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ORIGINAL ARTICLE

Evaluation of fluoride levels in bottled water and their contribution to health and teeth problems in the United Arab Emirates

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Abstract Fluoride is needed for better health, yet if ingested at higher levels it may lead to health problems. Fluoride can be obtained from different sources, with drinking water being a major contributor. In the United Arab Emirates (UAE), bottled water is the major source for drinking. The aim of this research is to measure fluoride levels in different bottled water brands sold in UAE, to determine whether fluoride contributes to better health or health problems. The results were compared to international and local standards. Fluoride was present in seven out of 23 brands. One brand exhibited high fluoride levels, which exceeded all standards, suggesting it may pose health problems. Other brands were either below or above standards, suggesting either contribution to better health or health problems, depending on ingested amount. A risk assessment suggested a potential for non-cancer effects from some brands. The results were compared to fluoride levels in bottled water sold in UAE and neighboring countries (e.g. Saudi Arabia, Qatar, Kuwait, and Bahrain), over 24 years, to reflect on changes in fluoride levels in bottled water in this region. The research presents the need for creating, stricter regulations that require careful fluoride monitoring and new regulations that require listing fluoride level on the bottled water label, internationally and regionally. The research will have local and global health impact, as bottled water sold in UAE and neighboring countries, is produced locally and imported from international countries, e.g. Switzerland, the USA, France, Italy, New Zealand, and Fiji.

1. Introduction

Water is important for our life, especially for drinking, and its quality will affect our health. Accordingly, different biological, chemical, and physical parameters are monitored and measured to determine the quality of the source water as well as the final drinking water (bottled or tap water). Water is an

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essential source of minerals as well, but if those mineral levels exceed or fall below certain limits, the benefits will no longer exist, and they can actually become harmful. For example, fluoride is important in preventing tooth decay and reduces it by about 25% over the lifetime of the individual (CDC, 2013), yet excessive amounts of fluoride may cause health problems.

Fluoride is naturally present in the environment, and as a result of human activities that lead to an increase in the fluoride levels in both ground and surface waters, through industrial waste release, steam generation stations, fertilizers, pesticides, and other sources (Jagtap et al., 2012; Rajkovic and Novakovic, 2007; Tahir and Rasheed, 2013; WHO, 2004). As a result, fluoride is available in the environment from different sources, and accordingly will contribute to the quality of our health and life.

Humans are exposed to fluoride through drinking water and beverages prepared with fluoridated water, food (Abouleish and Abdo, 2012; Harrison, 2005; Jagtap et al., 2012; Rajkovic and Novakovic, 2007; Tokalioglu et al., 2004; Whelton et al., 2004; Zohouri et al., 2003), stomatology prophylactic processes (Rajkovic and Novakovic, 2007), air (Jagtap et al., 2012; Tokalioglu et al., 2004), toothpaste (CDC, 2013; Khandare, 2013; Whelton et al., 2004), mouth rinsing solution treatments, cosmetics (Jagtap et al., 2012), fluoride supplements and drugs (CDC, 2013; Clarkson and Mcloughlin, 2000; Jagtap et al., 2012; Whelton et al., 2004), water fluoridation (CDC, 2013), and fluoridated milk and salt (Whelton et al., 2004). Therefore, water is considered as the major and most common source of fluoride for humans and, as a result, can act as the major contributor for toxicity (Amanlou et al., 2010; Cordeiro et al., 2012; Jagtap et al., 2012). Fluoride helps in teeth and bone growth and development (Alabdula'aly, 1997; Ghaderpoori et al., 2009; Khan and Chohan, 2010; Momani, 2006; Rajkovic and Novakovic, 2007; WHO, 2004), especially during the pre-eruptive stage of the formation of enamel, where fluoride intake will help in reducing dental caries, later in life (WHO, 2004; Zohouri et al., 2003). Alternatively, ingestion of excessive fluoride during the development of the tooth and specifically in the stage of maturation, can lead to different problems, such as skeletal and dental fluorosis, and also can interfere with the function of the enzymes (Cordeiro et al., 2012; Ghaderpoori et al., 2009; Jagtap et al., 2012; Jimenez-Farfan et al., 2011; Rajkovic and Novakovic, 2007; Rizk, 2009; Tahir and Rasheed, 2013; Whelton et al., 2004). Skeletal fluorosis acts as the initial stages for osteoporosis and can affect adults and children by causing arthritic symptoms, in the initial stages, then restriction of spine movements and finally possibly paralysis (Jagtap et al., 2012). Dental fluorosis is more prominent in children, with symptoms ranging from white chalky teeth at mild conditions, to brown pigmentation and severe pitting of the teeth at severe conditions (Jagtap et al., 2012). In addition, excessive fluoride may cause allergic manifestations, gastrointestinal problems, muscular manifestations, neurological disorders, and may also cause cancer (Jagtap et al., 2012). Therefore, fluoride levels are monitored in drinking water supplies to achieve the required safety (Jagtap et al., 2012).

The fluoride levels ingested by humans differ from one individual to another, depending on the sources they are exposed to, level, and amount ingested (Jagtap et al., 2012). Fluoride toxicity is dependent on the individual's age, health, and weight (Rajkovic and Novakovic, 2007). As a result, different international organizations have set standard limits for fluoride in water, for avoiding the toxicity caused from fluoride as well as to ensure that the fluoride in water may contribute to the final required health benefits.

Humans obtain drinking water from tap or bottled water. Bottled water dependence is growing rapidly around the world due to growing consumer confidence in its quality. Therefore, the quality of bottled water is important, and the levels of minerals and pollutants are monitored regularly. For example, since bottled water is used as the drinking and mineral source, fluoride is monitored to avoid any problems and also to make sure that it is a beneficial source for contributing to caries reduction. As a result, in this research, bottled water sold in the United Arab Emirates (UAE), that is produced locally or imported from international and regional countries was tested for fluoride and compared to the fluoride levels reported in the literature and to the set standard limits set by international and local organizations.

2. Materials and methods

2.1. Bottled water samples

Twenty-three different bottled water brands, which were purchased from local supermarkets in the UAE (Table 1), were analyzed in this research for fluoride. Four samples were analyzed for each brand. Some of the bottled water brands were produced in the UAE, while others were imported from neighboring and other international countries. The bottled water container was made of plastic, and the volume varied between 330 – 600 mL. The bottled water samples were analyzed after purchase.

2.2. Fluoride analysis

A Waters Ion Chromatograph (IC) system (Milford, MA, USA) in conjunction with the Millennium 32, were used for the analysis of the bottled water samples. The Water IC system consisted of a 616 pump with 600 S controller and an IC-Pak Anion HR 4.6×75 mm column. In addition, a 717 plus auto-sampler and 432 conductivity detector were used. The analysis was performed at room temperature, at a flow rate of 1.0 mL/min, using an isocratic mobile phase that was prepared by mixing 20 mL of n-butanol (HPLC grade, Hipersolv, UK) and 120 mL of acetonitrile (HPLC grade, Hipersolv, UK), and 20 mL of sodium borate/gluconate concentrate [18 g boric acid (Scharlau, Spain), 16 g sodium gluconate (HPLC grade, Hipersolv, UK), 25 g disodium tetraborate decahydrate (HPLC grade, Hipersolv, UK) and 250 mL glycerin diluted to 1 L with de-ionized water (Millipore "Simplicity" Purification System, USA)] then diluted to 1 L by de-ionized water, then homogenized, filtered through a 0.2 μm membrane filter (Schleicher & Schuell, Germany), and finally degassed by sonication for five minutes. The injection volume was 50 μL.

Using a multi-ion standard (Seven Anion Standard II Standard, Dionex, USA), different standards (0–10 mg/L range) for fluoride were prepared to develop the calibration curve (correlation coefficient $\geqslant 0.99$) for all the analysis. For the fluoride analysis, the limit of detection (LOD) and limit of quantitation (LOQ) were 0.0245 mg/L and 0.0817 mg/L,