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Appraisal of Sodium and Fluoride Variability in Groundwater Quality and Health Threat on Human: A Case Study of Abuja North-Central, Nigeria

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Abstract: *Poisonous stuffs tend to come into water physiques thru human-induced and geodetic sources, hence persistent drinking water monitoring schemes are crucial. The target of this paper was to estimate the human health threat posed thru superfluity fluoride (F^-) and sodium (Na^+) accumulation in borehole water utilized for both domestic as well as consumption deeds. In this paper, the accumulation of fluoride (F^-) in borehole water varied at distinct sites, span from 0.47mg/L to 1.84 mg/L with a mean value of 1.28 mg/L whereas that of sodium ranged from 55.98mg/L to 515.45mg/L with average value of 260.19mg/L. The Hierarchical cluster scrutiny (HCS) revealed three common clusters in which the samplings could be categorized. For Total Hazard Index (THI) 100 and 28% (adults and children respectively) are above 1.0 for sodium ingesting whereas all fluoride are below one unity in all the scrutinized locations.*

Keywords: *Fluoride, sodium, groundwater, elements, health, Abuja.*

1. INTRODUCTION

Water is natural resources as well as widespread solvent required by animal, plants and man to tackle their daily need on earth, which can be in vapour, solid, or liquid state. Also, water is one of imperative compounds for every kind of plants and animals, thus its contagion is fundamentally considered more indispensable than soil [1, 2]. Studies indicate that roughly 80% of infectious diseases are either water-borne or water related. Since, water served as vital resource for existence of animals, plants and man, the surface water rarity as well as deficient piped borne water supply have led to rise in groundwater demand in Abuja and its vicinities. Request for groundwater has been increase due to swift population evolution as well as the urbanization hastened pace besides industrial development in the last few years predominantly in developing countries like Nigeria [3, 4]. Communities around the world have utilized groundwater as only source of clean and drinking water in prior time and even currently above half of the world's occupiers rest solely on ground water for survival [5, 6]. Groundwater has long been pondered as one among the sparkling forms of water available in nature that meets the global demand for semi-rustic and rustic people [7, 8]. The intensification in groundwater demand for numerous human activities has put great significance on water management and science practice universally. Numerous groundwater is critically managed as a result of its obscure nature besides it usually takes longer period to detect after spoiled and once it is adulterated, its attribute can't be fix up by just averting the impurities from source, since contagion might carry on despite stopping or removing its source [9, 10]. Besides, in rustic districts, boreholes are sited either adjacent to a pit rest room or soak away pits downstream or dumpsites or contiguous landfills. In the rustic as well as peri-municipal districts bulk of the groundwater supplies are mostly unprocessed, though it has been avowed that it is tough for groundwater to distill itself, often challenging and exorbitant to treat, afterward. Utilization of groundwater sources of insensible attribute puts the users at threat of likely waterborne illnesses [3, 11]. Abuja, Federal capital of Nigeria is experiencing hasty population rising and this has led to growing in the waste generation. Abuja encompass of households that hinge on groundwater whereas, quite a lot of areas

are assigned for farming, burial ground, municipal landfill site as well as wastewater treatment plant, despite those landfills have been predictable as one of the main extortions to groundwater geneses in this district [12, 13]. At the moment no accessible records on the situation of groundwater attribute in Abuja satellite city as well as prospective healthiness threats that these water sources can have on homo sapiens, not like other chronicles of groundwater attribute in Nigeria that defined the effect of physical, heavy metals as well as chemical properties on human healthiness. Thus, it is obligatory to evaluate water quality of groundwater in Abuja satellite metropolis since infected water via leachate, faeces and other non-point origins might have both societal as well as economic evolution effects besides human healthiness threats attributable to activities within this region. Conclusively, the intention of this paper was to evaluate the state of water attribute from boreholes located at Abuja region by evaluating some heavy metal accumulation and determine potential health threat caused by exposure of human being to some heavy metals.

2. MATERIALS AND METHODS

2.1 The Study location

The case study for this study is Abuja, the capital as well as center of Nigeria. This location is well explained thru Aso rock, a four hundred (400) meter megalith at the midpoint, and close by Zuma Rock, a seven hundred and ninety-two (792) metre megalith, northern part of the metropolis on Kaduna artery. It located within latitude 9.4° N as well as longitude 7.29° E. The inhabitants of Abuja is approximately 6,000,000 with a yearly advance speed of 35%, maintain its position of African rapidest developing metropolis [3]. Abuja municipal double as the political and administrative center of Nigeria besides served via Nnamdi Azikiwe International Airport. Other contiguous metropolises that borders Abuja comprise of Mandalla, Keffi, Kaduna and Lokoja [14].

Fig. 1: Map of study district signifying the sampling locations.

2.2 Sample collection, preparation and storage

In this study, 25 localities were selected for water scrutiny (Fig. 1), and water samplings were accumulated, examined and equated with World Health Organization (WHO) water quality standards [13]. Pithily, plastic containers were clean up and stored in ten percent (10%) nitric acid for 2 days, then swabbed with duple sanitized water prior to sampling. Taps water samplings were tag based on their sources via the code P1–P25. The containers were swilled thrice and taps run for not less than 5 min before samplings collection and tagged correspondingly. Samplings for metals were conserved with addition of 3 mL of concentrated bicarbonate (HNO_3). All the samplings were put inside an ice chest and transferred to the laboratory then conserved at temperature of 4°C in the freezer for further scrutiny.

2.3 Analytical techniques

The on-site measurements were carried out on Twenty-five groundwater samplings collected from Abuja (Fig. 1) during March and July 2018 from boreholes taps situated in 25 dissimilar locations (P1–P25) via multiparameter Hanna HI98194 TDS/salinity meter / E. cond and Hanna HI2030 probe. The on-site measurements of water quality parameters consist of temperature (temp), pH (hydrogen ion concentration), E. Cond (electrical conductivity), total dissolved solids (TDS), also

alkalinity (Alka) Remaining water parameters, for example SiO_2 (dissolved silica), major anions (Cl^-(chloride), CO_3^{2-} (carbonates), nitrates (NO_3^-), HCO_3^-(bicarbonates), and sulphates (SO_4^{2-}), in addition major cations (Ca^{2+} (calcium), magnesium (Mg^{2+}), sodium (Na^{2+}), and potassium (K^+) were measured by means of standard techniques laid out by the American Public Health Association [15]. Likewise, Hanna HI98193 waterproof portable meter and probe was used to measured BOD, DO and COD. Fe^{2+} (iron) and Mn (manganese) concentration was weighed under a usual functional condition with a Perkin Elmer PinAAcle500 (flame nuclear absorption spectrophotometer), and F^- (fluoride ion) was measured by means of a standardized potentiometric ion selective probe (Hanna HI5315 cited electrode fitted to professional water-resistant Hanna HI98194 portable pH/ORP/EC/TDS//ISE meter).

2.4 Numerical health threat assessment

Pathways of human exposure threat of a person to trace metals contagion can be by three broad paths which comprises of dermal ingestion via skin exposure, breathing thru mouth and nose as well as direct absorption. General exposure paths to water (H_2O) are dermal ingestion as well as absorption paths. Exposure dose for human healthiness threat via these two paths could be work out using Equations. 1 plus 2 as revised from the USEPA threat appraisal control for superfund approach. The parameters were slot in the equations to estimate the exposure threat connected with sodium and fluoride accumulation cogitating consumption (EDD_{IN}) as well as dermal (EDD_{DE}) pathways correspondingly.
The figures in Tables 5 and 6 shows the EDD_{IN} in addition to HQ_{IN} of fluoride and sodium accumulation in the water samplings correspondingly. Also, deliberates on the HI for adults and children acquired from various sampling sites (P1−P25). Additionally, the figures in Tables 7 and 8 indicates the EDD_{DE} in addition to HQ_{DE} of fluoride and sodium correspondingly, whereas Table 9 shows chronic daily intake (CDI) calculated using equation (3). The data acquired from Tables 5-8, were utilized to compute the total Threat Index (TI) values (Table 10) for sodium in addition to fluoride. The total Threat index (TItotal) was computed for non-carcinogenic threat based on Equation (4).

$$EDDing = (Cw\ x\ WR\ x\ ER\ x\ ED) \div (MT\ x\ BW) \quad (1)$$
$$EDDderm = (CW\ x\ ER\ x\ EP\ x\ SR\ x\ ED\ x\ CF) \div (MT\ x\ BW) \quad (2)$$
$$\text{CDI} = CW\ x\ (DI \div BW) \quad (3)$$
$$TItotal = (EDDing + EDDderm) \div \text{R}f\text{D} \quad (4)$$
$$TItotal = HQin + HQde$$

where Cw is trace element concentration; WR is rate of water digestion (taken as 2 L/day and 1L/day for adults as well as children correspondingly) USEPA 2011; ED is exposure duration (taken as 30 years and 6 years for adult as well as child correspondingly); ER is the exposure rate taken as 365days; BW specifies body weightiness (taken as 32.5kg and 72kg for child and adult correspondingly); MT specifies mean time (taken as 10,950 days as well as 2190 days for adult and child correspondingly); SR denotes skin apparent region (taken to be 6365cm^2 and 19,652cm^2 for child as well as adult correspondingly); EP signifies exposure period (taken as 350days); Kp is the skin observance feature (taken as 1/100); CF denotes conversion factor (taken to be 1/100). DI represents average daily intake (taken to be 2.2L/day). RfD is the oral reference dose, children and adult (taken as 400 µg/kg-day and 500 µg/kg-day respectively for sodium), as stated by ITIS (Integrated Threat Information System) databank of the USEPA. RfD of fluoride is 60µg/kg-day [14]. A major threat may ensue for cancer impact if the Threat index is above one (>1). The Threat index value below one (<1) implies that there is no non-cancer coincidental effect occurring [4, 10].

2.5 STATISTICAL ANALYSIS

The descriptive statistics illustrations of the collected groundwater samplings are showed in Fig. 2(a-r). To checked prospective links, the degree of likeness and discrepancy that exist amidst the various sites, Hierarchical Cluster Scrutiny (HCS) technique was employed. Fig. 3 and 4 displayed the ward link dendrogram that sorted the parameters and observed samplings. The imperative parameters utilized for computing the exposure threat connected with sodium and fluoride contagion in adults in addition to children, make available via [16] daily dosage (EDD) of each chemical.

3. RESULTS AND DISCUSSION

Table 1 indicates the mean values of fluoride (F^-) gotten throughout the evaluation ranged from 0.47 to 1.84 mg/L, and were out of the suggested values of < 0.1 and 1.5 mg/L advocated by WHO for domestic water usage while, sodium (Na^{2+}) mean values ranged from 55.98 mg/L to 515.45mg/L as well as beyond Who suggested limit of < 0.1 and 50 mg/.L. Pearson's correlation constants were computed for every single hydrogeological variables as exhibited in Table 2. A momentous correlation was found to ensue between Na^{2+} in addition to F^- (α = 0.05, r = 0.38). The rate of violation of water attribute parameters versus WHO clean water attribute criterions was computed as a percent of the over-all number of times a parameter outshined set criterions as presented in Table 3. It was discovered that Na^{2+}, SO_4^{2-}, EC, Mg^{2+}, TDS, HCO_3^-, F^-, Fe^{2+}, TH, and Cl^- demonstrated the worst violation of clean or drinking water standards with percent non-compliance of 100, 76, 64, 56, 56, 44, 40, 40, 36, and 24 %, correspondingly.

Health studies have shown that water with F^- value which surpass 0.6 mg/L causes tooth decay reduction specifically in growing children while, consumption of water with F^- value above 1.5 mg/L generates dental fluorosis and in life-threatening scenario skeletal fluorosis [1, 8, 9]. Nevertheless, above 1.5 mg/L was revealed in water samplings taken from taps water P5–P15 during the months of April to September. High quantities of F^- in Abuja boreholes can be as a result of released of fluorine-bearing minerals such as fluorapatite, fluormica, fluorite, topaz, biotite, epidote, apatite, clays, muscovite into groundwater and some micas weathered from igneous, silicates, and sedimentary rocks, particularly shale [1, 6, 17], besides high evaporation and low precipitation in semiarid and arid regions can as well contribute to the fluoride amelioration. High concentration of Na^{2+} in Abuja boreholes groundwater can be attributable to erosion of salt deposits, naturally occurring brackish water from aquifers, infiltration of surface water polluted via road salt as well as sodium bearing rock minerals [2, 7]. Though, sodium is a dietary mineral for both animals and people suffering from diarrhea needed at higher dietary quantity for speedy recovery but it high dosage lead to oedema, increased blood pressure and arteriosclerosis while low amount of sodium lead to growth retardation, dehydration, muscle paralysis and convulsion [5, 9]. Sodium normal quantity regularizes membrane potential, extra cellular fluids and acid-base balance.

Table 1 Descriptive statistics of water samples collected from the study site

	F^- (mg/l)	Mg^{2+} (mg/l)	TDS (mg/l)	EC (µS/cm)	Cl^- (mg/l)	$SO4^{2-}$ (mg/l)	Na^+ (mg/l)
Mean	1.28	83.48	1068.24	1796.87	236.41	447.23	260.19
Min	0.47	21.34	468.40	497.34	32.56	34.56	55.98
Max	1.84	346.56	2122.32	3310.11	564.12	890.65	515.45
SD	0.45	100.93	577.44	857.13	178.23	307.84	195.77
V	0.21	10185.79	333431.44	734672.28	31764.28	94764.32	38324.82
Kurtosis	-0.96	3.77	0.74	-0.10	0.88	0.03	-1.78
Skewness	-0.32	2.23	-0.62	-0.82	-0.48	-1.35	0.27
Q1	1.02	23.18	493.78	1162.40	169.01	172.40	57.40
Q3	1.77	77.73	1178.77	2352.98	323.73	765.71	483.39
WHO	1.5	50	1000	1500	250	250	50

Table 2. Pearson coefficient

Parameters	pH	T	Alk	TDS	EC	Cl^-	SO_4^{2-}	CO_3^{2-}	NO_3	HCO_3^-	K	Na^+
pH	1.00											
T	0.31	1.00										
Alk	-0.67	-0.31	1.00									
TDS	-5.69	-0.64	0.27	1.00								
EC	-0.22	-0.23	0.62	0.29	1.00							
Cl	-0.68	-0.57	0.85	0.67	0.64	1.00						
$SO4^{2-}$	0.03	0.16	0.33	-0.23	0.07	0.08	1.00					
CO3	-0.09	-0.02	0.06	-0.09	-0.48	0.05	-0.08	1.00				
NO3	0.22	0.54	-0.45	-0.42	-0.27	-0.58	-0.15	-0.20	1.00			
HCO3	0.09	0.55	-0.01	-0.65	-0.31	-0.40	0.56	0.05	0.27	1.00		
F	0.53	0.66	-0.53	-0.53	-0.23	-0.57	-0.24	-0.01	-0.46	0.17	1.00	
Na	0.20	0.62	-0.40	-0.54	-0.69	-0.65	0.18	0.22	0.38	0.64	-0.47	1.00

Table 3: Diverse samples violation values

Variables	**Unit**	**WHO criteria**	**Violation Number**	**Violation %**	**Within %**
pH		6.5 - 8.5	0	0	100
TDS	mg/l	1000	14	56	44
EC	µS/cm	1500	16	64	36
Cl^-	mg/l	250	6	24	76
SO_4^{2-}	mg/l	250	19	76	24
HCO_3^-	mg/l	500	10	40	60
F^-	mg/l	1.5	10	40	60
Na^{2+}	mg/l	50	25	100	0
Fe^{2+}	mg/l	0.3	11	44	56
Mg^{2+}	mg/l	50	14	56	44
TH	mg/l	500	9	36	64

3.1 MULTIVARIATE ANALYSIS

The interactions amongst the metals were ascertained by means of HCA and they were clustered depending on the dissimilarities as well as similarities amongst disparate metals. Dendrogram scrutiny formed 3 clusters based on the metals spatial dispersal within five months (Fig. 3 & 4). Cluster 1 contained P1-P4 and P20-P25, cluster 2 encompasses of P5-P10 and cluster 3 has P11 –P19 (Table 4). Cluster 1 in the dendrogram formed for Gwagwalada and Kwali town is equivalent to the aforesaid cluster 1, whereas cluster 2 embroils of Lugbe satellite town and cluster 3 is Bwari satellite town of Abuja (Fig. 1). Cluster 1 was found to have the best hydrochemical attribute, then cluster 2 with percentage non-comformity of 0.00 and 10.0%, correspondingly. The increasing direction of water attribute was cluster 1 > cluster 2 > cluster 3. The outcomes of cluster scrutiny sustained the correlation results which recommended that the chosen metals are from natural as well as anthropogenic sources. Fertilizers surfeit or fungicides from farm, leachates into groundwater through the aquifer might also affect water attribute.

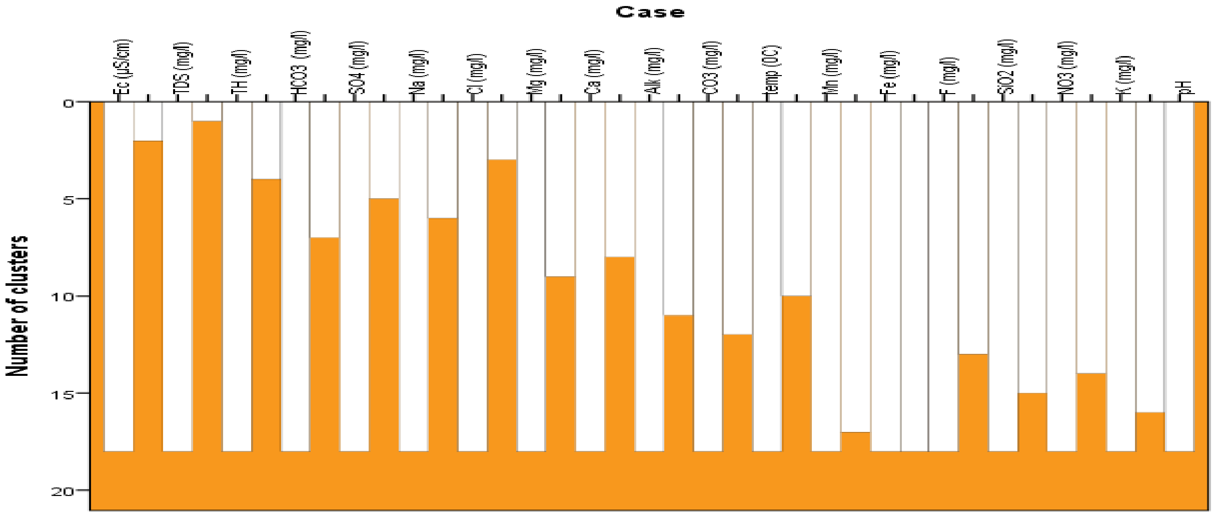

Fig.3. Dendrogram demonstrating all parameters analysed.

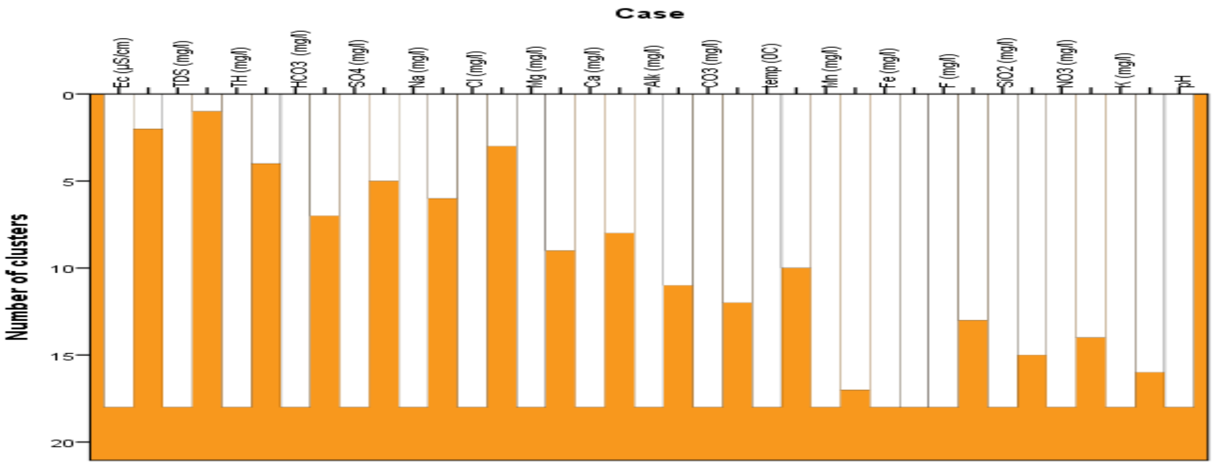

Fig.3. Dendrogram demonstrating all parameters analysed.

3.2 Assessment of Human Health Threat Caused by Heavy Metals in Groundwater Samplings

Health threat appraisal archetypal by the USEPA were utilized to compute the healthiness threats that heavy metals can impose on human being thru digestion in addition to dermal ingestion of groundwater in Abuja settlement. The exposure state thru EDD_{ing} and EDD_{derm} were appraised for the months of April to September. The end results propounded that chemicals from the boreholes within Abuja vicinity thru absorption as well as dermal passageways were the main exposure means to people in this settlement. Health correlated threat linked with the exposure via absorption hang on lifetime, weightiness as well as groundwater capacity ingested by an individual, which was computed by means of the quantified minimum and maximum accumulation of F^- and Na^{2+}. The TQ (threat quotient) a numeric approximation of the widespread toxicity prospective modelled via single component inside sole track of exposure were work out, both HQ_{in} as well as HQ_{DE} from April to September were below one unit (Table 4 - 7) for adults as well as children. This postulates slight or no antithetical healthiness impact can be initiated through these metals when the groundwater is swigged thru dermal consumption by any ages.

The outcomes are closely related to the discoveries of Achieng et al. 2017, in which HQ_{ing} for F^- and Na^{2+} accumulation from tested groundwater for children were surpassing one unit. The major instigators for carcinogenic healthiness threat in both paths were F^- and Na^{2+}. The valued of cumulative threat quotients (TI) via metal functioned as a predictable assessment instrument to guesstimate high-end threat instead of low end- threat so as to safeguard the societies (Table 8). This helped as exhibit pictogram to discover whether there is any major significant healthiness threat that heavy metals contact in the groundwater that could enforce on the humankinds and if there is any divergence in total healthiness threat all through the study period. The computed total HQ values were below one unit (Table 4 - 7), along these lines, exposure to these variables via mouth absorption as well as dermal ingestion thru the skin might possibly not wield harmful or collective adversarial threat on the occupiers of this settlement.

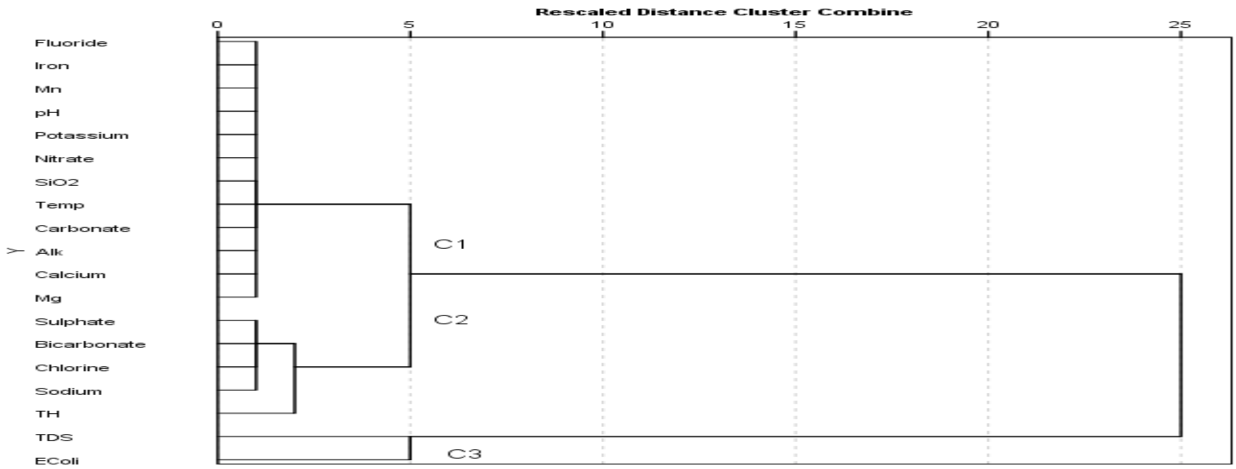

Fig.5. Dendrogram indicating all variables from study locations

Table 4 Cluster group of the water attribute parameters

Cluster 1	Cluster 2	Cluster 3
P1	P5	P11
P2	P6	P12
P3	P7	P13
P4	P8	P14
P20	P9	P15
P21	P10	P16
P22	P17	
P23	P18	
P24	P19	
P25		

As a whole, health threat evaluation index by means of the global non-carcinogenic threat evaluation (TI), CDI and HQ thru absorption as well as dermal ingestion paths were below one. This demonstrates that groundwater possess a reduced amount of significant healthiness endangerments to adults as well as children thru the paths, contrariwise measures must be invent so as to evade heavy metals accumulation that might pose any healthiness complications specifically in children. Carcinogenic threat (CT or TTI) can be expressed as the incremental odds that humans will develop cancer all through one's life time which is attributable to exposure below particular conditions were work out for the selected metals in this paper [4, 9, 17].

Carcinogenic threat of Na^{2+} and F^{-} for Abuja groundwater were work out for both children and adults (Table 9). Only sodium values from location P5, P6, P7, P8, P9, P10, P11, P23 and P25 of all the water samples examined for children are within unity, whereas all sodium values of all location for adults are above unity and though the rule state that value higher than unity is great concern. Meanwhile all fluoride values for both adults as well as children for all location is below unity. Hence, appropriate control measures to safeguard human's health within the study region must be put in place so as to ensure security of users. Likewise, rigorous efforts are vital for viability of the groundwater by eliminating these metals.

4. CONCLUSIONS

Merely 60.0% boreholes possess perfect water attribute in terms of F^{-} and Na^{2+} values with 0% discovered to be in the peripheral water attribute group, whereas 100% fell in the unsuitable water attribute category. In respect to chemical properties, it is hazardous for inhabitant within the examined region to use the taps water for drinking as well as domestic deeds without treatment. This paper further unveils that 62.5% boreholes water possess high quantities of Na^{2+} and F^{-}. The measured quantities of Na^{2+} and F^{-} for some of the examined taps water were noticed to be greater than the suggested limits by WHO. The HQ and the overall carcinogenic healthiness threat indices (HI) through the absorption and dermal ingestion of the groundwater were below one. Nevertheless, the results indicated the likely threat of some of the chosen metals on human, specifically children. The key contributors to carcinogenic threat were Na^{2+} for both pathways. It is consequently suggested that water attribute studies must be prioritize through addition into the integrated growth plans (IGPs), and to be conducted on a consistent basis so as to evaluate contagion threats. Healthiness and hygiene talk is extremely needed for people in rustic regions due to poor hygiene as well as water management practices. Additionally, further studies are suggested to examine the point sources of contagion and possible causes of high quantities of fluoride and TDS level in the boreholes within Kwali-Abuja town.

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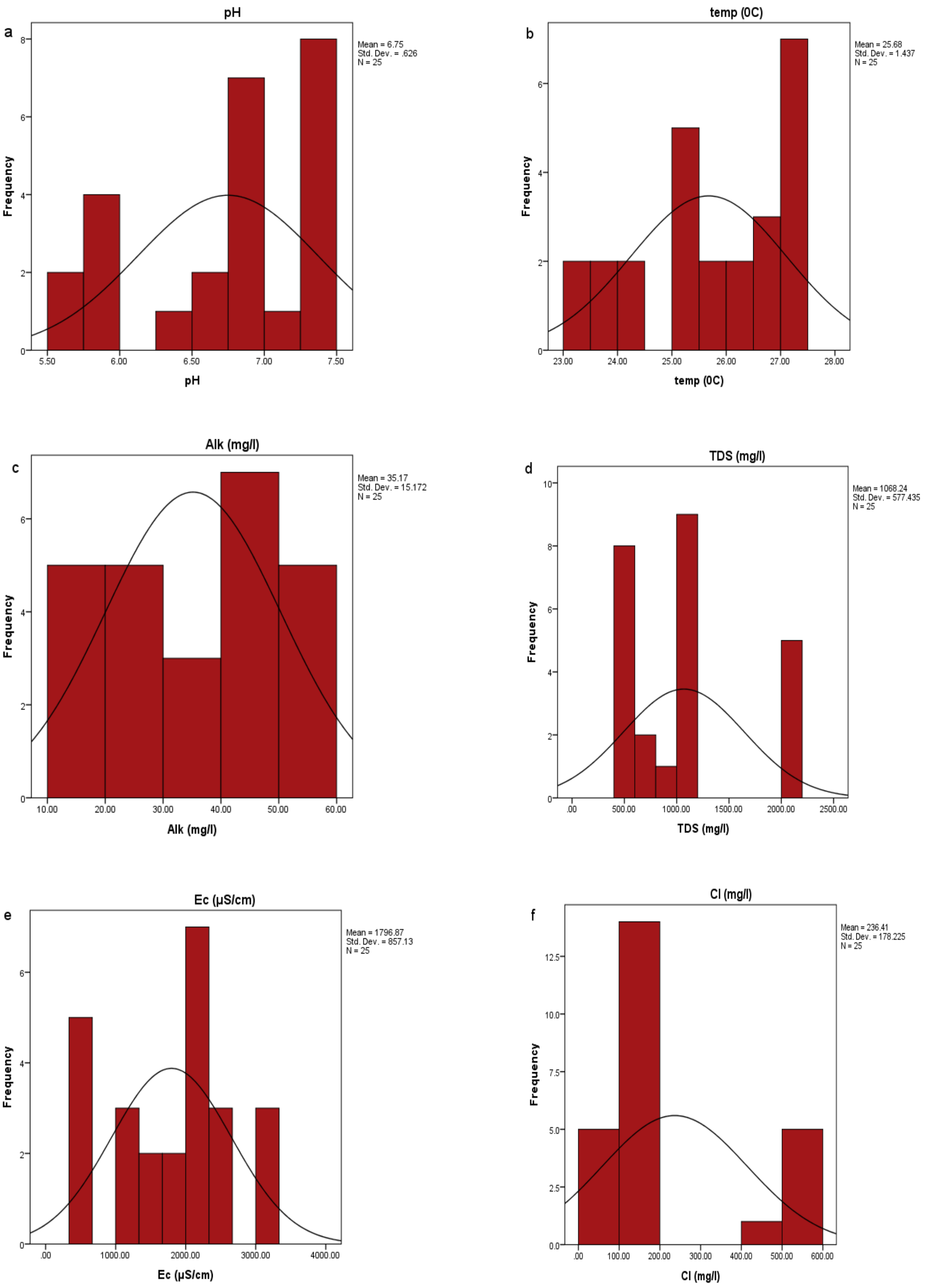

Fig. 2. Histogram shown normal curve of (a) pH (b) Temperature (c) Alkalinity (d) TDS (e) EC (f) Cl^- : Histogram shown normal curve of (g) SiO_2 (h) CO_3^{2-} (i) NO^{3-} (j) HCO^{3-} (k) F^- (l) K^+ : Histogram shown normal curve of (m) Na^+ (n) Fe^{2+} (o) Ca^{2+} (p) Mg^{2+} (q) Mn (r) SiO_2.

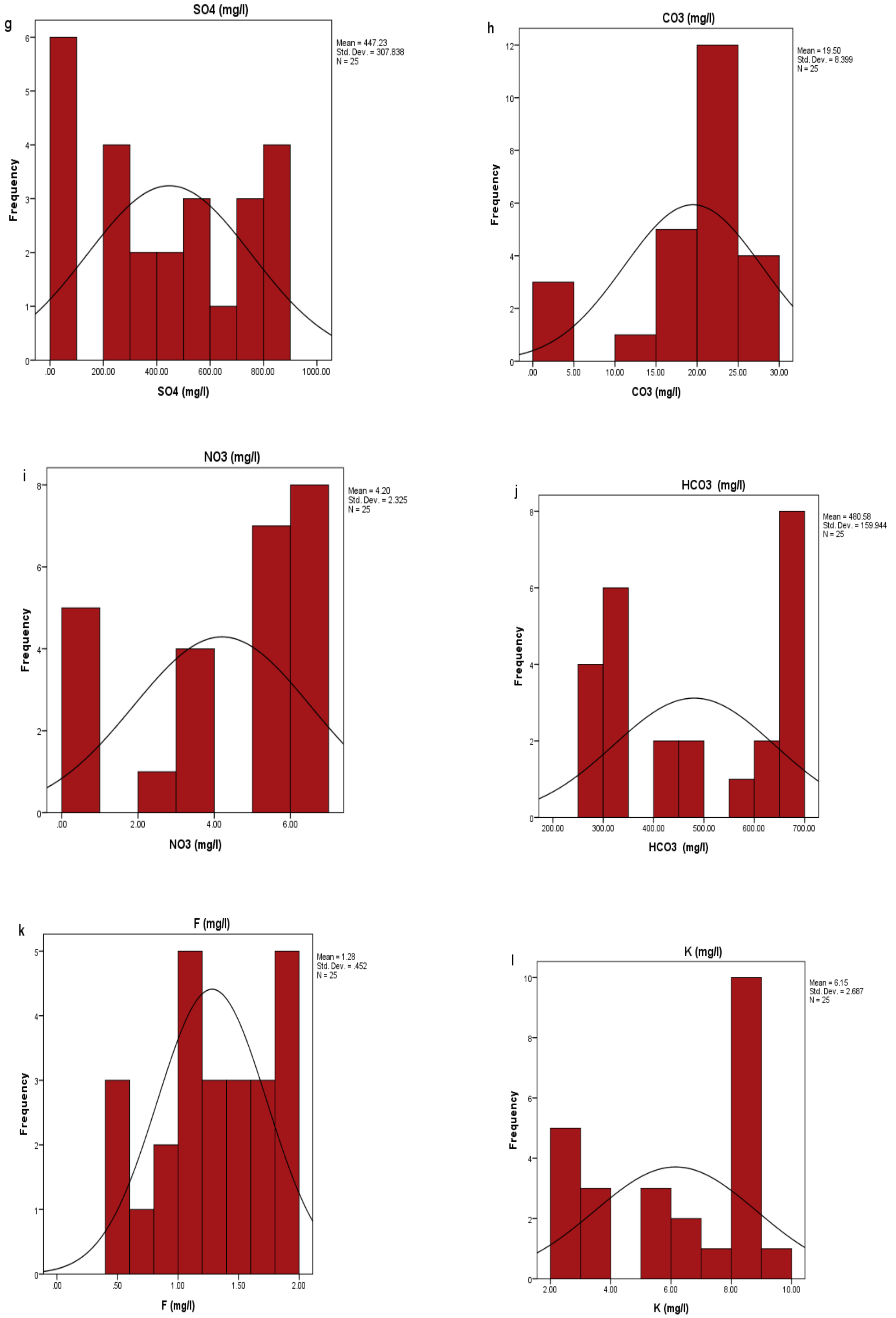

Fig.2. (continued)

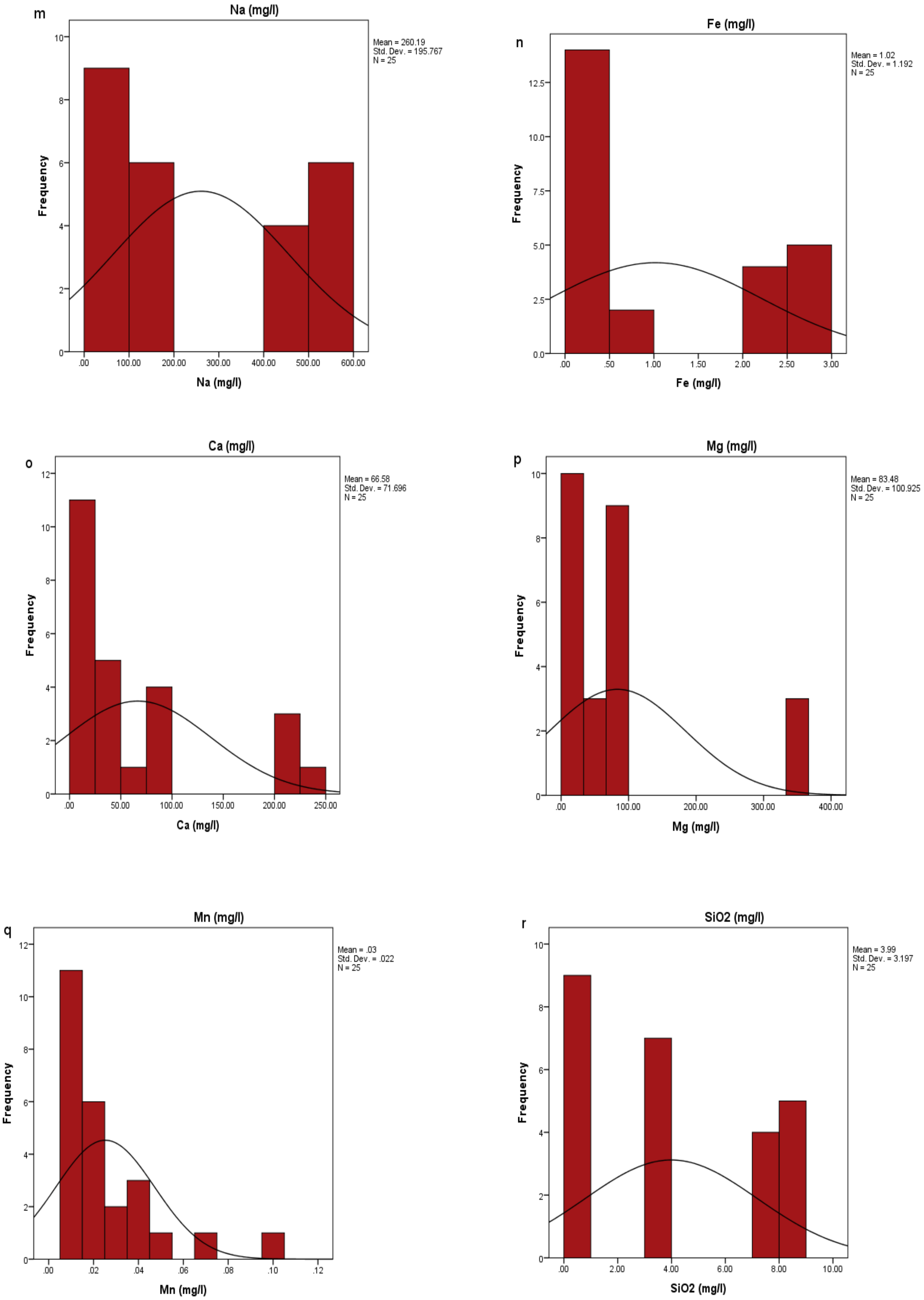

Fig.2. (continued)

Table 5: EDD_{ING} and HQ_{IN} values via ingestion pathway for sodium

Sample points	EDD_{ING} (Children)	EDD_{ING} (Adult)	HQ_{IN} (Adults)	HQ_{IN} (Children)
P1	5.95	5.37	1.12E-02	1.49E-02
P2	5.92	5.35	1.19E-02	1.48E-02
P3	5.96	5.38	1.19E-02	1.49E-02
P4	5.95	5.37	1.19E-02	1.49E-02
P5	1.75	1.58	3.50E-03	4.38E-03
P6	1.72	1.56	3.45E-03	4.31E-03
P7	1.72	1.56	3.45E-03	4.31E-03
P8	1.75	1.58	3.49E-03	4.37E-03
P9	1.78	1.61	3.56E-03	4.45E03
P10	1.81	1.64	3.62E-03	4.53E-03
P11	1.83	1.65	3.66E-03	3.49E-02
P12	13.95	12.59	2.79E-02	3.96E-02
P13	15.84	14.30	3.17E-02	3.97E-02
P14	15.86	14.32	3.17E-02	3.96E-02
P15	15.84	14.30	3.17E-02	3.96E-02
P16	15.83	14.29	3.17E-02	3.96E-02
P17	15.76	14.23	3.15E-02	3.94E-02
P18	15.71	14.18	3.14E-02	3.92E-02
P19	14.04	12.68	2.81E-02	3.51E-02
P20	13.32	12.02	2.66E-02	3.33E-02
P21	13.14	11.86	2.63E-02	3.28E-02
P22	5.83	5.27	1.17E-02	1.46E-02
P23	1.74	1.57	3.47E-03	4.34E-03
P24	5.43	4.90	1.09E-02	1.36E-02
P25	1.72	1.56	3.45E-03	4.31E-03

Table 6: EDD_{ING} and HQ_{IN} values via ingestion pathway for fluoride

Sample points	EDD_{ING} (Children)	EDD_{ING} (Adult)	HQ_{IN} (Adults)	HQ_{IN} Children)
P1	3.78E-02	3.42E-02	5.69E-04	6.31E-04
P2	5.66E-02	5.11E-02	8.52E-04	9.44E-04
P3	5.63E-02	5.08E-02	8.47E-04	9.39E-04
P4	5.60E-02	5.06E-02	8.43E-04	9.33E-04
P5	3.32E-02	3.00E-02	5.00E-04	5.54E-04
P6	1.45E-02	1.31E-02	2.18E-04	2.41E-04
P7	1.51E-02	1.37E-02	2.23E-04	2.51E-04
P8	1.48E-02	1.33E-02	2.22E-04	2.46E-04
P9	3.02E-02	2.72E-02	4.54E-04	5.03E-04
P10	2.74E-02	2.47E-02	4.12E-04	4.56E-04
P11	2.40E-02	2.17E-02	3.61E-04	4.00E-04
P12	5.47E-02	4.94E-02	8.24E-04	9.13E-04
P13	5.38E-02	4.86E-02	8.10E-04	8.97E-04
P14	5.57E-02	5.03E-02	8.36E-04	9.28E-04
P15	3.72E-02	3.36E-02	5.60E-04	6.21E-04
P16	3.34E-02	3.03E-02	5.05E-04	5.59E-04
P17	3.26E-02	2.94E-02	4.90E-04	5.44E-04
P18	5.14E-02	4.64E-02	7.73E-04	8.56E-04
P19	4.40E-02	3.97E-02	6.62E-04	7.33E-04
P20	3.78E-02	3.42E-02	5.69E-04	6.31E-04
P21	3.34E-02	3.03E-02	5.05E-04	5.59E-04
P22	3.29E-02	2.97E-02	4.95E-04	5.49E-04
P23	4.80E-02	4.33E-02	7.22E-04	8.00E-04
P24	4.80E-02	4.33E-02	7.22E-04	8.00E-04
P25	5.60E-02	5.06E-02	8.43E-04	9.33E-04

Table 7: EDD_{DE} and HQ_{DE} values for sodium

Sample points	EDD_{derm} (Children)	EDD_{derm} (Adult)	HQ_{DE} (Adults)	HQ_{DE} (Children)
P1	1325.82	1847.75	2.65	3.32
P2	1319.92	1839.54	2.64	3.30
P3	1336.78	1849.09	2.65	3.32
P4	1326.03	1848.04	2.65	3.32
P5	390.03	543.57	0.78	0.98
P6	383.72	534.78	0.77	0.96
P7	383.79	534.88	0.77	0.96
P8	389.21	542.42	0.78	0.97
P9	396.81	553.03	0.79	0.99
P10	403.74	562.68	0.81	1.01
P11	407.51	567.93	0.82	1.02
P12	3106.72	4329.73	6.21	7.77
P13	3528.21	4917.15	7.06	8.82
P14	3533.21	4924.12	7.07	8.83
P15	3528.21	4917.15	7.06	8.82
P16	3525.60	4913.52	7.05	8.81
P17	3511.89	4894.41	7.02	8.78
P18	3498.94	4876.36	7.00	8.74
P19	3127.90	4359.25	6.26	7.82
P20	2966.54	4134.37	5.93	7.42
P21	2926.17	4078.10	5.85	7.32
P22	1299.36	1810.88	2.60	3.24
P23	386.81	539.08	0.77	0.97
P24	1210.25	1686.69	2.42	3.03
P25	383.93	535.07	0.77	0.96

Table 8: EDD_{DE} and HQ_{DE} values for fluoride

Sample points	EDD_{derm} (Children)	EDD_{derm} (Adult)	HQ_{DE} (Adults)	HQ_{DE} (Children)
P1	8.43	11.75	0.20	0.14
P2	12.61	17.58	0.29	0.21
P3	12.54	17.48	0.29	0.21
P4	12.48	17.39	0.29	0.21
P5	7.40	10.32	0.17	0.12
P6	3.22	4.49	0.08	0.05
P7	3.36	4.68	0.08	0.06
P8	3.29	4.59	0.08	0.06
P9	6.71	9.36	0.16	0.11
P10	6.10	8.50	0.14	0.10
P11	5.35	7.45	0.12	0.09
P12	12.20	17.00	0.28	0.20
P13	12.00	16.72	0.28	0.20
P14	12.41	17.29	0.29	0.21
P15	8.29	11.56	0.19	0.14
P16	7.47	10.41	0.17	0.13
P17	7.27	10.13	0.17	0.12
P18	11.48	15.95	0.27	0.19
P19	9.80	13.66	0.23	0.16
P20	8.43	11.75	0.20	0.14
P21	7.47	10.41	0.17	0.13
P22	7.33	10.22	0.17	0.12
P23	10.69	14.90	0.25	0.18
P24	10.69	14.90	0.25	0.18
P25	12.48	17.39	0.29	0.21

Table 9: Chronic daily intake (CDI) for sodium and fluoride

Sample points	CDI			
	Sodium		Fluoride	
	Children	**Adult**	**Children**	**Adult**
P1	13.09	5.91	8.33E-02	3.76E-02
P2	13.03	5.88	0.12	5.62E-02
P3	13.10	5.91	0.12	5.59E-02
P4	13.10	5.91	0.12	5.56E-02
P5	3.85	1.74	7.31E-02	3.30E-02
P6	3.79	1.71	3.18E-02	1.44E-02
P7	3.79	1.71	3.32E-02	1.44E-02
P8	3.84	1.74	3.25E-02	1.47E-02
P9	3.91	1.77	6.63E-02	2.99E-02
P10	3.99	1.80	6.03E-02	2.72E-02
P11	4.02	1.82	5.28E-02	2.38E-02
P12	30.68	13.85	0.12	5.44E-02
P13	34.84	15.73	0.12	5.35E-02
P14	34.89	15.75	0.12	5.53E-02
P15	34.84	15.73	8.19E-02	3.70E-02
P16	34.82	15.72	7.18E-02	3.33E-02
P17	34.68	15.65	7.18E-02	3.24E-02
P18	34.55	15.60	0.11	5.10E-02
P19	30.89	13.94	0.10	4.37E-02
P20	29.30	13.22	8.33E-02	3.75E-02
P21	28.90	13.04	7.38E-02	3.33E-02
P22	12.83	5.79	7.24E-02	3.27E-02
P23	3.82	1.72	0.11E-02	4.77E-02
P24	11.95	5.40	0.11	4.77E-02
P25	3.79	1.71	0.12	5.56E-02