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Drinking water quality and fluoride concentration

ABSTRACT

This paper aimed to analyze the fluoride concentration in drinking water, taking into account the balance between the benefits and risks to health, in order to produce scientific backing for the updating of the Brazilian legislation. Systematic reviews studies, official documents and meteorological data were examined. The temperatures in Brazilian state capitals indicate that fluoride levels should be between 0.6 and 0.9 mg F/l in order to prevent dental caries. Natural fluoride concentration of 1.5 mg F/l is tolerated for consumption in Brazil if there is no technology with an acceptable cost-benefit ratio for adjusting/removing the excess. Daily intake of water with a fluoride concentration > 0.9 mg F/l presents a risk to the dentition among children under the age of eight years, and consumers should be explicitly informed of this risk. In view of the expansion of the Brazilian water fluoridation program to regions with a typically tropical climate, Ordinance 635/75 relating to fluoride added to the public water supply should be revised.

DESCRIPTORS: Potable Water. Fluoridation. Water Quality. Review. Dental fluorosis.

INTRODUCTION

Water is a public asset that is indispensable for life. Its importance for public health is widely recognized, but more than one billion people worldwide do not have access to treated water. Among these people, 19 million live in Brazil.[26]

Observational studies in the United States in the first half of the 20th century revealed an inverse correlation between the fluoride content in the water supply and the mean number of decayed teeth among the population. However, it was found that above a certain concentration, the occurrence of caries ceased to significantly diminish, while the prevalence of dental fluorosis increased significantly. This series of studies was essential for estimating the optimum fluoride level that would provide the maximum benefit of reduction in caries with the minimum risk of dental fluorosis and for consequently adopting water fluoridation as a public health measure.[3]

Fluoridation of the water in treatment plants has been obligatory in Brazil since 1974, as set forth in Federal Law 6050.[a] In 1975, Ordinance 635 established standards for implementing this measure,[b] which included the recommended limits for fluoride concentration as a ratio of the mean maximum daily

[a] Brasil. Lei Federal nº 6.050, de 24/05/1974. In: Coleção das Leis de 1974: Atos do Poder Legislativo: leis de abril a junho. Brasília, DF: Departamento de Imprensa Nacional; 1974. v.3, p.107.
[b] Ministério da Saúde. Portaria 635 de 26 de dezembro de 1975. Aprova normas e padrões sobre a fluoretação da água de sistemas públicos de abastecimento. *Diario Oficial Uniao*. 30 jan 1976 [cited 2006 Jan 18]. Available from: http://189.28.128.100/dab/docs/legislacao/portaria635_26_12_75.pdf

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temperature. Since then, the coverage of water fluoridation has increased, and it reached approximately half of the country's population in the first decade of the 21st century. Water fluoridation has been supported not only through resolutions approved at health and oral health conferences but also by the Brazilian Ministry of Health and by the main professional entities in Brazil within the fields of dentistry and public health.[21]

In 1988, fluoride was added to a brand of toothpaste widely used in Brazil, and by 1989, more than 90% of the products available to consumers were fluoridated.[8] The use of fluoride in the water and in toothpaste has been responsible for a significant decline in the levels of dental caries among children and adolescents in Brazil and has been heralded as an important change that may confer a different oral health pattern from that of the present for the coming generations.

Two years after the approval of the federal law relating to fluoridation, the Ministry of Health approved drinking water standards and criteria through Ordinance 56/1977.[c] Given the presence of both added and naturally occurring fluoride in water for human consumption, 1.7 mg F/l was set as the maximum permitted amount. This concentration was subsequently changed in 2000,[d] with the publication of Ordinance 1469, which defined 1.5 mg F/l as the maximum permitted amount. This guidance was maintained in Ordinance 518.[e] In 2009, the Ministry of Health instituted a working group with the aim of reviewing this ordinance.

Fluoride concentration is an important parameter for the quality assessment of drinking water because of its ability to prevent caries when fluoride is present at appropriate levels, and for its potential to provoke dental fluorosis when present at high levels. The establishment of safety levels for fluoride in drinking water is an essential measure for protecting human health.

The aim of this review was to analyze the potability of drinking water with regard to fluoride levels within the Brazilian context, while taking into consideration the balance between benefits and risks to health. In addition, supporting data were produced with consideration to revision of the national legislation.

METHODOLOGICAL PROCEDURES

To select the material for analysis, we consulted the database of the University of York Centre for Reviews and Dissemination, part of the National Institute for Health Research of the United Kingdom, which provides backing for decision makers. This database is updated daily and, among other information, includes studies indexed in PubMed/MEDLINE and those produced by important systematic review centers. The term "fluoride" was searched. Systematic reviews on the benefits and risks of fluoridated water for dentition and for bone health published between the years 2000 and 2009 were included. From this search, 77 systematic review studies were found, of which five covered the questions of interest. Two of them had the aim of investigating possible adverse effects.[18,31] The other three dealt with the effects of fluoride on bone health.[13,10,33] In addition, a systematic review commissioned by the Australian government on the efficacy and safety of water fluoridation was included.[f]

To determine the optimum fluoride levels in the Brazilian Federal District and state capitals, latitude, longitude, altitude and 2008 temperature data were obtained from the National Institute of Meteorology.

In addition, the electronic sites of government agencies and official documents relating to this topic were consulted.

The results from the analysis focused on three issues: the benefits of fluoride in the water, its risks and the standards adopted in different countries.

BENEFITS OF FLUORIDE IN THE WATER

Over the last decades of the 20th century, declines in tooth decay among child populations were described in several developed countries. The expansion of fluoride use was taken to be the most important cause of this epidemiological event, which was unprecedented.

It was believed that the main preventive effect came from fluoride intake during the formation of tooth enamel, which became more resistant to decay. Today, it is known that the anti-caries effect of fluoride depends essentially on having it constantly present in the oral environment (saliva, dental bacterial plaque and enamel surface). This presence can be ensured both through systemic use of fluoride (in water and cooking salt) and through topical use (toothpaste, mouth rinses, gels and varnish).[9]

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[c] Ministério da Saúde. Portaria nº 56/Bsb, de 14 de março de 1977. Aprova normas e o padrão de potabilidade da água a serem observados em todo o território nacional. *Diario Oficial Uniao.* 22 mar. 1977.

[d] Ministério da Saúde. Portaria 1.469, de 29 dez. 2000. Estabelece os procedimentos e responsabilidades relativos ao controle e vigilância da qualidade da água para consumo humano e seu padrão de potabilidade, e dá outras providências. *Diario Oficial Uniao.* 19 jan 2001; Seção 1:18-22.

[e] Ministério da Saúde. Portaria 518, de 25 de março de 2004. Estabelece os procedimentos e responsabilidades relativas ao controle e vigilância da qualidade da água para o consumo humano e seu padrão de potabilidade, e dá outras providências. *Diario Oficial Uniao* 16 mar 2004; Seção 1:266-70.

[f] Australian Government. National Health and Medical Research Council. A systematic review of the efficacy and safety of fluoridation. Part A: review of methodology and results. Australian Government, 2007.

Fluoride is widely used as a public health measure worldwide. In some countries, widespread use of fluoridated toothpaste is the only population-based strategy for preventing caries. Nonetheless, selecting the best option for ensuring access to fluoride in public health strategy terms depends on the prevalence and distribution of dental caries along with mobility, educational attainment, economic level and acceptability among the population.

The use of fluoride as a preventive and therapeutic measure for caries began in 1945 and 1946 in the US and Canada with four pioneering studies that had the main aim of investigating the effectiveness of this measure.[3] In 1951, water fluoridation became an official policy in the US. In 1960, approximately 50 million people in the US were benefiting from this measure, and by 2006, it had reached nearly 60% of the population of that country. This measure has been considered to be one of ten most important public health achievements of the 20th century.[5]

In the United Kingdom, the implementation of this measure began in 1960.[1] In New Zealand, approximately 65% of the population had received the benefit by 1968.[23] In the Republic of Ireland, by 1996, 66% of the population benefited from this measure.[23]

The fluoridation of drinking water has been recommended by the World Health Organization (WHO), among other important worldwide entities within the field of healthcare. In 1986, at an international conference on “Appropriate Use of Fluorides,” water fluoridation was highlighted as an effective, safe and cheap intervention that should be implemented and maintained wherever it is possible.[35]

In Brazil, fluoridation in treating the water supply began in 1953 in the municipality of Baixo Guandu. Comparisons of caries rates among schoolchildren aged 6 to 14 years between 1953 and 1963 showed results similar to those observed in the US and Canada. A study conducted in Barretos, Southern Brazil, on a similar population, confirmed the findings from Baixo Guandu.[25] After the federal law on fluoridation was enacted, use of this measure expanded enormously in the 1980s. By 2006, the benefits of fluoridation had reached approximately 100 million people. Brazil presented a notable reduction in caries experience between 1986 and 2003. The caries rate – mean DMFT - at 12 years of age went down from 6.7 to 2.8 affected teeth.[22] Data from 2003 showed that children and adolescents living in cities with water fluoridation exhibited caries levels approximately one third lower than those living in cities without this benefit.[g]

Among nearly 60 countries that adopted water fluoridation as a method for preventing and controlling dental caries, the following countries with the highest coverage can be highlighted: Hong Kong (100%), Singapore (100%), Israel (75%), Colombia (70%), Malaysia (approximately 70%), Ireland (66%), Australia (61%), US (61%), New Zealand (61%), Brunei (56%), Brazil (approximately 50%), Canada (43%) and Chile (40%). At the start of the 21st century, fluoridation was benefiting approximately 400 million people.[1]

One of the reviews consulted[18] included two prospective cohort studies, one retrospective cohort study and 23 others that compared caries rates before and after water fluoridation. The results from the studies indicated that water fluoridation was effective in preventing caries and was statistically associated with i) a lower proportion of children with tooth decay, with the median of the mean difference in proportions at 14.6% and ii) lower numbers of teeth that were decayed, missing and filled because of caries, equivalent to 40% prevention of new caries. The effect of the water fluoridation was evident, even if it is assumed that other sources of fluoride use were present, such as fluoridated toothpaste. Moreover, if fluoridation was halted, the differences in caries outcomes between regions with and without fluoridation became smaller.[18]

A review published in the US[31] included eight cross-sectional studies, one non-randomized clinical trial, eight prospective studies and one time series study. The results indicated i) a mean reduction of between 30% and 50% in the caries experience among individuals living in regions with fluoridated water, as compared with people living in regions without this measure and ii) that halting of fluoridation gave rise to a 17.9% increase in the experience of caries.

The Australian review[f] took into consideration the previous published papers and added one study conducted in Finland.[28] However, inclusion of this study did not modify the conclusions regarding the reduction in caries prevalence resulting from water fluoridation.

Based on these data, it can be concluded that water fluoridation is an effective measure for preventing and controlling dental caries in children and adolescents.

RISKS OF FLUORIDE IN THE WATER

One of the reviews consulted assessed the negative effects of water fluoridation that have been documented in the scientific literature.[18] The main association found at levels of less than 4.0 mg F/l was with dental fluorosis. This is a disorder of enamel development that occurs during tooth formation and is characterized by

[g] Ministério da Saúde, Secretaria de Atenção à Saúde, Departamento de Atenção Básica. Coordenação Nacional de Saúde Bucal. Projeto SB Brasil 2003: condições de saúde bucal da população brasileira 2002-2003: resultados principais. Brasília, DF; 2004.

Photo: Prof. Dr. Livia Tenuta (FOP-UNICAMP)

Figure 1. Rounded and delimited stains caused by non-fluorotic opacity.

Photo: Prof. Dr. Jaime Cury (FOP-UNICAMP)

Figure 3. Severe dental fluorosis (with esthetic and functional significance) in a child who had been exposed to water containing 3.6 ppm of naturally occurring fluoride.

Note: When the stains cover between 25% and 50% of the surface, they constitute mild dental fluorosis (without esthetic or functional significance).
Photo: Prof. Dra. Maria da Luz Rosário de Sousa (FOP-UNICAMP)

Figure 2. Diffuse and transverse stains caused by fluorotic opacity.

hypomineralization and greater porosity of the region immediately below the surface of the tooth enamel. At fluoride concentrations of more than 1.0 mg/l in the water supply, opaque areas start to become visible on the enamel surface.[27]

These opacities are symmetrical because the teeth formed at the same time have the same abnormality. Nonetheless, enamel opacities of non-fluorotic origin that can be manifested symmetrically also exist.[7] While non-fluorotic opacities are rounded and delimited (Figure 1), fluorotic opacities are diffused and transversed (Figure 2).

The effect of fluoride on tooth enamel is dose-dependent. In other words, whenever there is fluoride intake during enamel formation, there will be a certain level of fluorosis. However, the clinical significance of fluorosis provoked will depend on the various sources to which individuals are exposed and the time for which this exposure lasts.

As the fluoride dose to which children are exposed increases, the opacities become ever more visible, which may characterize a more severe degree of dental fluorosis. Figure 3 presents a case of severe fluorosis caused by well water containing 3.6 mg F/l, i.e., an amount five times greater than the optimum concentration level for the Brazilian climate.

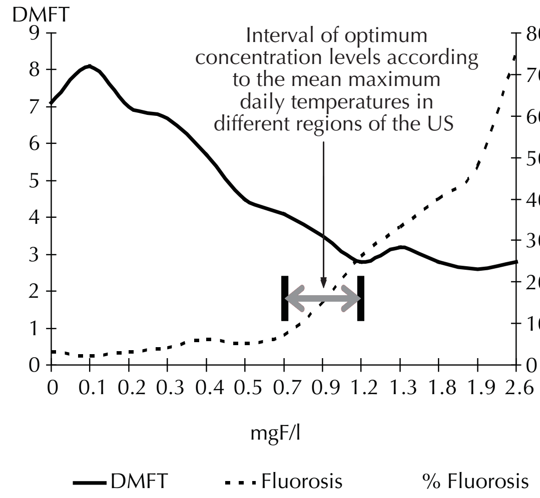
The critical period for exposure to excessive doses of fluoride to the two dentitions is from birth up to the age of 8 years.[17]

Given the expected effects from water fluoridation and in the light of the high prevalence rates and severity of dental caries in the 1950s, esthetically acceptable related dental fluorosis resulting from water fluoridation was considered to be the price to be paid for the benefit of caries prevention.

However, it was recognized that this value could vary according to the daily intake of water. Subsequently, it was shown that children living in hotter regions had less caries and more fluorosis compared to children living in colder regions with the same fluoride level in the drinking water.[12]

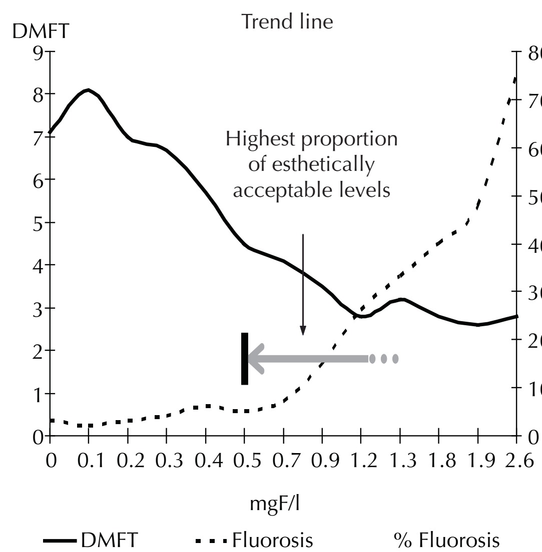
For this reason, a method for determining the optimum fluoride level in the water supply, taking into consideration the effect of mean maximum daily temperatures on the water consumed by children, was formulated. Thus, a range of optimum fluoride concentrations (0.7 to 1.2 mg F/l) was established according to the temperature in different regions of the US (Figure 4), which ranged from 10.9 °C (51.7 °F) to 29.6 °C (85.3 °F).[12] Thus, the specific optimum fluoride level for each region came to be defined through a mathematical formula that took into account fluid intake and the ambient temperature.

Adverse dental effects caused by prolonged intake of high levels of naturally occurring fluoride in the water



Source: Adapted from Burt & Eklund[3] (1999)

Figure 4. Caries experience (DMFT-Decayed, Missing and Filled teeth) and dental fluorosis in adolescents aged 12 to 14 years, according to fluoride concentration in the water. US, 1930. Trend line.



Source: Adapted from Burt & Eklund[3] (1999).

Figure 5. Caries experience (DMFT-Decayed, Missing and Filled teeth) and dental fluorosis in adolescents aged 12 to 14 years, according to fluoride concentration in the water. US, 1930.

are also known in Brazil. Tooth enamel defects in schoolchildren exposed to high levels of fluoride have been documented in Pereira Barreto, Southeastern Brazil, and in Cocal do Sul, Southern Brazil.[4,32] Through prohibiting the use of these water sources, the multiple cases of fluorosis found ceased to occur.

Only some of the cases of dental fluorosis presented esthetic problems. McDonagh et al.[18] reviewed 88 studies that met the inclusion criteria and separated the effects resulting from any degree of dental fluorosis from the effects associated with fluorosis of esthetic significance. The prevalence of fluorosis of esthetic significance was estimated to be 10.0% (95% CI: 5.0; 17.9) and 12.5% (95% CI: 7.0; 21.5) for 0.7 and 1.0 mg F/l, respectively. Regression analyses showed a strong association between the fluoride level and the proportion of the population with any degree of fluorosis. The effect of exposure to different concentrations of fluoride in the water compared with areas of up to 0.4 mg F/l was estimated, and a difference of 15% (95% CI: 4.1; 27.2) was found in areas with 1.0 mg F/l, and a difference of 18.9% (95% CI: 7.2; 30.6) was found in areas with 1.2 mg F/l.

It can be concluded that the proportion of fluorosis levels of esthetic significance in children and adolescents diminishes as the fluoride concentration in the water comes closer to the range of 0.5 to 0.7 mg F/l. This trend corresponds to a greater proportion of fluorosis without esthetic impairment and signifies a safe level of fluoride, either in water containing naturally occurring fluoride or in artificially fluoridated water (Figure 5).

A review of the literature on esthetic perceptions and dental fluorosis showed that very mild and mild degrees of dental fluorosis did not produce any negative impact on quality of life among the populations investigated.[6] In Brazil, studies in areas with optimum levels of fluoride in the water have not shown any impact of dissatisfaction with the appearance of the teeth.[19,20] An investigation among adolescents in Pelotas, Southern Brazil (with water fluoridated since 1962 and most cases of fluorosis in the very mild and mild categories) showed a positive association between dental fluorosis and more favorable quality-of-life scores.[24]

Bottled water may also carry a risk of fluorosis. In the United Kingdom, the levels of fluoride in 12 types of bottled water ranged from 0.1 to 0.8 mg F/l.[30] In the Brazilian market, levels higher than 0.7 mg F/l were noted in 10.6% of 104 commercial brands of mineral water,[34] indicating a need for greater control over manufactured mineral water products.

Occurrences of cancer and bone fractures were not associated with water fluoridation.[18] Skeletal fluorosis has been observed in areas with fluoride concentrations greater than 5.6 mg F/l.[7] Systematic reviews have shown that i) medical prescriptions of supplements containing fluoride may increase the bone mineral density of the hip and spine, depending on the duration of use; no evidence was observed in relation to the risk of hip or spine fracture and low doses of fluoride (20 mg per day or less) were associated with significant reductions in the risk of fracture;[33] ii) although fluoride is capable of increasing the bone mineral density (BMD) of the lumbar spine, it does not cause any reduction

Table. Geographical coordinates of the meteorological stations, annual mean maximum daily temperatures (ºCelsius) and recommended optimum fluoride content (mg/l). Brazil, 2008.

Cities	Latitude (S)	Longitude(W)	Altitude (meters)	Annual mean maximum daily temperature	Optimum content (mg F/l)
Aracaju	10º57′	37º03′	4.72	29.8	0.696
Belém	01º26′	48º26′	10.00	31.9	0.664
Belo Horizonte	19º56′	43º56′	915.00	27.3	0.737
Boa Vista[a]	02º49′	60º39′	90.00	33.8	0.638
Brasília (DF)	15º47′	47º56′	1159.54	27.0	0.744
Campo Grande	20º27′	54º37′	530.73	29.4	0.702
Cuiabá	15°33′	56º07′	151.34	32.5	0.655
Curitiba	25º26′	49º16′	923.50	23.3	0.817
Florianópolis	27º35′	48º34′	1.84	24.9	0.783
Fortaleza	03º45′	38º33′	26.45	31.1	0.676
Goiânia	16º40′	49º15′	741.48	31.3	0.673
João Pessoa	07º06′	34º52′	7.43	30.0	0.692
Macapá	00º03′	51º07′	14.46	31.8	0.665
Maceió	09º40′	35º42′	64.50	31.0	0.678
Manaus	03º07′	59º57′	67.00	32.1	0.662
Natal	05º55′	35º12′	48.60	29.8	0.695
Palmas	10º11′	48º18′	280.00	33.6	0.640
Porto Alegre	30º03′	51º10′	46.97	25.0	0.780
Porto Velho	08º46´	63º 55′	95.00	30.8	0.680
Recife	08º03′	34º57′	10.00	29.6	0.699
Rio Branco	09º58′	67º48′	160.00	30.9	0.679
Rio de Janeiro	22º53′	43º11′	11.10	29.8	0.696
Salvador	13º00′	38º30′	51.41	29.4	0.703
São Luís	02º32′	44º13′	50.86	31.1	0.676
São Paulo	23º30′	46º37′	792.06	25.6	0.769
Teresina	05º05′	42º49′	74.36	33.8	0.638
Vitória	20º19′	40º19′	36.20	28.9	0.710

Source: National Institute of Meteorology
[a] Boa Vista: Latitude North.

in occurrences of vertebral fractures; increases in the fluoride dose may result in a greater risk of non-spinal fractures and adverse gastrointestinal effects, without any effect on the spinal fracture rate;[13] and iii) up to 1.0 mg F/l, there is no adverse effect regarding bone resistance, BMD and fracture incidence.[10]

Thus, a high fluoride concentration in water represents a risk of dental fluorosis for children with dental enamel at the formation stage. The severity of the effect for the population is related to the concentration present in the water. A 15% difference (95% CI: 4.1; 27.2) in the prevalence of functionally significant fluorosis was found when comparing areas with 1.0 mg F/l and 0.4 mg F/l in studies mainly involving temperate-climate countries.[18]

WATER POTABILITY AND FLUORIDE CONCENTRATION

Several countries have specific recommendations relating to the fluoride parameter. In South America, most countries have taken 1.5 mg F/l as the maximum permitted amount.[h] In the US, the Environmental Protection Agency has defined 4.0 mg F/l as the maximum concentration level for fluoride in public water supply systems and as the potability standard.

[h] Pinto VG. Análise comparativa de legislações relativas à qualidade da água para consumo humano na América do Sul [master's dissertation]. Belo Horizonte: Universidade Federal de Minas Gerais; 2006.
[i] U.S. Environmental Protection Agency. Drinking water contaminants [cited 2010 Apr 5]. Available from: http://water.epa.gov/drink/contaminants/basicinformation/fluoride.cfm#four

However, there is a specific recommendation to adopt a limit of 2.0 mg F/l to reduce the risk of dental fluorosis.[i] In Canada, water fluoridation decisions are made by each municipality. The Federal Commission on Fluoridation recommends an optimum concentration of between 0.8 and 1.0 mg F/l. The Canadian government recommends an amount of 1.5 mg F/l as the maximum acceptable concentration.[j] In European countries, the maximum permitted fluoride concentration in the water supply is 1.5 mg F/l. Ireland has adopted specific legislation that is more restrictive than the European law, limiting the concentration in the water supply to 1.0 mg F/l.[k] In Australia, up to 1.5 mg F/l is accepted when it occurs naturally.[l] In Asia, Hong Kong has reduced its optimum levels of fluoride added to the water supply over recent years. Until 1978, the optimum level was 1.0 mg F/l, when it was reduced to 0.7 mg F/l.[11] In 1988, the level was reduced to 0.5 mg F/l.[15] It needs to be highlighted that the mean maximum daily temperature in the Hong Kong region is 24.7 °C.

In 1984, WHO defined 1.5 mg F/l as the limit for safe potable water. This amount was reassessed in the latest review[37] but was not adjusted due to the lack of reasonable evidence. However, the WHO did emphasize that this amount should not be fixed and it would dependent on the specific context.

In Brazil, the first federal standard was published in 1977, and the level of 1.7 mg F/l was adopted as the criterion for the water potability standard. Currently, the level of 1.5 mg F/l is used as the maximum permitted amount throughout the national territory.[d] This level was established based on technical reports from WHO, which served as the reference for many countries, independent of their climatic conditions. It is emphasized in the standard that "the recommended levels for the fluoride ion concentration should follow the specific legislation in force relating to water fluoridation, while in any case the maximum permitted amount of this Table shall be respected".[d]

This text may lead to the interpretation that the expression "in any case" refers both to naturally occurring fluoride and fluoride added to the water for the purpose of dental caries prevention, which is not justified in the context of the presented knowledge. Thus, the maximum permitted amount for fluoride naturally present in water cannot be used as the limit for fluoride added during water treatment.

It has been suggested that the optimum fluoride concentration in water should be established by taking into account not the air temperature but the dose to which children are exposed (mg F/day/kg of body weight). Thus, Burt[2] suggested in 1992 that a daily dose of 0.07 mg F per kg of body weight should be taken as the upper limit, so that the resultant fluorosis would not compromise the anti-caries benefits from fluoride intake among children within the at-risk age group. However, this limit should be validated by data from a longitudinal dose-effect study, and no association between the dose and the resultant fluorosis has been found[16], requiring more studies about a safety dose.

Based on the mean maximum daily temperatures recorded in Brazilian state capitals only for 2008 (Table), it is possible to calculate the optimum fluoride concentration levels in accordance with the formula recommended in Ordinance 635/75. This calculation shows a range from approximately 0.6 mg F/l in Boa Vista, Northern Brazil, to 0.8 mg F/l in Curitiba, Southern Brazil. Although records of daily air temperatures do not exist for all Brazilian municipalities, it can be seen from the temperature characteristics in the different regions that the appropriate fluoride levels recommended for most Brazilian municipalities will be around this band (Table).

From consultations in the electronic databases of state and municipal legislation, two states showed complementary legislation. In the State of São Paulo, Resolution SS-65/2005 establishes that the water should contain 0.7 mg F/l, with acceptable variation from 0.6 to 0.8 mg F/l.[m] In the State of Rio Grande do Sul, Ordinance SSMA 10/99 establishes that the ideal fluoride concentration in water for human consumption is 0.8 mg F/l, with acceptable variation from 0.6 to 0.9 mg F/l.[n]

Galagan and Vermillion[12] made an important contribution towards applying the method through their proposed formula for determining the optimum fluoride level, which considered the correlation between fluid intake and the mean air temperature. It should be emphasized that the optimum concentration was calculated based on temperature variations in the US, which has a temperate climate. Hence, their formula may not be applicable to regions with a tropical climate, for which a level of 0.5 mg F/l might be considered appropriate.[36] In the case of Brazil, this is not a concern for the

[j] Health Canada. Fluoride and human health: it is your health. Ottawa; 2008 [cited 2010 Apr 5]. Available from: http://www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/environ/fluor-eng.pdf

[k] The Council of The European Union. European Union legislation: Council Directive 98/83/EC (OJ L330, p32, 5/12/1998) of 3 November 1998 on the quality of water intended for human consumption [cited 2011 Apr 10]. Available from: http://www.fsai.ie/uploadedFiles/Legislation/Food_Legisation_Links/Water/Council_Directive_98_83_EC.pdf

[l] Australian Government, National Health and Medical Research Council. Australian drinking water guidelines 6. Canberra; 2004 [cited 2010 Apr 5]. Available from: http://www.nhmrc.gov.au/_files_nhmrc/file/publications/synopses/adwg_11_06.pdf

[m] Secretaria de Estado da Saúde de São Paulo. Resolução SS-65, de 12/05/2005. *Diario Oficial Estado Sao Paulo*. 13 maio. 2005; seção I:18.

[n] Secretaria Estadual da Saúde do Rio Grande do Sul. Portaria 10/99, de 16/08/1999. Define teores de concentração do íon fluoreto nas águas para consumo humano fornecidas por sistemas públicos de abastecimento [cited 2011 Mar 25]. Available from: http://www.portoalegre.rs.gov.br/dmae/doc_usu/SDDVP-portaria10-99.pdf

southern and southeastern regions, where the climate is predominantly subtropical,[14] but it may be so for cities in the northern, northeastern and central-western regions, which have genuinely tropical climates.

FINAL REMARKS

Based on the information reviewed here, most countries have adopted the level of 1.5 mg F/l as the maximum permitted amount for naturally occurring fluoride; Ireland, located to the north of the Tropic of Cancer, and Hong Kong, located to the south of it, constitute exceptions. In Australia, a country with climatic variation similar to that of Brazil, the maximum permitted amount of 1.5 mg/l is explicitly adopted for naturally occurring fluoride, and 1.0 mg F/l for areas where fluoride is added.[1]

In Brazil, the optimum fluoride levels in treated water (with the maximum anti-caries benefit and minimum risk of functionally significant dental fluorosis) for the state capitals and Federal District ranged from 0.6 to 0.8 mg F/l. For some cities in the south of the country, up to 0.9 mg F/l is accepted. As long as other sources of drinking water or technologies of acceptable cost for adjusting or removing fluoride from water remain unavailable, the maximum permitted amount of 1.5 mg F/l can be accepted as a tolerable level in water for human consumption in which the occurrence of fluoride is natural.

However, in compliance with Federal Decree 5440/2005,[o] when the naturally occurring fluoride concentration is more than 0.9 mg F/l, the entities responsible for the systems and alternative public water supply solutions must furnish the following information to consumers: “This water should not be consumed daily by children under the age of eight years”, in conformity with the current legislation.

The percentage of the Brazilian population supplied with naturally fluoridated water is unknown, but a study covering 74% of the municipalities of the State of Piauí (Northeastern Brazil) showed that although the concentration was low in 151 of them (< 0.3 ppm F), 13 had levels of 0.31 to 0.59 mg F/l.[29] Only one- third of the municipal sanitation services performed raw water analyses, and such analyses were more common on water from surface catchment areas than on underground aquifers.[p] Although the data available do not allow a panorama for the Brazilian population to be outlined, it is estimated that there are few localities in the country where naturally occurring fluoride reaches concentrations of 1.0 to 1.5 mg F/l.

The obligation to provide information to the public stimulates public authorities at all levels of government (federal, state and municipal), sanitation companies and other interested parties to ensure that the naturally occurring fluoride concentrations are close to optimum levels. This changing may occur over the medium to long term, depending on local measures, but in many cases, measures of greater complexity will be needed. These measures will involve agreements between different spheres of government and the sanitation companies. This process, through specific legislation, will constitute important support leading towards reviewing and defining the quality standards for mineral water commercialized in Brazil.

In relation to fluoride added to water, greater knowledge about the climatic conditions of different regions of Brazil justifies the need to review Ordinance 635, which was approved in 1975, in view of the expansion of the national program for water fluoridation to places with a typically tropical climate.

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[o] Presidência da República. Casa Civil. Decreto nº 5.440 de 4 de maio de 2005. Estabelece definições e procedimentos sobre o controle de qualidade da água de sistemas de abastecimento e institui mecanismos e instrumentos para divulgação de informação ao consumidor sobre a qualidade da água para consumo humano [cited 2006 Apr 3]. Available from: http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2005/Decreto/D5440.htm
[p] Fundação Nacional de Saúde, Departamento de Engenharia de Saúde Pública. Avaliação técnica do controle de qualidade da água para consumo humano em serviços municipais de saneamento: relatório final. Brasília, DF: ASSEMAE; 2008. v. 1 [cited 2010 Apr 5]. Available from: http://www.funasa.gov.br/internet/arquivos/biblioteca/eng/eng_avaliTecAgua1.pdf

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The authors declare that there are no conflicts of interests.