

# Integrated monitoring of red mud contaminated soil in microcosms

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## ABSTRACT

This paper deals with the environmental toxicity assessment of red mud contaminated soils. The aim of our experimental work presented in this study was the assessment of the short- and long-term environmental risks of red mud contamination. We mixed red mud with soil at 0–40% ratio in microcosms. The red mud containing soil was examined by integrated monitoring, which means the combination of physical, chemical, biological and ecotoxicological methods. The ecotoxicity of the soil was assessed by testorganisms from three trophic levels: *Vibrio fischeri* was the bacteria, *Sinapis alba* was the plant and *Folsomia candida* was the animal. The results showed that red mud can be mixed into the soil at up to 10% without any long-term adverse effect on soil living organisms.

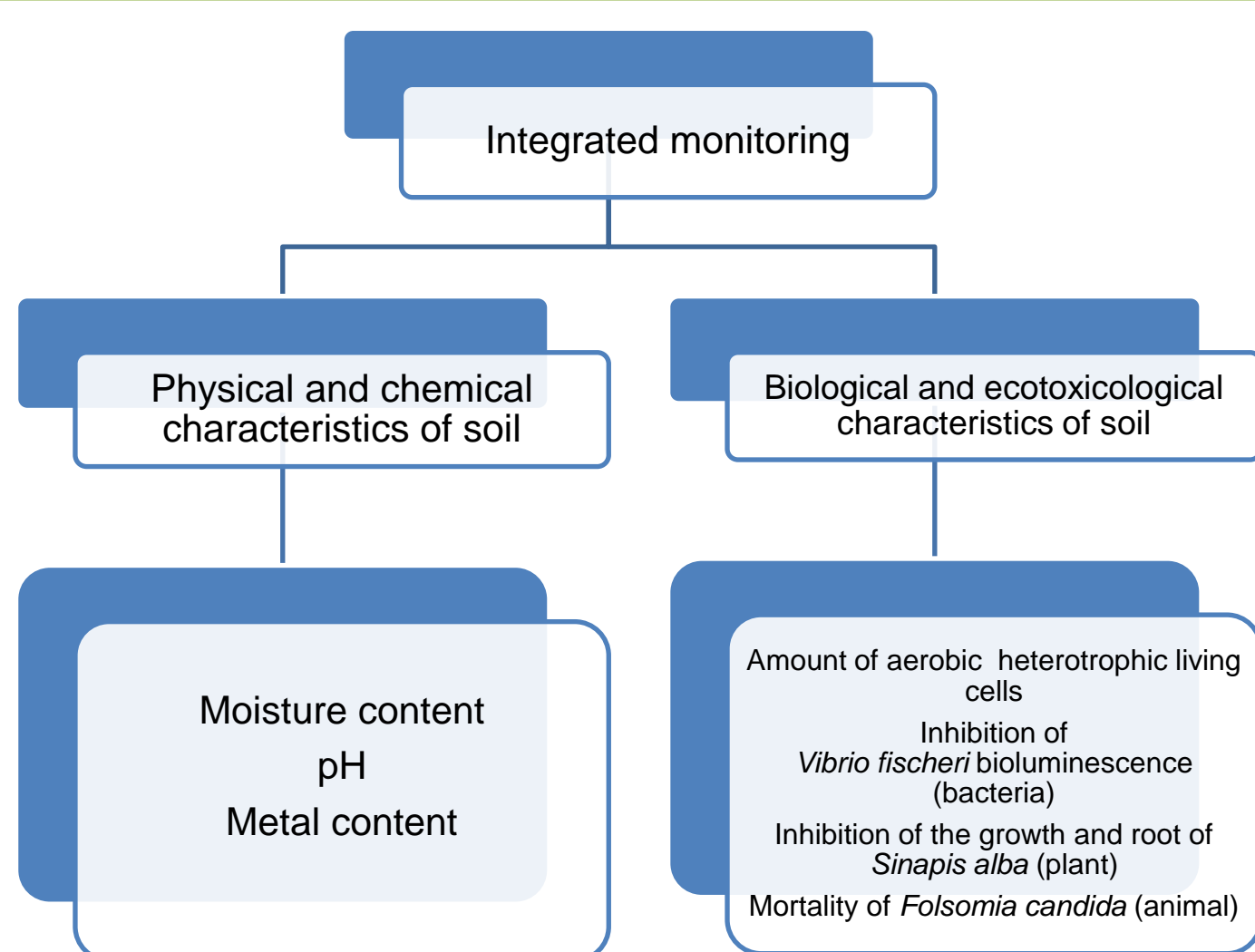


Figure 1. Integrated monitoring

## EXPERIMENTAL CONDITIONS

The red mud used in the laboratory experiments was collected from a flooded grassland in Ajka and the uncontaminated topsoil originated from a non-flooded grassland nearby. The red mud was mixed with soil at a narrow concentration range: 0%, 5%, 10%, 20%, 30% and 40%. Two reference soils were used: the first was uncontaminated soil from the non-flooded grassland nearby Ajka and the second was from the flooded grassland in Ajka, from which the red mud was removed. The soils mixed with red mud were placed into 2 kg flowerpots each. The microcosms were open and their moisture content was set to the 60% of their maximum water holding capacity.

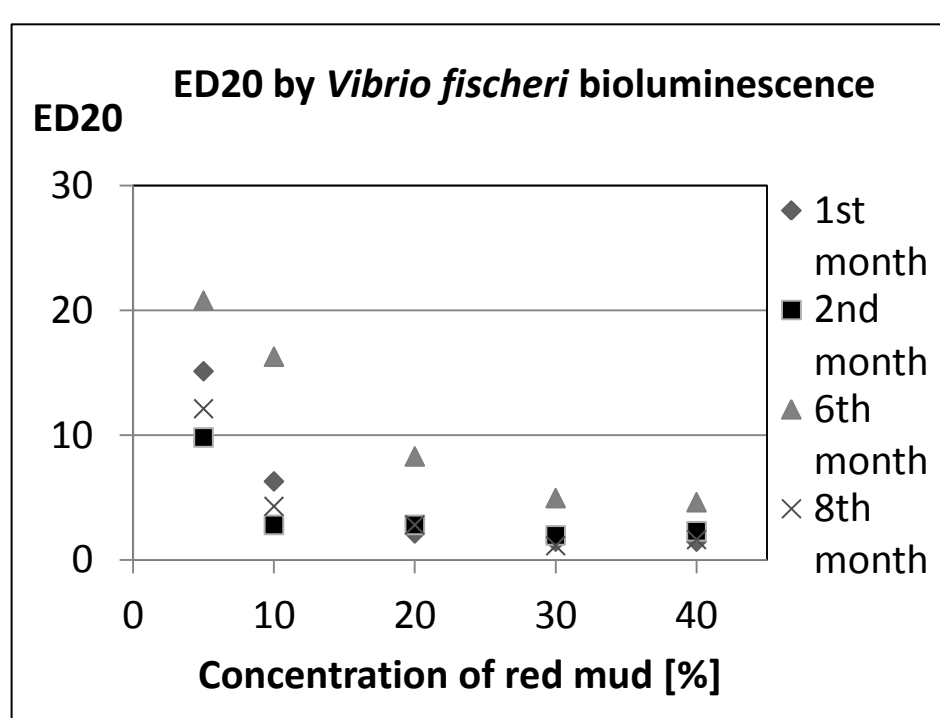


Figure 4. ED20 by *Vibrio fischeri* bioluminescence test

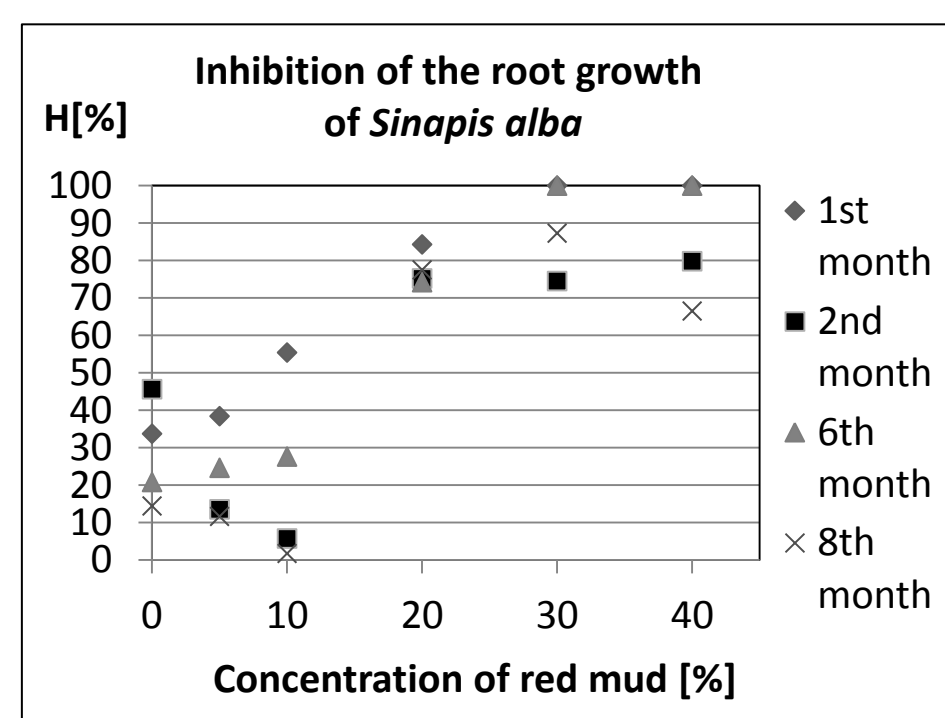


Figure 5. Inhibition of the root growth of *Sinapis alba*

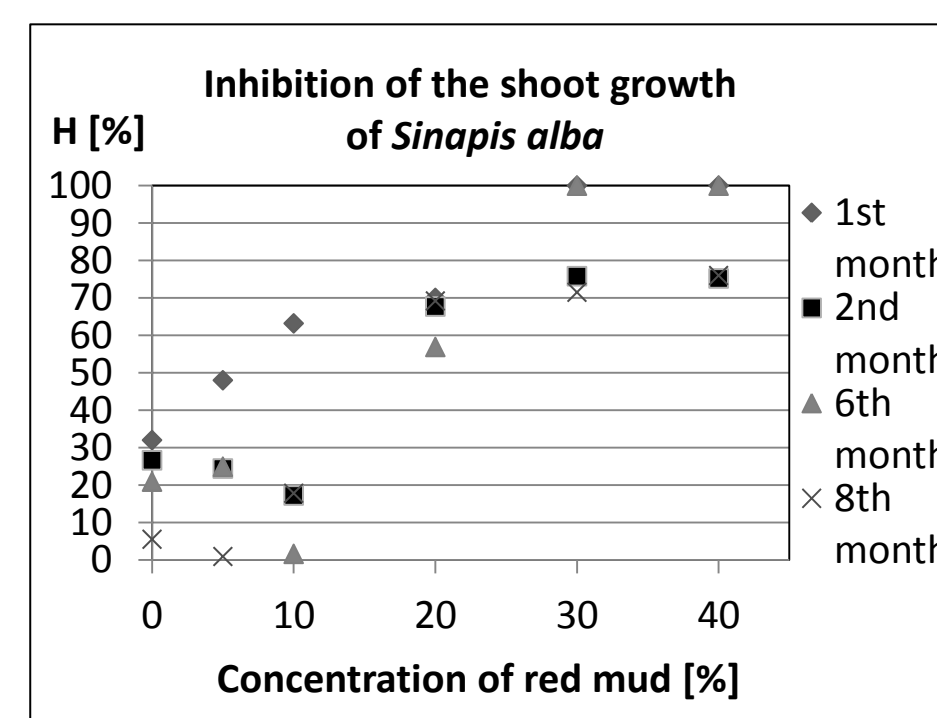


Figure 6. Inhibition of the shoot growth of *Sinapis alba*

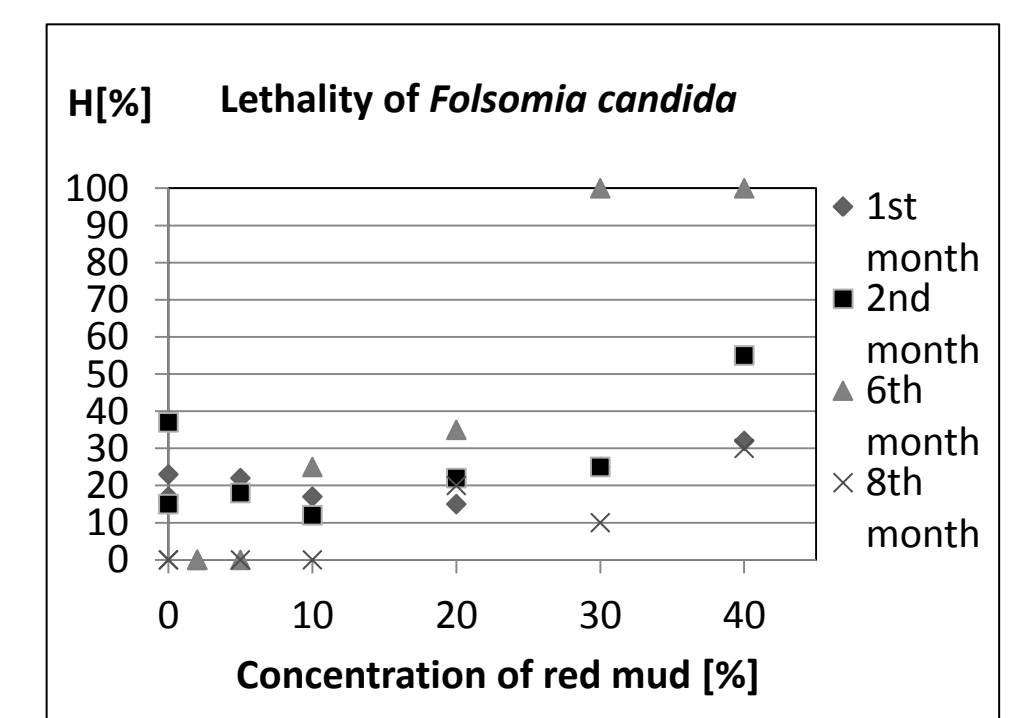


Figure 7. Lethality of *Folsomia candida*

From the ecotoxicological test results (Figure 4, 5, 6 and 7) we can see, that 5% red mud content has no inhibition effect on the testorganisms, but significant adverse effect was caused by higher than 10% red mud content.

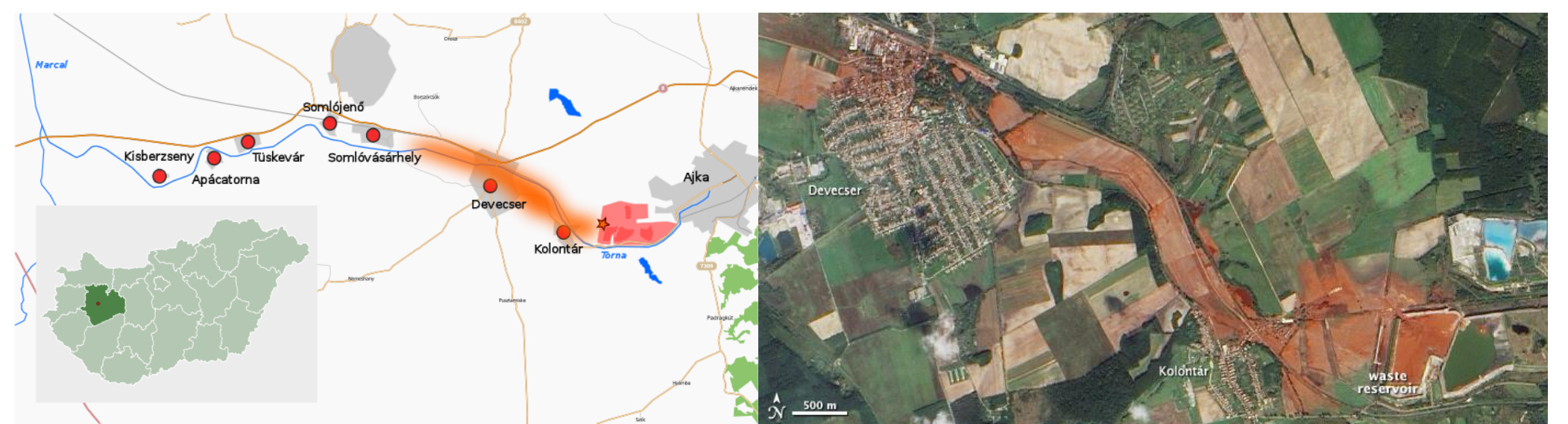
## CONCLUSIONS

Based on the results of this study we can state that red mud itself has no adverse effect on soil, a certain amount may be even advantageous for chemical and biological properties, as red mud did not inhibit or change soil microbiota adversely. The aim of this study was to assess the amount of red mud that can be mixed into the soil without causing toxic effect. The conclusion of our experiment was that red mud can be mixed into the soil at up to 10% without any long-term adverse effect on soil ecosystem.



## THE CHATASTROPHE

The worst environmental catastrophe of Hungary occurred on October 4, 2010. The red mud reservoir in Ajka storing 3–4 million cubic meters of highly alkaline (pH 13) red sludge broke and released 800.000 m<sup>3</sup> of slurry into the environment, which engulfed the downstream villages of Kolontár, Devcester and Somlóvásárhely in western Hungary.



[http://hu.wikipedia.org/wiki/Ajkai\\_v%C3%B6r%C3%B6siszap-katasztr%C3%B3fa](http://hu.wikipedia.org/wiki/Ajkai_v%C3%B6r%C3%B6siszap-katasztr%C3%B3fa)

## RESULTS

In the red mud contaminated soils three toxic metals exceeded the limit value (Hungarian 6/2009 (IV. 14.) KvVM-EüM-FVM decree) shown in the last row of the Table 1.

Table 1. Toxic metal content of aqua regia extract of red mud contaminated soil

Red mud content	Toxic metal content					
	As [mg/kg]		Cr [mg/kg]		Ni [mg/kg]	
	1 <sup>st</sup> month	8 <sup>th</sup> month	1 <sup>st</sup> month	8 <sup>th</sup> month	1 <sup>st</sup> month	8 <sup>th</sup> month
Control (0%) <sup>1</sup>	4.2	3.4	20.6	22.2	8.6	7.8
0% <sup>2</sup>	4.2	2.9	15.9	14.2	8.3	6.4
5%	11.0	7.7	58.6	39.5	27.7	19.2
10%	<b>18.6</b>	12.4	<b>107.0</b>	63.4	<b>51.5</b>	30.7
20%	<b>32.3</b>	<b>21.1</b>	<b>216.2</b>	<b>113.0</b>	<b>101.3</b>	<b>56.1</b>
30%	<b>35.2</b>	<b>29.6</b>	<b>238.4</b>	<b>200.0</b>	<b>110.4</b>	<b>98.6</b>
40%	<b>35.0</b>	<b>31.2</b>	<b>267.1</b>	<b>205.0</b>	<b>126.5</b>	<b>96.9</b>
Limit value <sup>3</sup>	15.0	15.0	75.0	75.0	40.0	40.0

<sup>1</sup> Uncontaminated reference soil from the non-flooded grassland nearby Ajka

<sup>2</sup> Reference soil from the flooded grassland in Ajka, from which the red mud was removed

<sup>3</sup> Hungarian 6/2009 (IV. 14.) KvVM-EüM-FVM decree

The results show, that pH increases with the amount of red mud mixed into soil (Figure 2). At 5% and 10% red mud ration the pH was under the value of 10. However, 5% red mud shifted the pH of soil to the highly alkaline domain. The colony forming cell concentration decreased with red mud ratio and time of incubation (Figure 3).

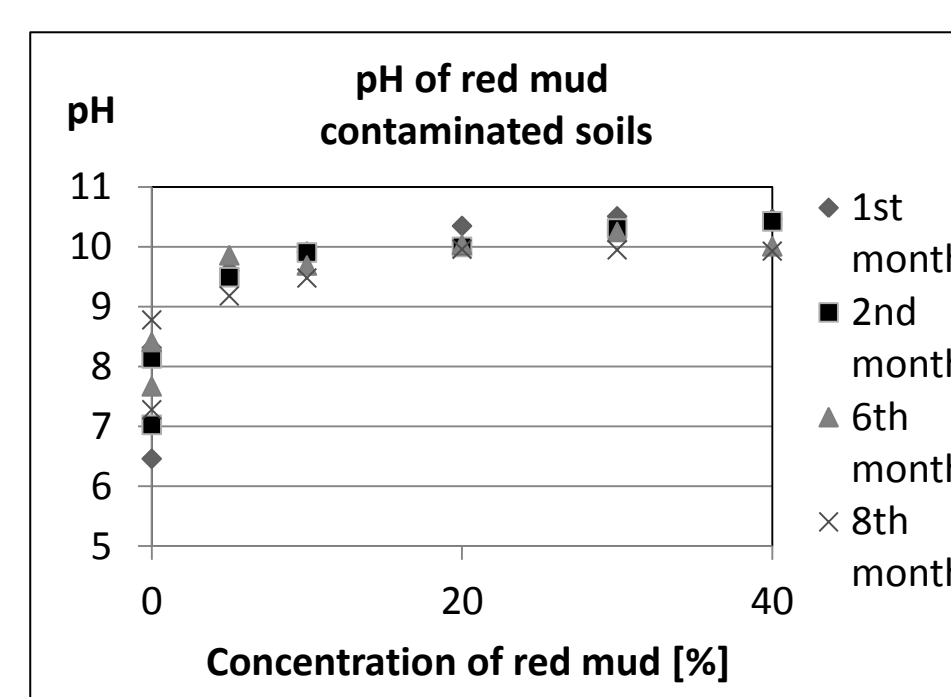


Figure 2. pH in function of red mud concentration

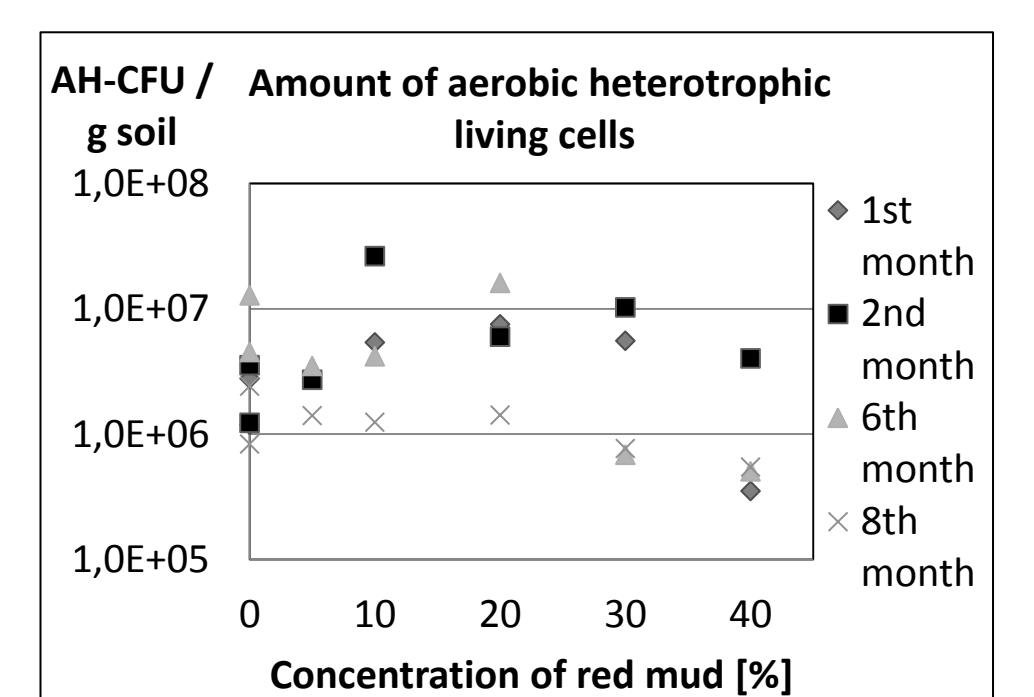


Figure 3. The number of colonies formed by aerobic heterotrophic cells (AH-CFU) in 1 g soil

## ACKNOWLEDGEMENTS

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