Landfill leachate treatment by chemical precipitation, carbonation, and phytoremediation fine-tuning

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Introduction

The high organic and inorganic loads of the leachates obtained from sanitary landfilling of municipal solid wastes pose a huge challenge in the search for efficient, cost effective and environmental friendly treatments. The objective of this work was to study an integrated solution of several treatment technologies – one-step lime precipitation (OSLP), carbonation (CB) and phytoremediation (Phyt) – to treat a sanitary landfill leachate (SLL), providing a simple, effective, and economically attractive solution for SLL treatment, without harmful effects to the environment and contributing to CO_2 mitigation and lower greenhouse gases.

Methodology

The SLL samples were treated by OSLP, CB and Phyt, in two different treatment sequences.

Raw SLL → OSLP → CB → Phyt
Raw SLL → OSLP → Phyt

OSLP

- Raw SLL
- [CaO]: 18, 21, 25, 28, 33 g L^{-1} *
- Stirring speed: 300 rpm
- Stirring time: 2, 10, 20, 30,40, 50, 60 min
- Sedimentation time: 2 h

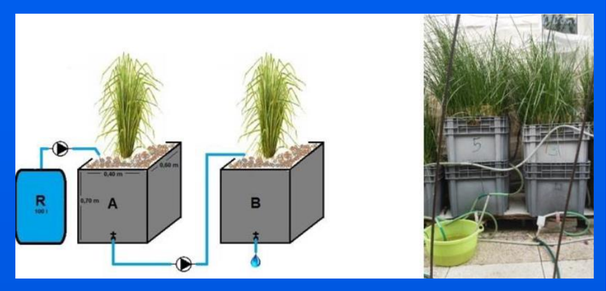
* Concentrations obtained from the addition of different volumes of a 200 g L^{-1} CaO aqueous solution

CB by atmospheric CO_2

- Supernatant from optimized OSLP
- Left at outdoor atmosphere
- Exposure time: 32 days

Phyt with *Vetiveria zizanioides*

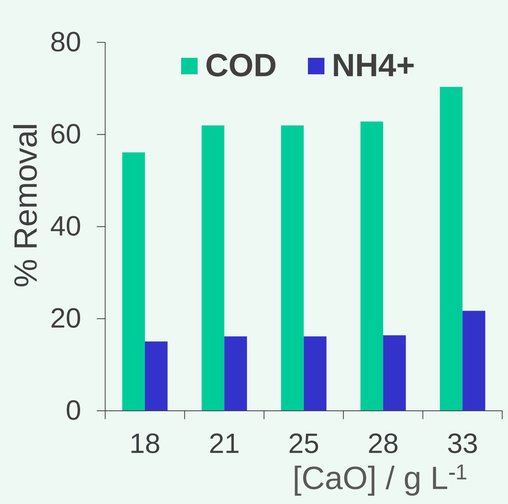
- Supernatant from OSLP or OSLP+CB
- Samples diluted with tap water (1:4)
- Two vertical flow beds in series
- Applied hydraulic load: 90 L m^{-2} d^{-1}

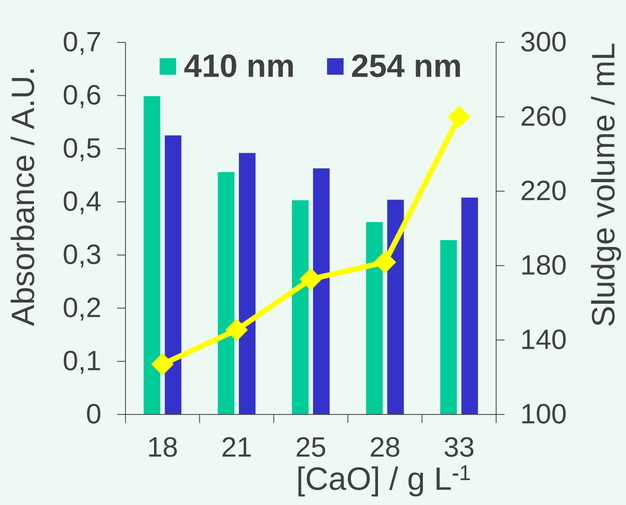


Results & Discussion

One-step lime precipitation

Influence of CaO concentration

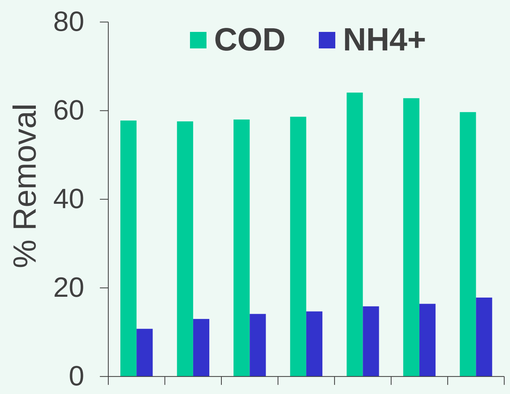


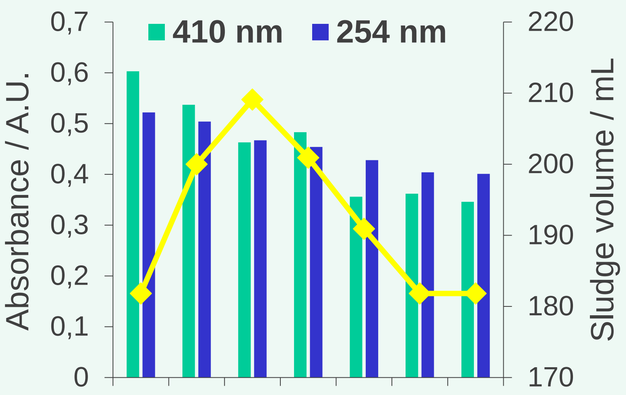


Pollutants removal increase with [CaO]
Sludge volume increase with [CaO]

→ **Optimal [CaO] = 28 g L^{-1}**

Influence of stirring time





NH_4^+ and $Abs_{254\ nm}$ decrease regularly with stirring time
COD and $Abs_{410\ nm}$ present the highest removals for 40 min stirring time
Sludge volume presents a maximum at 20 min and a minimum at 50 min

→ **Optimal stirring time = 40 min**

Samples characterization

Parameter	Raw SLL	After OSLP	After OSLP+CB
COD / g O_2 L^{-1}	1.33	0.46	0.47
Ammonia nitrogen / mg N L^{-1}	1060	889	< 0.1
Kjeldhal nitrogen / mg N L^{-1}	1201	938	46
Total hardness / g $CaCO_3$ L^{-1}	0.9	0.5	< 0.0001
Total alkalinity / g $CaCO_3$ L^{-1}	8.4	7.5	4.5
Abs - 254 nm	> 3	0.41	0.16
Abs - 410 nm	1.11	0.37	0.14
pH	8.13	12.5	11.5
Conductivity / mS cm^{-1}	19.7	23.1	15.0
Iron / mg Fe L^{-1}	16.46	0.25	0.02

Sludge characterization

Parameter	OSLP	CB	Parameter	OSLP	CB
Quantity / g L^{-1}	27.8	1.09	Organic matter / %	10.9	14.9
pH	12.4	10.0	Urea / %	0.04	0.12
Conductivity / mS cm^{-1}	28.5	61.5	Kjeldhal nitrogen / g N kg^{-1}	1.96	1.85
Dry solids / %	97.9	96.5	Organic nitrogen / mg N kg^{-1}	0.15	0.79
Humidity / %	2.1	3.5	Iron / mg Fe L^{-1}	4.89	–

Phytoremediation treatment results

Parameter		Phyt after OSLP	Phyt after OSLP+CB
pH		4.3	6.8
Conductivity / mS cm^{-1}		7.3	7.4
Dissolved oxygen / mg O_2 L^{-1}		4.6	4.6
Removals	- COD / g O_2 m^{-2} d^{-1}	4.9	6.2
	- Ammonia nitrogen / g N m^{-2} d^{-1}	5.0	*
	- Kjeldhal nitrogen / g N m^{-2} d^{-1}	6.8	*

* Already removed in the CB step

Conclusions

- OSPL combined with CB through atmospheric CO_2 leads to the complete removal of ammonia nitrogen and hardness and allows considerable reductions in COD, aromatic content, metals and color, showing to be a simple, effective and economically attractive process for SLL treatment, without harmful effects to the environment and contributing to lower greenhouse gases and CO_2 mitigation.
- Generated sludges characteristics allow its recovery in the landfill itself, eliminating the need for transport and dehydration, reducing the associated carbon footprint.
- Pre-treated SLL by OSLP or OSLP+CB is suitable for phytoremediation with *Vetiveria zizanioides* (with OSLP+CB samples attaining the best results), allowing the use of the green economy concept, since the biomass is reusable.

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