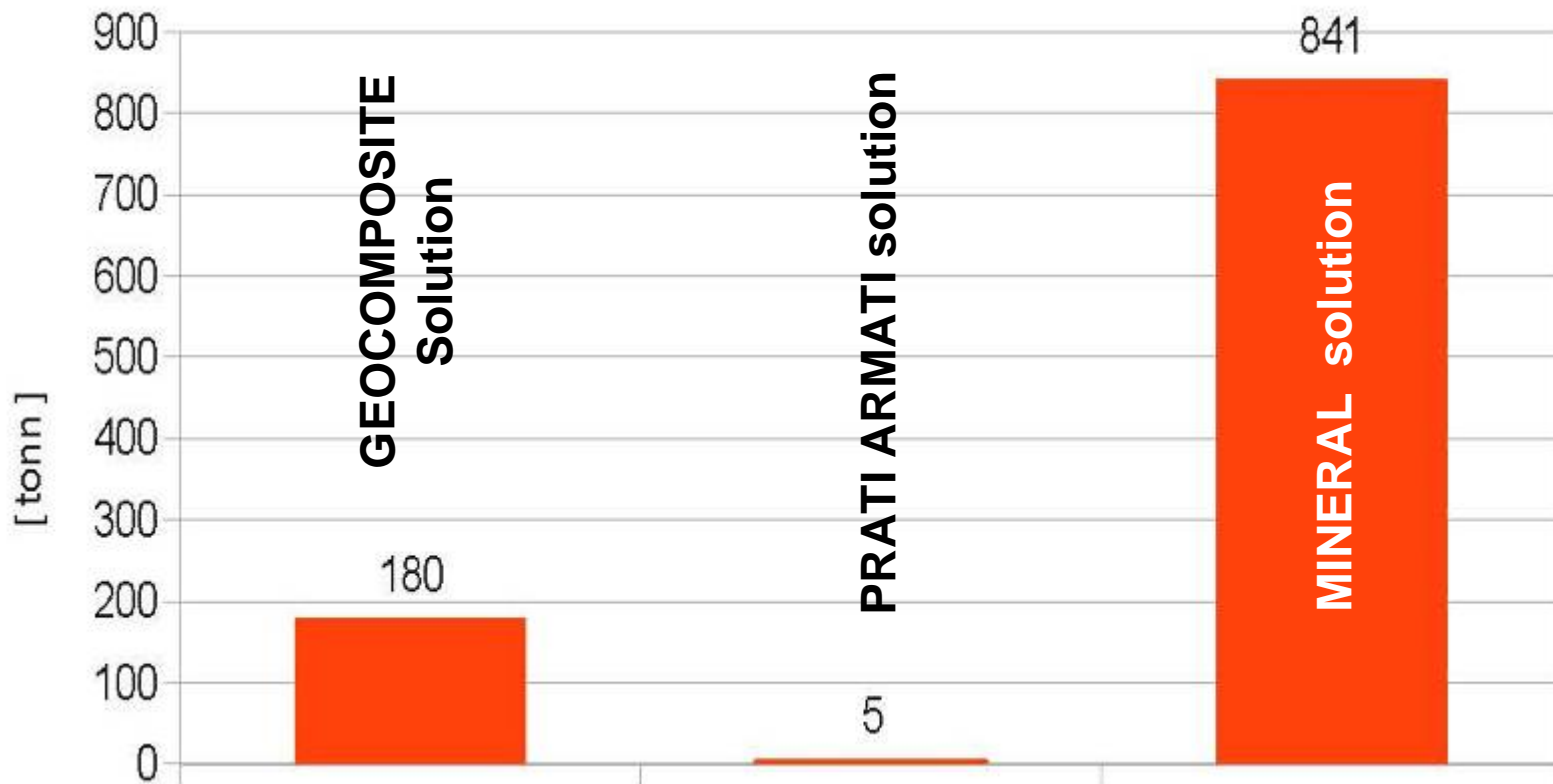


Figure 35: Comparison of CO₂ emissions for the three solutions

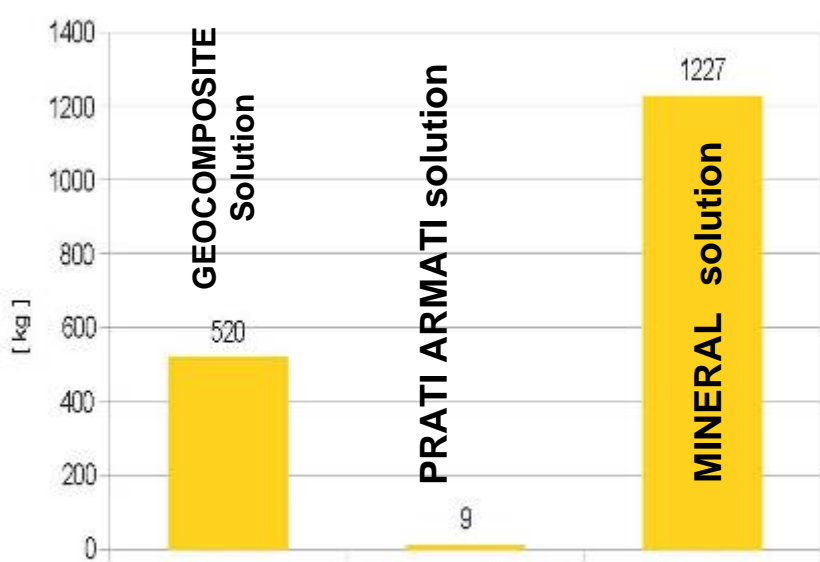


Figure 39: Comparison of CO emissions

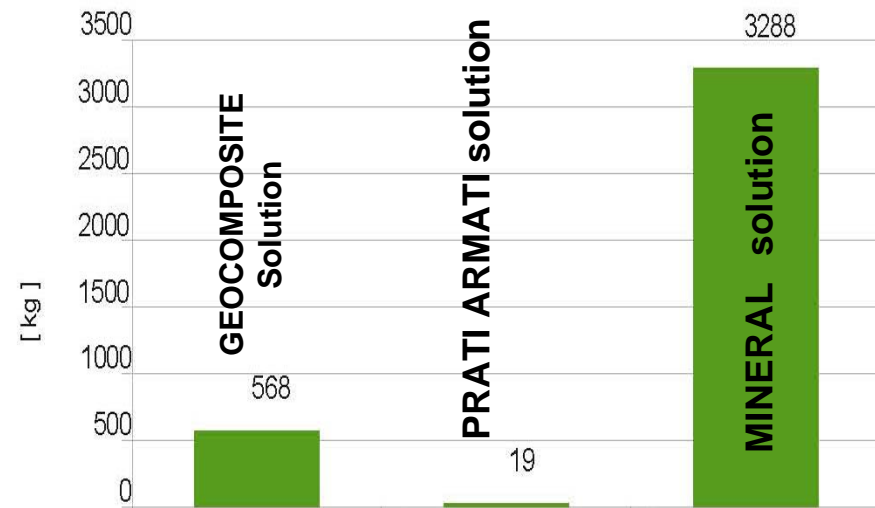


Figure 43: Comparison of NO_x emissions

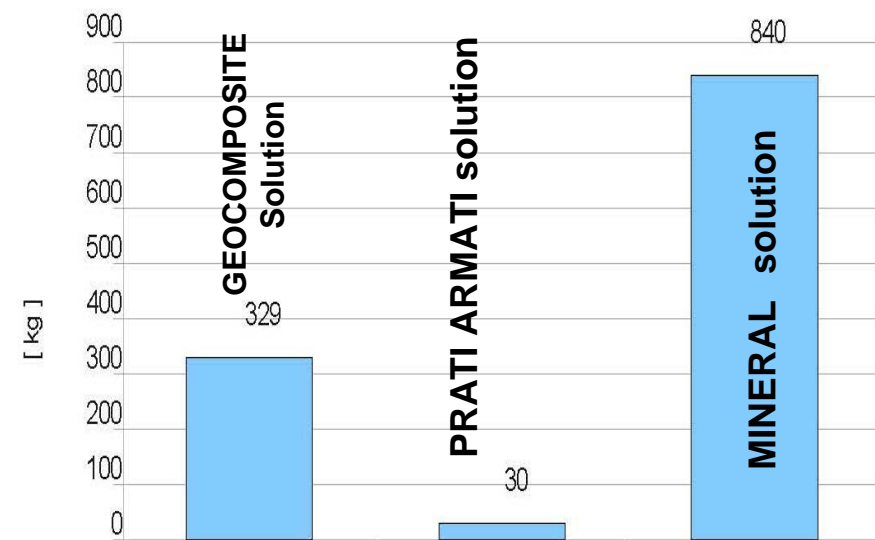


Figure 44: Comparison of SO_x emissions

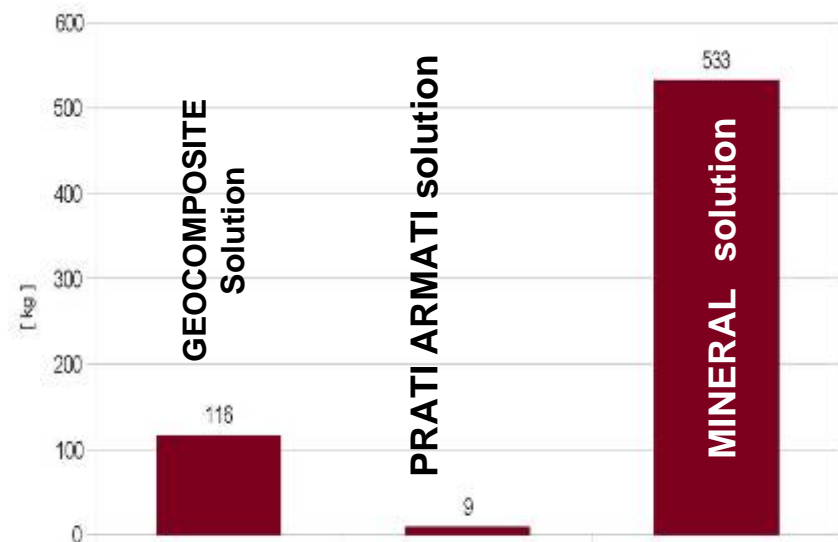
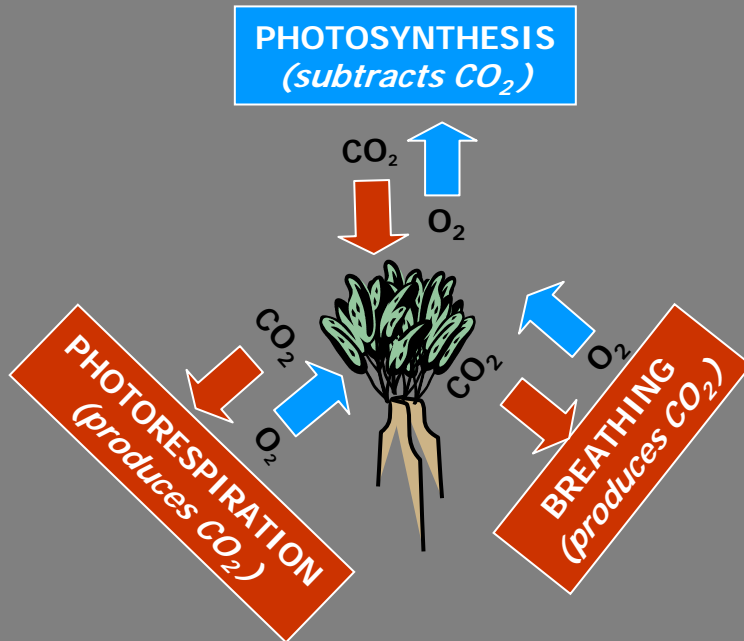


Figure 45: Comparison of PM emissions

PRATI ARMATI® absorbs up to 400% more CO₂ than most common traditional plants

TRADITIONAL PLANTS

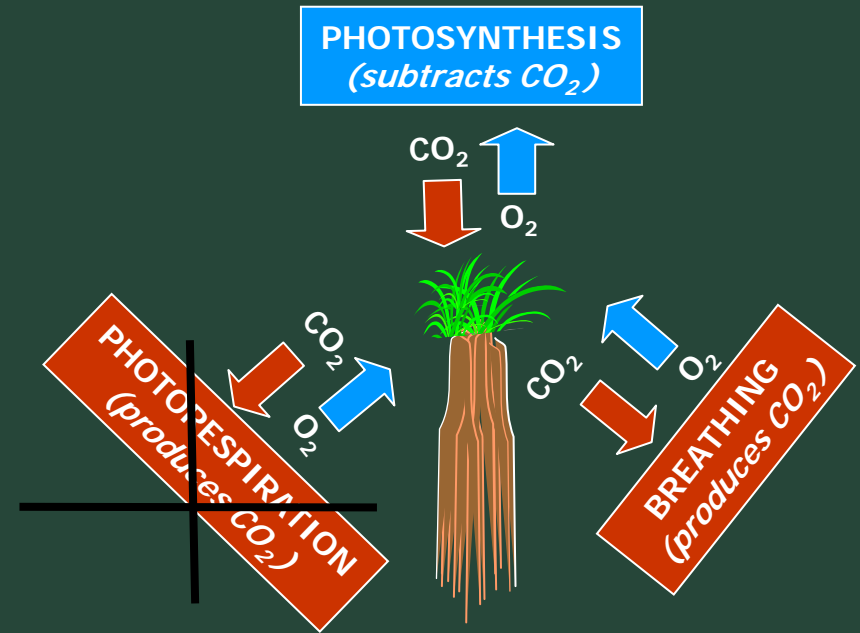


In these plants both breathing and photorespiration mechanisms are present.

Photorespiration may reduce photosynthesis by 50%

Photosynthesis is deactivated by high temperature and luminosity

PRATI ARMATI®



PRATI ARMATI® is much more efficient than traditional plants thanks to:

- better efficiency of photosynthesis
- resistance to arid climates
- tolerance of salty soil
- quick growth in prohibitive conditions

Photosynthesis is not deactivated by high temperature and luminosity

PRATI ARMATI® may store *up to* 400% more carbon dioxide (CO₂) than most common grassy plants used in traditional applications, thus contributing to the implementation of Kyoto Protocol

KIND OF GROUNDCOVER	TONS OF CO ₂ ABSORBED PER HECTARE EACH YEAR (t/ha/year)
Temperate deciduous forest (plants C3)	20
Temperate grassland (plants C3)	8
<i>Annual</i> corn plantation (plants C4):	41,5
<i>Perennial</i> PRATI ARMATI® anti- erosion groundcover (plants C4)	up to 40

CO₂ absorbing capability of different groundcovers, measured in tons per hectare per year