IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 13, Issue 3 Ver. I (May. – June. 2018), PP 20-26
www.iosrjournals.org

Construction of a Continuous Flow Eletroflocculation Prototype Supplied By Photovoltaic Energy for Effluents Purification

Vieira, S.P[1], Cordeiro, R.B.[2] Sarmento, S.M[3], Cavalcanti, L.A.P[4]
[1](*Electrical Engineering Department, Federal Institute of Bahia, Brazil)*
[2](*Chemical Engineering Department, Federal University of Pernambuco, Brazil)*
[3](*Chemical Engineering Department, Federal University of Pernambuco, Brazil)*
[4](*Education Department, Federal Institute of Bahia, Brazil)*
Corresponding Author: Vieira, S.P

Abstract: *Effluents production in the most varied industrial sectors has favored environmental degradation, especially when not treated and disposed in soil or water sources, for this reason, this work main objective was to design and construct a electroflocculation prototype under a continuous flow fed by photovoltaic energy to treat effluents in a way to meet the standards established by Resolution No. 430/2011 from CONAMA. The used parameters for the reactor design were conductivity, distance between the electrodes, reactor flow control and reaction time duration based on already performed works as well as on electroflocculation optimization works found in scientific literature. In order to verify the efficiency of the continuous flow electroflocculation reactor for wastewater purification, a residual wastewater effluent test was performed, separating it into two parts so that the effluent could be compared before and after treatment. The chemical analysis revealed a significant reduction of COD (83%) BOD5 (54%) and apparent color (84%). The results showed that the effluent conformed to standards established by CONAMA, thus enabling it to be used in several applications such as iron perchloride production, floors washing, disposal in water bodies, among other applications.*

Keywords *- Effluent treatment, Continuous flow electroflocculation, Photovoltaic energy.*

Date of Submission: 01-05-2018 Date of acceptance: 17-05-2018

I. Introduction

All human activities, whether industrial or not, imply in waste generation. There are several pollutants such as oils, dyes, greases, among other byproducts that cause numerous environmental problems, especially when they are incorrectly disposed and contaminate water bodies. Most of these by-products come from activities of oil refineries, chemical, textile and pharmaceutical industries [1].

There is a great diversity of physical, chemical and biological procedures accessible to promote waste water treatment from various human activities. The purpose of these treatments is to promote the material phase transfer of the interest effluent and, if possible, to transfigure the agents with high toxicity into inert compounds [2].

Among the various treatments, adsorption, coagulation and flotation are efficient when it comes with the interested compounds removal from complex matrices. In this sense, the electrochemical treatment appears as a viable alternative to carry out the oxidation and organic material phase transfer. Electrochemical coagulation technology is a promising technique and has been used in several researches on various effluents treatment, ranging from waste water to drinking water [3].

The electroflocculation, electroflotation or electrocoagulation has the purpose of treating complex effluents, with mixing of different substances in an efficient, economical and sustainable way, which allows its use in the textile industry effluents treatment. This technique use for waste water treatment can be considered a simple instrumentation and operation technology, involving the use of a pair of sacrificial metal plates, usually aluminum or iron, and the application of electric current, which through electrochemical reactions generate in situ coagulants. Thus, it reduces the chance of by-product generation and reduces sludge production [4].

However, electricity consumption can be expensive in some regions of the country for application in wastewater treatment through electroflocculation, making the process economically unviable. However the use of photovoltaic system as electric current source for process can be used on several types of effluents treatment with the same results as those obtained by the use of grid electrical power, but with low cost besides being treated of clean and renewable energy [5].

Based on these principles showed in [6] carried out electroflocculation application with the use of photovoltaic solar energy to treat biodiesel washing waters, since biodiesel is a biofuel usually obtained by homogeneous alkaline transesterification, in which uses a purification step for separation of the produced glycerin. In this sense, a large amount of waste is contained in the washing water resulting from biodiesel purification step, which requires a special treatment before reuse or [7].

The analysis made on a residual effluent from biodiesel washing water carried out after electroflocculation with iron electrodes [8] verified that the values obtained were framed under the conditions established by CONAMA Resolution 430/2011. The wash water pH was close to neutral, according to the indicated specifications, as well as a significant reduction in turbidity (97%), COD (85%) BOD5 (87%), oils and greases.

However, even with good results found, the treated effluent could not be reinserted in biodiesel production chain because the treated effluent still contains a high residual iron or aluminum content (depending on the electrode used). The presence of such metals accelerates the autoxidation reactions of biodiesel [9],[10].

Studies carried out by [8], in which biodiesel waste water was treated by electroflocculation with aluminum electrodes - constructed from recyclable cans fed by photovoltaic solar energy – with a treatment time of 10 minutes, showed a residual KCl and aluminum hydroxide formation, such compounds served as basis for potassium alum production which would be a possible application for this effluent. On the other hand, when the effluent is treated by electroflocculation with iron electrodes, the resulting solution is composed predominantly of ferrous chloride ($FeCl_2$) as a result of the potassium chloride electrolysis and the iron dispersion in the effluent, which generated a new compound after itself oxidation, iron chloride, which has an alternative application on printed circuit boards production.

This work aimed to size and construct a continuous flow electroflocculation prototype fed energetically by photovoltaic energy in order to verify the process efficiency compared with conventional electroflocculation for a larger scale to applications in the purification of waste water since electroflocculation efficiency reaction in direct flow is dependent on hydrodynamic properties of the used reactor.

II. Materials and Methods

Designed components and equipment for the continuous flow electroflocculation prototype construction were surveyed, planning which materials would be necessary for system construction aiming to reducing overall cost for the effluent purification process and the feasibility of the project in practical, technical and financial terms. The following characteristics were therefore considered:

A. Conductivity
B. Distance between electrodes
C. Reactor flow control
D. Reactional time duration

III.I Prototype Construction

The prototype was schematized as shown in Fig. 1. The system was composed of: feed tank with 8 liters (inlet), reactor with 4.75 liters, and outlet tank with 3.1 liters. Each of the compartments has been coupled with a flow regulating valve since the entire process will be happening by gravity, and by silicone hoses representing pipes (top) and outlet (bottom) of the reactor. A fixed bed filter was developed to conduct effluent filtration after electroflocculation built with layers of anthracite, gravel and foam.

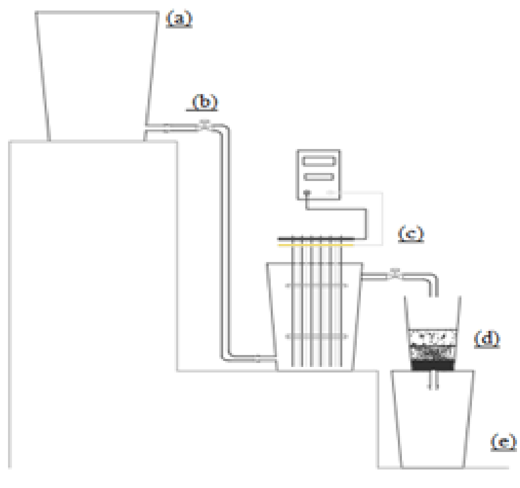

Figure 1 - Schematic drawing of electroflocculation prototype under continuous flow composed of: (a) feed tank (inlet), (b) valve, (c) electroflocculation reactor, (d) fixed bed filter and output.
Source: Own authorship.

III.II PLATES DISPOSITION

For plates construction, a monopolar model was used in parallel as shown in Fig. 2. Zinc plates were dimensioned with 12x24 cm with a total of 12 plates arranged in parallel with 6 mm spacing between them.

Figure 2 - Monopolar plates arrangement connected in parallel.
Source: Own authorship.

III.III EXPERIMENT PROCEDURES

For textile effluent analysis, a blue dye (brand TINGECOR) was used in a proportion of 10 mg / L. In total, 16 liters of water were used, the effluent was then divided into two 8-liter containers each. A vessel with the effluent was stored so the analysis could be performed prior to treatment. The other effluent parcel was submitted to treatment by electroflocculation with zinc electrodes. For the effluent submitted to the treatment, 8 g of NaCl were added as electrolyte and after 12 minutes of treatment the sample was submitted to a filtration process. Subsequently, the crude and treated effluent were analyzed. The experiment execution can be observed according to Fig. 3.

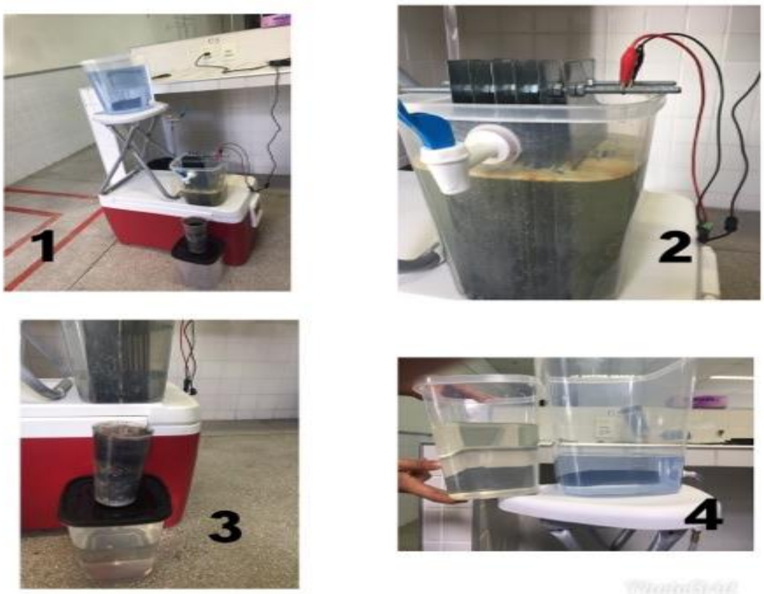

Figure 3- Purification of textile effluent at continuous flow. 1- electroflocculation reactor assembly with continuous flow, 2- electroflocculation reactor, 3 fixed-bed filter, 4-comparison of raw and treated effluent.
Source: Own authorship.

III.IV PHOTOVOLTAIC SYSTEM

The photovoltaic system used to as DC current source is presented in Fig. 4 [11]. The system was built to serve as a recharge center for mobile phones, tablets, notebooks, and serves as an integration site for students and servers of the Federal Institute of Education, Science and Technology of Bahia (IFBA), Paulo Afonso Campus. Its basic construction has the following structure: a) Frequency Inverter: Hayonik Modified Wave Inverter, 400 W 12 V / 127 V; b) Power Controller CMTP02 12 V and 10 A; c) Solar Panel: Golden Genesis PV-110E, 110 Wp; d) Battery: Tudor stationary 45 Ah.

Figure 4- Photovoltaic system used for supling DC current.
Source: Own autorship.

III.V EFFLUENT PARAMETERS ANALYSIS AFTER TREATMENT

The pH values for the raw and post-treatment waste water solutions were measured via digital pH meter (Quimis, model: Q400AS) at 25 ° C.

The COD analyzes were performed using a colorimetric method (Standard Methods 5220 D) with a TE-021 DryBlock Digester (TECNAL) type digestion block. The COD in the samples was quantified by spectrophotometry (Spectrophotometer SP1105, Bel Photonics), taking as a white standard a distilled water (BioClass)[12]. The BOD5 analyzes used the method defined in Standard Methods 5210 B [12], with subsequent quantitative determination of the samples in an oximeter (Digimed, model DM-4D).

The apparent color measurements for effluent were measured by UV spectrophotometer (Spectrophotometer SP2000UV, Bel Photonics), calibrated with a 460 nm filter [12].

III. Results and Discussions

III.VI PROTOTYPE DIMENSIONING

The prototype design was arranged so that the effluent could circulate from the inlet tank to the outlet tank under the gravity influence without requiring the use of a pump or an automation system, thereby reducing costs with instrumentation and energy consumption in the system.
The electroflocculation prototype reactor is shown in Fig. 5.

Figure 5- System mounted during textile effluent treatment.
Source: Own authorship.

III.VII ELECTRODE PLATES DISTANCES

The choice of the smallest spacing between the plates was determined based on [13] that affirms the larger the distance between the electrodes, the greater the potential difference between them, thus reducing the distance between the plates the process will also be optimized.

III.VIII FIXED BED FILTER

For effluent filtration after electroflocculation, a fixed bed filter was made, since the granular filters are more attractive due to of operation and construction low cost beyond the potential for simultaneous removal of solids or contaminants during the operation [14]. The results efficiency obtained in the purification of textile effluent, shown in Table 1, has direct influence on the use of the fixed bed filter.

III.IX PHOTOVOLTAIC ENERGY USE

The use of solar photovoltaic system has brought its benefits to the system, since it makes use of an alternative and renewable energy that proposes the reduction of costs in the process. This is due to the fact that electroflocculation is not economically viable when using conventional grid power offered by local utility, making it valid to replace the energy with a cheaper source to make the system operation less costly. (SINGH, 2012).

III.X CONTINUOUS FLOW TREATMENT OF TEXTILE EFFLUENT – ANALYSIS RESULTSENERGY USE

Based on obtained results (Table 1), it was verified that the values of all variables analyzed from the textile waste water, are located outside the standards established by Resolution 430/2011 CONAMA except the pH, so it cannot be ruled out without prior treatment.

Table 1 - Physical and chemical characteristics of the raw and electroflocculation treated effluents.

Water	pH	Apparent Color	COD (mg/L)	BOD5 (mg/L)
Raw Effluent	8,07	0,0755	741,22	235,9
Treated Effluent	10,25	0,0115	124,9	106,4
CONAMA nº 430/2011	5,00 a 9,00	Natural level of the receiving body	-	Minimum removal of 60%

In the results obtained after the treatment by electroflocculation under continuous flow, an attenuation of the analyzed parameters was observed, readjusting the effluent characteristics in the necessary specifications for disposal. The pH was close to the established value, but did not meet the Resolution due to the formation of hydroxides in the process treatment that increased the pH of the final effluent, however it was possible to obtain a significant reduction of apparent color (84%), COD (83%) BOD5 (54%). In Fig. 6, the textile effluent waters can be observed in a comparative way before and after the electroflocculation process.

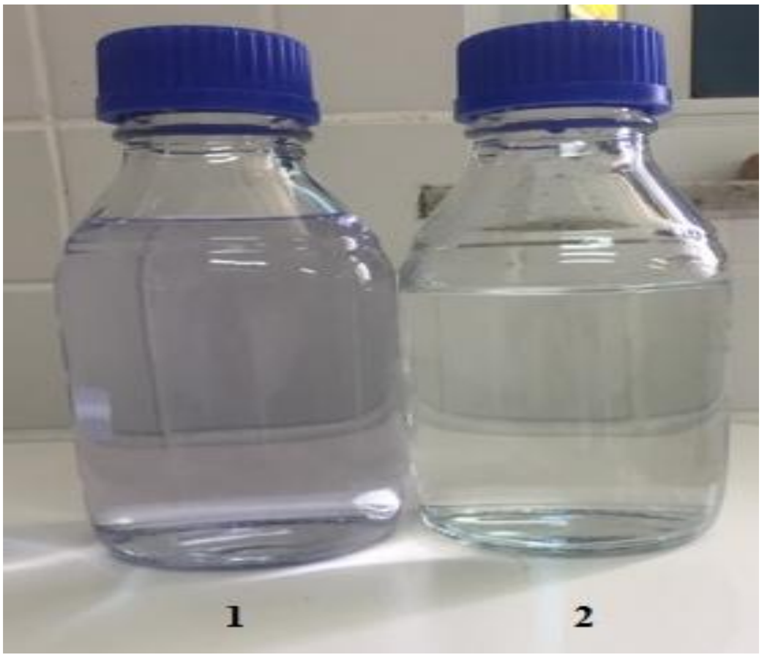

Figure 6 - Textile effluent. (1) - before electroflocculation, (2) - after electroflocculation.

Based on the results showed in Table 1, it can be indicated that the water after treatment in the continuous flow reactor could be applied in several applications such as the production of iron perchloride as suggested in the studies of [8], floors washing, disposal in water bodies, among other applications.

IV.Conclusion

The electroflocculation for continuous flow treatment prototype design showed good efficiency verified by the obtained results on a treated textile effluent with significant reduction of apparent color (84%), COD (83%) BOD5 (54%), fitting with the parameters established in CONAMA resolution No. 430/2011 being able to be discarded without offering risks to water bodies. Electrodes Plates arrangement made the process more efficient to continuous flow as well as the use of gravity effects made the process economically viable in terms of instrumentation and energy use. Photovoltaic power plant use as a power supply has also proved to be efficient since it makes use clean and renewable energy making the process more environmentally viable and less expensive.

References

[1]. RICHTER, C. A. Água: Métodos e Tecnologias de Tratamento. 1.ed. São Paulo: Blucher, 2009.

[2]. CERQUEIRA, A.A., MARQUES, M.R.C. Avaliação do Processo Eletrolítico em Corrente Alternada no Tratamento de Água de Produção. Quimíca Nova - Scielo, v. 34, p. 59 - 63, 2011.

[3]. KRITHIKA.R, VERMA, R.J, SHRIVASTAV, P.S. Antioxidative and cytoprotective effects of andrographolide against CCl4-induced hepatotoxicity in HepG2 cells. Hum Exp Toxicol. 2013;32:530–543.

[4]. FLECK, L; TAVARES, M.H.F; EYNG.E. Utilização da técnica de eletrofloculação para o tratamento de efluentes têxteis: uma revisão. Revista EIXO, Brasília - DF, v.2 n.2, Julho – Dezembro de 2013.

[5]. SINGH, G. Electroflocculation on textile dye wastewater. Patiala: Thapar University, 2012. (Dissertação de Mestrado em Tecnologia em Ciência Ambiental). Available<http://dspace.thapar.edu:8080/dspace/bitstream/10266/1943/1/electroflocculation.pdf>. Acesso em: 20 fev. 2018.

[6]. VIEIRA, S. P, NASCIMENTO F.A, ARAUJO, M.B, ANDRADE JUNIOR, S. J, CAVALCANTI, L.A.P. Reuso de latinhas de alumínio recicláveis para tratamento de águas residuais da produção de biodiesel via eletrofloculação. Revista Brasileira de Gestão Ambiental e Sustentabilidade, João Pessoa, v. 2, n. 3, p.145-151, 2015.

[7]. BRITO, F. J.; FERREIRA, O. V. L.; SILVA, J. P. Tratamento de água de purificação do biodiesel utilizando eletrofloculação. Quimica Nova, v. 35, n. 4. p. 728-732, 2012.

[8]. VIEIRA, S. P; OLIVEIRA F.C.F; CAVALCANTI, L.A.P. Síntese Do Percloreto De Ferro A Partir Das Águas Residuais Da Produção De Biodiesel Tratadas Por Eletrofloculação Para Confecção De Placas De Circuito Impresso. Holos, Natal, v. 33, n. 1, p.205-213, 2017.

[9]. KNOTHE, G.; GERPEN, J. V.; KRANI, J.; RAMOS, L. P. Manual do biodiesel. São Paulo: Edgard Blücher, 2006.

[10]. JUNQUEIRA, CN.; FRANCO, MM.; RUGGIERO, R.; BORGES NETO, W.; BUENO, JA.; SANTOS, D Q. Contaminantes metálicos no biodiesel de soja. Anais do 10° Congresso Internacional de Bioenergia, São Paulo, 2015.

[11]. NASCIMENTO, FA.; VIEIRA, S A.; ANDRADE JÚNIOR, S J.; CAVALCANTI, L A P. Integração de um sistema fotovoltaico isolado e de coleta seletiva de resíduos em um quiosque multifuncional. Revista Brasileira de Gestão Ambiental e Sustentabilidade, v. 2, n. 2, p. 43-50, 2015.

[12]. . EATON, A.D.; CLESCERI, L.S.; RICE, E.W.; GREENBERG, A.B. (Ed.). Standard methods for the examination of water and wastewater. 21st ed. Washington: American Public Health Association, American Water Works Association and Water Environment Federation, 2005. 1368p.
[13]. CRESPILHO, F. N., REZENDE, M.O.O. Eletroflotação: Princípios e Aplicações. ed. 1. São Carlos: Editora Rima, 2004.
[14]. DEUSCELE, T., JANOUSKE, U. e PIESCHE, M. A CFD model describing filtration, regeneration and deposit rearrangement effects in gas filter systems. Chemical Engineering Journal, v.135, p.49-55, 2008.

IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) is UGC approved Journal with Sl. No. 4198, Journal no. 45125.

Vieira, S.P "Construction of a Continuous Flow Eletroflocculation Prototype Supplied By Photovoltaic Energy for Effluents Purification"IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 12.3 (2018): 20-26.