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An ANN Model for Predicting the Quantity of Lead and Cadmium Ions in Industrial Wastewater

E. A. Olajubu, Department Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
Gbemisola Ajayi, Department of Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
Isaiah Oke, Department of Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
Franklin Oladiipo Asahiah, Department Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria

ABSTRACT

Rapid industrialization has contributed immensely to the discharge of heavy metals into receiving water bodies untreated. The quantity of heavy metals prediction in industrial wastewater is very essential before treatment so that the quantity is precisely removed. This article formulates, simulate and evaluate a predictive model that mimics electrochemical treatment of lead and cadmium ions present in paint industrial wastewater using artificial neural network. The predictive model was formulated using Fuzzy Logic toolbox in MATLAB and the simulation was done in the environment. The prediction of the model was evaluated by comparing the predicted quantity of lead ions and cadmium ions with the result of the experimental work in the laboratory. The article concludes that the developed prediction model demonstrated very high prediction accuracy in predicting the percentage of lead and cadmium ions present in paints wastewater.

KEYWORDS

Cadmium Ions, Heavy Metals, Industrial Wastewater, Lead Ions, Paints Industry

INTRODUCTION

The accumulation of heavy metals in human environment is responsible for many of the global health challenges of today. This is because heavy metals are non-biodegradable and carcinogenic. The rapid increase in industrialization has brought about an enormous amount of wastewater which contain very high quantity of heavy metals as pollutants (Somsak et al., 2016; Wolfova et al., 2013). Heavy metals are highly toxic with density of about five times that of water and also can penetrate the human body through various ways such as ingestion, absorption, and dermal contact. The presence of these metals in the environment also affects other living organisms, for example the production and quality of crops, the quality of the atmosphere, aquatic animals' health and the life of humans. Examples of heavy metals include but not limited to Lead, Zinc, Iron, Mercury, Cadmium and Arsenic metals. Among these metals, Lead and Cadmium are the most toxic, and they are readily available in the environment (Sardar et al., 2013; Singanan, 2011). Lead is a microelement that is naturally present in trace amount in all biological materials such as soil, water, plants and animals. It is one of the oldest metals known to man which is capable of causing an extensive environmental contamination and health problems in the world (Naja & Volesky, 2009). Lead when exposed to human body can cause damages to the vital organs of the body such as, kidney, brain, liver, bones, reproductive system,

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nervous system and gastrointestinal system (El-Wakil et al., 2014). The important sources of lead poisoning in the environment include Lead based paint, Lead pipes, Lead crystal, mining, refining, soldering, ceramics, lead acid batteries, jewelry making, volcanic activity, geochemical weathering, electronic waste, gasoline, and building materials (Tiwari et al., 2013). The source of Lead ions into the waterbody in Nigeria is from the proliferation of paint companies even in the rural areas (Onugbu et al., 2013; Mahre et al., 2007). Cadmium is a soft silvery white, slightly malleable and easily fusible metallic element that is found naturally in the earth crust. Cadmium is highly toxic at extremely low and high levels in man and animals. This is because of its ability to accumulate quickly. Cadmium is released from various sources such as electroplating, soldering, paints, weathering of rocks, waste incineration, batteries, television sets, ceramics, yellow pigments, photographic, insecticides, alloys of copper, fuel combustion, and agricultural products (Kabir et al., 2014). The effects of Cadmium poisoning in the environment can also lead to very serious damage health hazards. Like Lead, it could also lead to the kidney, renal failure, high blood pressure, bone demineralization and lung cancer because of its carcinogenic properties (Ismail et al., 2009; Järup, 2003).

The recent growth in industrial activities especially in the Paints industry in Nigeria is a possible treat to the health of Nigerians. This is because majority of the Paint industries in Nigeria are sited within residential areas with little or no regulation on how their effluences are discharged into the nearby streams or waterways. When these wastes find their way into the human system, through contaminated water, terminal illness such as cancer, kidney or liver diseases often ensue. It should be noted that there is some correlation between the increase in terminal diseases and the new industrial activities in Nigeria due to the release of their effluence, which are either partially or not treated at all (Olaoye & Oladeji, 2015; Egwuonwu et al., 2012; Onuegbu et al., 2013). These terminal diseases and associated illnesses impart natively on social-economic development of a nation. The affected individuals who are in their productive age have their man-hour withdrawn from national productivity and the cost of management of these diseases is detrimental to national development. So, the health of individuals in a nation contribute significantly to the development of the nation (Mathias et al., 2013). Health is wealth for individuals and the nation collectively (Odrakiewicz, 2012; Consolata, 2017). The concept of national development of a nation underscores an effective health delivery system which is strongly rooted in diseases prevention. Diseases prevention is an effective means of ensuring a healthy and productive society. To handle the aforementioned challenges, this study proposes an artificial neural network model that will be useful to predict the quantity of the heavy metal that are present in any wastewater before their removal. The proposed model mimicked the existing electrochemical process to predict the quantity of lead and cadmium ions that are present in industrial wastewater. This model will also be useful to aid the determination of the quantity of lead and cadmium ions present in the wastewater before the treatment of the effluence. This is with the aim of removing entirely pollutants from the wastewater which will ultimately minimizes societal health hazards. The proposed model will assist manufacturing companies to determine the quantity of heavy metals present in effluence, before experimental works are done in the laboratory to remove the metals. Also, it serves as a guiding tool for the Department or governmental agencies involved in assessing the degree of treatment of effluence from manufacturing companies before such water is discharged to water ways for human consuption. The next section presents existing work in this area. Section three then discusses our artificial neutral network model, while section four explains our data collection and management. The simulation result is presented in section six, while section seven concludes the paper.