Ecotoxicology and Environmental Safety 156 (2018) 391–402

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

Fluoride contamination in groundwater sources in Southwestern Nigeria: Assessment using multivariate statistical approach and human health risk

Chidozie PraiseGod Emenike[a,b,*], Imokhai Theophilus Tenebe[a], Peter Jarvis[b]

[a] Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria
[b] Cranfield Water Science Institute, School of Water, Energy and Environment, Cranfield University, Bedfordshire MK43 0TE, United Kingdom

ARTICLE INFO

Keywords:
Risk assessment
Abeokuta
Pollution
Groundwater
Dispersion
Southwestern Nigeria

ABSTRACT

The present study investigated the ionic and fluoride concentrations in tap water and its associated health risk to local dwellers of Ogun State (Abeokuta south), Nigeria. 63 samples were collected from twenty-one different locations. Results obtained revealed the mean concentration of fluoride (F^-) as 1.23 mg/L. Other water quality parameters such as total dissolved solids (TDS), electrical conductivity (EC), F^-, Fe^{2+}, and SO_4^{2-} surpassed the WHO guidance for drinking water. Strong positive correlation was observed between F^- and TDS; F^- and pH; TDS and EC; TDS and Mg^{2+}; TDS and SO_4^{2-}; TDS and HCO_3^-; EC and HCO_3^-; EC and SO_4^{2-}; Na^+ and Cl^-; SO_4^{2-} and Cl^-. In addition, Empirical Bayesian Kriging (EBK) model was employed to spatially distribute the concentration of the analyzed elements within the study region. The chronic daily dose (*CDD*) and hazard quotient (*HQ*) were also used to evaluate the health risk associated with F^-, considering dermal and ingestion as pathways. The results revealed that the associated *HQ* for infants between the age range of 6–12months within about 91% of the study region surpassed the accepted *HQ* limit. However, the *HQ* for age categories 11–16years; > 65years; 18–21years; 21years; 16–18years within 95.2%, 90.5%, 80.95% and 100% of the study location were less than 1. Conclusively, the *HQ* values obtained in this study should serve as a baseline information for water management authorities, policymakers and the society at large towards addressing these pollution issues.

1. Introduction

The presence of fluoride at elevated concentrations in drinking water has caused severe health effects in humans in some parts of the world (Bhatnagar et al., 2011; Shen and Schäfer, 2015). Fluorine exists in the environment through combination with other elements to form highly soluble fluoride compounds. The main source of fluorine in water is from natural deposition from geogenic sources in aquifers (EPA, 2010; Sun et al., 2013). The primary way by which humans ingest fluoride is through consumption of contaminated groundwater (Singh et al., 2013; Singh and Mukherjee, 2015; Subba Rao et al., 2013). The World Health Organization (WHO) recommended the concentration of fluoride that can cause minimal health risk to be 1.5 mg/l. However, more than 200 million people living across 20 developing and developed countries regularly consume water with elevated fluoride concentrations above the standard guidelines set by the WHO (Amini et al., 2008; Fawell et al., 2006; Shen and Schäfer, 2015). Some countries such as Tanzania in the East of Africa have a drinking water standard for fluoride of 4 mg/l, well above the WHO recommended value. This can cause a number of possible health problems, including dental and skeletal fluorosis. In the Rift Valley, East Africa, more than 80 million people display a range of symptoms consistent with dental fluorosis (Shen and Schäfer, 2015; Smedley et al., 2002). However, this should also be placed in the context of water scarcity, population growth and access to clean water in the region.

High concentrations of fluoride in humans can lead to various health problems such as nervous system damage (Kaoud and Kalifa, 2010), reduced fertility (Izquierdo-Vega et al., 2008), intellectual impairment in children (Ding et al., 2011; Shivaprakash et al., 2011), urinary tract disease (Jha et al., 2011), as well as dental and skeletal fluorosis in children and adults (Maguire, 2014). In turn, this can lead to significant lower back pains (Namkaew and Wiwatanadate, 2012). It has been proposed that regularly consuming water with fluoride concentrations of at least 0.9 mg/l is the cause of at least 37% of dental fluorosis cases (McGrady et al., 2012). Levy and Leclerc (2012) also correlated fluoride in drinking water with bone diseases (Osteosarcoma) in adolescents and children. Sun et al. (2013) discovered that cases of hypertension in adults could be linked to fluoride present in drinking water. They further emphasized that fluoride exposure could cause an increase in plasma Endothelin-1 (ET–1) levels. Liu et al. (2014)

* Corresponding author at: Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria.
E-mail addresses: praisegod.emenike@covenantuniversity.edu.ng (C.P. Emenike), imokhai.tenebe@covenantuniversity.edu.ng (I.T. Tenebe), p.jarvis@cranfield.ac.uk (P. Jarvis).

https://doi.org/10.1016/j.ecoenv.2018.03.022
Received 2 January 2018; Received in revised form 4 March 2018; Accepted 6 March 2018