



IMPROVEMENT OF MUNICIPAL WASTEWATERS BY ELECTRON BEAM ACCELERATOR IN BRAZIL

S.J. BORRELY, N.L.DEL MASTRO, M.H.O.SAMPA

INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES-IPEN/CNEN/SP

Cidade Universitária - Travessa R, 400 - 05508-900 - Sao Paulo - SP - BRAZIL Fax:55-11-816-9186 - Phone: 55-11-816-9267 - E-mail:sborrely@net.ipen.br

ABSTRACT

Radiation processing of municipal sewage and sludge has been considered not only for disinfection but also for solids and organic matter removal in Brazil. The improvement of irradiated systems were demonstrated by the elimination of indicator bacteria and by the reduction on the total bacteria count, on the chemical and biochemical oxygen demand from raw sewage and biologically treated effluents. The selected doses of radiation to be applied to sewage and sewage sludge are in the range of 3.0 to 4.0 kGy to sewage and 4.0 to 6.0 kGy to sewage sludge.

KEYWORDS

disinfection, electron beam, radiation processing, sewage, sludge

INTRODUCTION

There are some consistent reasons for the search of others advanced technologies for disinfection of wastewater and sludge, which has contributed to the development of ozone reactors dedicated for waters disinfection as well as to the progress of ionizing radiation, through the use of cobalt-60 and electron accelerators for environmental applications. To mention some of the reasons for the claim of new technologies it is important to point out that chlorine has been the most applied disinfectant for waters worldwide. As a consequence of this large use of chlorine, its toxicological effects to aquatic organisms has been evaluated (Ward, 1980). On the other hand, the inefficiency of chlorine to wastewater's needs to be considered as well as the generation of by-products by the combination of chlorine and some organic acids. The formation of trihalomethane compounds is a function of precursor concentration, contact time, chlorine dose, and pH (American Public Health Association, 1989).

Once the environmental regulations are being reviewed in Brazil and new conventional treatment plants are foreseen, the IPEN's Electron Beam Accelerator has being also dedicated to the study of the disinfection of sewage and sludge. There is an expectancy that until 2005, the São Paulo Metropolitan Region will generate 600 ton/day of dehydrated sewage sludge.

This work shows some results obtained when an Electron Beam Accelerator was applied to raw sewage, to biologically chlorinated and unchlorinated effluents and to sewage sludge, originated from distinct municipal wastewater treatment plants. The main objective was disinfection but the control of some physical-chemical parameters demonstrated other benefits besides disinfection.

MATERIAL AND METHODS

A Dynamitron II Electron Beam Accelerator, 1,5MeV - 37,5kW, from Radiation Dynamics Inc., was used to treat samples of sewage and sludge originated from two distinct wastewater treatment plants. The sewage was sampled from a lagoon system which discharge, approximately, 30 L/s of chlorinated effluent and there is no sludge generation. Sewage sludge was sampled from a conventional station which includes anaerobic digestion and generates, approximately, 200 ton/day of dehydrated sludge.

Irradiation were carried out in batch system, with samples contained in sterile Pyrex vessels. The thickness of the layer samples was 4.0mm, controlled by the volume of samples to be exposed to radiation. The required doses were obtaining varying the beam current, while the energy and the conveyor velocity were kept constant and selected in 1.4MeV and 6.72 m/min, respectively (Borrely, 1995). DL-Alanine Electron Spin Resonance dosimetry was utilized during the experiments.

The disinfection was observed by the elimination of indicators bacteria, i.e. total and fecal coliforms, enumerated by the Most Probable Number Technique, NMP/100mL, through the lactose fermentation, and by the reduction on the total aerobic bacteria count, plating count with Difco-Nutrient Agar.

The solids (total and settleable) and organic matter through chemical and biochemical oxygen demand, COD and BOD_{5,20}, were monitored before and after irradiation, using composite samples of raw sewage.

RESULTS AND DISCUSSION

SEWAGE - Concerning indicator bacteria, fecal coliforms were more radiosensitive than total coliforms. Figure 1 shows the reduction of total coliforms by the use of 3,0kGy dose applied to raw sewage, to the effluent from facultative lagoons and to the final chlorinated effluent. Doses between 3,0kGy and 4,0kGy reduced 5 log cycles of the most probable number for total coliforms. The efficiency of 3,0kGy was enhanced when applied to the effluent of facultative lagoons because of the higher concentration of dissolved oxygen, introduced by the algae. For the total aerobic bacteria count, doses between 3,0kGy to 4,0kGy assured a reduction of 3 to 4 log cycles, for raw sewage, Figure 2. The final chlorinated effluent presented 5.6×10^2 CFU/mL to 1.1×10^3 CFU/mL which were completely eliminated by means of a 3,0kGy dose. The organic matter reached a nearly 30% reduction with doses between 3,0kGy and 9,0kGy, TABLE 1.

SEWAGE SLUDGE - Irradiated dewatered sludge disinfection was observed by the reduction on total bacteria count. Initial counts were in the range of $2,0 \times 10^7$ up to $2,6 \times 10^9$ /g. Figure 2 shows the degree of disinfection obtained with doses in the range of 0.5kGy to 10.0kGy. From 4.0kGy to 10.0kGy doses it was obtained a 3 to 5 log cycles reduction on the total bacteria counts. When 15.0kGy dose was applied a considerably level of hygienization was obtained with counts being lower than 10 colonies forming units per milliliter in 17 samples.

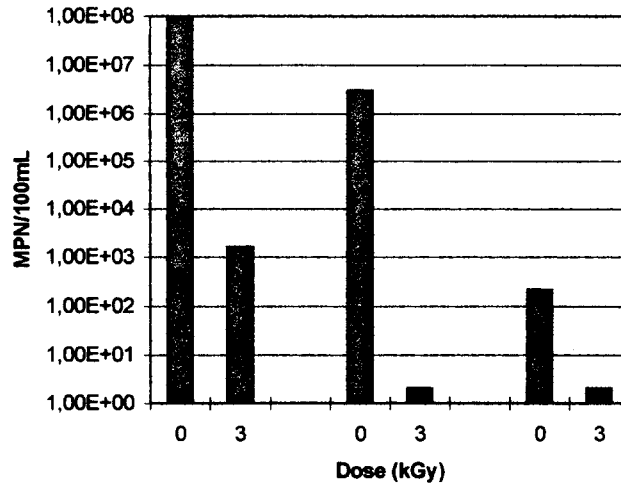


Figure 1. Coliforms elimination from raw sewage, secondary effluent and chlorinated final effluent with 3,0kGy radiation dose.

Table 1 - Organic matter and solids removal by radiation applied to raw influent

PARAMETER	CONTROL	DOSE		
		(kGy)	(kGy)	(kGy)
-	-	3.0	6.0	9.0
BOD (mg/L)	270.0	207.0	171.0	170.0
COD (mg/L)	749.0	697.0	632.0	560.0
TOTAL SOLIDS (mg/L)	806.0	722.0	702.0	640.0
SETTLABLE (mg/mL)	3.0	3.0	2.7	1.5

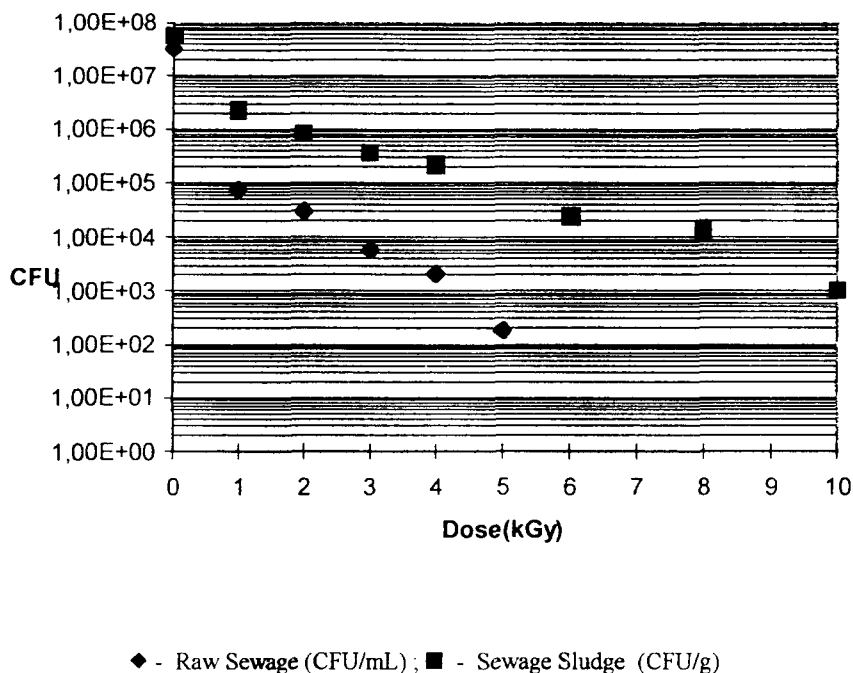


Figure 2 - Elimination of total bacteria count from sewage and sewage sludge by electron radiation

CONCLUSION

Although the susceptibility of microorganisms to irradiation varies considerably with different species, the results presented above allow us to conclude that by combined biological and radiation processing of sewage and sludge, in this case through electron beam radiation, the level of disinfection could be improved avoiding the chlorination.

Some other experiments with municipal effluents are planned in a larger scale on a pilot plant in order to compare to these results obtained in batch condition and to get feasibility data (Sampa, M.H.O. et al., 1995).

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