Evaluation of an alternative method for wastewater treatment containing pesticides using photocatalytic oxidation and constructed wetlands

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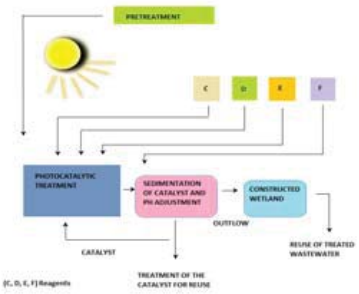

Graph of the wastewater treatment system using the combined action of photocatalytic oxidation and constructed wetlands

Aim of the present work is the study and the experimental evaluation of an alternative wastewater treatment system, which combines the action of photocatalytic oxidation with surface flow constructed wetlands. This low cost and environmentally friendly system is based on the utilization of solar irradiation and natural processes for wastewater treatment purposes. Experiments were conducted in pilot scale using artificial as well as solar irradiation, for the treatment of the pesticide clopyralid. The data evaluation revealed that the combined system may effectively reduce the organic load, as well as the toxicity of clopyralid and may provide a promising solution for the treatment of wastewater containing pesticides in the near future.

Agrochemical wastewater from widespread intensive agriculture in the Mediterranean Region is polluting water with pesticides. Although they play an important role in agriculture, pesticide compounds could cause significant environmental problems upon their release to the environment [1]. Their widespread application is an important concern due to their high toxicity, their ability to accumulate, as well as their tendency for mobility and the long-term effects on living organisms. Advanced oxidation processes (AOPs) have been recognized as an especially efficient approach to pesticide degradation [2-4]. AOPs are chemical oxidation processes characterized by the production of extremely reactive and unselective species such as hydroxyl radicals ($OH^{\bullet}$), which are able to degrade even the most recalcitrant molecules into biodegradable intermediate compounds or to completely mineralize them into CO_2, H_2O and inorganic ions [3, 5].

The need for alternative methods of treatment of wastewater containing pesticides, resulted in the evaluation of a low cost treatment system that is based on solar photocatalytic oxidation and natural processes. The system combines the synergetic action of photocatalytic oxidation to surface flow constructed wetlands, in order to utilize the high solar irradiation in the Mediterranean region and the ability of the constructed wetlands to improve water quality through natural processes, thus providing wastewater capable of being reused.

Aim of this work is to present results from the experimental evaluation of this wastewater system on the degradation of clopyralid, (3,6-dichloro-2-pyridine-carboxylic acid), a systemic herbicide from the chemical class of pyridine compounds, often detected in drinking water [6]. Clopyralid may be persistent in soil under anaerobic conditions, it presents high solubility in water and is particularly stable against hydrolysis and photolysis. Its chemical stability along with its mobility enables this herbicide to penetrate through soil, causing a long term contamination of ground water and surface water supplies [7, 8].

Experiments were conducted at pilot scale using simulated wastewater containing clopyralid. Each experiment consisted of two phases. In the first one, the wastewater was treated by photocatalytic oxidation, aiming to the reduction of the organic load, while the final effluent was channeled into surface flow constructed wetlands for the final purification. The photocatalytic treatment was tested using both artificial and solar irradiation in a pilot-scale unit able to treat 20 L of wastewater. The photocatalytic unit constitutes of three parts: A photocatalytic, fountain type, reactor. The main idea is based on the design of six nozzles, through which the waste to be processed, enters the tank from the bottom of the unit, to the reactor. The nozzles create parallel, turbulent flow and vigorous stirring of the wastewater, which is exposed to a light source (solar or artificial). Excess of the wastewater overflows and leads back to the tank, from which is recirculated to the reactor by a pump. The radiation source (solar or artificial) is located above the reactor, illuminating the suspension. b) A reservoir located at the lower part of the reactor, for storing wastewater, and c)

an Imhoff type tank for separation of the treated effluent from the catalyst.

For the needs of the second phase, 3 surface flow wetlands were constructed in parallel order. The design of the wetlands was based on the suggested by EPA method [9].

Preliminary data evaluation revealed that the combined system may effectively reduce the organic load, as well as the toxicity of clopyralid and may be proven a promising solution of the treatment of wastewater containing pesticides in the near future.

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