Treatment of landfill leachates by advanced oxidation processes and phytotoxicity assessment

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Introduction

The formation of landfill leachate in municipal landfills is one of the most important issues of the dominant waste disposal method. These highly contaminated fluids are produced through various routes with the main one being the percolation of the rainwater through the wastes placed in a landfill. Therefore, leachate samples contain a variety of pollutants like organic matter, inorganic species, metals and xenobiotic organic substances [1]. Especially, the latter subcategory is of major concern since it includes a plethora of chemicals like pesticides, herbicides, pharmaceuticals, personal care products and plasticizers. Given the particularly negative effects that these compounds can cause to living organisms and humans, efficient treatment methods must be developed and applied.

Advanced oxidation processes (AOPs) constitute a particularly attractive option for processing wastewaters, as can be observed from the literature. Among AOPs, classical Fenton process occupy a central position, as is based on the well-known reaction between dissolved ferrous ions (Fe^{2+}) and hydrogen peroxide (H_2O_2), resulting to production of hydroxyl radicals (E = 2.8 eV). The produced hydroxyl radicals react with the organic contaminants of the sample, leading to their destruction or transformation. The process becomes even more efficient when it is combined with UV irradiation as a result of the enhanced production of hydroxyl radicals [2].

Methodology

Two different leachate samples were collected and used for the experiments (Figure 1A, 1B, Table 1). The following experimental conditions were selected: COD:[H_2O_2] = 1:1, [Fe(II)]:[H_2O_2] = 1:10, pH = 3, treatment time = 60 min. The **photocatalytic experiments** were conducted using a glass cylindrical reactor and a UV-lamp (125W) (Figure 1C). A multi-parameter photometer (Hanna) and a TOC analyzer (Shimadzu) were utilized for the measurements.

Sorghum saccharatum seeds were used for the **phytotoxicity test** using Plant Growth Incubator (MRC, PGI-550RH) (Figure 2) and estimating the germination index (GI). Distilled water was used for positive control. Four (4) ml of each leachate sample was added to a petri dish containing five pieces of blotting paper onto which 20 seeds were evenly placed. Petri dishes were incubated for 72 h at 25 ^oC (Figure 3). After the incubation period, sprouted seeds and GI was estimated.

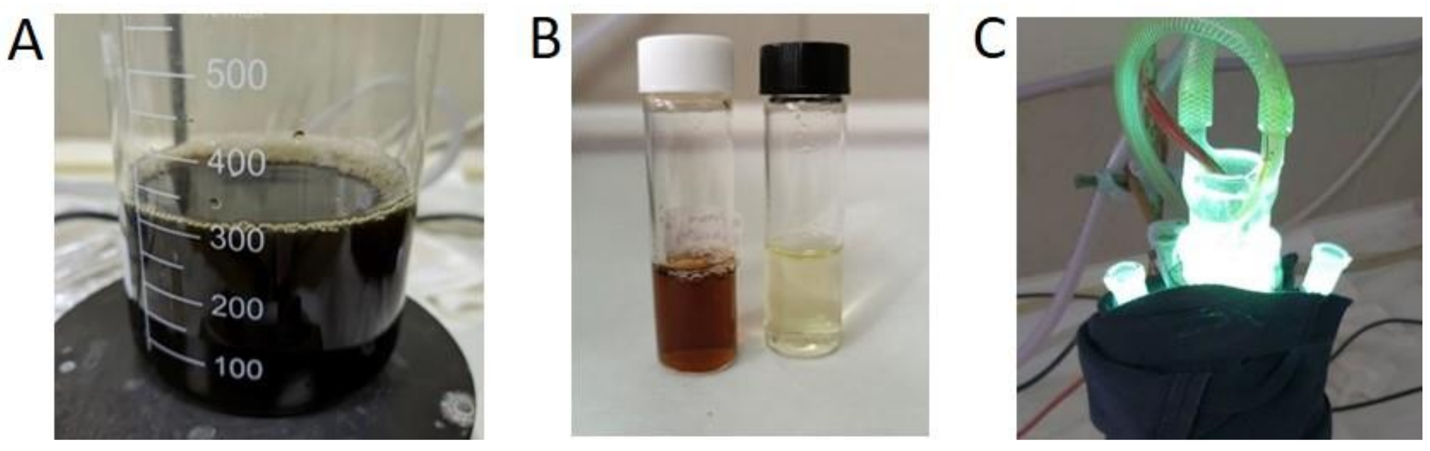

Figure 1: A. Untreated leachate sample, B. Leachate samples L1, L2 after treatment, C. Glass cylindrical reactor.

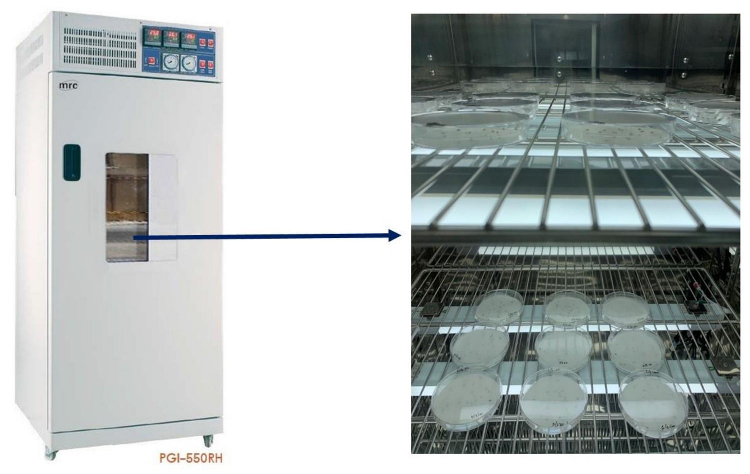

Figure 2: Petri dishes with 20 seeds of *Sorghum saccharatum each in a* Plant Growth Incubator (MRC, PGI-550RH).

Table 1. Characteristics of leachate samples used in the present study.

Leachate sample	COD (mg/L)	TOC (mg/L)	CI (mg/L)	pH
L1	6030	2190	3.56	7
L2	3350	1392	2.37	8

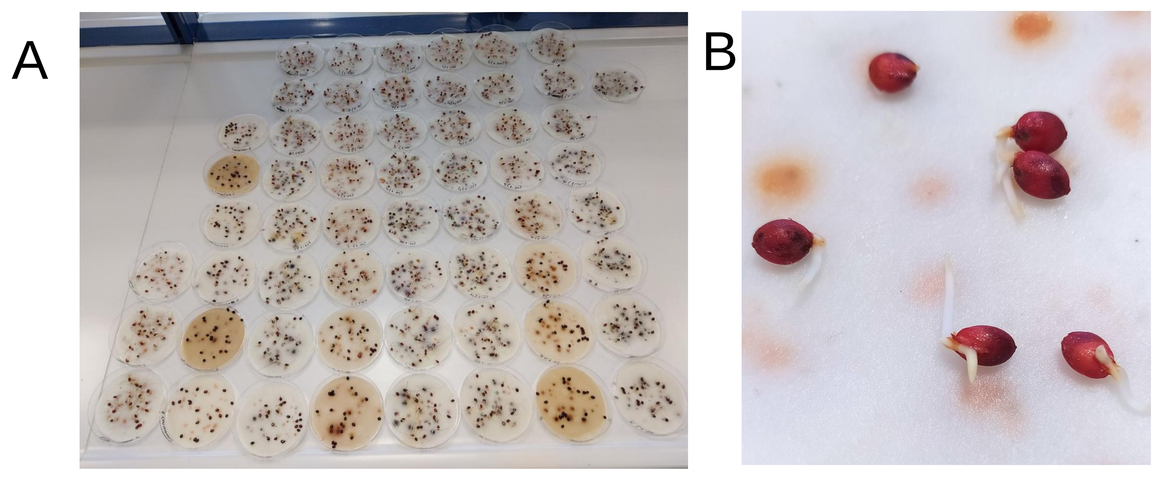

Figure 3: A. *Sorghum saccharatum* seeds in Petri dishes, B. *Sorghum saccharatum* germinated seeds (72 h)

Results & Discussion

Table 2. COD, TOC and CI removal percentages after the treatment of leachate sample L1.

Leachate sample L1	COD removal (%)	TOC removal (%)	CI removal (%)
Fe^{2+}/H_2O_2	32.17	57	85.49
$UV/Fe^{2+}/H_2O_2$	52.5	67.47	92.75

Table 3. COD, TOC and CI removal percentages after the treatment of leachate sample L2.

Leachate sample L2	COD removal (%)	TOC removal (%)	CI removal (%)
Fe^{2+}/H_2O_2	45.67	69.49	91.6
$UV/Fe^{2+}/H_2O_2$	54.62	74.2	94.11

Table 4: Overall Data.

Leachate Sample	Process	COD (mg/L)	TOC (mg/L)
L1	$UV/Fe^{2+}/H_2O_2$	2840	712.2
	Fe^{2+}/H_2O_2	4090	941.4
L2	$UV/Fe^{2+}/H_2O_2$	1520	359
	Fe^{2+}/H_2O_2	1820	424.6

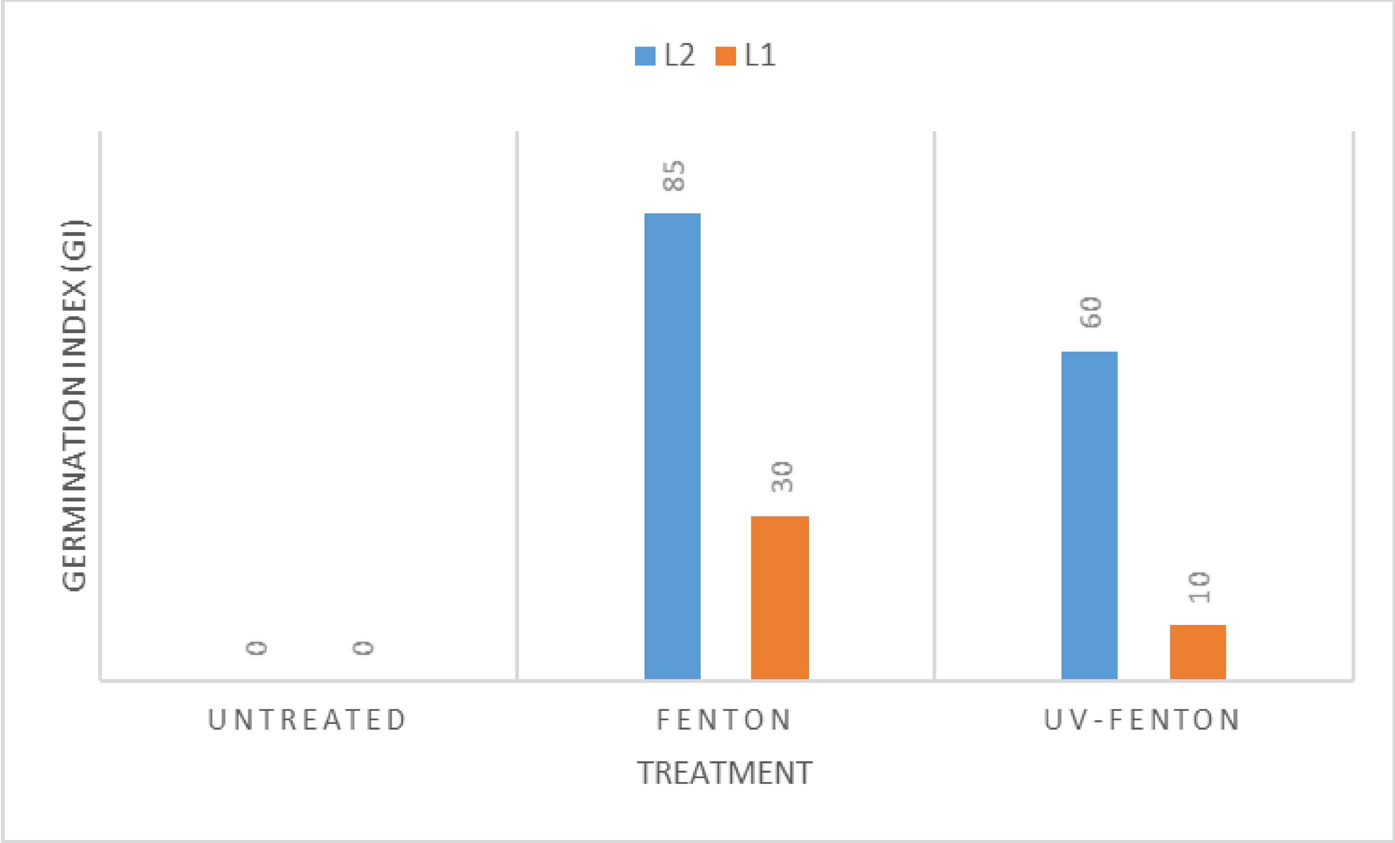

Figure 4. Germination Index (GI) of untreated, Fenton and UV-Fenton treated non-diluted leachate samples L1, and L2.

Conclusions

Overall, $UV/Fe^{2+}/H_2O_2$ process achieved greater removals of COD and TOC for both medium (L1) and stabilized (L2) landfill leachates, while Fe^{2+}/H_2O_2 process was more effective in reducing the phytotoxicity of both non-diluted leachates, as was assessed by phytotoxicity tests using *Sorghum saccharatum* seeds. In the case of the stabilized leachate (L2), a GI value of 85% could be achieved after Fe^{2+}/H_2O_2 treatment, indicating non phytotoxicity, while the $UV/Fe^{2+}/H_2O_2$ treatment resulted in moderate phytotoxicity (GI=60%). The treatment of medium (L1) landfill leachate with both processes resulted in GI values of 30% and 10%, respectively, for Fe^{2+}/H_2O_2 and $UV/Fe^{2+}/H_2O_2$ processes, indicating high phytotoxicity.

References

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