Valorization of non-toxic organic wastes and the Application of Technosols in soil remediation strategies

Centro de Valorización Ambiental del Norte, S.L.
Universidad de Santiago de Compostela
\[ 2S_2Fe + 7O_2 + 2H_2O \Leftrightarrow 2Fe^{+2} + 4SO_4^= + 4H^+ \]

\[ Fe^{+2} + 3H_2O \Leftrightarrow 3Fe(OH)_3 + 3H^+ \]

\[ S_2Fe + 14Fe^{+3} + 8H_2O \Leftrightarrow 15Fe^{+2} + 2SO_4^= + 16H^+ \]
What if we thought about making an integrated environmental management procedures in place to look for waste disposal?

- It is to return the items to the natural biogeochemical cycles, with health guarantee, fast and, if possible, solving other environmental problems through the use of the positive aspects of waste in each situation.
About us

Centro de Valorización Ambiental del Norte, S.L.

- Young company, created in 2012.
- Our installations are located in the old Mines of Riotinto in Touro - La Coruña. We began our activity in September 2013.
- The R&D linked to the recovery of waste, to the minimization of impacts and the implementation of systems for bioremediation are gathered in our foundational objective.

What is a Technosol?

- Solid mixture of natural or synthetic materials, mineral or organic, which is placed on the surface, allows rapid integration of anthro-geomorphic residual components in biogeochemical cycles as well as compliance with environmental and productive functions of the soil, improving the environmental situation preceding (Macías, 2004, 2007).

- Technosols waste derived ecotoxicity shall be free and have structural characteristics and nutritional quality to ensure their medium, minimizing environmental hazards and health and hygiene from their application, (ITR01/08).
Waste-derived Technosols must meet the ecological functions of soils

1) Food and biomass production.
2) Storing, filtering and transformation.
3) Habitat and gene pool.
4) Physical and cultural environment for mankind.
5) Source of raw material.

Furthermore, these features must be adapted to the conditions in the area of use to improve existing conditions.
Some possible objectives

Technosols can be made on demand to solve environmental problems and pollution

• Stabilize labile organic carbon.

• Immobilize heavy metals and/or toxic anions

• Balancing nutrients in degraded half
Technosol

1) Mineralogical composition and biogeochemical properties suitable.
   • Polluting processes neutralize acid-base characteristics.
   • Reducing capacity / oxidant depending on the type of problem.
   • Complexing Ability.
     Submit reactive surfaces capable of anion adsorption reactions / cations.
2) adequate physical properties (porosity, texture, ...). Water holding capacity, pore structure with formation of stable aggregates.
3) Capacity stabilization of C.
4) Adequate soil life.
5) No ecotoxicology.
6) Ability to evolve in soil processes.

Wanted

1. Solve the management of waste through recovery and the recovery of degraded or contaminated on an affordable and environmentally correct.
2. Eliminate or greatly reduce waste impacts on sensitive systems (water, air and biota).
3. To stabilize carbon in soils and biomass.
4. Recycling nitrogen, phosphorus, potassium and other macro and micronutrients.
5. Comply with the productive and environmental functions in accordance with the European strategy on soil protection.
PHASE 1. - Degraded slope.

PHASE 2. - Slope with Technosol.

PHASE 3. - Restored slope.

Excavation platform

Reactive WETLANDS with Technosols

Degraded tip

Recuperated tip.

Tip WITH and WITHOUT Technosols.

Recuperated tip.
### Comparison between the initial and Technosols

<table>
<thead>
<tr>
<th></th>
<th>Initial Mine Soil</th>
<th>Common Technosol Touro mine</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2.8</td>
<td>8-10</td>
</tr>
<tr>
<td>% C</td>
<td>&lt;0.01</td>
<td>2-10</td>
</tr>
<tr>
<td>% N</td>
<td>&lt;0.01</td>
<td>0.2-1.0</td>
</tr>
<tr>
<td>% Spiritic</td>
<td>2-3</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Acid neutralizing</td>
<td>Null</td>
<td>Very high</td>
</tr>
<tr>
<td>capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Extremophiles</td>
<td>High</td>
</tr>
<tr>
<td>Toxiciety</td>
<td>Very high (H⁺, Al, SO₄⁻)</td>
<td>Null</td>
</tr>
<tr>
<td>Productivity</td>
<td>Null</td>
<td>Normal-High</td>
</tr>
</tbody>
</table>
Technosols (6 years)

Original soil vegetation (9 years)
In which soil can be used Technosols

- Recovery of contaminated soils, quarries, mines and contaminated industrial and urban environments and/or degraded. Erosion control.
- Complement the previously stacked topsoil soil restoration activities, landfills, ...
- Substitute for peat and topsoil sealing work or land reclamation works affected by urban, industrial, infrastructure, etc..
- High intensity forest crops (eucalyptus, poplar, ...)
- Timber production forests.
- Agricultural soils in the process of degradation of surface horizons pollution, impoverishment, loss of organic matter and fertility, excessive tillage, compaction and loss of structure, ...
- Forced crop soils with high nutrient demand.
What soil should not be used compost or refuse derived Technosols?

- Protected areas or natural and scenic interest.
- Highly sensitive soils very susceptible to change its properties: fens, marshes and fens, hydromorphic soils, Podzols, Gypsisols ...
- Unique soils to be protected as a heritage edafogenético: Some Vertisols, Mollisols, Podzols, Calcisols, Ferralsols, Andosols, Ultisols and Alfisols red ..
- Climax forests.
- Natural grasslands.
The spontaneous growth shows no ecotoxicity.
Environmental benefits of using waste-derived Technosols

- Recovery of degraded soils and/or contaminated.
- Minimization of waste landfilled or treatment plant.
- Quick integration in biogeochemical cycles.
- Saving natural resources as "topsoil", peat, ... in land reclamation work, landfill sealing, ....
- Reduction of waste management costs while minimizing energy costs and waste storage.
- Increased utilization of nutrients (N, P, K, Mg, Ca, ...) existing in incorporating waste the food chain and soils with lower costs of fertilizer and amendment for.
- Significant increase in soil carbon sequestration and biomass they support.
- Increased biological activity and biodiversity in degraded soils or in areas where soil has been removed.
- Enhancement of the landscape by increasing the area revegetated and protected from erosion.
- Improving the quality of surface water and groundwater to recover buffer functions, filter and purification of soil themselves.
- Increased resistance to the risks arising from contamination.
- No new waste produced as other management techniques. Integrated process.
Slideshow where you can see the improvement obtained over the years in the Touro mine
Reactive Wetlands with Technosols
Reactive Wetlands with Technosols

- Alkaline Technosol
- Reductive Technosol
- Impermeable
- Nutrient
- Acid mine drainage
- Reactive Wetlands with Technosols
Reactive Wetlands with Technosols
<table>
<thead>
<tr>
<th></th>
<th>EXIT</th>
<th>MIDDLE</th>
<th>AMD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td>H₂O</td>
<td>7.79</td>
<td>4.83</td>
</tr>
<tr>
<td><strong>C.E.</strong></td>
<td>mS·cm⁻¹</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>SO₄²⁻</strong></td>
<td>mg·L⁻¹</td>
<td>1435.5</td>
<td>1958.5</td>
</tr>
<tr>
<td><strong>NO₃⁻</strong></td>
<td>mg·L⁻¹</td>
<td>9,4639</td>
<td>4,09</td>
</tr>
<tr>
<td><strong>Cl⁻</strong></td>
<td>mg·L⁻¹</td>
<td>111.97</td>
<td>42,649</td>
</tr>
<tr>
<td><strong>PO₄³⁻</strong></td>
<td>mg·L⁻¹</td>
<td>0.1258</td>
<td>0.1915</td>
</tr>
<tr>
<td><strong>Al</strong></td>
<td>mg·L⁻¹</td>
<td>0.077</td>
<td>2,112</td>
</tr>
<tr>
<td><strong>Fe</strong></td>
<td>mg·L⁻¹</td>
<td>&lt;0.05</td>
<td>0.066</td>
</tr>
<tr>
<td><strong>Cu</strong></td>
<td>mg·L⁻¹</td>
<td>0.31</td>
<td>4.42</td>
</tr>
<tr>
<td><strong>Mn</strong></td>
<td>mg·L⁻¹</td>
<td>3.36</td>
<td>14.95</td>
</tr>
<tr>
<td><strong>Ni</strong></td>
<td>mg·L⁻¹</td>
<td>0.21</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Pb</strong></td>
<td>mg·L⁻¹</td>
<td>&lt;0.50</td>
<td>&lt;0.50</td>
</tr>
<tr>
<td><strong>Zn</strong></td>
<td>mg·L⁻¹</td>
<td>0.06</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Cd</strong></td>
<td>µg·L⁻¹</td>
<td>1.84</td>
<td>7.81</td>
</tr>
<tr>
<td><strong>As</strong></td>
<td>µg·L⁻¹</td>
<td>7.54</td>
<td>2.12</td>
</tr>
<tr>
<td><strong>Ca</strong></td>
<td>mg·L⁻¹</td>
<td>480</td>
<td>262,5</td>
</tr>
<tr>
<td><strong>Mg</strong></td>
<td>mg·L⁻¹</td>
<td>90</td>
<td>117,5</td>
</tr>
</tbody>
</table>
Biodiversity

Athericidae
Ephemeroptero
Ryacophilidae
Gerridae
Baetidae
Odonatos
Biodiversity

We have created a food chain where none existed before and that space was so degraded that there were not even insects. To remedy the conditions applying Technosols has been gradually colonized by different organisms until predators such as foxes and birds of prey. There are also rabbits and other species of birds such as quail, ducks, herons, ...

Spontaneous colonizing plants. Technosol colonize and create biodiversity. They are usually annuals that are modified as the Technosol is maturing and changing their characteristics in terms of nutrients, pH, etc.
Despite the concrete projected spots are observed characteristics of acidic water with Fe precipitates.
Solutions for Civil construction.

A8 Slope Vertical Technosol

Dump of El Espiño. AVE Line. A Gudiña

Growth of vegetation

Technosols

Dump of Cerdedelo. AVE Line. Laza
Solutions for Agrifood Industries.

August 2012

Wetland

June 2014

Reactive Wetland with Technosols

August 2015

Extension of Reactive Wetland with Technosols
<table>
<thead>
<tr>
<th>Project</th>
<th>Year</th>
<th>Financed by</th>
<th>Colaborator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of new mycorrhizal fungi and mycotoxins to the bioremediation of disturbed soils contaminated by shale mining for their rehabilitation as productive ecosystems. (MICOTECHNOSOLS II)</td>
<td>2016-2018</td>
<td>Axencia Galega de Innovación-Xunta de Galicia.</td>
<td>Lab. Tecnología Ambiental – USC</td>
</tr>
<tr>
<td>Sustainable valorisation of vitivinicultural waste. (UVATEC)</td>
<td>2016-2018</td>
<td>Axencia Galega de Innovación-Xunta de Galicia.</td>
<td>Centro Tecnológico AIMEN</td>
</tr>
</tbody>
</table>
CONCLUSIONS

• It is possible to develop "Technosols a la carte" adequate to solve the various problems posed by mines or others sites.

• Technosols, properly designed, meet the environmental and productive functions of soils. They are means of life, soil processes are evolving in terms of training factors which are under and can solve several environmental problems simultaneously. Among others, the waste-derived Technosols are:
  – A new alternative for recovery of waste biogeochemistry rapid integration of nutrients in natural cycles with health guarantee.
  – An aid to climate forcing by setting C and N in biomass Technosol and minimizing the loss to the atmosphere.
  – Control the mobility and bioavailability of heavy metals, Al, As, and other organic and inorganic contaminants.
  – A quick system to recovery the production capacity and restores the environment affected soil and water.
  – Erosion control,…