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Evaluation of phytotoxicity of landfill leachates after treatment with UV radiation based processes

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Abstract. The aim of the present work was to evaluate the phytotoxicity of treated landfill leachates. For the abatement of the organic load of the samples, homogeneous (UV/Fenton) and heterogeneous (UV/TiO_2) photocatalysis took place. The phytotoxicity tests were performed using *Sorghum saccharatum* seeds. Germination index (GI) was calculated and the treated leachates were evaluated for their suitability as a potential source for irrigation. Homogeneous photocatalysis showed an enhanced removal of COD and TOC, compared to the heterogeneous photocatalysis, and thus the seed germination was improved when UV/Fenton process was applied.

Keywords: landfill leachate, phytotoxicity, advanced oxidation process, UV radiation

1. Introduction

Landfill leachate is a complex and highly variable wastewater that is generated when water percolates through a landfill. It typically contains a variety of pollutants, including organic and inorganic compounds, heavy metals and pathogens (*Vaccari et al. 2019*). If not treated properly it could contaminate groundwater and surface water, posing a serious risk to human health and the environment.

Existing landfill leachate treatment technologies, such as biological and physical methods, have limitations in terms of their efficiency. In addition, the increasing volume of waste generated globally along with the aging of landfills have led to a surge in the amount of landfill leachate that requires treatment, which has further strained existing treatment technologies.

Amongst several AOPs, UV based processes (UV/Fenton, UV/O_3, UV/TiO_2) have been proposed as an alternative because of their effective removal of the organic load of landfill leachates. TiO_2 photocatalysis has attracted interest from many researchers and has been thoroughly studied for environmental applications. Due to the wide band gap (3.2 V) that this catalyst appears to have, UV radiation is needed (*Kanmani et al., 2023*). On the other hand, Fenton process based on the reaction between dissolved ferrous ion and hydrogen peroxide, results to production of hydroxyl radicals. The produced oxidative radicals react with the organic contaminants of the sample, leading to their degradation or transformation. The combination of UV radiation and Fenton process has been developed to address the limitations of a single AOP in terms of efficient oxidative species generation and operating parameters. Due to the synergistic effect of different substances, the combination of AOPs can significantly improve the oxidation efficiency of contaminants compared to individual treatment technology (*Ma et al. 2021*).

The reuse of leachate in agriculture can be a challenging issue, as it requires careful treatment and management to ensure that the leachate does not pose a risk to the environment. Once treated, leachates could be potentially used for a variety of agricultural purposes, including irrigation, fertigation and soil amendment.

2. Experimental Procedure

UV/TiO_2 and UV/Fenton process were applied for the treatment of the landfill leachate samples. The experimental conditions of UV/TiO_2 treatment were [TiO_2] = 3 g/L, inherent pH and treatment reaction of 2400 min. For the UV/Fenton experiments, the conditions were as follows: COD: [H_2O_2] = 1:3, [Fe(II)]: [H_2O_2] = 1:10, pH = 3, treatment time = 180 min. The initial concentration of COD and TOC before treatment is between 4300 – 3900 mg/L and 1500 mg/L, respectively.

For the phytotoxicity test, *Sorghum saccharatum* seeds and a Plant Growth Incubator (MRC, PGI-550RH) were used. Distilled water was used for positive control. Four (4) ml of each leachate sample were added to a Petri dish containing four pieces of blotting paper onto which 20

seeds were evenly placed. Petri dishes were incubated for 72 h at 25 ºC. The results were estimated by calculating the germination index (GI).

3. Results and Discussion

Under the experimental conditions applied to all photocatalytic experiments of the present study, the UV/Fenton process achieved higher removals of COD and TOC (Table 1).

In Figure 1, the GIs of the phytotoxicity tests are shown. In the case of untreated landfill leachate, a GI value of 65 % was achieved after a dilution ratio of 1:10, indicating the necessity of sample treatment. The results showed inhibitory effect from UV/TiO_2 treated leachate on seed germination compared to the UV/Fenton treated samples, where GI reached 95 % at dilution ratios from 1:2 to 1:10. This discrepancy may be attributed to the low efficiency of the UV/TiO_2 process, which implies with high percentages of samples' organic load after treatment.

It is worth mentioning that without dilution, in case of UV/Fenton process, the GI value reached 90%, indicating that the treated leachate is suitable for safe disposal in agriculture.

However, further work is needed in order to examine the phytotoxicity of the leachates under both treatments.

Table 1. Removal (%) of characteristic landfill leachates parameters after different treatments. treatment.

Characteristics	UV/Fenton	UV/TiO_2
COD (%)	85	15
TOC (%)	88	33

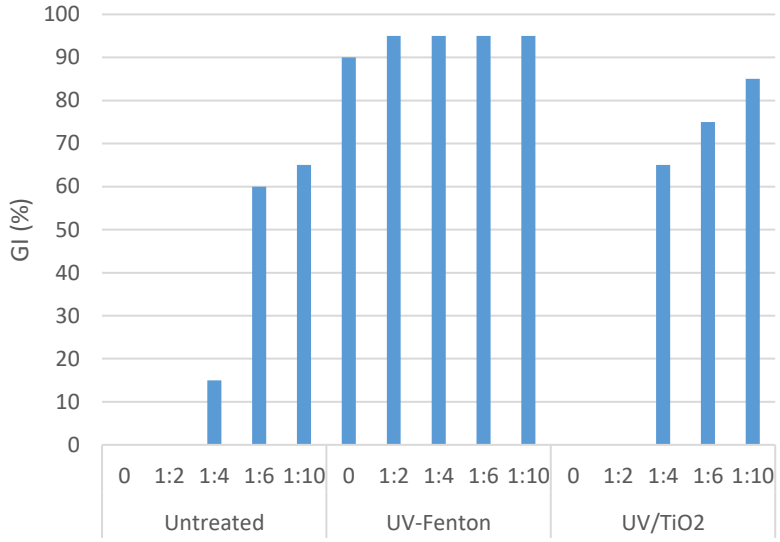

Figure 1. Germination index of *Sorghum saccharatum* seeds under different landfill leachate treatments.

References

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