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# Differences in Fluoride Content of Drinking Water in Mountain and Coastal Communities

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**ABSTRACT**

*Dental and oral health are essential components of overall health. One of the common dental issues is dental fluorosis, which results from excessive fluoride exposure during tooth development. Such exposure often originates from drinking water, particularly in areas with naturally high fluoride concentrations. Fluoride occurs in both surface and well water, but surface water typically contains lower fluoride levels. In contrast, the fluoride concentration in well water depends on several factors, including the geological, chemical, and physical characteristics of the aquifer, soil and rock porosity, acidity, temperature, chemical interactions among elements, and well depth. Previous studies have reported variations in fluoride levels between mountainous and coastal regions. This study aimed to determine differences in fluoride content in drinking water between mountainous and coastal communities. A comparative study design was used, with well water from Lahendong Village, South Tomohon District (mountainous area), and Meras Village, Bunaken District, Manado City (coastal area) as the population. The sample consisted of five water samples from each region, selected through purposive sampling. Fluoride levels were analyzed using a spectrophotometer. Results showed that the mean fluoride concentration in drinking water from mountainous areas was 0.108 mg/L, while in coastal areas it was 0.298 mg/L. Statistical analysis using an unpaired t-test indicated a significant difference (p < 0.05). The study concludes that fluoride content in drinking water from mountainous regions is significantly lower than that found in coastal areas, suggesting that geographical and geological conditions influence natural fluoride concentrations in groundwater.*

***KEYWORDS*** *Fluoride; drinking water; mountainous area; coastal area.*



## INTRODUCTION

Oral and dental health is an integral part of overall health. One common dental health problem is dental fluorosis, caused by excessive exposure to fluoride during tooth formation. Fluoride, while beneficial in preventing dental caries, can cause fluorosis if consumed excessively (Barker et al., 2016; Jones & Jones, 2021). Dental fluorosis is characterized by discoloration and white spots on tooth enamel. (Grover, 2019) Excessive fluoride exposure generally comes from drinking water, especially in areas with high levels of natural fluoride. Poor water quality is also associated with an increased risk of dental caries. Contaminated water or water with suboptimal mineral content worsens dental and oral health (Brown et al., 2020; Chakraborty et al., 2019; Eisenburger & Addy, 2002a; Indonesia, 2018; Organization, 2021; Ten Cate, 2013).

Fluoride, a mineral commonly found in water, plays a dual role in dental health. At the right levels, fluoride can help prevent tooth decay by strengthening enamel and inhibiting the activity of bacteria that cause tooth decay. Fluoride deficiency can lead to brittle teeth and susceptibility to caries (Aoba, 2004; Fejerskov & Kidd, 2015). However, excessive fluoride exposure can lead to dental fluorosis, a disorder of tooth enamel caused by impaired mineralization. Fluorosis can cause aesthetic changes and structural tooth damage, potentially reducing an individual's quality of life (Arifin & Handayani, 2020; Chae et al., 2015; *Counseling of Fluorosis, Utilization, and Clearance of Fluor in Water, Desa Mojosari Kecamatan Asembagus Kecamatan Situbondo*, 2024; Edmunds & Smedley, 2013; Eisenburger & Addy, 2002b; McLaren et al., 2018a).

According to the World Health Organization (WHO), a safe concentration of fluoride in drinking water is between 0.7 and 1.5 ppm (parts per million). This concentration helps prevent caries and maintains dental health by strengthening tooth enamel (Fejerskov et al., 2015; Harris et al., 2014; O. Selinus et al., 2012; Summitt et al., 2013).

Indonesia, as an archipelagic country, has extensive geographic variation, including mountainous and coastal areas (Goodarzi et al., 2016; Rahayu, 2015; Ritter, 2019; Sumiok, 2015). These geographic conditions influence the supply and sources of drinking water available (Novita, 2024). Differences in the fluoride content of drinking water between communities living in mountainous and coastal areas contribute to variations in the prevalence of dental fluorosis. (McLaren et al., 2018b) Mountain water can have different fluoride levels than coastal water, where geological factors such as volcanic activity and water salinity can contribute to increased fluoride concentrations. (Smith et al., 2020) Fluoride-contaminated drinking water sources have the potential to increase the risk of fluorosis in local residents.

In Indonesia, fluoride levels in drinking water have been found to vary between mountainous and coastal areas (Isyani, 2023; Press, 2018). Therefore, research into differences in drinking water quality and their impact on dental fluorosis incidence is important. (McLaren et al., 2018b) A better understanding of the differences in water fluoride content in these two regions could aid in dental fluorosis prevention efforts and improve public dental health.

According to data from the Ministry of Health of the Republic of Indonesia (2018), the prevalence of fluorosis in several regions shows a worrying trend, especially in areas with non-standardized water sources (Sumiok, 2015).

This study aims to determine the differences in fluoride content between the drinking water of mountain communities in Lahendong Village, South Tomohon District, Tomohon City, and the drinking water of coastal communities in Meras Village, Bunaken District, Manado City. This research is expected to provide a deeper understanding of how differences in fluoride content in water can be influenced by geographic factors and provide recommendations for improving drinking water management.

## METHOD

This study used a true experiment design to determine the differences in fluoride levels in drinking water in communities living in mountainous and coastal areas. This difference is likely due to geographic location.

The population in this study: mountain and coastal well water. These areas are Lahendong Village, South Tomohon District, Tomohon City, and Meras Village, Bunaken District, Manado City.

Mountainous area population: Well water at an altitude of ,â•500 meters above sea level.

Coastal population: Well water in lowland areas near the coast, with an altitude of ,â§100 meters above sea level

The sample was selected using cluster sampling (the population is divided into clusters based on geographical areas, then several clusters are randomly selected and all members of the selected clusters are sampled). from well water in Lahendong Village, South Tomohon District, Tomohon City and Meras Village, Bunaken District, Manado City.

The sample size of this study was determined by cluster sampling, with 5 (five) water samples each from the mountainous area (Lahendong Village) and 5 (five) water samples from the coastal area (Meras Village). The determination of the number of samples was based on the availability of community water wells and the availability of laboratory testing facilities.

The independent variables in this study are mountain and coastal communities. Geographical locations are categorized into mountainous areas, namely areas at an altitude of ,â• 500 meters above sea level and coastal areas at an altitude of ,â§ 100 meters above sea level. Geographic location is used as the basis for dividing sample groups to analyze their differences.

The dependent variable in this study is fluoride content in drinking water. Drinking water is measured in mg/L. Measurements were conducted on water samples taken from wells in mountainous and coastal areas. Fluoride content was measured spectrophotometrically at the Ministry of Health's Manado Public Health Laboratory.

**Table 1. Operational Definition**

| How to Measure | Measuring instrument | Measurement Results | Measuring Scale |
|---|---|---|---|
| Using *spectrophotometry* | Spectro-photometer | Normal value ≤ 1.5 mg/ l<br>High score ≥ 1.5 mg/ l | Ratio |
| Water Well Population | Using numbers and units | Well Unit | Ratio |
| Water Well Population | Using numbers and units | Well Unit | Ratio |

Tools and materials for water sampling were 1-liter sample bottle made of polyethylene, bucket with rope, funnel, label stickers, pen/marker, gloves, face mask, laboratory coat, and spectrophotometer.

Data were collected in stages:

1) Water Well Determination Water wells used in each community were identified.
2) Preparation of Tools and Materials A polyethylene sample bottle was prepared. Label stickers, a pen/marker, a funnel, gloves, a mask, and a lab coat were provided. A bucket was also prepared.
3) Water Sampling. Water sampling was carried out directly at the well site. A bucket was used to facilitate water collection. The water was transferred from the bucket to a bottle using a funnel. The bottle was filled to the brim with no air space to prevent oxidation. The bottle was immediately tightly closed and sealed, and labeled with the location code, collection date, and time. Each well sample was documented. Samples were immediately sent to the laboratory within 24 hours of collection to prevent water sample alteration.

Sample examination was conducted at the Manado Public Health Laboratory Center, Ministry of Health, Directorate General of Primary and Community Health. Fluoride level examination was conducted using a spectrophotometer with the SPADNS method (Sodium 2-(4-sulfophenylazo)-1,8-dihydroxynaphthalene-3,6-disulfonate). In fluoride analysis, SPADNS reacts with fluoride ions to form a complex compound that absorbs light at a certain wavelength, so that its levels can be measured quantitatively using a spectrophotometer (B. L. K. M. Manado, 2025).

Fluoride analysis using the SPADNS (Sodium 2-(4-sulfophenylazo)-1,8-dihydroxynaphthalene-3,6-disulfonate) reagent involved several steps:

1) Preparation of SPADNS solution: SPADNS powder was dissolved in water.
2) Preparation of zirconyl-acid reagent: Zirconyl chloride solution was combined with hydrochloric acid and dissolved in water.
3) Mixing: The SPADNS solution and zirconyl-acid reagent were mixed in a specified ratio.
4) Preparation of blank solution: The blank solution was prepared by mixing water with the SPADNS–zirconyl-acid reagent.
5) Sample analysis: Water samples containing fluoride were combined with the SPADNS–zirconyl-acid reagent, and the absorbance was measured using a spectrophotometer.
6) Determination of content: The absorbance of each sample was compared with the absorbance of the standard solution to determine the fluoride content.

The values obtained were converted to mg/L and compared with the safe limits recommended by the WHO.

The data analysis technique used was the unpaired t-test (Independent Samples t-test), which was employed to compare the mean fluoride content in drinking water between mountain and coastal communities, as it is designed to compare the means of two independent, unrelated groups.

Important research ethics included: respecting the rights of the research subjects, avoiding harm to them, using valid and reliable research methods, and reporting research results honestly and transparently. Each research subject received clear information about the research objectives, and permission to conduct the research was obtained from local village and sub-district officials. Subject data were kept confidential and used solely for research purposes.

## RESULT AND DISCUSSION

1. Research Location Overview

Lahendong Village, South Tomohon District, Tomohon City has a cool air temperature and there are 4 (four) mountains surrounding the residential area. The mountains in question are: Mount Lokon (1,579.6 m above sea level) active type, Mount Tampusu (1,500.0 m above sea level), Mount Tatawiran (1,474.0 m above sea level) and Mount Mahawu (1,33.0 m above sea level). From a geographical aspect, Tomohon City has a cool temperature because it is located in a mountainous area. Located at 01 $^{o}$ 18 '51" North Latitude and 124 $^{o}$ 49' 40" East Longitude; has an area of 147.21 km $^{2}$ and is at an altitude of 400-1500 m above sea level with a temperature range of 18 $^{o}$ c-30 $^{o}$ c. With mountainous and hilly topographic characteristics.

The altitude of the area in South Tomohon District is 780 m above sea level. Geologically, the South Tomohon region has a geological nature reserve located in Lahendong Village. This geological nature reserve has unique geological processes, namely the emergence of solfataras and fumaroles, hot water or steam (*fluids*).

Lahendong Village (Figure 3), South Tomohon District, Tomohon City, consists of eight neighborhoods, with a population of 2,416. Of these, 1,272 are male and 1,189 are female (Tomohon, 2016, 2025).

**Figure 4. Lahendong Sub-district Office**

Nearly every household has a water well. Data collection revealed 18 wells still used for water consumption. However, only five of these wells still use buckets for water collection, while the other 13 use pumps.

Meras Village (Figure 4), Bunaken District, Manado City Bunaken District is one of the districts in Manado City. It is directly bordered by North Minahasa Regency to the north, Tuminting District to the east, Tuminting District to the south, and the Manado Sea to the west. The area of Bunaken District is 36.19 km2 or 26% (percent) of the total land area of Manado City. The topography of Bunaken District is plains and hills. On average, the Bunaken District is at an altitude of 3 meters above sea level (P. K. Manado, 2016).

**Figure 5. Meras Sub-district Office**

2. Sample Characteristics

The samples used in this study: 5 water wells in mountainous areas and 5 water wells in coastal areas (Table 1).

**Table 2. Number of Water Wells by Location**

| Location | Number of Wells (points) |
|---|---|
| Lahendong Village Mountains | 5 |
| Meras Village Coastline | 5 |

3. Results of Flour Content Measurement using Spectophotometry.

The working method used to determine the fluorine content uses the SPADNS spectrophotometric method, based on the reaction of fluorine and zirconium color absorption. Fluorine reacts with zirconium color absorption to form a colorless complex anion ZrF6. The higher the concentration of fluorine in the solution, the reduction in the absorption of the SPADNS reagent complex causes its absorption value to decrease. The SPADNS reagent, which was originally red, becomes faded and tends to become orange along with the increase in the number of reacting fluorine ions, thus its absorption value in observations in the visible light region also decreases.

Working steps for determining fluorine through the spectrophotometric method applied at the Manado Public Health Laboratory Center (BLKM) is as follows:

1. In the pipette, 25 ml of sample is then put into the Erlenmeyer flask.
2. Added 10 ml of SPADNS-ZIRCONYL ACID mixed solution
3. Mix until homogeneous
4. Read with a spectrometer with a wavelength of 570 nm with a blank reference. is a solution used as a comparison or reference to measure the absorbance or transmittance of a sample. A blank reference is usually a solution that does not contain the analyte or substance to be measured, but has the same conditions as the sample, such as solvent, pH and temperature) (Irawan, 2019).

Based on the results of testing well water from mountainous and coastal locations (Table 2), each of the 5 samples tested obtained the following results:

**Table 2. Results of Fluoride Level Testing in Well Water in Mountains and Coastal Areas**

| Water Well (Point) | Fluoride content | |
|---|---|---|
| | Mountains (mg/L) | Coast (mg/L) |
| 1 | 0.04 | 0.27 |
| 2 | 0.1 | 0.31 |
| 3 | 0.17 | 0.28 |
| 4 | 0.12 | 0.26 |
| 5 | 0.11 | 0.37 |
| Average | 0.108 | 0.298 |

Based on the results of fluoride level testing in Table 2, it shows that the average fluoride level in mountainous locations is 0.108 mg/L and in coastal locations the average is 0.298 mg/L. Therefore, it can be concluded that all 10 drinking water samples are still within the normal threshold value. This is in accordance with the quality standard provisions of the Regulation of the Minister of Health of the Republic of Indonesia No. 492/Menkes/Per/IV/2010, which states regarding drinking water quality requirements, that the fluoride content in drinking water must not exceed 1.5 mg/L.

4. Unpaired T-test results

The research data is said to be normally distributed and homogeneous, so the appropriate test for this study is the unpaired T-Test. The analysis used was the Independent Samples T-Test. This method compares the means of two independent sample groups (Table 3).

The following are the results of the unpaired T-Test.

**Table 3. Results of the unpaired *T-Test***

| Fluoride content | Significant Value ( ρ) |
|---|---|
| Mountains | < 0.05 |
| Coast | < 0.05 |

Table 3 shows that the results of the *T-Test* Unpaired test results indicate differences in clean water samples taken at two locations. Water samples at the mountainous location differ from those at the coastal location. The fluoride content from mountain water wells is lower than that from coastal water wells. The p-value < α(0.05), then H0 is rejected, which means there is a significant difference between the averages of the two groups.

**Discussion**

Based on Table 3, the results of fluoride measurements conducted at the Manado Public Health Laboratory (BLKM) show significant differences. The differences in fluoride content are due to the geological conditions and altitude above sea level. The fluoride content of community water wells in the mountains is lower than that of coastal wells.

Fluoride is an essential element for humans. According to the WHO (1971), fluoride levels are within safe limits, at around 0.5-1.5 mg/L. Consuming too much or too little fluoride can cause health problems. Fluoride enters the human body through drinking water. Mineral-rich rocks containing fluoride are the primary source of high levels of fluoride in groundwater. Granitic rocks generally contain a high proportion of fluoride-rich minerals. The interaction between fluoride-containing minerals and water is the primary process by which fluoride is found in groundwater. Weathering of rocks facilitates the release of fluoride from minerals when the rocks interact with water (Leondra et al., 2013; B. L. K. M. Manado, 2025; Rochmawati, 2012; Sharma et al., 2023).

Several geological factors that can influence the fluorine content in drinking water are:

1. Rock types: Igneous, sedimentary and metamorphic rocks have different characteristics in storing groundwater and fluoride content.
2. Geological structures: fractures, faults and folds can affect groundwater flow and fluoride content.
3. Rock porosity: rock porosity can affect the rock's ability to store groundwater and fluoride content.

Based on statistical tests conducted, there are differences in fluoride levels in mountain and coastal well water. The fluoride content of mountain well water is lower than that of coastal well water. High-quality fluoride levels in this context refer to fluoride levels that are safe and effective for preventing tooth decay, which are generally found in high-fluoride toothpaste and drinking water with levels that meet the standards of the Minister of Health of the Republic of Indonesia Regulation Number 492 of 2010 concerning Drinking Water Quality Requirements, the maximum limit for fluoride levels in drinking water is 1.5 mg/L. Based on government regulations, both clean water sampling locations are classified as good for their fluoride levels. Good fluoride levels are found in the coastal area compared to the mountains. Fluoride content in water can come from natural sources such as weathering of fluoride-containing minerals, volcanic activity, and relief erosion. On the other hand, human activities such as the use of phosphate fertilizers, industrial waste disposal, and the use of chemicals in water treatment can also increase fluoride levels in water.

In the context of drinking water, fluoride concentrations that are too high or too low can indicate problems with the water filtration or treatment system. Excessive fluoride levels can cause dental fluorosis, while low levels may not provide optimal protection against tooth decay. Drinking water has varying fluoride content; groundwater passing through mountains is usually naturally mineralized and contains fluoride. The level of fluoride depends on the rocks and minerals it passes through. When consumed, almost all fluoride is absorbed by the digestive system, enters the bloodstream, and is stored in the bones and teeth.

In high doses, fluoride can be harmful to health, but in low doses, it is actually beneficial. A dose of 0.7 mg/liter is sufficient to have a positive effect on bones and teeth. For example, fluoride is added to bottled water or toothpaste because it can prevent tartar buildup and cavities. However, excessive doses can actually cause bone and tooth damage. For bones, excessive fluoride in the body can damage bone tissue, making them more likely to become porous, fracture, or even crumble. For teeth, excessive fluoride consumption, which occurs when the fluoride content in water ranges from 1.5-2 mg/liter, can cause dental fluorosis, a disorder or enamel discoloration, depending on how much water a person drinks.

Each region has relatively different fluoride levels, influenced by the season, geological characteristics, the chemistry and physical properties of aquifers, soil porosity, and the activity of other chemical elements. Mountainous areas generally have lower levels than coastal areas because in coastal areas, mineral content from the sea seeps into groundwater sources. The fluoride levels of a region can be determined by the fluoride content in its groundwater.

Fluoride enters groundwater, therefore well water can be a significant source of fluoride. General geological features are not an indicator of fluoride concentration in the soil. Rock distribution varies significantly in the way it releases fluoride. Within the same village, different wells often exhibit significantly different fluoride levels due to differences in local hydrogeological conditions. Groundwater exhibits variations in fluoride content according to the fluoride formation at different depths. Fluoride concentrations in groundwater are generally higher than those in surface water due to the interaction between water and rock. Fluoride in groundwater occurs primarily due to climatic degradation, which results in the dissolution of minerals in rocks into the water.

Drinking water in coastal areas comes from groundwater and seawater seepage, which contain fluoride minerals, so residents in these areas have higher fluoride levels than those in other areas. In coastal areas like Boyongpante Dua village, fluoride levels in the soil are high. The high fluoride levels in Boyongpante Dua village are due to its coastal location.

The depth of a water well can also affect the fluoride levels in groundwater. The deeper the well, the higher the dissolved fluoride levels. The well in Boyongpante Dua village is over 10 meters deep, resulting in high levels of dissolved fluoride in the water source.

## CONCLUSION

This study found a significant difference in fluoride content between the drinking water of mountainous and coastal communities, with mean fluoride levels of 0.108 mg/L in well water from Lahendong Village, South Tomohon District, Tomohon City, and 0.298 mg/L in well water from Meras Village, Bunaken District, Manado City — the latter being notably higher, likely due to geological and environmental factors such as soil composition, rock porosity, temperature, and seawater infiltration. Although both values remain within the safe limit of 1.5 mg/L established by the Ministry of Health of the Republic of Indonesia, the disparity underscores the need for continuous fluoride monitoring and region-specific water management policies to safeguard public dental and oral health. Future research should expand the geographic scope to include additional mountainous and coastal communities across Indonesia, incorporate seasonal water sampling to account for fluctuations in fluoride levels over time, and examine the direct clinical relationship between regional water fluoride concentrations and the actual prevalence of dental fluorosis among local populations.

## REFERENCES

Aoba, T. (2004). *Fluor and the Oral Environment*. Karger Medical Science Publishers.

Arifin, Z., & Handayani, W. (2020). *Metodologi Penelitian Kesehatan: Pendekatan Kuantitatif dan Kualitatif*. Pustaka Pelajar.

Barker, J. C., Guerra, C., Gonzalez-Vargas, M. J., & Hoeft, K. S. (2016). Acceptability of Salt Fluoridation in a Rural Latino Community in the United States: An Ethnographic Study. *PLOS ONE*, *11*(7). https://doi.org/10.1371/journal.pone.0158540

Brown, P., Smith, K., & Wong, T. (2020). Fluorosis and its Health Effects. *Journal of Oral Hygiene*, *29*(1), 45–50.

Chae, G. T., Yun, S. T., & Mayer, B. (2015). Fluor geochemistry in groundwater of south-eastern Korea. *Science of the Total Environment*, *385*(1–3), 272–283. https://doi.org/10.1016/j.scitotenv.2007.08.046

Chakraborty, R., Khan, K. M., Dibaba, D. T., Khan, M. A., Ahmed, A., & Islam, M. Z. (2019). Health Implications of Drinking Water Salinity in Coastal Areas of Bangladesh. *International Journal of Environmental Research and Public Health*, *16*(19), 3626. https://doi.org/10.3390/ijerph16193626

*Counseling of Fluorosis, Utilization, and Clearance of Fluor in Water, Desa Mojosari Kecamatan Asembagus Kecamatan Situbondo*. (2024).

Edmunds, W. M., & Smedley, P. L. (2013). *Fluor in natural waters* (O. B. T.-E. of M. G. Selinus (Ed.); pp. 301–329). Springer.

Eisenburger, M., & Addy, M. (2002a). Erosion and attrition of human enamel in vitro. *Journal of Dentistry*, *30*(7), 341–347. https://doi.org/10.1016/S0300-5712(02)00040-6

Eisenburger, M., & Addy, M. (2002b). Interaction effects in enamel erosion and abrasion.

*Journal of Dentistry*, *30*(7), 343–349. https://doi.org/10.1016/S0300-5712(02)00040-6

Fejerskov, O., & Kidd, E. A. M. (2015). *Dental Caries: The Disease and Its Clinical Management* (3rd ed.). John Wiley & Sons.

Fejerskov, O., Nyvad, B., & Kidd, E. (2015). *Dental Caries: The Disease and Its Clinical Management* (3rd ed.). Wiley-Blackwell.

Goodarzi, F., Mahvi, A. H., Hosseini, M., Nedjat, S., Nabizadeh Nodehi, R., & Kharazifard, M. J. (2016). The prevalence of dental fluorosis and exposure to fluor in drinking water: A systematic review. *Journal of Dental Research, Dental Clinics, Dental Prospects*, *10*(3), 127–135. https://doi.org/10.15171/joddd.2016.021

Grover, H. P. (2019). Assessment of Dental Fluorosis Prevalence and Fluor Levels in Water Supply of Different Geographic Regions. *Journal of Dental Science*, *15*(2), 44–52.

Harris, N. O., García-Godoy, F., & Nathe, C. N. (2014). *Primary preventive dentistry*. Pearson.

Indonesia, K. K. R. (2018). *Riset Kesehatan Dasar (Riskesdas)*. Badan Penelitian dan Pengembangan Kesehatan.

Irawan, A. (2019). Kalibrasi Spektrofotometer Sebagai Penjaminan Mutu Hasil Pengukuran Dalam Kegiatan Penelitian dan Pengujian. *Jurnal Universitas Gadjah Mada Yogyakarta*.

Isyani, B. G. (2023). *Studi Kandungan Fluorida dalam Air Dangkal pada Daerah Granitik di Sekitar Lokasi Tambang, Kabupaten Lingga, Provinsi Kepulauan Riau* (A. Harijoko & H. Hendrayana (Eds.)). Universitas Gadjah Mada.

Jones, R., & Jones, L. (2021). Fluor and Its Role in Dental Health: A Review. *International Journal of Dental Research*, *28*(3), 102–110.

Leondra, A., Gunawan, P., & Wicaksono, D. (2013). *Status Karies Dan Kadar Fluor Yang Dikonsumsi Penduduk Usia 12-14 Tahun Di Desa Wiau Lapi Barat*.

Manado, B. L. K. M. (2025). *Prosedur Kerja Pengukuran Kadar Fluor dalam Air*. Balai Laboratorium Kesehatan Masyarakat Manado.

Manado, P. K. (2016). *Statistik Daerah Kecamatan Bunaken Tahun 2016*. Pemerintah Kota Manado.

McLaren, C., Kelsey, D., & Cheung, J. (2018a). Effects of fluor exposure on enamel resistance to acid erosion. *Journal of Oral Health*, *32*(5), 321–330.

McLaren, C., Kelsey, D., & Cheung, J. (2018b). Fluor Exposure and Its Association with Dental Fluorosis Among Children in Areas with Different Water Sources. *Journal of Oral Health*, *32*(4), 256–267.

Novita, D. (2024). Kandungan Fluorida Sebagai Indikator Kualitas Air Minum. *Jurnal Pendidikan Kimia UIN Sunan Kalijaga*.

Organization, W. H. (2021). *Guidelines for Drinking-water Quality* (4th ed.). WHO.

Press, L. U. P. N. V. Y. (2018). *Hubungan Struktur Geologi dan Sistem Air Tanah*. LPPM UPN Veteran Yogyakarta Press.

Rahayu, Y. C. (2015). Peran Agen Remineralisasi Pada Lesi Karies Dini. *Stomatogantic*, *10*(1), 25.

Ritter, A. V. (2019). *Sturdevant's art and science of operative dentistry*. Mosby.

Rochmawati, T. (2012). *Gambaran Karies Gigi Berdasarkan Kadar Fluor Air Sumur Pada Masyarakat di Kecamatan Asembagus, Kabupaten Situbondo*.

Selinus, O., Finkelman, R. B., & Centeno, J. A. (2012). *Medical Geology*. Springer Science & Business Media.

Sharma, S., Ibkar, A., Javid, D., Sharma, N., Bhatia, K., & Prasad Panda, M. (2023). Bio Remedial Process: A Review on Removal of Fluoride from the Waste Water. *Ecology, Environment and Conservation*, *29*, 426–433.

Smith, A. L., Chen, Y., & Lin, Y. (2020). Geological Influence on Fluor Concentration in Drinking Water and Its Impact on Public Health. *Journal of Environmental Health*, *45*(2), 123–134.

Sumiok, J. B. (2015). Gambaran Kadar Fluor Air Sumur Dengan Karies Gigi Anak di Desa Boyongpante Dua. *Pharmacon UNSRAT*, *4*(4), 160767. https://doi.org/10.35799/pha.4.2015.10091

Summitt, J. B., Robbins, J. W., Hilton, T. J., & Schwartz, R. S. (2013). *Fundamentals of Operative Dentistry: A Contemporary Approach* (4th ed.). Quintessence Publishing.

Ten Cate, J. M. (2013). Contemporary perspective on the use of fluor products in caries prevention. *British Dental Journal*, *214*(4), 161–167. https://doi.org/10.1038/sj.bdj.2013.116

Tomohon, P. K. (2016). *Dokumen Rencana Kerja Pemerintah Daerah (RKPD) Kota Tomohon*. Pemerintah Kota Tomohon.

Tomohon, P. K. (2025). *Data Dinas Kependudukan dan Pencatatan Sipil Kota Tomohon*. Pemerintah Kota Tomohon.