

Comparative Analysis between Water Purification Systems

Lubaba Afzal

Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET);
lubaba.afzal@gmail.com; Tel.: +880-1799773355

[†] Presented at the 4th International Electronic Conference on Applied Sciences, 27 October–10 November 2023; Available online: <https://asec2023.sciforum.net/>.

Abstract: The global crisis of inadequate safe drinking water affects millions due to factors like poor infrastructure, environmental degradation, and natural disasters. To address this, water purification technologies are crucial, including filters that eliminate bacteria, viruses, and heavy metals. The thesis focuses on analyzing five water purification methods, considering their effectiveness and competence. It examines various water sources in Bangladesh, highlighting issues like excessive microorganisms and contaminants in tap water. The study aims to promote affordable, sustainable purification systems, acknowledging drawbacks in certain technologies. Findings reveal issues with tap and boiled water while other methods effectively remove contaminants.

Keywords: hazardous pollutant; purification system; drinking-water; safe water

1. Introduction

2021 Report from UNICEF/WHO expresses that 61.7 M people in Bangladesh lacks essential hygiene facilities. Billions of people worldwide will not have access to safely managed drinking water, sanitation, and hygiene services by 2030, as reported by WHO. The findings of international investigations show that, while the availability of safe water substantially decreases the possibility of diarrheal disorders and, consequently, death, the lack of sanitation significantly decrease this beneficial effect [1] (Caldwell et al., 2006). Existing researches deal with the capacity of water purifiers to kill germs but this research deals with the capacity of filters to retain electrolytes. Through its multi-stage series of filters, the alkaline water system provides the maximum level of filtration in the gravity filter, also known as the candle filter, producing clean, mineralized alkaline water. The pureit water filter uses a multi-stage purification process namely pre-sediment filter, activated carbon filter, post-carbon sediment filter and germkill chamber.

Though DWASA has plans to set up 300 units of water ATM's, it's journey initiated to give access to 100 water ATM's (forecasted) for low income people [2] (MELS, Blokland, Sterk, & Nazrul, n.d.). One has to deposit a refundable amount of 200 taka to the water booth's operator and collect a card from there. When the card is inserted water starts flowing and when the card is pooled out, the water flow stops. Reverse osmosis is a type of membrane enabled system that can segregate clean water from dissolved solids of feed stream and generate permeate as well as reject stream [3] (Garud, Kore, Kore, & Kulkarni, 2011).

Straining, interception, inertial forces, particle setting, diffusion and fluid dynamics forces are the transportation mechanism of candle filter commonly known as gravity filter [4] (Chen, Chang, Huang, Bauman, & Hung, 2005). Pureit was originally produced by Hindustani Unilever which was based on Ultraviolet and reverse osmosis mechanism and it did not require electricity to operate [5] (Rangan & Sinha, 2011). For biotoxicity assessment more sophisticated processes have to be applied to ensure the quality of treated water. A frequently used technique for treating recalcitrant pollutants is advanced oxidation process [6] (Kumari and Kumar, 2023). Though binary results show the highest

Citation: Afzal, L. Comparative Analysis between Water Purification Systems. *Eng. Proc.* **2023**, *52*, x. <https://doi.org/10.3390/xxxxx>

Academic Editor(s): Name

Published: date



Copyright: © 2023 by the author. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

adsorption capacity for toluene, the differential adsorption capacity of benzene and toluene can be used in designing purification processes to target specific contaminants in groundwater [7] (Erto, Chianese, Lancia, & Musmarra, 2017).

Fenton's reagent, a solution of hydrogen peroxide and an iron catalyst, can produce hydroxyl radicals, which are very reactive and can break down humic acid into smaller molecules [8]. Humic acid can affect color, taste and odor of water and can react with chlorine and other disinfectants. The use of iron oxide magnetic nanocatalyst can be introduced as an improved treatment process, including reduced mass transfer limitations, lower energy consumption, and enhanced catalyst selectivity [9].

The existing researches deal with the cost, competence to purify water from pollutants and availability of water treatment technology like boiling, candle filter, reverse osmosis, vending machine and pureit filter (germkill technology). In this research we will try to demonstrate the efficiency of the treatment systems to remove heavy metals and retain electrolytes.

2. Methodology

The overall approach of this research was decided on the analysis of collected data. The research was basically experimental. The parameters were tested in Environmental Engineering Laboratory of Civil engineering Department, BUET. The conclusion was derived from single sample test.

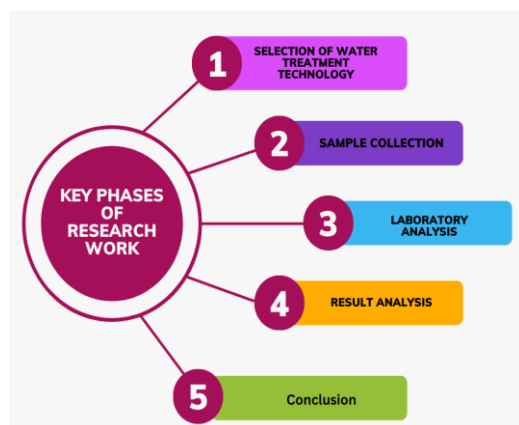


Figure 1. Steps of Research.

2.1. Location of Sampling Point

Study area selection is the primary and significant phase of conducting research. WASA ground water, water for boiling purpose, water sample from WASA water vending machine and water samples after filtering through RO, candle and pureit filter, all were collected from Dhaka WASA mod zone 3.

2.2. Sample Collection

Six samples were collected for the study. The date and location of sample collection were carefully recorded.

Samples which were selected for experiment:

1. Boiled Water
2. WASA Tap Water
3. Candle Filter
4. Reverse Osmosis
5. Water Vending Machine
6. Pureit Filter (Germkill Technology)

2.3. Boiled Water

Water was boiled in the vessel by heating from stove with the temperature being risen to around 100 degree Celsius and kept in the vessel so that the heavier suspended solids might get sedimented over night.

2.4. WASA Supply Water

WASA ground water was collected from household tap for testing purpose, on 21 August 2022.

2.5. WASA Water Booth

Water sample was collected from WASA vending machine on 1 December 2022. The source of the sample was Prominent Housing WASA water booth.



Scheme 1. Water ATM Booth Prominent Housing.

2.6. Candle Filter

Water sample from Candle filter (gravity filter) was collected from home of an inhabitant of Mohammadpur, Dhaka which falls into DWASA mod zone 3, on 3 December 2022. The name of the company, from which the candle filter was purchased, was Eva Water filter.



Scheme 2. Homebased Candle Filter.

2.7. Reverse Osmosis

Water sample from reverse osmosis filter was collected from home of an inhabitant of DWASA mods zone 3 on 21 August 2022. The filter was produced by the company Aqua Shine.

2.8. Pureit Filter

Water sample was collected for testing purpose from pureit filter produced by Uniliver Bangladesh. It was collected on 3 December 2022. Pureit water filter use ultraviolet

technology as one of its purification method. Ozone-based advanced oxidation technologies provide an efficient process to degrade micropollutants from the aquatic environment and thus it emphasizes the potential application of these techniques in water treatment and purification processes [10].

2.9. Physicochemical Testing

Testing of heavy metal such as Lead, chromium, Cadmium and some essential elements namely calcium, magnesium, sodium, potassium were carried out in the Environmental Engineering Laboratory of Civil Engineering Department at BUET. The Environmental Engineering Laboratory, BUET’s expert knowledge of DWASA drinking water characteristics were used to choose these criteria.

Table 1. Tested Parameters, Testing Methods and Equipment.

Heavy Metal Test			Electrolyte Test				
Parameters	Testing Method	Equipment	Operating condition	Parameters	Testing Method	Equipment	Operating Condition
Lead	USEPA 206.2 Rev 2.2 SM 3113 B	Shimadzu AA-6800 FLAAS	Lead hollow cathode lamp	Sodium	USEPA 206.2; SM 3113B	Shimadzu AA-6800 FLAAS	Sodium Hollow Cathode Lamp
Cr	USEPA 206.2; SM 3113B	Shimadzu AA-6800 FLAAS	Chromium hollow cathode lamp	Potassium	USEPA 206.2; SM 3113 B	Shimadzu AA-6800 FLAAS	Potassium Hollow Cathode Lamp
Cd	USEPA 206.2; SM 3113 B	Shimadzu AA-6800 FLAAS	Cadmium hollow cathode lamp	Calcium	USEPA 206.2; SM 3113 B	Shimadzu AA-6800 FLAAS	Calcium Hollow Cathode Lamp
				Magnesium	USEPA 206.9 SM 3113 B	Shimadzu AA-6800 FLAAS	Magnesium Hollow Cathode Lamp

3. Results and Discussion

The Bangladesh Standard Testing Institution (BSTI) created and published the Bangladesh Standard Specification for Drinking Water (BDS 1240:1989) to regulate the quality of drinking water. Table shows the Environmental Conservation Rules (ECR,23) and WHO drinking water criteria.

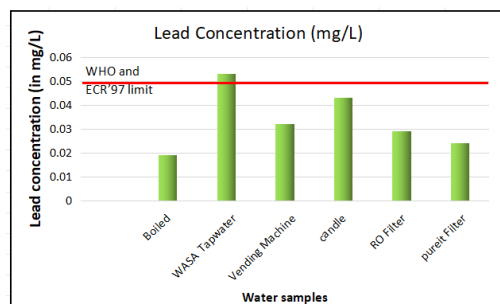


Figure 2. Lead Concentration of the Samples.

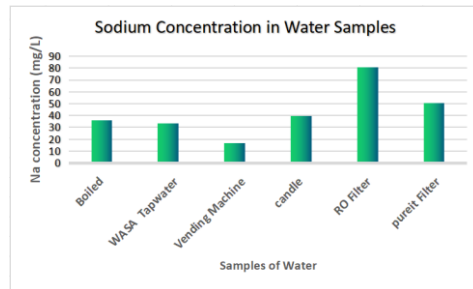


Figure 3. Sodium Concentration in the Samples.

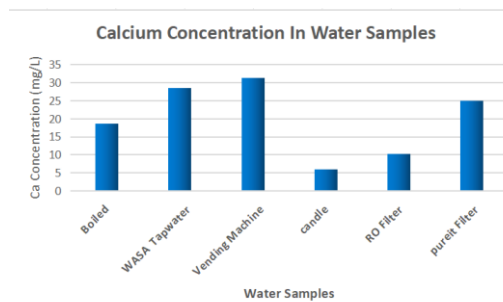


Figure 4. Calcium Concentration in Water Samples.

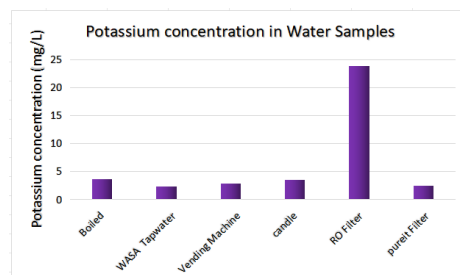


Figure 5. Potassium Concentration in Water Samples.

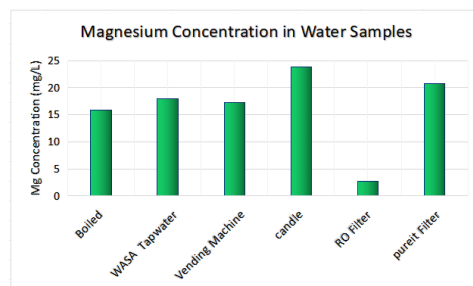


Figure 6. Magnesium Concentration in Samples.

3.1. Presence of Heavy Metals After Filtering

3.1.1. Lead

According to ECR'23 and WHO standard lead concentration limit for safe drinking water is 0.05mg/L. Lead concentration was tested in the environment laboratory by the equipment Shimadzu AA-6800 FLAAS which had minimum detection level 0.001 mg/L. As we can see from Figure 2 only WASA tap water exceeded the lead concentration limit set by ECR'97 and WHO standard.

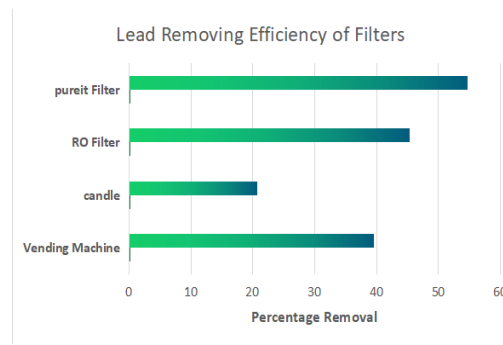


Figure 7. Lead Removing Efficiency of Filters.

3.1.2. Chromium

The ECR’23 and WHO guideline value for chromium in drinking water is a maximum of 0.05 mg/L. Chromium was tested by the equipment Shimadzu AA-6800 FLAAS that had a minimum detection level 0.001 mg/L. From the Table 2, we can see that none of the samples have exceeded the limit of chromium concentration set by ECR’23 or WHO.

Table 2. Chromium Concentration of the Samples.

Samples	Cr(mg/L)
Boiled	0.008
WASA Tapwater	Below MDL(0.001mg/L)
Vending Machine	0.001
candle	Below MDL(0.001mg/L)
RO Filter	Below MDL(0.001mg/L)
pureit Filter	Below MDL(0.001mg/L)

3.1.3. Cadmium

According to ECR’23 the maximum allowable limit of cadmium is 0.005 mg/L and according to WHO, it is 0.003 mg/L. The equipment used for Cadmium test was Shimadzu AA-6800 FLAAS that had a minimum detection level for Cadmium 0.1 mg/L. As we can see from the Table 3 all the samples which were tested had Cadmium concentration below minimum detection level.

Table 3. Cadmium Concentration in the Samples.

Samples	Cd(ppm)
Boiled Water	Below MDL(0.1)
WASA Tapwater	Below MDL(0.1)
Vending Machine	Below MDL(0.1)
candle	Below MDL(0.1)
RO Filter	Below MDL(0.1)
pureit Filter	Below MDL(0.1)

3.2. Efficiency of Retaining Electrolytes

3.2.1. Calcium

According to WHO guidelines the minimum desired level for Ca concentration is 75 mg/L to maximum permissible level 200 mg/L. From the Figure 4 we observe that none of the water samples have Ca concentration close to the desired concentration. So the water

which is purified by candle, RO or pureit filter might not fulfill the calcium requirement expected from water.

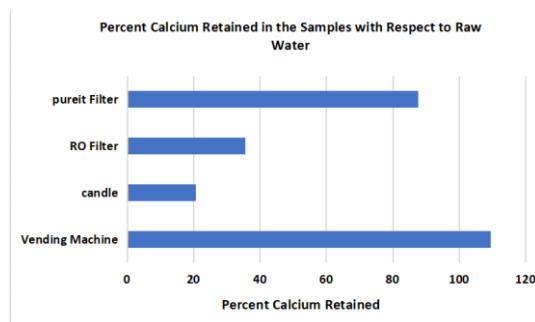


Figure 8. Percentage of Calcium concentration compared to Raw Water.

3.2.2. Magnesium

After analyzing the data we observe from Figure 6, that none of the samples are even close to the limit specified for magnesium concentration by WHO which is 50–200 mg/L.

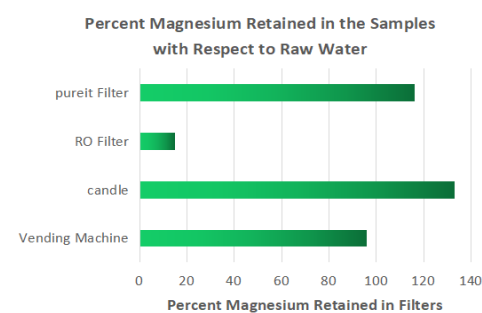


Figure 9. Percent Magnesium Contained in the Sample.

3.2.3. Potassium

From Figure 5 we see that only RO filter has potassium concentration that exceeds the limit set by Bangladesh standard which is 12 mg/L. As for the rest of the samples the potassium concentration is far below the desired level.

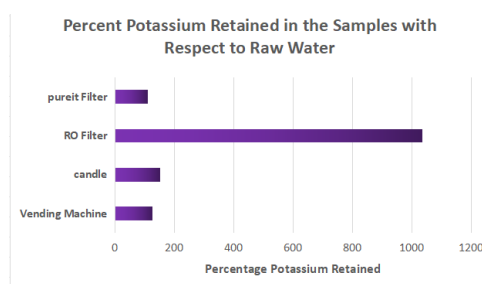


Figure 10. Percent Potassium Contained in the Sample.

3.2.4. Sodium

From the Figure 3, we see that none of the samples contain sodium concentration that exceed the limit set by ECR'23 or WHO guidelines which is 200 mg/L.

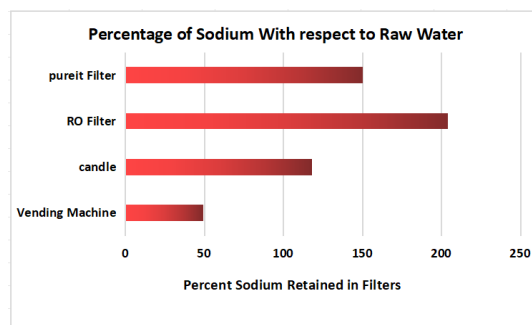


Figure 11. Percentage Sodium Retained in the Purified Water.

4. Conclusions

From overall analysis we can deduce that, in case of retaining essential elements, specifically potassium and sodium, vending machine shows the least effectiveness. In addition vending machine has low chromium removing efficiency compared to other filters tested. Considering the efficiency of removing cadmium, chromium and lead, reverse osmosis filter shows the best performance. However, it also remove significant amount of electrolytes, calcium and magnesium to be specific. For retaining the essential elements and removing the harmful metals from the water samples, pureit filter proves to be most balanced. Along with high lead removing efficiency and a moderate cadmium removing efficiency, pureit filter also retains a high percentage of sodium, potassium. Hence, water from pureit filter is most recommended for safe consumption. Candle filter being least efficient in removing Lead, also removes Calcium and Potassium from water to a great extent. High concentration of Sodium and Magnesium is found in the filtrate of Candle filter which is important for maintaining electrolyte concentration in water. If this filtrate water is used for industrial purposes rather than drinking, then it might prevent pipes from corrosion, as these minerals might contribute to form a protective scale on the inner surface of the pipes. Again for drinking purpose, water has to be boiled prior to filtering through the candle filter to kill micro-organisms.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Bangladesh University of Engineering and Technology, and approved by Bangladesh University of Engineering and Technology for ethical approval.

Informed Consent Statement: Informed consent from was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and confidentiality.

Acknowledgments: I acknowledge the contribution of Dr. Rowshan Mamtaz for giving me valuable insights for completing this research.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Caldwell, B.K.; Smith, W.T.; Lokuge, K.; Ranmuthugala, G.; Dear, K.; Milton, A.H.; Sim, M.R.; Ng, J.C.; Mitra, S.N. Access to drinking-water and arsenicosis in Bangladesh. *J. HealthPopul. Nutr.* **2006**, *24*, 336.
2. Mels, A; Blokland, M.; Sterk, B.; Nazrul, S. Water Services Provision to Low-Income Communities in Dhaka-Assessment of the Partnership Approach by Dhaka Wasa.
3. Garud RM, Kore SV, Kore, V.S.; Kulkarni, G.S. A Short Review on Process and Applications of Reverse Osmosis. *Univers. J. Environ. Res. Technol.* **2011**, *1*, 233–238.
4. Chen JP, Chang SY, Huang JY, Bauman, E.R.; Hung, Y.T. Gravity filtration. *Physicochem. Treat. Process.* **2005**, 501–543.
5. Rangan, V. K.; Sinha, M. *Hindustan Unilever's' Pureit' Water Purifier*; Harvard Business School: Boston, MA, USA, 2011; 9-511-067.

6. Kumari, P.; Kumar, A. ADVANCED OXIDATION PROCESS: A remediation technique for organic and non-biodegradable pollutant. *Results Surf. Interfaces* **2023**, *11*, 100122.
7. Erto A, Chianese S, Lancia, A.; Musmarra, D. On the mechanism of benzene and toluene adsorption in single-compound and binary systems: Energetic interactions and competitive effects. *Desalination Water Treat.* **2017**, *86*, 259–265.
8. Smith, J.A.; Brown, L.M. Electro-oxidation of humic acids using platinum electrodes: An experimental approach and kinetic modeling. *Water* **2020**, *12*, 2250.
9. Gallo-Cordova, A.; Castro, J.J.; Winkler, E.L.; Lima, E.; Zysler, R.D.; Morales, M.P. Improving degradation of real wastewaters with self-heating magnetic nanocatalysts. *Nanomaterials* **2021**, *11*, 1060.
10. Liu, Z.; Hosseinzadeh, S.; Wardenier, N.; Verheust, Y.; Chys, M.; Van Hulle, S. Combining ozone with UV and H₂O₂ for the degradation of micropollutants from different origins: Lab-scale analysis and optimization. *Environ. Technol.* **2018**, *40*, 3773–3782.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.