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Guidelines for teeth fluoridation with respect to fluoride concentration in Primorje-Gorski Kotar County

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The purpose of this study was to investigate fluoride concentration in drinking water in the Primorje-Gorski Kotar County and to provide guidelines for teeth fluoridation in the area. Data on fluoride concentration in drinking water in Primorje-Gorski Kotar County were analyzed at Department of Environmental Health, Primorje-Gorski Kotar County Teaching Public Health Institute. Fluoride concentration in drinking water was measured by the ion chromatography technique. Public water supply in Primorje-Gorski Kotar County is organized through 9 particular water supply systems. A high percentage of 96% of the population are connected to the public water supply, which is considerably higher than the mean estimate of 74% for the country as a whole. The mean concentration of fluoride in the main Primorje-Gorski Kotar County water sources assessed for a 5-year period (2007-2011) was as follows: Rijeka 0.010 mg F^-/L, Opatija 0.020 mg F^-/L, Crikvenica-Novi Vinodolski 0.007 mg F^-/L, Delnice 0.029 mg F^-/L, Vrbovsko 0.038 mg F^-/L, Čabar 0.031 mg F^-/L, Krk 0.044 mg F^-/L, Cres-Lošinj 0.054 mg F^-/L, and Rab 0.090 mg F^-/L. The Primorje-Gorski Kotar County public water supply systems do not include artificial fluoridation of drinking water. Fluoride concentration in drinking water was found to be low, ranging from the detected limit of <0.002 mg F^-/L in Opatija to 0.220 mg F^-/L in Rab, yielding the overall mean of 0.034 mg F^-/L. In conclusion, considering the amount of fluorides in drinking water, teeth fluoridation can be safely accomplished by individually adjusted doses of other fluoride agents.

Keywords: fluorides; fluoridation; drinking water; dental caries

INTRODUCTION

Fluorine is a naturally occurring, widely distributed element and member of the halogen family. The elemental form of fluorine is a pale yellow-green irritating gas with a sharp odor. Being rather chemically active, it rarely occurs naturally in the form of element. Conversely, fluorine occurs in ionic forms, or is combined with other chemicals found in the minerals, such as fluorspar, fluorapatite, cryolite, and other compounds (1).

The concentration of fluoride in natural water primarily depends on the content of fluorine in the soil through which water flows. Surface fresh waters are poor in fluoride, while higher concentration can be found in seawater (1.3 ppm). An average person ingests 0.3 to 3 mg of fluoride from food during the day. Absorption in the gastrointestinal tract is rapid and without enzymatic activity. Of the total amount of the ingested fluorine, 80%-90% is eliminated by urine, and a minor portion by feces and sweat. Higher accumulation of fluoride is present in bones and teeth (99%), while the total amount in the body is between 3 and 6 g (1-4).

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Fluoride deposition is a reversible process in bones and an irreversible process in the teeth. In dental medicine, it is proved as safe and effective in the prevention of tooth decay (2, 5). Being absorbed into the blood stream and interstitial tissue fluids surrounding the tooth crown, fluorine is slowly incorporated into the enamel. The amount of fluoride in the enamel reflects the ingested amount of fluoride. By drinking water in which the concentration of fluoride is 1 mg F-/L, its concentration in tissue fluids can reach a level of approximately 0.15 mg (6).

Fluoride is commonly found in the surface layer of tooth enamel. The highest concentration was found at a depth of 50 µm (300-1200 ppm) and individually varies depending on one's exposure to fluorides (7, 8).

Fluoridation of drinking water

Persistent and long exposure to fluoride through drinking water during the periods of growth, development and tooth mineralization, as well as during lifetime serves as protection against tooth decay in both childhood and adulthood (9, 10).

The concentration of 1 ppm of fluoride in drinking water ensures maximal protection against dental caries (tooth decay reduced by approximately 60%), while being minimally involved in the occurrence of dental fluorosis. However, in the majority of the population that cannot afford or do not use additional sources of fluoride, water fluoridation can still provide about 60% protection (2).

Fluoride can be found in drinking water as a natural "pollutant" or as an additive for protection against dental caries (artificial fluoridation of water). It occurs naturally in public water supply systems, being dissolved from the rocks during adverse weather conditions. Fluoride of industrial origin can also occur in the water through atmospheric deposition, or by direct deposition on the soil and subsequent runoff into the water (11, 12).

The purpose of the study

The purpose of this study was to evaluate the concentration of fluoride in drinking water in Primorje-Gorski Kotar County (PGKC). Based on the data obtained for this region, the aim was also to provide guidelines on teeth fluoridation.

MATERIALS AND METHODS

Data on fluoride concentrations in the sources of drinking water in the PGKC were analyzed at Department of Environmental Health, PGKC Teaching Institute of Public Health. Dissolved fluorides in natural waters were quantitatively measured by using ion chromatography. Measurements were done according to the HRN EN ISO 10304-1:1998 method (13). The instrument used was the Methrom ion chromatograph (Methrom AG, Herisau, Switzerland). Water samples were first filtered through a 0.20-mm pore size filter (Ion Chromatography Acrodisc® 25 mm Syringe Filters, Supor® polyethersulfone membrane), and then put in the chromatograph adding the standard solution. Analysis was automatically completed.

RESULTS

The PGKC has an area of 3582 km^2 with a population of 305 505 inhabitants distributed in 14 towns and 22 municipalities (14). The main PGKC water resources are groundwater sources (90%) with highly variable abundance. There are 79 water sources used for water supply with a total minimal abundances of approximately 4 170 L/s. The only surface waters used as drinking water sources are the lake Vrana (Island of Cres) and accumulation Ponikve (Island of Krk).

Public water supply in PGKC is organized through 9 water supply systems. A percentage of population connected to the public water supply is high (96%), which is considerably above the country average estimate (74%) (15).

Fluoride concentration of water sources in PGKC is generally very low. The lowest concentrations were determined in hinterland areas, ranging from <0.02 to 0.048 mg F^-/L in Rijeka, Opatija, Crikvenica and Novi Vinodolski, with the mean value of 0.008 mg F^-/L. Somewhat higher were the water source fluoride concentrations in the mountainous Gorski Kotar area, ranging from <0.02 to 0.064 mg F^-/L, with the mean value of 0.031 mg F^-/L. The highest (although still very low) values of fluoride concentrations were determined in water sources of the islands of Cres, Lošinj, Krk and Rab, ranging from <0.02 to 0.022 mg F^-/L, with the mean value of 0.034 mg F^-/L (Table 1).

Figure 1 shows the mean fluoride concentrations in 9 public water supply systems in the PGKC. The mean value of all analyzed samples during the study period was 0.034 mg F^-/L. Assessment of tooth fluoridation implementation with respect to fluoride concentration in drinking water in PGKC is shown in Table 2.

DISCUSSION

In the second half of the twentieth century, a great reduction in dental caries was recorded among children in the United States. Proponents of water fluoridation claimed that reduction of dental caries was primarily due to adding fluoride to drinking water. Water fluoridation with the concentration of fluoride ranging from 0.7 to 1.2 mg F^-/L is ap-

TABLE 1. Mean fluoride concentrations in the main water springs of the Primorje-Gorski Kotar County during the 2007-2011 period

Area	Water source	n	mg F^-/L mean ± SD (range)
Rijeka	Rječina	57	0.021±0.003 (<0.02-0.027)
	Zvir	59	0.009±0.012 (<0.02-0.034)
	B2	23	0.012±0.013 (<0.02-0.033)
	Dobra	66	0.016±0.015 (<0.02-0.048)
	Dobrica	55	0.009±0.012 (<0.02-0.034)
	Perilo	21	0.006±0.010 (<0.02-0.023)
Opatija	Tunel Učka	9	0.006±0.012 (<0.02-0.031)
	Mala Učka	9	<0.02
	Vela Učka	9	<0.02
Crikvenica--Novi Vinodolski	Novo Vrelo	61	0.009±0.012 (<0.02-0.045)
	Staro Vrelo	18	0.005±0.011 (<0.02-0.039)
	Čardak	18	0.006±0.010 (<0.02-0.023)
Delnice	Kupica	49	0.029±0.005 (<0.02-0.042)
	Ličanka	3	0.029±0.003 (0.026-0.031)
Vrbovsko	Ribnjak	37	0.038±0.008 (0.024-0.064)
Čabar	Izvor Čabranke	41	0.038±0.005 (0.03-0.058)
	Sokoli	3	0.037±0.007 (0.03-0.044)
	Mlake	4	0.040±0.006 (0.036-0.048)
	Žikovci	3	0.009±0.003 (<0.02-0.026)
Krk	Vela Fontana	18	0.043±0.013 (0.026-0.08)
	Baška Eb2	18	0.045±0.016 (0.032-0.077)
Cres-Lošinj	Vrana	43	0.054±0.013 (<0.02-0.077)
Rab	Gusić Polje	24	0.035±0.005 (0.028-0.046)
	Gvačići	22	0.120±0.028 (0.074-0.18)
	Mlinica	8	0.072±0.068 (0.024-0.22)
	Perići	11	0.103±0.027 (0.066-0.16)
	Podmravići	4	0.121±0.046 (0.094-0.19)

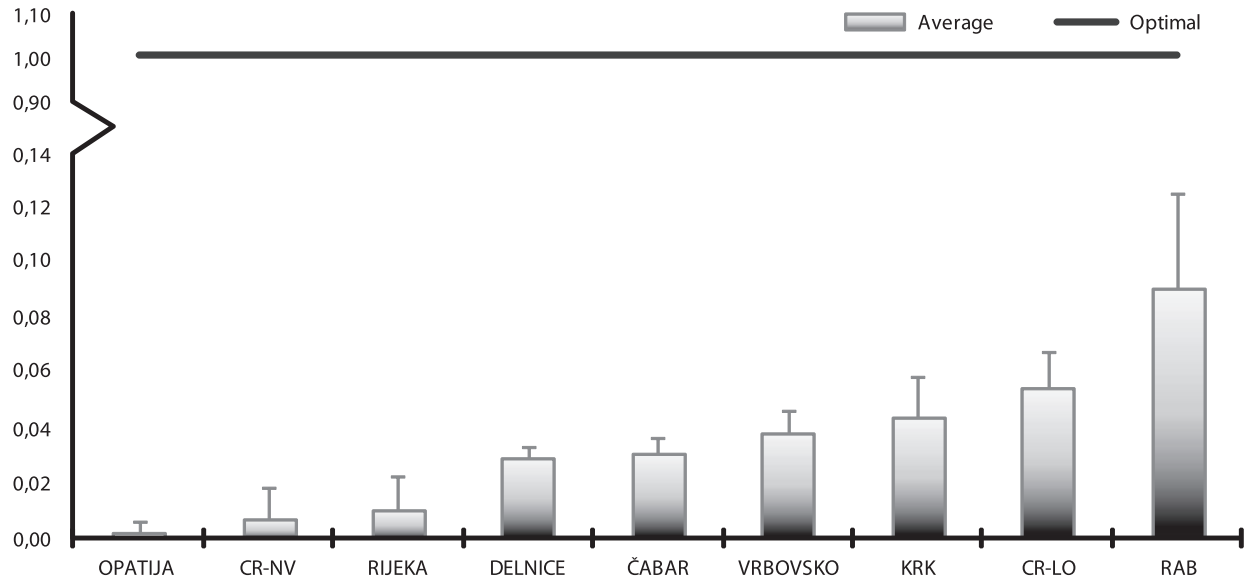

FIGURE 1. Mean fluoride concentrations of 9 water supply systems in the Primorje-Gorski Kotar County with assigned optimal fluoride
CR-NV – Crikvenica-Novi Vinodolski; CR-LO – Cres-Lošinj

TABLE 2. Assessment of implementation of tooth fluoridation in the Primorje-Gorski Kotar County

Area covered by water supply system	Fluoride dosage		
	Full recommended dose	Reduced recommended dose	Fluoridation not recommended
Rijeka	Yes	No	No
Opatija	Yes	No	No
Crikvenica--Novi Vinodolski	Yes	No	No
Delnice	Yes	No	No
Vrbovsko	Yes	No	No
Čabar	Yes	No	No
Krk	Yes	No	No
Cres-Lošinj	Yes	No	No
Rab	Yes	No	No

plied in the United States, Australia, New Zealand, Canada, Israel, United Kingdom and Ireland, as a legitimate and effective way to diminish inequalities in access to dental care (11, 12, 16, 17). There are many controversies related to water fluoridation. Some believe that adding fluoride to drinking water is an unreasonable risk, which may result in health hazard, especially being harmful in children. It is believed that one can have healthy teeth without drinking fluoridated water. If the concentration of fluorides in drinking water exceeds the recommended limit, the risk of developing fluorosis may occur. Fluoride overdoses occur if the drinking water contains higher concentrations of fluoride (either natural or artificial), and in cases of ingesting foods rich in these elements. It particularly refers to those individuals who apart from this undergo an uncontrolled use of other means of fluoridation. The consequences are not only the aesthetic appearance of the teeth, but also an increased risk of gastrointestinal disorders because of failing to control the amount of fluoridated water consumed in an individual on a daily basis (18).

Public water supply authorities do not provide artificial fluoridation of drinking water in the PGKC. Therefore, the concentration of fluoride in water springs of this area ranges from <0.02 to 0.22 mg F^-/L and depends mostly on the fluorine content in the soil through which water flows (19), the time of water retention in the underground, abundance of rainfall, etc.

The PGKC area has no geological layers containing significant quantities of fluorine. Underground drinking water resources are used by 90% of the PGKC inhabitants. This area is characterized by karst aquifers having considerable fracture porosity, which causes much shorter retention of water in the underground layers compared to the inland regions of Croatia (Pannonia basin). Due to these particular reasons, the fluoride concentrations in the waters of karst littoral areas are very low. Water originating from the water aquifer of intergranular porosity has usually higher hardness, containing increased fluoride concentrations compared to the softer waters of the karst areas (20).

Climatic features and seasonal temperature variations define water consumption, consequently defining the fluoride intake too. According to the study by *Dadić* (20), an optimal fluoride concentration of 1 mg F^-/L is reported in the waters of the Croatian coastal belt, which implies that the waters of the PGKC contain only 3% of the recommended quantity, considering that the mean fluoride concentration in PGKC is 0.034 mg F^-/L.

Regarding recommendations from the literature that a single source with artificial fluoridated water should cover at least 200 000 inhabitants in order to be profitable, it can be considered impractical to PGKC due to the high number of capped springs. Water supply fragmentation and the increased costs of drinking water fluoridation are probably the reasons why the water is not fluoridated either in the PGKC or in the rest of the country (10).

If water is not fluoridated or contains a natural amount of fluoride up to 0.3 mg F^-/L, various methods of topical fluoridation can be used. For patients with a high caries risk, an individual program of fluoride implementation, based on the principle of topical approach and including the following should be introduced: coating the teeth with fluoride solution, treatment with fluoride varnishes, and fluoride gel application. However, the total intake of fluoride including all available sources of fluoridation has to be taken into account in each patient (9).

If the water contains 0.3-0.5 mg F^-/L, it is necessary to reduce the fluoride dose and concentration. Finally, if the concentration is 0.7-1 mg F^-/L, recommendation is to avoid any additional methods of fluoridation (9, 21).

CONCLUSION

In the PGKC area, water is not artificially fluoridated. Fluoride concentrations in drinking water are very low and range from <0.02 to 0.22 mg F^-/L, mean 0.034 mg F^-/L. Considering the amount of fluorides in drinking water, tooth fluoridation can be safely accomplished by individually adjusted doses of other fluoride agents.

Abbreviations:

PGKC - Primorje-Gorski Kotar County

NOVČANA POTPORA/*FUNDING*

Nema/*None*

ETIČKO ODOBRENJE/*ETHICAL APPROVAL*

Nije potrebno/*None*

DOPRINOSI AUTORA/*DECLARATION OF AUTHORSHIP*

Bakarčić D., Jokić Ivančić N. – osmišljavanje studije, prikupljanje i analiza podataka, pisanje rada/*concept of research, data collection and analysis, writing paper*

Negovetić Vranić D., Majstorović M, Gržić R. – pretraživanje literature, pisanje rada/*literature search, writing paper*

Vukić Lušić D., Blečić E. – prikupljanje i analiza podataka/*collecting and data analysis*

SUKOB INTERESA/*CONFLICT OF INTEREST*

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SAŽETAK

Mogućnosti provedbe fluoridacije zuba s obzirom na koncentraciju fluora u vodi za piće Primorsko-goranske županije

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Cilj ovog rada bio je istražiti kolike su koncentracije fluora u vodi za piće u Primorsko-goranskoj županiji, te na temelju tih podataka dati smjernice o mogućnostima fluoridacije na ovom području. Podatci o koncentraciji fluora u vodi za piće ispitivali su se u Zdravstveno ekološkom odjelu Nastavnog zavoda za javno zdravstvo Primorsko-goranske županije. Koncentracija fluora mjerila se ionskom kromatografijom. Postotak stanovništva priključenog na sustav javne vodoopskrbe u Primorsko-goranskoj županiji je oko 96%, što je znatno više od prosjeka u ostatku zemlje (74%). Sustav javne vodoopskrbe u Primorsko-goranskoj županiji organiziran je kroz 9 vodoopskrbnih sustava. Prosječna koncentracija fluora izmjerena u vodoopskrbnim sustavima Primorsko-goranske županije kroz petogodišnje razdoblje iznosi: Rijeka 0.010 mg F^-/l, Opatija 0.020 mg F^-/l, Crikvenica - Novi Vinodolski 0.007 mg F^-/l, Delnice 0.029 mg F^-/l, Vrbovsko 0.038 mg F^-/l, Čabar 0.031 mg F^-/l, Krk 0.044 mg F^-/l, Cres – Lošinj 0.054 mg F^-/l, Rab 0.090 mg F^-/l. U sustavu javne vodoopskrbe Primorsko-goranske županije ne provodi se umjetna fluoridacija pitke vode. Koncentracija fluora u vodi je niska i kreće se od <0.002 mg F^-/l u Opatiji do 0.220 mg F^-/l na Rabu s prosječnom vrijednšću od 0.034 mg F^-/l. S obzirom na količinu fluora u vodi za piće može se nesmetano fluoridirati drugim sredstvima za fluoridaciju u individualno prilagođenim dozama.

Ključne riječi: fluor; fluoridacija; voda za piće; zubni karijes