Original Article

Effect of Drinking Water Fluoride on Gingivitis and Caries: A Study in Peat and Non-Peat Land: A Comparative Cross-Sectional Study

Sri Rezki[1,2], Sunardi Sunardi[1], Dudi Aripin[3], Khayan Khayan[4], Pawarti Pawarti[2], Aisya Rezki Noeriman[5]

[1]Doctor Programme of Environmental Science, Padjadjaran University, Bandung, Indonesia, [2]Department of Dental Nursing, Pontianak Health Polytechnic, Pontianak, Indonesia, [3]Department of Conservative Dentistry, Faculty of Dentistry, Padjadjaran University, Bandung, Indonesia, [4]Department of Medical Laboratory, Banten Health Polytechnic, Serang, Indonesia, [5]Department of Medical Science, Tanjungpura University, Pontianak, Indonesia

Received : 24-08-23
Revised : 08-11-23
Accepted : 23-11-23
Published : 27-12-23

ABSTRACT

Aim: Humans get fluoride from food and water available in their environment. The source of clean water in peatlands comes from rainwater with a low mineral content, especially fluoride. The objective of this study was to investigate the correlation between the fluoride level in drinking water and salivary fluoride levels, as well as their potential impact on dental and oral health conditions. **Materials and Methods:** It is a causal-comparative study with a cross-sectional approach at the Health Polytechnics of Pontianak and Yogyakarta. The population were indigenous people in peat land (Pontianak) and non-peat land (Yogyakarta). The data were pH and mineral content in drinking water, saliva, the number of *Streptococcus mutans* colonies, dental caries rates, and gingivitis. **Results:** Drinking water fluoride is only significantly correlated with salivary fluoride on non-peat land. If these data are combined, it can be seen that drinking water fluoride is positively correlated ($P < 0.05$; CI 95%) with pH water, fluoride water, and pH saliva. Increased levels of fluoride in drinking water were negatively correlated with gingivitis, dental caries, and *S. mutans*. **Conclusion:** Drinking water fluoride is negatively correlated with dental caries and gingivitis in peatland and non-peatland communities, but would be significantly associated with dental caries and gingivitis if both peatland and non-peatland data were analyzed together. This is due to the low content of fluoride in the drinking water of peatland. Therefore, it is necessary to add fluoride gel to the teeth to prevent the development of dental caries.

KEYWORDS: *Dental caries, drinking water fluoride, gingivitis, salivary fluoride*

INTRODUCTION

Drinking water sources are a vital need for society. Consumption water needs are obtained from available clean water such as groundwater. Peat soils have peat water which is characterized by high organic content, and odor, with high concentrations of iron and manganese (Mn).[1] So peat water is not suitable for consumption.[1,2] Rainwater is a better drinking option. The mineral content of drinking water will be influenced by the water source chosen.

Fluoride is a mineral that dissolves in water, affecting the strength of teeth in facing dental caries attacks. Fluoride levels affect the strength of teeth to withstand the demineralization process caused by a chemical process between bacteria and sucrose.[3]

The Global Oral Health Data Bank survey revealed that the prevalence of dental caries ranges from 49% to 83%. Adolescents aged 12 to 19 years have the highest prevalence of dental caries.[4] The 2018 Riskesdas

Access this article online
Quick Response Code:
Website: https://journals.lww.com/jpcd
DOI: 10.4103/jispcd.JISPCD_127_23

Address for correspondence: Mrs. Sri Rezki, Department of Ecology and Environmental Science, Padjadjaran University, Bandung, Jalan RE. Martadinata No. 27B, Pontianak, Kalimantan Barat 78115, Indonesia.
E-mail: sri20016@mail.unpad.ac.id

How to cite this article: Rezki S, Sunardi S, Aripin D, Khayan K, Pawarti P, Noeriman AR. Effect of drinking water fluoride on gingivitis and caries: A study in peat and non-peat land: A comparative cross-sectional study. J Int Soc Prevent Communit Dent 2023;13:509-15.

showed that in West Kalimantan Province an average of 49.55% of the population suffers from dental caries, 17.36% of rural communities experience gingivitis, and 16% of West Kalimantan residents suffer from bleeding gums.[5] This study aims to determine the relationship between fluoride in drinking water and fluoride in saliva, as well as their relationship with dental caries and gingivitis.

Materials and Methods

Population and samples

This research is a comparative causal research with a cross-sectional approach. The research was conducted in Pontianak and non-peat peatlands in Yogyakarta, from April to July 2022. The population in this study were first-year students of the Pontianak Health Polytechnic (48 students) and the Yogyakarta Health Polytechnic (30 students) aged 17–27 years, who are indigenous people and has lived all their life in the research area. The sampling technique is the purposive sampling method. Inclusion criteria include indigenous people who were the focus of this research and did not suffer from any systemic disease or infection during the study.

The samples collected from respondents are drinking water samples from sources they usually consume (250 ml per respondents), saliva of the respondents, and the intra-oral health data of the respondents. Respondents were advised to not eat any food 2 hours prior and to drink water from their usual drinking water sources. The saliva was then collected for 5 min with the non-stimulating method in a sterile pot. The drinking water and saliva samples would be analyzed for their mineral content and pH by pH meter and Fluoride Low Range Tool (HI729). The saliva was diluted to a concentration of 10% before the procedure [Figure 1].

Fluoride concentration is assessed by the ratio number. Grouping of measured fluoride concentrations was carried out into four groups. Fluoride concentrations <0.1 are categorized as very low; 0.1–0.5 mg/L as low; 0.5–1.5 mg/L as sufficient; and >1.5 mg/L as high.

The saliva samples would be also analyzed for its potential colonies of bacteria by culturing the saliva on TYS20B media. The target bacteria were *Streptococcus mutans*. The saliva (1 mL) was centrifuged and the sediment (100 ul) was cultured by pour plate method on the media. The culture was incubated in anaerobe condition, at a temperature of 37°C for 24 h before the data of *Streptococcus mutans* colonies were obtained [Figure 2].

Figure 1: pH Meter and Fluoride Low Range Tool (HI729) Kit. pH Meter (left) and Fluoride Low Range Tool (HI729) (right) Kit was used for analyzing the mineral contents and pH of drinking water and diluted saliva in this study

Respondents' intra-oral health data was collected in the form of active dental caries and gingival index (GI). The gingival index was obtained by oral examination of the gingiva surrounding teeth 16 and 26 in the buccal area, teeth 11 and 31 in the labial area, and teeth 36 and 46 in the lingual area. The examination is described based on the condition of the gingiva and given a score of 0 to 3 [Table 1]. The gingival index is calculated based on the formula below. The formula score will be classified into four groups indicating the severity of gingival inflammation [Table 2][6,7]:

$$\text{Gingival Index} = \frac{\text{Total gingival score}}{\text{Total teeth index} \times \text{total teeth surface}}$$

Data analysis

The normality test, Kruskal–Wallis, and Spearman correlation test using SPSS v.27 software all served as data analysis methods. The data were tested for normality with the Kolmogorov-Smirnov method but the result showed the data distribution was not normal. The data were then classified as nonparametric data. Furthermore, the comparative analytic test was performed with Kruskal–Wallis and Spearman correlation (P = 0.05; CI 95%; df 47).

Result

Fluoride intake in this study was only related to drinking water sources, ignoring drinking water consumption

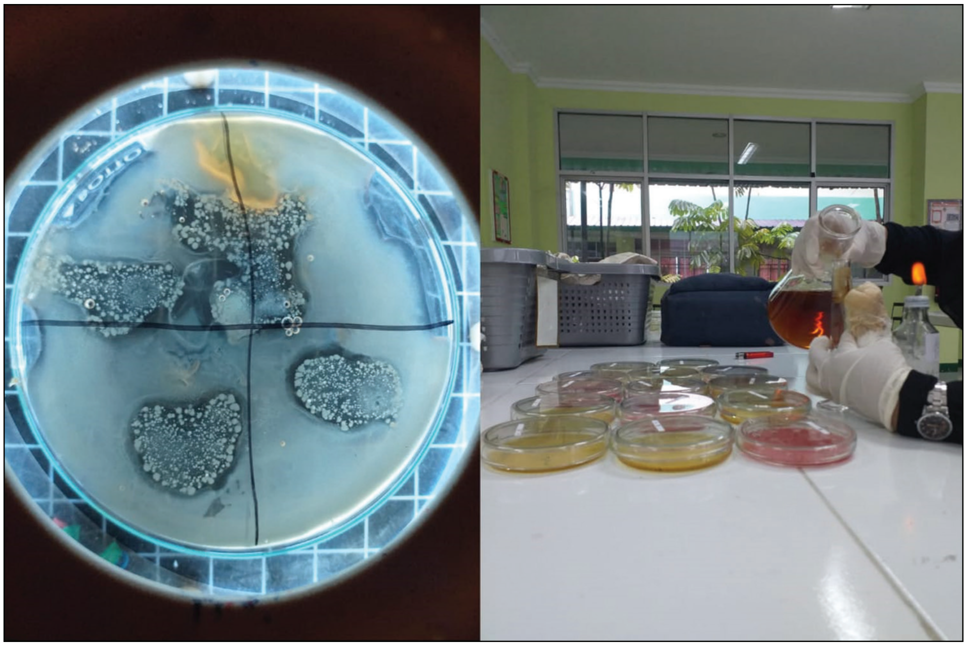

Figure 2: Culture of *Streptococcus mutans* on TYS20B Media. The saliva samples cultured on TYS20B media. The target bacteria were *Streptococcus mutans*. The saliva (1 ml) was centrifuged and the sediment (100 ul) was cultured by pour plate method on the media. The culture was incubated in anaerobe condition, at temperature of 37 degree of Celsius for 24 hours before the data of *Streptococcus mutans* colonies are obtained

Table 1: The gingival score[7]

Gingival Score	Description
0	Normal gingiva, absence of inflammation, no color alteration, and no hemorrhage
1	Mild inflammation, mild color alterations, mild edema, but no hemorrhage.
2	Moderate inflammation, redness in color, edema, and hemorrhage
3	Bright redness in color, edema, ulceration, vulnerable to spontaneous hemorrhage

Table 2: Gingival index classification[7]

Gingival index score	Criteria
0	Healthy
0.1–1.0	Mild inflammation
1.2–2.0	Moderate inflammation
2.1–3.0	Severe inflammation

outside the home and sources of fluoride in food. Water sources in West Kalimantan can be seen in Figure 3. Peat groundwater and river water are brown, while rainwater, tap water, and refill water (from non-peatland) are clear and more suitable for consumption.

The research results showed that the fluoride content in peat water was 0.06 mg/liter and non-peat water was 0.7 mg/L. Most drinking water in peatlands has very low fluoride levels (77%), so no cases of dental fluorosis were found [Figure 4]. Peatland respondents had an average of 5 carious teeth and a gingivitis index of 0.5.

In non-peat areas, drinking water fluoride levels are mostly distributed at medium-high levels (66%), with an average of 2 caries teeth, and a gingivitis index of 0.01 [Table 3].

The normality test results showed that the data was not normally distributed ($P > 0.05$) [Table 4]. The next test uses non-parametric tests. The results of the Kruskal–Wallis Test showed statistically significant differences ($P < 0.05$) between peat and non-peat soils in the pH and fluoride variables of drinking water; pH and fluoride content of saliva; dental caries, gingivitis, and *S. mutans*. Drinking water fluoride [Table 5] is significantly correlated with saliva. If these data are combined, drinking water fluoride is positively correlated ($P < 0.05$) with drinking water pH ($r_s = 0.358$), saliva fluoride ($r_s = 0.5640$) and saliva pH ($r_s = 0.543$).

The higher the fluoride content of water, the higher the saliva fluoride, drinking water pH, and saliva pH. Increased drinking water fluoride was negatively correlated ($P < 0.05$) with gingivitis ($r_s = -0.576$), dental caries ($r_s = -0.549$), and *S. mutans* ($r_s = -0.261$). The higher the fluoride, the lower the *S. mutans*, dental caries and gingivitis [Table 5]. Salivary fluoride was negatively correlated ($P < 0.05$) with gingivitis ($r_s = -0.441$), dental caries ($r_s = -0.411$), and *S. mutans* ($r_s = -0.172$). The higher the saliva fluoride, the lower the incidence of gingivitis, dental caries and *S. mutans* [Table 6].

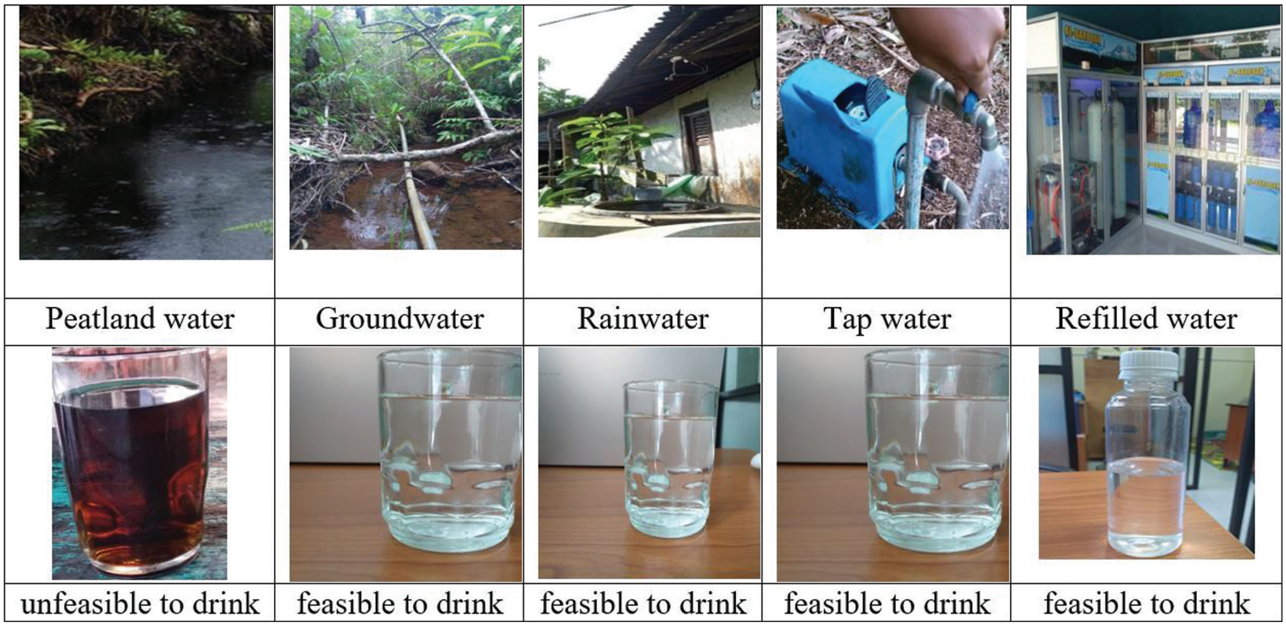

Figure 3: Drinking Water by Source in West Kalimantan. The physical appearance of drinking water from a variety of sources showed the differences in color and turbidity between peatland water and non-peatland water

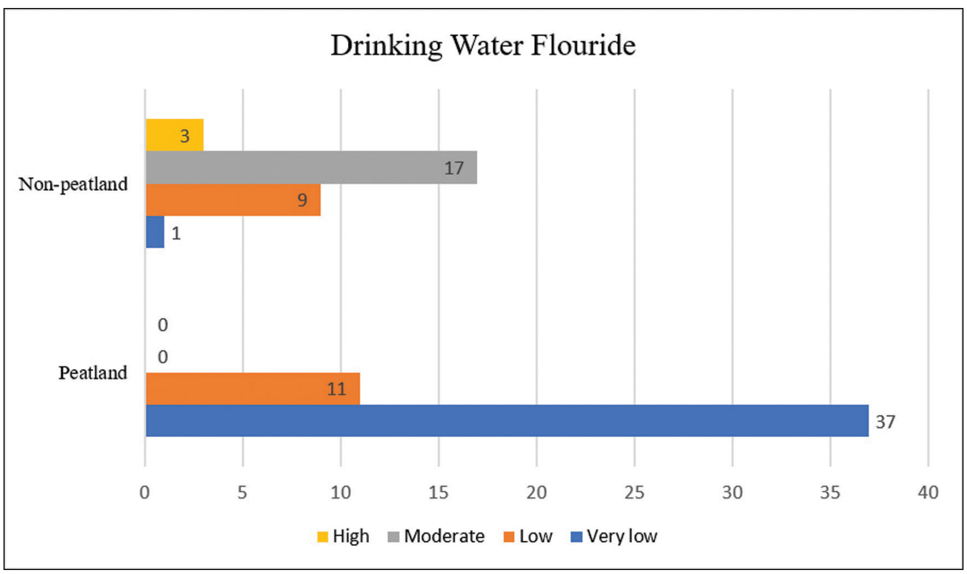

Figure 4: The variation of fluoride levels in drinking water between peatland and non-peatland. The chart illustrated variation of fluoride levels in drinking water between peatland and non-peatland. In non-peatland, drinking water fluoride level distributed mainly in moderate-high level (66%). Contrarily, most of drinking water in peatland have very low level of fluoride (77%) while the other samples have low level of fluoride. [Fluoride concentrations less than 0.1 mg/l are categorized as very low, 0.1-0.5 mg/l as low, 0.5-1.5 mg/l as moderate, and greater than 1.5 mg/l as high.]

Discussion

Peatlands have drinking water sources with very low fluoride content with an average of 0.06 mg/l, with a standard deviation greater than the average, this shows a large spread of data. Non-peat areas in Yogyakarta have an average drinking water containing fluoride of 0.766 mg/l, with good data distribution. Water sources from mountainous areas (Yogyakarta with an average height of 114 m above sea level) have higher water fluoride content than peat areas in Kalimantan (average height 1 meter above sea level). Fluoride concentrations in mountainous areas and areas with geological deposits of marine origin range from 0.8 to 1.4 mg/l.[8] Surface water has a low fluoride content, depending on geographical conditions, while ground water has a varying fluoride content.[9] In India, borehole water contains a fluoride concentration of 0.9 ppm, compared to company water of 0.48 ppm and bottled water of

Table 3: Description of the maximum, minimum and average values of research data

Variable	Sub-variable		Min	Max	Mean	Std. Deviation	95% Confidence Interval of the Difference	
							Lower	Upper
Drinking water	pH	Peatland	5.00	8.20	6.9667	0.68613	-1.01364	-0.38636
		Non-peatland	7.00	9.00	7.6667	0.66089		
	Fluoride	Peatland	0.00	0.38	0.0614	0.10164	-0.88811	-0.52185
		Non-peatland	0.08	2.00	0.7663	0.48493		
Saliva	pH	Peatland	6.00	7.00	6.6042	0.4942	-0.99086	-0.53414
		Non-peatland	7.00	8.00	7.3667	0.49013		
	Fluoride	Peatland	0.00	63.26	9.1671	9.27087	-9.27859	-2.01391
		Non-peatland	3.70	20.00	14.8133	4.65053		
Dental caries	Dental caries	Peatland	0	12	4.48	2.76	2.375	4.184
		Non-peatland	0	5	1.2	1.186		
Gingivitis	GI	Peatland	0.00	1.67	0.4958	0.42944	0.35899	0.61046
		Non-peatland	0.00	0.25	0.0111	0.04634		
S. mutans	*S. mutans*	Peatland	6.0	351.5	125.073	82.4368	-10.0676	66.2301
		Non-peatland	13.0	301.5	95.950	86.2146		

cfu/ml = colony-forming unit/ mililitre, GI = gingival index

Table 4: The results of the analysis of the mean difference and the normality test

Variable	Sub-variable	Kolmogorov-Smirnov Test	Kruskal Wallis	
		Sig. (p value <0.05)	Kruskal–Wallis H	Sig (p value <0.05)
Drinking water	pH	0	13.670	0.002
	Fluoride (mg/L)	0.001	52.892	0
Saliva	pH	0	27.795	0
	Fluoride (mg/L)	0.183	23.41	0
Dental caries	Decay	0.001	25.482	0
Gingivitis	Gingivitis	0	35.293	0
Bacteria	S. mutans (cfu/ml)	0.002	4.288	0.038

cfu/ml = colony-forming unit/ milliliter

Table 5: Relationship between drinking water fluoride with drinking water pH, salivary pH and fluoride, *S. mutans*, dental caries and gingivitis

V.independent	V.dependent	Peat		Non-peat		Combination	
		rs	Sig	*rs*	Sig	*rs*	Sig
Drinking water fluoride	Drinking water pH	0.089	0.549	0.113	0.553	0.380**	0.001
	Fluoride saliva	0.199	0.175	.467**	0.009	0.564**	0.00
	Salivary pH	0.073	0.622	0.216	0.252	0.543**	0.00
	S. mutans	-0.160	0.277	-0.005	0.980	-0.261*	0.021
	Dental caries	-0.207	0.158	0.152	0.423	-0.549**	0.00
	Gingivitis	0.030	0.840	-0.074	0.696	-0.576**	0.00

$r_{s=}$ coefficient corelation spearmann

0.2 ppm.[10] Regular consumption of fluoridated water reduces the prevalence of dental caries.[11]

The very low fluoride content (0.061 mg/l) is below the optimal value (0.5 – 1.5 mg/l, has no effect on the fluoride content in saliva (9.16 mg/l), causing an increase in the number of *S. mutans,* dental caries and gingivitis. Non-peat areas with optimal water fluoride content (0.76 mg/l), correlated with saliva fluoride, dental caries and gingivitis. The results of research with combined data show that drinking water containing fluoride has a fairly close relationship with fluoride in saliva (r_s = 0.564), water pH (r_s = 0.482), and has an inverse relationship with *S. mutans* (r_s =-0.261), dental caries (r_s = -.549) and gingivitis (r_s = -.576).

Saliva fluoride was significantly associated with saliva pH, in the opposite direction to dental caries and gingivitis, but was not associated with *Streptococcus mutans.*

Water fluoride with a concentration exceeding 1.0 mg/L reduces the risk of dental caries in permanent teeth,

Table 6: Relationship between salivary fluoride with dental caries, gingivitis, and *S. mutans*

Variable independent	Variable dependent	Peatland		Non-peatland		Combination	
		rs	Sig	*rs*	Sig	*rs*	Sig
Salivary fluoride	Dental caries	0.061	0.678	0.058	0.760	-.411**	0.00
	S. mutans	-0.066	0.654	0.186	0.326	-0.172	0.131
	Gingivitis	-0.054	0.717	-0.081	0.671	-.441**	0.00

$r_{s=}$ coefficient corelation spearmann

but if there is excess fluoride there is a risk of dental fluorosis.[8,12] Fluorosis increases in people who drink well water and when fluoride is added to drinking water.[13,14] In this study, no cases of fluorosis were found because the fluoride content in the water was low. Fluoridated water can reduce dental caries by 50-70%, reducing the risk of dental caries in primary teeth.[9,15,16] Fluorine has F- ions, which naturally occur in the form of fluoride molecules. Surface water generally has relatively low fluoride contents, below 1.5 mg/L, but groundwater may have high fluoride levels.[17] It can be concluded that the non-peat area (Yogyakarta) has a higher fluoride mineral content.

Drinking water sources in peatlands come from surface water (river water) and space water (rainwater) with an average fluoride content of 0.06 mg/l which correlates with high dental caries rates. Fluoride can be obtained from other sources such as food and toothpaste, this causes saliva fluoride to be higher than in drinking water. However, because the fluoride content in drinking water is low, the function of fluoride on tooth structure is not optimal. Fluoride is found in blood and teeth and is associated with dental caries.[18] Dental caries occurs when the pH is low resulting in demineralization accompanied by low saliva fluoride. Water with optimal fluoride content is correlated with low levels of dental caries.[19,20] The fluoride content in water affects the pH of the water. In this study, an increase in water fluoride concentration was followed by an increase in fluoride in saliva and saliva pH. Normal metabolism requires a normal and slightly alkaline pH in the body. Normal plasma pH ranges between 7.35 and 7.45, which is slightly alkaline.[21]

There is a relationship between fluoride from water and dentin.[22] Fluoride ions are antimicrobial, so they can reduce the number of bacteria that cause dental caries and gingivitis.[23] The results of the research show that the causes of gingivitis in peatlands are the presence of calculus on the necks of the teeth, a lack of fluoride in saliva, and the viscosity of saliva, which causes dirt on the necks of the teeth to stick and cause irritation to the gingiva. Gingivitis is also influenced by socio-economic conditions, oral hygiene status and oral health behavior.[24] West Kalimantan's peatlands have drinking water sources that are low in fluoride, so efforts to add fluoride are necessary. Fluoride can be obtained from food intake, adding fluoride to drinking water, toothpaste, salt.1[2] The American Dental Association (ADA) recommends 0.7 mg/l fluoride in water, in a stable concentration.[10,25] Further research is needed to find ways to overcome fluoride deficiency in society, other than adding fluoride.

A limitation of this study is that it did not link water fluoride to the incidence of fluorosis. Fluoride intake only calculates the fluoride content in drinking water, without taking into fluoride intake from other sources. This research has a small sample size because it was carried out at the end of the Covid-19 pandemic, so it was only carried out on a population that had been screened so that they did not suffer from Covid-19 infection. Apart from that, it is difficult to get a large number of saliva samples at one time, so saliva fluoride examination uses a Low Range Fluoride (HI729) tool which requires a small number of samples.

Conclusion

Peatlands have very low water fluoride content, so they do not correlate with dental caries, gingivitis, *S. mutans*, pH and salivary fluoride. Drinking water fluoride on non-peat land is at optimal levels, so it is positively correlated with saliva fluoride. By combining peat and non-peat land data, it was found that drinking water fluoride was significantly related to dental caries, gingivitis, *S. mutans*, pH and salivary fluoride.

Acknowledgment

We acknowledge the support and contribution of Padjajaran University Bandung, Pontianak Health Polytechnic, and Yogyakarta Health Polytechnic to this study.

Financial support and sponsorship

Financial funding was provided solely from institutional and/or departmental sources.

Conflicts of interest

There are no conflicts of interest.

Authors' contributions

Study conduct: S.R.

Writing paper: S.R., P.

Proofreading: A.R.N.

Revising paper: all authors.

Ethical policy and institutional review board statement

Informed consent of the participants was obtained by written consent and the study protocol was approved by the appropriate Committee for the Protection of Human Participants, the Health Research Ethics Committee (HREC) of Pontianak Health Polytechnic, Indonesia. The Health Research Ethics Committee states that the protocol of this study meets the ethical principle outlined in the Declaration of Helsinki 2008. The ethic approval was listed in No. 65/KEPK-PK. PKP/IV/2022, dated April 11, 2022.

Patient declaration of consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity.

Data availability statement

The data set used in this study are available on request from corresponding author.

References

1. Ali F, Lestari D, Putri M. Peat Water Treatment as an Alternative for Raw water in Peatlands Area. IOP Conf Ser Mater Sci Eng 2021;1144:012052.
2. Said YM, Yudi A, Zahar W, Wibowo YG. Karakteristik Fisika dan Kimia Air Gambut Kabupaten Tanjung Jabung Barat, Provinsi Jambi. J Sains dan Teknol Lingkung (Physical and Chemical Characteristics of Tanjung Jabung, Jambi Province) 2019;11:132-42.
3. Puspa Dewi SR, Safitri Y, Lany EV, Dwi RS. Gambaran Kadar Fluorida Dalam Air Minum Dan Skor Dmf-T Anak 12 Tahun Di Sungai Pedado Palembang (Picture of fluoride levels in drinking water and Dmf-T score for 12 year old in the river Pedado Palembang). J Ris Kesehat 2019;8:68.
4. Rathee M, Amit S. Dental Caries - StatPearls - NCBI Bookshelf [Internet]. 2020. p. 1–7. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551699/
5. Kementerian Kesehatan RI. Laporan Nasional Riskesdas 2018 (National Risk Report 2018), Report for Ministry of Health Indonesia. 2018.
6. Moradi G, Mohamadi Bolbanabad A, Moinafshar A, Adabi H, Sharafi M, Zareie B. Evaluation of Oral Health Status Based on the Decayed, Missing and Filled Teeth (DMFT) Index. Iran J Public Health 2019;48:2050-7.
7. Ayan G, Dayı B. Evaluation of plaque index, gingival index and oral health-related quality of life in obese patients. Odovtos 2023;25:166-78.
8. Revelo-Mejía IA, Gutiérrez-Idrobo R, López-Fernández VA, López-Rosales A, Astaiza-Montenegro FC, Garcés-Rengifo L, *et al*. Fluoride levels in river water from the volcanic regions of Cauca (Colombia). Environ Monit Assess 2022;194:327.
9. Chaulagain R, Chhatkuli A, Shrestha AR, Chhetri BK, Pandey S. Mean Fluoride Concentration in Drinking Water Sources of a Municipality: A Descriptive Cross-sectional Study. JNMA J Nepal Med Assoc 2022;60:947-51.
10. Mishra S, Kannan S, Manager C, Statistics A, Comments R, Alert E. Get started now. Indian J Occup Int Med 2019;23:8-13.
11. Çakır A, Şahin TN. Evaluation of the impact of fluoride in drinking water and tea on the enamel of deciduous and permanent teeth. BMC Oral Health 2023;23:565.
12. Jullien S. Prophylaxis of caries with fluoride for children under five years. BMC Pediatr 2021;21:1-11.
13. Das G, Tirth V, Arora S, Algahtani A, Kafeel M, Alqarni AHG, *et al*. Effect of fluoride concentration in drinking water on dental fluorosis in southwest saudi arabia. Int J Environ Res Public Health 2020;17:3914-10.
14. Alshammari FR, Aljohani M, Botev L, Lucy O, Marie A. Dental fluorosis prevalence in Saudi Arabia. Saudi Dent J 2021;33:404-12.
15. Jones C. Water fluoridation in Scotland. Br Dent J 2022;233:167.
16. Melough MM, Sathyanarayana S, Zohoori FV, Gustafsson HC, Sullivan EL, Chi DL, *et al*. Impact of Fluoride on Associations between Free Sugars Intake and Dental Caries in US Children. JDR Clin Transl Res 2022;8:215-23.
17. Akuno MH, Nocella G, Milia EP, Gutierrez L. Factors influencing the relationship between fluoride in drinking water and dental fluorosis: A ten-year systematic review and meta-analysis. J Water Health 2019;17:845-62.
18. Fatmasari D, Budihardjo T, Shobirun, Macdonalds KF. Increase of Fluoride Concentration on Mice Blood Plasma and Teeth after Consuming Bottled Water Fluoridation. J Int Dent Med Res 2021;14:105-8.
19. Sejdini M, Meqa K, Berisha N, Çitaku E, Aliu N, Krasniqi S, *et al*. The Effect of Ca and Mg Concentrations and Quantity and Their Correlation with Caries Intensity in School-Age Children. Int J Dent 2018;2018. Article ID 2759040, 8 pages.
20. Foley MA, Sexton C, Spencer AJ, Lalloo R, Do LG. Water fluoridation, dental caries and parental ratings of child oral health. Community Dent Oral Epidemiol 2022;50:493-9.
21. LeBaron TW, Sharpe R, Ohno K. Electrolyzed–Reduced Water: Review I. Molecular Hydrogen Is the Exclusive Agent Responsible for the Therapeutic Effects. Int J Mol Sci 2022;23:14750.
22. Razvan C, Popa M, Incze A-M, Cristina C. The correlation between the mineral drinking water composition and the relevance of dentine in health - A pilot study. Pakistan J Med Sci 2020;36:349-54.
23. Moran GP, Zgaga L, Daly B, Harding M, Montgomery T. Does fluoride exposure impact on the human microbiome? Toxicol Lett 2023;379:11-9.
24. Kyaw Myint ZC, Zaitsu T, Oshiro A, Ueno M, Soe KK, Kawaguchi Y. Risk indicators of dental caries and gingivitis among 10−11-year-old students in Yangon, Myanmar. Int Dent J 2020;70:167-75.
25. Motohashi J, Taguchi C, Song W, Kawamura K, Arakawa H, Kawagoe M, *et al*. Development of small-scale water fluoridation equipment. J Oral Sci 2022;64:283-5.