Levels of natural fluoride in the public water supply of São Luís, Maranhão, Brazil

Teores de flúor in natura em águas de abastecimento público de São Luís, Maranhão, Brasil

Abstract

Purpose: The objective of this study was to map out the residual levels of fluoride in isolated wells belonging to the municipality of São Luis, Maranhão, Brazil, during the period of August of 2009.

Methods: The wells were determined according to sectors of the company responsible for the public water supply. Collection points were near these wells. The analysis of fluoride concentration was carried out in triplicate, using an ion-specific electrode for fluoride connected to a previously calibrated temperature meter. After analysis, samples were considered adequate when the fluoride concentration was within the recommended limits from 0.60 to 0.80 ppm F (criteria I) or within the stipulated range from 0.55 ppm F to 0.84 ppm F (criteria II).

Results: The results show levels of residual fluoride less than 0.11 ppm in the water of isolated wells.

Conclusion: It may be concluded that the population of São Luis, supplied with water from its wells, does not benefit from the method of fluoridation. The levels of residual fluoride found cannot cause dental fluorosis in its most severe forms, nor even prevent dental caries.

Key words: Fluoride; fluoridation; dental fluorosis; dental caries

Resumo

Objetivo: O objetivo desta pesquisa foi realizar o mapeamento de teores residuais de flúor em poços isolados pertencentes ao município de São Luís, Maranhão, Brasil, no período de Agosto de 2009.

Metodologia: Os poços foram estabelecidos a partir das áreas de atuação da Companhia responsável pelo abastecimento público de água, sendo os pontos de coleta próximos a cada um desses poços. A análise da concentração de flúor foi realizada em triplicata, utilizando-se um eletrodo íon-específico para flúor conectado a um potenciômetro previamente calibrado. Após analisadas, as amostras foram consideradas adequadas quando a concentração de flúor estava dentro dos limites recomendados de 0,60 a 0,80 ppm F (critério I) ou dentro do intervalo estipulado de 0,55 ppm F a 0,84 ppm F (critério II).

Resultados: Os resultados demonstraram teores de flúor residual inferiores a 0,11 ppm nas águas dos poços isolados.

Conclusão: Conclui-se que a população ludovicense abastecida pelas águas desses poços não está sendo beneficiada pelo método da fluoretação. Os teores de flúor residual encontrados não são capazes de promover o desenvolvimento de fluorose dentária em suas formas mais severas, ou mesmo de proporcionar prevenção à cárie dentária.

Palavras-chave: Flúor; fluoretação; fluorose dentária; cárie dentária

Suyene de Oliveira Paredes[a]
Fábio Correia Sampaio[a]
Franklin Delano Soares Forte[a]

[a] Department of Clinical and Social Dentistry, Federal University of Paraíba, João Pessoa, PB, Brazil

Correspondence:
Franklin Delano Soares Forte
Departamento de Clínica e Odontologia Social
Universidade Federal da Paraíba, Campus Universitário I, Castelo branco I
João Pessoa, PB – Brasil
58051-900
E-mail: fdsforte@terra.com.br

Introduction

Research related to the natural fluoride content in water supplies are important in order to identify areas where the populace might be exposed to the risk of developing dental fluorosis because of residual fluoride (1).

In some locations of Northeast Brazil, it has been observed that the identification of low levels of residual fluoride has meant an unlikely risk for elevated instances of dental fluorosis (2). However, there are other sources of fluoride exposure that should be considered in the development of this condition, especially its elevated ingestion with fluoridated toothpaste (3).

Some severe cases of fluorosis, which can cause grave aesthetic and functional problems, were related to the ingestion of high concentrations of fluoride in naturally fluoridated waters in some areas of the countryside of Paraiba (4). In endemic regions of the South of Africa, Viswanathan et al. (5) identified dental fluorosis as being a public health problem. The identification of these regions is important so that serious measures can be taken by governmental authorities to offer water with low fluoride concentration, as well as adopt the necessary therapeutic measures to people that might be in risk (6).

On the other hand, in areas where there is a high rate of caries, fluoridated water is the public health measure used to control the illness with the best cost and effectiveness (7). Coming back to the municipality of São Luís, which showed a DMF index of 2.66 (95%CI 1.80-3.53) at the last oral health survey (8) and while knowing that this municipality is benefited by fluoridation, the addition of fluoride to the drinking water of non-fluoridated water systems would indicate the expansion of a efficacious and preventive method against dental caries.

The public water supply in São Luís (Maranhão) is formed by a set of systems, between treatment plants and a group of interconnected wells and isolated wells, where the isolated wells do not receive any additional quantities of fluoride by the company responsible for the water supply. For that reason, the knowledge of existing residual levels of fluoride would make it possible to infer if the population is exposed to the risk of development of dental fluorosis or neglected in what concerns the lack of processing of the preventive effects of fluoride in the water.

In virtue of the large number of deep wells drilled in isolated places in the municipality of São Luís, whose water is destined to supply an elevated number of residents, it is necessary to know the natural levels of fluoride in these water wells.

Methodology

The observational and transversal nature of this study consisted in performing a mapping of the areas of the municipality of São Luís (Maranhão), which are supplied by waters the come from deep isolated tubewells. The terminology "residual fluoride levels" will be adopted to signify the fluoride naturally present in the water of these wells. In the process of identifying and choosing the wells, help was provided by CAEMA (Environmental Sanitation Company of Maranhão). Initially, contact was made with professionals of this company in order to obtain information concerning the isolated wells.

Considering the number of wells given by the company (Table 1), it was necessary to exclude those that didn't belong to the municipality of São Luís (Maranhão), since the documentation given also contained wells belonging to neighboring municipalities, which, together with the city of São Luís, form part of Maranhão Island (peninsula). Some interconnected wells belonging to the Sacavém and Paciência Systems were also excluded, along with wells described as "deactivated" or "operated by local inhabitants" (Table 2).

Table 1. Distribution of wells according to CAEMA's commercial operational units.

Operational Unit	Number of wells
OMC	32
OMV	93
OMH	55
OMP	143
OMG	25
Total	348

Table 2. Distribution of wells to be considered according to CAEMA's commercial operational units.

Operational Unit	Number of wells	Wells excluded	Wells included
OMC	32	19	13
OMV	93	12	81
OMH	55	36	19
OMP	143	48	95
OMG	25	05	20
Total	348	120	228

Having all the necessary documentation (report of functional isolated wells, their distribution by operational unit and their location) and with the intention of obtaining baseline data for the mapping and identification of water wells an estimate of 20% of the possible wells were taken into consideration for samples. Thus, the final samples were made up of 45 isolated wells, chosen from the five commercial operational units of CAEMA. It was determined that in the case of identifying fluoride levels above the recommended limits, samples would be broadened to include other wells from the Operational Unit in question.

For the sample collection of water, 10 mL plastic bottles were used, after being washed with distilled and deionized water and properly labeled (with place and date). For mapping, two water samples were taken from a residential water faucet supplied by each of the wells included in this research.

After collection, the samples were frozen and forwarded for analysis at the Oral Biology Laboratory of the Federal University of Paraíba (UFPB), João Pessoa. Freighting was

done by the trucking company. It is noteworthy that all samples were kept under refrigeration in the laboratory and properly closed to avoid any kind of alteration of content before examination of fluoride content.

Analysis of fluoride concentration was performed using a fluoride half-cell electrode (9409BN, Orion Reserch Inc., Boston, MA, United States) in combination with a reference half-cell electrode (900200, Orion Reserch Inc., Boston, MA, United States), connected to a temperature meter 710A (Orion, United States). Measurements were given in millivolts (mV) which corresponds to a difference in potential between the liquid which is found inside electrodes and the solution under analysis. Previously, the calibration of the ion-specific electrode for fluoride was performed. To this end, standard solutions from 0.05 ppm Fluoride to 1.6 ppm Fluoride by serial dilution with standard stock solution of 100 ppm Fluoride (Orion, United States) in distilled and deionized water. A volume of 1 mL of each standard solution was pipetted and 1 mL of Total Ionic Strength Adjustor Buffer (TISAB II) was added.

Measurements in millivolts were converted into ppm F with the help of the Windows Excel® Program. Both the standard curve and the correlative coefficient $r^2 \geq 0.99$ were used. Only calibration curves with variation of a maximum of 10% were accepted.

After calibration, sample readings were carried out three times, following the same methodology, i.e. a reading of 1 mL of the sample together with 1 mL of the TISAB II solution. All solutions, samples included, were previously agitated and kept at room temperature (25ºC) at the time of reading.

The fluoride concentration was obtained by the average of the three sample readings from each well.

The total number of samples was reckoned for each commercial Operational Unit of CAEMA and, in accordance with the measured fluoride concentration, samples were classified according to two criteria:

Criteria I – in conformity with applicable law (9), whereby the recommended limits for the concentration of fluoride are standardized according to the average maximum daily temperatures. For localities with an average maximum daily air temperature of 26.7ºC to 32.5º, the minimum and maximum recommended limits for fluoride ion in mg/L are, respectively, 0.60 and 0.80

Criteria II – in agreement with the applied methodology of technical Consensus Document on classification of public water supply according to the fluoride content published by CECOL (Collaborating Centre of the Ministry of Health in Oral Health Surveillance) (10). According to the criteria, samples are to be classified as adequate when fluoride concentrations are within the scale stipulated of 0.55 ppm F to 0.84 ppm F.

Results

Samples from two wells were lost. Thus samples of water were analyzed from 43 isolated wells. Analysis was carried out in triplicate, coming to a total number of 129 readings.

Results revealed that in all the collection points, fluoride concentrations were inferior to the limits recommended by criteria I and II, in all the commercial operational units (Tables 3 and 4).

Table 3. Fluoride concentration (ppm F) in Wells from Operational Unit OMC e OMV, in São Luís, Maranhão, Brazil. August 2009.

Operational Unit	Local well	Fluoride concentration in ppm F
OMC	Parque Timbira	0.05
	Alto do Bom Jesus	0.02
	São Sebastião/Coroadinho	0.02
	Alto do Coroadinho	0.03
	Complexo Esportivo Castelão	0.09
	Vila dos Nobres	0.03
OMV	Res. São Domingos I	0.03
	Res. Manoel Beckman	0.05
	Parque Topázio	0.04
	Cohajap – P.02A	0.04
	Cohaserma – P.02	0.05
	Planalto Vinhais – P.02A	0.08
	Calhau	0.04
	Barramar/Calhau	0.05
	Parque Shalon – P.02	0.05
	Parque Shalon – P.03	0.02
	Res. Andorra/Olho D'Água	0.06
	Cantinho do Céu	0.09
	Res. Pinheiro – P.01	0.04
	Res. Pinheiro P.04	0.02
	Res. Parati	0.02
	Vila Cruzado	0.08
	Pq. Vitória – P.01	0.11
	Pq. Vitória – P.02	0.05
	Res. Canudos	0.06
	Planalto Turu I – P.01	0.08
	Turu – P.04	0.08

Table 4. Fluoride concentration (ppm F) in Wells from Operational Unit OMH, OMP e OMG, in São Luís, Maranhão, Brasil. August 2009.

Operational Unit	Local well	Fluoride concentration in ppm F
OMH	Res. Anil	0.06
	Pão de Açúcar – P.01A	0.05
	Pão de Açúcar – P.03	0.05
	Cohatrac IV – P.01	0.03
	Cohatrac IV – P.02	0.06
OMP	Planalto Anil	0.06
	Cidade Operária	0.01
	Cidade Operária – P.16	0.03
	Vila Santa Terezinha	0.02
	Vila Cafeteira	0.03
	São Bernardo	0.07
	Vila Vitória – P.01	0.04
	Vila Vitória – P.02	0.03
OMG	Vila Embratel – P.11	0.04
	Vila Embratel – P.06	0.03
	Gancharia	0.03

After comparing the averages of residual fluoride levels in the water publicly supplied from the commercial operational units, it can be noted that the values were all very close, between 0.03 ppm F and 0.05 ppm F (Fig. 1).
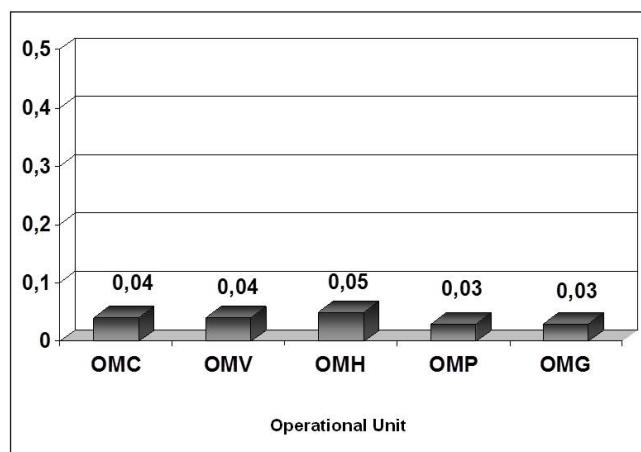

Fig. 1. Mean values of fluoride concentration (ppm F) in isolated wells, from Operational Unit. São Luís, Maranhão, Brasil. August 2009.

Discussion

The municipality of São Luís (MA) is partially favored by the fluoridation method, reinitiated in 2006. Based on information given by CAEMA (Environmental Sanitation Company of Maranhão), the public water supply in São Luís (MA) is formed by a series of systems, made up of treatment plants as well as a series of connected wells and isolated wells, where not all systems receive doses of fluoride by way of the responsible enterprise.

Italuís, Sacavém, Olho D'Água Treatment Plants and the series of deep wells that form the Paciência System are part of the artificially fluoridated supply systems. However, the neighborhoods of the municipality that are supplied by deep isolated tubewells do not receive dosages of fluoride in the water. Despite this fact, in analysis carried out by CAEMA, there were no residual levels of fluoride present in the water of these wells.

Considering this, it can be seen that there is a difference in exposure to fluoride, whose benefits are not conferred to a part of the population that receives non-fluoridated water from both deep and isolated wells. What concerns these wells, it is believed that the non-fluoridation of these well occurs due to operational difficulties which proceed from the existent quantity, the distinct locations of wells and isolated drilling.

What concerns social inequalities reflected in fluoridation, it can be seen that the implementation of this measure, with longer time of exposition, is more significant in cities with a higher Human Development Index, which also contains more favorable conditions of oral health. Areas where fluoridation was offered later show greater problems with dental caries (11,12).

Reverberations due to inequality of exposure to fluoride in São Luís (MA) opposes the affirmation of Carmo *et al.* (13) which say that neighborhoods that are economically less favored are more affected by under-fluoridation or lack of fluoridation. Beginning with isolated and non-fluoridated wells located both in more affluent areas of population and areas where communities are more socio-economically vulnerable, it is understood that the different social classes are not being favored in many locations.

Considering a greater coverage of fluoridated systems, Mário Júnior and Narvai (14) stress how important it would be to make greater efforts for spreading the measure, even in areas where fluoridation is used, in systems which might not have been fluoridated; not simply because it is a means whereby fluoride would be ingested, but also by an indirect benefit generated by it: the contribution for the improvement of the quality of the public water supply, which would significantly contribute to public health.

The 3rd National Conference of Oral Health proposed the amplification of distribution of treated and fluoridated water, intending to universalize the supply in the whole municipality according to current legal norms, as well as recommended the adoption of fluoridation of waters of well of public use (15). Bellé *et al.* (16) stress the need to expand the fluoridation method to the neighborhoods of Campo Grande (MS), supplied by artesian well. In the light of what has been said, a need can be seen for a greater area of the population of São Luís (MA) to be benefited.

In the present study, great effort has been taken to acquire the necessary information required for the company responsible for the public supply of water. Furthermore, after asking for the list of functioning wells that belong to the municipality of São Luís (MA), it was found that this report also contained wells that belonged to other municipalities of Maranhão Island, while also lacking more precise and trustworthy information. Another observation concerning mapping concerns the location and identification of some isolated wells within areas of difficult access or places that were very difficult to find.

It should also be communicated that, according to informal remarks by some functionaries of CAEMA, the municipality of São Luís (MA) also contains other isolated wells, either cared for by the Municipal City Council or by individuals, which were not taken into consideration by this study.

The finding of residual fluoride levels less than 0,11 ppm in the water of isolated systems consolidates information given by CAEMA that the localities of São Luís (MA) supplied by isolated well do not receive artificial dosages of fluoride in the water and that significant levels of natural fluoride were not identified in the water of these wells. The residual levels of fluoride established were not sufficient to prevent caries in all the samples referring to isolated wells.

Just as the municipality of São Luís (MA), the fluoride naturally present in water publicly supplied to cities in Piaui State is in low concentration, less than 0,3 ppm F (2).

It must be stressed that considerable concentrations of residual fluoride were already found in the Northeastern region of Brazil (4), causing concern for the development of dental fluorosis to children who might be exposed. On the contrary, in this study no levels of residual fluoride were identified that were capable of leading to the development of fluorosis in its most severe forms or to prevent dental caries. For that reason, mapping is necessary to indicate areas of risk and vulnerability.

Conclusion

Despite efforts taken by the company responsible for the public water supply in the municipality of São Luís (MA) for fluoridating the principal systems, greater attention should be given to those areas supplied by isolated wells. It can be concluded that the population of São Luís that is supplied by the water of these wells are not being favored by the fluoridation method. Considering the given operational difficulties, due to the number of wells, it is advised that greater measures should be taken for those with greater flow.

References

1. Xiang Q, Zhou M, Wu M et al. Relationships between daily total fluoride intake and dental fluorosis and dental caries. Journal of Nanjing Medical University 2009; 23:33-9.

2. Silva JS, Moreno WG, Forte FDS, Sampaio FC. Natural fluoride levels from public water supplies in Piauí State, Brazil. Ciênc & Saúde Coletiva 2009; 14:2215-20.

3. Omena LMF, Silva MF de A, Pinheiro CC, Cavalcante JC, Sampaio FC. Fluoride intake drom drinking water and dentifrice by children living in a tropical área of Brazil. J Appl Oral Sci. 2006; 14:382-7.

4. Sampaio FC, Von Der Fehr FH, Arnenberg P, Gigante DP, Hatloy A. Dental fluorosis and nutritional status of 6- to 11-year old children living in rural areas of Paraíba, Brazil. Caries Res. 1999; 33:66-73.

5. Viswanathan G, Jaswanth A, Gopalakrishnan S, Siva ilango S, Aditya G. Determining the optimal fluoride concentration in drinking water for fluoride endemic regions in South India. Sci Total Environ. 2009; 407:5298-307.

6. Viswanathan G, Jaswanth A, Gopalakrishnan S, Siva ilango S. Mapping of fluoride endemic areas and assessment of fluoride exposure. Sci Total Environ. 2009;407:1579-87.

7. CDC, Center for Disease Control and Prevention.Achievements in Public Health, 1900-1999. Fluoridation of drinking water to prevent dental caries. MMWR. Morbidity and Mortality Weekly Report. 1999; 48:933-56.

8. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde/ Secretaria de Vigilância em Saúde. Departamento de Atenção à Saúde. Coordenação Geral de Saúde Bucal. SB Brasil 2010. Pesquisa Nacional de Saúde Bucal. Resultados Principais. Brasília, 2011.

9. Brasil. Portaria n. 635 de 26 de dezembro de 1975. Aprova normas e padrões sobre a fluoretação da água dos sistemas públicos de abastecimento, destinada ao consumo humano. Brasília, 1975.

10. Centro Colaborador do Ministério da Saúde em Vigilância da Saúde Bucal. Consenso técnico sobre classificação de águas de abastecimento público segundo o teor de flúor. São Paulo: Faculdade de Saúde Pública da Universidade de São Paulo; 2011.

11. Frias AC, Antunes JLF, Junqueira SR, Narvai PC. Individual and contextual determinants of the prevalence of untreated caries in Brazil. Rev Panam Salud Publica. 2007;22:279-85.

12. Gabardo MCL, Silva WJ da, Olandoski M, Moysés ST, Moysés SJ. Water fluoridation as a marker for sociodental inequalities. Community Dent Oral Epidemiol. 2008; 36:103-7.

13. Carmo CDS, Alves CMC, Cavalcante PR, Ribeiro CCC. Evaluation of fluoride levels in the public water supply in São Luis Island, Maranhão State, Brazil. Ciênc & Saúde Coletiva 2010;15:1835-40.

14. Mario Júnior RJ, Narvai PC. Aspectos históricos e perspectivas da fluoretação das águas de abastecimento público no Estado de São Paulo. Bepa 2011;8:24-9.

15. Brasil. 3ª Conferência Nacional de Saúde Bucal. Acesso e qualidade superando a exclusão social. Relatório Final. Brasília, 2004.

16. Bellé BLL, Lacerda VR de, De Carli AD, Azfalon EJ, Pereira PZ. Water fluoridation analysis of Campo Grande (MS) urban zone public supply. Ciênc & Saúde Coletiva 2009;14:1261-6.