Inhibited Antibiotic–Resistant and Electrochemical Treatment of Pharmaceutical Wastewater

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INTRODUCTION

Water is vital both as a solvent in which many of the body's solutes dissolve and as an essential part of many metabolic processes within the human body. Potable water production and supply are essential ingredients in the community and to human beings and other living things. Waterborne diseases (diarrhoea, typhoid, and cholera) that are widely spread in developing countries and in sub- Sahara are caused mainly by poor sanitation and hygiene practices, which involve collection, treatment and disposal of solid and liquid wastes. In wastewaters (liquid wastes) microorganisms are removed by disinfection treatment processes using Chlorine dioxide, Chlorine compounds (monochloroamine, dichloroamine), Ozone and ultra-violet radiations. The stringent potable water standard and effluents quality limits by Environmental Regulatory Authorities, increasing energy cost and reports of outbreak of water-borne diseases in many parts of Africa have brought a greater challenge to Water experts (Water Science, Environmental and Water Engineers). These actions have caused Environmental and Water Engineers to look for effective methods of treating water and wastewaters rather than relying on conventional water and wastewater treatment methods.

In the last two decades several studies have been conducted on the performance of electrochemical treatment process as a wastewater treatment method. The electrochemical treatment process has been effectively used in the treatment of various industrial, municipal, domestic- institutional and domestic wastewaters. Wastewater generated from industrial processes such as distillery industry (Manisankar *et al.,* 2004), textile industries (Naumczyk *et al.,* 1996) and dye processing industry had been treatment using electrochemical treatment process. Chen (2004) presented documents on the design development,

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construction and applications of electrochemical techniques in water and wastewater treatment. In the documentation a particular focus was given to selected techniques such as electrodeposition, electrocoagulation, electroflotation and electrooxidation with little data on treatment of wastewaters from pharmaceutical industries. Over 300 related publications were reviewed with 221 cited or analysed. Literature (Li *et al.,* 2014, Zheng *et al.,* 2015) have provided more information on efficacies of various electrochemical treatment of water and wastewaters. The main focus of this study is to conduct a simple literature review on treatment wastewaters from pharmaceutical and related industries and establish efficacies of electrochemical treatment technique in removing selected pollutants form raw water.

BACKGROUND

Carbon resin electrodes were developed from used dry cells (Oke *et al.,* 2007a, b and c). Electrolysing equipment was developed from local materials. Synthetic (simulated) wastewaters were prepared using procedures and methods specified in APHA (1998). Fractional factorial (2^{K-P-1}) experiments were utilized at random to determine influence of selected factors (separation distance between the electrodes, volume of the wastewater used, applied current, temperature of the wastewater, treatment time, concentration of the pollutant, concentration calcium of hypochrite ($Ca(OCl)_2$) added and depth of the electrode into the wastewater used) on efficiency of electrochemical process in removing Biochemical Oxygen Demand concentration at five days (BOD_5) as follow-up on previous study (Oke *et al.,* 2007c). The choice of the parameters to be studied was done on the basis of the theoretical data about several factors that determine the efficiency of an electrochemical method and the scarce knowledge concerning carbon-resin / aluminium electrodes. An electrochemical treatment plant on a laboratory scale using public electricity source was setup (Figures 1a and b). BOD_5 determinations in wastewaters were carried out following procedures in APHA (1998) using respirometric method (CAMLAB HACH, model number 2173B BOD manufactured by Hach Chemical Company). The procedures and steps were repeated for blanks (to serve as controls). Efficacies of the system were computed using equation (1) as follows:

$$Y = 100\left(\frac{(C_0 - C_t)}{C_0}\right) \qquad (1)$$

Where; Y is the efficacy of the system (electrochemical treatment process), C_0 is the initial BOD_5 and C_t is the final BOD_5. Table 1 presents arrangement of Fractional factorial (2^{K-P-1}) experiments. Effects of the selected factors on the efficacy of the electrochemical treatment process were computed using contrast method (Guttman *et al.,* 1971; Gardiner and Gettinby, 1998; Davore and Farnum, 1999, Davore, 2000) as stated in equation (2) as follows:

$$ef = \left(\sum_{i=1}^{K-P-1} l_i Y_i\right) \qquad (2)$$

Where; K is the number of the factors (8), P is the fraction of the factorial experiment (3), l_i is the level (-1 or 1), and ef is the effect of the factor. Number of experiments required for both factorial and fractional factorial were computed using the following equations: