Toxicity reduction of landfill leachate by direct plasma treatment

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Leachate from solid waste landfills is highly toxic because it contains various organic and inorganic recalcitrant compounds including PFAS (per- and polyfluoroalkyl substances). The treatment of this complex mixture of environmental concern contaminants is a challenge for waste/wastewater management and conventional technologies usually have low efficiency. For this reason, the development of advanced approaches and innovative technologies for the removal of pollutants in leachate and sludges is an area of growing research interest in the last few years. Plasma methods have the potential to successfully contribute to solving existing treatment problems and to be the basis of effective hybrid technologies for the removal of hazardous pollutants [1].

Two types of plasma sources for landfill leachate treatment are used in this work – Surface-wave-sustained Argon plasma torch and DBD discharge with a liquid electrode. Both discharges operate at atmospheric pressure.

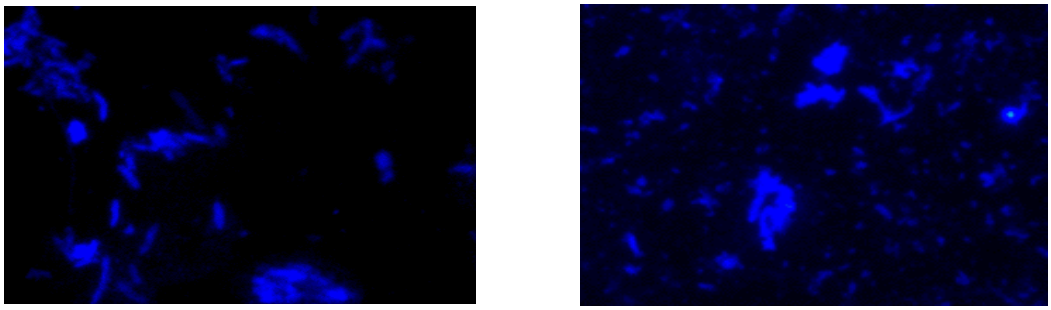
The Argon plasma torch is produced and sustained by 2.45 GHz electromagnetic wave excited by a Surfatron type wave exciter and travelling along the plasma–dielectric interface (Fig. 1a). Various types of such plasma sources knowing as surface-wave-sustained discharges (SWD) exist and can operate in wide range of discharge conditions producing non-equilibrium plasma with electron temperature T_e ~ 1–2 eV and much lower temperature of heavy particles (gas temperature T_g). Because of the charged particles (electrons and ions), UV radiation, reactive particles (excited atoms, molecules and radicals), electromagnetic field and the temperature such plasmas are highly reactive and useful for various applications [2]. In this work for the purpose of landfill leachate treatment the discharge conditions chosen are: wave power 100 W, Ar gas flow 3 l/min and treatment time is varied (1 min, 2 min, 3 min).

a) b)

Fig. 1: Experimental set-up for treatment of landfill leachate by a) Argon plasma torch; b) DBD discharge with liquid electrode.

The DBD discharge operates at electrical power of 36 W and frequency . The upper electrode is powered and the lower grounded electrode is a specially designed Petri dish with graphite electrode on the bottom and the treated liquid inside – the liquid electrode (Fig. 1b). The discharge is produced in the open space so the working gas is air. The treatment time is the same as for the Argon plasma torch, 1 min, 2 min, 3 min.

The toxicity of treated and untreated samples was studied by fluorescence staining of test bacterial culture *Escherichia coli* (Migula) Castellani and Chalmers (ATCC 700728). The fluorescence images were taken with a Leica DM6 B (Leica Camera AG, Wetzlar, Germany) epifluorescent microscope (Fig.2). The method assesses the intensity of metabolic processes in bacterial cells and their inhibition in the presence of toxic agents. The obtained images were processed with a digital analysis program daime 2.2 (University of Vienna, Vienna, Austria). The changes in the complex toxicity of the samples due to plasma treatment were assessed by comparing the effect of treated and untreated samples on two indicators of the test bacterial culture: (1) the share of viable cells; (2) the intensity of the CTC fluorescence. The share of viable bacteria was calculated based on the number of CTC-stained cells (metabolic active cells) and DAPI (all cells, including dead ones). The intensity of the fluorescence emitted by the CTC-stained cells corresponded to their level of metabolic activity [3].



a) b)

Fig. 2 Fluorescence images *E. coli* cells from epifluorescent microscope: a) untreated leachate; b) plasma treated leachate.

The results obtained show that the cells in the presence of highly toxic leachate after 1 hour of exposure are totally inhibited – their metabolic activity and the share of viable cells are really low. After plasma treatment the metabolic active and the share of viable cells increase. The reduction of toxicity is obtained for both Argon plasma torch and DBD leachate treatment.

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