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FLUORIDE LEVELS IN MÉXICO CITY'S WATER SUPPLIES

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Key words: caries, fluoride, prevention, fluoridated water, water supplies

ABSTRACT

The purpose of this study was to assess the fluoride concentration in water supplies of México City. Since Lerma-Cutzamala and Acuífero del Valle de México Water Supply Systems distribute water to the México City's Metropolitan Area (MCMA) we have analyzed their water fluoride concentration using 44 different sampling wells from the four geographical zones of the MCMA during 2002. The water sampling was monthly made during one year. All collected data showed a mean fluoride concentration of 0.70 ± 0.20 mg/L. Our results showed minor variability of fluoride concentrations in the water available in México City. The fluoride content of the different analyzed zones showed statistical differences. Although Mexican Health authorities have defined that fluoride concentration in water should be from 0.70 to 1.50 mg/L, cases of dental fluorosis have been reported in México City (Juárez-López *et al*. 2003). It is important to have a reliable evaluation of fluoride concentration in México City's natural water supplies prior to implementing any caries-prevention program and to avoid novel cases of dental fluorosis.

Palabras clave: caries, fluoruro, prevención, agua fluorada, pozos de abastecimiento

RESUMEN

El propósito de este estudio fue conocer la concentración de fluoruros en los pozos de agua de la ciudad de México. Debido a que los sistemas Lerma-Cutzamala y Acuífero del Valle de México distribuyen el agua potable al Área Metropolitana de la ciudad de México (AMCM), se analizó la concentración de fluoruros en 44 pozos de las cuatro zonas geográficas del AMCM durante el 2002. El muestreo del agua se realizó cada mes durante un año. Los datos obtenidos mostraron un promedio de concentración de fluoruros de 0.70±0.20 mg/L. Se encontraron diferencias estadísticamente significativas entre las concentraciones de fluoruros de las diferentes zonas analizadas. A pesar de que las autoridades mexicanas del Sector Salud tienen bien definido que la concentración de fluoruro en el agua potable es entre 0.70 mg/L y 1.5 mg/L, se han reportado casos de fluorosis dental en la ciudad de México (Juárez-López *et al*. 2003). Es importante realizar una evaluación confiable de la concentración de fluoruros en las fuentes naturales de

agua potable de la ciudad de México antes de implementar cualquier programa de prevención de caries e impedir la aparición de nuevos casos de fluorosis dental.

INTRODUCTION

Fluoride is an ion that appears in combination with other elements forming fluorides in rocks and soil. When water passes through and over the soil and rock formations containing fluoride, it dissolves these compounds resulting in small amounts of soluble fluoride present in virtually all water sources (Evans 1997).

México City is located in the central part of México and it is situated within a valley. Its altitude is 2235 meters above the sea level. There are no water fluoridation programs and fluoride from natural sources is in the drinking water. Due to fluoride effectiveness in prevention of dental decay, several countries have developed many alternatives to add this ion in toothpastes, mouth rinses, tablets, foods and drinks for children who live in not optimally–fluoridated communities (Keyes and Englander 1975, Levy 1986, Ismail 1994, Riordan 1999). As a result of the increasing in fluoride ingestion it has been observed an increased incidence of dental fluorosis (Dean *et al*. 1942, Aasenden and Peebles 1974, Pendrys *et al*. 1994, Wong and Gropen 1997, Clark 1998, Villa *et al*. 1998).

México City population receives naturally fluoridated water from two water systems known as Lerma-Cutzamala and Acuífero del Valle de México. To help the prevention of dental decay, in 1993 a salt fluoridation program in México was established (NOM-040-SSA-1-1993). Since 1993, some children of México City have shown dental fluorosis lesions (Juárez-López *et al*. 2003). This study was focused to determine the fluoride content in México City water supplies.

MATERIALS AND METHODS

The Lerma-Cutzamala and the Acuífero del Valle de México water supply systems provide water to México City. The supply systems have been divided in four geographical zones by the México City's government (**Fig. 1**). Forty four different wells distributed through the city were analyzed. Thirty three wells are part of the Acuífero del Valle de México and eleven wells compose the Lerma-Cutzamala System. Water samples were directly collected from the wells in plastic bottles. Which were washed several times with distilled water before taking the sample. All samples were stored at 4 ºC until their analysis. Four water samples were taken per month, per well (n = 48 samples per well).

Fluoride content in the water samples was quantified using the fluoride selective ion method (Orion Research 1991). A calibration curve was prepared using standard solutions from 0.01 to 10 mg/L. From each sample, 25 mL aliquots were taken and 1 mL of TISAB (total ionic strength adjustment buffer) was added. Readings were taken in mV by triplicate and the fluoride concentrations were calculated with the calibration curve ($r = 0.9999$). Data were analyzed with the SPSS software (version 11.0) applying the ANOVA and the Student's t test.

RESULTS AND DISCUSSION

Fluoride concentration was measured during one year and the results appear in **table 1**, the mean fluoride concentration was 0.70 ± 0.20 mg/L (range from 0.26 to 1.38 mg/L). Fluoride content from the 44 analyzed wells showed significant statistical differences ($p < 0.001$).

Data indicated that 59.1 % of the analyzed wells (26 wells) had a mean fluoride concentration below 0.70 mg/L. Of them, water from 12 wells (27.3 %) showed mean fluoride concentrations less than, but close to, 0.70 mg/L. Water from the other 18 wells (40.9 %) showed mean fluoride concentrations above of 0.70 mg/L. Three wells showed values above 1.0 mg/L.

México City is divided in four geographical zones: Northeast (NE), Northwest (NW), Southeast (SE) and Southwest (SW). According to this division we have found that the NW and SW zones showed the widest range in the fluoride content followed by the SE and NE zones. Significant statistical differences ($p < 0.001$) were found when comparing fluoride concentrations obtained from the four geographical zones.

The monthly mean fluoride concentration in the water samples of the individual wells did not show statistically significant differences when they were compared (**Table 2**).

We have analyzed fluoride concentrations dur-

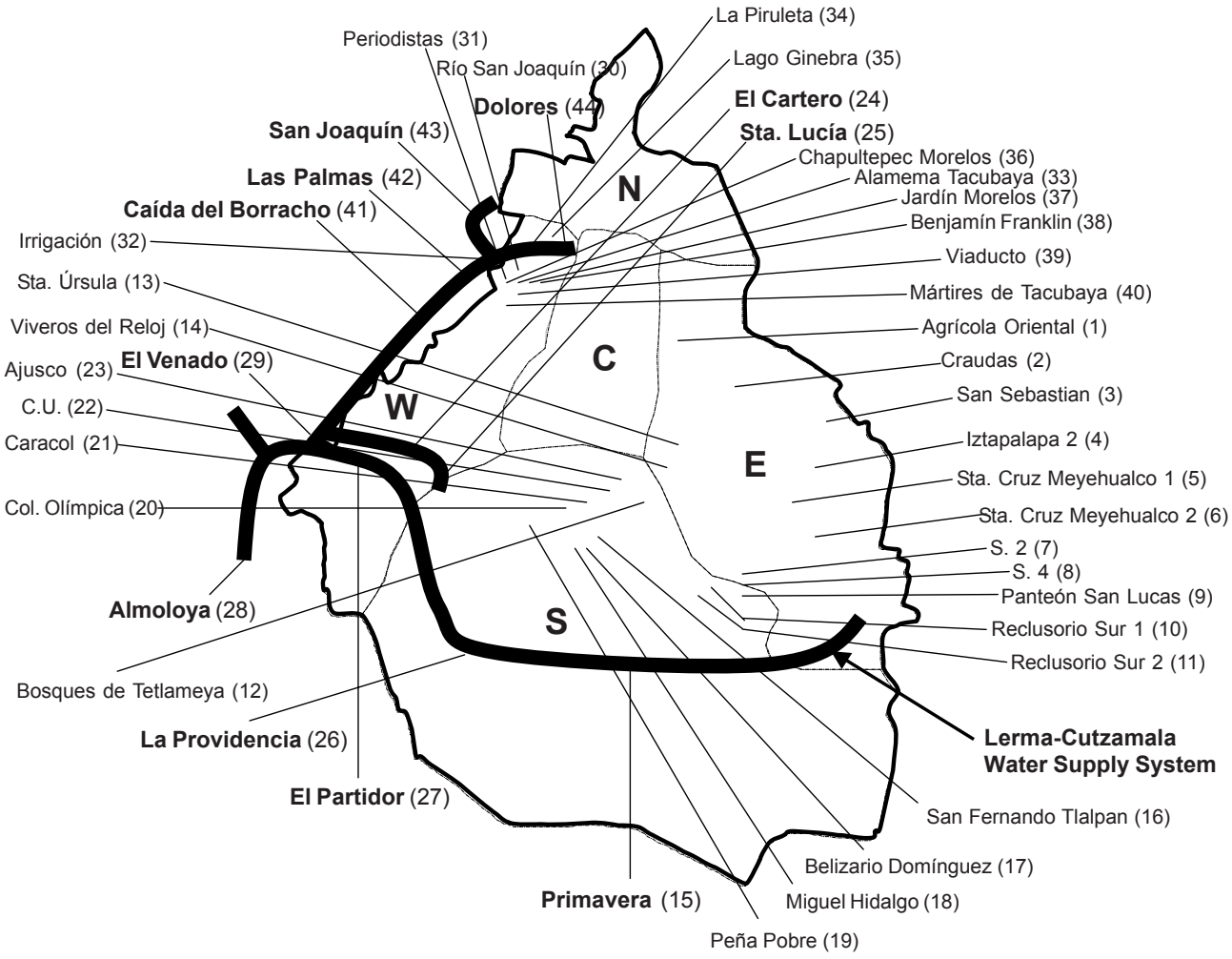

Fig. 1. Acuífero del Valle de México Water Supply System is drawn as individual wells. Lerma-Cutzamala Water Supply System is shown by a ramified, curved, thick line since it is a duct system

ing the rain (May to October) and the drought periods (November to April). Mean fluoride concentration during the rain period was 0.71 ± 0.20 mg/L (range from 0.26 to 1.38 mg/L) and during the drought period it was 0.69 ± 0.20 mg/L (range from 0.33 to 1.37 mg/L). No statistical differences were found.

Mexican Normativity establishes that fluoride concentration should not exceed 1.5 mg/L (NOM-OF-127-SSA1-1994). Our results showed that water from all the analyzed wells were within this rule. However, this normativity also establishes that when water fluoride concentration is over 0.70 mg/L, the use of fluoridated salt and fluoridated supplements should be avoided (NOM-OF-040-SSA1-1993).

Our data, which indicate that NW and SW areas of México City have wells with water fluoride concentrations above of 1.00 mg/L, are a possible cause of the results from recent studies reporting dental fluorosis cases in children living in these areas of México City (Molina-Frechero *et al.* 2000, Jiménez-Farfán *et al*. 2001, Juárez-López *et al*. 2002, Juárez-López *et al.* 2003).

According to our results, México City's water wells showed variations in their fluoride concentrations. This could be related with other associated factors as temperature, the kind of soil, the altitude or the depth of wells (Manji *et al*. 1986, Rwenyonyii *et al*. 1999). However, there were no differences among the monthly concentrations and the seasons. Other studies reported variations in the water fluoride concentrations during the year (Richards *et al*. 1967). Although our results differ with them, it is important to consider that the water consumption increases during hot seasons (Lima and Cury 2003), increasing the fluoride consumption by individuals

TABLE 1. FLUORIDE CONCENTRATION (mg/L) OF WATER SUPPLIES IN MÉXICO CITY. SAMPLING PERIOD: JANUARY-DECEMBER 2002*

Zone	Mean ± SD	Well	Mean ± SD	Range
NE	0.77 ± 0.07	Agrícola Oriental No. 5	0.75 ± 0.02	0.73 – 0.79
		Gracidas	0.80 ± 0.05	0.75 – 0.94
		San Sebastián	0.69 ± 0.03	0.63 – 0.73
SE	0.63 ± 0.14	Iztapalapa 2	0.86 ± 0.05	0.77 – 0.91
		Pozo Santa Cruz Meyehualco 1	0.79 ± 0.03	0.71 – 0.84
		Santa Cruz Meyehualco 2	0.68 ± 0.07	0.61 – 0.88
		Pozo S2	0.69 ± 0.02	0.65 – 0.71
		Pozo S4	0.56 ± 0.04	0.51 – 0.60
		Panteón San Lucas	0.69 ± 0.03	0.67 – 0.79
		Reclusorio Sur 1	0.76 ± 0.11	0.42 – 0.89
		Reclusorio Sur 2	0.53 ± 0.05	0.47 – 0.67
		Bosques de Tetlameya	0.40 ± 0.14	0.33 – 0.82
		Pozo Santa Úrsula 1	0.78 ± 0.08	0.52 – 0.82
		Viveros del Reloj	0.41 ± 0.11	0.26 – 0.71
		Tanque Primavera	0.69 ± 0.03	0.60 – 0.71
		San Fernando Tlalpan	0.62 ± 0.04	0.52 – 0.71
SW	0.69 ± 0.22	Belisario Domínguez	0.45 ± 0.05	0.37 – 0.54
		Miguel Hidalgo	0.52 ± 0.04	0.47 – 0.59
		Pozo Peña Pobre	0.41 ± 0.02	0.38 – 0.47
		Red Colonia Olímpica	0.69 ± 0.03	0.62 – 0.72
		Pozo Caracol	0.67 ± 0.04	0.57 – 0.69
		Pozo C.U.	0.64 ± 0.05	0.53 – 0.69
		Ajusco	0.74 ± 0.11	0.40 – 0.82
		Pozo El Cartero	0.68 ± 0.02	0.65 – 0.72
		Pozo Santa Lucía	0.74 ± 0.02	0.68 – 0.77
		Pozo Sifón La Providencia	0.59 ± 0.02	0.55 – 0.61
		Caída El Partidor	1.32 ± 0.05	1.25 – 1.38
		Almoloya	0.69 ± 0.05	0.60 – 0.76
		El Venado	0.06 ± 0.02	0.57 – 0.65
		Río San Joaquín	0.89 ± 0.01	0.87 – 0.91
NW	0.76 ± 0.23	Periodistas	0.77 ± 0.02	0.73 – 0.81
		Pozo Irrigación	1.29 ± 0.08	1.04 – 1.37
		Alameda Tacubaya	0.67 ± 0.03	0.57 – 0.69
		La Pirulera	0.78 ± 0.02	0.75 – 0.81
		Lago Ginebra	0.79 ± 0.02	0.75 – 0.81
		Chapultepec Morelos	0.79 ± 0.02	0.72 – 0.81
		Jardín Morelos	1.19 ± 0.15	0.78 – 1.38
		Pozo Benjamín Franklin	0.55 ± 0.08	0.38 – 0.62
		Pozo Viaducto	0.44 ± 0.25	0.33 – 1.22
		Mártires de Tacubaya	0.72 ± 0.01	0.70 – 0.75
		Caída del Borracho	0.78 ± 0.02	0.75 – 0.81
		Las Palmas	0.58 ± 0.07	0.38 – 0.62
		San Joaquín	0.67 ± 0.02	0.63 – 0.69
		Tanque Dolores	0.68 ± 0.03	0.61 – 0.71

*Each well was sampled four times each month (n = 48)

(Horowitz *et al*. 1984, Levy *et al*. 1995, Kiritsy *et al.* 1996).

Recent studies in México have found different fluoride concentrations in foods and beverages (Maupomé-Carvantes *et al.* 1995, Amato *et al*. 1997, Loyola-Rodríguez *et al*. 1998, Alanís-Tavira *et al*. 1999). Unlike other countries, México does not have studies to correlate the consumption of these products with the prevalence of dental fluorosis. The presence of dental fluorosis lesions could be related to the consumption of diverse products naturally or artificially fluoridated. Up to the time that Mexican Health authorities will establish adequate normativity to regulate the distribution and supplementation of fluoridated sources (drinking water, salt, supplements, drinks, foods and so on), taking in mind the requirements of our population, the necessary consequence will be that these prevention programs for dental decay will be more effective and the rate of novel dental fluorosis cases could decrease.

TABLE 2. MONTHLY MEAN FLUORIDE CONCENTRATIONS (mg/L) IN WATER SAMPLES

Month	Mean	Range
January	0.70 ± 0.21	0.33 to 1.37
February	0.70 ± 0.19	0.34 to 1.31
March	0.70 ± 0.21	0.33 to 1.37
April	0.70 ± 0.20	0.33 to 1.37
May	0.70 ± 0.20	0.26 to 1.25
June	0.71 ± 0.20	0.41 to 1.33
July	0.71 ± 0.20	0.38 to 1.29
August	0.72 ± 0.21	0.40 to 1.33
September	0.72 ± 0.21	0.40 to 1.38
October	0.71 ± 0.21	0.37 to 1.31
November	0.71 ± 0.21	0.33 to 1.33
December	0.68 ± 0.21	0.33 to 1.29

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