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Electrochemical Coagulation Followed By Sequencing Batch Reactor For Treating Coffee Pulping Wastewater

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Abstract: The coffee pulping wastewater used for this study is characterized by low pH with high concentration of COD, nitrogen and phosphorous. With aluminum plates as anode and cathode electrodes and at a current density of 93.87 A m^{-2} the electrochemical (EC) reactor performance was found to be good. The experimental results showed that the COD, ammonia nitrogen, nitrate nitrogen and phosphorus removal was found to be 94%, 90%, 89% and 94% respectively and the aluminum consumed was 0.2219 g with 120 minutes of electrolysis time. The BOD to COD ratio increased from 0.012 to 1.49 in 105 minutes of electrolysis duration, indicating improvement of wastewater biodegradability. Since there was an improvement of BOD/COD ratio, the EC treated wastewater was further treated in an anaerobic sequencing batch reactor (ASBR) to remove the remaining COD. In ASBR the COD removal was found to be 86 % and more than 99% removal of nitrogen and phosphorus was observed. The combined electrochemical treatment followed by ASBR removes 98% of COD and the concentration of ammonia nitrogen, nitrate-nitrogen, phosphorus was below detection level in the effluent.
Key words: COD, BOD, Cofee, wastewater, SBR.

Introduction

Coffee, which belongs to the genus Coffea of rubiaceae family, is one of the most popular beverages consumed through out the world[1]. Coffee as a primary agricultural produce, India grows about 3 lakh tonnes of coffee annually and has ranked sixth in the world[2]. Preparation of coffee beans requires parching and washing activities making use of significant quantity of clean water. The water consumption and the concomitant wastewater discharge range between 1.5 to 23 m^3 per tonne of fruit processed[3]. The characteristics of coffee pulping wastewater vary widely depending on the type of the crop cultivated; the nature of the process employed for depulping cherrie namely semiwashed, wetwashed processing; capacity of the processing unit and in-plant measures if any to reuse and recycle of water resources. In India coffee pulping is carried out by small and medium sized plantations normally by wet method for whom there is inadequate compulsions to carry out effluent treatment[2].

Several treatment methods are suggested by previous researchers for the treatment of wastewater generated from coffee processing units which include digestion of wastewater in UASB reactor at mesophilic and thermophilic temperatures[4], anaerobic hybrid reactor (UASB/Filter) [5], anaerobic digestion of coffee

pulping wastewater in multifeed bio reactor[3] aeration as the post treatment option for biomethanated coffee pulping wastewater[1], treatment of coffee pulping wastewater by Photo-Fenton and Fenton methods coupled to UASB reactor[6], decolourization of synthetic coffee effluent using solar Photo-Fenton reactor[7]. However problems of operation and maintenance as well as sustenance of bioreactors due to the accumulation of the volatile fatty acids and characteristic low pH of the coffee pulping wastewater is reported[4,5]. In addition it is observed that most of the physicochemical treatment methods attempted aim at decolorization of synthetically prepared coffee curing wastewater rather than real coffee pulping wastewater.

The coffee pulping wastewater subjected to present study was characterized by acidic pH, low BOD with high concentration of COD and nutrients. Since BOD to COD ratio of coffee pulping wastewater is very low, treatment by biological methods is very difficult. Many researchers have used electrochemical methods for improving BOD/COD ratio of high strength wastewater. Thus the present study was under taken to with the aim of developing complete treatment technology and Electrochemical and Sequencing.

Materials and methodology

2.1 Characterization of wastewater

The coffee pulping wastewater used in this study was collected from existing lagoons of coffee pulping units from the different coffee estates located in kodagu district of Karnataka state, India. The raw wastewater was analyzed for various parameters and the characteristics are shown in the Table 1. It can be seen that the COD concentration is very high with low BOD and pH. The initial BOD to COD ratio was found to be very low in the range of 0.05-0.045, which suggests that there is a presence of recalcitrant nature of organics in the wastewater.

2.2 Analytical methods

All the chemicals used for the analysis were of analytical reagent (AR) grade. All the analytical procedures followed the standard methods for examination of water and wastewater[6]. The solution pH was measured using pH meter. COD was determined by closed reflux system (Hach-389, USA) and titrimetric method. The aluminum concentration in the solution was measured using inductively coupled plasma spectrophotometer. Sulphate, ammonia-nitrogen, nitrate-nitrogen and phosphorus were analyzed as per standard methods (spectrophotometer (Hach, USA).

Table 1 Characteristics of coffee pulping wastewater

Parameter	Value
Ph	4.27-4.40
BOD_3@ 27^0C, mg/L	472-551
COD, mg/L	9360-12040
Ammonia nitrogen, mg/L	42-56
Nitrate nitrogen, mg/L	18-32
Phosphate, mg/L	122-125
TOC, mg/L	257-263
Chlorides	150-180

2.3 Experimental studies

2.3.1 Electrochemical experiments

The laboratory scale experimental setup used for electrochemical studies is schematically shown in Fig. 1. A glass beaker with working volume of 1 liter and monopolar electrode configuration using aluminum plates as electrode material (size of 7 cm × 7 cm with thickness of 1.5 mm) with inter gap of 1 cm. The samples were collected at regular time interval from the reactor and analyzed for various parameters.

2.3.2 SBR Experiments

An anaerobic sequencing batch reactor (ASBR) of working volume 2 L with cow dung as seed culture was used to treat the EC treated coffee pulping effluent. After electrochemical treatment the coffee pulping wastewater was fed into the reactor and kept under anaerobic condition for 23 hours. Every day 50 % of the reactor working volume was decanted followed by addition of the same volume as feed. Samples were collected for analysis of various parameters such as COD, ammonia nitrogen, nitrate nitrogen and phosphorus at the end of each cycle.

3.0 Results and Discussion

The electrochemical experiments were carried initially for various dilutions, Aluminum electrodes of surface area 49 cm^2 was used as both anode and cathode with distance between electrodes as 5 cm. Inially in the ratio of 1:1, 1:3 and for raw in order to test its treatability. The dilution of wastewater in the range of 1:3, 1:1 reduced the initial COD value to 5120 and 7680 mg/L to 598 mg/L and 800 mg/L respectively. For the raw coffee pulping wastewater the removal efficiency was found to be 81.60 %. The effluent obtained after EC treatment with aluminum was clear and stable with no further change in color.

From the results of electrochemical experiments the concentration of parameters such as COD, ammonium nitrogen, nitrate nitrogen and phosphorus have been reduced to greater extent. EC treated effluent contained COD in the range of 450 mg L^{-1} to 603 mg L^{-1}, ammonia nitrogen values were in the range 1 mg L^{-1} to 1.8 mg L^{-1}, the nitrate nitrogen concentration was in the range of 2.7 to 3.6 mg L^{-1} and phosphorus concentration was in the range of 2.2 mg L^{-1} to 2.7 mg L^{-1}.

With increase in the electrolysis duration the COD concentration would have reduced further but to reduce the power requirements the effluent from electrochemical reactor was further fed to SBR and anaerobic conditions were maintained since only COD was remaining in the electrochemical treated wastewater thus post treatment with SBR was attempted. For initial 11 days EC with synthetically prepared treated wastewater was fed to SBR and later on EC with aluminum electrode treated wastewater was fed to SBR. From day 9 onwards good performance of SBR was observed with COD and BOD values less than 33 mg/L and the nutrients (ammonia nitrogen, nitrate nitrogen and phosphorus) values were less than 1 mg/L.

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