The role of metals in methane production from shredder waste in landfills

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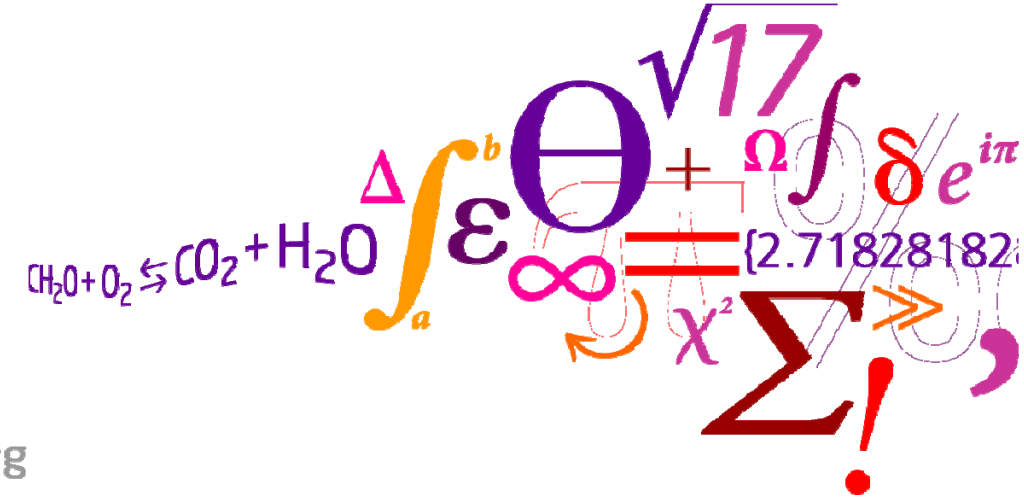

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Introduction

- Source separated iron and metal containing waste products including bicycles, prams, vehicles, white goods, etc.
- Mechanical treatment (shredding and magnetic separation)
- The residue: shredder waste
- Metals, plastic, rubber, wood and foam.

- Significant production of landfill gas at shredder waste (SW) monofills (Mønster et al., 2015; Olsen and Willumsen, 2013; Scheutz et al., 2011)

- Unusual composition

high methane content and very low content of carbon dioxide (Olsen and Willumsen, 2013; Scheutz et al., 2011)

Hypothesis

- In anaerobic digestion process 30% of CH_4 is produced by:

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$$

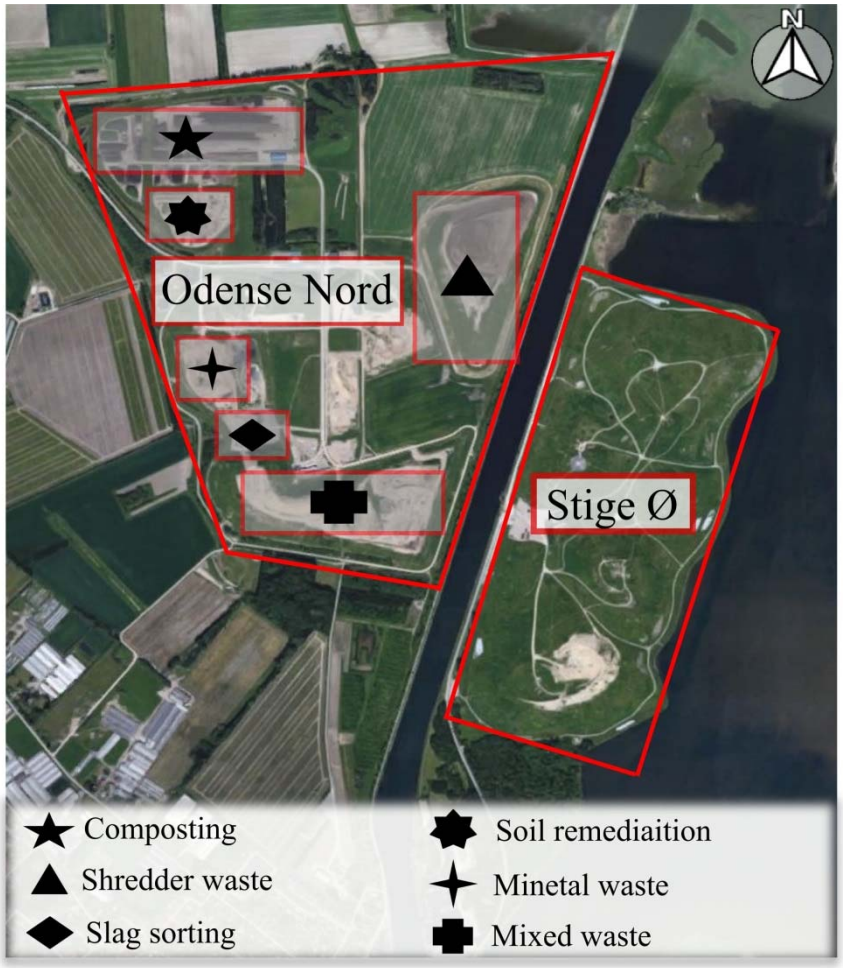
- H_2 by anaerobic corrosion of different metals in shredder waste

$$Fe^0 \rightarrow Fe^{2+} + 2e^-$$
$$2H_2O \rightarrow 2H^+ + 2OH^-$$
$$Fe^0 + 2H_20 \rightarrow Fe(OH)_2 + H_2$$

Objectives:

- The objective of this study was to investigate the role of metals contained in SW in CH_4 production from SW.

Site description



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Sampling and preparation of samples

- According to the year of deposition
  - 2009 (SW2009)
  - 2012 (SW2012)
  - Fresh SW (FSW)

- Long-pile principle:
  - Subdivided three time

Sampling and preparation of samples

In the lab:

- Long-pile principle:
  - Subdivided three time

- Combined (COM): SW2009+SW2012+FSW based on equal wet weight

Sampling and preparation of samples

- Metals, wires and stones were separated
- cutter mill with 1 mm sieve

Characterization

- Total solids (TS)
- Volatile solids (VS)
- Total carbon (TC)
- Total organic carbon (TOC)

Biocorrosion experiment

Table 1. Overview of materials used in the biocorrosion experiment.

Experimental step	Reactor name	Metals (g)				Inoculum (mL)	Water (mL)
		Fe	Al	Zn	Cu		
Step 1: H_2 generation by biocorrosion	Water+Fe	2.5	0	0	0	0	250
	Water+Al	0	2.5	0	0	0	250
	Water+Zn	0	0	2.5	0	0	250
	Water+Cu	0	0	0	2.5	0	250
Step 2: Impact of metal addition on CH_4 yield	Blank	0	0	0	0	250	0
	Inoc+Fe	2.5	0	0	0	250	0
	Inoc+Al	0	2.5	0	0	250	0
	Inoc+Zn	0	0	2.5	0	250	0
	Inoc+Cu	0	0	0	2.5	250	0

Batch incubation experiment

- 5 L bottles
- Substrates:
  - COM
  - COM+Fe
  - COM+Al
  - COM+Zn
  - COM+Cu
  - STE_COM
  - STE_COM+Fe
  - STE_COM+Al
  - STE_COM+Zn
  - STE_COM+Cu
  - Temperature: 37 ºC
  - Inoculum: 30 % of the samples wet weight
  - Moisture: 75%
  - Bottles containing only inoculum and water

- asd

Results and discussion

Waste characterization

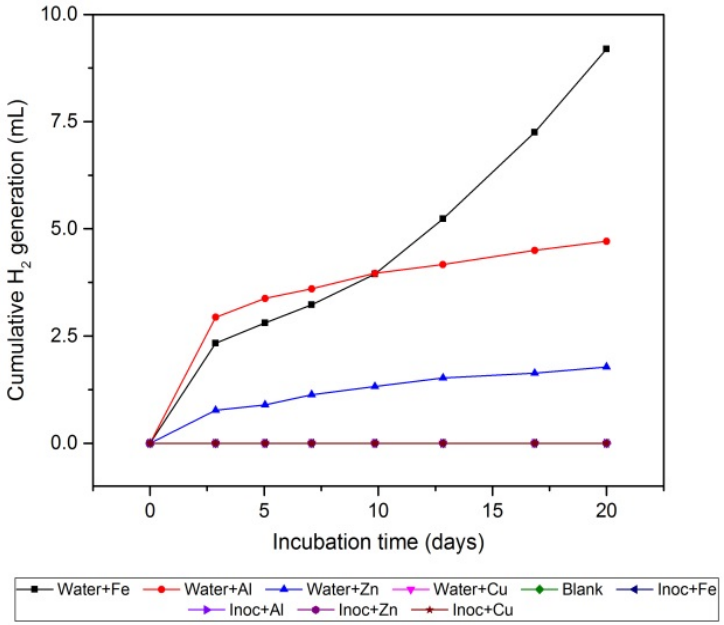
Table 2. Characteristics of different fractions of SW. Numbers in brackets give the standard deviation.

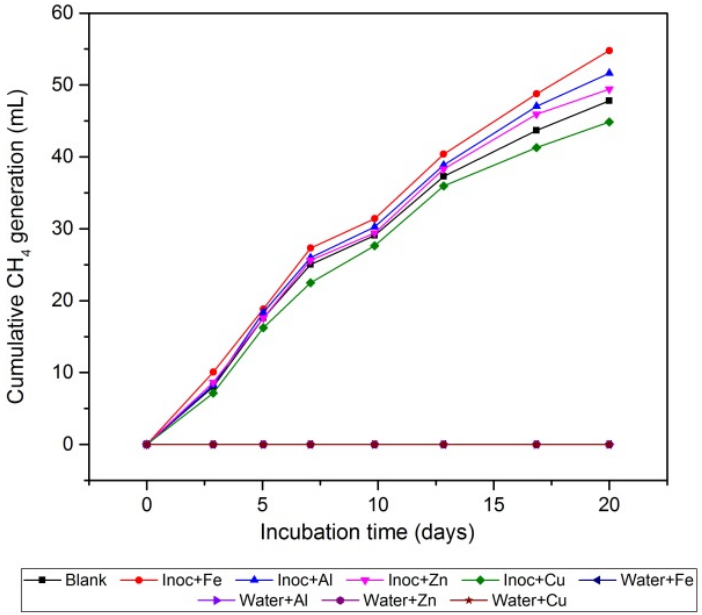
Shredder waste	TS (%, kg/kg wet waste)	VS (%, kg/kg wet waste)	TC (%, kg/kg dry waste)	TOC (%, kg/kg dry waste)
SW deposited in 2009 (SW2009)	89 (6.54)	18 (1.17)	14 (0.67)	11 (0.93)
SW deposited in 2012 (SW2012)	83 (1.48)	20 (0.35)	15 (0.82)	14 (0.57)
Fresh sample (FSW)	91 (0.02)	32 (1.15)	24 (1.99)	21 (1.29)
Composite SW sample (COM)	82 (0.71)	24 (0.92)	18 (1.24)	16 (0.60)

- FSW > COM > SW2012 > SW2009

Results and discussion

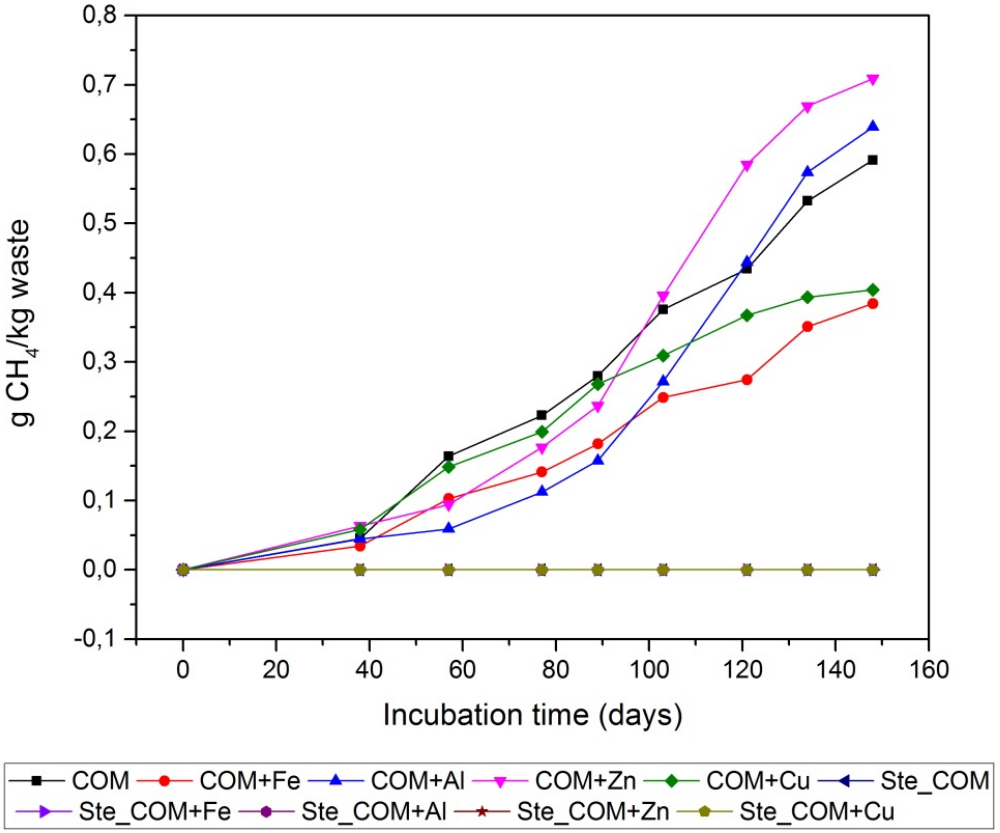
Biocorrosion experiment





- Fe, Al and Zn hydrogen production and enhancement of AD
- Cu inhibition

Results and discussion
Batch incubation experiment



- No abiotic reaction
- Al and Zn: enhancement
- Fe and Cu: inhibition

Results and discussion
Batch incubation experiment

Table 3. CH_4 and CO_2 concentrations in the headspace of the biotic reactors measured on the last day of the experiment (day 148).

Reactor name	CH_4 (%)	CO_2 (%)	CH_4/CO_2
COM	50.4	4.0	12.6
COM+Fe	44.5	3.6	12.4
COM+Al	53.3	3.2	16.5
COM+Zn	52.9	1.7	30.7
COM+Cu	44.7	3.8	11.7

- COM+Al and COM+Zn: higher CH_4 and lower CO_2 and in comparison to COM reactor.

Conclusions

- No abiotic production of methane
- Zn and Al contribute to high methane production of SW at landfills by producing H2

Thanks for your attention ☺