PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 5 No. 1 (2024) 652-662
https://publisher.uthm.edu.my/periodicals/index.php/peat

Assessing the Effectiveness of Water Filtration Machines in Providing Safe Drinking Water in Pagoh Area

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DOI: https://doi.org/10.30880/peat.2024.05.01.070

Article Info

Received: 27 December 2023
Accepted: 18 January 2024
Available online: 15 June 2024

Keywords

physicochemical quality, treated water, health impact, paid water filter machines

Abstract

This study aimed to evaluate both the physicochemical quality and the health impact of treated water from paid water filter machines in the Pagoh area. The research involved collecting 11 water samples from filtration units, employing a dissolved meter for assessing pH, turbidity, Total Suspended Solid (TSS), conductivity, and Dissolved Oxygen (DO), and utilizing an ICP-MS technique to determine mineral content, specifically magnesium. Treated water samples underwent thorough testing, with results consistently falling within safe levels for drinking. Notably, pH levels ranged from 6.98 to 12, meeting recommended standards, while turbidity remained between 0.24 to 0.52 NTU, and TSS fell within the range of 2.67 to 4.00 mg/L. Conductivity levels (137.53 to 166.53 µS/cm) and DO (6.09 to 9.03 mg/L) were also within safe parameters. Additionally, heavy metal concentration (Mg) ranged from 1.78 to 2.11 mg/L, all aligning with safety guidelines outlined by the Malaysian Drinking Water Quality Standard (MDWQS). The accompanying questionnaire revealed that respondents reported minimal adverse health events, such as symptoms, sore throat, and poisoning or vomiting, with mean values indicating relatively low occurrences. These findings collectively challenge the preconception that the use of water filtration negatively affects health, suggesting that treated water from paid filter machines in the Pagoh area not only meets regulatory standards but also contributes to positive health outcomes.

1. Introduction

Water is very important in maintaining health and vitality. Human welfare and access to safe drinking water have been recognized as basic human rights. Taste, fragrance, colour and concentration of organic and inorganic debris all affect water quality and suitability for use [1]. Drinking water is critical for healthy health and a simple and efficient approach to keep hydrated, which is essential for many physiological processes such as temperature regulation, nutrition and oxygen transfer to cells, and waste removal. A safe, clean, and adequate supply of drinking water is vital for optimal health. According to a United Nations report, an estimated 768 million people did not utilise improved drinking water sources in 2011, with 185 million relying on surface water to satisfy their daily drinking water needs. For the last two decades, urban drinking water coverage has been high and only 4% of the urban population now relies on unimproved resources [2].

While conducting a survey around Pagoh Town, there are many Vending Machine services available around Pagoh. Most of these water vendor machines are placed outside business premises in Pekan Pagoh and

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around mukim Pagoh such as in grocery stores, convenience stores, restaurants and there are also some in residential areas. This shows that the demand for water from the vending machine is quite high from the people around Pagoh. But there are several types and brands of water vending machines in Pagoh Town and each of them has a different level of water quality. Therefore, the decision was taken to conduct a study on the level of water quality of vending machines around Pekan Pagoh. This study was carried out by sampling water at selected sampling stations. The selected sampling stations are carried out at selected water vendor machines. Several water vending machines were identified to take water samples for physical parameter testing to be done at each sampling station.

The purpose of this study was to determine the physicochemical characteristics and to measure the healthy level of paid treated water drinks by the consumers of Pagoh area using a questionnaire. Physicochemical assessment of water such as determination of pH, turbidity, Total Suspended Solid (TSS), conductivity and dissolved oxygen while for chemical elements such as magnesium using the ICP-MS method. Then the result obtained was analyse from direct and indirect water supply and to compare the data based on the standard method Malaysian Drinking Water Quality Standard (MDWQS). The research findings were helpful in determining whether the water in the study area is safe for consumption.

2. Materials and Method

While conducting surveys around Pagoh, there are many services Vending Machine available. Most of these water vendor machines are placed outside business premises in Pekan Pagoh such as in grocery stores, convenience stores, restaurants and there are also some in residential areas. This shows that the demand for Vending Machine is quite high from the people around Pagoh. However, there are several types and brands of water vending machines around this Pagoh and each of them has a different level of water quality. For water sampling, the researcher collects samples by sampling 1 time for one vendor the water and averaged. Next, polyethylene bottles are used to collect water samples that have been thoroughly washed and rinsed using distilled water to avoid any contaminants. In addition, 6 parameters were used to measure the value of water samples in the study area. Table 1 below shows the location of treated water samples in the Pagoh area that have been found and Figure 1 is the range map of the study area. Therefore, the study area was conducted around Pagoh, Johor. Vending machines around Pagoh as shown in Figure 2 below were used as sampling points to study the level of water quality in vending machines.

Table 1. Locations of Treated Water Samples

Code	Company	Location
A	Dr. Sukida	A11, Kolej Kediaman, Pagoh
B	Dr. Sukida	A17, Kolej Kediaman, Pagoh
C	COOP	A10, Kolej Kediaman, Pagoh
D	Aquarius	Pagoh Jaya, Pagoh
E	Nano Hydrogen	Seven E, Bandar Universiti Pagoh
F	Hijrah	Panchor
G	Fuji Water	Pagoh Jaya, Pagoh
H	Aqua	Pagoh Lama, Pagoh
I	Go Green	Pagoh Lama, Pagoh
J	Hijrah	Bukit Pasir
K	Aquarius	Bukit Pasir

Fig. 1 *Map of the Pagoh area [3]*

The experiment was carried out using the method mentioned in Table 2. A total of 6 parameters were measured which are pH, Turbidity, Total Suspended Solid (TSS), Conductivity, Dissolved Oxygen (DO), and heavy metals.

Table 2. WQI Parameter, Method, And Equipment

Parameter	Equipment	Method	Unit
pH	HACH HQ440d	APHA, 2012 [4]	-
Turbidity	Hach Desktop Turbidity Metre	EPA, 2012 [5]	NTU
TSS	Filtration pump	APHA, 2012 [4]	mg/L
Conductivity	HACH HQ440d	EPA, 2012 [5]	µS/cm
DO	HACH HQ440d	EPA, 2012 [5]	mg/L
Heavy Metals	ICP-MS	APHA, 2005 [6]	mg/L

The collected data was analysed using the Microsoft Office Excel program. Statistical analysis is a technique or method used with the purpose of understanding data. The analysed data are comeout into graphs by the researcher. Data appeared in the form of graphs facilitates work and understanding. Next, the data for the questionnaire was taken and analysed using Microsoft Office Excel and Statistical Package for the Social Science version 27.

3. Result and Discussion

3.1 pH value in water filtration machine

Table 3 shows that pH value in water samples that have been analyzed and studied. According to [7], Waters pH shows whether it is acidic or alkaline. The pH scale runs from 0 to 14, with 7 representing neutral. Drinking water should have a pH of 6 to 8.5. This treatment method is utilised when the water is acidic (low pH). According to the table set by Malaysia Water Quality Standards (MDWQS), the range of drinking water set for pH value is between 6.5 - 9.0. From the table below, the pH value of the water provided by the water filter machine around the Pagoh is around 6.89 – 7.12.

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Table 3. pH value of water filtration Pagoh area

Sample	Minimum	Maximum	Value (Average)	Standard Deviation
A (Dr.Sukida)(A11 KKP)	6.98	7.07	7.01	0.05
B (Dr Sukida) (A17 KKP)	6.83	6.94	6.87	0.06
C (COOP) (A10 KKP)	6.85	6.89	6.87	0.02
D (Aquarius) (Pagoh Jaya)	7.02	7.12	7.08	0.05
E (Nano Hydrogen) (Seven E)	7.12	7.16	7.14	0.02
F (Hijrah)(Panchor)	7.06	7.1	7.08	0.02
G (Fuji water) (Pagoh Jaya)	7.03	7.07	7.05	0.02
H (Aqua) (Pagoh lama)	6.99	7.07	7.04	0.04
I (Go green) (Pagoh lama)	7.1	7.17	7.14	0.04
J (Hijrah) (Bukit pasir)	6.94	7.03	6.98	0.05
K (Aquarius) (Bukit Pasir)	7.02	7.05	7.03	0.02

Figure 3 shows the pH value of all water samples filtered by the chosen paid filter machine between the Malaysian Water Drinking Quality Standards (MDWQS) limits of 6.5 and 9.0. In the bar chart above, the greatest pH value is 7.14 from samples E (Nano Hydrogen) and I (Go Green), while the lowest is 6.87 from samples B (Dr. Sukida) and C (COOP) obtained at Pagoh Residential College. It may be inferred that the complete sample of drinking water provided by paid filtration machines in the vicinity of Pagoh and residential colleges is neutral, as shown by a value not less than pH 7 and more than pH 8. Drinking water with a pH below 6.5 can corrode pipes and plumbing systems, resulting in the leaching of harmful elements such as lead and copper into the water supply. Besides, Low pH water can also have an unpleasant taste and can damage tooth enamel over time [8]. A low pH water value can also lead to health problems if the drinking water has a low pH value because the human body has a tightly controlled pH range around (7.35 to 7.45) for blood and body fluids. According to [9] a very high pH value in drinking water may cause contamination with chemicals such as dissolved minerals, which can affect the taste and purity of the water. Overall, the pH of the study sample water was in the range safe standards.

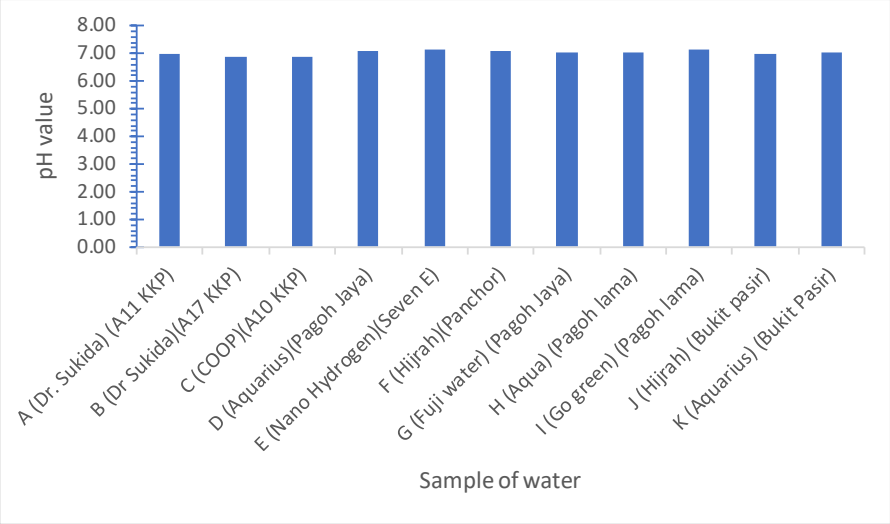

Fig. 3 pH value of water filtration Pagoh area

3.2 Turbidity value in water filtration machine

The turbidity values of 11 water samples tested through the water filter machine samples set up in the Pagoh region are shown in Table 4 below. [10] Water with a high turbidity is hazy or muddy, whereas water with a low turbidity is clear. Highly turbid water may be hazardous to aquatic ecosystems because it disturbs biological, chemical, and physical processes in bodies of water. Normal individuals can notice turbidity of more than 5 NTU, however turbidity in dirty water is above 100 NTU. Because of natural filtration that happens as water penetrates the earth, groundwater often has relatively low turbidity [11]. According to the table set by Malaysia Water Quality Standards (MDWQS), the range of drinking water set for turbidity value is 5 NTU. From the Table 4 below, the turbidity value of the water provided by the water filter machine around the Pagoh is below 5 NTU.

Table 4. Turbidity value of water sample Pagoh area

Sample	Minimum	Maximum	Value (Average)	Standard Deviation
A (Dr.Sukida)(A11 KKP)	0.42	0.6	0.52 NTU	0.09
B (Dr Sukida) (A17 KKP)	0.5	0.65	0.57 NTU	0.08
C (COOP) (A10 KKP)	0.22	0.27	0.24 NTU	0.03
D (Aquarius) (Pagoh Jaya)	0.25	0.3	0.28 NTU	0.03
E (Nano Hydrogen) (Seven E)	0.37	0.45	0.42 NTU	0.04
F (Hijrah)(Panchor)	0.2	0.24	0.22 NTU	0.02
G (Fuji water) (Pagoh Jaya)	0.3	0.46	0.39 NTU	0.08
nH (Aqua) (Pagoh lama)	0.2	0.29	0.25 NTU	0.05
I (Go green) (Pagoh lama)	0.25	0.28	0.26 NTU	0.02
J (Hijrah) (Bukit pasir)	0.29	0.37	0.33 NTU	0.04
K (Aquarius) (Bukit Pasir)	0.24	0.3	0.27 NTU	0.03

Figure 4 shows the turbidity values for the 11 treated water samples that have been studied. Through this study, sample C (COOP) (A10 KKP) has the lowest turbidity value which is 0.24 NTU and the highest turbidity value is from sample B (Dr Sukida) (A17 KKP) which is 0.57 NTU. According to [12], high turbidity values can be caused by poor source water quality, insufficient treatment, and disturbance of sediments and biofilms in the distribution system, as well as the entry of unclean water through main breaks and other damages. Turbidity at excessive levels can discolor materials, equipment and textiles exposed during washing, as well as interfere with the efficiency of treatment operations. Therefore, the turbidity value set by the Malaysian Drinking Water Quality Standard (MDWQS) is less than 5 NTU. Looking at the research that has been done, all treated water values in the Pagoh area are not more than 5 NTU and it is safe to drink.

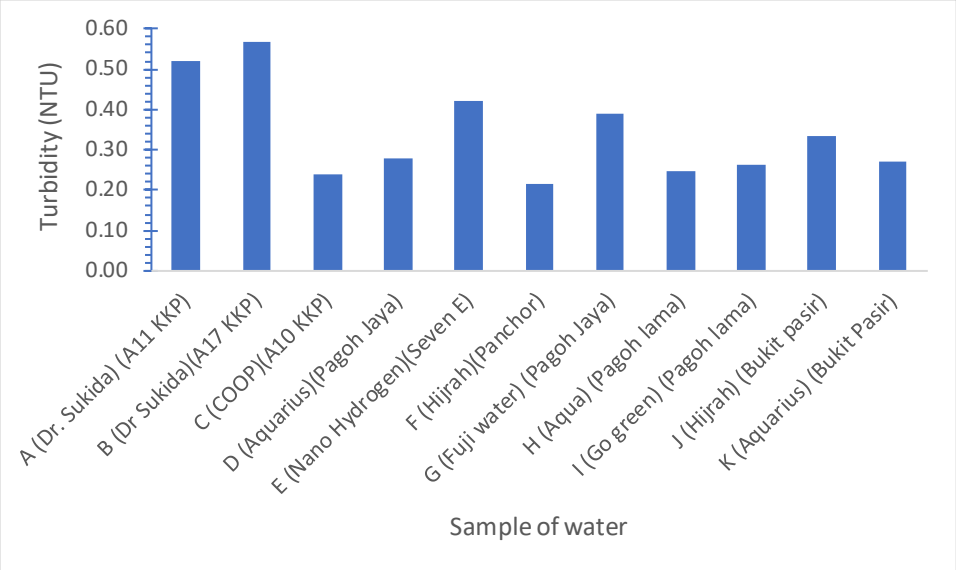

Fig. 4 Turbidity value of water sample Pagoh area

3.3 Total Suspended Solid (TSS) value in water filtration machine

Table 5 shows the results for Total Suspended Solids (TSS) of 11 treated water samples that have been studied in the Pagoh area. According to Malaysian Drinking Water Quality Standards (MDWQS), the standard limit of acceptable total suspended solids value is 25 mg/L. TSS is a measure of the concentration of suspended particles in a liquid larger than 2 micrometers. These particles can include both organic and inorganic matter that does not dissolve in water but instead remains suspended. TSS is often used as an indicator of water quality and can affect the clarity and appearance of water. Based on the Table 5 below, water samples values for the 11 sampling stations were found to be in the range between 2.67 mg/L to 4.00 mg/L.

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Table 5. Total Suspended solid (TSS) value of water sample Pagoh area

Sample	Minimum	Maximum	Value (Average)	Standard Deviation
A (Dr.Sukida)(A11 KKP)	3	4	3.67 mg/L	0.58
B (Dr Sukida) (A17 KKP)	3	3	3.00 mg/L	0.00
C (COOP) (A10 KKP)	3	4	3.67 mg/L	0.58
D (Aquarius) (Pagoh Jaya)	3	4	3.67 mg/L	0.58
E (Nano Hydrogen) (Seven E)	2	3	2.67 mg/L	0.58
F (Hijrah)(Panchor)	3	3	3.00 mg/L	0.00
G (Fuji water) (Pagoh Jaya)	4	4	4.00 mg/L	0.00
H (Aqua) (Pagoh lama)	4	4	4.00 mg/L	0.00
I (Go green) (Pagoh lama)	2	4	3.33 mg/L	1.15
J (Hijrah) (Bukit pasir)	4	4	4.00 mg/L	0.00
K (Aquarius) (Bukit Pasir)	3	4	3.33 mg/L	0.58

Based on Figure 5 below, of the 11 selected treated water samples in the Pagoh area, sample G (Fuji water) (Pagoh Jaya), H (Aqua) (Pagoh lama), J (Hijrah) (Bukit pasir) showed the highest TSS values is from drinking water with 4.00 mg/L and the lowest TSS value is from sample E (Nano Hydrogen) (Seven E) with 2.67 mg/L. As mentioned before, the TSS value for drinking water should not exceed 25 mg/L and all water samples in the pagoh area should not exceed the set value. This is due to a well-managed water treatment process, settling tanks or settling basins can effectively remove suspended solids, leading to low TSS levels in treated water. In addition, it is also due to the maintenance of the water machine according to the set time. However, since the TSS values did not exceed the MDWQS limit, these 11 treated water machine samples were categorized as safe to drink.

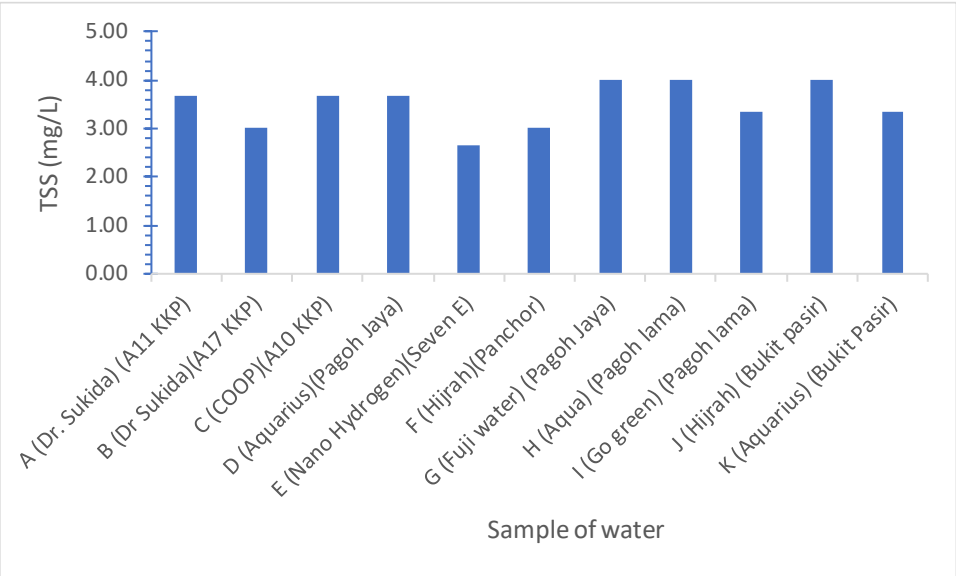

Fig. 5 Total Suspended Solid (TSS) value of water sample Pagoh area

3.4 Conductivity value in water filtration machine

Table 6 shows data from the conductivity analysis of drinking water samples for 11 treated water samples in the Pagoh area. Conductivity in water refers to the ability of water to conduct electricity. It is a measure of water's ability to carry an electrical charge, which is primarily affected by the presence of dissolved ions, such as salts. The unit of measurement for conductivity is usually expressed in microsiemens per centimetre (µS/cm) or millisiemens per centimetre (mS/cm).

Table 6. Conductivity value of water sample Pagoh area

Sample	Minimum	Maximum	Value (Average)	Standard Deviation
A (Dr.Sukida)(A11 KKP)	145.6	145.7	145.63 µS/cm	0.06
B (Dr Sukida) (A17 KKP)	138.9	139	138.97 µS/cm	0.06
C (COOP) (A10 KKP)	144.3	145.6	144.97 µS/cm	0.65
D (Aquarius) (Pagoh Jaya)	147.7	147.9	147.77 µS/cm	0.12
E (Nano Hydrogen) (Seven E)	150.3	152.6	151.70 µS/cm	1.23
F (Hijrah)(Panchor)	135.7	139.2	137.53 µS/cm	1.76
G (Fuji water) (Pagoh Jaya)	148.4	148.5	148.43 µS/cm	0.06
H (Aqua) (Pagoh lama)	139.4	141.4	140.43 µS/cm	1.00
I (Go green) (Pagoh lama)	136.6	141.9	140.03 µS/cm	2.98
J (Hijrah) (Bukit pasir)	134.3	168.2	166.53 µS/cm	2.01
K (Aquarius) (Bukit Pasir)	161.8	164.7	163.40 µS/cm	1.47

Based on Figure 6, the conductivity values for 11 treated water samples that have the highest value with 166.53 µS/cm is from sample K (Aquarius) (Bukit Pasir). Temporary the lowest conductivity value is 137.53 µS/cm from sample F (Hijrah) (Panchor). however, according to the MDWQS standard, there is no specific value set for the conductivity of drinking water. According to the WHO Guidelines for Drinking Water Quality (2017), the electrical conductivity of drinking water should be less than 800 microsiemens per centimetre (S/cm) at 25 degrees Celsius. So, it can be said that the conductivity value of 11 treated drinking water samples in the Pagoh area has a conductivity value of 137.53 - 166.53 µS/cm and is not considered as ionized because it has a low ionic concentration value due to small dissolved solids. Therefore, the treated drinking water provided in the Pagoh area is safe to drink because the conductivity level does not exceed the limit as stated by the WHO [12].

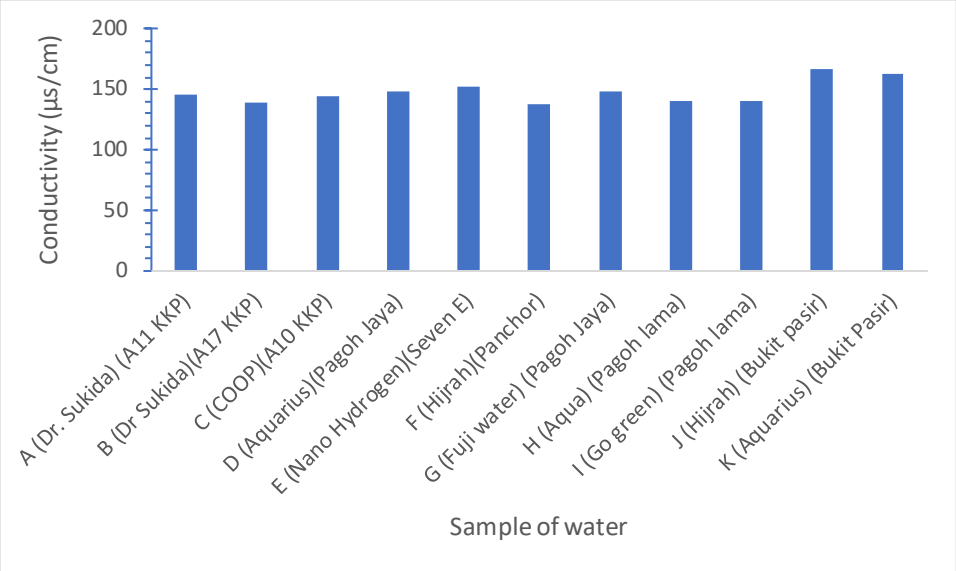

Fig. 6 Conductivity value of water sample Pagoh area

3.5 Dissolved Oxygen (DO) value in water filtration machine

The findings of dissolved oxygen sample readings from 11 processed water machines surrounding Pagoh are shown in Table 7. According to the National Water Quality Standards (NWQS), the value of dissolved oxygen above level 7 is the value of water that is safe to use and requires almost no treatment. Water temperature has an effect on dissolved oxygen concentration. Warmer water typically has less dissolved oxygen because the solubility of gases, including oxygen, decreases as temperature rises. This connection is frequently represented by Henry's law, which is temperature dependent [13]. Based on the Table 7 below, the values of 11 samples of treated water around Pagoh were found to be in the range between 6.09 mg/L to 9.03 mg/L.

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Table 7. Dissolved Oxygen (DO) value of water sample Pagoh area

Sample	Minimum	Maximum	Value (Average)	Standard Deviation
A (Dr.Sukida)(A11 KKP)	6.85	7.0	6.93 mg/L	0.08
B (Dr Sukida) (A17 KKP)	6.37	6.48	6.43 mg/L	0.06
C (COOP) (A10 KKP)	6.84	6.93	6.88 mg/L	0.05
D (Aquarius) (Pagoh Jaya)	8.61	8.67	8.64 mg/L	0.03
E (Nano Hydrogen) (Seven E)	7.44	7.55	7.49 mg/L	0.06
F (Hijrah)(Panchor)	8.38	8.47	8.42 mg/L	0.05
G (Fuji water) (Pagoh Jaya)	7.52	7.61	7.56 mg/L	0.05
H (Aqua) (Pagoh lama)	7.92	8.0	7.96 mg/L	0.04
I (Go green) (Pagoh lama)	8.16	8.21	8.18 mg/L	0.03
J (Hijrah) (Bukit pasir)	6.06	6.13	6.09 mg/L	0.04
K (Aquarius) (Bukit Pasir)	9.01	9.06	9.03 mg/L	0.03

Based on Figure 7, dissolved oxygen (DO) values for all 11 treated water samples ranged from 6.09 mg/L up to 9.03 mg/L. The highest dissolved oxygen value shown in the bar chart above is 9.03 mg/L obtained from sample K (Aquarius) (Bukit Pasir) and the lowest is 6.09 mg/L obtained from water sample J (Hijrah) (Bukit Pasir). Looking at the level of dissolved oxygen for sample D to K except for sample J shown above level 7, which is the value of 7.49 to 9.03. According to National Water Quality Standard (NWQS), value category value for dissolved oxygen falls on class IIA, shows that water quality requires conventional treatment. However, dissolved oxygen values greater than 7 mg/L generally do not cause concern in drinking water because dissolved oxygen is not always the main criterion in assessing drinking water quality. Dissolved oxygen is even more important in natural aquatic habitats, where it is essential for the health of aquatic creatures. The main focus in drinking water is on the characteristics that have a direct influence on human health. The World Health Organization (WHO) and other regulatory authorities produce drinking water quality recommendations and standards, specifying permissible amounts for different pollutants [12].

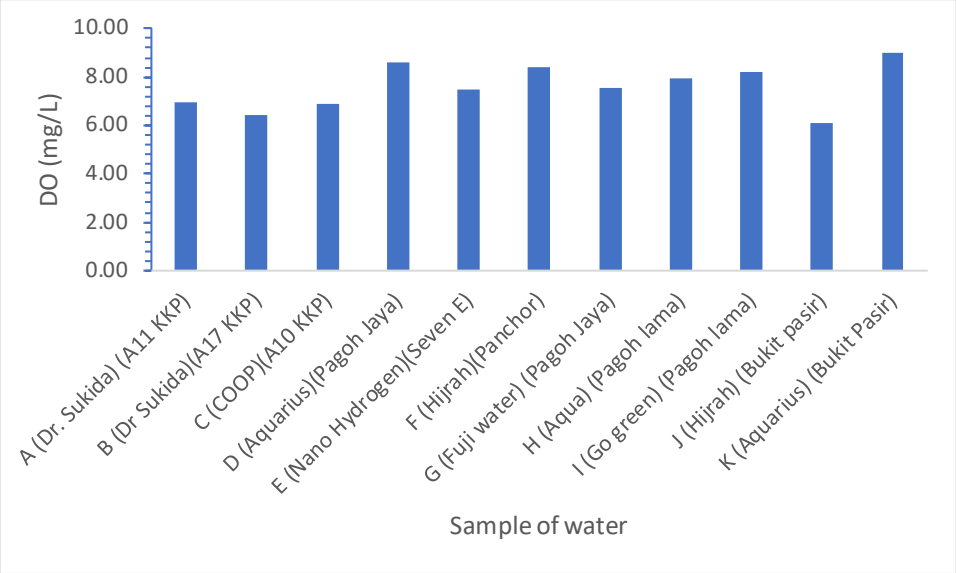

Fig. 7 Dissolved Oxygen (DO) value of water sample Pagoh area

3.6 Heavy Metals (Magnesium) value in water filtration machine

Table 8 shows the heavy metal content of the 11 treated water samples studied. Among the heavy metals studied is magnesium (Mg). For the concentration of magnesium (Mg), the range for all samples is in the range of 1.78 to 2.11 mg/L. According to [9] the maximum value of magnesium (Mg) concentration allowed set by the Food Act (1983) is 150 mg/l. According to [14], magnesium is associated with cardiovascular health, and some studies suggest that a higher intake of magnesium may be associated with a reduced risk of cardiovascular disease.

Table 8. Magnesium value of water sample Pagoh area

Sample	Value (Average)
B (Dr Sukida) (A17 KKP)	1.83 mg/L
C (COOP) (A10 KKP)	1.78 mg/L
E (Nano Hydrogen) (Seven E)	1.79 mg/L
F (Hijrah)(Panchor)	1.88 mg/L
G (Fuji water) (Pagoh Jaya)	1.84 mg/L
H (Aqua) (Pagoh lama)	2.00 mg/L
I (Go green) (Pagoh lama)	1.84 mg/L
K (Aquarius) (Bukit Pasir)	2.11 mg/L

Referring to Figure 8 below, 8 treated water samples were studied for magnesium parameters, the highest magnesium value was from sample K (Aquarius) (Bukit Pasir) which was 2.11 mg/L. Meanwhile, the lowest value is 1.78 mg/L which is from sample C (COOP) (A10 KKP). According to the standards from MDWQS, there is no specific value set for magnesium, but according to [9], the maximum value set by the Food Act (1983) is 150 mg/L. Therefore, high concentration of Mg in the sample may be due to underground deposits minerals and High concentrations of magnesium in drinking water can contribute to undesirable tastes or Odors. Therefore, all samples are within the safe range for drinking.

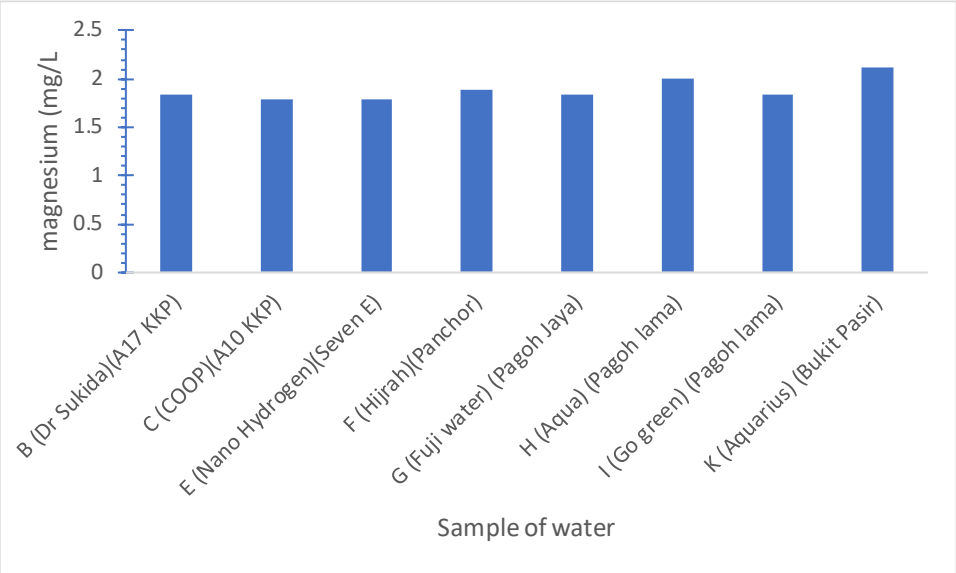

Fig. 8 Magnesium value of water sample Pagoh area

3.7 Questionnaire

Consumers reported relatively low occurrences of adverse health effects such as diarrhea (Mean = 2.05, SD = 1.226), sore throat (Mean = 2.51, SD = 1.026), and poisoning or vomiting (Mean = 2.21, SD = 0.928) attributed to water from the filter machine. These findings suggest a general disagreement with the notion that using the paid water filter machine leads to negative health outcomes. However, there were mixed responses regarding the belief in the potential of poor-quality water to cause diseases, with a mean score of 3.76 (SD = 1.238), indicating agreement. Moreover, participants overwhelmingly perceived positive health impacts from using the paid water filter machine. They reported improvements in health (Mean = 3.69, SD = 0.987), feeling more refreshed and energetic (Mean = 3.76, SD = 0.891), and enhanced comfort with digestive systems (Mean = 3.76, SD = 0.937). Additionally, participants believed in the added health benefits of the water from the paid filter machine compared to other sources (Mean = 3.70, SD = 0.860) and expressed confidence in the system's potential to improve the immune system (Mean = 3.62, SD = 0.909). Mixed responses were observed in statements related to the impact on sleep. While participants reported a history of sleep-related problems before using the paid water filtration system (Mean = 2.86, SD = 1.092), their perceptions of improvement in sleep quality were less conclusive (Mean = 3.31, SD = 0.966). The ambiguity in responses regarding headaches (Mean = 3.32, SD = 0.888) further highlights the complexity of linking water quality to specific health outcomes.

4. Conclusion

In conclusion, this study successfully achieved its primary objective of assessing the physico-chemical quality of treated water from paid water filter machines in the Pagoh area. Analyzing various parameters, including pH, turbidity, total suspended solids, conductivity, Dissolved Oxygen, and Heavy Metals, revealed that all values fell within the limits stipulated by the Malaysian Drinking Water Quality Standards (MDWQS). Consequently, the study asserts that water from the selected paid water filter machines is safe for consumption and does not pose health risks. The turbidity analysis indicated acceptable levels across all samples, with the highest value at 0.57 NTU (sample B - Dr. Sukida) and the lowest at 0.24 NTU (sample C - COOP), well below the MDWQS limit of 5 NTU. These findings align with the second objective which is positive responses from users in the questionnaire, who reported perceived health benefits associated with the use of paid water filter systems. While some respondents acknowledged minor health issues, the overall consensus highlighted positive impacts on well-being, including increased energy, digestive comfort, and belief in additional health benefits. The study also revealed a need for continued investigation into the complex relationship between water quality perceptions and individual health outcomes. Future research should focus on scheduled maintenance, long-term effectiveness, and a broader analysis of potential contaminants to further enhance the understanding of water filtration system efficacy.

Acknowledgement

The author would like to express gratitude to the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, for assistance. The author would also like to thank everyone who has contributed, both directly and indirectly.

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