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Electron Beam Treatment Plant for Textile Dyeing Wastewater

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1. Introduction

High positive effect of electron-beam treatment involved into the process of wastewater purification is now well established. The most effective for the purpose seem to be combine methods including both electron-beam and any conventional treatment stages, i.e., under conditions when some synergistic effects can take place. Daegu Dyeing Industrial Complex (DDIC) includes about hundred factories occupying the area of 600,000m^2 with 13,000 employees in total. The production requires high consumption of water (90,000m^3/day), steam, and electric power, being characterized by large amount of highly colored industrial wastewater. Because of increase in productivity and increased assortment of dyes and other chemicals, substantial necessity appears in re-equipment of purification facilities by application of efficient methods of wastewater treatment.

2. Results

Laboratory feasibility study.
The results of laboratory investigations showed the application of electron beam treatment of wastewater to be perspective for its purification The most significant improvements result in decolorizing and destructive oxidation of organic impurities in wastewater. Installation of the radiation treatment on the stage of chemical treatment or immediately before biological treatment may results in appreciable reduction of chemical reagent consumption, in reduction of the treatment time, and in increase in flow rate limit of existing facilities by 30-40%.

Construction of pilot plant.
Being convinced with the feasibility of laboratory scale tests, a pilot plant for a large-scale test (flow rate of 1,000m^3 per day) of wastewater has constructed and is now under operation with the electron accelerator of 1MeV, 40kW. The size of extraction window is 1500mm in width and Titanium foil is used for window material. For the uniform irradiation of water, nozzle type injector with the width of 1500mm was introduced. The wastewater is injected under the e-beam irradiation area through the injector to obtain the adequate penetration depth. The speed of injection could be varied upon the dose and dose rate. Once the wastewater has passed under the irradiation area, then directly into the biological treatment system.

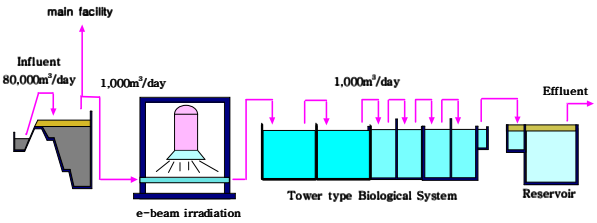

Figure 1 Schematic diagram of Pilot Plant with e-beam

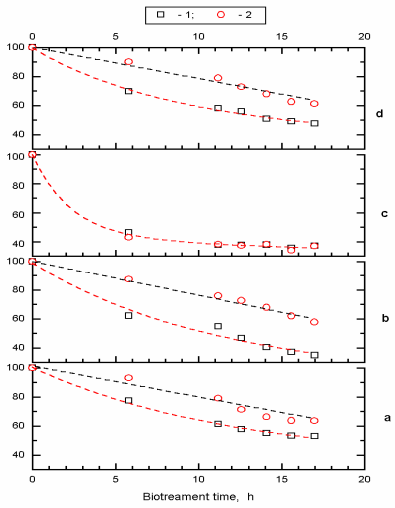

Figure 2 Effect of irradiation and biological treatment on wastewater parameters:

a- TOC; b-COD_{Cr}; c-COD_{Mn}; and d-BOD. 1- after EB treatment; 2- without EB treatment

Figure 2 shows that the wastewater can be efficiently purified by biological treatment. However, preliminary electron-beam treatment improves the process, resulting in more significant decreasing TOC, COD_{Cr}, and BOD_5. As concerns changes in TOC, COD_{Cr}, and BOD_5 during biological treatment, from the data presented in Figure 2

it follows that preliminary electron-beam treatment make it possible to reduce bio-treatment time twice at the same degree of removal. Coincident results were obtained in a separate set of experiments on the same pilot plant but with reduced wastewater flow rate (~130 l/day).
In this case inlet flow was divided into two flows: the first one passed only biological treatment while the second one passed electron-beam treatment, then biological treatment with reduced hydraulic retention time (HRT). Averaged for one month's period decrease in TOC values amounted 72%, for the first flow (48h HRT biotreatment), and 78%, for the second flow (1 kGy electron-beam treatment followed by 24 h HRT biotreatment).

Construction of industrial plant.
On the evaluation of economies and efficiency of pilot plant, industrial plant for treating textile dyeing wastewater is under construction from 2003 for decreasing the amount of chemical reagent, improving the removal efficiency and decreasing the retention time in Bio-treatment facility. According to the data obtained in laboratory and pilot plant experiments with DDIC wastewater, the optimum absorbed dose for electron-beam treatment was chosen to be near 1 kGy. For those purpose 400 kW electron accelerators with three separate irradiators was manufactured as a source of ionizing radiation. The plant is located on the area of existing wastewater treatment facility in DDIC and to have treatment capacity 10,000 cubic meters of wastewater a day using one 1MeV, 400kW accelerator, and combined with existing bio- treatment facility.

3. Conclusion

1. A pilot plant for treating 1,000m^3 of textile dyeing wastewater per day with electron beam has constructed and operated continuously since October 1998. This plant is combined with biological treatment system and it shows the reduction of chemical reagent consumption, and also the reduction in retention time with the increase in removal efficiencies of COD_{Cr} and BOD_5 up to 30~40%.
2. Increase in biodegradability after radiation treatment of aqueous-organic systems is due to radiolytical conversions of non-biodegradable compounds. In present experiments the improvement of biological treatment of wastewater after preliminary electron-beam treatment was found to be caused by radiolytical transformations of biodegradable compound.
3. On the basis of data obtained from pilot plant operation, construction of actual industrial scale plant has started in 2003, and finished by December 2005. This plant is located on the area of existing wastewater treatment facility in DYCEN and to have treatment capacity 10,000m^3 of wastewater per day using one 1MeV, 400kW accelerator, and combined with existing bio- treatment facility.

Acknowledgment

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