Human Health Risks with Fluoride Ions via Drinking water of Al-Daden water Supply Station in Mosul City, Iraq.

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Abstract

The current study aimed to assess the human health risks of fluoride in the drinking water of the Deaden water supply station and the residential quarters covered by its distribution pipelines network on the right side of Mosul city in northern Iraq. As 100 water samples were collected from ten sites, which included the intake water, water after treatment, and the rest is distributed in the residential quarters. The results of the study indicated The results of the current study indicate that the hazard quotient (HQ) values ranged from (0.13332 to 0.35978), which is within the safe limits for drinking because the chronic daily intake (CDI) fluctuated use "between" (0.00799 to 0.21583) mg/kg/day. The highest values were for the category of infants who were most affected when the concentrations of fluoride ions in drinking water were high, and the lowest were in the age group (12 to 16) years. Also, the concentration of fluoride ions did not exceed the permissible limits for drinking water, which reached (0.326) ppm, but was less than the limits Required for natural mineralization of bones and protection of tooth enamel according to United states environmental protection agency's (US.EPA), which was determined according to the temperature of Mosul city with (0.7) ppm.

Keyword: Fluoride ions concentration in drinking water, HHR of fluoride. Mosul city.

1. Introduction

Since ancient times, civilizations have arisen in Iraq, such as the Sumerian, Akkadian, Babylonian and Assyrian civilization, due to the presence of abundant sources of fresh water represented by the Tigris and Euphrates rivers, in addition to the tributaries of the Tigris River, such as the Khabur, the upper and lower Zab and the Azim rivers, etc., which is the main source of water for domestic and industrial, irrigation uses, and watering livestock. Many challenges that Iraq and the world suffer from, such as the increase in population numbers, cultural and social development, and global warming have led to the scarcity of rainfall in Iraq and the region, followed by a decrease in the discharge of the Tigris and Euphrates rivers and their tributaries, in addition to the construction of dams in upstream countries, which poses a threat to water security in Iraq [1, 2].

Likewise, the conditions that Iraq has experienced in the last three decades, including the destruction of infrastructure, weak oversight and the application of deterrent laws to those who tamper with water resources, led to the dumping of agricultural, industrial and civil activities into the Tigris River without any treatment for it, which further deteriorates the ecosystem of the Tigris River. This excessive contamination of water resources may be ignorant of a meager commodity. The continuation of these abuses may lead in the very near future to contribute to the problem of the shortage of safe water with the possibility of the emergence of many health and environmental impacts [3].

Globally, since recent decades, the problem of pollution of water sources with fluoride and nitrates has become a major public health concern, as more than 500 million people in 37 countries are exposed to fluoride risks in many regions of the world, ranging from the effect on tooth enamel to skeletal fluorosis[6-4] , as shown in picture (1), especially India, Africa, China and South America, to exceed concentrations standard limits for fluoride in drinking water (1.5) ppm to reach its concentration in water sources: in India (69.7) ppm, Kenya (6.6) ppm, Ethiopia (17) ppm , Norway (9.5) ppm, Munster, Germany (8.8) ppm[6, 7].

In Iraq, studies related to the concentration of fluoride ions in water are very rare, and there are also no studies related to the health risks of fluoride in drinking water.

Picture (1): High level of fluoride that causes dental and skeletal fluorosis.

Generally, fluoride ions are present in varying concentrations in water, (fresh water, salt water), soil, rocks, vegetables (especially green), milk and fish [3]. Despite the fact that fluoride is a trace element in the environment that has vital health benefits, high

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concentrations of it have negative effects on the general health of humans, Table (1), shows the impact of different levels of fluoride ion in drinking water on the health of the human body.

Therefore, the current study was conducted to estimate the concentration and human health risks (HHR) of fluoride ions in drinking water for Dnadan water supply station, and the residential quarters.

Table 1. The possible effect of fluoride ion via drinking water on public health.

Fluoride concentration in drinking water (ppm).	Health effects
0.0 t 0 0.5	Impaired growth, fertility and tooth decay.
0.5 to 1.0	Maintaining healthy and healthy teeth.
1.0 to 4.0	Preventing tooth decay.
4.0 to 10.0	Dental fluorosis (tooth spotting).
More than 10.0	Dental fluorosis, fluorosis of the skeleton with back and neck pain, fluoride paralysis.

2. Materials and Methods

Al-Dandan water supply station is located on the left side of Mosul city near the Tigris River to supply treated water for each of the following neighborhoods: Al-Dawasah, Al-Dandan, Al-Jawsaq, Al-Nabi Sheet, Bab Al-Jadid, Al-Akidat, Al-Sijn, etc. as shown in Figure (1) and Table (2). The city of Mosul is characterized by a hot, dry weather in

Figure 1: A satellite image of Al-Dandan water supply station and the residential quarters On the right side of Mosul City.

Summer and cold, rainy in winter. The city is also characterized by the presence of the Al-Fatha formation (Middle Miocene formation), which is rich in evaporated salts, gypsum and anhydrite, which are soluble in water, causing erosion in the ground layers, which may be accompanied by a break in the connecting parts of the network pipes, causing the infiltrated water from the septic tanks to enter in the water distribution network pipes, as well as the legal violations in connecting water pumps directly to the network, which increases the possibility of polluted water entering the water distribution

Table (2): Characteristics of AlDnadan water supply station and the Residential quarters on the right side of Mosul city.

Sites	Latitude	Longitude	Altitude	Uses
1	36˚33'54" N	43˚14'65" E	231 m	for different uses
2	36˚33'50" N	43˚14'47" E	213 m	
3	36˚33'12" N	43˚14'25" E	240 m	
4	36˚33'13" N	43˚14'02" E	240 m	
5	36˚32'87" N	43˚13'75" E	235 m	
6	36˚33'40" N	43˚13'66" E	246 m	
7	36˚33'35" N	43˚13'05" E	246 m	
8	36˚33'06" N	43˚12'90" E	232 m	
9	36˚32'75" N	43˚13'57" E	235 m	
10	36˚32'71" N	43˚14'65" E	213 m	

Network [2, 3]. 100 water samples were collected from the outlet water (Tigris River), after treatment, and the rest from the residential neighborhoods of the station for the period use “between” September 2021 until February 2022 using clean polyethylene bottles. In the laboratory. Fluoride concentration in drinking water samples was determined using a mixed fluoride electrode (ISE-BNC), versus a reference silver chloride/silver hydrogen electrode (pH/ION 735, GmbH Company). Due to its simplicity and short analysis time; the concentration of fluoride ranging from (0.2 to 3.0) ppm fluoride to find the standard curve [3].

To estimate the health risks of fluoride, which is a non-carcinogenic contaminant, the best and simplest tool to express these risks according to a US Environmental Protection Agency report. (US EPA 2006) The mean daily intake (CDI) ingested via drinking water and the hazard quotient (HQ) for the study area are calculated from the

following equations [4, 8-11].

$$\text{CDI oral (mg/kg. day)} = \frac{\text{Cw} \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

$$\text{HQ oral} = \frac{\text{CDI oral}}{\text{RFD oral}}$$

Where CDI: represents Chronic Daily Intake (mg/kg. day). HQ: Hazard Quotient, Cw: the measured nitrate concentration for water samples. IR: The daily rate of drinking water (liters. day-1). EF: Frequency of exposure by age (day. year). ED: duration of exposure to nitrates (years). Bw: body weight of cohorts (kg.). AT: average time (day). RfD: reference dose for nitrate (0.06 mg/Kg/Day).

If the HQ value is less than one, this indicates that the drinking water is safe and has no harmful health risks to consumers, but if the value is greater than 1, there may be potential health effects due to the consumption of water contaminated with fluoride [3, 12].

3. Results and Dissections

The results shown in Table (2) and Figure (2) indicate that there are no clear differences in the concentration of fluoride ions in the water before (Tigris River water)

Table (2): The concentration of fluoride ions in the water samples of the sites under study (in ppm unit)

Repli. Sites.	2021							2022			
	7/11	22/11	28/11	5/12	12/12	15/12	22/12	2/1	16/1	20.2	± Sd
1	0.288	0.301	0.297	0.301	0.301	0.298	0.302	0.304	0.326	0.310	0.009
2	0.301	0.296	0.295	0.298	0.297	0.296	0.302	0.303	0.304	0.309	0.004
3	0.295	0.296	0.296	0.299	0.299	0.296	0.303	0.304	0.304	0.308	0.004
4	0.295	0.295	0.296	0.300	0.299	0.297	0.303	0.303	0.303	0.306	0.003
5	0.275	0.295	0.295	0.300	0.299	0.297	0.303	0.303	0.303	0.307	0.008
6	0.301	0.295	0.294	0.299	0.299	0.298	0.302	0.303	0.302	0.309	0.004
7	0.296	0.295	0.294	0.299	0.299	0.298	0.302	0.303	0.302	0.309	0.004
8	0.295	0.296	0.294	0.299	0.300	0.297	0.303	0.303	0.303	0.309	0.004
9	0.295	0.295	0.295	0.299	0.300	0.298	0.302	0.303	0.302	0.308	0.004
10	0.295	0.295	0.298	0.300	0.299	0.298	0.301	0.303	0.302	0.309	0.003

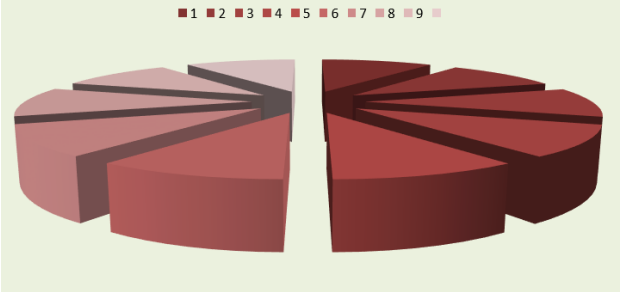

Figure (2): The average concentration of F- ions in drinking water for the studied sites.

And after treatment (site 1, 2) because the water treatment processes are traditional and there are no removal processes for the ions present in the water (which includes sedimentation-filtration processes and then sterilization of water with chlorine) as the rates ranged between (0.303 ± 0.009 to 0.300 ± 0.004) ppm. As for the concentration of fluoride ions in the drinking water of residential quarters, it ranged use "between" (0.294 to 0.310) ppm. This decrease in the concentration of fluoride ions is due to the lack of pollution by sources of the main forms of fluoride such as fluorspar or calcium fluoride (CaF2), apatite or rock phosphate [Ca3F(PO4)3], and cryolite (Na3AlF6) [13]. Since the upper, lower limits and the desired concentration depends mainly on the average temperatures of the region (Mosul city) because the relationship is inverse between them, when the temperature rates rise, the desired concentration, upper and lower levels according to US.EPA [13] will decrease as a result of the consumer's need to drink more water especially during the hot months of the year (from April to November to reach temperature rates of 25.75 to 31.33 ˚C, respectively) to compensate for what the body loses of water through sweating, so the person in the hottest areas will receive doses of fluoride ions More than people get in cold regions.

From the available data for the monthly averages temperature for the city of Mosul and its districts and sub-districts for a period of more than five years (data of the weather station), the annual average of the air temperature was calculated, which amounted to (28.35) C, according to the specifications of the US Environmental Protection Agency [13] shown in Table (3) The upper and lower limits of the concentration of fluoride ions in the drinking water of the city of Mosul, the center of Nineveh Governorate, ranged between (0.6 to 0.8) ppm and the desired concentration (0.7) ppm consecutively.

Table ():The upper, lower and ideal limits for the concentration of F- ions in Drinking water according to the annual average temperature.

Annual average temperatures for more than five years ˚C	Limits of fluoride concentration in ppm		
	Lower	Upper	Ideal
10.00 to 12.05	0.9	1.7	1.2
12.15 to 14.61	0.8	1.5	1.1
14.66 to 17.66	0.8	1.3	1.0
17.72 to 21.44	0.7	1.2	0.9
21.50 to 26.22	0.7	1.0	0.8
26.27 to 32.50	0.6	0.8	0.7

However, the concentration of fluoride ions in the studied water samples was less than the recommended minimum limits of Mosul city as well as relatively less than the optimal limits (0.5) ppm recommended by the World Health Organization [14].

Fortunately, this confirms the results of the fluoride risk quotient (HIFluoride = HQ) values did not exceed the dangerous limits (greater than 1.0) for all age groups studied, as the HI values for the infant group fluctuated between (0. and 0.3578). As for the age group (21 Old), HI values for females were relatively more expensive than males, which fluctuated between (0.19221 to 0.19469), while for the rest of the age groups it ranged between (0.13377 to 0.22750) as shown in Table (4). It is also noted

from the table that HI values decrease proportionally with increasing age, that the decrease in fluoride risk quotient (HIFluoride = HQ) values for all age groups is mainly due to the decrease in the concentration of fluoride ions in drinking water, which led to a decrease in CDI values, so it ranged for both infants, 21-old group and the rest of the age groups between (0.02122 to 0.021137), (0.01152 to 0.01168) and (0.00802 to 0.01365) consecutively.

In general, the rate of absorption of fluoride from the stomach has a direct relationship with the acidity of its contents, as well as the solubility of ingested fluoride compounds. Soluble compounds such as sodium fluoride (NaF) and hydrogen fluoride are rapidly absorbed by the digestive system, while calcium fluoride (CaF2) and magnesium fluoride compounds (MgF2) is less soluble in the digestive system, which slows down the speed of its absorption [15].

Of the blessings of God upon us, the concentration of fluoride and (HIFluoride = HQ) in drinking water was within the internationally recommended limits. Otherwise, there would be problems from high concentrations in drinking water, such as low levels of calcium in the blood, which causes muscle tetany or cramps and pain in the abdomen, convulsions, and irregular

Table 2. CDIoral results and HIfluoride = HQ (for different cohorts) for drinking water of Al-Dnadan water supply station.

Cohorts Sites		Infants	6 to11	11to16	16to18	18to21	21 to Old	
							males	Females
1	CDI	0.02151	0.01365	0.00995	0.00813	0.01045	0.01007	0.01168
	HI	359780	0.22750	0.16584	0.13556	0.17429	0.16790	0.19468
2	CDI	0.02137	0.01351	0.00995	0.00805	0.01045	0.00997	0.01156
	HI	0.35616	022525	0.16584	0.13421	0.17429	0.16624	0.19275
3	CDI	0.02137	0.01351	0.00995	0.00805	0.01045	0.00997	0.01156
	HI	0.35616	022525	0.16584	0.13421	0.17429	0.16624	0.19275
4	CDI	0.02129	0.01347	0.00981	0.00802	0.01031	0.00994	0.01152
	HI	0.35497	0.22450	0.16365	0.13377	0.17199	0.16569	0.19221
5	CDI	0.02122	0.01342	0.00978	0.00799	0.01028	0.00990	0.01148
	HI	0.35379	0.22375	0.16311	0.13332	0.17141	0.16513	0.19146
6	CDI	0.02137	0.01351	0.00995	0.00805	0.01045	0.00997	0.01156
	HI	0.35616	022525	0.16584	0.13421	0.17429	0.16624	0.19275
7	CDI	0.02137	0.01351	0.00995	0.00805	0.01045	0.00997	0.01156
	HI	0.35616	022525	0.16584	0.13421	0.17429	0.16624	0.19275
8	CDI	0.02137	0.01351	0.00995	0.00805	0.01045	0.00997	0.01156
	HI	0.35616	022525	0.16584	0.13421	0.17429	0.16624	0.19275
9	CDI	0.02129	0.01347	0.00981	0.00802	0.01031	0.00994	0.01152
	HI	0.35497	0.22450	0.16365	0.13377	0.17199	0.16569	0.19221
10	CDI	0.02137	0.01351	0.00995	0.00805	0.01045	0.00997	0.01156
	HI	0.35616	022525	0.16584	0.13421	0.17429	0.16624	0.19275

Heartbeat, etc. these harmful effects of fluoride are due to four different actions [5]

1. Tissue damage (hydrofluoric acid is formed as a result of interaction with water that has a corrosive effect) as in the following equation

F- + H2O → HF + OH-

2. Influence on nerve function through its affinity with calcium vital to nerve function.
3. Cytotoxicity due to inhibition of enzyme systems.
4. Impairment of cardiac function due to electrolyte imbalance leading to hyperkalemia.

4. Conclusions and Recommendations

The current study is one of the very limited and even rare studies in Iraq, where HHR was estimated based on different age groups, duration of exposure, body weight, daily consumption of drinking water, levels of fluoride ions in drinking water, etc. It was observed that the concentrations of fluoride in the drinking water sources of Al-Dnadan water supply station were lower than the internationally permissible levels.

The fluoride hazard quotient (HIFluoride = HQ) values were relatively low for levels that pose a public health hazard for all age groups, especially infants. Thus, the studied water is healthy and safe to drink in relation to the concentration of fluoride ions, and there are no health risks to humans and livestock.

Therefore, we recommend not to add fluoride to the drinking water of Al-Dnadan water supply station because the amount of fluoride ingested varies from one person to another. Also, the local population gets fluoride from other sources such as toothpastes, eating fluoride-rich fish (100) ppm, drinking tea, etc.

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