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ASSESSMENT OF WATER SUPPLY SYSTEM: A QUESTIONER STUDY

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Abstract:
A universal water supply system was the subject of numerous studies in an effort to help designers create more reliable systems for long-term operation. These efforts also target the convenience of the systems in use in the Kurdistan Region of Iraq as well as the optimization of the region's entire construction distribution networks. This research aims to find out how people think about the quality, quantity, and problems with the water distribution systems (in Sulaimani City). The data was collected through a questionnaire by asking people various questions, and their opinions about the water distribution systems in the region, as well as the convenience of the systems used (continuous or intermittent) to deliver water. For accessing water in the intermittent water distribution system, around 44%, 28%, and 3% of the respondents have access to water once in three days, once in two days, and have no watering schedule for accessing water, respectively. During the week, the water is distributed in a continuous system. As it's obvious from the duration of water distribution, in most of the intermittent water distribution systems, 56.2% of respondents have 2–3 hours of access to water. According to the frequency of water availability, approximately 25% and 7.5% have access to water for only one hour and less than one hour, respectively. Respondents with continuous systems don't have any major problems with the drinking water's odor, taste, or color. Results show that 72% of them accept the provided water as safe, and the breakdown of the water pipelines is confirmed by all.

Keywords: *Water Supply; Continues; Intermittent; Quality; Quantity*

1. Introduction

Since ancient times, people have been looking for pure water. Human civilization was established on freshwater and only emerged in areas with a sufficient water supply. These civilizations flourished along the banks of the rivers [1]. Water is an important good for the sustainable use and management of human life. Access to drinking water is a fundamental necessity, but many areas around the world have unstable circumstances or even have minimal water quality infrastructure. There are Roughly about 17% of the world's population without access to safe drinking water [2]. The same source predicts that the number of people in developed countries will worsen by 2050. A suitable water source, on the other hand, is essential to good sanitation and, therefore, public health [3]. Surface water is a significant source of water available in rivers and reservoirs and is used for various purposes, such as

drinking, irrigation, and fish culture. Nowadays, as a result of the worldwide increasing population and pollution, surface water has become a significant issue. Water quality management for drinking purposes must be focused on disease prevention, so that it may transmit diseases and pollutants in many cases [4]. Therefore, drinking water has to be fit for human needs. Also, water supplies must be suitable for all domestic uses. Domestic water supplies are usually subjected to pollutants that are directly introduced into the water distribution system from the treatment plant, erosion, and pipe leakages [5]. The availability of water refers to an enhanced water supply that meets relevant quality requirements by its uses. In turn, the definition of water supply for human use, including for drinking, cooking, and washing, is normally assigned to water. Water access also depends in developing countries on water points, such as springs, lakes, and rivers, without regulation or quality control [3]. Four northern governorates make up the Kurdistan Region of Iraq (KRI): Halabja, Sulaimani, Erbil, and Duhok. 95% of urban homes and 62% of rural households in the Kurdistan Region had access to drinking water through the water distribution network as of 2013. A piped water distribution network that runs directly into the houses of 70% of the region's residents provides them with access to safe drinking water. However, the KRI continues to face significant challenges, particularly in rural regions. Only 25% of people in urban areas and 18% of people in rural areas have more than 10 hours of daily access to the water delivery network. Inhabitants of some places, particularly in Sulaimani, can only access the general water distribution network for two hours every three days. A lot of the water distribution networks in Erbil, the capital of KRI, need to be upgraded because they are very old and were installed in more than a century ago. The estimated ratio of water leakage is greater than 50% [6].

Moreover, 1.8 million people live in the city of Sulaimani, which is situated in the Kurdistan region of northeastern Iraq at an elevation of 880 meters [30]. The two primary water sources that provide water to nearly the entire province of Sulaimani is the Dokan and Darbandikhan lakes. The majority of the Sulaimani governorate is supplied by the Dukan water system. Pumping capacity is the fundamental constraint on the production system. Users generally receive 2 hours of potable water every three days. According to the Directorate of Water, over 95% of habitations in the city of Sulaimani have access to the public network. To handle the brief distribution intervals, a substantial storage capacity is required. The vast majority of users also have access to private truck sellers, private wells, and private boreholes [7]. Since the first measurement of water demand was made available in 1957, the rate of water consumption in Sulaimani city has been steadily rising. The relatively low amount of 57 liters per capita per day in 1957 climbed to 220 liters per capita per day in 2006. Consumption increased steadily until 2010 when it peaked at 250 liters per person per day. If the Sulaimani Statistic Directorate's (SSD) estimates of 895531 inhabitants per capita in 2017 and 1040459 inhabitants per capita in 2022 are taken into account, it can be seen that the bulk volume of water consumption has reached 9328 m3 per hour for 2017 and will increase to 10838 m3 per hour in 2022 [8]. Water quality is another issue that should be investigated in distribution systems. The studies on water quality also made a comparison between intermittent and continuous distribution systems (IWS and CWS). It was concluded that indicator bacteria were detected at higher concentrations in intermittent taps. [9] investigated that the quality of drinking water in Sulaimani City is monitored for a study period of one year. The study's findings revealed that, for the most part, every metric was within the acceptable ranges, except the turbidity parameter, which occasionally exceeded them.

The water supply system of both IWS and CWS in Sulaimani City. Recently, it has been used to transport drinking water for customers from water treatment plants and reservoirs. IWS produces the highest distribution factors at Sulaimani. In a variety of places, IWS induces low pressure. People have

to store water for day-long consumption in their homes. Most residents would like to be linked to a 24-hour water supply.

Water is considered an important resource for life. The method of water distribution in the city and the establishment of a good master plan plays a major role in reducing water wastage and also lead to better use of water by the population. This research aimed to analyze the people's opinion towards water supply and distribution systems in Sulaimani, Kurdistan Region, Iraq. It's important to know what people think about their water supply system, water quality, prices, and maintenance. Therefore, a questionnaire is used for gathering information from a large number of people. The questions of the questionnaire are designed in such a way as to get as much information from the participants in a short period of time. The content of the questions is mentioned in the materials and method section.

2. Material and Methods

To investigate, the authors made a questionnaire regarding water distribution systems in the KRI. A survey was conducted with a questionnaire that asked several crucial questions. The study outcomes were statistically analyzed using Statistical Package for the Social Sciences (SPSS) software version 26. The investigation's specific information is illustrated in the various subsections.

2.1 Study Area

Sulaimani Province is located in northeastern Iraq. In Iraqi Kurdistan, it is one of the largest governorates (Kurdistan Regional Government). Sulaimani's elevation is approximately 830 meters above sea level, and its geographic coordinates are 35° 33′ 40″N and 45° 26′ 14″E. Sulaimani Province covers 17,023 km2 in total [10]. Figure 1 shows the location of the study area, including the districts of Sulaimani Province. The summer months (June-August) are dry and hot in Sulaimani, with an average temperature of 31.5 °C. The winter (December to February) has an average temperature of 7.6 °C and is significantly colder, wetter, and windier. Rainfall, which ranges between 400 and 600 mm annually [11] begins in October with brief storms, picks up in November, and then carries on until May. Participants were required to reside in the city center of Sulaimani in the KRI to be excluded from the study. Anyone who has this information is eligible to participate in this survey.

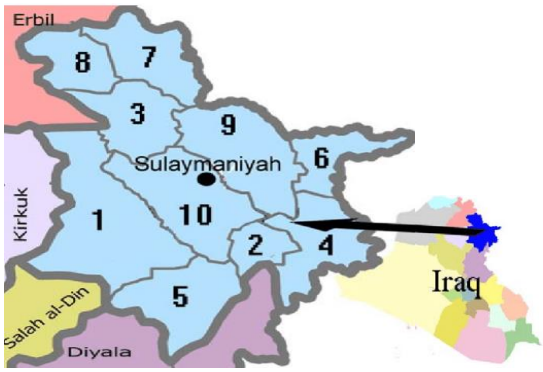

Figure 1: study site (Sulaimani city. Numbers indicate towns linked to the province) [12]

2.2 Participants and Sample Size Technique

According to estimates, Sulaimani City will have 1.893 million residents in 2020, making up the majority of all Iraqis [10, 11]. In this case, the below formula will be enough to figure out how many samples are needed for this study [12, 31].

$$\mathbf{n} = \frac{\mathbf{N}}{1 + \mathbf{N}\mathbf{d}^2} \quad (1)$$

Where n = number of samples, N = size of the population, and d = error margin (considered d = 0.05) [13]. Due to the sample size determined by taking into account the population in KRI, the formula indicated that approximately 400 samples would be sufficient for this study [14]. Cross-sectional and quantitative research on this subject was done between January 1 and February 1, 2022.

2.3 Questionnaire Design and Data Collection

The purpose of the current study was to better understand how people in the Kurdistan Region of Iraq thought about distribution systems. Show how the outcomes have unintended consequences as well. Primary data was collected using the standardized questionnaires created after a review of the literature. This cross-sectional study used a self-administered online questionnaire in addition to in-person interviews to collect the data. To voluntarily collect information, the questionnaire was created using Google Forms, a free electronic tool offered by Google [15]. This survey consisted of 18 questions with a suggested filling time of 3–5 minutes. The survey link was disseminated by the authors in Sulaimani City using snowball sampling. The questions were divided into three sections. Demographic information, which describes the participants' general characteristics, is covered in the first section. The perspectives of the respondents, including their age, gender, and educational background, were more clearly discernible thanks to this type of data. The second category contained questions about the water distribution approaches and properties of quality. The final section discussed the respondents' issues and suggestions for resolving them. The survey questionnaire was sent to about 1000 participants, and half of the participants were interviewed. Therefore, of the 403 responses collected during data collection, 202 and 201 respondents have IWS and CWS, respectively.

2.4 Statistical Analysis Instrument

All statistical evaluations were performed using the Statistical Package for the Social Sciences (SPSS) version 26.0. The software evaluated the frequency, percentage, and A technique for analyzing the relationship between several variables quantitatively. A cross-tabulation, which is also called a contingency table or cross-tab, is a way to group variables so that you can understand how they are related [16].

3. Results and Discussion

3.1 Demography of Participants

The authors conducted a questionnaire, and a total of 403 people participated in this research. In the first part of the questionnaire, the authors wanted to find out about the demography of the respondents; for instance, sex, age, and level of education. Without distinguishing those variables, it would be difficult to understand the specific groups' concerns regarding environmental aspects [17]. Several charts displaying the results are given below:

Figure 2 shows the total number of participants distributed among gender ratios. In the Kurdistan Region of Iraq, mostly females deal with water [18]. Their participation ratio in the questionnaire is more than males by 10%.

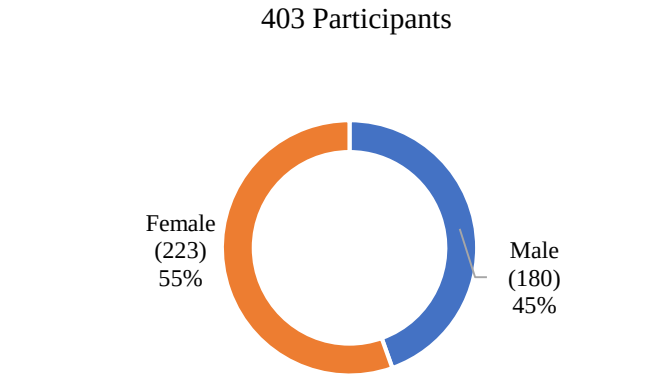

Figure 2: Gender determination of participants

Figure 3 illustrates the age group of participants. In this research, the authors divided the age groups of participants into 7 categories, and as it's obvious, mostly youth from 19–23 years old participated in the questionnaire. In general, youth aged 19 to 30 make up 63.9% of the population. So, the youth played an important role in providing input for this research. It's worth mentioning that youth participation is an important step in changing and developing any society and any project. If any development is wanted in society, youth should be the main focus of that activity [19].

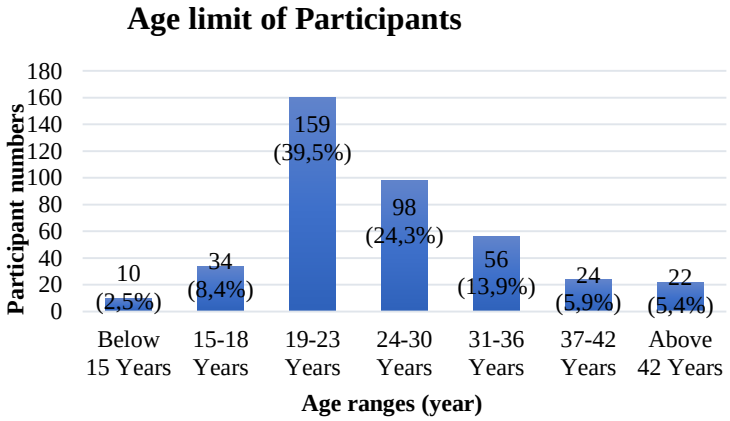

Figure 3: Age Range of Participants

Figure 4 illustrates the education level of participants, and it's obvious that 57,9% of participants were university students or graduates. Around 92,8% of participants have received formal education. On the other hand, 7.2% of participants lack official education. To have data that reflects Kurdish society, the authors wanted to have an overall opinion of every level of society. According to the Iraq education fact sheet prepared by UNICEF, in the Kurdistan Region, around 96% of the total population has received formal education [20]. In the survey, the authors also wanted to somehow reflect the reality of the research area.

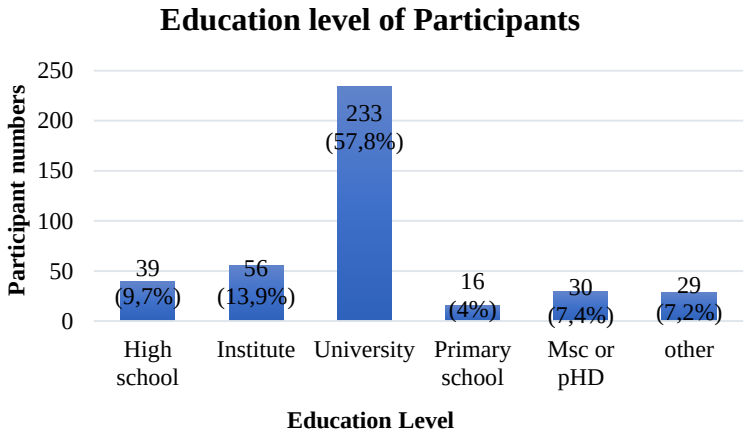

Figure 4: Education Level of Participants

3.2 Water Distribution Approaches and Properties

Generally, in the Kurdistan Region of Iraq, there are two types of water distribution systems: IWS and CWS [21]. Many studies have been carried out to compare the two systems in terms of quantity and quality [22]. Table 1 elaborates on the frequency of the water supply in the IWS. According to the respondents, around 44% have access to water once in three days, and around 28% have access to water once in two days. Only 3% of respondents don't have a scheduled time for having access to water. As it's obvious from the duration of water distribution, most of the IWS. respondents have 2-3 hours of access to water, which is 56.2%. According to the frequency of water availability, approximately 25% have access to water for only one hour. On the other hand, only 7.5% of respondents have access to water for less than 1 hour, which is a critical number and quantity.

The analysis of people's opinions on the quantity of water and the necessity of using water pumps to have an adequate amount of distributed water is illustrated in Table 1. As a result, the quantity of water in systems is obvious that CWS leads to better access to water by the participants. Regarding using water pumps, 33.6% of respondents thought they needed a water pump to receive enough, while 49.6% thought they didn't need a water pump. With CWS, people do not need to use water pumps, of which only 17% use water pumps and 75.3% do not. On the other hand, people with IWS rush to fill their water barrels, so they use water pumps to get more water in a shorter period, in which 50.7% continuously use water pumps and only 24% do not use water pumps. In the section on "sometimes" using water pumps, people with IWS use water pumps more, with 25% sometimes using water pumps, while with CWS the percentage is only 8%. Around 60,5% of the respondents were satisfied with the quantity of water.

Only 37 people thought that the water quantity was inadequate, which is 9.14% of all respondents. It can be observed that households with a continuous water distribution system have fewer complaints regarding the quantity of drinking water, with 5% of complaints, while within IWS there are 13% of complaints. In addition, the ratio of people who think that their water quantity is sometimes good is three times greater in CWS households [23].

Table 1: The frequency of the water supply system

Questions	Possible answers	IWS (201)	CWS (202)	Total (403)
What is the frequency of the water supply during the week?	Once a day	14	0	14
	once in a week	24	0	24
	once in three days	24	0	88
	once in two days	56	0	56
	The entire week	5	202	207
	more than once day	8	0	8
	Not scheduled	6	0	6
On the days that you get water, how many hours do you usually get water?	Less than 1 hr.	15	0	15
	1 hr.	50	0	50
	2-3 hrs.	113	0	113
	4-5 hrs.	23	0	23
	24 hrs. I have Continuous W.D.S.	0	202	202
Do you need the water pump to receive adequate amount?	Yes	102	34	136
	Sometimes	50	16	66
	Not	49	152	201
Is the quantity of water that you receive adequate?	Yes	84	161	245
	Sometimes	90	31	121
	Not	27	10	37

3.3 Quality of Water Supply

Water is necessary for life; thus, efforts should be made to preserve its quality [24]. In this section, the authors will reflect on the participants' ideas about their houses' water quality. Table 2 elaborates more on water quality in terms of color, taste, and smell, and it's dramatic that in the IWS, only 4.7% of respondents are sure of their water quality to a very good extent. In the CWS, the percentage is 13.9%. In support of this argument, with the respondents who chose that they are sure of their water quality to a very low extent, the ratio of people with IWS is greater than the CWS. The most frequently ticked answer is knowing the water quality to a good extent (33%). The second most ticked choice is knowing the water quality to a low extent, with 23%. Generally, their responses vary, and the result is not significant. Respondents with CWS don't have any major problems with the drinking water's odor,

taste, or color. Results show that 72% of them accept the provided water as safe. On the other hand, respondents with IWS are distributed between having good-quality water and having low-quality water. Their response is not significant [25].

Table 2: The quality of water in the household

Questions	Possible answers	IWS (201)	CWS (202)	Total (403)
To what extent are you sure of the water quality with regard to your available W.D.S?	V. Good Extend	19	56	75
	Good Extend	69	64	133
	Not sure	34	20	54
	Low Extend	50	41	91
	V. Low Extend	29	21	50
Generally, how does the water smell?	Yes, it smells, tastes, cloudy	72	38	110
	Sometimes it smells, tastes, is cloudy	32	10	42
	No smell, no taste, it's clear	97	154	251
Does the water have a taste?	Yes, it smells, tastes, cloudy	84	37	121
	Sometimes it smells, tastes, is cloudy	35	16	51
	No smell, no taste, it's clear	82	149	231
What does the color of the water look like?	Yes, it smells, tastes, cloudy	86	42	128
	Sometimes it smells, tastes, is cloudy	66	23	89
	No smell, no taste, it's clear	49	137	186

3.4 Barrier's to the Water Distribution System

Water scarcity has become a major constraint to socio-economic development and a threat to livelihoods in increasing parts of the world. Since the late 1980s, water scarcity research has attracted much political and public attention [26]. The city of Thi-Qar governorate in Iraq is one of those that faced serious water scarcity, which had a negative impact on the local people [27].

Table 3 explains the participants' opinions regarding water scarcity during certain seasons. It can be observed that in spring, fall, and winter, the ratio of water scarcity is very low since the precipitation rate is high in those seasons [28]. The critical season for water scarcity in the Kurdistan region of Iraq

is summer because the precipitation rate is low, and natural surface water decreases [29]. In all, around 73% of participants with IWS faced water scarcity in the summer season. On the other hand, only 27% of participants with CWS faced water scarcity in the summer season. The table also shows that 123 people checked all season, which means that most people don't have easy access to water.

Problems have been faced by the Kurdistan region's people, such as the breakdown of the water supply pipelines and their fixing by the public authority teams. According to the statistics, all respondents agree that the water pipelines broke down. The participant's opinions are distributed among having a broken pipeline sometimes and most of the time. To elaborate more on this issue, the authors did another cross-tabulation. The respondents' opinion is not significant for the mentioned frequents. Approximately 25% of both water distribution systems agree that once a month, their water pipelines break down. On the other hand, around 45–50% of both WDs agree that there isn't any frequent time for their water pipeline to break down, but it does from time to time.

Then the authors wondered how promptly the broken water pipelines were fixed by the public authorities. As a result, in the IWS, 48% of respondents believe that it's not fixed promptly. On the other hand, 52% believe that it will be fixed promptly. The insignificance of the result may be due to different geographical locations because, in each location, a different authority is handling the fixing of the broken water pipelines.

Table 3: Barriers in the water distribution system

Questions	Possible answers	IWS (201)	CWS (202)	Total (403)
Which season do you face scarcity?	Spring	2	3	5
	Summer	142	56	198
	Fall	5	3	8
	Winter	7	17	24
	All Seasons	45	123	168
Has the public water pipeline broken down?	Sometimes	92	85	177
	Most of the time	109	117	226
	No	0	0	0
How frequently do the water pipelines break down?	Once in six months	17	10	27
	More than twice in a year	28	21	49
	Once a year	19	23	42
	Once a month	53	47	100
	None of the mentioned frequents	84	101	185
Are the water pipelines fixed promptly when it breaks down?	Yes	105	170	275
	No	96	32	128

3.5 Cost of Water Supply

Water bills are introduced all around the world, and in many areas, rising infrastructure costs for water providers and the rising cost of water for households pose several challenges for water providers, policymakers, and the research community [30].

In Table 4, the monthly cost of the water bill is illustrated. In the IWS and CWS systems, around 21.3% and 25.8%, respectively, pay 10.000–20.000 Iraqi Dinars (IQD), which has a higher rate. Whenever the bill rate range for both systems was increased, this rate decreased proportionally. The most obvious difference between paying a monthly bill for both systems is that they almost both cost the same for the consumer. This can be due to the water meter measurement, or the usage of people with CWS being less than that of people with IWS. This can be investigated in further study.

Table 4: Monthly Cost of Water

Questions	Possible answers	IWS (201)	CWS (202)	Total (403)
What is your monthly water bill?	10.000-20.000 IQD	88	104	192
	21.000-25.000 IQD	50	34	84
	26.000-30.000 IQD	30	27	57
	31.000-36.000 IQD	15	13	28
	More than 36.000 IQD	18	24	42

3.6 Overall Opinion on Different Water Supply Systems

Generally, Table 5 explains people's ideas regarding both WDS systems and the theory behind their opinions. As a result, about 68%–78% of participants agree that CWS are better than IWS. Around 14–18% of participants are not sure whether it's better to have a continuous system or not, but they voted for a light yes. while only 13% of IWS participants and 7.5% of CWS participants think that it's not better. The theory behind their answer may be due to the ideology that they think having CWS would lead to high bills. Only higher costs and wasting water were among the highest-rated choices, in which people don't want to change their water system from intermittent to CWS due to higher costs and the fact that in CWS more water will be wasted, which can harm the water resources. Based on the data analysis, it appears that respondents do not consider CWS to be better than IWS. The results indicate that the majority of respondents who preferred IWS - 36 individuals - cited the reason as simply wasting more water. In contrast, the majority of respondents who preferred CWS-23 individuals - cited various other concerns as the reason for their preference.

Table 5: people's general ideas regarding both W.D.S

Questions	Possible answers	IWS (201)	CWS (202)	Total (403)
Do you think a continuous water supply is better than an intermittent distribution system?	Yes	137	158	295
	No	27	15	42
	To an extent, yes	37	29	66
If it's no, what are the main reasons?	increase in water crisis	10	4	14
	higher costs, health concerns	4	3	7
	higher costs, wasting water	6	5	11
	Only higher costs	23	16	39
	Only wasting water	36	16	52
	health concerns	10	5	15
	Other Concerns	24	23	47

4. Conclusion

This study was conducted to determine the people's opinion towards water supply systems in Sulaimani City, Kurdistan Region, Iraq, and to show how the results have unintended consequences. The following points were found:

- C.W.D.S. improves participants' water access. 60% of respondents were satisfied with the water. Only 37 people (9.14%) thought there wasn't enough water. Continuous W.S.D. has 5% fewer complaints than IWS. Continues WDS households have three times fewer people who think their water quantity is sometimes better than IWS households.
- Only a few responders are sure of their water quality to a very good extent in IWDs.
- Respondents with CWS don't have any major problems with the drinking water's odor, taste, and color. Results show that 72% of them are accepting the provided water as safe.
- The breakdown of the water pipelines is confirmed by all responders. One-fourth of both WDS agree that their water pipelines fail once per month. On the other hand, about half of WDS agree that while their water pipeline doesn't frequently break down, it occasionally does so.
- The most obvious matter in paying a monthly bill for both systems is that almost both systems cost the same for the consumers. Only higher cost, and only wasting water was among the highest rated choices, in which people don't want to change their water system from intermittent to CWS due to higher cost, and in CWS more water will be wasted, which will harm the environment.

5. Authors Contribution

We confirm that the manuscript has been read and approved by all named authors. We also confirm that each author has the same contribution to the paper. We further confirm that the order of authors listed in the manuscript has been approved by all authors.

6. Conflicts of Interest

The authors state that there is no conflict of interest.

7. Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

8. Data Availability

The data used in this study are available on request from the corresponding author.

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