Entry to the Stockholm Junior Water Prize 2025

The Effectiveness of Various Natural Materials in Freshwater Filtration

Scientific Research Work in the Field of Natural Sciences

Work Author: Keta Vajevska

Supervisor: Mg. psych. Jeļena Torčinava

Advisor: Ph.D. Brigita Dejus

Latvia, 2025

Abstract

In this scientific research work, the hypothesis was tested, whether it is possible to obtain drinking water for human consumption by filtering the freshwater through natural materials. As part of the research, experiments were carried out in which the water sample was filtered through sand, charcoal, and moss. After filtration, the water was boiled at 100 °C for 10 minutes. After boiling, the water samples were tested in the Scientific Institute of Food Safety, Animal Health and Environment BIOR (Latvia, Riga). By comparing the obtained test results, it was concluded that these filter materials, combined with boiling, have great potential to filter drinking water for short-term use.

Keywords: Drinking water, water filtration, natural materials, sand, moss, charcoal, natural filters.

Table of Contents

1. Introduction 5
1.1. Relevance of the Study 5
1.2. Background of Water Filtration 6
1.3. Types of Freshwater Pollution 7
1.4. Water Filtration Methods 9
2. Materials and Methods 11
2.1. Experimental Set Up 11
2.2. Water Filtered Through Sand 13
2.3. Water Filtered Through Charcoal 13
2.4. Water Filtered Through Moss 14
3. Results 15
4. Discussion 16
5. Conclusions 17
Reference List 18

Acknowledgment

The author extends sincere gratitude to the teachers of Marupe State Gymnasium, in particular to Jeļena Torčinava, parents, and advisors. This work has been revised and mentored by Ph.D. Brigita Dejus and Dr. Sandis Dejus, senior researchers of Riga Technical University Water System and Biotechnology Institute. The author thanks the Scientific Institute of Food Safety, Animal Health and Environment BIOR for testing the filtered water samples and the Latvian Water and Wastewater Works Association, in particular the project manager Ilze Karklina, for their trust and for giving the opportunity to take part in the Stockholm Junior Water Prize 2025.

1. Introduction

1.1. Relevance of the Study

Access to clean drinking water is one of the basic human rights. Based on the statement from *the Annual Review of Chemical and Biomolecular Engineering Volume 6, 2015*, "Clean drinking water is water that is free from physical, chemical, and biological pollutants and may be employed for purposes such as drinking, bathing, and cooking." (1) According to data published by the World Bank in 2023, only 74% of the world's population have access to safely managed clean water. (2) This means that 26% of the world's population, mainly living in developing countries, still do not have access to clean drinking water or water as such. In addition, access to clean water is also limited in countries where military conflicts and hostilities are currently taking place, resulting in the complete or partial destruction of water supply infrastructure. Access to clean water is also one of the 17 UN (United Nations) Sustainable Development Goals, which is an essential prerequisite for human health and well-being. (3)

Although in many countries drinking water purification technologies are not fully developed or are not operational, in a large part of these territories, there is access to surface freshwater, as well as natural materials that could potentially be used to filter the freshwater. The aim of this scientific research work is to investigate whether it is possible to independently, at any place and time, partially or completely purify water obtained from a natural body of freshwater, using available natural materials, which, after filtration and treatment, could be used for human consumption in the short term. In developing countries or countries affected by military conflicts, natural materials can play a crucial role in surface water filtration due to their wide availability.

The proposed hypothesis: by using natural materials as a filter in combination with boiling, it is possible to filter surface freshwater to an extent that it is safe to use in human consumption. The aim of the research is to determine how effective is the independent filtration of drinking water with the selected natural materials. In this study, the author will analyse the results of the unfiltered river water samples after each filtration in the Scientific Institute of Food Safety, Animal Health and Environment BIOR and evaluate their potential. To reach the aim of the study, the author will test the filtered water with the classical cultivation method which, within itself, comprises sampling the freshwater, filtering it and testing it for pollutants in the laboratory.

1.2. Background of Water Filtration

Since the beginning of time, people have been aware of the importance of water for survival, which is why ancient civilizations settled near water. Researcher Jadhav A.S. in his article “Advancement in drinking water treatments from ancient times” has indicated that an understanding of drinking water quality by ancient civilizations was not documented. It is believed that at that time the quality of water was tested only by considering its external characteristics – appearance, taste and smell. It took thousands of years for people to recognize that the external characteristics of water were not accurate indicators of water quality. Only with time did people learn that water can also be contaminated chemically or bacteriologically, which is why chlorine was used in water filtration for the first time in 1908. (4)

In the following decades, methods of filtering drinking water developed significantly, so there are now many ways to purify water. The book “Super Simple Chemistry” describes that today centralized water filtration takes place in a 5-stage sequential system, with the aim of purifying water from unwanted impurities:

1. Water flooding through the grids to remove larger objects.
2. Filtration of water through a natural filter layer to remove small solid particles.
3. Disinfection of water with, e.g., chlorine gas to kill microorganisms.
4. Storing water in a tank to allow water sediment to settle.
5. Water supply to the end consumer through a distribution network. (5)

In this study, the author wants to simulate the time when centralized and technological water purification had not yet been introduced, and when water was filtered independently or not filtered at all. However, since information is available today about the main stages of water filtration, the principles of modern filtration systems can be used to perform this independent filtration. Also, nowadays, there is a much greater understanding of the quality of the surface freshwater, so the next section will deal with the most common water pollutants to identify the necessary experimental filtration methods to increase the efficiency.

1.3. Types of Freshwater Pollution

There are countless possible types of freshwater pollution that can affect water quality. According to the "UN World Water Development Report 2", there is a range of sources and activities that cause water pollution. (6) Conceptually, river water pollution can be divided into 3 large groups: chemical, physical and biological pollution. Physical pollutants affect mainly the external parameters of water, such as colour, taste or smell, but do not pose a health hazard when consumed, e.g. fallen tree branches and leaves, rocks and sand. Chemical pollution mainly arises from industrial wastewater and agricultural fertilizers, which are discharged directly or through groundwater to the nearest freshwater reservoir, like a river. Biological pollution mainly arises from human and animal faeces and waste, or from external human impact on the natural microbiome of the water reservoirs, e.g., dams in a river, which impede the natural flow of the river and promote water warming, stagnation and the reproduction of microorganisms. (7)

Along with the development of drinking water purification technologies, the possibility of laboratory testing of any water and identifying its purity, quality, and recommendations for use has also developed. Today, there are many parameters by which drinking water quality is tested, and individual laboratories, e.g., an accredited laboratory, offer several types of drinking water filtration panels, which differ by the pollutants analysed. (8) It can be used both for monitoring water quality for external use, e.g., on the farm or while swimming, and for testing water quality for human consumption. Today, this service is available to any interested party who can submit any water sample for laboratory testing.

Laboratory analysis panels usually evaluate the long-term impact of a specific water composition on human health; therefore, they include a relatively wide panel of microorganisms and minerals. However, since the aim of this scientific research work is to evaluate the use of filtered surface freshwater for human consumption in situations, when clean drinking water is temporarily unavailable, within the framework of the work, using the above-mentioned laboratory analysis panel as a standard, the most critical chemical and biological contaminants (pathogens and nitrites) that potentially pose the most immediate threat to human health were selected from the full panel – *Escherichia coli,* intestinal enterococci and nitrites (see Table 1). It is important to emphasize that the use of surface freshwater for consumption should only be considered as a short-term solution in emergency situations, when clean drinking water is not available. This is because many freshwater pollutants might be harmful to the individual's health, causing infections and other diseases. (9) Secondly, in case of the previously mentioned influence on health, the individual may not receive the needed help from healthcare professionals, due to the accessibility of hospitals and availability of medical resources. (10)

Table 1: Freshwater pollution sources, effects, and constituents of concern

Pollution type	Primary sources	**Constituents of concern**
Pathogens and microbial contaminants	Domestic sewage, cattle and other livestock, natural sources.	*Shigella*, *Salmonella*, *Cryptosporidium*, Fecal coliform (coliform), *Escherichia coli* (mammal faeces – *E. coli*)
Nutrients	Principally runoff from agricultural lands and urban areas but also from some industrial discharge.	Total N (organic + inorganic), total P (organic + inorganic) For eutrophication: (Dissolved Oxygen, Individual N species (NH_4, NO_2, NO_3, Organic N), Orthophosphate)

Source: *The United Nations World Water Development Report 2*, https://www.greenfacts.org/en/water-resources/figtableboxes/5.htm, visited: 04/01/2025.

Nitrates are chemical pollutants that are most commonly found in agricultural fertilizers, as they can increase the yield of crops. (11) The World Health Organization has issued guidelines on the amount of nitrites that a person can consume without it being harmful to human health and life. The consequences of high nitrite intake include cancer. This is further supported by a study in which some of the participants developed cancer. (12)

E. coli is a pathogen. *E. coli* is a biological contaminant. This anaerobic organism is found both in water and in gut of humans. It has a high resistance to antibiotics, which is why *E. coli* is considered a significant risk to human health. There are both harmless and harmful *E. coli* strains. The consequences of ingesting these harmful *E. coli* strains include various types of infections (meningitis, diarrhoea, septicaemia). (13) *Intestinal enterococcus* is a biological contaminant. It is most commonly found in intestinal microbiomes and is spread through faeces. It has developed good resistance to antibiotics. If a person ingests this pathogen through drinking water, they will become infected. (14)

Currently, when the critical water pollutants that will be tested have been identified and selected, it is necessary to get to know the existing water filtration methodologies to choose the most suitable methods for this scientific research work.

1.4. Water Filtration Methods

Nowadays, freshwater filtration is widely researched and practiced around the world, providing both centralized water purification solutions on a larger scale, for example, at the city level (SIA “Rīgas Ūdens” (Riga Water), AS “Mārupes Komunālie pakalpojumi” (Marupe Communal Services)), and also offering various individually tailored solutions and equipment of different complexities and effectiveness. Individual solutions are mainly designed for the filtration of groundwater (e.g., water from wells, springs, taps, deep boreholes), where some of the pollutants are naturally filtered through the upper layer of soil. The Environmental Protection Agency of Ireland presents several water filtration methods, which are summarized in Table 2. (15)

Table 2: Water Treatment Guide: Filtration

Filtration method	Description
1. Slow sand filtration	The process by which water flows down gradually through the sand.
2. Rapid Gravity Filtration (RGF) and Pressure Filtration	Gravity filtration systems in which the water level and/or pressure above the filtration layer of the granular medium causes water to flow through the filter.
3. Granular activated carbon	The process by which molecules of a dissolved substance (adsorbate) adhere to a solid surface.
4. Membrane filtering	The separation process within vacuum, in which particles larger than 1 μm are filtered out by an engineering barrier, mainly using a dimensional cut-off mechanism.
5. Cartridge filtration	Pressure-operated separation devices that remove particles using an engineering porous filtration agent.
6. Combined purification-filtration packaged systems	Two standardized packaged units containing both clarification and filtration in one step of the process unit.

Source: *THE ENVIRONMENTAL PROTECTION AGENCY* https://www.epa.ie/publications/compliance--enforcement/drinking-water/advice--guidance/EPA-Water-Filtration-Manual.pdf, visited: 04/01/2025.

The above methods are mainly used during technological processes. Within this scientific research work, it is planned to use a derivative of some of the methods mentioned in the table, by significantly simplifying them. This is done with the aim that this filtering method, if its effectiveness is proven, could be used in practically any conditions relatively quickly and simply, without complex engineering and technological support:

- Water filtration through sand will be derived from a simplified slow sand filtration.
- Water filtration through charcoal will be derived from simplified granular activated carbon filtration.
- Water filtration through sand, charcoal, moss will be derived from simplified rapid gravity and pressure filtration.

Summarizing the stages of water filtration, types of contaminants and filtration methods studied so far, research work will be carried out in the following sections.

The natural materials used play an important role, as the natural materials themselves act as a mechanical filter for larger contaminants and cannot eliminate microorganisms. However, boiling itself is not a filtration method – it helps to ensure that most microorganisms are destroyed. It is also important to emphasize that boiling is not the solution to the problem. Whilst boiling destroys microorganisms in the freshwater, the same cannot be said about other pollutants, such as heavy metals and hard particles. So that alone proves that additional mechanical filtration is needed for the water to be classified as safe for drinking.

2. Materials and Methods

2.1. Experimental Set Up

The experiment was conducted on 18 December 2024. The experiment was conducted at home. The results of the experiment were tested in the Scientific Institute of Food Safety, Animal Health and Environment BIOR (Riga, Latvia).

The experimental phase included the following activities:

1) Collection and purification of water filtration materials
2) Freshwater sample collection
3) Freshwater sample filtration with three selected natural materials
4) Boiling of water samples
5) Filling water samples into test containers
6) Submission of water sample test containers to the Scientific Institute of Food Safety, Animal Health and Environment BIOR, 3 Lejupes Street, Riga
7) Receipt and analysis of water sample test results

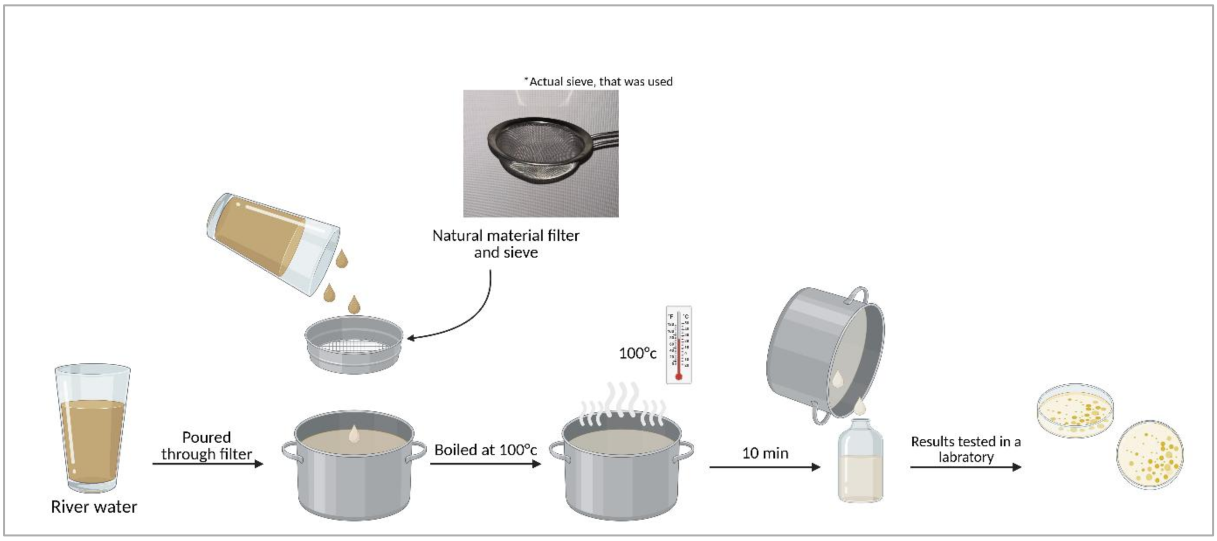

Figure 1. Conceptual Scheme of experimental set up (created by the author using BioRender.com)

Since the proposed topic is based on the inaccessibility and insufficiency of clean drinking water in certain parts of the world, a river was chosen as a freshwater source, which has the widest geographical availability in Latvia, but also the potentially greatest pollution. The River Daugava was chosen as the freshwater body from which the water samples were taken. Five litres of water containers were used to collect water.

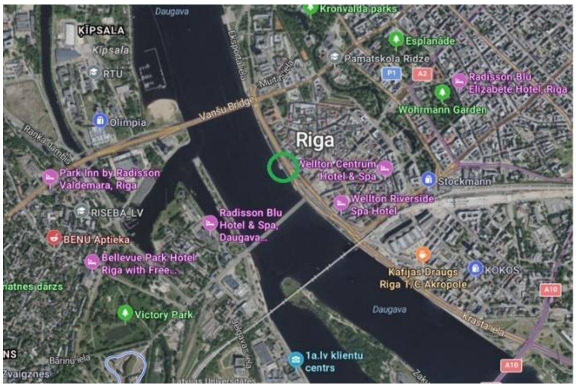

Figure 2. Freshwater sampling point from the River Daugava in Riga, Latvia

Source: https://www.bing.com/maps

Since it was also planned to study the presence of microorganisms in water both before and after filtration, it was decided to boil all filtered water samples at a temperature of 100 °C to maximally exclude the presence of microorganisms.

Natural materials available in various parts of the world were chosen as filtration materials, which could potentially serve as an effective mechanical filter for the water.

The experiment was carried out at home following the steps that are similar to those used in centralized water filtration and treatment (5):

1. Water screening through grids to remove large objects.
2. Water filtration through a natural filter layer to remove small solid particles.

   During the experiment, the natural filtering materials will be placed in a cotton cloth so that their particles do not enter the filtered water. This will filter out both the small solid particles in the water and prevent the small particles of the filter materials themselves from entering the filtered water.
3. Disinfection of water with chlorine gas and a disinfectant to kill bacteria.

   Water disinfection during the experiment will be performed by boiling filtered water at a temperature of 100 °C for 10 minutes from the start of boiling.
4. Storing water in a tank to allow water sediment to settle.
5. Water supply to the end consumer through special pipes.

   The filtered and disinfected water will be filled into sterile and non-sterile containers and settled.

The samples were put into sterile containers provided by the laboratory, while for nitrite analysis – into unused drinking water bottles. The laboratory will also conduct analyses of the original unfiltered water sample form the Daugava in order to assess the efficiency of filtration and water treatment in the context of the hypothesis.

2.2. Water Filtered Through Sand

Water for this study was taken on 18 December at 18:30 from the River Daugava in Riga, opposite the AB Dam, and was delivered to the laboratory the next morning at 10:20. The sand was taken from a sand quarry and kept outside until the moment of filtration. The sand was sieved before the experiment so that it did not contain any unwanted impurities. The grains were weighed and, as a result, 230 g of sand were used in the experiment per one and a half litres of collected river water. When it was time to conduct the experiment, the sand was placed in a non-sterile cloth with 32 layers. However, when water passed through it, some sand particles ended up in the pot. Then the filtered water was boiled for 10 minutes at a temperature of 100 °C from the moment of boiling. Once boiled, the water was filtered again through 32 layers of cloth to reduce the amount of sand in the water. The water was poured into two containers from the Scientific Institute of Food Safety, Animal Health and Environment BIOR – a sterile standard bottle for studying pathogens, and a new drinking water bottle for studying nitrites. Although not all the sand was filtered out of the water, there was a lower concentration of sand in the liquid. The water samples were left outside at +4 °C overnight.

2.3. Water Filtered Through Charcoal

Water for this study was taken on 18 December at 18:30 from the River Daugava in Riga, opposite the AB Dam, and was delivered to the laboratory the next morning at 10:20. The charcoal was acquired from a store and kept outside until the moment of filtration. The charcoal was broken into small pieces before the experiment so that it could be more efficient. It was then weighed, and 19 g of charcoal was used in the experiment per one and a half litres of collected river water. When it was time to conduct the experiment, the charcoal was placed in a non-sterile cloth with 32 layers. However, when water passed through it, some smaller particles of charcoal ended up in the pot. Then the filtered water was boiled for 10 minutes at a temperature of 100 °C from the moment of boiling. Once boiled, the water was filtered again through 16 layers to mechanically filter out the unwanted charcoal in the boiled water. The water was stored in two separate containers from the Scientific Institute of Food Safety, Animal Health and Environment BIOR – sterile standard bottle for the study and a new drinking water container for the nitrite study. The water samples were left outside at +4 °C overnight.

2.4. Water Filtered Through Moss

Water for this study was taken on 18 December at 18:30 from the River Daugava in Riga, opposite the AB Dam, and was delivered to the laboratory the next morning at 10:20. The moss was taken from the woods and kept outside until the moment of filtration. The moss was washed before the experiment so that there were no particles and black soil in it. Its leaves were weighed and, as a result, 73 g of moss were used in the experiment per one and a half litres of collected river water. When it was time to conduct the experiment, the moss was placed in a non-sterile cloth with 32 layers. When water passed through it, nothing got into the water, however, the water turned slightly green. Then the filtered water was boiled for 10 minutes at a temperature of 100 °C from the moment of boiling. Once boiled, the water was filtered again through 16 layers of cloth. The water was poured into two containers from the Scientific Institute of Food Safety, Animal Health and Environment BIOR – a sterile standard bottle for studying pathogens and a new drinking water bottle for studying nitrites. The water samples were left outside at +4 °C overnight.

3. Results

To assess the suitability of filtered water for human consumption, the testing results were compared with the mandatory harmlessness and quality requirements for drinking water set out in the Cabinet Regulation No. 63. (16) According to the test report results prepared by the Scientific Institute of Food Safety, Animal Health and Environment BIOR, after filtering and boiling of water, the results obtained are identical for all filtration materials. The test results are summarized in Table 3.

Table 3: Summary of Results

Parameter	Permissible values (16)	NOTHING (Daugava water without filtration) (17)	MOSS (filtered, boiled) (17)	SAND (filtered, boiled) (17)	CHARCOAL (filtered, boiled) (17)
Escherichia coli	**0/100 ml**	4,8 x 10 /100ml	<1 /100ml	<1 /100ml	<1 /100ml
Nitrites	**0,5 mg/l**	<0,01 mg/L	<0,01 mg/L	<0,01 mg/L	<0,01 mg/L
Intestinal enterococci	**0/100 ml**	2,3 x 10 KVV*[1]/100ml	<1 KVV*/100ml	<1 KVV*/100ml	<1 KVV*/100ml

Source: The Scientific Institute of Food Safety, Animal Health and Environment BIOR, TEST REPORT No. PV-2024-P-93644.01 (17)

The results demonstrated that the unfiltered water sample from the River Daugava exceeded the permissible drinking water standards in all tested parameters: *E. coli*, enterococci, and nitrites.

Briefly, after filtration with natural materials and boiling, most of the studied pollutants were filtered out and destroyed. The results show that the level of nitrites complies with the values specified in the Cabinet Regulation No. 63 (16). The level of enterococci and *E. coli* in the water samples is KVV*<1/100ml, in both cases their number is less than one, but exceeds the permissible amount specified in the Cabinet regulations.

The results obtained almost completely comply with the values set out in the Cabinet Regulation No. 63. (16) The results prove that the hypothesis of this scientific research work is partially true – the way the water was filtered and boiled is not

*KVV – colony forming units. This is a unit used to estimate the number of viable bacteria or microorganisms.

completely safe for consumption. However, since the indicators only slightly exceed the permissible values, it proves that water filtered and boiled with natural materials has the potential to provide water for human consumption in a short-term emergency.

It would be recommended to conduct further research on this method to verify the hypothesis that by extending the boiling time of filtered water (e.g., up to 30 minutes), microorganism testing indicators would fully reach the values defined in the Cabinet regulations.

4. Discussion

Within the framework of this study, certain limitations must be considered before generalizing the results obtained. The results of the study may be different if different natural materials are used: different species of moss, different sand textures, different sand or charcoal mining locations, different types of cotton fabric, etc. Filtration efficiency can vary depending on the quality of the filtration materials. It is possible that the materials used in this study were worse or better filters than, for example, the same material taken from another location. The study was conducted in winter. The results could be different at other times of the year, for example, in summer, when bacteria in water could multiply faster and more, both due to higher air temperatures and human interaction. The location of the fresh water can also create different results. The results could be different if water is taken from a place that is densely populated and closely adjacent to both industry and other forms of urbanization (e.g., Riga), where the water could be more polluted. On the other hand, in places where the fresh water is mostly surrounded by natural terrain – forests and meadows – the water could naturally be cleaner. When performing water filtration in a real situation, it would be preferable to choose a water body that is further away from industry and forms of civilization. The results of the study also depend on the types of pollution being studied. They should be selected according to what potential pollutants could end up in the specific water body. In this experiment, *E. coli*, nitrites and enterococci were studied, and it is not possible to judge from the results whether other pollutants present in the water were also filtered out.

5. Conclusions

This study is relevant because, according to the World Bank data, 26 % of the world's population still does not have access to clean drinking water. In ancient times, water quality was assessed by its physical properties, and only in the late 19th century the research of its chemical and bacteriological composition began. Water pollution is influenced by many factors, which can be divided into three large groups: biological, physical, and chemical pollutants. Today, many methods are used in water filtration, including filtration with certain natural materials, such as sand. The results from this study proved that moss, charcoal, and sand were equally effective as water filtration materials. The boiling of the water for 10 minutes was not effective enough, as the microbial contamination was not removed. For example, the amount of *E. coli* in the water, even after filtration and boiling, still exceeded the limit. The hypothesis put forward by the scientific research work was that it is possible to filter water sufficiently with natural materials to make it safe for human consumption. The hypothesis was partially confirmed, as the tested microorganisms were not completely removed after filtration, however, the filtration method in combination with water boiling has good potential in water treatment to obtain drinking water from freshwater. Further research is recommended to determine the necessary boiling time for complete microbial elimination.

Reference List

1. *Volume 6* (2015) *Volume 6 | Annual Reviews*. Available: https://www.annualreviews.org/content/journals/chembioeng/6/1 (Visited: October 3, 2024).
2. Kashiwase, H. and Fujs, T. (2023) *World Water Day: Two billion people still lack access to safely managed water*, *World Bank Blogs*. Available: https://blogs.worldbank.org/en/opendata/world-water-day-two-billion-people-still-lack-access-safely-managed-water (Visited: October 3, 2024).
3. *The 17 goals | sustainable development* (2015) *United Nations*. Available: https://sdgs.un.org/goals (Visited: 2024. gada 3. oktobrī).
4. Jadhav, A.S. (2014) CITESEERX, CiteSeerX. Available: https://citeseerx.ist.psu.edu/ (Visited: October 3, 2024).
5. Supervienkāršā ķīmija (2022). Rīga: Zvaigzne ABC (2022). Resursu izmantošana. Dzeramais ūdens. 270. lpp
6. The United Nations World Water Development Report 2, https://www.greenfacts.org/en/water-resources/figtableboxes/5.htm ,Visited: January 4, 2025).
7. Feldman, D.L. (2012) *Water*.
8. *Drinking water analysis by E.Gulbja Laboratory*. Available: https://www.egl.lv/dzerama-udens-analizes/ikvienam-interesentam (Visited: November 13, 2024).
9. Team, E. (2025) Can I drink river water?, The Environmental Literacy Council. Available at: https://enviroliteracy.org/animals/can-i-drink-river-water/ (Visited: June 2, 2025).
10. Team, E. (2025) Can I drink river water? The Environmental Literacy Council. Available at: https://enviroliteracy.org/animals/can-i-drink-river-water/ (Visited: June 2, 2025).
11. Picetti, R. *et al.* (2022) *Nitrate and nitrite contamination in drinking water and cancer risk: A systematic review with meta-analysis*, *Environmental Research*. Available:

https://www.sciencedirect.com/science/article/pii/S0013935122003152 (Visited: January 8, 2025).

12. Chazelas E;Pierre F;Druesne-Pecollo N;Esseddik Y;Szabo de Edelenyi F;Agaesse C;De Sa A;Lutchia R;Gigandet S;Srour B;Debras C;Huybrechts I;Julia C;Kesse-Guyot E;Allès B;Galan P;Hercberg S;Deschasaux-Tanguy M;Touvier M; (2022) *Nitrites and nitrates from food additives and natural sources and cancer risk: Results from the NutriNet-Santé cohort*, *International journal of epidemiology*. Available: https://pubmed.ncbi.nlm.nih.gov/35303088/ (Visited: January 8, 2025).
13. Ramatla, T. *et al.* (2023) *A systematic review and meta-analysis on prevalence and antimicrobial resistance profile of Escherichia coli isolated from water in africa (2000–2021)*, *https://www.cell.com*. Available at: https://www.cell.com/heliyon/fulltext/S2405-8440(23)03330-3. (Visited: January 8, 2025)
14. Makvana, S. and Krilov, L.R. (2015) *Escherichia coli infections | pediatrics in Review*, *Escherichia coli Infections*. Available at: https://publications.aap.org/pediatricsinreview/article/36/4/167/34858/Escherichia-coli-Infections (Visited: January 8, 2025).
15. Environment Protection Agency of Ireland (2020) *Water treatment manual: Filtration*. rep. Johnstown Castle, Co. Wexford: ENVIRONMENTAL PROTECTION AGENCY. Available: https://www.epa.ie/publications/compliance--enforcement/drinking-water/advice--guidance/EPA-Water-Filtration-Manual.pdf (Visited: January 4, 2025).
16. Vestnesis.lv (1999) *Dzeramā ūdens obligātās Nekaitīguma Prasības - Latvijas Vēstnesis*, *www.vestnesis.lv*. Available: https://www.vestnesis.lv/ta/id/22311-dzerama-udens-obligatas-nekaitiguma-prasibas (Visited: January 8, 2025).
17. The Scientific Institute of Food Safety, Animal Health and Environment “BIOR” Testing Results Nr.PV-2024-P-93644.01