Ultrasonics - Sonochemistry 61 (2020) 104825

Contents lists available at ScienceDirect

Ultrasonics - Sonochemistry

journal homepage: www.elsevier.com/locate/ultson

Ultrasound and heterogeneous photocatalysis for the treatment of vinasse from pisco production

Rodrigo Poblete[a,*], Ernesto Cortes[a], Guray Salihoglu[b], Nezih Kamil Salihoglu[b]

[a] Universidad Católica del Norte, Facultad de Ciencias del Mar, Escuela de Prevención de Riesgos y Medioambiente, Coquimbo, Chile
[b] Environmental Engineering Department, Engineering Faculty, Bursa Uludag University, Bursa, Turkey

ARTICLE INFO

Keywords:
Vinasse
Pisco
Ultrasound
Heterogeneous photocatalysis

ABSTRACT

Production of the distilled alcohol pisco results in vinasse, dark brown wastewater with high polyphenols contents and chemical oxygen demand (COD). No prior research exists on the efficiency of advanced oxidations processes (AOPs) in treating pisco vinasse. Therefore, the purpose of this study was to assess the efficiency of ultraviolet (UV), ultrasound (US), US + UV, heterogeneous photocatalysis (HP), and HP + US treatments. Polyphenols, COD, and color removal, as well as oxidation-reduction potential, were monitored over a 60-minute treatment period. Energy consumption levels and synergies were also calculated. The HP + US treatment achieved the best removal ratios for polyphenols (68%), COD (70%), and color (48%). While the HP treatment was the second most efficient in terms of polyphenols (62%), COD (58%), and color (40%) removal, this AOP comparatively required the least amount of energy. Considering the energy efficiency and relatively high pollutant-removal rates of the HP treatment, this AOP is recommended as a practical alternative for treating pisco vinasse.

1. Introduction

Pisco, a distilled alcohol made from grapes, is emblematic to Chile and Perú [1]. In 2017, Chile produced 40,000 m^3 of pisco for domestic sales and 412 m^3 for international markets which figures that underscore the importance of this product for the national economy [2]. Nevertheless, pisco production also results in waste products. Likewise, distillation produces wastewater termed vinasse, which amounts to 70% of the liquid distillate [3].

Vinasse is constituted mainly of water, organic pollutants (phenols and carboxylic acids), suspended solids, and inorganic minerals. Vinasse characteristically has a high polyphenols contents, chemical oxygen demand (COD), biochemical oxygen demand, and, depending on the distillation process, an acidic pH [4]. The direct discharge of vinasse into waterbodies would result in environmental pollution, including eutrophication and toxicity due to the high content of organic and dissolved solids, as well as toxic constituents such as phenols [5,6]. The presence of phenol compounds also causes vinasse to take on an undesirable dark brown color [7,8]. Therefore, wastewater treatment of vinasse before discharge is necessary for environmental protection.

Several studies have investigated the efficiency of fungi in reducing the biochemical oxygen demand and COD of vinasse and in neutralizing vinasse pH [4,9]. While the anaerobic digestion of vinasse results in high levels of COD removal and energy recovery [7,10], the problem of phenolic compounds persists, necessitating further treatment [8,11]. Additional treatment options, such as adsorption [12], coagulation-flocculation [13], ozonation [14], and electrochemical oxidation [15] have consequently been researched.

Alternatively, refractory organic contaminants and certain inorganic matters can be removed from wastewater through the application of advanced oxidation processes (AOPs), which are based on the *in situ* generation of potent oxidizing chemical agents, mainly hydroxyl radicals (˙OH) [16,17]. AOPs occur using a combination of catalysts and oxidants, such as ozone, ultrasound (US), ultraviolet (UV) photolysis, and hydrogen peroxide (H_2O_2). Among the available approaches, US technology has faster degradation kinetics and is cleaner and simpler than conventional AOPs [18]. The economic advantages of US technology compared to conventional AOPs include a nonrequirement of reagents, relatively shorter operation time to obtain the needed mass transfer, and higher oxidation rates caused by an enhanced formation of •OH radicals [19,20].

The irradiation of liquids through power ultrasound results in the acoustic cavitation, formation, growth, and transient collapse of gas bubbles, which can produce high temperatures and pressure fields, leading to the thermal decomposition of water molecules into radicals, as shown in Eqs. (1)–(3) [19,20]:

* Corresponding author.
E-mail address: rpobletech@ucn.cl (R. Poblete).

https://doi.org/10.1016/j.ultsonch.2019.104825
Received 15 April 2019; Received in revised form 1 October 2019; Accepted 3 October 2019
Available online 08 October 2019
1350-4177/