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THE USE OF ELECTRON BEAM ACCELERATOR FOR THE TREATMENT OF DRINKING WATER AND WASTEWATER IN BRAZIL

SAMPA, M.H.O.; BORRELY, S.I.; SILVA, B.L.; VIEIRA, J.M.; RELA, P.R.; CALVO, W.A.P.; NIETO, R.C.; DUARTE, C.L.; PEREZ, H.E.B.; SOMESSARI, E.S.LUGÃO, A.B.

INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES - IPEN-CNEN/SP
Cidade Universitária - Travessa R, 400 - 05508-900 - São Paulo - SP - BRAZIL

ABSTRACT

Brazil started a research program using high-energy electrons from accelerators for treating drinking water and wastewater in 1991. The objective is to study the potential use of this technique for disinfection of domestic wastewater, chemical degradation of dyes, phenols, oils and greases in industrial wastewater and reduction of trihalomethanes (THM's) concentration in drinking water. An Electron Beam Accelerator, 1.5MeV - 25mA from Radiation Dynamics Inc., was used for all experiments. A pilot plant designed to treat up to $3m^3/h$ was built.

KEYWORDS

High energy electron beams, disinfection, trihalomethanes, wastewater treatment,

INTRODUCTION

The industrial development has generated halogenated hydrocarbons, used as solvents, dielectric fluids. The land application of pesticides, fertilizers by the agriculture, as well as the large quantities of domestic wastewater generated in the most developed regions of the country has introduced pollution into the air, land and waters. Most of the pollutants in industrial wastewaters are chemically and biologically resistant, thus the application of conventional treatments is often not sufficient. Besides, the reduction of microorganisms in wastewater treatment plants with chlorination was found insufficient and it may generate the formation of carcinogenic chlorinated hydrocarbons. The same phenomenon was observed with the chlorination of drinking water containing humic substances which will promote the trihalomethanes formation, regarded as toxic or carcinogenic (Getoff, N., 1989.)

At IPEN, Nuclear Energy Research Institute, in São Paulo, Brazil, studies have been carried out with the use of ionizing radiation for the treatment of drinking water and wastewater using high energy electron accelerator as source for the radiation processing from the point of view of safety, handling and large energy output.

OBJECTIVES

IPEN is developing one research program which includes ionizing radiation application for domestic wastewater disinfection, chemical degradation of dyes, phenols, oils and greases in industrial wastewater and reduction trihalomethanes (THM's) concentration in drinking water. For this purpose a pilot plant was built at the IPEN's Electron Beam Facility with the following objectives: a) technical and economical feasibility studies of irradiation technology for environmental pollution mainly with industrial and domestic wastewater, sludges , hazardous wastes; b) conventional process comparison; c) association with other technologies for efficiency improvement and d) in the middle term services in reduced scale to industries with environmental problems without solution on conventional technologies.

EXPERIMENTAL

a) Batch system: Electron irradiation was performed using a Dynamitron II Electron Beam Accelerator from Radiation Dynamics, Inc., 1.5MeV, 37.5kW with multipurpose uses. Using a conveyor with 6.7m/min, the maximum 4mm thickness of wastewater layer was irradiated by an electron beam 2cm width and scanned 120cm length. Samples were placed in Petri dishes or in a pyrex vessel to obtain different volumes and the irradiation was performed with doses from 2kGy to 10kGy

b) Pilot plant: It was built to get information on scale-up effects of wastewater and drinking water treatment for a commercial scale plant design and economic feasibility studies of this technology. This pilot plant was designed to receive up to $3m^3/h$, is very simple and low cost (Fig.1). Samples to be irradiated are in $2m^3$ tank and a pumping system is used for liquid homogenization and another pumping system feeds samples to the irradiation box specially built to this purpose (Fig. 2)

A calorimetric system to measure the dose was developed in order to record the continuous dose rate of water flow. Absorbed dose is calculated by measuring the temperature difference of the water stream before and after irradiation. Eight sensors of temperature (thermistors) were mounted in the irradiation box and connected to an electronic system, to amplify the signal, and to a computer. A special software was developed to acquire in real time the temperature signals, calculate the absorbed dose and display each one at measured temperatures and the mean absorbed dose.

RESULTS AND DISCUSSION

Wastewater Disinfection

Since the aim of our study has been the disinfection of domestic wastewater, and due to the sanitary significance of total and fecal coliforms, this study includes a one year period of sampling from Lagoon System at São Paulo Municipal Wastewater Treatment Plant, concerning to coliforms and total bacterial count reduction. To study coliforms and total bacteria reduction, samples were examined by multiple

Table 1. - Disinfection of Raw Domestic Wastewater by Electron Beam Irradiation

Irradiation Dose (kGy)	Total Coliforms (MPN 100 ml)	Fecal Coliforms (MPN 100ml)	Total Bact.Count (CFU/ml)
0	1.3×10^7	7.3×10^6	3.1×10^6
2.0	4.0×10^4	9.0×10^2	1.2×10^4
3.0	9.0×10^2	3.2×10^1	4.1×10^2
4.0	2.4×10	2	7.6×10

tube technique, (five tubes series), and Plate Count /Nutrient Agar, respectively, before and after irradiation, using Difco medium as showed in Table 1.

Salmonella reduction. From 894 examined samples of sewage, salt water and freshwaters for Salmonella, the most frequent serotype were: *S.derby, S.typhimurium, S.infantis* and *S.meleagridis* (Martins et al., 1988). These four cepas were accordingly maintained at laboratory conditions with tryptic soy agar, Difco, and irradiated in buffer solution with standardized population density after growing on selenite broth, Difco, at 42,5°C, 24/48 hours, results are showed in Fig. 3.

Trihalomethanes Reduction

To study trihalomethanes reduction, potable water samples from São Paulo city were taken and analysed by Gas Chromatography. A pilot plant was used with a flow rate of 1.3m^3/h, the energy was fixed on 1.5MeV and the current was varied. Table 2 shows the trihalomethanes concentrations with the irradiation doses and the pH.

Table 2. THM's reduction with the doses

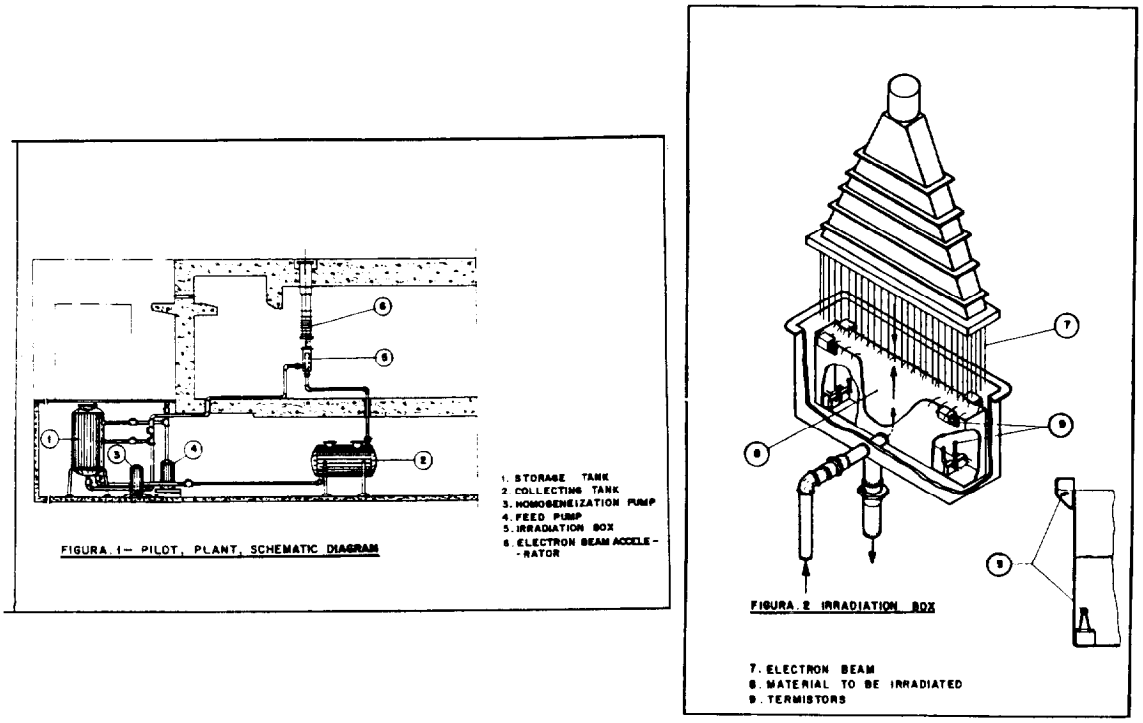
Dose kGy	CHCl3 µg/l	CHBrCl2 µg/l	CHBr2Cl µg/l	CHBr3 µg/l	pH
0	77.99	12.25	3.16	168.32	7.64
2	9.80	n.d.	n.d.	n.d.	5.81
3	7.11	n.d.	n.d.	n.d.	4.53
4	8.90	n.d.	n.d.	n.d.	4.20
5	6.78	n.d.	n.d.	n.d.	4.94
6	3.72	n.d.	n.d.	n.d.	4.22

n.d. not detected (below detection limits);
CHCl3 = Chloroform; CHBr3 = Bromoform;
CHBrCl2 = Bromodichloromethane;
CHBr2Cl = Dibromochloromethane.

This table shows a dose of 2 kGy may remove approximately 87.4% of Chloroform, while the increase of the dose until 6 kGy provokes a near 95.2% removal. Other compounds were not detected with the dose of 2kGy. Other experiments were performed with high Chloroform concentrations, varying from 145µg/l to 7800µg/l and the results showed a reduction efficiency near to 95% at the doses below 6kGy.

CONCLUSIONS

The experiments using the pilot plant show to the local private and governmental institutions responsible for wastewater treatment an alternative and effective technology for the significant destruction of halogenated hydrocarbons. In close cooperation with such institutions these experiments are currently being conducted for: the pilot plant operational parameters optimization, the studies of the reactions by-products formation, the effectiveness of the process and the possibility of the associated costs being competitive with conventional treatments methods. Referring to disinfection, the data show that radiation technology can contribute to the environment avoiding chemical addition as well as reducing contaminants.



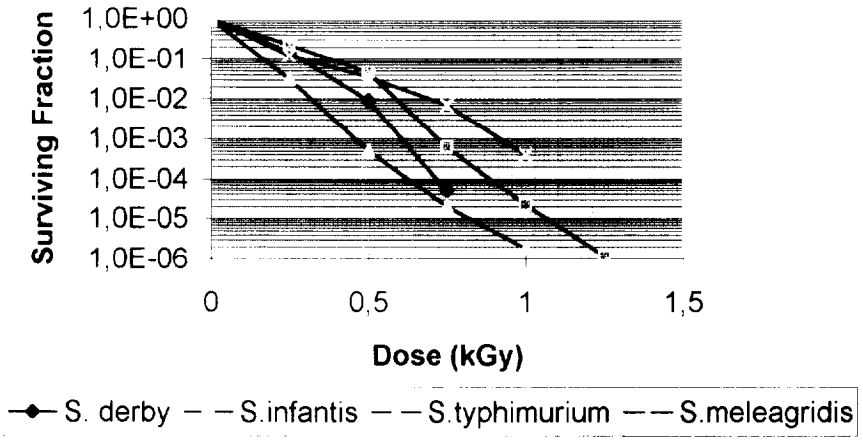


Figure 3 - Salmonella radiosensitivity

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