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### **Review Article**

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#### Abstract

Lime-soda softening for treating very hard waters is generally applied as a conventional water treatment process for municipal use. However, for industrial use, this treatment is not applied because: (a) it requires a long detention time for magnesium and calcium precipitation (about 4, 5 hours); (b) a supersaturation associated with an hexahydrate CaCO, IRUPDWLRQ FDQ EH DFFRPSOLVKHG OHDGLQJ WR VHYHUH LQFUXVWDWLRQ R water is needed. This paper addresses a study on the performance of the electrolysis process applied "per se" and with alkaline chemical dosing for removal of noncarbonated hardness for industrial use. The water used in experiments was the tap water of the reticulation system of Campina Grande in Paraiba state, Brazil. Results showed WKDW WKH SURGXFWLRQ RI SULPDU\ FRDJXODQW GXULQJ HOHFWURO\VLV LPSUR  $CaCO_3$ ) and magnesium hydroxide, Mg (OH)<sub>2</sub>. The overall removal rate obtained with this process was 80% with a detention time of 40 minutes which is about 17% of the time needed in conventional Water Treatment Plants.

Keywords: Noncarbonated hardness removal; Electrolysis process; As the water treatment process, electrolysis of water produces two Chemical dosing types: (1) alkaline water is reduced and (2) acidic water and oxidized. In the anode, water is oxidized when the metal electrode is placed in

#### Introduction

solution. ere by releasing electrons in the metal, the pH decreases Lime-soda so ening is generally applied in waters with high concentrations of dissolved solids such as high calcium and magnesium increasing the hydroxyl ion, OHwhich contributes to the increase of around 11.00 and a er hydroxyl ions addition, magnesium ions are

precipitated as solid magnesium hydroxide, Mg(QHe hydroxyl ions added are lime, CaO or calcium hydroxide, Ca(OB)alcium of 5 mg/L CaCQ

$$2H_2O$$
 2e o  $H_{2(a)}$  2O $H_{aa}$  (1)

Most of the waters from the semi-arid region of Northeast Brazil the slurry of precipitate until calcium concentration reaches a pre xed value. Generally, it is adjusted for potable use of water, a calcium concentration of 60-70 mg/L CaCoefore discharge to a concentration of 60 mg/L CaCoefore discharge to a concentration of 60 mg/L CaCoefore discharge to a distribution system. During the drought period of the ninety decade concentration of 60 mg/L CaC@nd for magnesium a maximum value of 16<sup>th</sup> Century total hardness concentrations reached values in the range 300 to 1900mg/L CaCOlence, extensive CaCOrecipitation

Lime-soda process was applied by Cavalcanti and Bonifacio [Was observed causing a rapid reduction in the carrying capacity of the to the blend "raw water, rw":"aerated water, aw" in samples from the onduits. Also, because of the high chloride concentration with values Water Treatment Plant, WTP at Gravatá, Paraiba State, Brazil. eabove 5000 mg/L Cand of the widespread use of metallic components mixing channel where the samples were taken was placed prior thmethe water distribution networks (as, for instance, ironed conduits) following processes: sedimentation, Itration and disinfection. e corrosion is observed. e e ects are brown-reddish waters, nodules results showed a nal pH value of about 11.07 which was inadequatermation and a progressive destruction of pipelines. for general distribution. Another disadvantage of this process is that it

requires a long detention time (above eight hours) in the sedimentation. us a localized area of the cathode to which is highly insoluble tank in order to precipitate total alkalinity and calcium carbonate the liquid surfac CaCQ.

According to Agostinho et al. [2] the process of electrolysis has been

used for removing impurities from a variety of domestic wastewater Corresponding author: Agostinho LCL, Chemistry Department-CD/CST-UEPB, eutrophic waters and industrial wastes. In water treatment, electrolysia Juvêncio Arruda, s/n-Bodocongó-CEP: 58.109-790, Campina Grande, can be de ned as a combination of the processes of coagulation, Brazil; E-mail: cristina.uepb@gmail.com

occulation, otation and disinfection. e observed e ects are Received July 18, 2012; Accepted September 27, 2012; Published October 01, various such as: destabilization of colloids (for color removal), rapido12

occulation with material eroded electrodes, and electrochemicatitation: Agostinho LCL, Nascimento L, Cavalcanti BF (2012) Water Hardness reactions redox with the removal of various industrial pollutants suchemoval for Industrial Use: Application of the Electrolysis Process. 1:460. VFLHQWL466FUHSRUWV as heavy metals, rust faster and stronger among others. e electrolysis

also allows chloride is naturally present in dissolved form in the rawopyright: © 2012 Agostinho LCL, et al. This is an open-access article distributed water produces chloride ions and other antibacterial substances with the terms of the Creative Commons Attribution License, which permits under the terms of the Creative Commons Attribution License, which permits the transfer the terms of the Creative Commons Attribution License, which permits water produces chloride ions and other antibacterial substances with the terms of the Creative Commons Attribution License, which permits the terms of the Creative Commons Attribution License, which permits water produces chloride ions and other antibacterial substances with the terms of the Creative Commons Attribution License, which permits the terms of the Creative Commons Attribution License, which permits the terms of the terms of the Creative Commons Attribution License, which permits the terms of the Creative Commons Attribution License, which permits the terms of the terms of the Creative Commons Attribution License, which permits the terms of the Creative Commons Attribution License, which permits the terms of term improving the disinfection process. original author and source are credited.

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Page 2 of 5

Ca<sup>2</sup><sub>3(ad)</sub> 'Alk 'Ca

Page 3 of 5

with di erent polarities to a battery with 12V and 36 A by means of exible connecting wires.

e anode or sacri ced electrode (aluminum sheet) was connected to the cathode of the battery and the cathode (inox electrode) was connected to the anode of the battery.

e initial experiments were made by utilizing only tap water or tCG water. In the next experiments chemical dosing was applied using the following chemicals: Water A: 316 mg/L NaOH (sodium hydroxide addition); Water (B): 310 mg/L NAOH (ammonium hydroxide addition) and Water (C): 270mg/L CaO (lime addition). In all experiments in the sedimentation tank a detention time was applied varying from 45 minutes to 2.00 hours.

## Results

Table 1 shows the water quality of tap water from the reticulation system of Campina Grande, Paraiba State, Brazil. Table 2 shows the theoretical results of lime so ening process applied to tCG tap water. eoretical results a er conditioning application; i.e. lime-soda so ening are shown in Table 3. e values were obtained by applying the STASOFT so ware [8], for terrestrial waters. ese values can also be obtained 7111(7n69(va)-5(l)1(711 21(b)11(t)29)5(b)11(t)-6(a)9

TDS( mg/L)

reduction produces an increase in hydroxyl ions, Oelrati cation/ transformation unit of the reactor furnishes a continuous current of low voltage which circulates between the electrodes and, thus, propitiates the electrolysis.

# Electrolytical so ening

Generalities: e electrolysis process was applied to so en the hard water from the reticulation system of Campina Grande, Paraiba, Brazil. is water, here termed tCG, has the following chemical classi cation:"Low ionic strengtwater (lonic strength calculated by using Langelier Equation given by I=0,5\* 10-5TDS where TDS is in mg/L), chloride concentration adequate for public use but showing corrosiveness (CJ 50mg/L) and with predominance of permanent hardness or noncarbonated hardness".

e electrolytic station is showed in Figure 2 and is described as follows: A reactor of two liters was used in which was immersed an electrolyte cell made with two steel electrodes and two aluminum electrodes. Both had an area of 50, cmthickness of 2 mm and are 0.5 cm far from each other. In the corner of the electrodes a 3 mm hole was made located 1 cm on the edges of the electrode. e end of a rigid wire was isolated in the small side of the electrode. is wire had 1.5 mm diameter and its length was 20 cm. eight isolating spaces were made to ensure a good distance between the electrodes. even were interlinked