

Case Study: Investigating Drinking Water Quality in Water Appliances at UTHM Pagoh Campus

Nadzmi Norsyfulhizam, Ain Nazira Amran, Nur Hana Wajaluddin, Masiri Kaamin*, Siti Noorain Mohd Razali

*Department of Civil Engineering, Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600, Pagoh, Johor, MALAYSIA*

*Corresponding Author: masiri@uthm.edu.my

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Abstract

Most campuses and residential colleges are already equipped with water filtration systems that enhance the quality of life. Although various evaluations have examined the cleanliness of each system in campuses and residential colleges, there is still a need to verify the quality of water and products, whether they meet the quality specified in the national standard and the standard of each product. This study aims to identify water filter products and systems that compare filtered water quality with the Malaysian Drinking Water Quality Standards. Several parameters are studied to determine the level of cleanliness and safety of each product and water filter system, namely pH, Turbidity, Total Dissolved Solid (TDS), Inorganic Iron (Fe), and Chemical Oxygen Demand (COD). The one-month-long test gave positive and negative results, which showed some of the water filters at the scene were safe and drinkable, but some did not pass the level of the product itself.

1. Introduction

Although the water filter system Reverse Osmosis, Nanotechnology filtration, 4 Stage Filtration System, and 10" Inch PP Sediment and 10" Inch CTO Carbon are expected to provide clean and quality water to users, there are some issues and problems related to the quality of the water produced after some year used and does the market water filter system ensure that the water supplied to consumers is of a high standard [1]. After the monthly or annual maintenance work is completed, will the relevant party conduct maintenance and investigate water samples in each household since the water quality may deteriorate, including the level of filtration and the ability to remove contaminants such as heavy metals, chlorine, or harmful microorganisms. Users need to pay more attention to the maintenance of the water filter machine [2]. The fact is that water filter systems require frequent maintenance when used for a long period of time. The quality of water produced may be affected due to maintenance delays or errors [3]. Inadequate water filter system maintenance, such as cleaning water filter tubes and replacing membrane cartridges, can affect filtered drinking water pH, conductivity, biological oxygen demand (BOD), chemical oxygen demand (COD), and bacterial growth [4].

According to [5], drinking water quality may be affected by distribution channels, sources for storage, and cooling systems installed by users before use, and there are concerns about secondary microbiological and chemical contamination during filter change. Therefore, the main purpose of this study is to determine whether this drinking water meets the national water standards and standards for each product. This study could be a starting point for additional research aimed at minimizing college students' concerns about the safety of their drinking water and the reliability of their water supply. The study's results can focus on the state of water quality and offer recommendations to improve water management and safety. These findings have the potential

to provide useful information for other studies and lead to better water quality and safety procedures at the college.

Knowing that water purification involves taking unwanted elements to prepare water suitable for a specific use. For those living in poor countries, the lack of clean water leads to a significant disease burden, such as diarrheal diseases and others that can be fatal [6][7]. Malaysia took the initiative to sell several types of water treatment systems, for example, Activated Carbon Filters, Membrane Filters, Reverse Osmosis (RO), Kent Reverse Osmosis, Distillation, Ultraviolet Light (UV light), Combined Filters, and Nano Technology [8]. Each system has a standard that needs to be achieved to guarantee the quality of drinking water, which is the standard for each system and the national standard for drinking water quality, as shown in Table 1.

Table 1 Comparison between standard and National standards for drinking water quality for each system

The selected system for this research	The standard for each system	National standard for drinking water quality
Reverse Osmosis [9],[10]	pH: 6.0 – 6.5 pH Turbidity: 0.5 NTU Total Dissolved Solid: 190 and 350 mg/L Iron content: 0.03 and 0.17	pH: 6.5 - 9.0 Turbidity:5 Total Dissolved Solid: 500 Iron content: 0.3
Nanotechnology filtration [11]	pH: 6.8-7.5 Turbidity: ≤ 0.3 NTU Total Dissolved Solid: 3.31-16.5 mg L Iron content: < 0.1 mg/L	pH: 6.5 - 9.0 Turbidity:5 Total Dissolved Solid: 500 Iron content: 0.3
4 Stages of Filtration System (Sediment Filter, Pre-carbon Filter, UF Membrane Filter, Post-carbon Filter) [12]	pH: 6.5-8.5 Turbidity: < 5 NTU Total Dissolved Solid: 190-350 mg/L Iron content: 0.75	pH: 6.5 - 9.0 Turbidity:5 Total Dissolved Solid: 500 Iron content: 0.3
10" Inch PP Sediment and 10" Inch CTO Carbon	pH: 7.3 Turbidity: < 0.3 NTU Total Dissolved Solid: Iron content: < 0.1	pH: 6.5 - 9.0 Turbidity:5 Total Dissolved Solid: 500 Iron content: 0.3

2. Material and Method

Water samples were taken 3 times in a month, which was at the beginning of the month (December 6), the middle of the month (December 12), and the end of the month (November 29). Samplings collected from Pagoh Residential College are from Block A1, Block A11, Block A12, and Block A17, but samples collected from the UTHM administration office are on Level 2 (right wing) and Level 2 (left wing). The water samples that had been taken would have been stored in a cold room to be preserved. Each sample differed in cured time and temperature according to the test to be carried out, as shown in Table 2.

Five laboratory tests were conducted with the samples: pH, turbidity, TDS, iron, and COD. Samples were analyzed for iron using HACH DR6000. Chemical Oxygen Demand was determined using a HACH DR6000 reactor, turbidity with a turbidity meter, and total dissolved solids (TDS) by using calculation, and pH was determined using a pH meter. All the test procedures are almost the same but have different apparatus.

Table 2 Water sample survive time for each parameter.

Parameters	Survive Time	Reference
pH	Analyzed in 15 min	[13]
Turbidity	Analyzed immediately	[13]
Total Dissolve Solid (TDS)	None	None
Inorganic Iron (Fe)	Keep the preserved samples at 2-6°C (36-43°F) for a maximum of 28 days.	[14]
Chemical Oxygen Demand (COD)	Keep the preserved samples at 2-6°C (36-43°F) for a maximum of 28 days.	[14]

3. Results and Discussion

Fig 1 to Fig 5 shows the average value for each water filtration system for pH, turbidity, iron, total dissolved solids (TDS), and chemical oxygen demand (COD) concentration. All results originate from Tables 2 and 3. Table 2 compares each system's product and national drinking water quality standards. Meanwhile, table 3 provides the values obtained from three water sample periods. All parameter analyses performed on the graph below are based on the data from Tables 2 and 3. The dotted lines in all graphs represent each parameter's standard national product range. Whereas the highlighted section displays the range promised for each product.

The results of the pH analysis are displayed in Fig 1. All systems fall within the range defined by the national product standard. The highlighted area in the RO system between the two dotted lines indicates that the pH range of the RO water sample is greater than the designated system range. It promises a range of 6 to 6.5, however the results obtained are slightly higher than that. Most drinking water has a pH between 6.5 and 9.0 [15]. Higher pH levels may increase the toxicity of several compounds, including ammonia and hydrogen sulfur, cause growth retardation, and harm physiological organs, including the eyes and olfactory organs [16]. Still, the value remains within the national standard range, ensuring the user is not negatively affected.

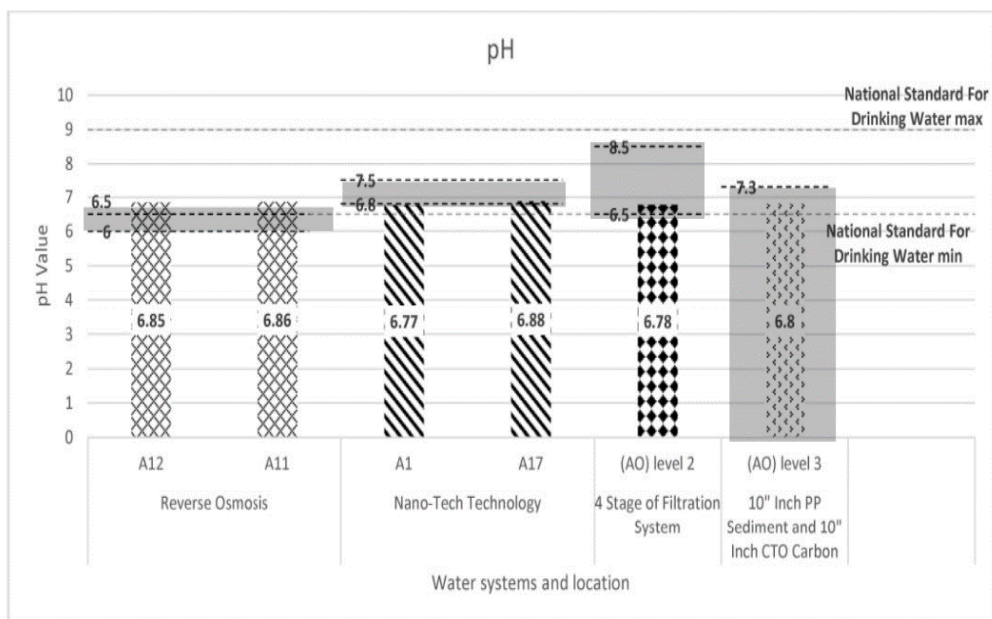
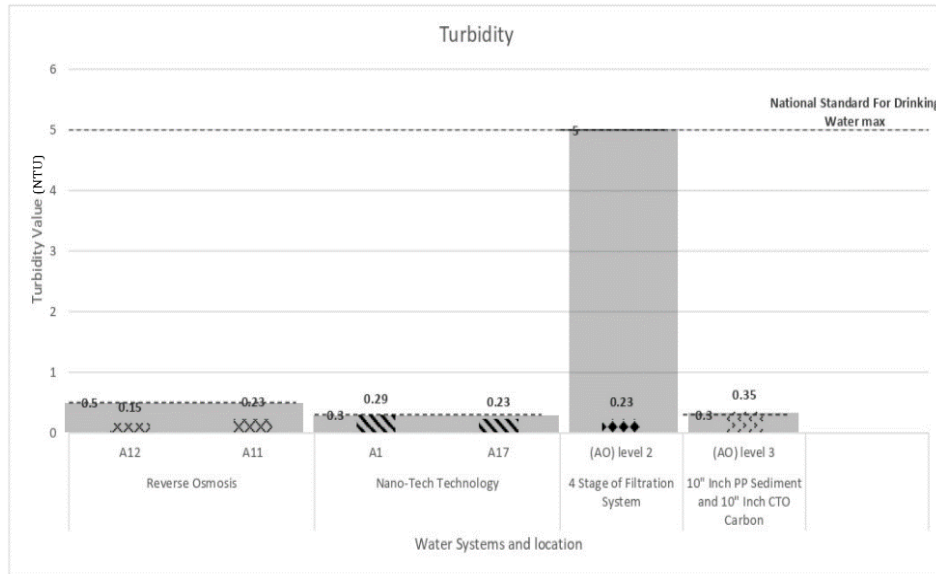


Fig. 1 Analysis of pH

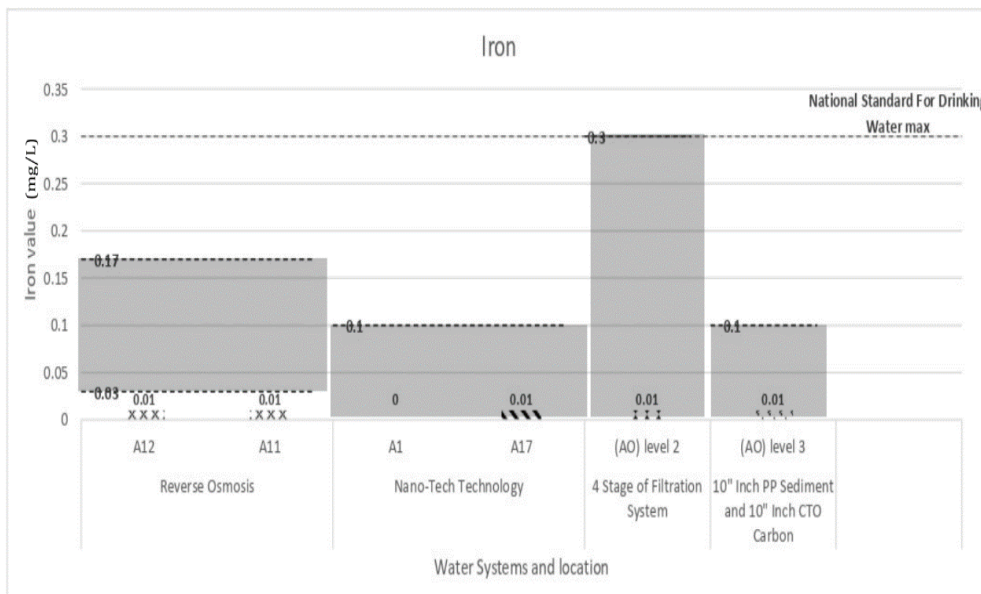
Table 3 Value analysis of data testing

System	Location	Parameter (Mean)														
		pH			Turbidity (NTU)			TDS (mg/L)			Iron (Fe) (mg/L)			COD (mg/L)		
		Value	Standard Product	National Standard	Value	Standard Product	National Standard	Value	Standard Product	National Standard	Value	Standard Product	National Standard	Value	Standard Product	National Standard
Reverse Osmosis	Male block (A11)	6.86	6.0-6.5	6.5-9.0	0.23	0.5	5	366.67	190-350	1000	0.01	0.03	0.3	2	-	10
	Male block (A12)	6.85			0.15			400			0.01			2.50		
Nano technology filtration	Male block (A1)	6.77	6.8-7.5		0.29	≤ 0.3		600	3.31-16.5		0	< 0.1		3		
	Female block (A17)	6.88			0.23	500		0.01			6					
4 Stages of Filtration System	Administration office level 2 (right wing)	6.78	6.5-8.5		0.23	< 5		500	190-350		0.01	< 0.1		5		
10" Inch PP Sediment and 10" Inch CTO Carbon	Administration office level 2 (left wing)	6.80	6.5-8.5		0.35	< 0.3		633.33	-		0.01	< 0.1		3.5		

A common indicator of microbiological contamination is turbidity, which measures how cloudy water is [17]. When comparing the data in Fig. 2(a), it is evident that the results acquired from all the systems show a very good outcome as they are all below range national standard product. Also, based on Fig. 2(a), the system's claimed range for permissible 10-inch PP sediment and 10-inch CTO carbon is 3.0 NTU; nevertheless, the values obtained are 0.35 NTU, which just barely meets the product standard. Every other water system is operating at a particular level.



(a)

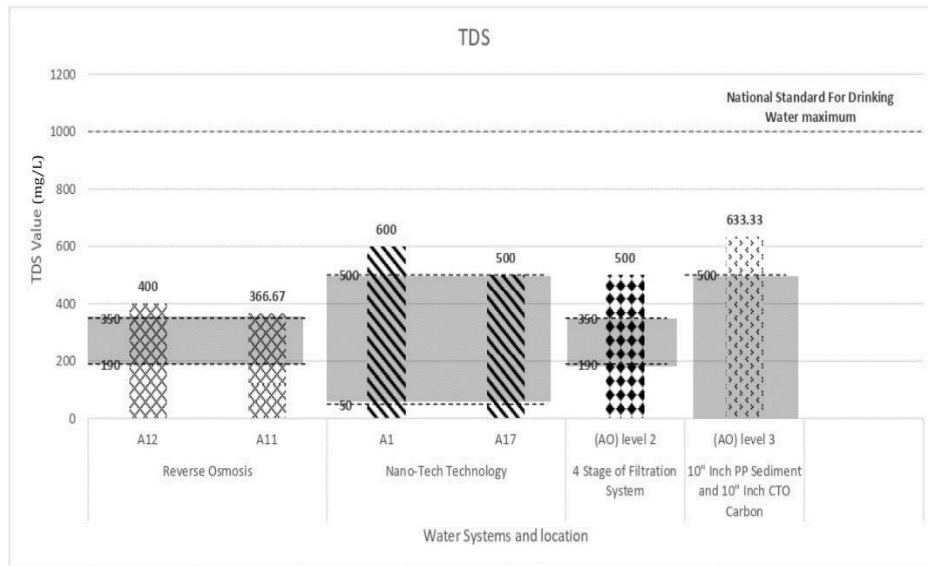


(b)

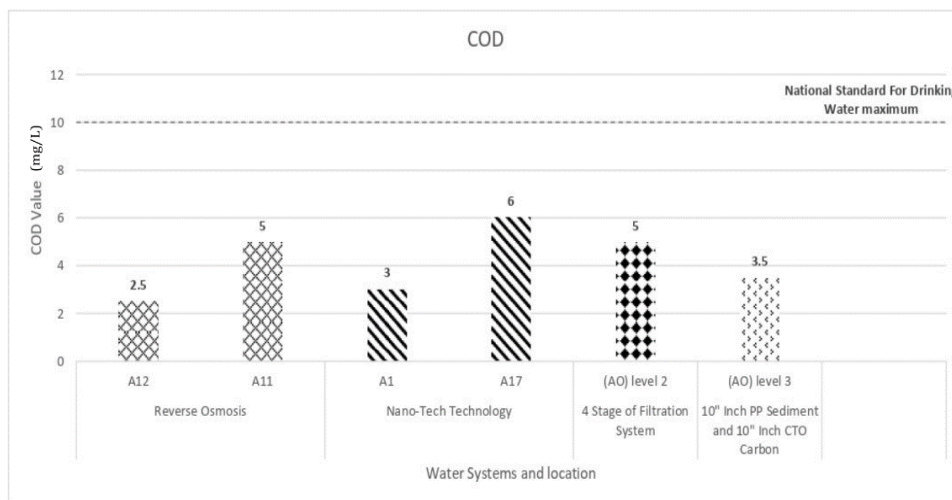
Fig. 2 (a) Analysis of Turbidity, and (b) Analysis of Iron

Meanwhile, Fig.2(b) displays the iron content values for each system. Comparing the results it indicates that all the values of iron content for drinking water fall within the national standard range. As can be seen, for Reverse Osmosis drinking water samples, both samples are below the standard for each product but different from the other water samples; all lie within the standard for each product. A strong correlation was found between high iron concentration and a lower likelihood of childhood anemia. Excess iron accumulates in the body's organs in a hemochromatosis disease, which can lead to major health issues. High amounts of iron (Fe) in drinking water can worsen this condition. According to [18], the highest amount of iron in permitted drinking water is 0.3 mg/l.

The results obtained from the TDS analysis are shown in Fig. 3(a). All the systems are within the national standard range. Even so, all systems exceeded the value for each product standard stated. For the standard value for each product, 4 stages of the filtration system have the biggest difference contrary to the other drinking water samples, which have barely any difference within the standard, and 10-inch PP sediment and 10-inch CTO carbon water samples stated the highest value among all which is 633.33. According to John Woodard (2024), the highest permissible value for TDS is 1000 mg/l [19].



(a)



(b)

Fig. 3 (a) Analysis of Total Dissolved Solid (TDS), and (b) Analysis of COD

The COD test aims to find the amount of organic matter in a water sample, and the amount of oxidation that will occur is determined by chemical oxygen demand testing [20]. From Fig.3(b), all the water systems are still under the national standard range. For COD, there is no product standard for all systems, but it can rely on the national standard value of 10 mg/L. As can be observed, the RO system at A12 had the lowest value of 2.5 mg/L, while the nano-technology system at A17 had the greatest value of 6 mg/L.

Based on the laboratory results, reverse osmosis, nano-tech technology, 10" Inch PP sediment, and 10" Inch CTO carbon are the systems that have 3 problems with the drinking water samples. The results show that the values from each of the water samples that represent those three are slightly out of range from the system's standard. Above all, the 4 Stage Filtration System is the system that has the best drinking water sample, which is from the administration office level 2 right-wing water cooler.

4. Conclusion

In conclusion, this study accomplished its goal by effectively determining whether the drinking water meets local and national safety requirements and regulations using a pH, Turbidity, Total Dissolved Solid (TDS), Inorganic iron (Fe), and Chemical Oxygen Demand (COD) test. The results also revealed that the 4 Stage Filtration System approach surpassed the other three systems, but overall, all of the water samples are in good condition and safe to drink because they meet the national standard of drinking water. With the acquired results, periodic inspections can be carried out to ensure that the water provided fulfills the stated product standards. Thus, sanitation is necessary as a maintenance service to maintain and improve the efficiency of the water filter system.

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Conflict of Interest

The authors declare no conflict of interest regarding the paper's publication.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Arif Nadzmi Norsyfulhizam, Ain Nazira Amran, Nur Hana Wajaluddin; **data collection:** Arif Nadzmi Norsyfulhizam, Ain Nazira Amran, Nur Hana Wajaluddin; **analysis and interpretation of results:** Arif Nadzmi Norsyfulhizam, Ain Nazira Amran, Nur Hana Wajaluddin, Masiri Kaamin; **draft manuscript preparation:** Arif Nadzmi Norsyfulhizam, Ain Nazira Amran, Nur Hana Wajaluddin, Masiri Kaamin. All authors reviewed the results and approved the final version of the manuscript.*

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