

River Water Quality Analysis Using RO Filtration

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Abstract

This study focuses on the analysis of river water quality before and after undergoing filtration using a 5-stage reverse osmosis (RO) system. Access to clean and safe drinking water is essential for maintaining public health and quality of life. However, many communities face challenges due to polluted river sources, limited municipal water treatment, and dependence on bottled water. The water samples were evaluated based on key physicochemical parameters including Total Dissolved Solids (TDS), Electrical Conductivity (EC), pH, and physical characteristics such as appearance and smell. The filtered river water was also compared to commercial mineral water and municipal tap water to assess overall quality. From the result, it shows that the quality of filtered river water was improved. Unlike complex or energy-intensive treatment systems, this study highlights the effectiveness of a basic RO-based setup for field or domestic applications. By providing practical data and a comparison with standard water sources, this study promotes awareness of filtered river water as a reliable alternative and contributes to improving safe water access in rural or backup scenarios.

1. Introduction

Access to clean and safe drinking water is critical for human health and daily well-being. However, in many regions, especially rural or undeveloped areas, river water is often the main water source and is highly susceptible to contamination from industrial runoff, sewage, and agricultural waste [1]. Conventional treatment methods may not always be available due to high costs, infrastructure needs, or energy requirements [2].

Boiling or chemical disinfection is commonly practiced but may not remove dissolved solids or unpleasant odors. For this reason, household-based water filtration methods such as reverse osmosis (RO) systems are becoming more relevant and accessible due to their effectiveness in producing clean and safe drinking water [5]. Although RO systems have several drawbacks, including high initial installation and maintenance costs, significant water wastage during operation, and the removal of beneficial minerals [6], their capability to remove a wide range of contaminants such as heavy metals, dissolved solids, and microorganisms makes them one of the most reliable purification technologies for domestic use [7]. Overall, the advantages of RO systems outweigh their limitations, especially in regions where centralized water treatment infrastructure is limited [3].

This project aims to evaluate the quality of river water before and after filtration through a 5-stage RO system. The focus is on comparing it with tap and mineral water in terms of physicochemical properties to determine the suitability of the filtered water for human use [4].

1.1 Research Background

Access to clean and safe water is an essential need, yet many rural and semi-urban communities still rely on untreated surface water such as rivers for daily use. These sources are often contaminated with dissolved solids, pollutants, and microbial impurities, posing health risks if consumed directly. In such regions, municipal water supply may be inconsistent or unavailable, and bottled water is often expensive and environmentally unsustainable [5][6]. Therefore, using a basic household reverse osmosis (RO) filtration system could serve as a practical and low-cost solution. This study aims to test the effectiveness of such filtration by comparing water quality parameters—TDS, EC, pH, appearance, and smell—before and after filtration, and against other common water sources such as tap and mineral water.

1.2 Problem Statement

Many communities continue to rely on river water for daily use, despite its high risk of contamination by organic waste, industrial runoff, and microbial pollutants [1]. This untreated water can pose serious health hazards if consumed without proper filtration. In rural and underserved areas, access to treated water is limited, and bottled water is often not a sustainable or affordable option [2][8][9].

There is also a lack of understanding about the quality of filtered river water compared to tap and mineral water. While RO systems are commonly used, data comparing their effectiveness in improving actual river water quality is limited. Therefore, it is necessary to test and compare filtered river water with other sources using measurable physicochemical and physical parameters such as TDS, EC, pH, color, and odor [3].

1.3 Literature Review

A literature review's objective is to outline the planned study using trustworthy data and an understanding of the connections between the topics under investigation. The material found is particular and typically focuses on the topic and problem being studied. A brief introduction to the study topic, concepts, and associated theories is one of several essential elements that must be included in a literature review chapter. Additionally, this literature evaluation needs to cover both recent and prior research as well as studies on related materials. The literature review is concluded with a summary. Instead of only summarizing research done by other researchers, a literature review additionally defines the study by searching for titles of studies that have been done in the field of study.

1.4 Types of Industrial Water Filters

Nowadays, there are many types of industrial water filters in the market. Table 1 shows the types of industrial water filters function and their application.

Table 1 *Types of industrial water filters*

Types	Function	Application
Sand filter	Remove suspended solids by passing water through a bed of sand.	Often used in water treatment plants and for swimming pools.
Activated carbon filter	Remove organic compounds, chlorine, and other chemical contaminants using activated carbon.	Used in water treatment plants, industrial processes, and municipal water systems.
Cartridge filter	Filter fine particulates and microorganisms using replaceable cartridges.	Used in various industries including pharmaceuticals, food and beverage, and electronics.
Bag filter	Remove suspended solids from liquids through a bag-like filter.	Common in chemical processing, paint and ink manufacturing, and water treatment.
Membrane Filters	Separate contaminants based on size and chemical properties using semi-permeable membranes.	Used in water purification, wastewater treatment, and process water preparation
Self-cleaning filter	Automatically clean the filter media, minimizing maintenance and downtime.	Ideal for continuous operations in industries like power generation, steel, and paper mills.

1.5 Comparison Between Sand Filter and Membrane Filter

Industrial water filtering requires the use of sand filters, each type of which is made to fit a particular application's

specifications, flow rate, and maintenance demands. The operational tempos of rapid sand filters and slow sand filters differ. Rapid sand filters are best suited for applications with high and continual water demand, such as industrial process water systems and municipal water treatment, because of their high flow rates and frequent backwashing. Rapid sand filters can have several drawbacks, though, including the need for a lot of water during washing, variable quality, and the ability for microorganisms smaller than 0.01 mm to pass through. Slow sand filters, on the other hand, are more appropriate for smaller-scale enterprises or rural drinking water systems where water quality is crucial and maintenance can be more complicated but less frequent due to their lower flow rates and reliance on biological filtration. Microfiltration membranes provide better filtration efficacy in a more compact device with a greater surface area per volume [10]. When compared to sand filters, immersed membrane microfiltration with a pore size of 0.05 μm , for instance, demonstrated superior overall performance with a 100% removal efficiency for E. Coli and total suspended solids (TSS) as well as a significant reduction in turbidity and microplastics [11].

Microfiltration membranes are a more effective option for contemporary water treatment demands because of their far better productivity compared to fast sand filters. Pressure sand filters and upflow sand filters address space and flow direction concerns. Pressure sand filters are encapsulated in pressure vessels, making them suitable for industrial applications with space constraints and high flow requirements, such as cooling systems and irrigation. Their pressurized operation allows for higher throughput in a smaller footprint compared to gravity-based systems. Pressure decrease in an upflow sand filter can be predicted using the Kozeny-Carman equation prior to filter bed fluidization and Fair and Hatch's equation following bed fluidization by utilizing RMSE and Chi-Test to analyze the experimental-theoretical comparison [12]. Upflow sand filters, with their upward water flow, provide effective filtration in wastewater and stormwater management scenarios, utilizing the natural tendency of particulates to settle in lower regions of the filter, thereby optimizing particulate removal and potentially reducing clogging.

1.6 Booster Pump

In a water filter unit, a booster pump increases the water pressure of the pre-treated feedwater before it enters the Reverse Osmosis (RO) membrane. RO membranes require a specific pressure range to function effectively. Booster pump is used to make sure the pressure output should exceed the pressure requirement of the RO membrane to account for pressure drops.

2. Methodology

This chapter explains the systematic approach used in conducting the study on river water quality before and after filtration using a 5-stage RO system. The methodology outlines how samples were collected, filtered, and analyzed based on chemical and physical water quality parameters. This structured method ensures reliability and consistency in the findings.

2.1 Water Sample Collection

Water samples were collected from three sources:

- Raw river water from a local river.
- Tap water from a residential supply.
- Commercially available mineral water.

Two trials were conducted for each source (except physical observations), and samples were stored in clean containers to avoid contamination.

2.2 Filtration Process

The collected river water was filtered using a 5-stage reverse osmosis (RO) system. The filtration stages typically include:

- Sediment filter
- PPF filter
- Carbon filter
- RO membrane
- Post carbon/mineral balancing filter

This method was chosen for its effectiveness in removing dissolved solids and improving water taste and clarity.

2.3 Testing Parameters

Each sample was tested based on the following parameters:

- Total Dissolved Solids (TDS) – measured using a digital TDS meter.
- Electrical Conductivity (EC) – measured using an EC meter.
- pH level – measured using a calibrated digital pH meter.
- Physical properties – appearance and smell were observed and recorded manually.

2.4 Data Recording and Analysis

Two trials were conducted for each water sample (for TDS and EC), and results were averaged. pH and physical appearance were recorded once. Data was organized into tables and charts to visualize differences across sources and pre/post-filtration. From the analysis, river and filtered water will be compared with tap and mineral water.

2.5 Tool and Materials

Tools and materials used in this reasearch are as below:

- 5-stage RO water filter system
- pH meter
- TDS/EC dual meter
- Clean plastic bottles for sample storage
- Data recording sheets or software

2.6 Finalizing the Mechanical Structure

To effectively fit the filtration components, the portable water filtration system's mechanical construction was altered. The PPF filter, sediment filter, RO membrane, and water pump were all fitted snugly into the original shell. To guarantee lifespan and portability, a sturdy structure was created using lightweight, corrosion-resistant components. The parts were put together to make the most use of available space while preserving simple access for filter maintenance and replacement.

To enable effective water flow through the system, the water input and exit were placed in key locations. To stop component movement and vibration while in use, a support structure was incorporated. Appropriate sealing methods were used to stop leaks and guarantee the system works well. To enable dependable functioning, electrical components such as the pump and power supply were linked and installed firmly. Following the completion of the structure, the system was put through one more round of testing to confirm its general functionality and mechanical stability.

3. Result and Discussion

To assess the effectiveness of household RO filtration, water samples were collected and analyzed before and after the filtration process. Raw river water, known for its potential contamination, showed slightly turbid, brownish appearance with an earthy smell. After being processed through the 5-stage RO system, the water became clear and odorless. Table 2 shows the water sample test results for tap water, river water, filtered river water and mineral water.

Table 2 Water sample test results

Types	Trial	Parameter				
		TDS (PPM)	EC ($\mu\text{S}/\text{CM}$)	pH	Appearance	Smell
Tap water	1	75	148	7.25	Clear	Ordorless
	2	73	146			
	Average	74	147			
River water	1	63	128	6.06	Slightly turbid, brownish	Slightly earthy
	2	65	124			
	Average	64	126			
Filtered river water	1	90	178	7.05	Clear	Ordorless
	2	84	180			
	Average	87	179			
Mineral water	1	117	237	6.75	Clear	Ordorless
	2	105	235			
	Average	111	236			

Based on Table 2, the test results for Total Dissolved Solids (TDS), Electrical Conductivity (EC), and pH showed improved water quality. Raw river water initially had low TDS and EC values, but after filtration, a slight increase in both values was observed due to post-filtration mineral balancing. Importantly, pH improved from slightly acidic (6.06) to near-neutral (7.02). These values were compared with tap and mineral water as references.

The comparison demonstrated that the filtered river water was within safe and acceptable ranges for consumption. The physical and chemical improvements indicate that even untreated surface water can be made suitable for daily use through effective domestic filtration.

3.1 Data Analysis

The water quality analysis based on TDS (Total Dissolved Solids), EC (Electrical Conductivity) and pH reveals significant differences among the water sources. From the graph shown in Fig.1, mineral water recorded the highest TDS (average 111 ppm) and EC (average 236 $\mu\text{S}/\text{cm}$), indicating a higher presence of dissolved minerals, which is typical and desirable for bottled drinking water. Tap water, on the other hand, showed the lowest TDS (average 74 ppm) and moderate EC (average 147 $\mu\text{S}/\text{cm}$), suggesting that it is treated and safe for household use. Interestingly, filtered river water showed higher TDS (average 87 ppm) and EC (179 $\mu\text{S}/\text{cm}$) than unfiltered river water (TDS: average 64 ppm, EC: average 126 $\mu\text{S}/\text{cm}$), likely due to the removal of particulates but retention of fine dissolved ions during filtration.

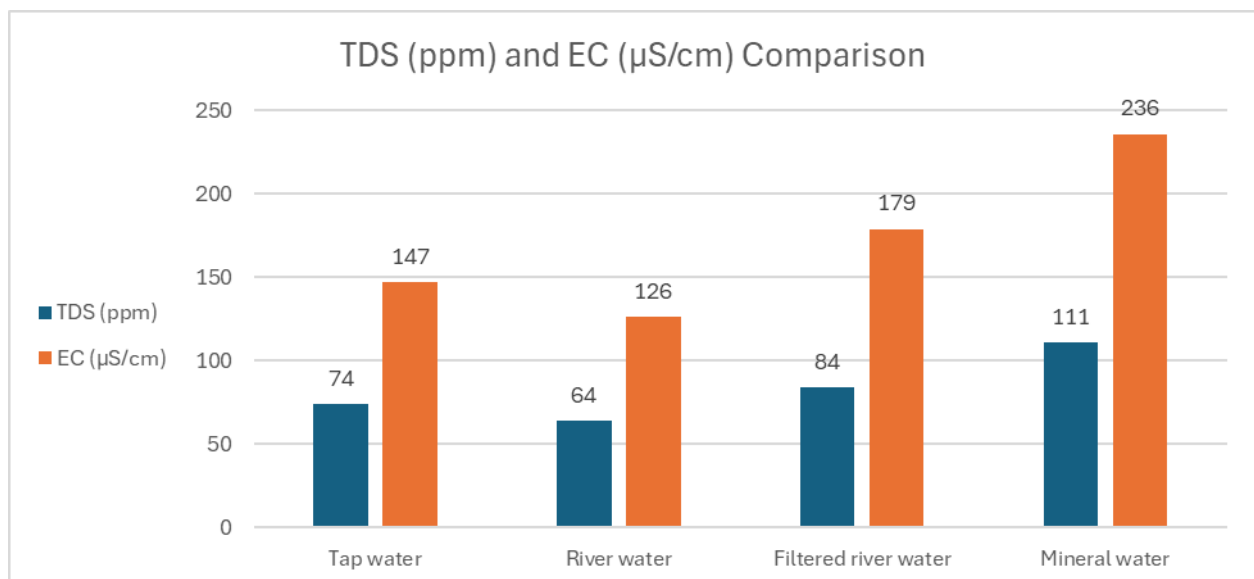


Fig. 1 Graph TDS (ppm) and EC ($\mu\text{S}/\text{cm}$) comparison

All the samples had pH values between 6.5 and 8.5 as shown on the graph in Fig. 2, which is the permissible range for drinking water. The unfiltered river water had a slightly acidic pH of 6.06, whereas tap water had a slightly alkaline pH of 7.25. Following filtering, the pH of the river water increased to 7.02, which is almost neutral. The pH of mineral water was 6.75, which is little below neutral but still within acceptable bounds. Overall, the investigation shows that while tap and mineral water already showed qualities that were in line with potable water regulations, filtering enhanced the safety and pH balance of river water. However, the increase in EC and TDS during filtration indicates that some dissolved minerals were either concentrated or remained after the apparent contaminants were eliminated.

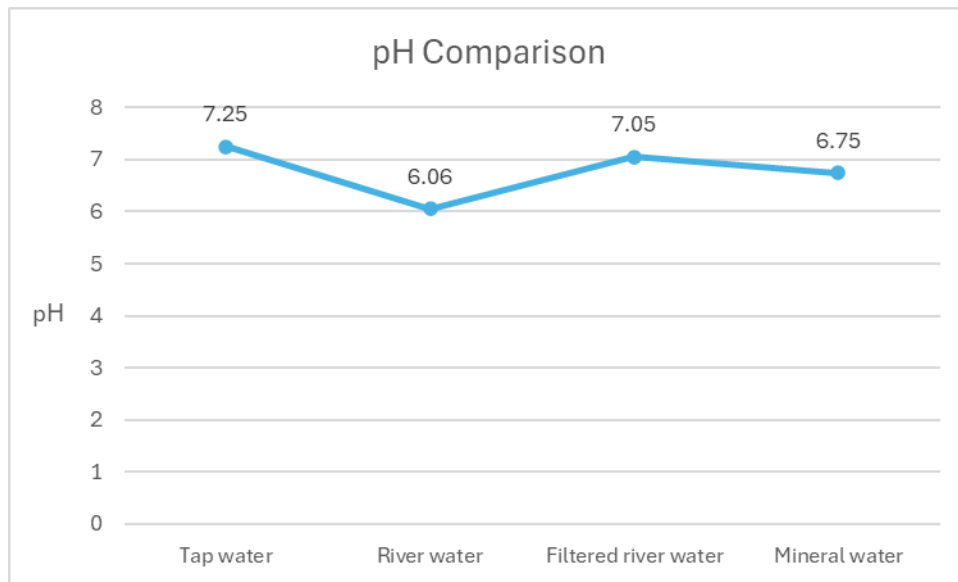


Fig. 2 Graph pH comparison

4. Conclusion

This study successfully analyzed the changes in water quality of river water before and after undergoing RO filtration. The results showed that the 5-stage RO system effectively improved the physicochemical and physical properties of the water. TDS, EC, and pH levels post-filtration were comparable to or better than those of tap and mineral water.

The filtered river water had a clearer appearance, neutral pH, and no odor, meeting basic criteria for safe drinking water. Although the TDS and EC levels slightly increased due to added minerals in the final filtration stage, all values remained within acceptable limits.

The findings suggest that filtering untreated river water using a simple RO-based system is a viable method for producing safer water for household use, particularly in areas lacking access to clean municipal supplies.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Rhishwan Vadivelu, Mohd Hadri Mohamed Nor; **data collection :** Rhishwan Vadivelu, Muhammad Amir Fitri Hairol Akhma, Tuan Muhammad Syafiq Tuan Masrohaizat; **analysis and interpretation of results:** Rhishwan Vadivelu, Mohd Hadri Mohamed Nor; **draft manuscript preparation:** Rhishwan Vadivelu, Mohd Hadri Mohamed Nor. All authors reviewed the results and approved the final version of the manuscript.

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