Landfill Leachate Treatment by the Active Clay Sediments Process

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Typical landfill cross section
Leachate Collection and Drainage System

- Waste
- Drainage Layer
- Geomembrane Liner
- Leachate Collection Pipe
Drainage system
Landfill leachate
Typical characteristics of landfill leachate

- High COD (up to 30,000 mg/L)
- Low BOD$_5$/COD ratio (0.4-0.1)
- High concentration of ammonia (up to 2,000 mg/L)
- Moderate concentration TSS (up to 800 mg/L)
- Moderate concentration of phosphate
- High concentration of heavy metals
- High conductivity (up to 50,000 μS/cm)
- Close to neutral pH
- Dark color

Characteristics depend on the landfilling stage
Common treatment practices

Activated sludge
Coagulation/flocculation
Membrane bioreactors
Chemical oxidation
Reverse osmosis
Landfill leachate

Usually, combinations of the above are employed

Non of the above or even combinations are effective

Some processes generate recalcitrant by-products (e.g. RO concentrate)
Geopolymers

Geopolymers (active clay sediments):
Three-dimensionally cross-linking alumininosilicates amorphous inorganic materials
Consist of various inorganic repeating units, such as:
silico-oxide (-Si-O-Si-O-)
silico-aluminate (-Si-O-Al-O-)
ferro-silico-aluminate (-Fe-O-Si-O-Al-O-)
alumino-phosphate (-Al-O-P-O-)

Geopolymerisation:
A relatively complex reaction (polycondensation) between aluminosilicate-containing powders (e.g. fly ashes and/or reactive clays) with alkali metal silicates or hydroxides
Uses of geopolymers:

- Binding materials
- Ceramics
- Arts and decoration
- Restoration of archeological findings
- Fire resistance materials
- Adsorption/encapsulation of wastes

Use of geopolymers for wastewater treatment:

- Irreversible adsorption of a large spectra of wastes (organic, inorganic, heavy metals)
- Can be structured so to be adsorption-selective (eg: for heavy metals, organic wastes, radioactive wastes, etc)
Geopolymer
Landfill leachate wastewater treatment using active clays sentiments (geopolymers)

- Flow equalization
- pH adjustment
- Coagulation- flocculation
- Removal of solids (filtration)
- Chemical oxidation
- Adsorption on geopolymer-coagulation-flocculation
- Removal of sediment (clarification)
- Filtration of supernatant
- Equalization
- Reduction of conductivity (reverse osmosis)
- Disinfection
- Sludge dewatering
Process diagram for landfill leachate treatment
Visual observation at various stages of treatment

Experiments have been performed at lab scale

(a) Raw landfill leachate
(b) After coagulation-filtration
(c) After chemical oxidation,
(d) After geochemical reaction
(e) After reverse osmosis

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Treatment efficiency stage by stage: COD and BOD$_5$
Treatment efficiency stage by stage: TSS and conductivity

- **TSS**
  - Inlet: 500 mg/L
  - Primary filtration: 100 mg/L
  - Chemical oxidation: 50 mg/L
  - Geochemical reaction: 20 mg/L
  - Final filtration: 5 mg/L
  - Reverse osmosis: 1 mg/L

- **Conductivity**
  - Inlet: 35,000 μS/cm
  - Primary filtration: 35,000 μS/cm
  - Chemical oxidation: 35,000 μS/cm
  - Geochemical reaction: 35,000 μS/cm
  - Final filtration: 35,000 μS/cm
  - Reverse osmosis: 35,000 μS/cm
Treatment efficiency stage by stage: TN and TP

**Total Nitrogen**

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<tr>
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<th>mg/L</th>
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<tr>
<td>Inlet</td>
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<tr>
<td>Primary filtration</td>
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<tr>
<td>Chemical oxidation</td>
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<tr>
<td>Geochemical reaction</td>
<td>1.200</td>
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<td>Final filtration</td>
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<td>Reverse osmosis</td>
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**Total Phosphorus**

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<tr>
<td>Chemical oxidation</td>
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<td>Geochemical reaction</td>
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<td>Final filtration</td>
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<td>Reverse osmosis</td>
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Treatment efficiency stage by stage: As and Ni

**As**

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<th>Stage</th>
<th>Concentration (mg/L)</th>
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<tr>
<td>Primary filtration</td>
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<tr>
<td>Chemical oxidation</td>
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<td>Geochemical reaction</td>
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<td>Final filtration</td>
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<td>Reverse osmosis</td>
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**Ni**

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<td>Primary filtration</td>
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<td>Chemical oxidation</td>
<td>1400</td>
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<td>Geochemical reaction</td>
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<tr>
<td>Final filtration</td>
<td>1000</td>
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<tr>
<td>Reverse osmosis</td>
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Equalization tank
Geopolymer addition tank

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Geopolymer inside the feeding silo
Filter press and sedimentation tank
The capital cost of a full geochemical wastewater treatment plant with capacity of 50 m³/8h/d has been calculated between 800,000-900,00 €

The operation cost (including chemicals, geopolymer and energy) has been calculated between 8-9 €/m³

Cost is competitive, taking into account the process stability and the fact that discharge limits can be achieved.
Conclusions

- The use of active clay sediments process can achieve complete treatment of landfill leachate, producing reclaimed water suitable for agricultural irrigation.

- The process comprises by a series of sub-processes, including pH adjustment, coagulation-flocculation, chemical oxidation, geopolymer reaction, clarification, filtration, reverse osmosis, disinfection.

- The capital and operational costs for small-medium olive processing faculty has been calculated as 800,000-900,000 €, 8-9 €/m³, respectively.

- Wastewater treatment process should take into account recent technological achievements and the needs of the modern society.

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Thank you for your attention

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