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TREATMENT OF COFFEE WASTEWATER BY GAMMA RADIATION

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Abstract

Radiation energy can be an important resource in the treatment of wastewaters from different industries both directly and in combination with other processes to improve economics. The aim of this study was to evaluate the effect of an ionizing radiation on coffee wastewater in order to decompose chemical organic refractory substances which can not be degradated by biological treatment. One of the approaches employed in the survey was the chemical treatment followed by the irradiation of the samples since no nuclear changes of the coagulant solution or wastewater samples were expected. Irradiation is a high cost treatment although has increased its applications nowadays. The method is safe, fast and effective and it does not generate any pollution.

1. INTRODUCTION

In the last years the irradiation treatment of the wastewaters has been a new alternative to face the pollution problems caused by the disposal of the waters to rivers and grounds. This treatment is enhanced by the action of ionizing radiation and its roll in the intensification of the oxidation of mineral and organic impurities with resulting effects like: water disinfection, deodoration and decoloration, chemical decomposition of substances like phenols, cyanides, surface active substances and other slowly oxidizing compounds [1].

The increase in the environmental pollution caused by wastewaters from coffee industries in our country has lead to analyzing, and carefully choosing the most effective and simple technological treatment to be used. The aerobic and anaerobic treatment have been used although a low effectiveness has been achieved as a consequence of the presence of toxic compounds inhibiting fermentative processes. The irradiation processing of coffee wastewater can contribute in an important way to solving this problem as well as the possibility of using irradiation for the disinfection of this waste.

One of the features of the coffee industry is the use of large volumes of water. Although some attempts were made to reduce it in the last years through the use of "dry" approaches, for many reasons the technological treatment remains unchanged up to date. Almost half of the world coffee production is processed by the "wet method", producing two major waste products: pulp and wastewater from depulping and washing the beads. The depulping wastewater has a low pH (4-4.5) and a high content of organic mater e.g. acetic acid,

propionic acid, valeric acid, caffeine, phenols, etc. with a Chemical Oxygen Demand ranging from 10 to 16 mg/L.

2. MATERIALS AND METHODS

A survey of the effect of gamma radiation on wastewater from coffee wet depulping was carried out. Samples were collected from Wajay Coffee Treatment Plant in Havana. The depulping wastewater contains normally about 16 g/L COD (Chemical Oxygen Demand) and a high concentration of phenols (120 mg/L) which negatively influence the biological treatment of such wastes. The COD analysis were made using the standard permanganate method.

The samples were irradiated by a batch procedure, using 1L volume capacity Pyrex glass vessels at 20 °C with doses ranging from 0.5 to 100 kGy. For the irradiation of the samples a MP-γ-30 installation was used, been its technical parameters the following: Installed activity: 10.5 KCi Dose power: 4.377 Gy/s, volume capacity: 4.4 L, Source: ^{60}Co, Half life: 5.26 years. The dosimetry control of the irradiation system was carried out using Frikke and Cerium dosimeters.

3. RESULTS AND DISCUSSION

Table 1 shows the effect of gamma radiation on conventional parameters of wastewaters. It should be noted that the major influence of radiation on phenol content is observed at lower doses rather than at greater ones. In fact about 50-60 % of phenols is degradated up to a dose of 1 kGy and from that value on the phenol content undergoes only a slight decrease. This is well established by [2]. It was also noted that between 5 and 50 kGy an intensification of the color of the samples was observed. As it is stated in the literature [1], in the irradiation of wastewater containing phenols (10^{-3} M) the values of the radiochemical yield G(-phenol) ranges from 2.66 to 0.45 with and without air respectively.

Comparatively 1.17×10^{-3} M phenol solutions need degradation doses of approximately 4.23 and 1.9 KGy with and without air respectively. Phenol decomposes in hydroquinone, hydroxyhydroquinone, pirocatechol, resorcine etc. which must undergoas further decomposition up to final products (maleic acid and non aromatic compounds) through high doses (0.2-0.25 MGy) of irradiation. These high doses make this method uneconomic. Nevertheless the beneficial effect of radiation treatment may be obtained at a lower dose in combination with other processes.

Regarding suspended solids, it was observed along the experiments the formation of solids. This can be the result of a radiation induced polymerization in such a complex system which could involve the suspended particles, so that from the dose 5 KGy on, no suspended matter is observed.

The Chemical Oxygen Demand undergoes an exponential decrease from its starting value 16 g/L. Values showed in table I are taken under non aerated conditions. As it is showed here, from the dose 25 KGy on, COD remains almost constant but is still large. As stated in [3] further decomposition of the waste can occur when it is submitted to air bubbling, thus an aerated treatment combined with irradiation could seem in this case apparent.

Table II shows the effect of gamma radiation of the samples at 25 kGy. The simultaneous action of chemical treatment ($Ca(OH)_2$-precipitation followed by $Al_2(SO_4)_318H_2O$-coagulation)is compared to the combined treatment (chemical treatment + simultaneous irradiation), being the last more efficient. It is probably due to structural changes

TABLE I. EFFECT OF GAMMA RADIATION ON DIFFERENT PARAMETERS OF WASTEWATER

Dose, KGy	0	0.5	1	5	10	25	50	75	100
COD,g/L	20.7	10.8	10.8	14.4	13.0	14.4	14.7	15.5	15.2
Total suspended solids (mg/L)	8.66	0.56	0.87	-	-	-	-	-	-
Phenol (mg/L)	120	84	50	42	39	30	32	34	32

TABLE II. EFFECT OF IRRADIATION DOSE ON SAMPLE ORGANIC CONTENT AT 25 KGY

	Turbidity (% removed)	BOD (% removed)	COD (% removed)
Chemical treatment	56.7	47	23.8
Chemical treatment plus irradiation	87.5	70	32.5

of molecular aggregates and ions, as well as the activation of the coagulant under radiolysis.[4], which results in a large increase of the flocules formation rate.

Fig. 1 shows the radiation decomposition of coffee wastewater as a function of dose in aerated and non aerated conditions. As it was noted before, we could expect that the wastewater decontamination would not be so high because of the oxygen lack, which is consumed along the irradiation. All this could cause a slower decomposition at the beginning (lower doses) and slower decomposition at the end (higher doses). In order to check this effect there were arranged experiments in which air was bubbled simultaneously with irradiation of the samples. The air flow rate was changed from 30 to 90 L/h.

4. CONCLUSIONS

The irradiation process is a new alternative for the treatment of coffee wastewaters and the preservation of the environment from toxic substances like phenols and other organic substances. Study have also shown that irradiation of wastewater is a feasible process, capable

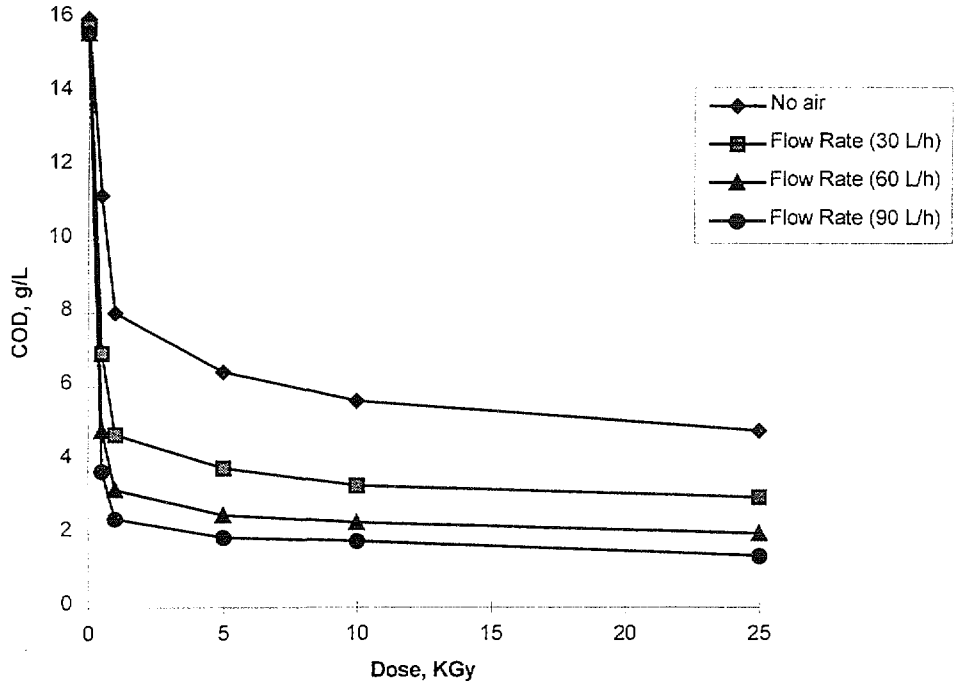

FIG. 1. Radiation induced decomposition of coffee wastewater.

of destroying toxic organic compounds and in many instances those toxic organics can be made more biodegradable or "softer" to chemical treatment by irradiation. It has been shown that in the presence of air it was possible to destroy up to 70 % of the COD at different air flow rates. Under those circumstances we can state that the irradiation combined process is effective and feasible at low doses. It was also shown that irradiation of the mixture solution +coagulant results in a higher decontamination, due to a radiation activation of the coagulant [4].

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