ELECTRON BEAM RADIATION APPLIED TO SEWAGE AND SLUDGE AS A DISINFECTANT TECHNOLOGY

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ABSTRACT

The present paper brings some results obtained by the use of an electron beam accelerator applied to sewage and sludge as a disinfectant technology. The samples were collected at two different wastewater treatment stations from São Paulo. The disinfection efficiency was observed by the enumeration of total and fecal coliforms and total aerobic bacteria, which were selected for this study once they are universal indicators for biological contamination of water. Doses to be applied were selected in the range of 3.0 to 4.0 kGy for sewage and 5.0 to 15.0kGy for sludge. The irradiation induced other benefits than disinfection. The removal of chemical and biochemical oxygen demand was slightly reduced as well as the total solids residues.

I. INTRODUCTION

In São Paulo the quality of waters is threatened by several and primary factors such as: disorganized distribution of population[1] , the few amount of sewage receiving treatment nowadays, the level of waters contamination submitted to conventional treatments and the limitations of some technologies for non biodegradable contaminants. On the other hand the need of alternative technologies dedicated to waters improvement can be demonstrated by the increasing number of health cases associated to the contamination of chlorinated water and food.

Since radiation techniques are well established for sterilization of medical devices it can be useful as a disinfectant technology for wastewater. Radiation processing of wastes has been considered a promising technology due to its ability to penetrate the material and induce fundamental changes through the following events: oxidation of organics molecules, disturbance of the structure of organic and inorganic molecules, killing of microorganisms and changes in colloidal systems[2].

This paper presents some results obtained when an electron beam accelerator, EBA, was applied to samples of sewage and sludge, collected at different wastewater treatment plants.

II. MATERIAL AND METHODS

The disinfection was observed by the elimination of indicators bacteria, i.e. total and fecal coliforms, enumerated by Most Probable Number Technique[3], NMP/100mL, through the lactose fermentation. The enumeration of total aerobic bacteria, plating count with Difco-Nutrient Agar, was also conducted as an evaluation of the degree of disinfection obtained by the irradiation of raw domestic sewage and dehydrated sludge.

A Dynamitron EBA, 1,5MeV - 37,5kW, was applied to samples of sewage and sludge originated from two distinct wastewater treatment plants. The sewage was sampled from a lagoony 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.

Irradiations were carried out in batch system, with samples contained at sterile pyrex vessels. The thickness of the layer samples was 4.0mm, controled 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[4]. DL-Alanine

Electron Spin Resonance dosimetry was utilized during the experiments.

Other physical-chemical parameters were monitored before and after irradiation for liquid effluents. They are total solids and organic matter through chemical and biochemical oxygen demand, COD and $BOD_{5,20}$,using raw sewage composite samples.

III. 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 applied to raw sewage and to the effluent from facultative laggons, before chlorination tank. The efficiency of 3,0kGy was enhanced when applied to the effluent of facultative laggons because of the higher concentration of dissolved oxygen, introduced by the algae.

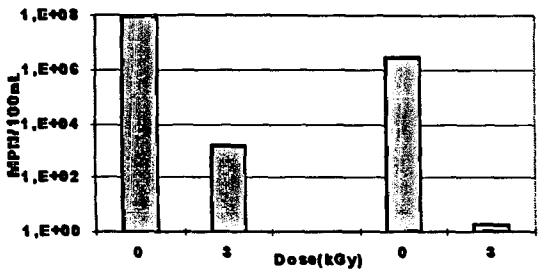

Figure 1 - Elimination of total coliforms from raw sewage and secondary effluent, respectively, by a 3.0kGy radiation dose.

The reduction on the total aerobic bacteria count was obtained with doses between 3,0 to 4,0 kGy , which assured a reduction of 3 to 4 log cycles, for raw sewage, as indicated in Figure 2. The final chlorinated effluent presented 5.6 x 10^2 to 1.1 x 10^3 CUF/mL which were completely eliminated by means of a 3,0kGy dose.

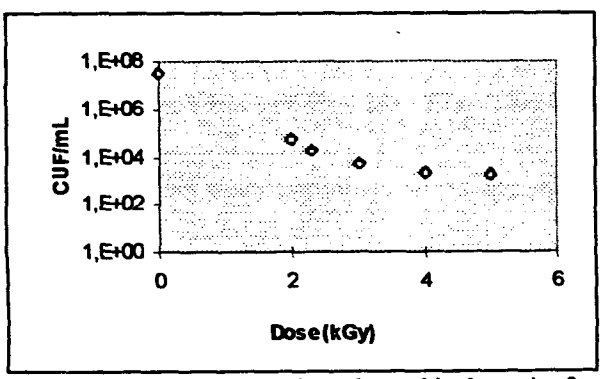

Figure 2 - Elimination of total aerobic bacteria from sewage by radiation.

The efficiency of radiation was observed not only for disinfection but also for organic matter reduction on the raw sewage. It can be noted a removal of , approximately. 30% for BOD and COD, see Table 1. Figure 3 shows the effect of radiation on solids residues. When higher doses were tested a significant reduction on settleable solids was obtained.

Table 1 - Physical-chemical parameters modification induced by radiation doses

PARAMETER	CONTROL	DOSE (kGy)		
-	-	**3.0**	**6.0**	**9.0**
DBO (mg/L)	270.0	207.0	171.0	170.0
DQO (mg/L0	749.0	697.0	632.0	560.0
COLOR (appar) (UC)	320.0	220.0	260.0	340.0
TOTAL SOLIDS (mg/L)	806.0	722.0	702.0	640.0
SETTL. (mg/mL)	3.0	3.0	2.7	1.5

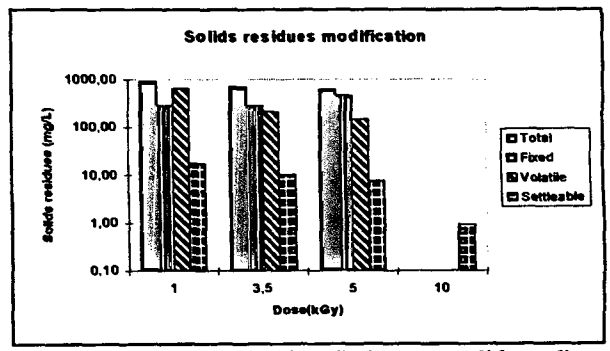

Figure 3 - The effect of radiation on solids redisues contained on primary domestic effluents

Sewage Sludge - Dewatered sludge disinfection was observed by the reduction on coliforms and on total bacteria count. Initial counts were in the range of 2,0 x 10^7 up to 2,6 x 10^9 . Figure 4 shows the degree of disinfection obtained with doses of 5.0 to 15.0kGy. With a 10.0kGy dose it was obtained a 3 to 5 log reducing on the total bacteria number. When 15.0kGy dose was applied a considerably level of hygienization was obtained with counts reaching lower than 10 CUF/mL in 17 samples.

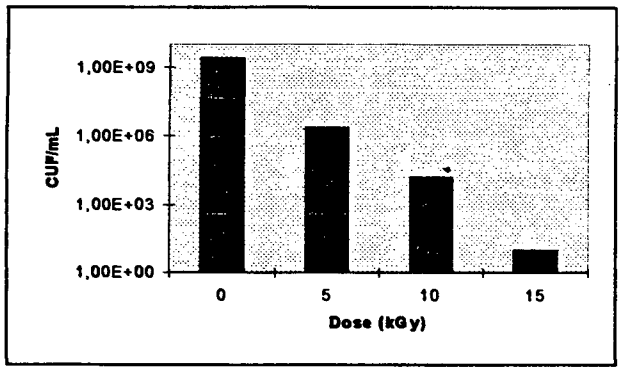

Figure 4 - Elimination of total aerobic bacteria from dewatered sludge

IV. CONCLUSION

The results presented on this paper shows that electron beam radiation can be useful as a disinfectant technology. When radiation was applied for substituting chlorination at one of the station studied an improvement on disinfection was obtained. The doses selected as ideal for the elimination of indicator bacterial were 3.0 to 4.0kGy for sewage and from 4.0 to 6.0kGy for sludge.

Higher doses may be required for sludge, depending on the situation, once this product can be applied as a soil conditioner.

ACKNOWLEDGMENTS

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REFERENCES

[1] - Gusmão, R. P. **Diagnóstico Brasil: a ocupação do território e o meio ambiente**, IBGE, Rio de Janeiro, 1990.

[2] - Ballantine, D.S. **Potential Role of Radiation in Waste-Water Treatment**. Isotopes and Radiation Technology,V.8. n.4, 1971.

[3] - American Public Health Association . **Standard Methods for the Examination of Water and Wastewater**. 17th Edition, 1989.

[4] - Borrely, S.I. **Tratamento de Esgoto Sanitário com o Uso de Acelerador de Elétrons,** (*Master Thesis*), 1995.