

# ANALYSIS OF BACTERIAL AND FLUORIDE CONTENT ADDED TO WATER SUPPLY IN A STATE OF BRAZIL'S NORTHEAST

*Análise microbiana e do teor de flúor adicionado à água de abastecimento em um estado do Nordeste*

*Análisis microbiano y de la concentración del flúor añadido al agua del abastecimiento de un estado del noreste de Brasil*

Original Article

## ABSTRACT

**Objective:** To assess the levels of fluoride ions and microbiological standard present in the public water supply of cities that fluoridate their water in the state of Alagoas. **Methods:** Descriptive cross-sectional study conducted in the period 2012-2014 to analyze all reports issued by the Public Health Central Laboratory of Alagoas (*Laboratório Central de Saúde Pública de Alagoas - LACEN-AL*) with the results of drinking-water analysis of the eleven cities in Alagoas that fluoridated their water – a total of 3,089 reports. We assessed the total number of samples sent for analysis of water quality, the number of samples for analysis of fluoride, levels and variation of fluoride ions, and the microbiological standard of fluoride samples. Data underwent descriptive analysis with absolute frequencies and percentages. **Results:** 429 (83.9%) of the samples collected were in the range 0.0-0.5 mgF/L, which is considered below the recommended levels, and there was a great variation in the concentration of fluoride ions; 128 (26.3%) fluoridated water samples were outside the potability standards. **Conclusion:** Data showed a great variation and a high percentage of samples with low concentrations of fluoride as well as the need to improve the quality of water provided in order to guarantee a continued access to drinking-water.

**Descriptors:** Dental Caries; Fluoridation; Water Quality.

## RESUMO

**Objetivo:** Analisar os teores de íons de fluoreto e o padrão microbiológico encontrado nas águas de abastecimento público dos municípios alagoanos que fluoretam suas águas. **Métodos:** Estudo transversal descritivo realizado no período de 2012 a 2014, no qual se analisaram todos os laudos emitidos pelo Laboratório Central de Saúde Pública de Alagoas (LACEN-AL) com os resultados da análise da qualidade da água para consumo humano dos onze municípios alagoanos que fluoretaram suas águas, totalizando 3.089 laudos. Avaliou-se o número total de amostras enviadas para análise da qualidade da água, a quantidade de amostras em que foi solicitada a análise de fluoreto, teores e variações dos íons de fluoreto e o padrão microbiológico das amostras fluoretadas. Realizou-se a análise descritiva dos dados, obtendo-se as frequências absolutas e relativas percentuais. **Resultados:** Foram encontradas 429 (83,9%) amostras coletadas no intervalo 0,0-0,5 mgF/L, número considerado abaixo do recomendável, além de grande variação na concentração dos íons de fluoreto e 128 (26,3%) amostras de água fluoretada fora dos padrões de potabilidade. **Conclusão:** Os dados mostraram uma grande variação e um alto percentual de amostras com baixas concentrações de fluoreto, assim como a necessidade de melhoria da qualidade da água ofertada, de modo a garantir para a população o acesso contínuo à água potável.

**Descritores:** Cárie Dentária; Fluoretação; Qualidade da Água.

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## RESUMEN

**Objetivo:** Analizar las concentraciones de los iones de fluoruro y el patrón microbiológico de las aguas del abastecimiento público de los municipios de Alagoas que añaden el flúor en sus aguas.

**Métodos:** Estudio transversal descriptivo realizado entre 2012 y 2014 en el cual se analizó todos los laudos emitidos por el Laboratorio Central de Salud Pública de Alagoas (LACEN-AL) con los resultados del análisis de la calidad del agua para el consumo humano de los once municipios de Alagoas que añadieron el flúor en sus aguas en un total de 3.089 laudos. Se evaluó el número total de muestras enviadas para el análisis de la calidad del agua, la cantidad de muestras de las cuales fueron solicitadas el análisis del fluoruro, las concentraciones y variaciones de los iones de fluoruro y el patrón microbiológico de las muestras con flúor. Se realizó el análisis descriptivo de los datos obteniéndose las frecuencias absolutas y las relativas porcentuales. **Resultados:** Fueron encontradas 429 (83,9%) muestras recogidas en el intervalo de 0,0-0,5 mgF/L, número abajo del recomendable, además de una gran variación de la concentración de los iones de fluoruro y 128 (26,3%) muestras del agua con flúor fuera de los patrones de potabilidad. **Conclusión:** Los datos muestran una gran variación y un elevado porcentual de muestras con bajas concentraciones de flúor así como la necesidad de mejoría en la calidad del agua ofrecida de manera a garantizar la población el acceso continuo de agua potable.

**Descriptor:** Caries Dental; Fluorucación; Calidad del Agua.

## INTRODUCTION

Water is essential to life, and therefore, to save it from any substance hazardous to health, the means to make it potable have been sought<sup>(1)</sup>. Diarrhoeal diseases are directly related to water supply, sanitation, and hygiene conditions, which, combined with the lack of population's knowledge, increase the occurrence of waterborne diseases, especially in children and young people, thus making vital to people's well-being the evaluation of water potability, and hygiene and sanitary conditions<sup>(2-4)</sup>.

In Brazil, to be regarded good-quality water, it must be legally according to Ordinance No. 2914, of December 12, 2011, by the Ministry of Health<sup>(5)</sup>, which sets forth the procedures of quality control and surveillance of water for human consumption and its potability standards. This ordinance also establishes the maximum permitted values (MPV) to the physical, chemical, and microbiological parameters<sup>(1,6)</sup>.

The potability standard of the water intended for human consumption, from a microbiological point of view, is the absence of total coliforms and *Escherichia coli* (*E. coli*) in samples with 100 ml of water<sup>(5)</sup>. The total coliform group

includes bacteria that occur naturally in soil, water, and plants. *Escherichia coli*, on the other hand, is only faecal in origin, being used as the best accurate indicator of that type of contamination<sup>(7)</sup>.

Fluoride concentration is another important parameter in the evaluation of quality in drinking water. The Smiling Brazil Program<sup>(8)</sup> aims at improving the oral health status in Brazil, expanding the coverage of fluoridated water supply<sup>(9)</sup>. However, for the water fluoridation to be effective with respect to preventing tooth decay, it is mandatory that the addition of fluoride ions be done continuously and observing the appropriate levels for each location<sup>(10,11)</sup>.

Because of this characteristic, a strict control becomes essential. Therefore, those responsible for providing water have the responsibility to maintain a preventive and permanent operational control of this water potability, which should be done since its release from the Water Treatment Plant (WTP) until its entry into the residential connections<sup>(12)</sup>. In the area of surveillance, it is necessary to perform the external control, which consists in carrying out control measures and monitoring by an institution other than that responsible for the water supply, in order to maintain the quality standard<sup>(13)</sup>.

For fluoride, the maximum allowed value is 1.5 mgF/L since 2000, when the publication of Ordinance No. 1469/2000. This value was kept in Ordinance No. 518/2004<sup>(10)</sup> and Ordinance No. 2914/2011<sup>(5)</sup>. However, from the perspective of health surveillance for the assessment of water fluoridation in Brazil, fluoride contents below 0.6 or above 0.8 mg F/L are considered outside the acceptable limits<sup>(14)</sup>.

Temperature is an important environmental factor that must be considered when calculating the fluoride content required in the water supply of a particular locality, because it is directly linked to water consumption<sup>(15,16)</sup>. Continuous intake of fluoride above the recommended levels can cause the appearance of dental fluorosis<sup>(15,17)</sup>.

The state of Alagoas is located in the east part of the Brazilian northeast and, according to the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística - IBGE*)<sup>(18)</sup>, it had in 2010 a population of 3,120,922 inhabitants and a population density of 112.33 inhabitants/km<sup>2</sup>, obtaining in 2013 the Human Development Index (HDI) of 0.631<sup>(19)</sup>. It is a state whose social, economic, and health care access conditions present great inequalities<sup>(20,21)</sup>. Maceió is one of the few Brazilian cities that does not perform fluoridation of public water supplies; among the 102 municipalities of Alagoas, only eleven add fluoride to their water<sup>(22,23)</sup>.

Microbiological analysis is an important requirement to ensure the potability of drinking water, and fluoridation,

as a method of great coverage in controlling dental caries, brings the great potential of social inclusion that would help reduce those differences. Considering this, the objective of the current study was to analyze the fluoride ion content and the microbiological pattern found in the public water supply of the municipalities of Alagoas that add fluoride to their waters.

## METHODS

This is a descriptive cross-sectional study, which analyzed reports issued by the Public Health Central Laboratory of Alagoas (*Laboratório Central de Saúde Pública de Alagoas - LACEN-AL*) with the results of the water samples collected by environmental health surveillance of health secretariats of Alagoas municipalities that add fluoride to the public water supply.

The reports from the period 2012-2014, relating to the eleven municipalities that perform fluoridation of their water supply were analyzed. The initial period election was due to the fact that, since the enactment of Ordinance 2914/11<sup>(5)</sup>, it became no longer necessary for the company responsible for fluoridation to perform the analysis of fluoride contents in the distribution network.

The reports are filed in an electronic database. After authorization from the Project Analysis Sector of LACEN-AL for this study to be performed, the requirements needed to access the system were obtained, i.e., a user profile and the release of a password.

Data collection occurred between the months of May 2014 and January 2015, in the afternoon, by one only calibrated examiner, who initially entered the following data in an Excel spreadsheet: case number, date of collection,

number of samples of water intended for human consumption submitted to analysis of quality, and number of samples submitted to fluoride ion analysis. Subsequently, this data was grouped by month of sending. Data from fluoridated samples was recorded in another Excel spreadsheet: sample number, date of collection, fluoride content, and data on the microbiological pattern.

The municipal environmental health surveillance is responsible for collecting samples for the analysis of water quality, sending them to LACEN-AL, and specifying the samples to be submitted to fluoride ion analysis, which causes the sending frequency and the number of samples to be different from municipality to municipality.

This study considered below the recommended fluoride levels the contents within the range 0.0 to 0.5 mgF/L; contents within the range 0.6 to 0.8 mgF/L were considered satisfactory, and levels above 0.8 mgF/L were regarded as above the recommended<sup>(14,24,25)</sup>. As to the microbiological pattern, the study evaluated the presence or absence of total coliforms and *E. coli* in samples with 100 ml of water<sup>(5)</sup>.

The names of the municipalities were kept in secrecy for ethical reasons, being encoded in letters A-K.

The results were tabulated and analyzed using descriptive statistics, through which absolute and relative percentage frequencies were obtained.

## RESULTS

Table I shows the total samples of water intended for human consumption that were sent by the municipal environmental health surveillance for analysis of quality and the total number of samples in which the fluoride ion analysis was requested in the eleven municipalities

Table I - Number of samples of water intended for human consumption sent for analysis of quality and for fluoride ion content analysis. Alagoas, 2012-2014.

Municipality	2012		2013		2014	
	WHC	Fluoride	WHC	Fluoride	WHC	Fluoride
A	121	06	170	15	165	25
B	215	61	175	38	130	37
C	42	05	59	0	93	0
D	150	50	160	52	170	60
E	139	16	14	01	115	17
F	111	0	27	0	10	0
G	60	20	40	12	50	16
H	90	06	120	10	85	03
I	31	03	44	0	40	02
J	74	06	95	21	50	14
K	100	15	44	0	100	0
<b>TOTAL</b>	<b>1133</b>	<b>188</b>	<b>948</b>	<b>149</b>	<b>1008</b>	<b>174</b>

WHC = water intended for human consumption.

surveyed. A total of 3,089 samples of the water intended for human consumption were sent for analysis, with 1,133 samples in 2012, 948 samples in 2013, and 1,008 samples in 2014.

It was found that in a small percentage of samples – 16.5% (n=511), the analysis of fluoride ion content was also required. It was also observed that between 2012 and 2013 there was a decrease in both the total annual number of samples collected for water quality analysis and the number of samples in which fluoride ion analysis was requested. Between 2013 and 2014, however, there was an increase but not exceeding the values achieved in 2012.

Municipalities C and K did not request fluoride ion analysis in the years 2013 and 2014, and municipality F did not request it along the three years studied, even though these municipalities have sent samples of water intended for human consumption for analysis of quality.

As regards Table II, it displays information about fluoride ion contents and variation. It was verified that in approximately 83% (n=156), 88.6% (n=132), and 81% (n=141) of the samples in years 2012, 2013, and 2014, respectively, there were fluoride contents in the range considered below the recommended (0.0 to 0.5 mgF/L).

Table II - Contents and variation of fluoride ions. Alagoas, 2012-2014.

Mun	2012				2013				2014			
	Fluoride content (mgF/L)											
	0.0 to 0.5	0.6 to 0.8	> 0.8	Var	0.0 to 0.5	0.6 to 0.8	> 0.8	Var	0.0 to 0.5	0.6 to 0.8	> 0.8	Var
A	6	0	0	0.0-0.3	15	0	0	0.0-0.5	25	0	0	0.0-0.3
B	47	7	7	0.0-2.2	31	3	4	0.0-1.5	33	2	1	0.0-1.0
C	5	0	0	0.1-0.5	0	0	0	NA	0	0	0	NA
D	48	0	2	0.0-2.0	52	0	0	0.2-0.5	56	2	2	0.0-1.0
E	16	0	0	0.0-0.5	1	0	0	0.1	9	7	1	0.0-1.2
F	0	0	0	NA	0	0	0	NA	0	0	0	NA
G	9	6	5	0.0-1.2	8	2	2	0.0-1.2	9	4	4	0.0-1.5
H	6	0	0	0.0-0.3	10	0	0	0.0-0.2	3	0	0	0.0-0.0
I	0	2	1	0.7-0.9	0	0	0	NA	2	0	0	0.2-0.4
J	5	1	0	0.1-0.7	15	6	0	0.1-0.7	4	10	0	0.3-0.8
K	14	1	0	0.1-0.6	0	0	0	NA	0	0	0	NA
Total	156	17	15		132	11	6		141	25	8	

Mun: municipality; Var: variation; NA: not applied

Table III - Number of fluoridated water samples at variance with the potability standards. Alagoas, 2012-2014.

Mun	2012			2013			2014		
	TC	EC	NR	TC	EC	NR	TC	EC	NR
A	3	1	0	11	4	0	16	6	0
B	11	0	0	10	0	0	11	0	0
C	1	1	0	NA	NA	NA	NA	NA	NA
D	16	4	2	10	1	9	7	2	7
E	4	1	0	0	0	0	3	2	0
F	NA	NA	NA	NA	NA	NA	NA	NA	NA
G	1	0	2	0	0	0	1	1	2
H	1	0	1	3	1	0	0	0	0
I	1	0	0	NA	NA	NA	1	1	0
J	2	1	0	1	0	2	4	0	0
K	10	2	0	NA	NA	NA	NA	NA	NA
Total	50	10	5	35	6	11	43	12	9

NA=not applied; TC=Total coliforms; EC=Escherichia coli; NR=no request; Mun=municipality

Municipality B showed the greatest variation in fluoride contents during the three years studied (0.0 to 2.2 in 2012; 0.0 to 1.5 in 2013; 0.0 to 1.0 in 2014), followed by municipality G.

Table III shows the results of fluoridated samples at variance with the potability standards recommended by the Ministry of Health, which advocates the absence of total coliforms and *Escherichia coli* in samples with 100 mL of water<sup>(5)</sup>.

Microbiological analysis was not required for five of the samples sent for fluoride ion analysis in 2012, eleven in 2013, and nine in year 2014. However, it was observed that more than 20% (n=128) of the samples collected in the period 2012-2014, in the eleven cities studied, were outside the microbiological standard recommended by Ordinance No. 2914 from the Ministry of Health<sup>(5)</sup>.

## DISCUSSION

Upon the enactment of Ordinance 2914 from the Ministry of Health on 12 December 2011<sup>(5)</sup>, it became no longer necessary for the company responsible for fluoridation to perform the analysis of fluoride contents in the distribution network, thus rendering the control performed by municipal health surveillance systems (external control) a valuable tool to ensure the quality of water supplied to the consumer.

The national guideline of the sampling plan of the environmental health surveillance related to the quality of water intended for human consumption<sup>(26)</sup> established that the minimum number of samples to be collected to implement the sampling plan for surveillance of quality of water intended for human consumption should be calculated according to the total population of the municipality, including the various types of water supply. Therefore, municipalities with population smaller than or equal to 50,000 should collect a minimum of five monthly samples for analysis of the levels of fluoride ions, and municipalities with population ranging from 50,001 to 100,000 should collect a minimum of ten monthly samples. In 2014, a new guideline was published<sup>(27)</sup>, and the minimum amount was lowered from ten to seven samples to be collected in localities with population between 50,001 and 100,000.

In 2010, municipalities G, H, and J had a population around 60,389, 54,591 and 62,401 inhabitants, respectively<sup>(16)</sup>, being at the population range from 50,001 to 100,000 inhabitants; therefore, in accordance with the above-mentioned guidelines, they should collect a minimum of ten monthly samples in the years 2012 and 2013, and seven in 2014. The remaining municipalities in this research, on the other hand, had a population smaller than 50,000 inhabitants and should collect at least five

monthly samples<sup>(26,27)</sup>. Only municipality B, in 2012, and municipality D, in 2014, actually evaluated the minimum amount of samples required by the sampling plan; in year 2013, none of the municipalities met the minimum established amount.

Water is the environmental compartment most directly affected by climate changes<sup>(26)</sup>. In tropical countries with maximum temperatures above 27°C, it would be most appropriate to use fluoride concentrations between 0.6-0.7 mgF/L<sup>(27)</sup>. A study published in 2011, which took into account the average of maximum temperatures, determined that the ideal concentration of fluoride to be added to the water in Maceió would be 0.678 mgF/L<sup>(28)</sup>. In the current study, samples were mainly concentrated on the 0.0-0.5 mgF/L range, considered below the recommended<sup>(14,24,25)</sup>. These data are consistent with the study performed in the state of Maranhão, according to which 53.57% of the samples had inadequate concentrations of fluoride ions<sup>(29)</sup>.

The current research found a wide variation in the fluoride ion concentration in the samples, with the largest range recorded from 0.0 to 2.2 mgF/L. Similar data was found in Chapecó, in the state of Santa Catarina<sup>(30)</sup>; on the other hand, in the city of Canoas, state of Rio Grande do Sul<sup>(31)</sup>, there was the smallest variation, with the fluoride concentration found within the range of 0.1 to 1.6 mgF/L.

The results of this study showed that more than 70% (n=486) of the fluoridated samples surveyed were in accordance with the microbiological standard required by Ordinance No. 2914/11. However, the percentages found with presence of total coliforms, or total coliforms and *E. coli*, should not exist in a water considered fluoridated and treated, as required by the Ministry of Health<sup>(5)</sup>.

The results found in this research partially reflect the situation addressed, as one must take into consideration the limitations of a cross-sectional study, which performs only a diagnosis of the proposed situation. It is thus suggested that new epidemiological studies be performed in order to further examine the subject, so that one can discriminate and correlate more accurately the existing relationships with the findings in this study. However, given the data presented, it becomes necessary to implement measures in order to strengthen preventive and external control actions, which should not be made solely by actions developed by the public administration, but through engagement with different segments of society, forming a social consortium to ensure the continuous access to drinking water and adequate fluoride contents for the population.

## CONCLUSION

The data showed a wide variation and a high percentage of samples with low concentrations of fluoride, which may

have led to the ineffectiveness of the tooth decay preventive measure for the population in the studied municipalities. It was also evidenced the need to improve the quality of the water supplied.

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