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Evaluation of Fluoride level in Drinking Water Wells and its Effects on Human Health

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Abstract

Fluorides are classified as one of the inorganic forms of Fluorine and consuming high level of fluoride will have several adverse health effect. The study aims to evaluate the concentrations of fluoride in drinking water wells and its effect on human health. A total of 11 water samples were collected from different areas in Khartoum, Soudan for chemical analysis. Public survey was implemented with 100 participants to measure their level of awareness and understanding about the fluorides problem in drinking water. The study revealed that a high percentage of participants knew about fluoride and its benefits to human health. However, the study showed that the level of fluoride in water samples s less than the WHO standard value (1.5 g/L) of fluoride that exists naturally in drinking water.

The results obtained indicated that most of the participants do not suffer from kidney problems and were not aware of deflouridation. So, raising awareness about defluoridation techniques has many positive impacts.

Keywords: Deflouridation, Flouridation, Dental Caries, Skeletal Fluorosis, Dental Fluorosis

Introduction

Fluorine is a high reactivity element that is not available in the elemental state naturally. Fluorides are one of the inorganic non-metallic compounds of Fluorine. Natural Fluoride sources are water and soil. Fluoride is used in industry, such as it has been used as one of the key components in certain products such as toothpaste, and mouth rinses, and it is involved in the reinforcement of teeth and bones as they are absorbed into the blood through the gastrointestinal tract and therefore it assembles in areas which contain a high amount of calcium, such as the bones and teeth (Kanduti, 2016). Fluoride compounds are considered crucial to teeth because it aids to re-mineralize damaged tooth enamel, counter initial signs of tooth decay, and inhibit the development of bad oral bacteria. The spatial change in concentration of fluoride can get affected by the seasonality (Rahman, et al., 2020). The most electronegative and reactive element in the periodic table is fluorine. Due to its reactivity, it is always found in nature mixed with a few other elements. Fluoride is a naturally occurring, widely dispersed element that can be found in variable concentrations in rocks, minerals, volcanic gases, and other materials. The increase in the level of uorine in the atmosphere is also caused by anthropogenic sources, including coal-fired power stations, aluminum smelters, phosphate fertilizer companies, glass, brick, and tile works, and plastics factories. 1,2 As was mentioned in earlier chapters, when uoride uptake is in a healthy amount, humans benefit.(Gupta, and Ayoob 2016). In addition to its natural availability in water, it can also be included and added to water supplies, and this method is called water fluoridation regarding dental health, to prevent dental caries, getting a higher concentration of fluoride in drinking water is a beneficial solution. Hence, the prevalence of dental caries is inversely proportional to the concentration of fluoride in drinking water. (Cafasso, 2019). As the need for groundwater becomes a crucial demand (Ibrahim, The Relation between Risk and Level of Chemical Components in Drinking Water, 2021), the intake of groundwater naturally rich in fluoride results in dental fluorosis or skeletal fluorosis, and bone deformities. Like many

elements, fluorine is beneficial to human health in small amounts, but can be toxic in large amounts (F. M. Fordyce, 2007). According to WHO, the recommended value of fluoride that exists naturally in drinking water is considered 1.5 mg/L when consuming 2 L water/day. Furthermore, water supplies can be fluoridated artificially but in a condition that the fluoride concentration should not surpass 1.0 mg/L (J. Fawell, 2006). Gupta, and Ayoob (2016) evaluated the stress effect of fluoride on human. Certain European countries carry out the fluoridation of drinking water and apply the process at concentrations ranging from 0.8 to1.2mg/L (J.Farwell, 2003). In addition, as per The US Department of Health and Human Services, 0.7 mg/L is the specific concentration of fluoride in water required for inhibiting tooth decay and for controlling and placing a limit on the damaging and undesirable health effects. Bo et al., (2003) evaluated the level of fluoride in groundwater in in the West Plain Region of Jilin Province, China. Dental fluorosis occurs due to local effects of fluoride on the mineralizing tooth germ, predominantly the maturation stage of enamel formation that is up to the age of 8 years. Fluorosis clinical spectrum ranges from mild discoloration of tooth surface to severe staining and pitting (Iftekhar Ahmed, 2020). Majumdar (2011) evaluated the health impact of drinking water containing fluoride below permissible level on flourosis patients in a fluoride-endemic rural area of West Bengalwith food habits in India. The study found an increasing of prevalence of dental, skeletal, and non-skeletal fluorosis among the study population. Skeletal fluorosis is a disorder that occurs as a consequence of high fluoride concentration in drinking water mostly 3–6 mg of per liter (Fluoridation, 2015). Whereas, the most severe form of skeletal fluorosis is known as crippling skeletal fluorosis. It is described as containing an excessive accumulation of fluoride within drinking water (over 10 mg of fluoride per liter). The US EPA demonstrates that 4mg/L is the optimal concentration of fluoride in drinking water that protects against crippling skeletal Fluorosis. Moreover, an additional cause for developing skeletal Fluorosis is that kidney patients drink fluoridated water. As a comprehension, patients suffering from kidney problems are unable to excrete and

effectively get rid of fluoride from the body. Thus, fluoride is built up to four times more fluoride in the bones and their blood as well so kidney patients are at higher risk of fluoride poisoning (J.Farwell, 2003). The study intended to determine the concentrations of fluoride in drinking water wells and to examine and study the relationship between fluoride in drinking water and their effects on teeth, bones, and kidneys by carrying out a chemical analysis of multiple water samples collected from 11 locations in Khartoum state.

Materials and Methods

Study Design

This cross-sectional study utilizes a chemical analysis and a questionnaire. The study was conducted on multiple samples of drinking water during 2016 from 11 locations in Khartoum, and Omdurman. A questionnaire was distributed to 100 participants from different educational backgrounds. The study has conducted 11 samples of drinking water which were collected during 2016 from different locations in Khartoum and Omdurman. The water sources involved were well water, rivers, and groundwater.

Questionnaire Development

The questions in the questionnaire were produced from information provided from a literature review covering the related topic. The questions were intended to meet the Sudanese culture in terms of phrasing the questionnaire. A 26-question paper questionnaire was distributed online among people who live in Khartoum, Omdurman, and Bahri. The questionnaire involved two domains; the first domain focused on the sociodemographic information about the respondents. It collected simple demographic information like age, gender, and place of residence. The second domain assessed the level of awareness and knowledge about fluoride and its related topics such as its effects and sources . In this domain, respondents were asked to answer by "yes", "no", and "not sure" to some of the questions. Furthermore, this domain contained additional questions in which the participants needed to give specific answers. For instance, some of these questions were about fluoride and its water sources as well as the effects of fluoride on teeth, bones, and kidneys' health.

Analytical study

This study carried out particular methods for the analysis of water samples for fluoride levels. Regarding fluoride levels, SPANDS method was applied by utilizing Spectrophotometer (HACH) 2000 DR. This method involves the reaction of fluoride with red zirconium – dye

solution the fluoride reacts with part of the zirconium to form a colorless complex thus bleaching the red color in an amount proportional to the concentration of fluoride in the sample

Results and discussion

Results of Lab Experiments for Fluoride

According to the chemical analysis of the samples obtained from the 11 areas in Khartoum and Omdurman, the values of the results ranges from 0.1 mg/L and 0.77 mg/L

As shown in the following table:

Table 1: Result of Fluoride Analysis in Khartoum and Omdurman

No	Location	F	UNIT
1	Nuzha	**0.2**	mg/L
2	Jabra	**0.2**	mg/L
3	Al shajra 1	**0.77**	mg/L
4	Al Kalakla	**0.17**	mg/L
5	AlLamab	**0.1**	mg/L
6	Al Shajra 2	**0.27**	mg/L
7	Abu Seid	**0.66**	mg/L
8	AlKalakala	**0.16**	mg/L
9	H.Shati	**0.47**	mg/L
10	Banet	**0.69**	mg/L
11	Al Shigla	**0.32**	mg/L

The mean fluoride across the 11 locations is (0.365 mg/L). The standard deviation is 0.242 mg/L. Regarding the Khartoum area, the minimum and maximum fluoride content is 0.1 mg/L and 0.77 mg/L respectively. Furthermore, the mean fluoride for Khartoum locations is 0.316 mg/L, and the standard deviation is 0.236 mg/L.

On the other hand, the results collected from Omdurman were ranging from 0.3 mg/L and 0.56 mg/L and having a mean value of 0.493 mg/L and a standard deviation of 0.151 mg/L. Table (1) and figure (1) show the Fluoride component contained in water for Khartoum state is significantly different from both WHO and Sudan standards (1.5) (for **One-Sample Test**, Sig. = 0.000 < 0.05),

while the mean Fluoride component was (0.365±0.242 Mg/l) compared to (1.5 Mg/l) for both WHO Guidelines value and Sudanese Standards for Drinking Water.

Table 2: T-test for mean Fluoride in Khartoum state compared to WHO and Sudan standards

One-Sample Statistics		**One-Sample Test** (Test Value = 1.5)			
Mean	Std. Deviation	T	Df	Sig. (2-tailed)	Mean Difference
0.365	0.242	-15.590	10	0.000	-1.135

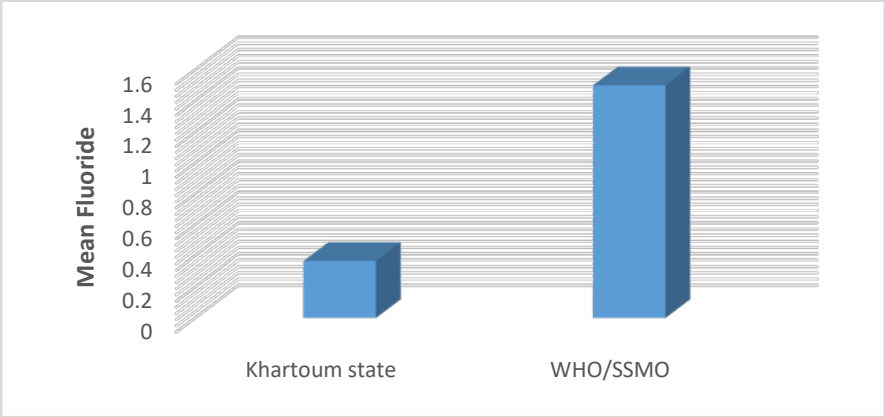

Figure 1: Mean Fluoride in Khartoum state compared to WHO and Sudan standards

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Sociodemographic Information

A total of one hundred participants were enrolled in the survey. The results show that most of the participants were in the range between 16 and 30 years old (75%). Whereas, the respondents who were part of the range >30 years old were (19%) and the minority were 5-15 years old (6%). The gender ratio (M: F ratio) is approximately recorded with 3:1.8 , hence most of the participants were females. Tables 3 to 5 present the distribution of participant according to their age, gender and place of residence.

Table 3: Distribution of participants according to age:

Age	Frequency	Percent%
5-15 years	6	6.0
16-30 years	75	75.0
More than 30 years	19	19.0
Total	**100**	**100.0**

Table 4: Distribution of participants according to gender

Gender	Frequency	Percent%
Male	40	40.0
Female	60	60.0
Total	**100**	**100.0**

Table 5: Distribution of participants according to their place of residence

Residence	Frequency	Percent%
Khartoum	52	52.0
Omdurman	24	24.0
Bahri	24	24.0
Total	**100**	**100.0**

Level of Awareness

The distribution of participants according to their water resource is presented in table 6. approximately half of the participants use tap water from the public drinking water supply as the main source of their water (49%). Furthermore, the second source of water which had (28% n=28) was the Nile River. The remaining respondents use groundwater and different sources of water (10 % and 13%, respectively).

Table 6: Distribution of participants according to water resource

Water resource	Frequency	Percent%

Tap water from public drinking water supply	49	49.0
Ground water	10	10.0
Nile river	28	28.0
Other	13	13.0
Total	**100**	**100.0**

Table (6) shows that the most (49%) common resource of drinking water according to the participants was tap water from public drinking water supply, whereas (28%) of the participants use the Nile river, while only (10%) of them use groundwater. Moreover, (13%) of the respondents use other resources for drinking water.

Table (7) shows that most (68%) of participants have heard about Fluoride, mostly from schools/college (48%) or social media (16%). Furthermore, (55%) of participants were not sure what the source of Fluoride is, while (34%) thought that the main source of Fluoride is water.

It is shown that (54%) of participants thought that Fluoride has positive effects on human health and the majority (56%) of them was aware that Fluoride can be found in drinking water.

Most (50%) of participants knew that drinking fluoridated water can affect human health. On the contrary, (28%) of them were not sure about that. In addition, (38%) of participants believed that Fluoride can be added to public drinking water supplies, while (40%) of them were not sure.

Table (8) shows that most of the participants did not have spinal restriction in their back (back stiffness) (54%), numbness in the limbs and the trunk (73%), joint pain (64%), nor feel pain or stiffness in your neck (76%). Therefore, there were no significant effects of fluoride on bones seemed in the study area.

Table (9) indicates that the majority (92%) of the participants revealed that they do not have problems with their Kidneys. Moreover, most (66%) of them have never heard about the Water Defluoridation process. Only (26%) of them believed that drinking water that contains a small amount of Fluoride can lead to Dental Caries, while (40%) of them were not sure. According to the results, (48%) of the participants have Dental Caries and most of the participants brushed their teeth with fluoride toothpaste (69%). In addition, the majority of the respondents eat a lot of sugars and starches and do not clean their teeth well afterward (59%). Based on the results, the most common dental problem was a painless brown stain in one pair of teeth or more (11%) compared to having a painless brown stain with a corroded appearance in one pair of teeth or more (6%). In contrast, the highest percentage was 68%, in which the participants revealed that they do not have those dental problems and 32 % of them had problems during childhood. The results showed 9% of the participants believed that the reason for getting those kinds of dental problems is drinking water. However, 36% of them had a different opinion. They thought that drinking tea or coffee can cause dental problems. Moreover, 55% of the participants were not sure. The majority of the participants (82%) have gone to the dental clinic and (18%) have not gone. Furthermore, (3%) of the participants who went to any dental clinic, have done a fluoride blood test, while (89%) have not done fluoride blood test and (8%) were not sure.

Table 7: Distribution of participants according to knowledge about Fluoride

		Count	Percentage
Have you ever heard about Fluoride?	Yes	68	68 %
	No	20	20.0%
	Not sure	12	12.0%
What was your source of information about Fluoride?	Schools or College	48	48.0%
	Social media	16	16.0%
	Other	15	15.0%
	None	21	21.0%
What is the main source of Fluoride?	From food	11	11.0%
	From water	34	34.0%
	Not sure	55	55.0%
Does Fluoride have positive effects on human health?	Yes	54	54.0%
	No	8	8.0%
	Not sure	38	38.0%
Do you know that Fluoride can be found in drinking water?	Yes	56	56.0%
	No	22	22.0%
	Not sure	22	22.0%
Do you know that drinking fluoridated water can affect human health?	Yes	50	50.0%
	No	22	22.0%
	Not sure	28	28.0%
Do you believe that Fluoride can be added to public drinking water supplies?	Yes	38	38.0%
	No	22	22.0%
	Not sure	40	40.0%

Table 8: Distribution of participants according to Fluoride's effects on bones:

		Yes	No	Not sure
Do you have spinal restriction in your back (back stiffness)?	Frequency	28	54	18
	Percentage	28%	54%	18%
Do you have numbness in the limbs and the trunk?	Frequency	15	73	12
	Percentage	15%	73%	12%
Do you have joint pain?	Frequency	32	64	4

	Percentage	32%	64%	4%
If you try to touch your chest with your chin, do you feel pain or stiffness in your neck?	Frequency	17	76	7
	Percentage	17%	76%	7%

Table 9: Distribution of participants according to effects of fluoride on kidneys and teeth

		Count	Percentage
Do you have any problem with your Kidneys?	Yes	4	4.0%
	No	92	92.0%
	Not sure	4	4.0%
Have you ever heard about Water Defluoridation (Removing excess Fluoride from drinking water by filtering with a strong adsorbent like alumina or carbon)?	Yes	18	18.0%
	No	66	66.0%
	Not sure	16	16.0%
Do you believe that drinking water that contains a small amount of Fluoride can lead to Dental Caries?	Yes	26	26.0%
	No	34	34.0%
	Not sure	40	40.0%
Do you have Dental Caries?	Yes	48	48.0%
	No	49	49.0%
	Not sure	3	3.0%
Do you brush your teeth with fluoride toothpaste?	Yes	69	69.0%
	No	13	13.0%
	Not sure	18	18.0%
Do you eat a lot of sugars and starches and do not clean your teeth well afterwards?	Yes	59	59.0%
	No	41	41.0%
Do you have one of the following dental problems?	Painless white spots in one pair of teeth or more	8	8.0%
	Painless white areas in one pair of teeth or more	7	7.0%
	Painless brown stain in one pair of teeth or more	11	11.0%
	Painless brown stain with corroded appearance in one pair of teeth or more	6	6.0%
	None	68	68.0%

When did these dental problems occur?	During Childhood	32	32.0%
	I do not have these problems	68	68.0%
What do you think is the reason for these kinds of dental problems?	Drinking Water	9	9.0%
	Drinking Tea or Coffee	36	36.0%
	Not sure	55	55.0%
Have you ever gone to a dental clinic?	Yes	82	82.0%
	No	18	18.0%
If you went to any dental clinic, have you ever done a Fluoride blood test?	Yes	3	3.0%
	No	89	89.0%
	Not sure	8	8.0%

Discussion

As we know, observational studies and epidemiological studies habitually constitute a valuable provider that is used for pointing a weight of evidence for an acurate approach (A.K. Gupta, 2016). The study assessed the public awareness on the effect of drinking water that contains fluoride on human health. (Samuel Y Ganyaglo, 2019) .According to the study, a high percentage of participants knew about fluoride and this is because schools and colleges gave the way for students to gain information about fluoride. Furthermore, the study showed that participants are aware that fluoride can be found in drinking water but unfortunately they were not certain what the main source of fluoride is.

The majority of the participants thought that fluoride is beneficial to human health, and that was expected to be since it is well-established that fluoride plays a major role in increasing the strength of the tooth enamel by applying fluoride on the surface of the teeth, therefore, using fluoride in a wide range of dental products is considered as a significant mean to enhance dental health. On the contrary, the participants lack information about the standard amount of fluoride this is crucial to their body.

The chemical analysis of fluoride samples obtained from the 11 locations from Khartoum and Omdurman revealed that all values were less than the WHO standard value of fluoride that exists naturally in drinking water. In addition, the results showed that almost all of the values of fluoride

found in drinking water were less than the recommended concentration for inhibiting tooth decay which is 0.7 mg/L (J.Farwell, 2003). This is indicated in the results of the questionnaire as the majority of the participants enrolled showed that they are suffering from tooth decay. Therefore, there is a high possibility that the people in those areas are affected by lower levels of fluoride contained in their drinking water.

According to the results, a high percentage of participants said that they did not have spinal restriction in their back (back stiffness), numbness in the limbs and the trunk, joint pain, nor feel pain or stiffness in their neck. Therefore, the process of bone turnover is homeostasis controlled by osteoblasts and osteoclasts. Consuming huge amounts of fluoride can interfere with this balance, affecting osteoblasts and osteoclasts and ultimately leading to skeletal fluorosis (ChenYANG, 2017). Since the values of fluoride received from the chemical analysis were lower than the value that can cause skeletal fluorosis, there were no significant effects of fluoride on bones seemed in the study area.

The results obtained indicated that most of the participants do not suffer from kidney problems. The reason behind that is the low amount of fluoride found in the samples of drinking water. On the contrary, a previous literature review suggested that when getting a high amount of fluoride, there could be high risk of harming kidneys. A study was done in 2006 about the toxic effects of fluoride on kidney function and histological structure. The results showed that extreme fluoride exposure caused multiple renal histological changes as well as increased renal cell apoptosis in the study groups. Moreover, the study revealed that the enzymes of kidney tissues such as lactate dehydrogenase (LDH) activity were significantly raised, whereas alkaline phosphatase (AKP) activity was decreased. Furthermore, there was an increase in urea nitrogen (UN), an elevation in creatinine (Cre), and a reduction in Na+. These findings show that chronic excessive fluoride

exposure is toxic to kidney structure and its function. Therefore, the fluoride in drinking water should be in a moderate amount in order not to damage kidneys. (Xiu-An Zhan, 2006)

A high percentage of participants were not aware of deflouridation. This pattern was expected given the poor education and low level of knowledge of people about fluoride. Drinking water that contains an excessive amount of fluoride leads to an accumulation of fluoride in the body (toxicity of fluoride). Consequently, this causes a variety of adverse effects on human health involving kidney diseases, dental fluorosis, skeletal fluorosis, and influences on IQ (Shabiimam M. A, 2017). Various defluoridation techniques have been developed to eliminate such an extreme amount of fluoride. Fluoride removal can be done by the application of some techniques such as precipitation, adsorption, ion exchange, and deionization (Elhessin, 2004). So, to ensure drinking safe water, some measures such as popularizing defluoridation techniques and optimizing water supply strategies need to be implemented (Hui Jia, 2019)

The results showed that the majority of participants have no idea that fluoride can damage their teeth and they only thought that drinking tea and coffee is the main reason. Furthermore, the majority of the participants went to dental clinics and a few of them have done fluoride blood tests. Important findings are the fact that people's knowledge about fluoride is very poor. Since dentists and science teachers are well educated about fluoride, they need to emphasize the significance of fluoride for human health for people and students in schools and colleges by increasing awareness about fluoride. Also, during their study, they should concentrate on practical chemical analysis of fluoride to have accurate information about fluoride levels that are required to inhibit health problems. As a result, conducting the Fluoride tests in patients is very crucial. The reason behind that is that while fluoride is a naturally occurring compound, it can still possess hazardous effects when taken in large amounts or small amounts. Dentists should properly

counsel their patients, parents, and children on correct tooth brushing behaviours. (Ritu Bansal, 2012).

Conclusion

In conclusion, it is important to raise awareness about diverse chemical analyses of fluoride amongst students and people. Moreover, educating them about the positive and negative effects of fluoride in drinking water is required. Also, carrying out the fluoridation process (adding low concentrations of fluoride to drinking water) to raise the fluoride level in drinking water is considered as a solution to prevent diseases caused by the decline in fluoride levels in the human body. In case of having high levels of fluoride, using the defluoridation process can help to reduce it.

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