Natural fluoride levels from public water supplies in Piauí State, Brazil

Concentração de flúor *in natura* em águas de abastecimento público no Piauí, Brasil

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Abstract ***The aim of this work was to determine the natural fluoride concentrations in public water supplies in Piauí State, Brazil, in order to identify cities in risk for high prevalence of dental fluorosis. For each city, two samples of drinking water were collected in the urban area: one from the main public water supply and another from a public or residential tap from the same source. Fluoride analyses were carried out in duplicate using a specific ion electrode and TISAB II. From a total of 222 cities in Piauí, 164 (73.8%) samples were analyzed. Urban population in these towns corresponds to 92.5% of the whole state with an estimated population of 1,654,563 inhabitants from the total urban population (1,788,590 inhabitants). A total of 151 cities showed low fluoride levels (<0.30 mg/L) and 13 were just below optimum fluoride concentration in the drinking water (0.31-0.59 mg/L). High natural fluoride concentration above 0.81 mg/L was not observed in any of the surveyed cities. As a conclusion, most of the cities in Piauí have low fluoride concentration in the drinking water. The risk for a high prevalence of dental fluorosis in these urban areas due to natural fluoride in the water supplies is very unlikely. Thus, surveys about the dental fluorosis prevalence in Piauí should be related with data about the consumption of fluoridated dentifrices and other fluoride sources.***

Key words ***Dental caries, Fluoridation, Surveillance, Dental fluorosis***

Resumo ***O objetivo deste trabalho foi realizar um levantamento dos teores residuais de flúor (F*** in natura***) da água de abastecimento em municípios do Piauí para identificar localidades com risco de elevada prevalência de fluorose dentária. Para cada município, foram coletadas duas amostras da água de abastecimento da zona urbana, uma amostra da principal fonte de abastecimento público do município e a outra de uma torneira pública ou residencial abastecida pela mesma fonte. As análises de flúor foram realizadas em duplicata, utilizando um eletrodo específico e TISAB II. Dos 222 municípios do Piauí, 164 (73,8%) enviaram amostras para análise. A população urbana desses municípios corresponde a 92,5% (1.654.536 habitantes) da população urbana total do estado (1.788.590 habitantes). Observou-se que 151 municípios apresentam baixos teores residuais de flúor (<0,30 mg/L) e treze municípios apresentaram teores residuais abaixo do nível ideal (0,31 – 0,59 mg/L). Nenhum município analisado apresentou teor residual de flúor acima do aceitável (> 0,81 mg/L). Conclui-se que a maioria dos municípios do Piauí possui água de abastecimento com baixos teores de flúor residual. O risco de uma elevada prevalência de fluorose dentária pelo flúor residual da água de abastecimento é pouco provável. Estudos sobre a prevalência de fluorose dentária no Piauí devem considerar outras fontes de flúor.***

Palavras-chave ***Cárie dentária, Fluoração das águas, Vigilância sanitária, Fluorose dentária***

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Introduction

In the Northeastern region of Brazil some inland cities from Paraíba and Ceará have moderate to high natural fluoride levels (>1.0 mg/L) in the drinking water resulting in high prevalence of dental fluorosis and some severe cases[1-3]. In Rio Grande do Norte, Paz ***et al***.[4] observed natural fluoride concentrations up to 1.1 ppm (mg/L), and in such areas severe cases of dental fluorosis is likely to occur due to high local temperatures and a high consumption of rich fluoride drinking water.

It is estimated that in the Northeastern region of Brazil only 16.5% of the cities have water fluoridation systems[5]. Therefore, the recent federal program named "Brasil Sorridente" has given the opportunity to implement water fluoridation systems in many cities of the Northeastern region where technical requirements for potable water are accomplished[6, 7] . Evaluation of the natural fluoride concentration in the drinking water is important since this information is relevant to establish the ideal concentration of fluoride in the drinking water in accordance to the mean annual temperature[8, 9] .

The mean annual temperature in Piauí is around 28ºC[10] . Therefore, the optimal fluoride concentration in the drinking water is around 0.7 mg/L with accepted values between 0.6 and 0.8 mg/L[11]. In Piauí, three cities have artificial water fluoridation systems: Parnaíba, Floriano and Teresina[12, 13]. The Parnaíba River is the only source of water for these cities and the residual fluoride concentration is low[14]. However, the state of Piauí has a great deal of its territory placed in the semi-arid region where wells are the only source of drinking water available[10]. The probability of having higher fluoride concentrations in underground waters than in surface waters has already been observed in many parts of the world including in the Northeast region of Brazil[3,15]. Thus, the aim of this study was to determine the natural fluoride concentration in public water supplies in Piauí State, Brazil, in order to identify cities at risk for high prevalence of dental fluorosis.

Methods

Areas under study

The state of Piauí has 222 cities and an estimated population of 2,843,278 inhabitants[16]. It is also estimated that 63% lives in urban areas (1,788,590 inhabitants). The annual average temperature in Piauí is high and around 28ºC in most part of its territory[10].

Water samples collection and analysis

In each city at least two samples of the drinking water were collected. One sample was from the main public water supply and another from a public or residential tap from the same source. The Health Secretariat of the State of Piauí (SESA-PI) informed to all local authorities about the methodology of water samples collection. The samples were collected by local sanitary vigilance workers. Plastic recipients of 500 mL were distributed and they were requested to identify the samples (city, address, date of collection and water source) in accordance to methods reported by Funasa, 2004[17]. Just after collection, the samples were transported by fast mail to the Laboratory of Oral Biology at Federal University of Paraíba where the analyses were carried out.

All the samples were analyzed within 30 days after collection. The procedures were in duplicate using a fluoride specific electrode (Orion model 9609, Orion Research Inc., USA) coupled to an ion analyzer meter (Orion model 710-A, Orion Research Inc., USA). The samples were analyzed in 1:1 with TISAB II. Calibration was frequently carried out with fresh fluoride standards of 1 mL of 0.2 up to 1.6 mg/L. The data in mV were transformed in µg of fluoride and in fluoride concentration (mg/L) using a Windows-Excel file. Only calibration curves with variation in percentage until 5% for all standards and $r^3 0.99$ were accepted.

The mean SD of the residual fluoride concentrations of each city was calculated from the two samples obtained. The mean SD of few cities was calculated from three or four original samples due to different water sources in the same urban area. The data were classified according to the fluoride concentration in mg/L in four groups: 1) from 0.01 to 0.30 mg/L (very low F concentration); 2) from 0.31 to 0.59 mg/L (low F concentration); 3) from 0.60 to 0.80 mg/L (optimum F concentration) and 4) above 0.81 mg/L (high F concentration).

Results

From 222 towns in Piauí, 164 (73.8%) samples were sent for fluoride analyses. Based on the estimates of IBGE, 2000[16], the urban population of all these cities corresponds to 92.5% (1,654,536 inhabitants) from the total urban population in Piauí (1,788,590 inhabitants).

In Table 1, it is observed that 151 cities presented very low natural F concentration, whereas 13 showed low natural F concentration.

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Table 2 shows that the 13 cities with low natural F concentrations in the drinking water are in small cities covering approximately 80,000 inhabitants.

Table 3 lists all cities according to their distribution in the regional health offices and natural F concentration in the water.

Table 4 relates the official data of caries as DMFT recorded by SB Brasil (2003) in the same cities where water samples could be analyzed. Note that for Teresina artificial water fluoridation is available.

Discussion

This work applied standard methodologies to collect and determine water fluoride concentrations[9, 17]. The set up of two samples of the main water source from urban areas was established due to fact that in few cities of Piauí a record of more than one source of water could take place particular during drought periods[19]. However, there are few publications about water quality and supplies in Piauí. Water quality vigilance is implemented in 171 cities and so far there is no data about natural fluoride concentrations in these cities[18].

From the 222 cities contacted 74% responded and sent water samples for analysis (Table 1). It can be estimated that this work covers drinking water sources of almost all inhabitants of the urban areas in Piauí[16]. The 58 cities that are not covered in this research would give water samples of small cities that represent only 7.5% of the total urban population in the state.

Table 1. Number of cities according to the natural fluoride levels in the drinking water and estimated population exposed.

Fluoride levels (mg/L)	Cities		Urban population*	
	N	%	n	%
0.01 a 0.30	151	92.0	1,594,269	96.3
0.31 a 0.59	13	8.0	60,267	3.7
Above 0.60	-	-	-	-
Total	164	100.0	1,654,536	100.0

* Source: IBGE, 2000[16].

Table 2. List of cities and estimated population exposed to natural fluoride concentration in the drinking water above 0.30 mg/L.

City	Samples (n)	Mean (SD) Fluoride (mg/L)	Source*	Estimated population **
Angical do Piauí	2	0.47 (0.14)	NA	5,065
Curral Novo do Piauí	2	0.46 (0.00)	W	1,050
Dom Inocêncio	2	0.42 (0.02)	W	856
Francisco Macedo	2	0.50 (0.08)	NA	639
Ipiranga do Piauí	2	0.39 (0.04)	NA	4,923
Jacobina do Piauí	2	0.56 (0.00)	NA	851
Jatobá do Piauí	2	0.36 (0.11)	NA	657
Luzilândia	2	0.42 (0.00)	NA	13,453
Miguel Alves	2	0.46 (0.00)	W	9,609
Miguel Leão	2	0.36 (0.05)	NA	749
Pio IX	2	0.49 (0.12)	NA	4,278
São Braz do PI	2	0.37 (0.04)	L	935
São Raimundo Nonato	2	0.43 (0.08)	NA	17,202
Total		-	-	80,438

* W = well, L = lake; NA= not available

** Estimated population based on IBGE records for the year 2000[16].

Table 3. List of cities in Piauí according to the natural F levels in the drinking water and regional health offices.

N*	Cities according to fluoride levels (mg/L)	
	0.01 a 0.30	0.31 a 0.59
I	Buriti dos Lopes, Caraúbas, Caxingó, Cocal, Cocal dos Alves, Ilha Grande, Luis Correia, Murici dos Portelas, Parnaíba.	-
II	Barras, Batalha, Cabeceiras do Piauí, Campo Largo, Esperantina, J. Pires, J. Marques, Madeiro, Matias Olímpio, Morro do Chapéu do Piauí, N. Senhora dos Remédios, Porto, S. João do Arraial.	Luzilândia.
III	Brasileira, Capitão de Campos, Domingos Mourão, Lagoa de S. Francisco, Milton Brandão, Pedro II, Piracuruca, Piripiri, S. José do Divino.	-
IV	Altos, Curralinhos, Demerval Lobão, José de Freitas, Lagoa do Piauí, Monsenhor Gil, Palmeirais, Teresina, União.	Miguel Alves.
V	Alto Longa, Assunção do Piauí, Boqueirão do Piauí, Campo Maior,Castelo do Piauí, Cocal de Telha, Coivaras, Juazeiro do Piauí, Nossa Senhora de Nazaré,Novo Santo Antônio.	Jatobá do Piauí.
VI	Agricolândia, Água Branca, Amarante, Arraial, Barro Duro, Hugo Napoleão, Lagoinha do Piauí, Passagem, Franca do Piauí, Regeneração, S. Gonçalo do Piauí, S. Pedro do Piauí.	Angical do Piauí, Miguel Leão.
VII	Aroazes, B. d´Álcântara, Elesbão Veloso, Francinópolis, Inhuma, N. Oriente do Piauí, Pimenteiras, Prata, S. C. dos Milagres,S. Felix do Piauí,Valença do Piauí, Várzea Grande.	-
VIII	Cajazeiras do PI, Campinas do PI, Colônia do PI, Floresta do Piauí, Isaías Coelho, Oeiras, Santa Rosa do PI, S. Francisco do Piauí,S. José do Peixe, S. Miguel do Fidalgo,Tanque do PI.	-
IX	D. Expedito Lopes, Itainópolis, Jaicós, Massapê do PI, Picos, S. Cruz do PI, Santana do PI, S. João da Canabrava, Sussuapara.	Ipiranga do Piauí,
X	Canavieira, Colônia do Gurguéia, Eliseu Martins, Flores do Piauí, Floriano,Guadalupe, Landri Sales, Manoel Emídio, Marcos Parente, Nazaré do Piauí, Pavussu.	-
XI	Bela Vista do PI, Brejo do PI, Capitão G. Oliveira, J. Costa, Lagoa do Barro do PI,Pedro Laurentino, Ribeira do PI, São João do PI, Simplício Mendes, Tamboril do PI.	-
XII	Anísio de Abreu, Caracol, Coronel José Dias, D. Arcoverde, Fartura do Piauí, Guaribas, Jurema, Nova Santa Rita, Rio Grande do PI, S. Lourenço do PI,Várzea Branca.	D. Inocêncio, S. Raimundo Nonato, S. Braz do PI.
XIII	Alvorada do Gurguéia, Bom Jesus, Cristino Castro, Currais, Redenção do Gurguéia, ,Santa Luz	-
XIV	Barreiras do PI, Corrente, Curimatá, Júlio Borges, Monte Alegre do Piauí, Morro Cabeça no Tempo, Riacho Frio, Sebastião Barros.	-
XV	Antônio Almeida, Baixa Grande do Ribeiro, Porto Alegre do Piauí, Uruçuí	-
XVI	Caridade do Piauí, Fronteiras, Padre Marcos, São Julião.	C. Novo do Piauí, F. Macedo, Pio IX.
XVI	Patos do Piauí, Paulistana, Queimada Nova, S. Francisco de Assis do Piauí.	Jacobina do Piauí.

* N = Regional Health Office number.

Thirteen cities in Piauí showed residual fluoride concentrations above 0.31 mg/L. The highest concentration of natural fluoride in the water was found in Jacobina do Piauí with 0.56 mg/L (Table 2 and 3). This level of fluoride is close to "optimal" fluoride concentration in the water according to

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Table 4. Natural fluoride concentration in the drinking water and DMFT index*.

City	DMFT (SD)*	Mean (SD) natural F in mg/L	Artificial fluoridation
Tamboril do PI	5.49 (4.05)	0.04 (0.00)	no
Marcos Parente	5.25 (3.75)	0.04 (0.00)	no
Coronel José Dias	5.04 (3.41)	0.08 (0.05)	no
Júlio Borges	3.63 (3.01)	0.30 (0.14)	no
Teresina	2.52 (2.48)	0.08 (0.00)	yes

* DMFT data from SB-Brasil[18].

the local mean annual temperature. Two other cities were also close to these values. However, most of them have few inhabitants. The most populated city with natural fluoride in the water was São Raimundo Nonato with an estimated population of almost 20 thousand inhabitants. Seven cities with natural fluoride levels above 0.3 mg/L are located in the Central and Southeast part of the state in four Health Regional Offices numbers: IX, XI, XVI and XVII. This was expected since in the Northeast region the presence of natural fluoride is higher in wells located in crystalline soils in the semi-arid zone[3]. Therefore, it can be expected that most of the cities with natural F concentrations close to 0.5 mg/L would be closer to Ceará border where a similar situation can be observed[1]. This is probably the region in Piauí where rural communities might have elevated fluoride levels in the drinking water due to its geological pattern of crystalline soils[3].

The F concentrations data obtained in this study represent a punctual value of fluoride for each city and do not reflect possible fluoride fluctuations. However, one cannot disregard the fact that the data can provide an estimate of fluoride exposure among the permanent residents of those cities. For those cities with F concentrations above 0.5 mg/mL, the data are relevant because it can indicate a moderate or a high fluoride intake among children and consequently a potential risk for dental fluorosis. Most cities in Piauí showed low natural F concentrations in the drinking water, but these data of low F exposure from the water are important because they are the basic technical information for implementing water fluoridation programs in the near future[5].

Although few cities had been investigated for dental caries in Piauí, Table 4 gives a rough picture that fluoride in the drinking water can play a role for controlling caries prevalence. Recently, Ramirez ***et al.***[20] pointed out several positive arguments for implementing water fluoridation in areas where caries is a prevalent condition. The fact that water fluoridation does not have a selective risk approach for controlling caries is not a strong argument to avoid its implementation. In Piauí, as well as in many states in the Northeastern region, water fluoridation might be questioned more due to economical, political and philosophical reasons rather than scientific ones.

Certainly the use of fluoridated dental products and other related variables for caries control cannot be disregarded for a complete evaluation about fluoride exposures [21, 22]. Regarding dental fluorosis, it is very unlikely that the severe cases of dental fluorosis, if there is any, can be attributed solely to the natural F in the drinking water. Cities in the Northeastern region with 0.4 mg/L of fluoride show in general 20% of children with dental fluorosis and most of them without aesthetic concern[23]. However, fluoride intake among children in living in the Northeastern regions suggests that the F-intake is 2 fold higher than in children from the Southeastern region of the country[24]. This is mainly due to the use of 1,500 ppm fluoridated toothpaste for children. How far this is also a trend in Piauí, this is a matter of investigation. A survey about the consumption of fluoridated dentifrice by children in Piauí and its contribution for dental fluorosis is warranted since contribution of water F in many cities can be already estimated.

Conclusion

It can be concluded that most of the cities in Piauí have low fluoride concentration in the drinking water. The risk for a high prevalence of dental fluorosis in these urban areas due to the natural fluoride content in the water supplies is very unlikely. Thus, for the majority of the cities of Piauí, surveys about the dental fluorosis prevalence should be related with data about the consumption of fluoridated dentifrices and other fluoride sources.

Collaborators

JS Silva conceived and worked out the methodology, and wrote down this paper. VW Moreno worked out the methodology. FDS Forte worked out the methodology. FC Sampaio conceived and revised this paper.

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