Engenharia Sanitária e Ambiental: Tecnologias para a Sustentabilidade 5

Helenton Carlos da Silva
(Organizador)

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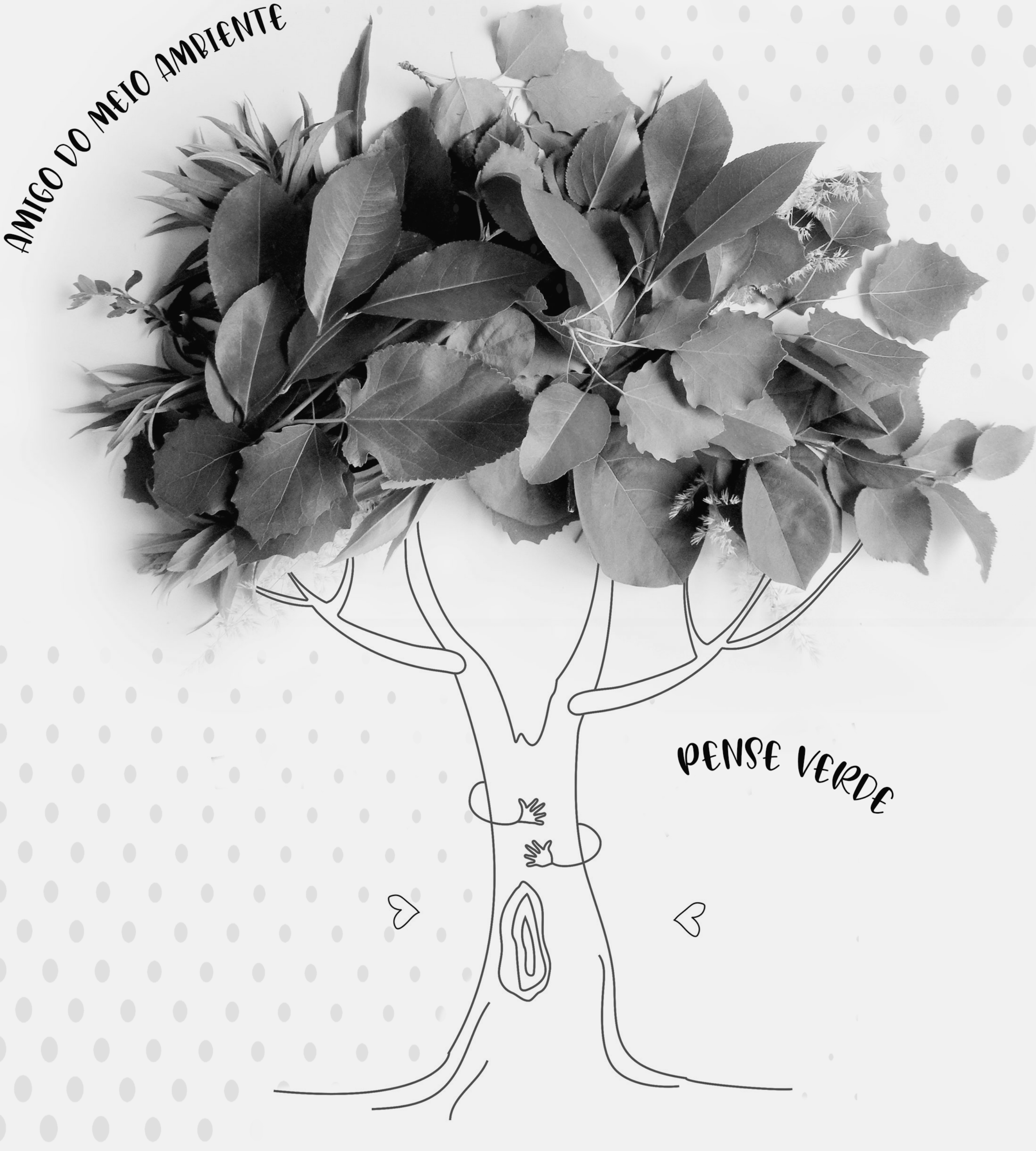

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APRESENTAÇÃO

A obra "*Engenharia Sanitária e Ambiental: Tecnologias para a Sustentabilidade 5*" aborda uma série de livros de publicação da Atena Editora e apresenta, em seus 25 capítulos, discussões de diversas abordagens acerca da importância da sustentabilidade aplicada às novas tecnologias na engenharia sanitária e ambiental.

No campo do saneamento básico pouco esforço tem sido feito para refletir sobre a produção do conhecimento e os paradigmas tecnológicos vigentes, embora a realidade tenha, por si, só exigido inflexões urgentes, principalmente, no que diz respeito ao uso intensivo de matéria e energia e ao caráter social de suas ações.

Um dos grandes problemas da atualidade refere-se à quantidade de resíduos sólidos descartado de forma inadequada no meio ambiente. E com o objetivo de promover a gestão dos resíduos sólidos foi instituída a Política Nacional de Resíduos Sólidos (PNRS), Lei Federal 12.305/2010, considerada um marco regulatório, que permite o avanço no enfrentamento dos problemas relacionados ao manejo inadequado dos resíduos sólidos.

Desta forma a conservação da vida na Terra depende intimamente da relação do homem com o meio ambiente, especialmente, quanto à preservação dos recursos hídricos. A água, dentre seus usos múltiplos, serve ao homem como fonte energética. Atualmente, em um contexto de conscientização ambiental, a opção por essa matriz de energia vem se destacando tanto no Brasil como no mundo.

O uso desordenado dos recursos hídricos pela população vem afetando na disponibilidade da água, a qual é indispensável para a manutenção da vida. Diante disso, buscam-se alternativas de abastecimento visando á preservação da mesma.

A utilização de recursos hídricos representa um desafio para a sociedade mundial e a as águas residuárias de origem doméstica ou com características similares, podem ser reutilizadas para fins que exigem qualidade de água não potável.

Com o aumento da população e avanços científicos e tecnológicos, a cada dia a produção de resíduos cresce mais e os impactos ao meio ambiente, na mesma proporção. Com isso, os problemas relacionados à gestão destes resíduos necessitam da adoção de técnicas e tecnologias desde sua segregação à disposição final, visando à destinação adequada e a implantação de programas voltados tanto para uma redução na produção de resíduos, como também na disposição final destes.

Neste sentido, este livro é dedicado aos trabalhos à sustentabilidade e suas tecnologias que contribuem ao desenvolvimento da Engenharia Sanitária e Ambiental. A importância dos estudos dessa vertente é notada no cerne da produção do conhecimento, tendo em vista a preocupação dos profissionais de áreas afins em contribuir para o desenvolvimento e disseminação do conhecimento.

Os organizadores da Atena Editora agradecem especialmente os autores dos diversos capítulos apresentados, parabenizam a dedicação e esforço de cada um, os quais viabilizaram a construção dessa obra no viés da temática apresentada.

Por fim, desejamos que esta obra, fruto do esforço de muitos, seja seminal para todos que vierem a utilizá-la.

Helenton Carlos da Silva

SUMÁRIO

CAPÍTULO 17

ELECTROCOAGULATION PROCESS TO THE INDUSTRIAL EFFLUENT TREATMENT

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ABSTRACT: Electrocoagulation it is an emergent technology to the treatment of industrial effluent that are colloidal such as the fish industry wastewater. This technical has received attention on research and development at last years, but efforts are necessary to understand fundamental mechanisms related to the parameters of projects that can conduct to the optimization of the process. Principal operational variables are electrolysis time, pH of effluent, electrical current density and distance between electrodes. The evaluation of the process efficiency occurs by determination of the chemical oxygen demand, total solids and its fractions and also the turbidity of the water. Negative consequences of the use of this technology are the electrodes material that have tendency to undesirable compounds releasing during the electrolysis.

KEY-WORDS: treatment – effluent – electrocoagulation – wastewater.

PROCESSO DE ELETROCOAGULAÇÃO PARA TRATAMENTO DE EFLUENTE INDUSTRIAL

RESUMO: Eletrocoagulação é uma tecnologia emergente para o tratamento de efluentes líquidos industriais que sejam coloidais. Esta técnica tem recebido atenção em pesquisa e desenvolvimento nos últimos anos, porém esforços são necessários para entender os mecanismos fundamentais relacionados com os parâmetros de projetos que possam levar à otimização do processo. As principais variáveis operacionais são o tempo de eletrólise, o pH do efluente, a densidade de corrente elétrica e a distância entre os eletrodos. A avaliação da eficiência do processo ocorre pela determinação da demanda química de oxigênio, de sólidos totais e suas frações e também da turbidez. As consequências negativas do uso desta tecnologia são os materiais dos eletrodos, que tendem a liberar compostos indesejáveis durante a eletrólise.

PALAVRAS-CHAVE: Tratamento-efluente-eletrocoagulação-água residual

1 I INTRODUCTION

The water it is involved in several steps of the processing in food industry and its operational units, being characterized by high consume by processed food (MIN et al., 2015). Effluents of industrial processes are constituted of high organic charge. Effective removal of its components it is of vital importance on the controlling of increasing pollution of receives water, because the excessive nutrients, especially nitrogen and phosphorus, can cause eutrophication and ecologic imbalance in the ecosystem (BASSALA et al., 2017).

There are initiatives to reuse industrial effluents, but some characteristics such as soluble solids, traces of organic compounds, heavy metals, altered flavours and other industrial effluent compounds, can causes health damages and this factor has hampered the reuse of wastewater. Changes such as these can be solved with the use of advanced technologies, but the high cost just making it impossible to treat this water to supply (MORES et al., 2016). Given these difficulties, the electrocoagulation (EC) is a promising alternative in the treatment of effluents from various sectors of the supply chain (UN et al., 2014).

The formation of hydrogen bubbles at the cathode adsorb the flakes formed by the process and are aimed at simplifying the flotation separation of treated water.

Thus, the electrocoagulation it is a cryptic technology, although it has been widely used for over a century, there is still no domain of the principles involved. The main cause is that electrocoagulation is a technology that is linked to three other separation processes: electrochemistry, coagulation and flotationand there must be interaction between these three technologies (HOLT et al., 2005).

The knowledge of the electrocoagulation process can contribute to the future use of this technology in industrial sectors where the wastewater treatment must be improved.

2 I ELECTROCOAGULATION USED IN WASTEWATER TREATMENT

The development of legislation on water discharges contaminated in the natural environment and the advancement of research of electrochemical processes in the 1980s raised again the interest by electrocoagulation for treating wastewater (GEREK et al., 2017).

Wastewater treated with electrocoagulation process has demonstrated good results, but it is still a little-known technology. According to Mollah (2001) in the last decade, this technology has been growing use in South America and Europe for the treatment of industrial effluents containing metals. In North America the electrocoagulation is applied to various liquid wastes, as in the treatment of wastewater from the paper industry, mining and metal processing industries and pulp of cellulose (SHARMA et al., 2015; MIN et al., 2015).

The electrocoagulation has been applied to the treatment of wastewater containing food, chemical, mechanical polishing, and metal-containing solutions. Typically, empirical studies are made in electrocoagulation to set the operating parameters for large volumes of waste water. The technology is optimized and applied to specific effluents to minimize energy consumption and maximize waste transfer rates (MOLLAH, 2001; BASSALA et al., 2014).

The electrocoagulation has the potential to be the economic and environmental choice for the treatment of wastewater and other issues related to water management. It is an efficient technique since the adsorption surfaces of mineral hydroxides is 100 times higher *in situ* as compared to precipitated pre-hydroxides when metal hydroxides are used as coagulants. The electrocoagulation requires simple equipment and can be allocated to process all scales, besides being cost-effective and easily accessible. *Start-up* cost and operation are relatively low. It requires low maintenance, no moving parts, since virtually no chemical addition is needed in this process, which brings minimal chance of secondary pollution. It is operated at low current, and can be performed even by green processes, where the electricity is produced by systems such as solar, wind mills and fuel cells (MOLLAH, 2004).

The electrocoagulation has the capability to break down and remove from the environment with relatively rapidly biodegradable organic compounds. Hydrophobic colloids are responsible by the water colour and characteristically have organic origin, with R-NH or R-OH suspense compound. Hydrophilic colloids are of mineral origin. The precipitation is due the concentration of negative charges in the surface, with agglomeration of particles. Colloids are never perfectly hydrophobic or hydrophilic, the fraction of each one of any of these characteristics depends of its molecular constitution. Due to the low sedimentation rate, the best way is to remove colloids coagulation-flocculation process. The aim of the coagulation is to destabilize the electrostatic charge to promote bonding colloids, thus allowing their agglomeration during the flocculation step (TSIOPTSIAS et al., 2015; VALENTE et al., 2015).

2.1 Definition

The electrocoagulation (EC) system consists of an electrodes group usually connected to an external source and relies on the in situ generation of coagulants by anodic dissolution (aluminium or iron) and production of hydroxide by hydrolysis of water at the cathode, which destabilize and aggregate the particles to promote the adsorption of the dissolved contaminants and its precipitation (TSIOPTSIAS et al., 2015).

The electrocoagulation happens when the sacrificial anode undergoes oxidation releasing metal ions and the cathode undergoes reduction occurring formation of hydroxyl ions by hydrolysis of water. The metal ions dissolved at a pH suitable form coagulant that combine with hydroxyl ions to form metal hydroxides compounds that favour the formation of flakes in the destabilization of suspended particles or contaminants, allowing removal of pollutants by sedimentation or flotation (PALÁCIO et al., 2015).

According to AKYOL et al. (2012) when aluminium and iron are used as anode material, reactions that occur in electrodes during the electrocoagulation are as shown on Equations 1, 2 and 3.

Aluminium electrodes

Equation (1)

Reaction of oxidation occurs on anode

$$Al_{(s)} \rightarrow Al_{(aq)}^{3+} + 3e^{-}$$

Equation (2)

Reaction of reduction occurs on cathode

$$3\,H_2O + 3e^{-} \rightarrow (3/2)\,H_2 + 3OH^{-}$$

Equation (3)

Global reaction during the electrolysis

$$Al^{3+} \rightarrow Al(OH)_{n}^{(3-n)} \rightarrow Al_2(OH)_2^{+4} \rightarrow Al_3(OH)_4^{+5} \rightarrow Al_{13}\ \text{complex} \rightarrow Al(OH)_3$$

The material of the electrode applied to the wastewater treatment cans not be toxic to the human health and to the environment. The commonly used materials are aluminium, iron, stainlesssteel, carbon steel and graphite; all have efficiency, low cost, easy acquisition and are not toxics (BASSALAR et al., 2017; GEREK et al., 2017).

The utilization of different electrodes combinations of Al / Al, Al / Fe, Fe / Al, Fe / Fe to the wastewater treatment have been published (AKYOL et al., 2012).

2.2 Types of reactors to electrocoagulation

Several types of reactors were proposed on literature, monopolar, bipolar between others, being the monopolar the more used reactor (BASSALAR et al., 2017). The reactors consist of pairs of metal plates using electrical connection in parallel and connected to a source of direct electrical current. The plates of metal are known as sacrificial electrodes. The electrodes may be made of the same or different materials (MOLLAH, 2004).

A monopolar electrocoagulation reactor can be composed of an electrolytic cell with an anode and a cathode. When connected to an external potential source, the anode corrodes as a result of oxidation, while the cathode is subject to reduction reactions. In this case, the use of large electrodes, or use of electrodes connected in parallel is required, as shown in Figure 1. In parallel arrangement, the current is divided between all the electrodes in relation to resistance of individual cells. This type of reactor is the most used in the treatment of industrial effluents (PALACIO et al., 2015).

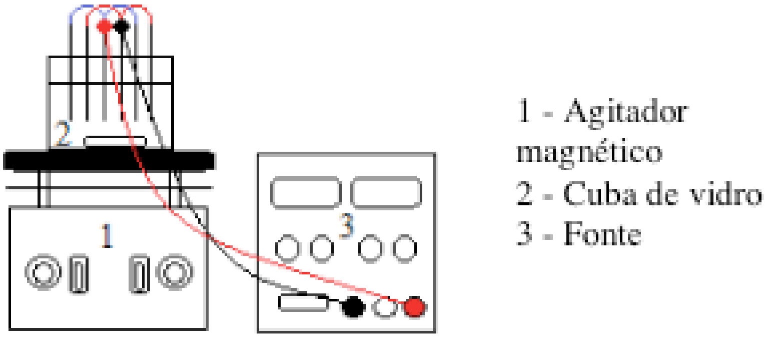

Figure 1 – Electrocoagulation reactor monopolar scheme.

Source: Author's collection

The usual settings of electrocoagulation reactors are typically plates reactors (vertical or horizontal), perforated plates, concentric tubes, and fluidized bed reactors (MIN et al., 2015). A variety of reactors are mentioned in the literature, in different geometric form as used in the electrode material or arrangement. The design variations include: a bed-fluidized reactor, which employs aluminium pads and electrodes in parallel (VALENTE et al., 2015); reactors with mechanical agitation systems or magnetic bar or external recirculation; reactors with electrodes hives in iron, reactors in series with electrodes in flat steel wire mesh, reactors with aluminium plates arranged in parallel in the form monopolar and bipolar (ABDALHADI; KURT, 2016). UN et al (2014) reports the use of continuous flow reactor with flows vertically and horizontally with square or rectangular electrode plates mounted in parallel, also reports the use of reactors formed by concentric tubes, and these flow ducts and also anode and cathode electrodes.

The essence of an EC reactor is an electrochemical cell in which a metal sacrificial anode is used to add a coagulating agent to the polluted water (OLYA; AZAM, 2013). The electrode material used determines the type of the coagulant, the sacrificial electrode and the cathode may be composed of the same or different materials (ABDALHADI; KURT, 2016). In general, materials used for electrocoagulation are aluminium and iron in the form of plateshaped or bundled scrap (VALENTE et al., 2015).

In addition, there are reports that the use of various materials as electrodes, including stainless steel and platinum, but some of them showed rapid loss of activity due to the surface (glassy carbon), they released other toxic ions (PbO_2) and others have shown to have life limited (SnO_2) (ABDALHADI; KURT, 2016; DÍAZ et al., 2014).

The use of identical materials in the manufacture of electrodes, for the treatment of effluents has the advantage the same potential, wear uniforms between the electrodes, simplify maintenance and low cost to be the same material (THIRUGNNA et al., 2015).

There is certainly no “ideal reactor” of the EC in use. Operations conditions follow a large variation between projects, with adjustments for specific applications (BASSALA et al., 2017). Each electrolytic system has its own set of advantages and disadvantages, including varying degrees of treatment and skill; however, important in a design of an electrocoagulation reactor is to get the maximum efficiency of the equipment is achieved (DÍAZ et al., 2014).

3 I PARAMETERS OF ELECTROCOAGULATION PROCESS CONTROL

3.1 pH

The pH of the water or of the wastewater on electrocoagulation, affect the efficiency, as well as, the solubility of the metallic hydroxides. In presence of chloride ions, the chlorine release is also affected (CHEN, 2004). The effectiveness of the treatment depends on the nature of the pollutants, with better removal of pollutants at pH 7 (CHEN; HUNG, 2007). The consumption of energy is superior at neutral pH, due to the variation of the conductivity. When the conductivity is high, the pH effect is not significant (SHARMA, et al., 2015).

When electrodes of aluminium are used in EC process at different current densities, the variation of pH can influences generating various aluminium species (VALENTE et al., 2015).

The aluminium speciation change significantly with the pH and the current density. To low pH values, monomeric species of hydrolysis are the principal, with a low quantity of precipitate and of polymeric species. To pH proximal to the neutrality (between 5 and 9), the precipitate of aluminium hydroxide it is the principal specie, with several others soluble species to lower density current. Starting at pH 9, the formation of precipitates increases and decreases the proportion of monomeric and polymeric aluminium. Largest proportion of polymeric aluminium is produced at pH between 4 and 5 (GEREK et al., 2017).

3.2 Electrical conductivity

The conductivity of the effluent has influence on the final response of the EC mechanism. The higher the conductivity better is the process performance. In addition, other characteristics, such as pH, particle size and the concentrations of chemical constituents can also affect the process.

The conductivity of the solution is a very important parameter in the process of electrolysis, since the pollutant removal efficiency and operational cost is directly related to this property

(MORES et al., 2016).

The solution must have some minimum conductivity to permit a flow of electric current. The conductivity of the effluent can be adjusted by adding a sufficient amount of salts, in general, sodium chloride (NaCl) is used because it is a low cost product is non-toxic and is known to affect cell voltage (U), the current efficiency and consumption of electricity, due to reduced Ohmic drop of wastewater. In this condition, the consumption of energy that is proportional to U*I, will be reduced (BASSALA et al., 2017).

High concentrations of NaCl, can contribute to the Cl^- ions releasing with the production of organochlorine compounds of considerable toxicity (PALACIO et al., 2015). According to DÍAZ et al. (2014), the presence of chlorite ions could reduces significantly the adverse effect of anions, such as HCO_3^- and SO_4^{-2}. These ions can precipitate ions Ca^{+2} and Mg^{+2}, which can form an insulating layer on the surface of the electrodes, increasing the electrical resistance of the electrodes causing a significant decrease in the intensity of the current (ABDALLADI; KURT., 2016).

The addition of salts increases the current density and conductivity of the effluent, the cell voltage or constant decrease the voltage of the cell at a constant speed (TSIOPTSIAS et al., 2015). With the current density is an increase in the number of ions in solution, thus contributing to the oxidation of chloride ions, earning forms of active chlorine and hypochlorite anion that can oxidize the dyes and acting as disinfectant. The consumption of energy is also reduced when the conductivity of the solution is suitable (UN et al., 2014).

3.3 Electrical current density

The current used in electrocoagulation will determine the amount of metal (Fe, Al and others) which will be oxidized at the anode. Care must be taken when choosing the value of the electric current density applied. High current can mean loss of power; because part of it will dissipate by Joule effect and also more frequent maintenance of electrodes (PALACIO et al., 2015).

The electric current density is identified as the key CE operating parameter affecting not only the system's response time, but also greatly influence the dominant mode of separating and removing pollutants (SHARMA et al., 2015).

The current density is a critical point in the electrocoagulation process, since it is the only operating parameter that can be directly controlled. It determines directly the production rate and the generated bubbles, strongly influencing both the mixed solution, and the mass transfer to the electrodes (THIRUGNNA et al., 2015; BASSALA et al., 2017).

3.4 Stirring and mixing

The mixture strongly influences the performance and the effectiveness of the electrocoagulation reactor (UN et al., 2014). In the process of electrocoagulation and flotation, mass transport can be more efficient by increasing the turbulence or mixing. The fluid mixture can be increased by increasing the flow rate inside the electrocoagulation reactor. The increase in level of turbulence helps reduce the passivation of the electrodeplates (TSIOPTSIAS et al., 2015).

Agitation increases the homogeneity throughout the reactor and is usually due to a mechanical source such as a stirrer. In electrocoagulation, the batch electrolytic reactors produce gas bubbles *in situ* which are oxygen and hydrogen that can help in agitation (THIRUGNNA et al., 2015).

These bubbles are spheres with insulating property, and if they accumulate on the electrode surface will increase the electrical resistance of the cell and, as a result, more power should be used to achieve better removal efficiency (MOLLAH, 2004). Thus, to minimize or eliminate the accumulation of bubbles around the electrodes, the flow within the reactor should be sufficient (GEREK et al., 2017).

4 I ENERGY CONSUMPTION

The treatment of wastewater is a process with high energy consumption the main operating expenses of the electrolytic process refer to the wear of electrodes and energy consumption. The energy consumption is defined as the amount of energy consumed per unit of removed organic matter, it is related to the current intensity used, effluent conductivity, electrode spacing and passivation (GOVINDARAJA; PATTABHIB, 2015). According to MUTHY; PARMAR (2011), the energy consumption of a bath reactor can be calculated by Equation 4.

Equation 4

$$C = \frac{U \cdot i \cdot t}{v}$$

Being C the energy consumption (in Wh/m^3), U it is the electrical tension applied to the process in Volts (V), it is the applied electrical current (in A), and the time of current application or time of the process (h) and v it is the volume of the treated effluent (in m^3).

The benefits of electrocoagulation process should be in addition to the efficient removal of pollutants, low power consumption, a condition which may be possible if the wastewater to be treated is of high conductivity (GOVINDARAJA; PATTABHIB, 2015).

5 I PASSIVATION OF THE ELECTRODE

The passivation of the electrode is the formation of an inhibiting layer (typically an oxide) on the surface thereof, which is undesirable for the dissolution of the anode and operation of electrocoagulation. The current and power depend on the total system resistance. Any passive resistance layer increases the potential of the cell, but does not affect the coagulating or bubbles production rates. The use of de-ionized water minimizes the presence of contaminants, such as carbonates, which can easily passivate the electrodes (GEREK et al., 2017).

The electrodes must be cleaned periodically to remove any passivation material. This maintains the integrity of the electrode and ensures constant anodic dissolution. The formation of impermeable layer prevents the transports tream makes the process inefficient between the anode and the cathode. Corrosion on the electrodes can be removed using alternating current instead of direct current in the electrocoagulation (GOVINDARAJA; PATTABHIB - 2015; GEREK et al., 2017).

6 I EFFECT OF THE ELECTROCOAGULATION TIME

The treatment time is the most important parameter in the electrocoagulation process. It is to be understood as the scheduled time, deemed sufficient to occur throughout the process of formation of metal hydroxides to complete the coagulation of the impurities present in the effluent to be treated. Generally, the normal process is between15and 175 minutes obtaining the maximum possible removal of various metal ions (ABDALHADI; KURT, 2016), having different time systems according to the dimensions and characteristics of the effluent.

7 I DISTANCE BETWEEN THE ELECTRODES

According to the wastewater characteristics, process efficiency can be improved by varying the distance between the electrodes, the influence on the process can be explained by the fact that the electric field between the electrodes decreases as this parameter increases. The greater the distance between the electrodes, the greater will be the potential difference applied, because the solution has resistivity to the passage of electric current (GEREK et al., 2017).

In high conductivity electrolyte, by increasing the distance between the electrodes, the removal efficiency increases. This change probably because the electrostatic effects depend on the distance between electrodes, so when it increases, the movement of ions produced slower and would have a greater opportunity to produce flakes and aggregate. Moreover, these flakes are more capable of adsorbing molecules (TECZAN et al., 2014).

It comes to operating cost reduction is an important variable, so it is recommended that when the effluent conductivity is relatively high, use a larger spacing between the electrodes. Already in situations of moderate value is recommended to use a smaller distance, as this will reduce energy consumption without changing the degree of separation, in which case, the current would not change. Thus, the current is not altered, to facilitate the flocculation of the pollutant (VALENTE, 2015).

The influence of the distance between the electrodes is correlated with the maximum removal of contaminants, varying the range of1 to 5 cm (UN et al., 2014). Experiments have shown that with increasing distance between the electrodes increases slightly and the removal of the pollutant that is observed for whatever the nature of the electrode.

8 I 8. ADVANTAGES AND DISADVANTAGES OF ELECTROLYTIC TREATMENT

The advantages related to electrocoagulation system are as follows (VALENTE et al., 2015):

- Requires simple and easy to operate equipment;
- The sludge formed tends to be quickly decanted and is easy to dehydration, since it is composed of a series of metal oxides and hydroxides, unlike the sludge generated by conventional coagulants;
- The electrocoagulation produces effluents with a lower amount of dissolved solids as compared to chemical treatments;
- Avoids the addition of chemicals, thus reducing the possibility of secondary pollution (elevated sulphate concentration, for example, organic matter, polymers);
- The gas bubbles produced during electrolysis may favour the electrocoagulation process where solid particles are carried to the top of the solution. Thus, they have aggregate reuse of concentration, collection, and removal of contaminants.

Although electrocoagulation presents numerous advantages, it has some drawbacks among the limitations of the process can be cited (MOLLAH, 2004):

- The electrodes are electro-soluble and must be constantly replaced.
- The high consumption of electricity increases the operating cost of the process.
- An oxide layer may be formed on the cathode surface, leading to loss of process efficiency (as may occur with aluminium, for example), however, the polarity may help reduce the interference.
- High conductivity of the effluent is required which limits its use with water containing low solids dissolved.
- In the case of removal of organic compounds, some toxic chlorinated compounds can be formed in situ, for example, chlorides are also present. Wastewater with high humic acid content can be favourable for the formation of trihalomethanes. If phenols and metabolites and break down products are present, the chlorine can lead to the generation of compounds with objectionable odours and flavours.

9 I PARAMETERS ANALYZED IN THE ELECTROCOAGULATION PROCESS

The efficiency of the electrocoagulation process is monitored by analysis of parameters, pH being one of the main parameters evaluated in the effluent treated by electrocoagulation process.

Besides being an important indicator of the quality of the treated effluent, is a major requirement parameters of the legislation, with the desired value7 ± 2 and influences the BOD and COD reduction values. Some authors such as DÍAZ et al., (2014), VU (2014) and GEREK et al., (2017) have done pH adjustments before electrocoagulation in order to increase the percentage of reduction of major components. Others studies of THIRUGNANA et al,. (2015);

BASSALA et al. (2017), VALENTE et al. (2015) and TECZAN (2014), the pH was not adjusted and the end of the process presented is desirable, indicating that the effluent can be discarded in the environment safely only when the pH is measured, which does not apply to all effluents, for the other parameters control must be met.

Mostly of agro-industrial effluents have a high biochemical oxygen demand (BOD) which is the main item of interest removal when the goal is to treat wastewater. Studies by several authors showed significant BOD reduction results, including: BAYAR et al. (2011) poultry slaughterhouse wastewater reduced 90 %; KATAL; PAHLAVANZADEH (2011) pulp and paper industry, reduction of 88 %; VALERO et al. (2011) residual water of almond industry, removed 80 %; DÍAZ et al. (2014) industrial processing station (poultry, swine and bovine), reduction of 78 % and TECZAN (2014) residual water of milk whey, removed 86 %, GEREK et al. (2017) tannery wastewater reductions being 82 % is within the standards required by legislation (BRASIL, 2011). It may be stated that the electrocoagulation is a major wastewater treatment process, with significant reduction responses components when it comes to compliance with environmental parameters.

The materials used in the manufacture of electrodes are the first and main assessment before starting the treatment process with electrocoagulation. Several studies realized by MOLLAH (2004); SENGIL; OZACAR (2006); MORALES (2007); PALÁCIO et al. (2015); MIN et al. (2015), BAYAR et al. (2011); BASSALA et al. (2017); VALENTE et al. (2015); GEREK et al. (2017) DÍAZ et al. (2014); TECZAN (2014); QUIÑONES-ESPINZOLA et al. (2009) have measured the efficiency of aluminium, stainless steel, iron, copper and nickel, and yet was not found material that is as efficient to the point of no release of the compounds of the electrode during electrolysis.

According to TECZAN (2014) the junction with electrocoagulation combined process (centrifugation, adsorption with active charcoal, nanofiltration, ultrafiltration and other technologies), can minimize this impact, making treatment with electrocoagulation applicable to different industries, treating the various effluents with unquestionable efficiency.

10 | CONCLUSION

The electrocoagulation is a promising alternative in the treatment of effluents from various sectors of the production chain and requires in-depth studies in order to unravel this complex technology, but with promising results.

The electrocoagulation mechanism is not completely understood, but it is known that the treatment efficiency depends on the interactions between the particles of the disperse system and the coagulating agent and the electrolysis conditions.

The use of systems with subsequent polishing and re-use of the separated material for other industrial applications may mean important perspective to the application of sewage treatment system.

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