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Article

Statistical Analysis of Green Laboratory Practice Survey: Conservation on Non-Distilled Water from Distillation Process

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Abstract: The water crisis is identified as the most serious global risk for the coming decade. Distilled water is one of the on-demand elements in academic laboratories; however, water scarcity may eventually affect the education sector, necessitating the implementation of new policies. Human behavior, awareness, knowledge, and opinion is having an impact on water management; accordingly, a questionnaire was purposely designed and validated to assess these variables in a Malaysian public university regarding the use of non-distilled water produced by the distillation process. An exploratory factor analysis yielded four factors: "concept of green laboratory and water", "usage of non-distilled water", "knowledge about water distillation", and "behavior related to water conservation". Using the Mann–Whitney U test to compare laboratory and non-laboratory users' responses, the variables "Knowledge", "Behavior", and "Opinion" revealed statistically significant differences, with laboratory users scoring higher in all four variables. Employing the Kruskal–Wallis H test in an occupation-based comparison among laboratory users, and with an additional variable "Practice", showed that "Lecturer" has the highest mean rank for "Awareness", "Behavior", and "Opinion", while "Laboratory Assistant" has the highest mean rank for "Knowledge". This study provides a rationale analysis for future insights to educate faculty members about the reuse of non-distilled water sustainably.

Keywords: exploratory factor analysis; water distillation; non-distilled water; higher education; water conservation; university sustainability

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1. Introduction

The mismatch between freshwater demand and availability is the essence of global water scarcity, resulting in increased competition for freshwater resources, while estimated reliance on water resources is on the rise, posing serious challenges to Earth's future food security and environmental sustainability [1]. In fact, water availability and accessibility are two of the most significant constraints for various economic, industrial, healthcare, agricultural, and food sectors [2–6]. The increasing global population, rising living standards, shifting consumption patterns, and the expansion of irrigated agriculture are the primary drivers of the rising global demand for freshwater [1,7]. Future climate change projections foresee an increased global pressure on water resources; as a result, the salinity level of seawater is constantly increasing, making flooding more likely and thereby dwindling the availability of freshwater [8,9]. Accordingly, the water crisis was identified as the most serious global risk for the next decade [10].

Pursuant to the United Nations World Water Development Report 2017, improving wastewater management is as much about eliminating emissions at the source; this includes reusing reclaimed water through various recycling strategies as a necessary practice to achieve the 2030 Agenda for Sustainable Development [11]. On the other hand, a total of 2.1 billion people (29% of the global population) do not have access to safe drinking water, and this access lack is responsible for 1.2 million deaths each year [12]. Currently, ~4.0 billion people face severe water scarcity at least one month of the year [13].

Malaysia is one of the countries with a high domestic water consumption, ranging from 209 to 228 L per capita per day (lcd). The consumption is still above the World Health Organization's (WHO) recommended target of 165 lcd. In this context, Penang state has the highest domestic water consumption, while Sabah state has the lowest. As a result, if water consumption is not improved, Malaysia may face a water shortage crisis in the foreseeable future [14].

On the other hand, distilled water is one of the most commonly used elements in undergraduate and postgraduate laboratories, as well as research centers, due to its inert nature. Despite the evident reuse potentials of non-distilled water produced during the distillation process, studies have revealed that water reuse implementation remains a rare practice [15–18]. Distilled water is produced by boiling water and then condensing the vapors. The non-distilled water will be produced during the water distillation process, and most of the time it will be drained into the sink rather than fully utilized. Previously, in 2004, professor Sharma proposed that 200 L of fresh water would be consumed to produce approximately 2.5 L of distilled water as a daily average use per laboratory, and upon using the conventional glass distillation apparatus, this estimates that to generate 100 mL of distilled water, it needs 4000 mL to 8000 mL of tap water [19,20]; i.e., a minimum of 3000 mL tap water will be drained, and the quality of this water will be diminished instantly. As previously published in Chan et al. 2020, the immense amount of water use in the distillation process could be linked to the billed water. Such uncontrolled water distillation practices might place academic institutions' laboratories and many foundations far away from the United Nations' Sustainable Development Goals (SDGs), particularly goal number six which emphasizes the importance of water management in sustaining humankind, i.e., "ensure availability and sustainable management of water and sanitation for all". Consequently, the massive waste of clean water from the outlet of the distillation process is one of the silent causes of water scarcity which is oftentimes being overlooked [21]. In this regard, the underutilization of such clean water may indirectly contribute to water shortages especially during the drought. This might eventually hit the same research cycle and human life in general, necessitating the enforcement of new policies, as the COVID-19 pandemic did. Therefore, addressing distilled water waste management within academia and research is indispensable to offer insights on current challenges and suggest future practical strategies for application once needed.

Human behavior has been recognized to have an impact on sustainability, including water management, and thus it is necessary to regulate human behavioral contributions to the water scarcity issue [22–25]. The same holds true for human awareness [26–28], knowledge [29,30], and opinion [31,32]. Of this, the study and analysis of such variables could help in understanding and achieving distilled water waste management.

On the same line, having faculty members who behave sustainably on campus is the ultimate goal of higher education institutions, but this remains difficult. However, their daily life tasks involve online courses, zoom meetings, coursework preparations and delivery, administrative work, undergraduate practical courses, and postgraduate research experiments, all of which are closely related to sustainability [33,34]. Furthermore, because the majority of campus members do not pay their utility bills, they are frequently unaware of water and energy consumption issues. Faculty members' behavior has an influence on the overall on-campus environmental sustainability; thus, regulating their behavior may provide opportunities for resources' savings [21].

Study Trend

Using the Google Scholar engine, the keyword "Green laboratory" yields approximately 5,600,000 published works; however, when searching "Distilled water" this number drops to approximately 1,940,000. Furthermore, a search for "drained water" and "Distilled water waste reuse" revealed a sharp decline in research articles with only 703,000 and 86,200 published works. Interestingly, as shown in Figure 1, searching the PubMed engine yields a much lower number of articles using the exact same keywords (by 23rd May 2021). Such numbers illustrate the critical need for research in the field of green laboratories' applications via distilled water waste management in universities.

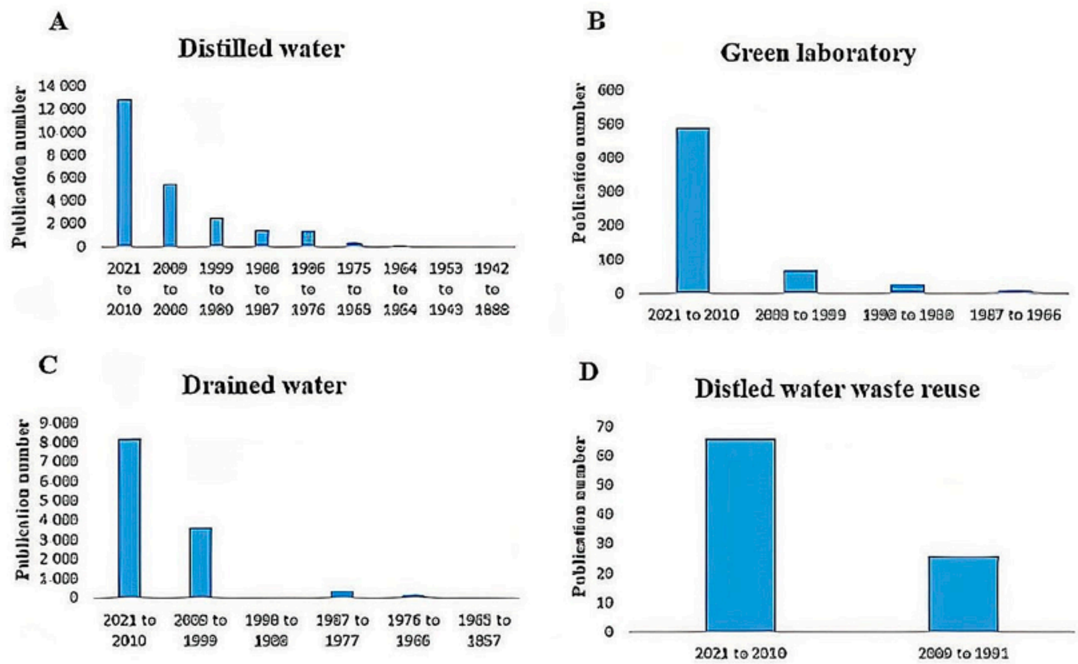

Figure 1. Number of published articles via PubMed engine using the keywords of (**A**): Distilled water; (**B**): Green laboratory; (**C**): Drained water; (**D**): Distilled water waste re-use (23 May 2021).

To the best of our knowledge, this is the first questionnaire designed to assess Knowledge, Awareness, Behavior, Opinion, and Practice of faculty members and students (laboratory and non-laboratory users) on the use of non-distilled water produced by the distillation process. The resulting data, along with its statistical analysis, could pave the way for understanding the significance of evaluating such factors to assist schools, universities, sustainability departments managers, and policymakers in applying the correct approach as a key to successful non-distilled water waste reduction.

This work is conducted at a Malaysian public university using a purposely designed and validated new 23-item questionnaire that studied the green laboratory practice from the point of conservation of non-distilled water from distillation process. Such an approach could help to raise faculty members' awareness of non-distilled water reuse, laying the groundwork for the subsequent plan, which could include the launch of a targeted online or on-campus campaign, as well as seminars aimed at educating faculty members about non-distilled water reuse and leading to the introduction and implementation of green standard operating procedures (SOP) at the laboratory levels.

2. Methods

2.1. Participants' Selection and Study Design

The study used an online-based questionnaire method, and data was collected via email, with a total of 222 responses received. There were no exclusion criteria, thus, the questionnaire was open to all faculty members enrolled on all four campuses of a Malaysian public university. The questionnaire contains 23 items divided into six sections, namely "Respondent's Information", "Knowledge" (6 items), "Awareness" (5 items), "Practice" (3 items), "Behavior" (5 items), and "Opinion" (4 items). There are items with dichotomous questions (Two response options. i.e., Yes or No) and items accompanied by a five-point Likert-scale (i.e., 1. "Very weak" or "Strongly disagree", 2. "Weak" or "Disagree", 3. "Neutral" or "Not sure", 4. "Strong" or "Agree", and 5. "Very strong" or "Strongly agree").

2.2. Statistical Analysis

For data analysis, the Statistical Package for the Social Sciences (SPSS version 27) and MATLAB (version R2010a) were used. The data were analyzed using Principal Axis Factoring (PAF) followed by the Oblique Oblimin Rotation to extract latent factors in an exploratory factor analysis. For factor selection, three criteria were used: eigenvalue greater than one, scree plot point of inflection, and cumulative percentage of variance explained. Furthermore, two phases of analysis were performed; the first phase seeks to determine whether there are statistically significant differences in knowledge, awareness, behavior, and opinion between laboratory and non-laboratory users. The second phase of analysis was limited to the laboratory users, and included, in addition to all of the investigated fields in the first phase, the level of practice. The level of significance, α, was set at 0.05 [35,36].

3. Results and Discussion

3.1. Respondents' Demography

The demographics of this study's respondents are represented in Table 1. Surprisingly, more than half of the respondents (67.12%) were females, and the majority of the respondents (73.42%) were students, mostly affiliated with the school of pharmaceutical sciences (36.04%), and under the age of 46 (95.95%), also with 165 out of the 222 respondents being laboratory users.

Table 1. The demographic distribution of the survey participants.

Variable	Descriptor	Frequency	Percentage
Gender	Female	149	67.12
	Male	73	32.88
Age	<20	12	5.41
	20–25	107	48.20
	26–45	94	42.34
	46–60	7	3.15
	>60	2	0.90
Nationality	Malaysian	203	91.44
	Foreigners (non-Malaysian)	19	8.56
School	Pharmaceutical Sciences	80	36.04
	Biological Science	27	12.16
	Chemical Science	22	9.91
	Industrial Technology	18	8.11
	Physics	19	8.56
	Other	56	25.23
Occupation	Undergraduate student	109	49.10
	Postgraduate student	54	24.32
	Lecturer	31	13.96
	Laboratory assistant	10	4.50
	Other	18	8.11
Laboratory user	Yes	165	74.32
	No	57	25.68

3.2. Questionnaire Reliability and Validity

Table 2 shows the item means and standard deviation scores from the dichotomous questions section of the questionnaire. The relatively low standard deviation scores suggest that the data points tend to cluster around the mean.

Table 2. Mean and standard deviation (SD) of item score.

	Item	Mean	SD
1	Do you know about Green Laboratory?	1.71	0.45
2	Do you know about water distillation process?	1.10	0.30
3	Have you seen distiller machine before?	1.22	0.41
4	Do you know that to generate 100 mL of distilled water we need 4000 mL of tap water?	1.77	0.42
5	Based on question B5 (i.e., previous question), do you think that it is a waste of resource?	1.18	0.39
6	Do you know the differences between tap water, and distilled water?	1.08	0.27
7	Are you aware of the water conservation issue?	3.89	0.87
8	How important is water conservation to you?	4.32	0.74
9	Are you aware of the water crisis issue happening in India and Africa?	3.84	1.09
10	Lowering the rate of running tap water into the water distiller can produce a relatively higher amount of distilled water as compared to the non-distilled water.	3.31	0.99
11	Have you thought of the other potential uses of the non-distilled water?	3.24	0.99
12	In your laboratory, is the non-distilled water being collected from the distiller during the distillation process?	1.79	0.41
13	On average, how long is the distiller in your laboratory switched ON during a working day?	1.94	0.88
14	Will you support if Universiti Sains Malaysia (USM) proposes the conservation of non-distilled water generated from the distillation process?	1.07	0.25
15	I am interested to learn more about water conservation.	4.08	0.78
16	I am willing to get involved in the water conservation program.	3.87	0.86
17	I am willing to use the non-distilled water from the distiller after the water distillation process.	4.04	0.82
18	I will use non-distilled water efficiently.	4.08	0.79
19	Do you practice a water conservation lifestyle in your daily life?	1.25	0.43
20	The non-distilled water produced from distillation process can be used for other purposes.	4.26	0.73
21	The USM community needs to promote water conservation practice.	4.36	0.72
22	Do you think that USM should apply the green laboratory concept in designing a new laboratory?	4.36	0.78
23	Do you think improving the distillation process could contribute to the concept of a green laboratory?	4.27	0.80

Given that the Kaiser–Meyer–Olkin measure of sampling adequacy equals 0.825 (close to 1.0), and Bartlett's Test of Sphericity is significant (i.e., X^2 = 1731.659, p = 0.000), the data were considered suitable for factor analysis [37,38]. Cronbach's Alpha coefficient (0.731) for the entire dataset was acceptable and reflects the reliability of the developed questionnaire [39,40].

For further questionnaire validation assessment, an exploratory factor analysis was conducted using Principal Axis Factoring (PAF) where the Oblique Oblimin rotation was carried out [41]. Three criteria were used to extract latent factors for factor selection, i.e., eigenvalue greater than unity [42], scree plot [43], and cumulative percentage of variance explained [44]. The analysis of the twenty-three items returned eight factors with eigenvalues greater than one, and a cumulative percentage of the variance of 66.14%. The items are classified to a certain factor if loadings on both the pattern and the structure matrices are above 0.3 [44,45]. Factors with only an item were excluded, resulting in four factors with 13 items. Table 3 illustrates the variance explained by the extracted factors accordingly.

Table 3. Pattern and structure matrixes with communalities and explained variance of the extracted factors.

Items by Factor	Communalities	Explained Variance (%)	Matrix	
			Pattern	Structure
Factor 1: Concept of Green Laboratory and Water Conservation		26.21		
Do you think improving the distillation process could contribute to concept green laboratory?	0.862		0.934	0.919
Do you think that USM should apply the green laboratory concept in designing a new laboratory?	0.791		0.851	0.885
The USM community needs to promote water conservation practice.	0.716		0.824	0.843
The non-distilled water produced from distillation process can be used for other purposes.	0.556		0.353	0.614
Factor 2: Usage of Non-distilled Water		7.60		
Have you thought of the other potential uses of the non-distilled water?	0.668		0.827	0.796
Lowering the rate of running tap water into the water distiller can produce a relatively higher amount of distilled water as compared to the non-distilled water.	0.336		0.413	0.486
Factor 3: Knowledge about Water Distillation		7.10		
Do you know about the water distillation process?	0.527		0.741	0.718
Have you seen a distiller machine before?	0.553		0.662	0.716
Do you know the differences between tap water, and distilled water?	0.187		0.382	0.409
Factor 4: Behavior related to Water Conservation		5.86		
I am willing to get involved in the water conservation program.	0.695		0.810	0.816
I am interested to learn more about water conservation.	0.668		0.747	0.805
I will use non-distilled water efficiently.	0.618		0.436	0.654
I am willing to use the non-distilled water from the distiller after the water distillation process.	0.673		0.399	0.645

The popular graphical technique based on the scree plot, as shown in Figure 2, displays the eigenvalues in decreasing order. A visual inspection of a scree plot determines where the curve's "elbow" occurs; this is a strategy for determining how many principal components to use [46]. Accordingly, Figure 2 depicts the "elbow" at the fifth factor, implying that four factors were retained via the exploratory factor analysis.

Out of these four factors, the first is highly related to the green laboratory concept and water conservation. It also contains an item on encouraging water conservation practices at the university. The second factor, about the use of non-distilled water, discusses the potential uses of non-distilled water and includes an item on the effect of the tap water running rate into the water distiller in producing distilled water. Water distillation knowledge, the third factor, focuses on the water distillation process as well as the differences between tap water and distilled water. The last factor, which investigates the behavior related to water conservation, mainly related to the willingness of respondents to participate in water conservation activities.

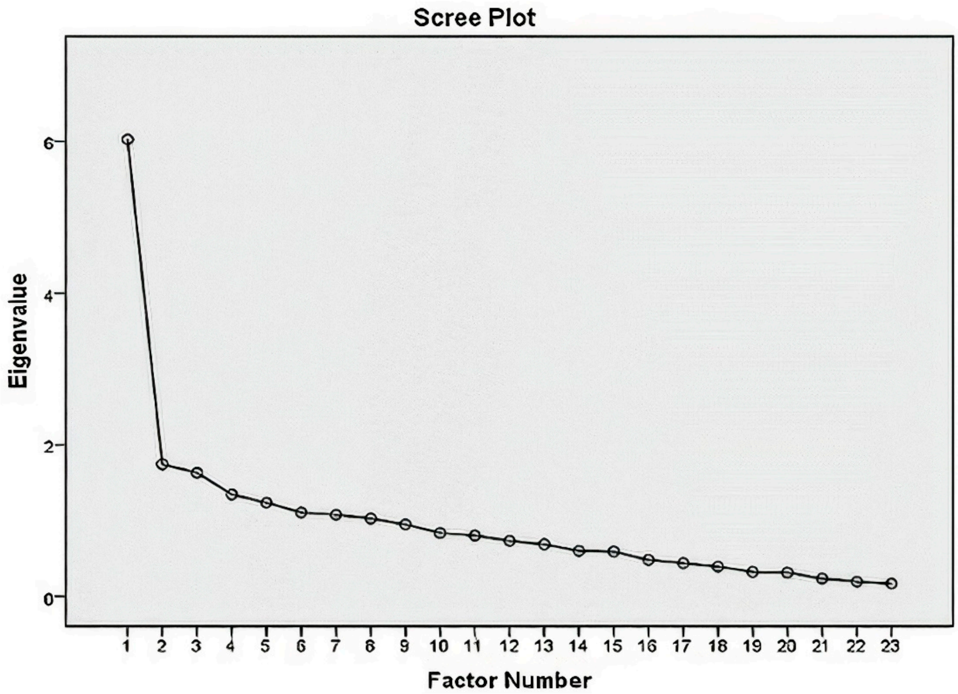

Figure 2. A scree plot via the exploratory factor analysis with the "elbow" at the fifth factor.

3.3. Responses Comparison between Laboratory and Non-Laboratory Users

In this phase of the study, the analysis investigated if there are statistically significant differences in the responses from both laboratory user and non-laboratory user, measured by four variables (i.e., "Knowledge", "Awareness", "Behavior", and "Opinion"). Precisely, a two phase analysis was performed; in the first phase of the analysis, several criteria have to be fulfilled first to conduct the independent-samples t-test and compare the means between the two investigated groups; this includes the dependent variables' data distribution normality (or approximal normality), and for this purpose, the Shapiro–Wilk test was employed [47]. If the significant (i.e., Sig.) value of the Shapiro–Wilk Test is larger than the level of significance, which is 0.05, the data are normally distributed, as the null hypothesis stating the sample data are not significantly different than a normal population cannot be rejected. All the data from dependent variables as demonstrated in Table 4 returned a value of $p < 0.05$ indicating that they are not normally distributed; thus, the independent-samples t-test cannot be performed.

Table 4. Normality test for phase 1 analysis using Shapiro–Wilk test.

	Laboratory User	**Statistic**	**df.**	**Sig.**
Knowledge	Yes	0.904	171	0.000
	No	0.919	70	0.000
Awareness	Yes	0.978	171	0.007
	No	0.965	70	0.048
Behavior	Yes	0.931	171	0.000
	No	0.960	70	0.025
Opinion	Yes	0.881	171	0.000
	No	0.862	70	0.000

The Mann–Whitney U test is used to compare differences between two independent groups when the dependent variable is not normally distributed [48,49]. Accordingly, the Mann–Whitney U test was conducted as illustrated in Table 5. Interestingly, among the four variables, only "Awareness" did not show a significant difference between the laboratory user and non-laboratory user (p = 0.119), with the "Awareness" rank average scores of 125.45 for laboratory user, while the non-laboratory user has the "Awareness" score rank average of 110.14. Overall, the differences between the laboratory user and non-laboratory user for "Knowledge", "Behavior", and "Opinion" are statistically significant, where the higher scores of the laboratory user are indicating that this group has more knowledge and behave more sustainably, though their awareness does not differ significantly.

Table 5. Mann–Whitney U test in phase 1 analysis.

Variable	Group	Mean Rank	Sum of Ranks	*p*-Value	Mann-Whitney U
Knowledge	Laboratory User Non-laboratory User	137.06 81.76	23,437.50 5723.50	0.000	3238.500
Awareness	Laboratory User Non-laboratory User	125.45 110.14	21,451.50 7709.50	0.119 *	5224.500
Behavior	Laboratory User Non-laboratory User	130.92 96.78	22,386.50 6774.50	0.001	4289.500
Opinion	Laboratory User Non-laboratory User	129.45 100.35	22,136.50 7024.50	0.003	4539.500

* *p*-value is not significant.

The boxplot is a standardized way of displaying the distribution of data as shown in Figure 3. These plots can be extremely useful for conveying a detailed picture regarding the investigated four variables for laboratory and non-laboratory users [50]. All plots have a small amount of outliers, indicating that there are fewer extreme data that are abnormally distant from other values. Figure 3A shows that the laboratory user gained higher scores in "Knowledge" than the non-laboratory user. This could be explained by the fact that non-laboratory users are unlikely to be exposed to the distillation process, and four of the six questions in this section are related to the water distillation; thus, the non-laboratory user may have less knowledge. As shown in Figure 3B, the median scores for section "Awareness" of both laboratory and non-laboratory users are similar. The data from non-laboratory users are more dispersed than those from laboratory users, though their scores do not differ significantly.

In terms of "Behavior," the laboratory user acted more sustainably in terms of water conservation, as manifested in Figure 3C. While in Figure 3D, a similar trend can be observed for the "Opinion," where the median score for laboratory users is higher than non-laboratory users. Overall, there is no statistically significant difference between laboratory and non-laboratory users in terms of "Awareness"; in contrast, in terms of "Knowledge", "Behavior", and "Opinion", there was a statistically significant difference, with the laboratory user scoring higher in all of these three categories. The findings are encouraging as the laboratory user is directly involved in the distillation process.

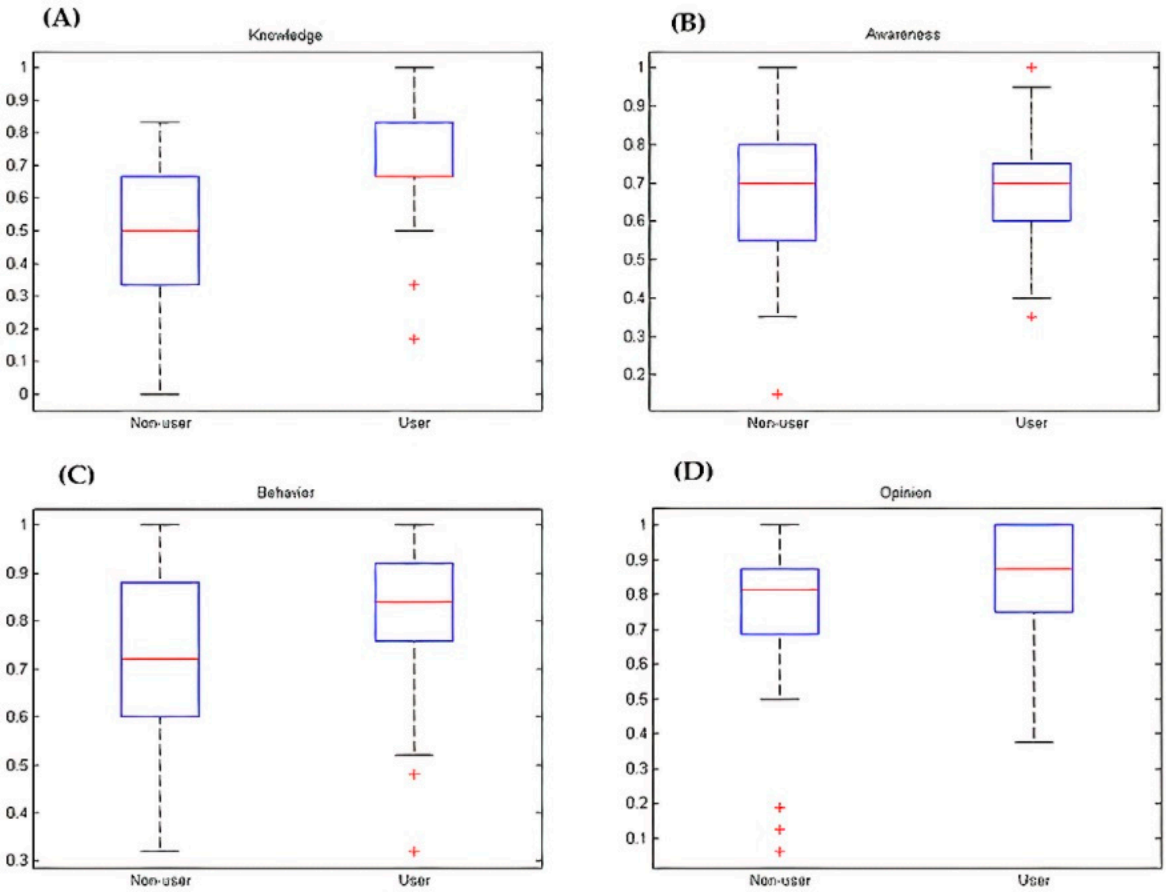

Figure 3. Boxplot of variables (**A**) "Knowledge, (**B**) "Awareness", (**C**) "Behavior", and (**D**) "Opinion" between laboratory and non-laboratory user.

3.4. *Responses Comparison between Laboratory Users' Different Occupations*

In this phase of analysis, the study is focusing on the responses from the laboratory user only. The data used here are extracted from the responses that indicated "Yes" for the item of the questionnaire which asked if the respondent is a laboratory user, and accordingly, a total of 165 responses were considered. The normality test analysis was conducted as previously described in Section 3.1 to check if the data fulfilled the criteria for Analysis of Variance (ANOVA) [51]. Table 6 displays the normality test results for five categories of occupations among the laboratory users, namely "Undergraduate student", "Postgraduate student", "Lecturer", "Laboratory assistant", and "Other".

It can be seen from Table 6 that only data from variable "Awareness" are normally distributed, so the conventional ANOVA could not be conducted. Alternatively, the Kruskal–Wallis H test was used to determine whether there are statistically significant differences between two or more groups [52]. The Kruskal–Wallis H test is a nonparametric test that does not assume normality in the data [53]. As demonstrated in Table 7, the occupation "Lecturer" has the highest mean rank for "Awareness", "Behavior", and "Opinion". The occupation "Laboratory assistant" has the highest mean rank for the variable "Knowledge", whereas "Undergraduate student" obtained the highest mean rank for the variable "Practice". Based on responses from different categories of faculty members, it is found that lecturers not only have higher awareness, but they also think (i.e., represented by the "Opinion" score) and behave better than those from other occupations. Meanwhile, because the occupation "Laboratory assistant" typically requires training to handle the laboratory tasks, this suggests why they have demonstrated a greater amount of knowledge concerning the distillation process.

Table 6. Normality test analysis using Shapiro–Wilk test.

	Occupation	Statistic	df.	Sig.
Knowledge	Undergraduate student	0.904	77	0.000
	Postgraduate student	0.874	44	0.000
	Lecturer	0.840	24	0.001
	Laboratory assistant	0.655	9	0.000
	Other	0.625	11	0.000
Awareness	Undergraduate student	0.979	77	0.217 *
	Postgraduate student	0.970	44	0.313 *
	Lecturer	0.969	24	0.630 *
	Laboratory assistant	0.967	9	0.867 *
	Other	0.960	11	0.771 *
Practice	Undergraduate student	0.907	77	0.000
	Postgraduate student	0.875	44	0.000
	Lecturer	0.815	24	0.001
	Laboratory assistant	0.776	9	0.011
	Other	0.625	11	0.000
Behavior	Undergraduate student	0.941	77	0.001
	Postgraduate student	0.928	44	0.009
	Lecturer	0.772	24	0.000
	Laboratory assistant	0.829	9	0.043
	Other	0.930	11	0.406 *
Opinion	Undergraduate student	0.922	77	0.000
	Postgraduate student	0.849	44	0.000
	Lecturer	0.694	24	0.001
	Laboratory assistant	0.751	9	0.006
	Other	0.843	11	0.034

* *p*-value is not significant.

The results of the five variables analysis using the Kruskal–Wallis H test are shown in Table 8, where the statistically significant differences (Asymp. Sig) are presented in three variables, namely "Knowledge", "Practice", and "Opinion", via the *p*-values of the Chi-Square statistic and equal to 0.000, 0.016, and 0.006, respectively. It is noteworthy that these variables are more closely related to participation in the laboratory distillation process. Furthermore, the Kruskal–Wallis H test analysis demonstrated no significant difference in the "Awareness" and "Behavior" variables, depending on the occupation. This is more correlated with an individual's socioeconomic status and the environment in which the individual grew up, as well as the environmental and social constraints in daily lives that affect individual personalities.

Table 7. Mean ranks of Kruskal–Wallis H test analysis for the laboratory users' different occupations.

	Occupation	N	Mean Rank
Knowledge	Undergraduate student	77	62.73
	Postgraduate student	44	98.67
	Lecturer	24	101.08
	Laboratory assistant	9	106.89
	Other	11	103.23
Awareness	Undergraduate student	77	75.34
	Postgraduate student	44	83.03
	Lecturer	24	109.00
	Laboratory assistant	9	81.61
	Other	11	80.86
Practice	Undergraduate student	77	95.93
	Postgraduate student	44	75.74
	Lecturer	24	71.06
	Laboratory assistant	9	67.11
	Other	11	60.59
Behavior	Undergraduate student	77	77.42
	Postgraduate student	44	89.32
	Lecturer	24	95.15
	Laboratory assistant	9	77.94
	Other	11	74.45
Opinion	Undergraduate student	77	69.58
	Postgraduate student	44	90.69
	Lecturer	24	107.54
	Laboratory assistant	9	92.33
	Other	11	85.00

Table 8. Test statistics of Kruskal–Wallis H test of five variables for laboratory users.

	Knowledge	Awareness	Practice	Behavior	Opinion
Chi Square	29.048	9.250	12.171	3.920	14.600
df.	4	4	4	4	4
Asymp. Sig.	0.000	0.055 *	0.016	0.417 *	0.006

* *p*-value is not significant.

Figure 4 (from A to E) depicts the boxplots for the five occupation-based variables. According to Figure 4A, the median values of "Knowledge" for "Post-graduate student", "Lecturer", and "Other" occupations are similar. All data from the "Laboratory assistant" are greater than 0.65. In comparison to other occupations, responses from "Undergraduate students" show relatively low scores for "Knowledge". The boxplots in Figure 4B show that all occupations have nearly the same median values for "Awareness," except for "Lecturer", which has the highest median value. In terms of "Practice", the response from "Undergraduate student" has the largest interquartile range, indicating that their response varies the most when compared to the other occupations. This is demonstrated by the boxplots in Figure 4C, which shows that all other occupations have a relatively small interquartile range for the variable "Practice".

According to the boxplots in Figure 4D, which depict the response distribution for variable "Behavior", the median values for all occupations appeared to be the same. Responses from the occupation "Laboratory assistant" are more consistent than responses from the other occupations. Similarly, to the response for variable "Practice", the response from "Undergraduate student" varies the most because it has the widest interquartile range. "Lecturer" has slightly higher scores for "Behavior", whereas the opposite is true for "Other occupation" responses. The occupations of "Lecturer" and "Laboratory assistant" have the highest median values for "Opinion" responses (Figure 4E). In this regard, both occupations' median scores achieved the maximum score of one.

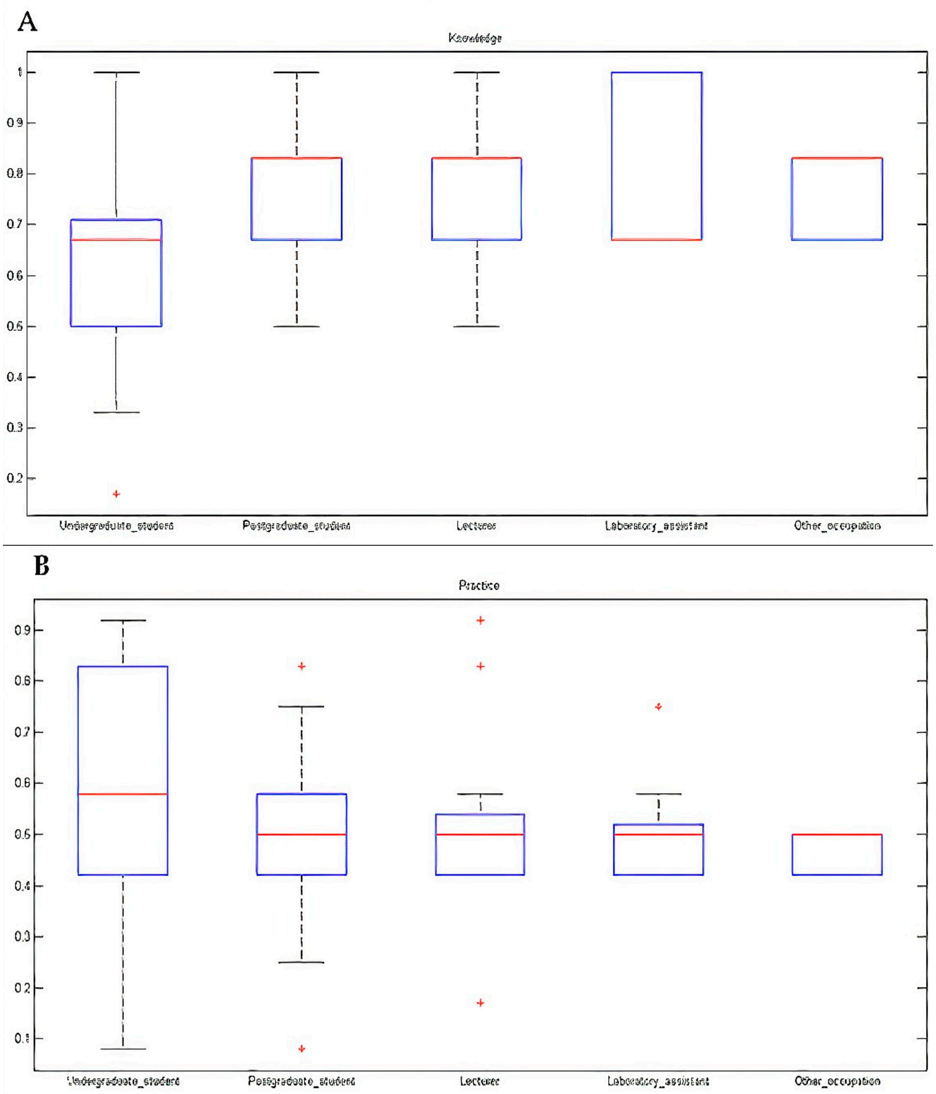

Figure 4. *Cont.*

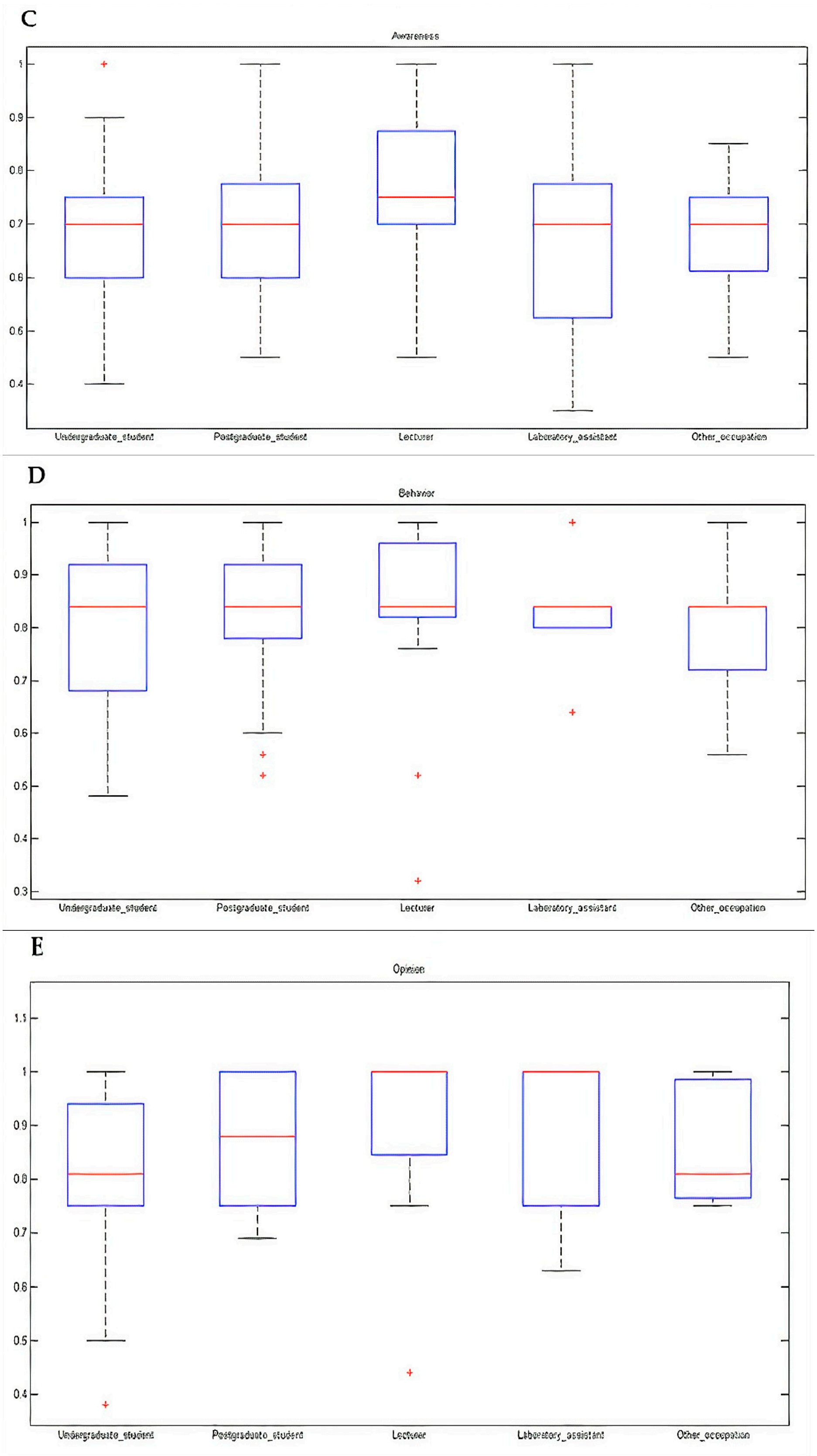

Figure 4. Boxplot of variables (**A**): "Knowledge", (**B**): "Awareness", (**C**): "Practice", (**D**): "Behavior", and (**E**): "Opinion" among laboratory users' various occupations including undergraduate students, postgraduate students, lecturers, laboratory assistant and others.

4. Study Limitation

There has been no previous study of its kind for this specific group to draw a comparison from. Precisely, no study compares faculty members' levels of awareness, knowledge, behavior, and opinion about distilled water concerning its drained water reuse as part of green laboratory practices. Furthermore, the data were gathered from faculty members at a Malaysian public university, so the sample size, while adequate, is small. The covered age range in this study is limited to respondents from 20 to 45 years old, which may have an impact on the results. Furthermore, the majority of respondents were females and from the student's occupation, which may have influenced the findings. Besides that, the findings of this study are limited to the truthfulness of the respondents, so there may be errors in recalling some answers. Future studies will use larger samples with different backgrounds, such as the community in primary and secondary schools, with laboratory water distillers, to represent the entire society.

5. Discussion and Suggestions

Universities have a primary responsibility to promote a systemic approach to influencing policymakers in the field of green laboratories by first understanding the members of their faculties, which can lead to the creation of water scarcity programs that can be encouraged to become mandatory upon enrollment in degree-based studies in certain fields. This study shed light on the presence of a significant gap in addressing water scarcity in academia, specifically the method of handling the massive amount of drained water from the distillation process, which is carried out daily to produce enough distilled water for undergraduate, postgraduate, and research laboratories.

In this work, the results showed good awareness and knowledge among the academic staff and the laboratory assistant, respectively; thus, both personnel are having a highly critical role in pushing for the reuse of wastewater to their corresponding laboratory users, mainly students, which also scored highest in practice. Aside from that, higher management of the university shall play a role in seeing into the overlooked problem. For instance, regardless of the working domain but only if it involves the use of distilled water, new-era personnel are expected to have sufficient distilled water waste management skills, either from their undergraduate curriculum or through specific training. Thus, even when the personnel have full access to water resources, this will instill a sense of responsibility toward water resources and make it easier to regulate distilled water use and its waste reuse.

Subjective opinions from this questionnaire showed that more than 97% of the respondents supported the effort to recycle wastewater from the distillation process. Examples of the received comments include "Water crisis is always an issue in other states such as Selangor. Although Penang state may not have this problem, we should be aware of it as part of our efforts to protect the environment.", "Recycled for plants or industrial", "Water crisis, especially freshwater, has recently become an issue as its resources are depleting at an alarming rate. Pollution and contamination cause the water supply to become even more limited, so we must conserve while we still have the resource to ensure its long-term viability". Others make recycling suggestions, such as "A chiller can be installed to recycle the water. However, electricity is required to cool the water and allow condensation to occur. So, make a chiller that doesn't require electricity?" Investigating this comment led us to the negative side of the collected opinion, where one of the respondents, who is under the lecturer category, mentioned, "Too much effort required to save the non-distilled water, not value for money." Thus, and based on these subjective opinions, additional suggestions could be the initiation of community-wide competitions and financial awards initiatives, in the context of distilled water reuse policies, as well as strategies to inspire youth and junior researchers to put theory into action.

It is worth highlighting that the sanitary or water management system is heavily reliant on the development of local water infrastructure. Professor Sharma's innovation of a modified Recycling Distillation Technique that uses an earthen pot as a cooling reservoir is one of the commendable individual efforts made while resources are limited [19,20]. Another one was recently published where a group of dedicated team members made up of students, laboratory technicians, and instructors designed their new distillation system to waste no fresh water out of the distillation unit and replace the conventional glass distillation apparatus [54]. More designs should be encouraged to investigate the impact of such implementations in various laboratories, in terms of the annual volume of reused non-distilled water, as well as the amount of tap water consumed in the first place to generate the distilled water.

Furthermore, the findings of this study could be presented to the top management of Housing, Building, and Planning, at the very least for future infrastructure expansion. A secondary piping system for different water distribution, for instance, may be considered for more sustainable water system usage, which channels the distilled water waste to further usage such as but not limited to toilet washing and watering plants (for gardening and herbal research). This necessitates additional research into the efficiency of water pumps as well as their robustness in the face of such water shortages.

A top-down enforcement manner could be beneficial in this regard; thus, governments and their related organizations can implement a "reward and punishment" strategy in which a specially designed water meter for distilled water waste is installed in laboratories, research centers, and schools with a water bill waiver if the institute achieves a certain level of distilled water reuse, and vice versa in terms of excessive use of distilled water without waste management.

Future scientists maybe are required to provide data on the benefits, drawbacks, and sensitivity of using non-distilled water from the distillation process in washing, as well as daily experiments from basic solvent preparations into molecular experiments. In this regard, a collection of such experiments' results will contribute to the establishment and activation of on-hands SOP.

Since the COVID-19 pandemic in 2020, and with the implementation of the new norms such as virtual education and academic events, different E-platforms should be studied and used to raise awareness for non-distilled water reuse from the distillation process based on game activities using different approaches including the internet of things, which was recently employed for raising awareness on water pollution [27], aiding in the development of water-sensitive communities [28], as well as reducing water reuse illiteracy and promoting green laboratory practices with a focus on distilled water waste reuse.

6. Concluding Remarks

This paper evaluated four variables, namely, the human behavior, awareness, knowledge, and opinion, regarding reusing non-distilled water produced by the distillation process in a Malaysian public university. Findings from an exploratory factor analysis revealed that the designed questionnaire has adequate construct validity and reliability. Interestingly, among the four variables, only "Awareness" did not show a significant difference between the laboratory user and non-laboratory user, but only laboratory users showed more knowledge and behaved more sustainably. Upon comparing different occupations among laboratory users, "Lecturer" has the highest mean rank for "Awareness", "Behavior", and "Opinion". The occupation "Laboratory assistant" has the highest mean rank for the variable "Knowledge", whereas "Undergraduate student" obtained the highest mean rank for the variable "Practice". These preliminary results could help the university management or the water policymakers in addressing the issue of non-distilled water waste.

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