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Sip Smart: Unveiling pH and TDS Variability in Beverages

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ABSTRACT

Introduction: Beverages play a crucial role in hydration and health, influencing oral health through their pH and mineral content. While water supports enamel remineralization, acidic beverages like sodas and juices can erode enamel. This study aims to evaluate the TDS and pH levels of various beverages across pune city & comparing them with WHO guidelines.

Methodology: The study analyzed 20 beverage samples, including bottled water, groundwater, soft drinks, and juices. TDS and pH levels were measured using TDS, pH meters with each sample tested in triplicate for better accuracy. The collected results were compared with WHO guidelines (which recommend a pH range of 6.5–8.5 and a maximum TDS of 1000 mg/L) & analyzed.

Results

- **Bottled Water**: TDS ranged from 25–98 mg/L and pH values from 6.8–7.2, all within WHO guidelines.
- **Groundwater**: TDS ranged from 212–587 mg/L, with some samples exceeding the ideal range, but pH values remained within range.
- **Soft Drinks**: TDS ranged from 250–598 mg/L, and pH values were highly acidic (2.96–3.96), exceeding WHO limits, posing a risk for enamel erosion.
- **Juices**: pH ranged from 5.7 to 7.05, showing moderate acidity, with high TDS levels.

Conclusion: Bottled water and groundwater generally comply with WHO guidelines, presenting minimal risk to dental health. However, soft drinks, with their low pH and high TDS, pose significant risks for enamel erosion. Juices are less erosive but still a concern for dental health. The findings emphasize the importance of transparency in labeling and informed beverage choices to maintain oral health.

Keywords: TDS, pH, enamel erosion, oral health, WHO guidelines.

INTRODUCTION

Beverages are far more than simple thirst-quenchers—they are integral to modern life, shaping our hydration habits, dietary choices, and even long-term health outcomes. Consumer preferences for convenience, taste, and purported health benefits have fueled this variety, with many individuals shifting from traditional tap water to alternatives like bottled water, flavored drinks, and energy beverages. [1] However, these choices bring with them significant implications for oral health, often hidden beneath the surface. Each beverage interacts uniquely with the oral cavity, influencing salivary production, the pH environment, and the mineralization or demineralization of tooth enamel. [2] While water is celebrated for its neutral composition, beverages such as sodas, juices, and energy drinks are often acidic, accelerating

enamel erosion and contributing to cavities.[3] Even bottled waters, though marketed as healthy alternatives, can vary widely in their mineral content and pH, influencing their ability to support dental health.[4] The lack of transparency regarding key parameters like Total Dissolved Solids (TDS) and pH further complicates consumers' ability to make informed decisions. [5]

TDS reflects the concentration of dissolved minerals, salts, and compounds, with essential minerals like fluoride, calcium, and magnesium playing a pivotal role in enamel remineralization—restoring minerals lost due to dietary acids and microbial activity. [6] Conversely, beverages with low TDS or imbalanced salt content can fail to support remineralization or even harm dental health. [7] Similarly, pH levels have a profound influence, as acidic drinks erode enamel, while neutral or slightly alkaline beverages help maintain tooth integrity. [7]. Research has shown a strong correlation between fluoride, pH, and TDS, highlighting their combined role in water quality and health outcomes. [8]

Understanding these relationships is crucial for making informed choices about hydration and oral health, as the right balance of minerals and pH can significantly enhance protective effects against dental erosion. Maintaining optimal hydration with the right beverages not only supports overall health but also plays a vital role in preserving dental enamel and preventing decay. This issue has been magnified by shifts in beverage consumption patterns. [9] Fluoridated tap water, long relied upon for dental health, is often replaced by bottled or filtered alternatives, many of which lack critical minerals.[10] Meanwhile, sugary and acidic options like soft drinks and juices significantly increase the risk of dental erosion and decay.[11] Despite these risks, most commercially available beverages do not disclose their TDS and pH levels.

The World Health Organization (WHO) recommends a pH range of 6.5–8.5 for drinking water and a maximum TDS of 1000 mg/L to ensure safety and health benefits. [12] However, many beverages fall outside these thresholds without consumer awareness, leaving them vulnerable to unintentional health impacts.

This study seeks to systematically analyze TDS and pH levels across a spectrum of beverages, including tap water, groundwater, filtered water, juices, and soft drinks, to explore their effects on oral health. By emphasizing the need for transparent labeling of these parameters, it advocates for empowering consumers, supporting dental professionals in guiding better choices, and encouraging manufacturers to prioritize public health in their formulations.

This study aimed to systematically analyze the Total Dissolved Solids (TDS) and pH levels in a variety of commonly consumed beverages, including tap water, groundwater, juices, and soft drinks. The methodology involved the following steps:

METHODOLOGY:

Sample Selection

A total of 20 samples were collected from across pune city for analysis, the samples were anonymized through masking. These samples included:

- **Bottled Water**: 5 different brands, purchased from local markets of pune (marked as B1, B2, B3, B4, B5)
- **Ground water:** Samples from 5 different regions in pune (marked as G1, G2, G3, G4, G5)
- **Commercial Soft Drinks**: 5 widely consumed soft drinks, including cola and lemon-lime sodas. (marked as S1, S2, S3, S4, S5)
- **Juices**: 5 samples, freshly squeezed (marked as J1, J2, J3, J4, J5)

1. **Data Collection**: Each beverage sample was collected in sterile containers to prevent contamination. The samples were stored at room temperature until analysis.

1. **TDS Measurement**: TDS levels were measured using a portable TDS meter calibrated according to the manufacturer's instructions. The meter was rinsed with distilled water between samples to ensure accuracy. Each sample was triplicated for more accuracy.
2. **pH Measurement**: The pH of each beverage was determined using a calibrated pH meter., and the pH value was recorded. Each sample was triplicated for more accuracy.
3. **Comparison with WHO Guidelines**: The measured TDS and pH values were compared against the World Health Organization (WHO) guidelines for drinking water.

Readings were recorded by recorder & analyzed to ensure reliability and validity of results.

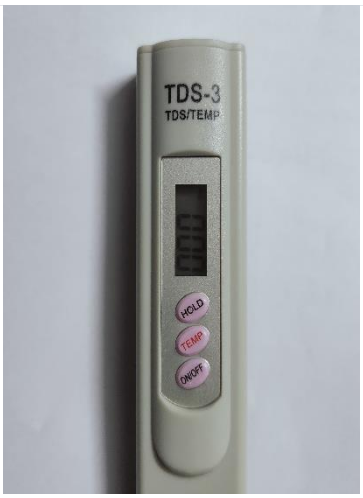

Figure 1. TDS METER

Figure 2. pH METER

RESULT:

Table 1. mean values of pH and TDS and SD value of different brands of bottled water

NAME OF PRODUCT	Mean TDS (mg/L) & SD value	Mean pH &SD value	ADHERENCE WITH WHO GUIDELINES
B1	98.6 ±2	7.01 ±0.1	TDS-MEETS WHO LIMITS PH- WITHIN RANGE
B2	31.8 ±4	6.85 ±0.2	TDS- MEETS WHO LIMITS

			PH- WITHIN RANGE
B3	25.3 ±3	7.27 ±0.1	TDS- MEETS WHO LIMITS PH- WITHIN RANGE
B4	44.1 ±4	6.99 ±0.2	TDS- MEETS WHO LIMITS PH- WITHIN RANGE
B5	27.2 ±5	7.03 ±0.3	TDS- MEETS WHO LIMITS PH- WITHIN RANGE

Table 1. shows Bottled water samples had TDS levels well below the WHO guideline of 1000 mg/L, ranging from 25–98 mg/L. The pH values fell within the optimal range of 6.5–8.5, indicating minimal risk to dental health but limited enamel remineralization due to low mineral content. B1 exhibited the highest TDS, while B3 had the lowest. B2 had the lowest pH, and B1 had the highest.

Table 2. mean pH , TDS values & SD value of different samples ground water across pune city.

NAME OF PRODUCT	Mean TDS (mg/L) & SD value	Mean pH & SD value	ADHERENCE WITH WHO GUIDELINES
G1	212 ±1	7.02±0.1	TDS- MEETS WHO LIMITS PH- WITHIN RANGE
G2	313.2±2.25	7.06	TDS- MEETS WHO LIMITS PH- WITHIN RANGE
G3	587.9±2.25	7.14±0.1	TDS- SLIGHTLY EXCEEDS WHO IDEAL RANGE PH- WITHIN RANGE
G4	450.8±3	6.81±0.1	TDS- MEETS WHO LIMITS PH- WITHIN RANGE
G5	385.1±2.23	8.13±0.1	TDS- MEETS WHO LIMITS PH- WITHIN RANGE

Table 2. shows TDS of G3 was the highest and that of G1 to be lowest. pH of G4 was lowest and that of G5 is the highest. Groundwater samples provide beneficial minerals for enamel remineralization, with TDS levels ranging from 212–587 mg/L. However, the high TDS sample (G3) warrants caution due to potential over mineralization effects.

Table 3. mean pH , TDS values & SD value of different juices

NAME OF PRODUCT	Mean TDS (mg/L)& SD value	Mean pH& SD value	ADHERENCE WITH WHO GUIDELINES
J1	689±36.59	6.32±0.38	TDS-EXCEEDS WHO IDEAL LIMIT PH- IN THE RANGE
J2	498±3	6.12±0.51	TDS-EXCEEDS WHO IDEAL LIMIT PH- IN THE RANGE

J3	590±21	6.87±0.48	TDS-EXCEEDS WHO IDEAL LIMIT PH- IN THE RANGE
J4	806±12	7.05±0.18	TDS-EXCEEDS WHO IDEAL LIMIT PH- IN THE RANGE
J5	569±48	5.70±0.14	TDS-EXCEEDS WHO IDEAL LIMIT PH- ACIDIC

Table 3 indicates TDS of J4 highest and J2 to be the lowest. pH value of J5 lowest and J4 highest**.** The pH values of most of the juice sample are within the acceptable WHO range while the TDS level exceeds the ideal limit in all samples.

Table 4. Mean pH , TDS values & SD value of different brands of soft drinks

NAME OF PRODUCT	Mean TDS (mg/L)& SD value	Mean pH& SD value	ADHERENCE WITH WHO GUIDELINES
S1	598±22	2.96±0.23	TDS-EXCEEDS WHO IDEAL LIMIT PH- TOO ACIDIC
S2	525±36.5	3.02±0.1	TDS-EXCEEDS WHO IDEAL LIMIT PH- TOO ACIDIC
S3	566±23	3.65±0.7	TDS-EXCEEDS WHO IDEAL LIMIT PH- TOO ACIDIC
S4	425±34	3.96±0.3	TDS- WITHIN IDEAL WHO LIMIT TDS- TOO ACIDIC
S5	250±3	3.65±0.4	TDS- WITHIN IDEAL WHO LIMIT TDS- TOO ACIDIC

Table 4. shows that S1 has the highest while S5 has lowest TDS. pH is highest of S4 and lowest of S1. Soft drinks exhibit extremely low pH and high TDS.

DISCUSSION:

Beverages play a significant role in both hydration and nutrition, but their impact on oral health can vary widely depending on factors such as pH and Total Dissolved Solids (TDS). The pH and TDS levels of beverages influence their potential for enamel demineralization, with acidic beverages posing a particular risk for dental erosion and cavities.

The WHO recommends a pH range of 6.5–8.5 and a maximum TDS of 1000 mg/L for drinking water to ensure safety and palatability [12]. Bottled water varied significantly; some brands exceeded the recommended TDS levels, reflecting findings from similar studies on commercial beverages. The low pH levels observed in soft drinks and juices confirm previous research linking acidic beverages to enamel demineralization and increased risk of cavities[7].

Bottled Water and Oral Health

The results of this study confirm that bottled water, across all brands tested, adhered to WHO's recommended pH range of 6.5–8.5 and had TDS levels well below the 1000 mg/L limit. These findings align with similar studies conducted globally, which suggest that bottled water presents minimal risk for enamel erosion due to its neutral pH and low mineral aggressiveness. However, the limited mineral content in bottled water indicates a reduced potential for enamel remineralization, which relies on minerals like calcium and fluoride to restore enamel after exposure to acids. While bottled water is safe for hydration and poses little risk for dental health, it is important to note that it lacks the beneficial minerals found in other water sources, such as fluoridated tap water.

Soft Drinks: A Major Risk for Dental Erosion

In contrast, the low pH levels and high TDS values observed in soft drinks in this study indicate a significant risk for dental erosion. The pH of soft drinks ranged from 2.96 to 3.96, well below the enamel dissolution threshold of pH 5.5. This low pH is conducive to enamel demineralization, which can lead to cavities and tooth sensitivity over time. The high TDS values, due to the presence of acidic substances like phosphoric and citric acids, further exacerbate this risk. These findings corroborate research from both this study and previous studies in Bangladesh, underscoring the dental hazards of frequent soft drink consumption[13].

Fruit Juices: Moderate Risk for Dental Erosion

In a previous study conducted in Nigeria juices extracted from fruits show that Fresh fruit juices, although less acidic than soft drinks, still present a moderate risk for dental erosion due to their acidity and relatively high TDS values[14]. In this study, the pH of fruit juices ranged from 5.7 to 7.05, with some juices falling just above the critical pH for enamel. These findings are consistent with previous studies, including those conducted in Bangladesh, which reported fruit juice pH values ranging from 3.9 to 5.6 [13]. While fruit juices are less erosive than soft drinks, their frequent consumption can still lead to enamel wear, particularly with prolonged exposure. The higher TDS values observed in fruit juices indicate that, while acidity remains the primary concern, the presence of sugars and minerals could also contribute to the potential for tooth wear.

Regional Comparisons of Bottled Water pH and TDS

A comparison of bottled water pH levels across different regions further highlights the variability in the erosive potential of bottled waters. In the U.S., bottled water pH values range from 2.7 to 6.1, which are significantly lower than those observed in this study. These low pH levels fall below the critical thresholds for enamel (pH 5.5) and dentine (pH 6.5), suggesting that U.S. bottled waters may pose a higher risk for dental erosion, particularly for dentine. In contrast, bottled waters in Portugal, Chile, and Malawi tend to

have pH values closer to the neutral range, which are generally safe for both enamel and dentine, although waters with a pH near 6.0 may still pose some risk for dentine erosion [15]. These global comparisons emphasize the importance of understanding local bottled water characteristics and their potential impact on dental health.

Implications for Oral Health

1. TDS and pH Variability in Bottled Water

The variability in TDS and pH levels among bottled waters highlights potential discrepancies in their ability to support enamel remineralization. Consumers may be unaware that certain brands lack essential minerals necessary for dental health, particularly in areas where tap water quality is inconsistent or unavailable.

2. Acidity of Soft Drinks and Juices

The consistently low pH levels found in soft drinks and juices confirm their role in accelerating enamel erosion. Regular consumption can disrupt the natural pH balance of the oral cavity, increasing susceptibility to cavities and dental sensitivity.

3. Impact of Groundwater and Tap Water

Groundwater sources often contain beneficial minerals but can exceed acceptable TDS limits due to excessive salts. Regional variations necessitate additional monitoring to ensure safety.

Limitations

This study faced several limitations:

- A limited sample size and geographic scope may not fully capture the variability present across all beverage types.
- The analysis did not include additional parameters such as sugar content or artificial additives that could further impact oral health.
- Variations in testing methods may have introduced inaccuracies in TDS and pH measurements.

Conclusion

The comparative analysis highlights a global pattern of beverage consumption impacting dental health through mechanisms of acidity and mineral content. While bottled water in remains a safe hydration option with minimal dental risk, the high erosive potential of carbonated beverages underscores the need for moderated consumption. Groundwater's beneficial role in providing minerals invites further exploration, particularly in contexts with varying TDS profiles. These findings reinforce the importance of informed beverage choices to maintain optimal oral health.

Recommendations:

- Consumers: Prefer beverages with balanced TDS and neutral/alkaline pH for oral health.
- Manufacturers: Ensure transparency in TDS and pH labeling to enable informed choices.
- Public Health: Promote awareness and guidelines for healthier beverage habits to protect dental well-being.

REFERENCES:

1. Doria, Miguel. (2006). Bottled Water Versus Tap Water: Understanding Consumers' Preferences. Journal of water and health. 4. 271-6. 10.2166/wh.2006.008.

2. Abou Neel EA, Aljabo A, Strange A, Ibrahim S, Coathup M, Young AM, Bozec L, Mudera V. Demineralization-remineralization dynamics in teeth and bone. Int J Nanomedicine. 2016 Sep 19;11:4743-4763.
3. Inchingolo AM, Malcangi G, Ferrante L, Del Vecchio G, Viapiano F, Mancini A, Inchingolo F, Inchingolo AD, Di Venere D, Dipalma G, Patano A. Damage from Carbonated Soft Drinks on Enamel: A Systematic Review. Nutrients. 2023 Apr 6;15(7):1785.
4. Kurup, Pranav & Patel, Rahul & Suraja, R. & Mishra, Mayur. (2024). Comparative evaluation of alkaline ionized water and normal water on oral microbial flora: An in-vitro study. Journal of Oral and Maxillofacial Pathology. 28. 62-69.10.4103
5. Islam, Rubiat & Faysal, Md & Amin, Md & Juliana, Farha & Islam, Mohammod & Alam, Md. Jahangir & Hossain, Mohammad & Asaduzzaman, Mohammad & Corresponding, †. (2017). Assessment of pH and Total Dissolved Substances (TDS) in the Commercially Available Bottled Drinking Water. 6. 35-40. 10.9790/1959-0605093540.
6. Xu J, Shi H, Luo J, Yao H, Wang P, Li Z, Wei J. Advanced materials for enamel remineralization. Front Bioeng Biotechnol. 2022 Sep 13;10:985881.
7. Cheng R, Yang H, Shao MY, Hu T, Zhou XD. Dental erosion and severe tooth decay related to soft drinks: a case report and literature review. J Zhejiang Univ Sci B. 2009 May;10(5):395-9.
8. Yadav, R. & Yadav, R.N. & Chandrawat, M.P.S. & Sharma, Sanjay. (2008). Assessment of fluoride content, pH and TDS in potable water of Alwar city: An environmental concern. Rasayan Journal of Chemistry. 1. 929-935.
9. Ng SW, Ni Mhurchu C, Jebb SA, Popkin BM. Patterns and trends of beverage consumption among children and adults in Great Britain, 1986-2009. Br J Nutr. 2012 Aug;108(3):536-51.
10. Victory, Kerton R et al. "Comparison of Fluoride Levels in Tap and Bottled Water and Reported Use of Fluoride Supplementation in a United States-Mexico Border Community." *Frontiers in public health* vol. 5 87. 27 Apr. 2017.
11. Ehlen LA, Marshall TA, Qian F, Wefel JS, Warren JJ. Acidic beverages increase the risk of in vitro tooth erosion. Nutr Res. 2008 May;28(5):299-303 /j.nutres.2008.03.001. PMID: 19083423; PMCID: PMC2516950.
12. Islam, Rubiat & Faysal, Md & Amin, Md & Juliana, Farha & Islam, Mohammod & Alam, Md. Jahangir & Hossain, Mohammad & Asaduzzaman, Mohammad & Corresponding, †. (2017). Assessment of pH and Total Dissolved Substances (TDS) in the Commercially Available Bottled Drinking Water. 6. 35-40. 10.9790/1959-0605093540.
13. Enam, Fatima & Mursalat, Mehnaz & Guha, Upoma & Aich, Nirupam & Anik, Muzahidul & Khan, Mohidus Samad. (2014). Characterizing Dental Erosion Potential of Beverages and Bottled Drinking Water in Bangladesh. 10.13140/RG.2.1.1315.9521.
14. Mehta LK, Hegde A, Thomas A, Virdi MS. Acidogenic Potential of Packaged Fruit Juices and its Effect on Plaque and Salivary pH. *Int J Clin Pediatr Dent*. 2019;12(4):312-317. /jp-journals-10005-1644
15. Jeremiah Schmidt , Boyen Huang, The pH of bottled water commercially available in Australia and its implications for oral health Journal of Water and Health Vol 20 No 5, 871