Ethiopian International Journal of Multidisciplinary Research

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

HYGIENIC SIGNIFICANCE OF FLUORIDE CONCENTRATION IN DRINKING WATER AND ITS IMPACT ON PUBLIC HEALTH IN THE FERGANA REGION (UZBEKISTAN)

Atadjanova Dilfuza Sharobidinovna
Fergana Medical institute of Public health

Abstract: Fluoride concentration in drinking water is a critical hygienic parameter influencing population health, particularly dental and skeletal systems. The Fergana region of Uzbekistan is characterized by diverse hydrogeological conditions that determine spatial variability of fluoride levels in groundwater sources used for drinking purposes. Both insufficient and excessive fluoride intake are associated with adverse health outcomes, including increased prevalence of dental caries and development of dental and skeletal fluorosis.
This study aims to assess the hygienic significance of fluoride concentration in drinking water and evaluate its long-term impact on public health in the Fergana region. A comprehensive analysis of regional sanitary-hygienic reports, published scientific literature, and international drinking water standards was conducted. The findings indicate that deviations from optimal fluoride concentrations represent a significant medical-ecological risk for the population. The study highlights the necessity of region-specific hygienic regulation, continuous monitoring, and preventive interventions to ensure safe drinking water quality and protect public health.

Keywords: Fluoride; drinking water; hygiene; medical ecology; Fergana region; public health; fluorosis; dental caries.

1. Introduction

Safe drinking water is a fundamental determinant of public health and a core priority of preventive medicine and environmental hygiene. The chemical composition of drinking water has a direct and long-term influence on human health, particularly when exposure occurs continuously over prolonged periods. Among the various inorganic constituents of drinking water, fluoride occupies a unique position due to its dose-dependent biological effects and its dual role as both a protective and potentially harmful trace element. Fluoride is widely distributed in natural water sources as a result of geological processes, including the dissolution of fluoride-containing minerals in aquifers. The concentration of fluoride in drinking water is therefore largely determined by local hydrogeological conditions, mineral composition of soils and rocks, depth of groundwater sources, and climatic factors influencing water consumption patterns. These natural determinants lead to significant spatial variability in fluoride levels, creating region-specific hygienic and medical-ecological challenges. The Fergana region, one of the most densely populated and economically active areas of Uzbekistan, relies predominantly on underground water sources for domestic and drinking purposes. Due to its complex geological structure and intensive use of groundwater, the region exhibits considerable heterogeneity in fluoride concentration across different localities. Such variability increases the likelihood of long-term population exposure to non-optimal fluoride levels, which may remain undetected without systematic hygienic monitoring. From a public health perspective, inadequate fluoride intake is associated with increased susceptibility to dental caries, particularly among children and adolescents during critical periods of tooth development. Conversely, excessive fluoride exposure may result in dental fluorosis and, in cases of prolonged intake, skeletal fluorosis, leading to functional impairment and reduced quality of life. These conditions represent not only clinical concerns but also broader medical-ecological risks affecting large population groups.

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

Therefore, regionally focused evaluation of fluoride concentration in drinking water and its health implications is essential for effective preventive strategies. Integrating principles of hygiene, medical ecology, and public health into water quality assessment allows identification of population-level risks and supports evidence-based decision-making aimed at protecting and improving public health in environmentally diverse regions such as the Fergana Valley.

2. Materials and Methods

This study employed a descriptive and analytical research design based on secondary data analysis. The materials included regional sanitary-epidemiological monitoring reports of the Fergana region, national drinking water quality standards, and peer-reviewed scientific publications indexed in international databases. Comparative analysis was performed to evaluate fluoride concentration ranges in drinking water sources across different localities of the region. Hygienic risk assessment principles were applied to estimate potential health effects associated with long-term exposure to fluoride. International guidelines, particularly those of the World Health Organization, were used as reference benchmarks. No direct human or animal experimentation was conducted, and the study relied exclusively on publicly available data and literature sources.

3. Results

The analysis demonstrated substantial spatial heterogeneity in fluoride concentration across drinking water sources in the Fergana region, reflecting the region's complex hydrogeological structure. Groundwater-derived drinking water, which constitutes the primary source for both urban and rural populations, exhibited notable variation in fluoride content depending on aquifer depth, mineral composition, and local geological formations. Shallow aquifers generally showed lower fluoride concentrations, whereas deeper groundwater sources were more likely to contain elevated fluoride levels due to prolonged water–rock interaction.

In several districts, measured fluoride concentrations were consistently below the optimal hygienic range of 0.7–1.2 mg/L recommended for caries prevention. These areas demonstrated a clear epidemiological tendency toward increased prevalence of dental caries, particularly among children and adolescents. Reduced fluoride availability in drinking water was associated with insufficient enamel remineralization, decreased resistance to acid demineralization, and higher susceptibility to cariogenic bacterial activity. School-age children appeared to be the most vulnerable population group, reflecting the critical role of fluoride during tooth development and enamel maturation.

Conversely, certain localities within the Fergana region exhibited fluoride concentrations approaching or exceeding recommended hygienic limits. Populations residing in these areas showed a higher frequency of dental fluorosis, clinically manifested by enamel discoloration, opacity, and structural hypomineralization. The severity of fluorosis appeared to correlate with both fluoride concentration and duration of exposure, indicating a cumulative effect of long-term intake. Mild to moderate forms were more commonly observed, although prolonged consumption of high-fluoride water increased the potential risk of more severe manifestations.

In addition to dental outcomes, long-term exposure to elevated fluoride concentrations was associated with increased risk of skeletal fluorosis among adult populations. Although clinical skeletal fluorosis is typically a result of prolonged exposure over many years, the findings suggest that continuous consumption of high-fluoride water may contribute to early musculoskeletal symptoms, including joint stiffness, chronic bone pain, and reduced mobility.

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

These effects are particularly significant from a public health perspective, as they may lead to decreased quality of life and functional limitations.

Overall, the results indicate that fluoride-related health outcomes in the Fergana region are strongly dependent on local hydrogeological conditions, water source characteristics, and long-term consumption patterns. The coexistence of both fluoride deficiency and excess within the same region underscores the need for geographically differentiated hygienic regulation rather than uniform standards. These findings highlight fluoride imbalance in drinking water as a region-specific medical-ecological risk factor requiring targeted preventive and regulatory interventions.

4. Discussion

The findings of this study confirm that fluoride concentration in drinking water is a critical hygienic determinant of public health in the Fergana region. The observed coexistence of areas with both deficient and excessive fluoride levels highlights the complex nature of fluoride exposure and its strong dependence on local hydrogeological and environmental conditions. This pattern is consistent with reports from other regions characterized by heterogeneous geological formations, such as parts of Central Asia, South Asia, and Eastern Europe, where natural fluoride distribution in groundwater varies considerably.

The dual biological role of fluoride presents a unique challenge for water quality management. At optimal concentrations, fluoride exerts a well-documented protective effect against dental caries by enhancing enamel mineralization and resistance to acid demineralization. However, when intake exceeds physiologically acceptable levels, fluoride becomes a risk factor for dental and skeletal fluorosis. The results of the present study support existing evidence that both ends of the exposure spectrum are associated with adverse health outcomes, emphasizing the narrow margin between beneficial and harmful fluoride concentrations.

The findings further indicate that reliance on uniform national drinking water standards may be insufficient in regions with pronounced spatial variability in fluoride content. In the Fergana region, localized hydrogeological conditions result in significant differences in fluoride exposure even within relatively small geographic areas. This underscores the need for region-specific and, in some cases, community-level approaches to hygienic regulation. Adaptive strategies based on local risk assessment are more likely to ensure effective prevention than centralized, standardized interventions alone.

Continuous hygienic monitoring emerges as a key component of effective preventive medicine. Regular surveillance of fluoride levels in drinking water allows early identification of deviations from optimal ranges and facilitates timely corrective measures. From a medical-ecological perspective, such monitoring is essential not only for protecting dental health but also for preventing long-term skeletal complications that may develop after prolonged exposure. The integration of exposure assessment with population health indicators can significantly improve risk management and policy planning.

The results also highlight the importance of interdisciplinary collaboration between hygiene specialists, medical ecologists, public health professionals, and water management authorities. In regions with heterogeneous natural fluoride distribution, isolated interventions may be ineffective or even counterproductive. Coordinated efforts that combine environmental monitoring, health education, and regulatory control are required to address fluoride-related risks comprehensively.

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

Overall, the findings reinforce the global relevance of fluoride as a medical-ecological factor and demonstrate that regionally differentiated water quality management is essential for safeguarding public health. Incorporating hygiene and medical ecology principles into public health policy can enhance the effectiveness of preventive strategies and contribute to sustainable improvements in population health, particularly in environmentally diverse regions such as the Fergana Valley.

5. Conclusion

Fluoride concentration in drinking water represents a critical hygienic factor influencing population health in the Fergana region. Both deficiency and excess of fluoride are associated with significant long-term health risks, primarily affecting dental and skeletal systems. The study underscores the importance of regionally differentiated monitoring, scientifically justified regulation, and preventive interventions to maintain fluoride levels within optimal limits. Application of medical-ecological principles in water quality management can significantly contribute to improving public health outcomes.

References:

1. World Health Organization. *Guidelines for Drinking-water Quality*. Geneva: WHO.
2. Fawell J., Bailey K., Chilton J., Dahi E., Fewtrell L., Magara Y. *Fluoride in Drinking-water*. WHO Press, 2006.
3. Whitford G.M. Fluoride metabolism and toxicity. *Monographs in Oral Science*. 2011;22:1–45.
4. Featherstone J.D.B. The science and practice of caries prevention. *Journal of the American Dental Association*. 2000;131(7):887–899.
5. Burt B.A., Eklund S.A. *Dentistry, Dental Practice, and the Community*. Elsevier, 2005.
6. Sanitary-Epidemiological Service of Uzbekistan. Regional drinking water quality reports.
7. Rahmatshoyev M. The importance of vitamins and minerals for athletes. *Ethiopian International Journal of Multidisciplinary Research*