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# Health Risk Assessment of Fluoride Removal from Drinking Water

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## تقييم المخاطر الصحية لإزالة الفلورايد من مياه الشرب

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**Abstract:**
Fluoride is a naturally occurring mineral that can be found in various water sources, including groundwater and surface water. In controlled amounts, fluoride has been proven to have dental benefits, preventing tooth decay and strengthening tooth enamel. Reverse Osmosis (RO) is considered as an effective method used to separate and extract dissolved solids, organics, and bacteria from water. This study aimed to assess the health risks associated with fluoride removal from drinking water in Tripoli, the Capital city of Libya by using purification systems. Forty water samples were collected before and after desalination process different areas of Tripoli. Water Samples (groundwater, water distribution network and desalinated) were coded from 1 to 20 based on the source type. Samples were analyzed using DR3900 Laboratory VIS Spectrophotometer. Mean difference concentration of fluoride in the collected baseline water samples (before RO filtration) were found to vary between 0.08 and 1.16 mg/L. All of the water samples showed a complete reduction in fluoride content by 100% after passing through various RO filters. The results of the study showed that the use of reverse osmosis water filtration technologies has a substantial effect in reducing the fluoride levels in drinking water within unacceptable limits set by the World Health Organization (WHO) and the Environmental Protection Agency (EPA).

**Keywords**: Risk assessment, Fluoride levels, Drinking water, Spectrophotometer.

**الملخص**
الفلورايد هو معدن طبيعي يمكن العثور عليه في مصادر المياه المختلفة، بما في ذلك المياه الجوفية والمياه السطحية. ثبت أن الفلورايد له فوائد في طب الأسنان، حيث يمنع تسوس الأسنان ويقوي مينا الأسنان اذا استخدم بكميات خاضعة للرقابة. يعتبر التناضح العكسي (RO) طريقة فاعلة تستخدم لفصل وازالة المواد الصلبة المذابة والعضوية والبكتيريا من الماء. تهدف هذه الدراسة إلى تقييم المخاطر الصحية المرتبطة بإزالة الفلوريد من مياه الشرب في العاصمة الليبية، طرابلس وذلك باستخدام أنظمة التنقية. تم جمع أربعين عينة من المياه قبل وبعد عملية تحلية المياه في مناطق مختلفة من طرابلس. تم ترميز عينات المياه (المياه الجوفية وشبكة توزيع المياه وتحليتها) من 1 إلى 20 بناءً على نوع المصدر. تم تحليل العينات باستخدام مقياس الطيف الضوئي ((DR3900. وجد أن متوسط تركيز الفلورايد في عينات المياه قبل الترشيح بواسطة التناضح العكسي يتراوح بين 0.08 و 1.16 ملغم/لتر. كما أظهرت جميع عينات المياه انخفاضًا كاملاً في محتوى الفلورايد بنسبة 100٪ وذلك بعد المرور عبر مرشحات RO المختلفة. أظهرت نتائج الدراسة أن استخدام تقنيات ترشيح المياه بالتناضح العكسي له تأثير كبير في تقليل/إزالة مستويات الفلورايد في مياه الشرب ليصل الى حدود غير مقبولة وضعتها منظمة الصحة العالمية (WHO) و وكالة حماية البيئة (EPA).

**الكلمات المفتاحية:** تقييم المخاطر، مستويات الفلورايد، مياه الشرب، مقياس الطيف الضوئي.

## Introduction

A Fluoride is a naturally occurring mineral commonly found in groundwater and surface water sources. The main source of fluoride ingestion into the human body is through drinking water (Community Water and Sanitation [CWSA], 2017. While it is recognized for its dental health benefits in low concentrations, excessive fluoride exposure can lead to significant health issues, including dental fluorosis and skeletal fluorosis [1-4]. The Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) recognize the benefits of fluoride in preventing dental cavities [5,6]. Fluoride has been added to drinking water in many communities for several decades as a public health measure to prevent tooth decay [7,8]. As a result, many countries have established guidelines to limit fluoride levels in drinking water. Various purification systems have been developed to effectively remove fluoride from water, including reverse osmosis, activated alumina, and ion exchange methods. However, the implementation of these systems raises concerns regarding their efficacy, economic viability, and potential environmental impacts. The removal of fluoride from drinking water has been extensively studied, with a variety of purification technologies. Reverse Osmosis (RO) is one of the most widely adopted methods, known for its ability to significantly reduce fluoride concentrations. Research by Garud et al. [9] demonstrated that RO systems could achieve fluoride removal rates exceeding 90%, making them suitable for communities with high fluoride levels. Spectrophotometric methods are widely used to determine the fluoride content because of their simplicity, accuracy and reproducibility [10].

However, in recent years, there has been a growing movement to remove fluoride from drinking water due to concerns about potential health risks. This study aims to conduct a risk assessment of fluoride removal from drinking water using (RO) purification system. By evaluating the effectiveness of this technology, this research seeks to provide valuable insights for policymakers and public health officials.

## Material and methods

### *Collection of the water samples*

Total of forty water samples were collected from various sources in Tripoli. This included twenty samples from groundwater sourced from drilled wells and the others from home-used water purifiers. The samples were gathered from different residential areas to ensure a comprehensive analysis. Samples were collected in plastic bottles (polyethylene) that had been rinsed twice with deionized water to eliminate any fluoride residue. The bottles were coded and stored in a laboratory at a cool temperature (4°C) till analysis. The most common types of RO filters were made in Libya (AquaCare® RO filters), which utilized either carbon-based or thin-film composite membranes. The filters had filtration capabilities ranging from 1 to 7 stages.

### *Analysis of Fluoride Content*

The fluoride concentrations in the samples were analyzed using a DR3900® Laboratory UV-VIS Spectrophotometer with RFID. A standard method provided by the American Public Health Association was used [11]. The analysis was standardized using fluoride solutions (NaF supra pure reagent) ranging from 0.1 to 10 ppm. Standard solutions were prepared by sequential dilution of the stock solution. Both standard and stock solutions were placed in polyethylene bottles. For each sample, 20 ml of water was combined with a total ionic strength adjustment buffer solution, agitated to remove air bubbles, and then measured. The fluoride concentrations found in the samples before and after the (RO) filtration process were compared. This comparison helped to determine the effectiveness of the purification system in removing or reducing fluoride levels.

### *Statistical Analysis*

The data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS, IBM Corporation, Armonk, NY, USA) version 16 software. Descriptive statistics were used to report mean fluoride concentrations before and after filtration, as well as standard deviation (SD), the relative standard deviation (RSD%) and the mean difference in fluoride concentration. P value of less than 0.05 was considered statistically significant.

## Results and discussion

### *Reduction in Fluoride Concentration*

The study found that all water samples showed a reduction in fluoride content after passing through various RO filters, with reductions ranging from 0.01 to 0.05 ppm. The baseline mean fluoride concentration before RO filtration was determined to be 0.39±0.27 ppm (Fig. 1). The study confirms that RO filtration systems significantly reduce fluoride concentrations in drinking water where showing the greatest fluoride removal 100%. The overall fluoride reduction was 85% across the different sample sources. The precision of the method expressed by RSD (relative standard deviation) was lower than 4%. The results showed that the described method demonstrated a good accuracy and precision.

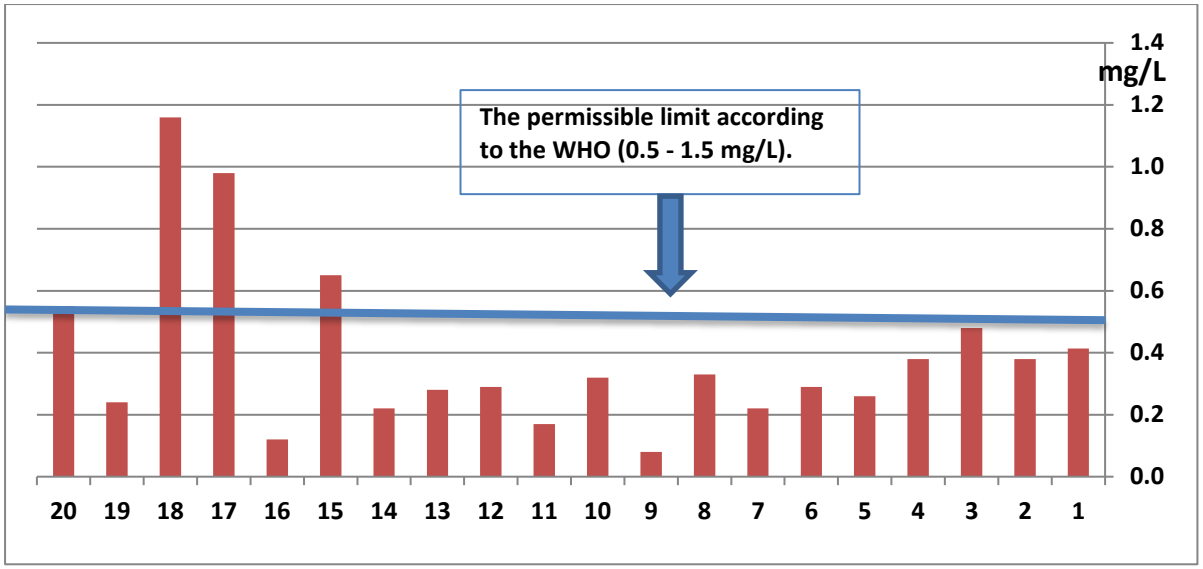


**Figure 1**: Fluoride content in drinking water samples before passing through the RO filters comparing to WHO permissible limit (0.5-1.5mg/L). Results after passing through the filters were lower than 0.05mg/L.

***Public Health Implications***

While the reduction of fluoride is beneficial in terms of removing potential contaminants, the study raises concerns regarding the potential decrease in fluoride levels due to the use of RO filtration systems, and its potential impact on dental health. Fluoride is known to play a crucial role in preventing dental caries, and excessive removal of fluoride from drinking water could lead to an increased risk of dental issues, particularly in children. The study emphasizes that while the removal of harmful substances from water is essential, it is equally important to maintain adequate fluoride levels to support oral health [12].

**Table 1**: Mean concentrations of fluoride (mg/L) recorded in this study were lower than the permissible limit of WHO and Libyan Standard Specifications.

| Water type | Range | Overall mean concentration | Fluoride removal % | Libyan Standard Specifications | WHO Standard Specifications |
|---|---|---|---|---|---|
| **Before RO filtration** | 0.08-1.16 | **0.39±0.27** | 85 | 0.5-1.5 | 0.5-1.5 |
| **After RO filtration** | 0.01-0.05 | **0.01±0.01** | 100 | 0.5-1.5 | 0.5-1.5 |

The standard deviation of precision for the method performance is ranged from ±0.025 to ±0.040 ppm fluoride.

***Recommendations for Public Awareness***

The authors emphasize the importance of public awareness regarding the fluoride content in drinking water, especially for communities relying on bottled or filtered water. They suggest that health practitioners, particularly dentists, should be informed about the fluoride levels in the water consumed by their patients to provide appropriate guidance on fluoride supplementation when necessary, and to educate the public about the importance of maintaining optimal fluoride exposure for dental health.

Regulatory Considerations: The discussion also touches on the need for regulatory bodies to consider the optimal fluoride levels in drinking water, balancing the benefits of fluoride for dental health with the potential risks associated with contaminants in tap water. The study advocates for ongoing research and monitoring of fluoride levels in water supplies to ensure public health safety.

***Future Research Directions***

The study concludes by emphasizing the need for ongoing research to explore the long-term effects of reduced fluoride exposure due to RO filtration and to establish guidelines for maintaining optimal fluoride levels in drinking water. This includes investigating the potential consequences for dental health and developing strategies to ensure that communities maintain adequate fluoride levels in their drinking water supplies.

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***Declaration of Competing Interest***

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

***Data Availability***
Data will be made available on request.

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