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Morphofunctional Changes in Salivary Glands under the Influence of Groundwater

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Abstract Currently, the shortage of drinking water is becoming one of the global issues, and scientists emphasize that in the future, groundwater may become the main source of drinking water. However, direct consumption of groundwater may have negative effects on the human body due to its mineral composition, which affects many organs. The minerals present in groundwater play an important role in both general health and oral health. Salivary glands are vital to the body, with their main function being the secretion of saliva into the oral cavity. The composition and secretion of saliva support various physiological functions essential for maintaining overall health. This article presents changes in the major salivary glands caused by groundwater consumption, along with the results of biochemical and immunological studies of saliva. **Research objective**: To study the effect of groundwater on the major salivary glands.

Keywords Immunological, Interleukin, pH, Water hardness, Groundwater, White rat

1. Introduction

It is well known that the scarcity of drinking water is becoming an increasingly pressing global concern. Scientists emphasize the utilization of groundwater as a potential source of potable water. [5,13] However, the composition of drinking water can differ significantly from that of treated tap water. In particular, the use of saline or mineral-rich groundwater as a drinking source has been associated with various physiological changes in the human body. [6,14] Continuous consumption of water with distinct physicochemical properties may also affect the salivary glands and, consequently, the composition and function of saliva. [8,9] It is established that many diseases in the human body originate from external factors. Every substance that enters the body from the environment—especially via the digestive tract—exerts both direct and indirect influences on physiological systems. When such influences are negative and persist over time, they can result in serious pathological changes. While the impact of groundwater on certain organs—such as the thyroid gland—has been previously studied, its potential effects on the salivary glands remain largely unexplored [10,12]. This research gap highlights the urgent need for further investigation and underscores the relevance of the topic.The oral cavity is often referred to as the "mirror" of the body, and the salivary glands play a critical role in maintaining oral and systemic health. [9,11,15] In addition to initiating digestion, saliva protects the oral mucosa and teeth, combats microbial invasion, and helps regulate the oral pH balance. Impaired salivary gland function or reduced saliva production can lead to a range of health complications. Therefore, preserving the health of the salivary glands is essential for overall physiological well-being. [3,4]

Objectives:

1. To analyze the chemical composition of groundwater extracted from a depth of 10 meters on the territory of the Bukhara State Medical Institute and compare it with tap water and the standards set by O'zDSt 950:2011.
2. To identify morphological changes in the salivary glands of healthy white laboratory rats (6–9 months old, 250–300 g) consuming groundwater.
3. To evaluate the immunological composition of saliva in rats over a three-month period and compare results between those consuming groundwater and those consuming tap water.

2. Materials and Methods

For this study, healthy, non-breed-specific white rats weighing 250–300 grams were used as experimental subjects. A total of 130 white laboratory rats were divided into two experimental groups. The first group, comprising 50 rats, consumed centralized (tap) drinking water. The second group, consisting of 80 rats, was provided with groundwater extracted from a depth of 10 meters.The rats were divided into the following two groups:Group I (Control Group): These

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laboratory rats consumed centralized tap water according to municipal standards. The water was administered daily for a period of three months.Group II (Experimental Group): These rats consumed groundwater sourced from a depth of 10 meters below the surface. The groundwater was administered daily over a three-month period.

Below, the composition standards for potable water as established by the Uzbekistan State Standards in 2011 are provided. Additionally, the physicochemical characteristics of the groundwater used in this study—sourced from the Bukhara State Medical Institute—are compared to the composition of the municipal tap water used.

3. Results and Discussion

Table 1. Chemical Analysis of water (mg/dm³)

Indicators	UzDSt 950:2011	Tap water	ground water
Nitrates	13	12,2	18,8
Total Hardness	7	6,3	32,5
Dry Residue	1000,0	711,0	2216,0
Sulfates	400.0	245,0	648,0
Chlorides	250,0	127,3	445,6
Fluoride	0,7	0,18	0,04
Ammonia	-	-	-
Nitrite	-	-	0.13
Ferrum	0.3	0,02	-

It was observed that the total hardness of the groundwater exceeded the maximum allowable limit defined by the Uzbekistan State Standards (UzDST) by approximately 4.5 times. Such a significant deviation is unlikely to be without impact on the organism. The level of total dissolved solids (TDS) was found to be 2.2 times higher than the normative value, which may contribute to oral hygiene disturbances, increased viscosity of saliva, and the formation of dental plaque. Moreover, the chloride concentration in the groundwater was nearly twice the permissible limit. This poses a particular threat to oral health, as elevated chloride levels are associated with an increased risk of xerostomia (dry mouth). The fluoride content, on the other hand, was found to be below the recommended threshold, which may predispose individuals to the development of dental caries. Additionally, the presence of nitrites and nitrates in the water is likely to contribute to the emergence of unpleasant oral odors.During the course of the study, morphological changes were observed in the parotid salivary glands of 6-month-old, non-breed-specific white laboratory rats that had consumed groundwater for three months. Notably, hypertrophy of parotid gland cells and interstitial edema in the intercellular spaces were detected, indicating adverse histopathological effects induced by prolonged consumption of mineral-rich groundwater.

Morphological Observations: The sublingual gland is the smallest of the three major salivary glands and is classified as a mixed gland with a predominance of mucous acini. [1,7] Histologically, it is composed primarily of mucous secretory units, which contain pale-staining cytoplasm due to the high mucin content and basally located, flattened nuclei. Serous demilunes, crescent-shaped serous cells, may be observed capping the mucous acini and contribute a minor serous component to the secretion [8,12]. The gland is organized into lobules separated by connective tissue septa that contain blood vessels, nerves, and excretory ducts. The intralobular ducts include intercalated and striated ducts, though these are less prominent than in serous-dominant glands. The sublingual gland's secretion is primarily mucous, which plays a role in lubrication and protection of the oral mucosa. [2,14]

Histological analysis of the sublingual salivary glands in rats that consumed groundwater revealed hypertrophy of acinar cells and interstitial edema.

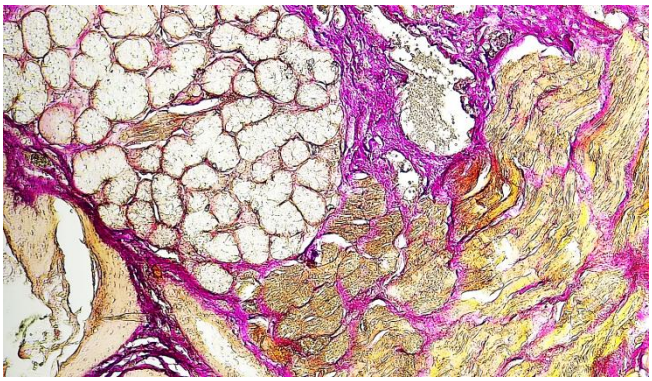

Figure 1. Histological description: sublingual salivary gland. Hematoxylin and eosin staining. Magnification 10×4

1 – glandular lobes
2 – interlobular connective tissue
3 – intralobular duct

Table 2. Immunological Analysis of Saliva

Indicator	Norm	Results ground water
SIgA	50-116	72,5
Il-6	0,8	15,8
Il-10	0,28	14,5
lysozyme	0,159-10	2,9

Notably, IL-6 levels (a pro-inflammatory cytokine) were significantly elevated, while IL-10 (anti-inflammatory cytokine) and lysozyme (antimicrobial enzyme) levels decreased. These shifts indicate weakened anti-inflammatory responses and antimicrobial defense, alongside activated inflammation in the oral cavity.

4. Conclusions

1. The groundwater used in this study exceeds several parameters outlined in O'zDSt 950:2011 and requires treatment before being used as drinking water.
2. Groundwater consumption in rats led to morphological changes in the parotid salivary glands, including cellular hypertrophy and edema.
3. Immunological analysis of saliva demonstrated inflammatory activation, weakened immune defense,

and decreased antimicrobial protection.

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