IV RESULTS AND DISCUSSION

The current research entitled ***"Exploration of Domestic Water Management Practices and Paradigm Shift using IoT Enabled AI System for Devising Water Conservation in Ingenious Homes"*** was carried out in four separate phases, and the findings of each phase are described in this chapter. For simplicity of understanding as well as for convenience, the findings and commentary were provided under the following sequence.

This portion of the results deals with the survey performed among 385 homemakers picked from North, South, East, West and Central zones of Coimbatore city. The outcome of the survey is reported under the following headings:

Phase I: Descriptive Study - Homemakers' Socio-demographic Characteristics

A. Socio-economic Background of the Homemakers - Personal Minutiae of the Homemakers
B. Specifics of Alternate Water Sources Available
C. Basics of Water Conservation Techniques
D. Information on the Water Distribution Procedure
E. Complete Contentment on the Availability of High-Quality and Sufficient Amounts of Soft Water
F. Reasoning behind the Status of Inadequacy and Discontentment of Water

Phase II: Experimental Investigation: Water's Qualitative and Quantitative Status Quo

A. Evaluation of the Physical, Chemical and Biological Qualities of Water Delivered in Various Zones of the Coimbatore District that was Preserved for Drinking Purposes.
B. Inspection of Drinking Water Quality after Common Purification Methods
C. Monitoring and Assessing the Quality of Water Stored in Different Containers
D. Water Consumption Analysis by Micro Components

Phase III: Knowledge Germination and Dissemination

A. Effectiveness of the Knowledge Dissemination Programme on Residential Water Management
B. Comparison of Behavioural Attitude Scores before and after the Knowledge Dissemination Programme

Phase IV: Designing the IoT Enabled AI System for Devising Water Conservation

A. Conspectus Minutiae of the Invention
B. Invention's Detailed Picture
C. Block Diagram Representing the Thorough Architecture of the Invention
D. Novelty and Highlights of the Invention
E. Honour of the Invention Acknowledged

Phase I: Descriptive Study: Homemakers' Socio-Demographic Characteristics

In order to understand the attitudes of the chosen households towards domestic water management, more about the socioeconomic background, housing details, information on the process of distributed water to homes, water collection and storage methods, and water consumption profile of the selected households, a household survey was carried out. The details of the homemakers are presented under the following sub-headings:

A. Socio-economic Background of the Homemakers

To document the pertinent information about the homemaker's personal particulars such as educational background and employment status, family details and income category, and housing features were gathered.

Personal minutiae of the homemakers

Coverage: Personal information of the homemakers including educational background, employment, family information, income category, ownership status, type of house, and period of living were elicited and the findings were shown in Tables: 5 (a), 5 (b) and 5 (c).

- ***Educational Qualification and Employment Status***: data regarding age, educational qualification, and employment condition are discussed in Table:5 (a).

- ***Family Details and Income Category***: information concerned with type, size of the family, and income category was given in Table: 5 (b).
- Table: 5 (c) tabulates and displays information on ***Ownership status, Type of Housing, and Period of Living.***

1. Educational qualification and employment status

Table: 5 (a) portrayed the personal minutiae of the homemakers like age, educational qualification, and employment status.

Table 5 (a): Personal Minutiae of the Homemakers – Educational Qualification and Employment Status

Personal Details		N=385	%
Age (in years)	20 – 30	31	8
	31 – 40	71	18.5
	41 – 50	118	30.6
	51 – 60	102	26.5
	Above 60	63	16.4
Educational Qualification	Illiterate	34	8.8
	Middle-High School	86	22.3
	Higher Secondary	53	13.8
	ITI	12	3.1
	Graduate	83	21.6
	Post Graduate	38	9.9
	Diploma	23	6.0
	Professional	56	14.5
Employment Status	Full-time homemakers	214	55.6
	Employed homemakers	171	44.4

Age

Age is the number of years, months or days since one's birth expressed in terms of years, months or days (https://www.healthline.com/health/chronological-ageing). Among the homemakers, about 30.6 per cent belonged to the age group of 41 – 50 years, while 26.5 per cent were from 51 – 60 years of age group and 16.4 per cent of homemakers were above 60 years.

Educational qualification

Bhushan (2016) defined education as the process of encouraging the cognitive, physical, social, emotional and moral growth and development of people or groups. Regarding the educational background of the homemakers, it was startling to see that 8.8 per cent of homemakers were still illiterate.

Employment status

According to Mangla (2020), employment is an activity that allows a person to make a livelihood. There are two categories for the employment status of homemakers: full-time homemakers and employed homemakers. As per the data, a greater proportion of 55.6 per cent were full-time homemakers.

2. Family details and income category

The information concerned with type, size of the family, and income category is given in Table 5 (b).

Table 5 (b): Personal Minutiae of the Homemakers – Family Details and Income Category

Personal Details		N=385	%
Type of Family	Nuclear	276	71.7
	Joint	108	28
	Extended	1	0.3
Size of Family	Two	77	20
	Three	81	21
	Four	135	35
	Five	69	18
	Six	22	6
Income Category (Rs)	Less than 10,000	22	5.7
	10,001 to 20,000	92	23.9
	20,001 to 30,000	108	28.1
	30,001 to 40,000	72	18.7
	More than 40,000	91	23.6

Type of family

The percentage distribution of the selected homemakers according to the type of family was shown in the above Table 5 (b). Out of the total samples, 71.7 per cent of the homemakers were from nuclear families. It was also evident from the Table. 5(b) that the nuclear family structure had dominated the other family structures. As stated by (Sammaiah, 2021), majority of city households were nuclear models. The joint family system was gradually disappearing and their functions were also changing.

Family size

Salkind (2006) defined family size as all individuals within a household. This may include parents, children, and members of the extended family. With regard to the size of the family, 35 per cent of them had 4 members in their family, followed by 21 per cent with 3 members and 20 per cent were couples.

Income category

Respondents household income classes were divided based on the groupings by Center for Monitoring Indian Economy (CMIE) (2022). (https://economictimes.indiatimes.com/jobs/middle-income-households-account-for-largest-chunk-of-indias-unemployed populationcmie/articleshow/90563660.cms?from=mdr). They had divided households into five income classes. At the bottom of the income pyramid were households who earn less than Rs.1,00,000 a year. The next group earned between Rs.1,00,000 and Rs.2,00,000 a year and is called the lower middle class. The third group of households earned between Rs.2,00,000 and Rs.5,00,000 a year and belonged to the middle-income class. The fourth earned between Rs.5,00,000 and Rs.1 million a year and could be classified as the upper middle class and the richest group of households earned more than Rs 1 million in a year. **(The Economic Times, 2022)**

As per CMIE classification the selected households were categorized into five income groups. About 28.1% of family members earned Rs.20, 000–30,000 per month.

3. Housing details of the homemakers

The housing details of respondents are presented in Table: 5 (c)

Table 5 (c): Personal Minutiae of the Homemakers – Housing Details of the Homemaker

Housing details		N=385	%
Ownership Status	Own	237	61.6
	Rent	135	35.1
	Lease	13	3.4
Type of Housing	Independent	215	55.8
	Portioned house	170	44.2
Period of Living	Less than 1 year	33	8.6
	1 – 3 years	52	13.5
	4 – 6 years	87	22.6
	7 – 9 years	39	10.1
	More than 10 years	174	45.2

Ownership status

Regarding the ownership of the house, it was found that more than half of the selected samples (61.6%) were living in their own houses.

Type of housing

Among the selected samples, 55.8 per cent of the homemakers were living in independent houses.

Period of living

From the above Table, it was apparent that respondents had resided in the area for varied period of time with 45.2 per cent residing there for more than a decade.

The overall result of socio-economic profile of the homemakers showed that more number of homemakers were in the age group of 41 – 50 years completed middle high schooling and graduation and were full-time homemakers. Most of them lived in a nuclear family system having four members in their family. Majority earned around Rs.20,000 – 30,000 per month. A greater number of the households lived in their own independent houses for more than 10 years.

B. Specifics of Alternate Water Sources Available

Particulars regarding the type of water sources available such as soft water, hard water, and various additional water sources are detailed in Table. 6.

Table 6: Specifics of Alternate Water Sources Available

Water Connection Details		N=385	%
Soft Water Connection	Own	385	100
Hard Water Connection	Own	180	46.8
	Common	86	22.3
	No connection	119	30.9
Additional Sources of Water *	Borewell	119	30.9
	Bottled water: ***Drinking purpose***	49	12.7
	Purchase water: ***Non-drinking purpose***	47	12.2
	Obtain water from their friends/neighbours/ relatives	8	2
	Rainwater	20	5.2
	No added source	188	48.8

**** Multiple Responses***

The primary sources of water are storm runoff, springs, streams, lakes or storage reservoirs and groundwater from wells and bore wells. Of course, the ultimate source of all water is rainfall, as mentioned by Yoo and Boyd (1994).

Since the researcher purposively selected homemakers with corporation water supply, all the selected households (100%) possessed soft water (drinking water) pipeline on their house premises where the water distribution was maintained by city Corporation. For other household activities 46.8 per cent of the selected households relied on the hard water connection that was within their premises, 22.3 per cent used water that was circulated during specific times through a common street connection and 30.9 per cent stated that the selected households did not have a hard water connection, but they managed to meet their water needs out of bore well, while 48.8 per cent of the selected households did not access any other alternate water source since they depended wholly on the corporation water supply – both soft and hard water. Even 5.2 per cent of households collected and used nature’s gift - rainwater for drinking and other purposes when it was available.

C. Basics of Water Conservation Techniques

This section of the study's findings is discussed under the headings mentioned below:

1. Water Literacy – Acquaintance of water conservation
2. Utilization of water conservation tools
3. Understanding rainwater collection
4. Rainwater collection practices and
5. Quantifying water waste

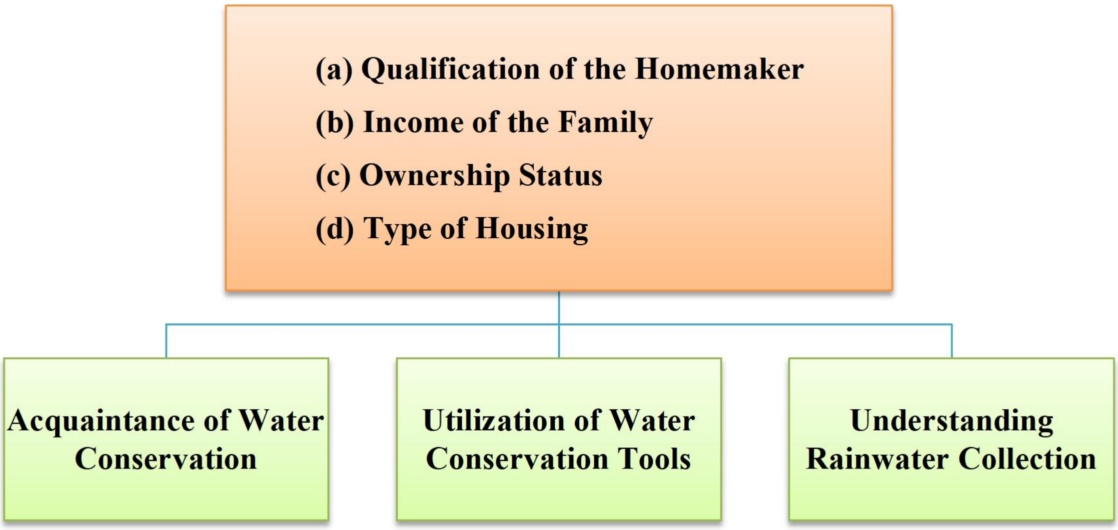

Figure 21: Basics of Water Conservation Techniques

The relationship between the qualification of the homemaker, income of the family, ownership status and type of housing with the acquaintance of water conservation, utilization of water conservation tools and understanding rainwater collection is detailed as follows:

1. Water literacy - Acquaintance of water conservation

Understanding water difficulties in the community is seen as a crucial element in resolving water-related challenges.

Association between selected socio-demographic variables with awareness of water conservation

The present study aimed to examine the association between socio-demographic variables and awareness of water conservation by employing the Chi-Square test. The results are summarized in Table. 7.

Table: 7. Association of Socio-demographic Variables with Awareness of Water Conservation

Socio-demographic Variables	No. of Home makers N	Awareness of Water Conservation Yes (265)		No (84)		Probably Heard (36)		Chi-Square Value	df	p Value
		No.	%	No.	%	No.	%			
Homemaker Educational Qualification								32.953	14	0.002^{**}
Illiterate	34	24	70.6	10	29.4	-	-			
Middle-High School	86	50	58.1	24	27.9	12	14.0			
Higher Secondary	53	38	71.7	14	26.4	1	1.9			
ITI	12	7	58.3	5	41.7	-	-			
Graduate	83	64	77.1	16	19.3	3	3.6			
Post Graduate	38	28	73.7	3	7.9	7	18.4			
Diploma	23	16	69.6	3	13.0	4	17.4			
Professional	56	38	67.9	9	16.1	9	16.1			
	385	**265**		**84**		**36**				
Family Income								30.268	8	0.000^{**}
Less than Rs.10,000	22	12	54.5	10	45.5	-	-			
Rs.10,000 to Rs.20,000	92	65	70.7	22	23.9	5	5.4			
Rs.20,000 to Rs.30,000	108	73	67.6	30	27.8	5	4.6			
Rs.30,000 to Rs.40,000	72	46	63.9	14	19.4	12	16.7			
More than Rs.40,000	91	69	75.8	8	8.8	14	15.4			
	385	**265**		**84**		**36**				
Ownership Status								2.978	4	0.561^{Ns}
Own	237	158	66.7	54	22.8	25	10.5			
Rented	135	96	71.1	29	21.5	10	7.4			
Lease	13	11	84.6	1	7.7	1	7.7			
	385	**265**		**84**		**36**				
Type of House for Housing								28.189	6	0.000^{**}
Independent	215	136	63.3	61	28.4	18	8.4			
Portioned House Double	114	82	71.9	14	12.3	18	15.8			
Triple	33	31	93.9	2	6.1	-	-			
Multiple	23	16	69.6	7	30.4	-	-			
	385	**265**		**84**		**36**				

Ns Not significant ** Significant at 1% level

The Chi-Square value (X^2 = 32.953; p = 0.002) implies that there was a highly significant association at the 1 % level between the educational qualification of the homemaker and awareness of water conservation in the residence. This confirms the assertion by Dean *et al.* (2016) that high water knowledge is associated with higher level of education.

It is understood from the above Table: 7 that a high level of awareness (77.1%) was found among the Graduates followed by 73.7 per cent of Post Graduates and a lower level (58.1%) was identified among those who have completed their high school education. It was apparent that as the level of education increased, the awareness regarding water conservation also increased. This may be due to the higher exposure of educated homemakers towards the various issues of water conservation and hence, had a greater awareness of water management.

The Chi-Square test result (X^2 = 30.268; p = 0.000) was judged to be statistically significant at the 1% level which shows that there is a significant relationship between family income and awareness of water conservation. Among the homemakers, in the income group of less than Rs.10,000/-, only 54.5 per cent were aware of water conservation. The homemakers whose income ranged between Rs.10,000 to 20,000 had an awareness rate of 70.7 per cent about water conservation. Among the families whose family income was more than Rs. 40,000, 75.8 per cent were aware of the need for water conservation. Higher household income correlates positively with knowledge of water conservation, as seen in Table: 7.

It was found that the ownership status of the homemakers of the selected samples did not have any association with the awareness of water conservation (X^2 = 2.978; p = 0.561). Awareness of water conservation was highly reported by 84.6 per cent of the homemakers who were residing in leased houses. Consequently, 71.1 per cent of the homemakers who were living in rented dwellings stated that they had some understanding of water conservation due to the fact that they were sharing the water supply as they received a restricted amount of water from the house owner. With regard to the type of house of the homemakers, it was found to exhibit a significant association (X^2 = 28.189; p = 0.000) between the two variables. It is apparent from the above Table that 93.9 per cent of the homemakers living in triple portioned houses had a high knowledge of the concepts of water conservation since they experienced a shortage of water supply by sharing the available water with neighbouring houses on sharing basis. Water conservation was practiced effectively by 71.9 per cent of double portioned households and 69.6 per cent of multiple portioned houses, respectively. Daily challenges in facing water problems made them follow water conservation techniques unconsciously.

The overall result showed that the homemaker's educational qualification, family income, and the type of house of selected households had an association with the knowledge of water conservation among the selected homemakers. According to one of the initial surveys, the vast majority of homemakers were uninformed of water limitations and had a poor grasp of terms characterising water sources. Higher water knowledge was related to older age, a higher level of education, and rural residence. Greater water knowledge was associated with the adoption of water-saving and pollution-reduction behaviours.

From the result presented in Table 7, it is proved that ***Hypothesis*** H_01.*(a)*, *"selected socio-demographic variable -* ***home maker's educational qualification*** *did not influence the* ***awareness on water conservation*** *among the selected families", was hereby rejected.*

H_01.***(b):*** *"Selected socio-demographic variable -* ***family income*** *did not influence the* ***awareness on water conservation*** *among the selected families", was hereby rejected.*

H_01.***(c):*** *"Selected socio-demographic variable –* ***type of house*** *did not influence the* ***awareness on water conservation*** *among the selected families", was hereby rejected.*

H_01.***(d):*** *"Selected socio-demographic variables –* ***ownership status*** *did not influence the* ***awareness on water conservation*** *among the selected families", was accepted.*

2. Utilization of water conservation tools

Hoque (2014) opined that many policies and programmes was implemented to promote the installation of water-saving appliances within the household. In industrialised and developing countries water conservation tools such as faucets, toilets, shower heads, and equipment like washing machines, and dishwashers, all of which consume substantially less water than their older equivalents. These tools, once installed, will continue to save water for the rest of their lives.

Among the households studied, 41.8 per cent of the homemakers did not believe that the installation of water conservation equipment may be used to regulate water flow. Among the surveyed households, 58.2 per cent (161 households) used tools such as low-flow faucets, dual-flush cistern, water aerators, and overflow controls. Table: 8, presented the different water saving tools used by the chosen samples.

Table 8: Households Using Water Conservation Tools

Water Conservation Tools*	**N = 161**	
	No. of Respondents	**%**
Dual-flush cistern	72	44.7
Water sprayers attached to taps	53	33
Overflow control tools	27	16.7
Using shower cans for plants	9	5.6

Among the surveyed ethical water users who employ water conservation tools, 44.7 per cent were utilising dual flush cistern, 33 per cent used water sprayers connected to the taps, and 16.7 per cent used overflow control tools. However, only 5.6 per cent used water spraying cans to water their garden plants.

Plate 8. depicted some of the water conservation tools used by the surveyed households.

(a) Water Sprayers

(b) Dual Flush Cistern

(c) Watering Cans

(d) Water Sprayers

Plate 8: Water Conservation Tools Identified in the Selected Households

Association between selected socio-demographic variables with the usage of water conservation tools

The association between the socio-demographic variables and the usage of water conservation tools was analysed and proved with the support of statistical analysis. The findings are portrayed below in Table. 9.

Table 9: Association between Socio-demographic Factors and Use of Water Conservation Tools

Socio-demographic Variables	No. of Home makers N	Usage of Water Conservation Tools				Chi-Square value	df	p value
		Yes (161)		No (224)				
		No.	%	No.	%			
Homemaker Educational Qualification								
Illiterate	34	6	17.6	28	82.4	36.865	7	0.000**
Middle-High School	86	20	23.3	66	76.7			
Higher Secondary	53	26	49.1	27	50.9			
ITI	12	3	25.0	9	75.0			
Graduate	83	47	56.6	36	43.4			
Post Graduate	38	15	39.5	23	60.5			
Diploma	23	12	52.2	11	47.8			
Professional	56	32	57.1	24	42.9			
	385	**161**		**224**				
Family Income								
Less than Rs.10,000	22	6	27.3	16	72.7	9.442	4	0.050Ns
Rs.10,000 to Rs.20,000	92	34	37.0	58	63.0			
Rs.20,000 to Rs.30,000	108	50	46.3	58	53.7			
Rs.30,000 to Rs.40,000	72	24	33.3	48	66.7			
More than Rs.40,000	91	47	51.6	44	48.4			
	385	**161**		**224**				
Ownership Status								
Own	237	109	46.0	128	54.0	5.265	2	0.071Ns
Rented	135	49	36.3	86	63.7			
Lease	13	3	23.1	10	76.9			
	385	**161**		**224**				
Type of House for Housing								
Independent	215	93	43.3	122	56.7	1.087	3	0.780Ns
Portioned House Double	114	45	39.5	69	60.5			
Triple	33	15	45.5	18	54.5			
Multiple	23	8	34.8	15	65.2			
	385	**161**		**224**				

Ns – Not significant ** - Significant at 1% level

The homemakers who used water conservation tools were found to be higher among professionals like doctors and professors (57.1%), followed by graduates (56.6%), and diploma holders (52.2%) when compared to homemakers having lesser qualifications. The availability of such tools in the market was easily identified, and the homemakers were geared up to use the newly developed conservational tools to maximize water conservation at home.

From the above Table, the Chi-Square value (X^2 = 36.865; p=0.000) entailed that there is a highly significant association between the educational qualification of the homemaker and the usability of water conservation tools.

The comparison of the income of the households based on usage of water conservation tools among the surveyed homemakers is explained in Table. 9. Usability of water conservation tools to control the flow of water was noticed to be higher in the category of households who earned more than Rs.40,000 per month (51.6%) as they were professionals like doctors and professors. Out of the surveyed homemakers, 46.3 per cent who were water conscious, were earning from Rs. 20,000 up to 30,000 per month. Even those whose income was less than Rs.20,000 (37%) had also been involved in spending their money towards saving water with the help of water conservation tools. Households earning Rs.30,000 to 40,000 think a lot and even hesitate about their plan to pay for water conservation compared to the category who earn less than Rs.20,000. In fact contribution towards water conservation may not be feasible among the households earning less than Rs.10, 000 (27.3%), owing to the fact that their meagre financial means may prevent them from being able to spend money on such items.

The relationship between family income and usage of water conservation tools was tested statistically by employing the Chi-Square test. The critical value was (X^2 = 9.442; p=0.050) found not to be significant. This shows that there is no significant relationship between family income and usability of water conservation tools.

Homemakers residing in their own houses had a greater level of freedom and did not require approval thus this could have caused an increase in their usability of water conservation tools. According to the collected primary data, 36.3 and 23.1 per cent of the homemakers lived in rented and leased homes, respectively. It is evident that the ownership status of the selected samples did not have any relationship with the usage of water conservation tools (X^2 = 5.265; p = 0.071).

Triple portioned houses of living spaces was shared by 45.5 per cent of homemakers whereas 43.3 per cent stayed in independent houses followed by 39.5 per cent in double portioned houses and 34.8 per cent in multiple portioned houses (more than three portioned houses). The relationship between the type of house with usage of water conservation tools was tested statistically and the results ($X^2 = 1.087$; $p = 0.780$) revealed that there is no significant relationship between these two tested variables.

On the whole, the results showed that the homemaker’s educational qualifications had an invariable association with the adaptability and usability of water conservation tools among the selected homemakers.

From the outcome presented in Table 9, it is proved that ***Hypothesis 2, which stated that “There is no association between the educational qualification of selected families and their usage of water conservation tools”, was rejected.***

3. Understanding rainwater collection

Eslamian and Eslamian, (2021), explained that the major source of water for rivers is precipitation; lakes and groundwater are secondary sources. Currently, the majority of people get all of our water supplies from secondary sources. Typically, the value of rainwater is disregarded. The collection of seasonal precipitation that would otherwise be lost to flow or evaporation has been practiced for thousands of years, according to Levario (2007).

Eslamian (2016) revealed that in the Indian state of Tamil Nadu, the construction of a rainwater collecting system is mandatory before any new water or sewage connections may be sanctioned. Even though rainwater harvesting installation has been made compulsory for all buildings, 57 per cent of the samples did not install or harvest rainwater, while only 42.9 per cent had installed rainwater harvesting to collect rainwater in containers or sumps as showcased in Plate 9.

Plate 9: Models of Rainwater Harvesting Observed

Association between selected socio-demographic variables with the presence of rainwater harvesting system

The Pearson's Chi-Square test was used to establish the association between selected socio-demographic variables and the harvesting of rainwater and the results are summarized in Table 10.

Table 10: Association between Selected Socio-demographic Variables and Presence of Rainwater Collection System

Socio-demographic Variables	No. of Home makers N	Presence of Rainwater Collection System Yes (165)		No (220)		Chi-Square value	df	p value
		No.	%	No.	%			
Homemaker Educational Qualification								
Illiterate	34	14	41.2	20	58.8	15.758	7	0.027*
Middle-High School	86	42	48.8	44	51.2			
Higher Secondary	53	21	39.6	32	60.4			
ITI	12	7	58.3	5	41.7			
Graduate	83	26	31.3	57	68.7			
Post Graduate	38	16	42.1	22	57.9			
Diploma	23	6	26.1	17	73.9			
Professional	56	33	58.9	23	41.1			
	385	**165**		**220**				
Family Income								
Less than Rs.10,000	22	14	63.6	8	36.4	5.192	4	0.268^{Ns}
Rs.10,000 to Rs.20,000	92	35	38.0	57	62.0			
Rs.20,000 to Rs.30,000	108	46	42.6	62	57.4			
Rs.30,000 to Rs. 40,000	72	33	45.8	39	54.2			
More than Rs. 40,000	91	37	40.7	54	59.3			
	385	**165**		**220**				
Ownership Status								
Own	237	116	48.9	121	51.1	9.362	2	0.009**
Rented	135	45	33.3	90	66.7			
Lease	13	4	30.8	9	69.2			
	385	**165**		**220**				
Type of House								
Independent	215	101	47.0	114	53.0	5.186	3	0.158^{Ns}
Portioned House Double	114	47	41.2	67	58.8			
Triple	33	10	30.3	23	69.7			
Multiple	23	7	30.4	16	69.6			
	385	**165**		**220**				

Ns – Not significant * - Significant at 5% level ** - Significant at 1% level

The household study revealed that 58.9 per cent of the sampled professionals had installed rainwater collecting systems in their property. Those who had completed their industrial training (58.3%), Middle High School education (48.8%), 42.1 per cent of Post Graduates, 41.2 per cent of Illiterates, 39.6 per cent of Higher Secondary Education, 31.3 per cent of Graduates, and 26.1 per cent of Diploma holders had established rainwater collection system in their respective houses. They made rainwater collection possible by saving rainwater in sumps and pumped to overhead tanks. They also made attempt to collect rainwater in drums for washing clothes, utensils, cleaning outdoor areas, and gardening. They also conveyed rainwater into the ground by proper installation of rainwater harvesting technique to recharge the underground water (42.9%).

Chi-Square analysis was executed to find the association between the educational qualification of the homemaker and the installation of rainwater harvesting system. The critical value (X^2 = 15.758; p=0.027) suggested there was a significant association between variables at 5% level.

The enthused reality is that homemakers whose family income is less than Rs.10,000 have contributed to a large extent (63.6%) towards rainwater harvesting followed by those who earn Rs.30,000 – 40,000 (45.8%) and followed by 42.6 per cent of household who were paid Rs.20,000 – 30,000 per month. Not only does money decide the setting of rainwater harvesting, but the majority was decided by people's behavioural attitude toward effective water management. The statistical analysis showed that (X^2 = 5.192; p=0.268) the family income of the selected samples did not have any relationship with the installation of rainwater harvesting system.

Concerning the ownership status of the homemakers, 48.9 per cent of the homemakers who lived in their own houses were free to perform any civil works and alterations as per their convenience. Although the local government insisted people needed to set rainwater harvesting before any new building approval, old building sales, name transfer, and tax fixation process, people went beyond the laid down rules that showed lack of interest in rainwater harvesting. The homemakers, only 33.3 per cent had a formal system of rainwater harvest. The result that was derived (X^2 = 9.362; p = 0.009) implied that there was a highly significant association between the ownership status with the presence of rainwater harvesting system at the 1% level of significance.

Forty seven per cent of independent houses had the rainwater harvesting system, 41.2 per cent of double portioned houses, and 30.3 and 30.4 per cent of triple portioned and multiple portioned house had the active system of rainwater harvesting respectively. With the critical value (X^2 = 5.186; p = 0.158), the output of the analysis showed there was no association between the type of house and the presence of rainwater harvesting system.

4. Rainwater collection practices

There are various ways to conserve water. One of the prime methods is the collection of rainwater for potable and non-potable daily water needs (Bahadir and Haarstrick, 2022). The habit or willingness expressed by the homemakers to collect rainwater was shown in Table: 11 and the reasons for not saving rainwater are given in Figure: 22.

Table 11: Habitude of Saving Rainwater among Selected Homemakers

Habitude of Saving Rainwater		N=385
Response	**No. of Response**	**%**
Willing	174	45.2
Non-willing	211	54.8

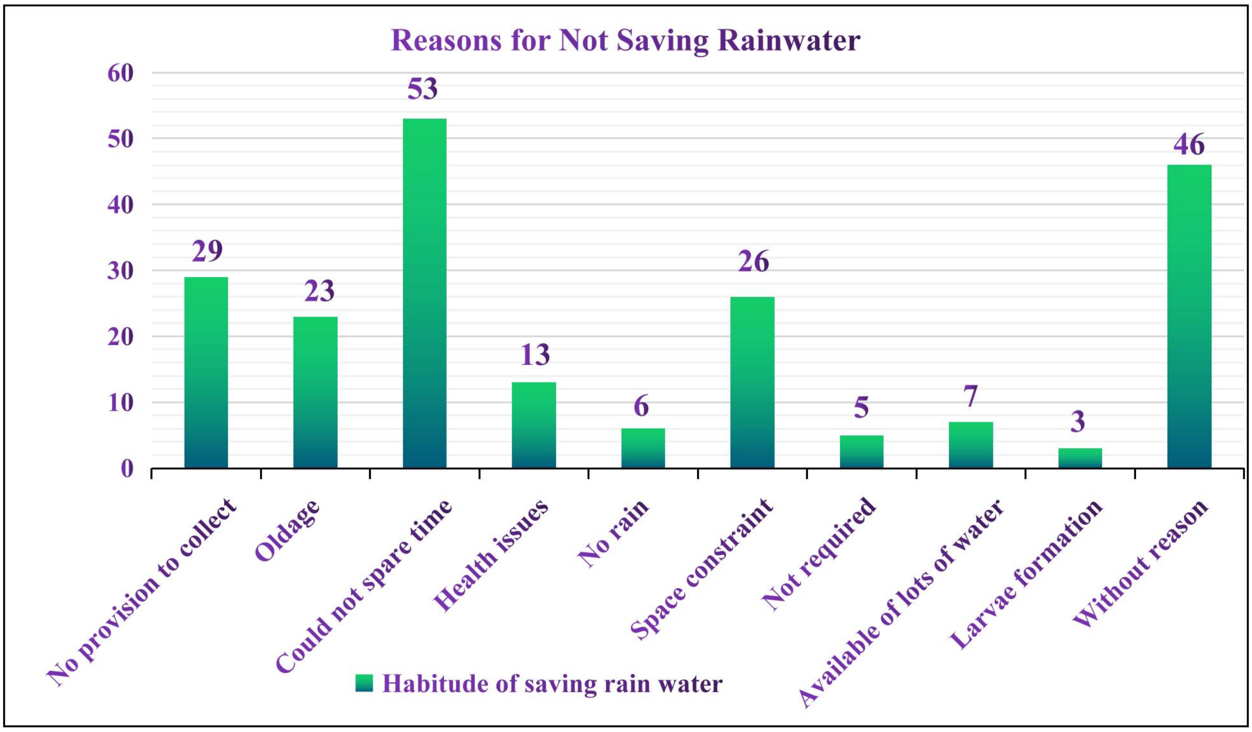

Figure 22: Reasons for Not Saving Rainwater

A total of 54.8 per cent of the surveyed homemakers did not save rainwater for future use for a variety of reasons, including: inability to collect due to old age (11%), could not spare time while raining (25%), unable to collect rainwater because of health issues (6%), no provision for collection of rainwater (14%), and space constraints for storing rainwater (12%). Twenty two per cent could not provide a justification for not utilising rainwater because they did not recognize its significance.

Two per cent of homemakers, however, reported the production of larvae within a few days in the stored water and the availability of sufficient water (2%) were the other reasons which hindered them to collect rainwater (Figure: 23). Effective use of rainwater was made by 45.2 per cent of homemakers. They collected rainwater for future usage in the sump or containers. They also allowed rainwater to seep into the earth in order to replenish subsurface water – a formal method of rainwater harvesting.

5. Quantifying water waste

According to Gowri *et al*., (2015), w**astage of water** means the wasteful running of water which goes waste without any purpose or usage. It also means the excessive use of water or the failure to beneficially use abstracted water and includes water spilled from conveyors or installations due to breakage or poor maintenance. In the present statistics, the wastage of water due to overflow of tanks has a major impact on the water scarcity.

The following Table. 12 enumerates information on excess water usage associated with domestic water-based activities as perceived by the homemakers.

Table 12: Extravagance of Water Usage in Domestic Water-based Activities

Extravagance of Water Usage in Domestic Water-based Activities				
Water Wastage Activities	**Level of Water Wastage (N=385)**			
	Frequently N (%)	**Moderately N (%)**	**Rarely N (%)**	**Never N (%)**
Overflow of the Overhead Tank	105 (27.3)	83 (21.6)	92 (23.9)	105 (27.3)
Washing Vehicles	22 (5.7)	74 (19.2)	130 (33.8)	159 (41.3)
Taking Shower Bath	38 (9.9)	70 (18.2)	80 (20.8)	197 (51.2)
Taking Long Bath	34 (8.8)	54 (14.0)	70 (18.2)	227 (59.0)
Brushing	29 (7.5)	62 (16.1)	95 (24.7)	199 (51.7)
Cleaning Utensils	108 (28.1)	153 (39.7)	42 (10.9)	82 (21.3)
Shaving	7 (1.8)	35 (9.1)	58 (15.1)	285 (74.0)
Washing Outdoors	16 (4.1)	57 (14.8)	120 (31.2)	192 (49.9)
Water Leakages	31 (8.1)	64 (16.6)	109 (28.3)	181 (47.0)
Flushing Toilets	156 (40.5)	130 (33.8)	20 (5.2)	79 (20.5)
Wastewater from Water Purification Systems	58 (15.1)	23 (6.0)	14 (3.6)	290 (75.3)

Data presented showed homemakers believed they were wasting water (liquid resource) as follows: The Table. 12 indicated that the homemakers believed that they were wasting the liquid resource as follows. A figure of 40.5 per cent wasted water in flushing, dish washing (28.3 per cent) overflow of water when filling the overhead tank (27.3 per cent). These three areas were identified to be the red spots related to water wastage. Around 40 – 75 per cent of the selected homemakers believed that the water was never wasted in the given areas like while washing vehicles, taking long bath and shower bath, during brushing and shaving, water leakages, water purification systems etc.

Water wastage

An analysis of the relationship between respondents, educational qualifications and wastage of water is presented in Table 13.

Table 13: Quantified Daily Water Waste as per Data Collected

Homemaker's Educational Qualification		**Quantified daily water waste as per data collected**		
		No.	**Mean**	**S.D**
Homemaker's Educational Qualification	Illiterate	34	21.88	6.86
	Middle-High School	86	22.49	7.24
	Higher Secondary	53	21.58	5.66
	ITI	12	19.58	3.06
	Graduate	83	21.22	6.59
	Post Graduate	38	23.08	6.63
	Diploma	23	22.65	5.09
	Professional	56	22.70	7.51
	Total	**385**	**22.04**	**6.63**

Concerning educational qualification, the above Table revealed that the Post Graduate homemakers had the highest mean water wastage score ($\bar{X}$ = 23.08). With the higher mean knowledge score ($\bar{X}$ =22.70) professional category of homemakers who have the highest education stands second in water wastage.

ANOVA for Water Wastage Score

Table 14: ANOVA for Quantified Water Waste

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	231.531	7	33.076	.750	Ns
Within Groups	16630.719	378	44.113		
Total	16862.249	385			

Ns – Not significant

One-way ANOVA was carried out to analyse the difference in the behaviour of water wastage among the homemakers based on their educational qualifications. ***The result from the Table. 14 revealed that the residential water wastage was not influenced by the educational qualification of the homemakers (F=.750).***

D. Information on the Water Distribution Procedure

The Tamil Nadu Water Supply and Drainage Board is responsible for ensuring that all of the states, with the exception of the greater Chennai Metropolitan Region, had access to clean drinking water and adequate sanitation services. Urban local bodies are also responsible for water supply schemes on a limited scale.

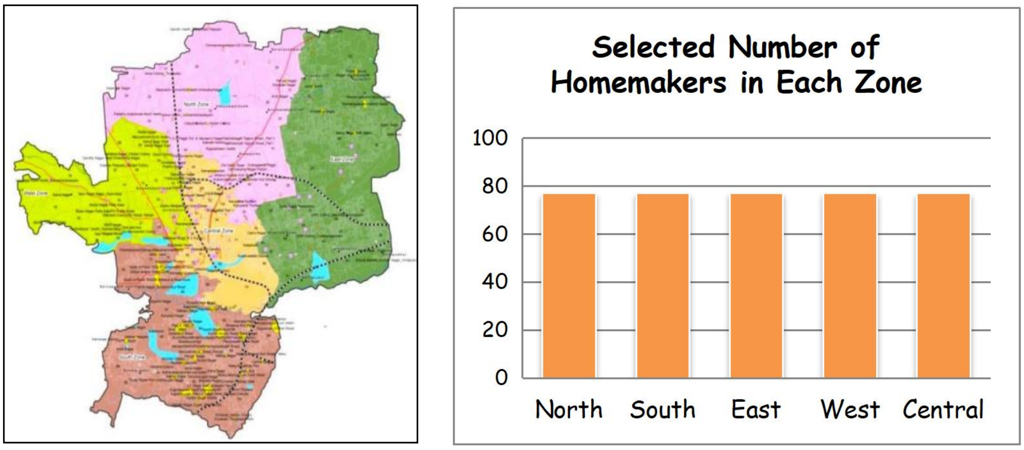

Figure 23: Division among City Zones - Number of Homemakers in Each Zone

When the projects are finished, they are turned over to the appropriate local entities so that they may be maintained. The following are the details of per capita standards that have been implemented for Water Supply to Urban Towns in Tamil Nadu.

- Corporations 110 litres per capita per day (135 LPCD with UGSS),
- Municipalities 90 litres per capita per day (135 LPCD with UGSS), and
- Panchayats of the Towns: The Tamil Nadu Water Supply and Drainage Board has mandated a standard of 70 litres of water per person, per day, or 90 litres per person, per day with UGSS (https://twadboard.tn.gov.in/content/urban-water-supply-schemes).

Figure: 23 portrayed the even distribution of samples (N=77 in each zone) considered from all the zonal divisions of the city namely North zone, South zone, East zone, West zone and Central zone.

CCMC has made the announcement that the soft water supply in the city of Coimbatore is currently distributed once in every two days under the Siruvani scheme and once in every three or four days under the Pillur Scheme Phases I and II. (https://payment.ccmc.gov.in/Water_Supply.asp).

Contrary to the statement of CCMC, the residents of Coimbatore have begun to feel the pinch, as the frequency of water delivery has been reduced in the city as attested in Figure: 25. Many households were under pressure to purchase water from private sources for drinking and cooking as most of the communities get water once every 10 to 15 days. A resident complained that, in January 2022, he was able to acquire water only once every five days. In February, the frequency was reduced to once every seven days and once every 15 days in March, respectively. In addition, the number of hours has also been lowered. It was said by the majority of inhabitants that they were buying bubble top cans for drinking, which increased their overall cost of living, reports The Times of India, March 25, 2022 issue.

THE TIMES OF INDIA

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RESIDENTS FEEL HEAT OF WATER CRISIS NEWS

Residents feel heat of water crisis

Mar 25, 2022, 04:20 (IST)

City residents have started feeling the pinch as frequency of water distribution has come down.Most of the neighbourhoods are receiving water once in 10 to 15 days, forcing residents to purchase water from private players for drinking and cooking.

Source: https://timesofindia.indiatimes.com/city/coimbatore/residents-feel-heat-of-water-crisis/articleshow/90429805.cms

Figure 25: Raise of Water Needs during Seasonal Periods (Summer)

The frequency of soft water supply during seasonal and non-seasonal period is represented in Table 15.

Table 15: Frequency of Soft Water Supply During Seasonal and Non-Seasonal Variation

Frequency of Soft Water Supply During Seasonal and Non-Seasonal Variation (N=385)				
Number of days	**Soft water – Non-seasonal Period**		**Soft water – Seasonal period**	
	Frequency	**%**	**Frequency**	**%**
Daily	9	2.3	11	2.9
1 to 5 days	104	27.0	29	7.5
6 to 10 days	171	44.4	145	37.7
11 to 15 days	45	11.7	82	21.3
16 to 20 days	15	3.9	65	16.9
More than 21 days	23	6.0	28	7.3
Continuous supply for 3 days	10	2.6	17	4.4
Not aware	8	2.1	8	2.1
Total	**385**	**100.0**	**385**	**100.0**

Based on the availability of water, Coimbatore City Corporation decided the frequency and hours of water supply. The difference in the frequency of water supply was recorded in two periods: i). Seasonal – the period during summer in April, May and June and ii). Non-seasonal – months other than summer like January, February, March, July, August, September, October, November, and December. Data in Table. 15 evidently showed that during the non-seasonal period, considerable number of households (44.4 per cent) received soft water once in 6 to 10 days intervals. Water was supplied once in 1 to 5 days in 27 per cent of households. A group of homemakers (11.7%) disclosed that they received water in 11 to 15 days intervals. Few households (2.3%) had received water in daily basis, (3.9%) once in 16 – 20 days, and (6%) even once in more than 21 days; there was a continuous flow for three days (2.6%) and finally some did not know when water was supplied (2.1%) as the collection of drinking water was taken care of the caretaker and they have RO systems in their houses for collecting water for drinking purposes.

During the summer, however, the frequency of water delivery varied significantly, with 16.9 per cent of assessed homes receiving water between 16 and 20 days apart and 7.3 per cent received water often more than 21 days once. They had to collect, store, and use water for 16 and 20 days until the next water delivery cycle. Potable water was supplied within six to ten days in 37.7 per cent of the surveyed houses and only 7.5 per cent of households obtained water within one to five days. Nonetheless, even in the summer, just a handful of houses had daily water supply (2.9%). These houses may be located near the main water storage tanks that helped them get water supply every day.

E. Complete contentment on the availability of high-quality and sufficient amount of soft water

An effort was also made to find out the level of satisfaction derived from the quality and quantity of the supplied drinking water. The homemaker's opinion towards the quality and quantity of the water was found using an attitude scale from Highly Satisfied, Satisfied, Partially Satisfied and finally Not Satisfied. It was represented in Table 16.

Table 16: Quality and Quantity of Soft Water Supplied during Seasonal and Non-Seasonal Variation

Quality and Quantity of Soft Water Supply during Seasonal and Non-Seasonal Variation (N=385)				
Level of Satisfaction	**Soft water – Non-seasonal**		**Soft water – Seasonal**	
	Frequency	**%**	**Frequency**	**%**
Quality				
Highly Satisfied	47	12.2	21	5.5
Satisfied	131	34.0	135	35.1
Moderately Satisfied	139	36.1	168	43.6
Not Satisfied	68	17.7	61	15.8
Total	**385**	**100.0**	**385**	**100.0**
Quantity				
Highly Satisfied	57	14.8	21	5.5
Satisfied	214	55.6	142	36.9
Moderately Satisfied	69	17.9	101	26.2
Not Satisfied	45	11.7	121	31.4
Total	**385**	**100.0**	**385**	**100.0**

The Tamil Nadu Water Supply and Drainage Board ensured that the city of Coimbatore is supplied with good-quality water using a variety of water treatment systems. Proportions (12.2%) of homemakers were Highly Satisfied and Satisfied (34%) with the quality of water during non-seasonal period. A total of 14.8 per cent were Highly Satisfied and 55.6 per cent were Satisfied with the quantity of water delivered to them during months whenever supply exceeds demand (non-seasonal period).

Plate 10: Noted Colour Changes with Increased Turbidity

During non-seasonal and seasonal periods, due to sewage contamination in their drinking water, 17.7 per cent and 15.8 per cent of the homemakers respectively, were dissatisfied with the water quality. This may be due to any leak present in the pipe line since these pipe lines are laid before several years.

Even they had also noted colour changes with increased turbidity, as seen in Plate: 10, as well as a pungent iron odour. Regarding the quantity of water supplied during non-seasonal period, 11.7 per cent of homemakers expressed that the water they got was insufficient to fulfill their daily requirements.

During the seasonal period, 43.6 per cent and 15.8 per cent of homemakers have an unfavourable opinion on water quality. Contradictory to this 35.1 per cent and 5.5 per cent of homemakers said the water supplied to them was of good quality. A high degree of dissatisfaction with the amount of water delivered was expressed by 31.4 per cent and 26.2 per cent of homemakers when the demand for water is high especially during summer.

a. Association between the attribute of satisfaction about the distributed soft water quality (during seasonal) of the selected homemakers with Zonal division in Coimbatore city

This part of the current study attempted to observe the association between the attribute of satisfaction on the distributed soft water quality and quantity of the selected homemakers with zonal division in Coimbatore city by applying the Chi-square test. The results are compiled in Table. 17.

Table 17: Homemaker's Satisfaction with the Distributed Soft Water Quality and Quantity (During Summer)

Particulars	N	Homemaker's Satisfaction with the Distributed Soft Water Quality and Quantity of Water								Chi-Square value	df	p value
		Highly Satisfied		Satisfied		Moderately Satisfied		Not Satisfied				
		No.	%	No.	%	No.	%	No.	%			
Soft water – Quality during Seasonal Period (Summer)												
Zonal Division												
North	77	4	5.2	36	46.8	25	32.5	12	15.6	26.201	12	0.010**
South	77	2	2.6	14	18.2	40	51.9	21	27.3			
East	77	6	7.8	28	36.4	37	48.1	6	7.8			
West	77	3	3.9	30	39.0	33	42.9	11	14.3			
Central	77	6	7.8	27	35.1	33	42.9	11	14.3			
Total	**385**	**21**	**5.5**	**135**	**35.1**	**168**	**43.6**	**61**	**15.8**			
Frequency of Water Supply												
Daily	11	-	-	6	54.5	4	36.4	1	9.1	54.897	21	0.000**
1 to 5 days	29	-	-	12	41.4	13	44.8	4	13.8			
6 to 10 days	145	10	6.9	45	31.0	78	53.8	12	8.3			
11 to 15 days	82	7	8.5	34	41.5	17	20.7	24	29.3			
16 to 20 days	65	3	4.6	24	36.9	27	41.5	11	16.9			
> 21 days	28	-	-	6	21.4	17	60.7	5	17.9			
3 days *	17	-	-	6	35.3	11	64.7	-	-			
Not aware	8	1	12.5	2	25.0	1	12.5	4	50.0			
Total	**385**	**21**	**5.5**	**135**	**35.1**	**168**	**43.6**	**61**	**15.8**			
Soft water – Quantity during the Seasonal Period (Summer)												
Zonal Division												
North	77	4	5.2	34	44.2	19	24.7	20	26.0	28.717	12	0.004**
South	77	2	2.6	21	27.3	18	23.4	36	46.8			
East	77	6	7.8	30	39.0	25	32.5	16	20.8			
West	77	1	1.3	24	31.2	27	35.1	25	32.5			
Central	77	8	10.4	33	42.9	12	15.6	24	31.2			
Total	**385**	**21**	**5.5**	**142**	**36.9**	**101**	**26.2**	**121**	**31.4**			
Frequency of Water Supply												
Daily	11	2	18.2	4	36.4	1	9.1	4	36.4	63.821	21	0.000**
1 to 5 days	29	2	6.9	18	62.1	6	20.7	3	10.3			
6 to 10 days	145	13	9.0	57	39.3	48	33.1	27	18.6			
11 to 15 days	82	4	4.9	32	39.0	21	25.6	25	30.5			
16 to 20 days	65	-	-	23	35.4	13	20.0	29	44.6			
> 21 days	28	-	-	5	17.9	5	17.9	18	64.3			
3 days *	17	-	-	1	5.9	5	29.4	11	64.7			
Not aware	8	-	-	2	25.0	2	25.0	4	50.0			
Total	**385**	**21**	**5.5**	**142**	**36.9**	**101**	**26.2**	**121**	**31.4**			

* 3 days continuous supply ** Significant at 1% level

It was evident from Table. 17 that, across all zones in the city, the homemakers (43.6% and 15.8%) thought that the water quality was poor and that they were Moderately Satisfied or Not Satisfied with the quality of water supplied during summer time. In the South zone, a maximum of 51 per cent and 27.3 per cent of homemakers were Moderately Satisfied or Not Satisfied with the water's quality and quantity, respectively. Among the homemakers, 42.9 per cent and 14.3 per cent in the West zone were Moderately Satisfied and not Satisfied with the quality of water delivered, respectively. The water quality supplied was rated as Moderately Satisfactory by 48.1 per cent of homemakers from the East zone. The water quality was acknowledged by 35.1 per cent of homemakers who were Satisfied and 5.5 per cent of homemakers who were Highly Satisfied through out all the zones of the city. About 46.8 per cent of homemakers from the North zone expressed a high level of satisfaction with the water quality. In the other zones (East, West and Central) of the city throughout the summer, 48.1 per cent, 42.9 per cent, and 42.9 per cent of homemakers reported Moderate Satisfaction on the quality of water. At 1% significance level, a highly significant association was identified between the attribute of satisfaction on the distributed soft water quality during the summer of the selected homemakers and zonal division in Coimbatore, as indicated by the obtained critical value (X2 = 26.201; p = 0.010).

Therefore Hypothesis 3, which stated that "Household's satisfaction about the quality of water distributed irrespective of seasonal and non-seasonal variations was not influenced by the distribution of water in their zone", was hereby rejected.

b. Association between the attribute of satisfaction about the distributed soft water quality (during seasonal) of the selected homemakers with the frequency of water supply

Fifty nine per cent of the homemakers recorded that they were Partially Satisfied (43.6%) and Not Satisfied (15.8) with the frequency of water supply since it extends more than 11 days up to 25 days, especially during summer months. The employed homemakers, and aged family members were not aware of the supply of water. A high significant difference was recommended at 1% level with the results (X^2 = 54.897; p = 0.000) displaying that there was a high relationship between homemaker's attitudes of satisfaction with the quality of water, especially during summer with the frequency of water supply.

c. Association between the attribute of satisfaction about the distributed soft water quantity (during seasonal) of the selected homemakers with Zonal division in Coimbatore city

A total of 44.2 per cent of the homemakers who resided in the central zone of the city are Satisfied with the amount of water provided, while 26 per cent were Not Satisfied. It was also observed that 46.8 per cent of the homemakers from the South zone were Not Satisfied with the availability of water, while 32.5 per cent of homemakers reported the same in the West zone. The Chi Square value ($X^2 = 28.717$; $p = 0.004$) indicated that there was a high significant relationship between the attribute of satisfaction and the quantity of soft water distributed (during seasonal) in different zones of the city.

d. Association between the attribute of satisfaction about the distributed soft water quantity (during seasonal) of the selected homemakers with the frequency of water supply

Even though very few per cent (4.4%) of the surveyed samples (N=17), had a three-day continuous water supply, the majority of homemakers (64.7%) were Not Satisfied with the water supplied. They believed that two hours of water delivery with great force once a week would be sufficient, as opposed to the current situation where the water flow is inadequate. When asked about their satisfaction with the frequency of water supply, 44.6 per cent and 30.5 per cent of homemakers were Dissatisfied with supply of water every 16 to 20 days and every 11 to 15 days, respectively. They were experiencing the heat of shortage, and also the crisis of water quality deterioration during storage of water for long days.

From Table. 17, a highly significant association at $p<0.001$ level is found between the attribute of satisfaction about the distributed soft water quantity (during seasonal) of the selected homemakers with the frequency of water supply across the city ($X^2 = 63.821$; $p = 0.000$).

e. Association between the attribute of satisfaction about the distributed soft water quality (during non-seasonal period) of the selected homemakers with the Zonal division in Coimbatore city

By applying the Chi-Square test, the association between the level of satisfaction with the supplied soft water quality and quantity of the selected homemakers with the zonal division in Coimbatore city and the frequency of water supply was analysed. The acquired findings are summarised in Table. 18.

Table 18: Homemaker's Satisfaction with the Distributed Soft Water Quality and Quantity (During Non-summer)

Particulars	N	Homemaker's Satisfaction with the Distributed Soft Water Quality and Quantity of Water								Chi-Square value	df	p value
		Highly Satisfied		Satisfied		Moderately Satisfied		Not Satisfied				
		No.	%	No.	%	No.	%	No.	%			
Soft water – Quality during the Non-seasonal Period (other than summer)												
Zonal Division										47.295	12	0.000**
North	77	16	20.8	32	41.6	19	24.7	10	13.0			
South	77	5	6.5	17	22.1	32	41.6	23	29.9			
East	77	13	16.9	38	49.4	20	26.0	6	7.8			
West	77	7	9.1	28	36.4	32	41.6	10	13.0			
Central	77	6	7.8	16	20.8	36	46.8	19	24.7			
Total	**385**	**47**	**12.2**	**131**	**34.0**	**139**	**36.1**	**68**	**17.7**			
Frequency of Water Supply										43.262	21	0.002**
Daily	9	-	-	3	33.3	6	66.7	-	-			
1 to 5 days	104	20	19.2	35	33.7	32	30.8	17	16.3			
6 to 10 days	171	17	9.9	64	37.4	58	33.9	32	18.7			
11 to 15 days	45	6	13.3	18	40.0	14	31.1	7	15.6			
16 to 20 days	15			4	26.7	8	53.3	3	20.0			
> 21 days	23	4	17.4	5	21.7	11	47.8	3	13.0			
3 days *	10	-	-	-	-	9	90.0	1	10.0			
Not aware	8			2	25.0	1	12.5	5	62.5			
Total	**385**	**47**	**12.2**	**131**	**34.0**	**139**	**36.1**	**68**	**17.7**			
Soft water – Quantity during the Non-seasonal Period (other than summer)												
Zonal Division										48.552	12	0.004**
North	77	14	18.2	41	53.2	15	19.5	7	9.1			
South	77	7	9.1	27	35.1	23	29.9	20	26.0			
East	77	18	23.4	48	62.3	7	9.1	4	5.2			
West	77	8	10.4	44	57.1	14	18.2	11	14.3			
Central	77	10	13.0	54	70.1	10	13.0	3	3.9			
Total	**385**	**57**	**14.8**	**214**	**55.6**	**69**	**17.9**	**45**	**11.7**			
Frequency of Water Supply										79.731	21	0.000**
Daily	9	-	-	8	88.9	1	11.1	-	-			
1 to 5 days	104	22	21.2	57	54.8	19	18.3	6	5.8			
6 to 10 days	171	29	17.0	101	59.1	31	18.1	10	5.8			
11 to 15 days	45	6	13.3	25	55.6	5	11.1	9	20.0			
16 to 20 days	15	-	-	6	40.0	4	26.7	5	33.3			
> 21 days	23	-	-	7	30.4	7	30.4	9	39.1			
3 days *	10	-	-	9	90.0	-	-	1	10.0			
Not aware	8	-	-	1	12.5	2	25.0	5	62.5			
Total	**385**	**57**	**14.8**	**214**	**55.6**	**69**	**17.9**	**45**	**11.7**			

*3 days continuous water supply **Significant at 1% level

Among the North zone homemakers 20.8, 41.6 per cent and 16.9, 49.4 per cent of East zone homemakers were Highly Satisfied and Moderately Satisfied with the quality of water supplied during the non-seasonal period, respectively. Amongst the homemakers in the South (41.6 %), West (another 41.6%), and Central regions (46.8 %) respectively were Moderately Satisfied whereas 29.9 per cent, 24.7 per cent and, 13 per cent of the above said regions were Not Satisfied with the water supply during non-seasonal period. The obtained p-value ($p<0.001$) ($X^2 = 47.295$; $p = 0.000$) at 1% significant level strongly suggests that there is a highly significant association between the attribute of satisfaction on the distributed soft water quality (during non-seasonal) of the selected homemakers with the zonal division in the selected city. ***Hence Hypothesis 3, "Household's satisfaction about the quality of water distributed irrespective of seasonal and non-seasonal variations was not influenced by the distribution of water in their zone", is hereby rejected.***

f. Association between the attribute of satisfaction about the distributed soft water quality (during non-seasonal period) of the selected homemakers with the frequency of water supply

An attempt was made to discover the relationship on the above statement. The results revealed that cent per cent of the homemakers who received water supply for continuous three days were Not Satisfied with the quality of water. Those who has got water supply once in 16 – 20 days (73.3%), daily (66.7%), and once in more than 21 days (60.8%) were Highly Dissatisfied. Hence the analysed Chi-Square value ($X^2 = 43.262$; $p = 0.002$) signifies that there is a strong relationship between the attribute of satisfaction about the distributed soft water quality (during non-seasonal period) of the selected homemakers and with the frequency of water supply across the selected city.

g. Association between the attribute of satisfaction about the distributed soft water quantity (during non-seasonal period) of the selected homemakers with the Zonal division in Coimbatore city

More than half of the homemakers were contented with the availability of supplied water in all the zones of the city except the South during the non-seasonal period other than summer. With a high significant level ($X^2 = 48.552$; $p = 0.004$), the relationship between the attribute of satisfaction about the distributed soft water quantity (during non-seasonal period) of the selected homemakers with the zonal division in Coimbatore city was established.

h. Association between the attribute of satisfaction about the distributed soft water quantity (during non-seasonal period) of the selected homemakers with the frequency of water supply

The fact revealed that even during the non-seasonal period, a remarkable number of homemakers received water once in more than 10 days and also more than 16 days. This shows the unplanned circulation pattern in the water supply where the homemakers were put into a condition to store the available water irrespective of seasonal or non-seasonal periods. The satisfaction level seems to be high among those who acquired water within 10 days duration. This was evident with the critical value (X^2 = 79.731; p = 0.000) that shows a highly significant association between the attribute of satisfaction on the distributed soft water quantity (during non-seasonal period) of the selected homemakers with the frequency of water supply across the city. A known truth is that homemakers who received water on a daily basis were 100 per cent Satisfied when the supply exceeded the demand.

i) Overall satisfaction regarding the distribution of soft water

One way ANOVA was carried out to analyse the overall satisfaction with the distribution of soft water based on the selected socio-demographic variables such as educational qualification, family income, ownership status, type of house, zonal division (location), and frequency of water circulation (during seasonal and non-seasonal periods) differences. Table 19 showed the overall satisfaction with the distribution of soft water based on the selected socio-demographic variables.

Table 19: Overall Satisfaction with the Distribution of Soft Water

Socio-demographic Variables		Overall Satisfaction Score – Soft Water Supply				p-value
		N (385)	Mean	S.D	F Value	
Homemaker Educational Qualification	Illiterate	34	10.26	3.11	3.032	0.004**
	Middle-High School	86	10.31	2.27		
	Higher Secondary	53	9.32	2.93		
	ITI	12	9.33	3.08		
	Graduate	83	9.69	3.45		
	Post Graduate	38	9.24	2.15		
	Diploma	23	7.65	2.53		
	Professional	56	9.39	2.07		
Family Income	Less than Rs. 10,000	22	10.05	3.08	2.839	0.024*
	Rs. 10,000 to Rs.20,000	92	10.20	2.98		
	Rs. 20,000 to Rs.30,000	108	9.81	2.62		
	Rs. 30,000 to Rs.40,000	72	9.01	2.92		
	More than Rs. 40,000	91	9.13	2.48		
Ownership Status	Own	237	9.60	2.77	2.646	0.048^{Ns}
	Rented	135	9.78	2.86		
	Lease	13	7.92	1.66		
Type of House	Independent	215	9.47	2.80	1.354	0.256^{Ns}
	Double Portioned house	114	9.57	2.79		
	Three portioned house	33	9.88	2.52		
	More than 3 portioned house	23	10.65	2.93		
Zonal Division	North	77	10.21	2.97	9.415	0.000**
	South	77	8.14	2.68		
	East	77	10.57	2.74		
	West	77	9.39	2.47		
	Central	77	9.73	2.48		
Frequency of water supply during the non-seasonal period (other than summer)	Daily	9	10.44	1.67	5.360	0.000**
	1 to 5 days	104	10.18	2.55		
	6 to 10 days	171	9.84	2.73		
	11 to 15 days	45	9.33	3.24		
	16 to 20 days	15	7.60	2.38		
	More than 21 day	23	7.91	2.27		
	3 days continuous supply	10	9.70	2.06		
	Not aware	8	6.25	3.11		
Frequency of water supply during the seasonal period (summer)	Daily	11	9.73	2.45	5.009	0.000**
	1 to 5 days	29	10.79	2.37		
	6 to 10 days	145	10.12	2.67		
	11 to 15 days	82	9.55	2.98		
	16 to 20 days	65	9.40	2.45		
	More than 21 day	28	7.57	3.10		
	3 days continuous supply	17	8.53	1.12		
	Not aware	8	7.50	3.96		

Ns Not significant   * Significant at 5% level   ** Significant at 1% level

Table. 19 revealed a significant relationship between the educational level of homemakers and their overall happiness with the distribution of soft water at 1% level, [F(7,377)=3.032; p=0.004]. The findings indicated that the mean score ($\bar{X}$ =10.31) for the level of satisfaction was greater among homemakers who had completed Middle School, and it also seems to be higher among homemakers with advanced degrees.

The t-test revealed a significant difference between household income and overall satisfaction with soft water distribution at 5% level. Those who earn between Rs. 10,000 and Rs. 20,000 per month had a mean score of 10.20, followed by those who earn less than Rs. 10,000 with a mean score of 10.5. This indicated that homemakers who are earning less than Rs. 20,000 had a more positive outlook on the distribution of soft water.

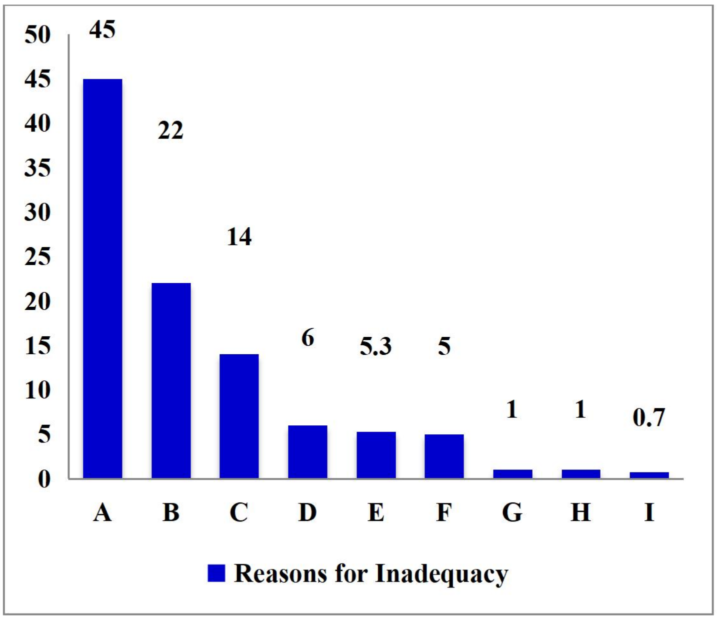
According to the findings of a one-way ANOVA, neither the homemakers' home ownership [F(2,382)=2.646; p=0.048] nor their house type [F(3,381)=1.354; p=0.256] did not influence their satisfaction with the distribution of soft water supply.

There was a highly significant relationship between homemaker residence zone and overall satisfaction with water distribution [F(4,380)=9.415; p=0.000] in the selected city. The East zone homemakers were the Most Satisfied with a mean score of $\bar{X}$ =10.57, followed by the North zone with a mean score of $\bar{X}$ =10.21.

Concerning the frequency of water distribution during non-seasonal periods (other than summer), a substantially significant difference in overall satisfaction was observed [F(7,377)=5.360; p=0.000]. When there is a daily water supply, the mean score is $\bar{X}$ =10.44 but it is $\bar{X}$ =10.18 when the water is supplied within 5 days.

It also indicated that a high degree of significance at the 1% level was established between the frequency of water supply throughout the seasonal period (summer) and the overall satisfaction gained from homemakers [F(7,377)=5,059; p=0.000]. Table: 19 demonstrated that the overall satisfaction score was better for homemakers who received water distributions every 1 to 5 days ($\bar{X}$ =10.79) and every 6 to 10 days ($\bar{X}$ =10.12).

F. Reasoning behind the Status of Inadequacy and Discontentment of Water



A - Seasonal Changes
B - Guests at Home
C - Frequency of Supply is More
D - Functions at Home
E - No Intimation on Supply
F - Negligence in Fetching Water
G - More Family Members
H - Owner Restrictions
I - Regular Cleaning

***** Multiple responses***

Figure 26: Reasons for Inadequacy of Water

Regarding the primary reason for water shortages in the family which is clearly represented by the graph in Figure: 26, 45 per cent of homemakers have mentioned seasonal changes (summer season), followed by 22 per cent visits of frequent guest at home. Unexpectedly, 20 per cent of homemakers said that they had never experienced such a deficiency condition. Even situations such as regular cleaning activity in residences, increased frequency of water supply, enlarged family size, owner restrictions, while organizing functions at home, negligence in fetching water and lack of prior notification about water supply were cited by homemakers as other reasons for inadequate water supply.

Phase II: Experimental Investigation: Water's Qualitative and Quantitative Status Quo

This section of the findings, discussed the outcomes of an experiment conducted with a group of homemakers from Coimbatore. The experimental results were organised into the following sections:

A. Evaluation of the physical, chemical and biological qualities of water delivered in various zones of the Coimbatore district that was preserved for drinking purposes.
B. Inspection of drinking water quality after common purification methods
C. Monitoring and assessing the quality of water stored in different containers:
    i. Physical properties
    ii. Chemical properties and
    iii. Biological properties
D. Water consumption analysis by micro components

The collected samples of drinking water were analysed for the Indian Standard Specifications for Drinking Water and WHO - recommended quality parameters (Indian Standard Drinking Water Specification, 2012 and Central Pollution Control Board, 2007). Idealistically, all distribution system samples should be devoid of chemical, bacterial, viral and biological contamination.

A. Evaluation of the Physical, Chemical and Biological Qualities of Water Delivered in Various Zones of the Coimbatore District that was Preserved for Drinking Purposes

Safe drinking water was an important part of any health protection policy and should be available to all people as a fundamental human right. The drinking water in Coimbatore was tested to analyze the physical, chemical and biological properties of the water collected from five different zones of the city: the North, South, East, West and Central. The TWAD board was responsible for monitoring and ensuring the quality of public water supplies and consumption. After much deliberation and approval by the Food and Agriculture Division Council and the Drinking Water Sectional Committee, the Bureau of Indian Standards finally adopted the standard for drinking water in India. The public health benefits of safe drinking water were the primary focus of these regulations. The following was the discussion of findings:

The requirements for potable water supply as given by the Indian government and the World Health Organization was given in Appendix. C

An effort was made to compare the quality of the collected water from the city's five zones to the Indian Standard Drinking Water Specifications and the World Health Organization drinking water specifications, (2012). All the water's characteristics and components were shown to be within the acceptable and allowable limits when the water was collected from the distribution tap during the water delivery. The details are given in Table. 20.

Table 20: Physical, Chemical and Biological Parameters of the Samples from Different Zones of the Selected City

Characteristics	Units	Acceptable Limits	Samples				
			N	S	E	W	C
Physical Parameters							
Color	Hazen unit	5 to 15	0.12	0.11	0.35	0.18	0.06
pH value		6.5 - 8.5	6.87	6.56	6.86	6.71	6.27
Turbidity	NTU	1 to 5	0.18	0.52	0.94	0.44	0.18
Electrical Conductivity	µS/cm	Upto 400	0.03	0.005	0.06	0.1	0.02
Total Dissolved Solids	mg/l	500 - 2000	98	88	196	254	164
Total Suspended Solids	mg/l		AB	28	60	8	AB
Chemical Parameters							
Hardness	mg/l	200 - 600	37.07	37.07	63.54	47.66	31.77
Alkalinity	mg/l	200 - 600	15	25	25	20	15
Oil and Grease	mg/l	0.01	AB	AB	AB	AB	AB
Carbonate	mg/l		NIL	NIL	NIL	NIL	NIL
Bicarbonate	mg/l		15	20	25	20	15
Iron	mg/l	1	0.004	0.003	0.004	0.008	0.006
Calcium	mg/l	75 - 200	8	14	12	10	10
Chloride	mg/l	250 - 1000	19.5	23.01	23.04	21.27	24.82
Copper	mg/l	0.05 - 1.5	0.002	0.001	0.002	0.002	0.002
Fluoride	mg/l	1.0 - 1.5	0.001	0.001	0.001	0.001	0.001
Magnesium	mg/l	30 - 100	2.43	1.22	1.22	3.65	1.22
Manganese	mg/l	0.1 - 0.3	0.001	0.001	0.001	0.001	0.001
Nitrate	mg/l	45	4.98	4.12	5.97	6.07	5.83
Sulphate	mg/l	200 - 400	44.21	17.3	90.64	141.73	50.26
Sulphide	mg/l	0.05	BDL	BDL	BDL	BDL	BDL
Ammoniacal Nitrogen	mg/l	0.5	BDL	BDL	BDL	BDL	BDL
Silica	mg/l	39	6.35	5.48	7.83	8.32	7.91
Microbiological Parameters							
Total Plate Count (37deg for 24 hrs)	CFU/ml	< 20	18	130	AB	65	AB
E.coli (37deg for 24 hrs)		Absence	AB	AB	AB	AB	AB
Coliforms		Absence	AB	AB	AB	AB	AB

N – North; S – South; E – East; W – West; C – Central; CFU/ml – Colony Forming Unit per ml; BDL – Below Detectable Level; AB – Absent; µS/cm – Milli Siemens per centimetre; NTU – Nephelometric Turbidity Unit

Regarding the **colour** of water, samples collected from the East and West regions exhibited to have a mild change and not clear. So the homemakers were in a position to choose any of the purification methods to get clear water for drinking purpose.

The **pH value** of water was an essential metric in determining its acid-base balance. Indian Standard Specifications and WHO (Indian Standard Drinking Water Specification, 2012) advised that maximum allowable level of pH from 6.5 to 8.5. This study had a range that was acceptable by World Health Organization criteria (6.27-6.87). The overall result suggested that all the water samples included for this research from the five zones of the city were within the desired and appropriate range.

The **turbidity** of water was determined by the number of solid materials suspended in it. The turbidity values recorded from the various city zones were (0.18, 0.52, 0.94, 0.44, and 0.18), which was lower than the recommended threshold of 5.00 NTU (Nephelometric Turbidity Unit).

Boyd (2020) discussed that pure water was an excellent insulator rather than a strong conductor of electric current. An increase in **ion concentration** improvised water's electrical conductivity. According to the present study, the EC value was 0.005 - 0.1 µS/cm (Micro siemens per centimetre). The above findings clearly showed that the water in the study region was not significantly ionised and had a lower level of ionic concentration activity as a consequence of the lower amount of dissolved solids.

A high **TDS measurement** implied that the water was heavily mineralized. The desirable limit for TDS was 500 mg/l, with a maximum limit of 1000 mg/l advised for drinking purposes as pointed out by (Naddeo, HoChoo and Ksibi, 2023). TDS concentrations in the current research were found to be between 88 to 254 mg/l, which was within the prescribed limits.

More precisely, in 60 per cent of the selected samples (collected from South, East, and West), **total suspended solids** ranged from 6 to 28 mg/l, while the north and central zones were devoid of suspended solids. The Indian Standard Drinking Water Specification (2012) recommended a carbonate content of 200mg/l with a maximum of 600mg/l. The experimental measurement indicated that there were no traces of carbonate in the samples collected.

According to Indian Standard Specifications for Drinking Water, (2012) and WHO guidelines, the **chloride** content should not exceed 250 mg/l. In the five zones of the chosen city, the chloride concentration ranged from 19.5 to 24.82 mg/l in the study locations. Oil and grease were not detected in the water samples that were collected. Other chemicals below the permitted level were water hardness, alkalinity, bicarbonate, iron, calcium, chloride, copper, fluoride, magnesium, manganese, nitrate, sulphate, sulphide, ammoniacal nitrogen and silica. The amount of sulphide and ammoniacal nitrogen in the sample water was below the detection threshold.

Total Plate Count was a measurement of the microbial load in a sample (i.e., an enumeration of all heterotrophic bacteria that can thrive in aerobic or microaerophilic conditions and at 350^{o} C) (https://www.bioscience.com.sg/total-plate-count/#:~:text=This%20is%20a%20count%20of,grow%20at%20350C).

All the tested water samples showed no signs of microbial contamination (E.Coli, Coliforms). Water samples from the west zone had a total plate count of 65 CFU/mg, while those from the south zone had a total of 130 CFU/mg, indicating a potential hazard to water quality due to oozing of sewage contaminants into the pipes that supply the water.

B. Inspection of Drinking Water Quality after Common Purification Methods

Kumar, Kamboj and Payum (2020) quoted that potable water was safe to drink, tastes well, and may be utilized in the home. Water purification was the removal of impurities from water such as chemicals (pollutants, toxic metals), biological contaminants (algae, bacteria, fungi, parasites, viruses), suspended particles, and gases.

According to Omer (2020), water purification procedures included physical techniques like filtration, sedimentation, or distillation; biological processes such as sand filters and active carbon; and chemical treatments take account of flocculation, chlorination, and the application of UV radiation. The most prevalent purifying techniques used in the households in selected city were listed in Table 21.

Table 21: Type of Water Filtration Practiced by the Selected Homemakers

Type of Water Filtration Practiced	Response (N=385)	
	No	**%**
Boiled water (Rolling boil for 1 minute)	137	35.6
Purified water (Using membrane filters)	80	20.8
RO water (Reverse Osmosis)	68	17.7
Packaged drinking water (Leading brand)	48	12.4
Directly fetched water from the distribution tap (Without treatment)	52	13.5
Total	**385**	**100.0**

Out of the five zones of Coimbatore city, the west zone was picked to conduct the water quality assessment, and it was evident that individuals employed a lot of water treatment before its consumption. Table 22 presented information about the physical, chemical and biological parameters of drinking water after it had undergone different water treatments as well as without any treatment.

Table 22: Analysis of Drinking Water Quality after Common Purification Methods

Characteristics	Units	Acceptable Limits	Purification Methods				
			BW Boiled Water	**PW** Purified Water	**ROW** Reverse Osmosis Water	**PDW** Packaged Drinking Water	**WOT** Without Treatment
Physical Parameters							
Color	Hazen unit	5 to 15	0.48	0.42	0.13	**0.73**	0.34
pH value		6.5 - 8.5	6.52	6.4	5.99	**6.64**	6.85
Turbidity	NTU	1 to 5	0.35	0.30	0.28	**0.59**	0.24
Electrical Conductivity	µS/cm		0.16	0.11	0.04	**0.27**	0.11
Total Dissolved Solids	mg/l	500 - 2000	248	174	168	**420**	182
Total Suspended Solids	mg/l		AB	AB	AB	AB	AB
Chemical Parameters							
Hardness	mg/l	200 - 600	37.07	37.85	31.77	**68.84**	20.09
Alkalinity	mg/l	200 - 600	15	25	20	**30**	22.50
Oil and Grease	mg/l	0.01	AB	AB	AB	AB	AB
Carbonate	mg/l		NIL	NIL	NIL	NIL	NIL
Bicarbonate	mg/l		15	25	15	**35**	25
Iron	mg/l	1	0.006	0.006	0.004	**0.007**	0.004
Calcium	mg/l	75 - 200	12	10	10	8	7
Chloride	mg/l	250 - 1000	19.49	26.59	14.18	14.18	27.70
Copper	mg/l	0.05 - 1.5	0.003	0.002	0.002	0.002	0.002
Fluoride	mg/l	1.0 - 1.5	0.002	0.002	0.001	0.001	0.001
Magnesium	mg/l	30 - 100	1.22	1.38	1.22	1.22	1.82
Manganese	mg/l	0.1 - 0.3	0.001	0.001	0.001	0.001	0.001
Nitrate	mg/l	45	6.18	4.95	4.27	5.91	5.78
Sulphate	mg/l	200 - 400	99.7	91.05	88.99	90.64	58.5
Sulphide	mg/l	0.05	BDL	BDL	BDL	BDL	BDL
Ammoniacal Nitrogen	mg/l	0.5	BDL	BDL	BDL	BDL	BDL
Silica	mg/l	39	5.89	6.55	5.18	6.87	7.21
Microbiological Parameters							
Total Plate Count (37deg for 24 hrs)	CFU/ml	< 20	1	240	AB	AB	AB
E.coli (37deg for 24 hrs)		Absence	AB	AB	AB	AB	AB
Coliforms		Absence	AB	AB	AB	AB	AB

BW – Boiled water; PDW - Packaged drinking water; WOT - Without treatment; PW – Purified water; ROW – Reverse Osmosis water; AB – Absent; BDL – Below Detectable Level; CFU/ml – Colony Forming Unit; µS/cm – Milli Siemens per centimetre; NTU – Nephelometric Turbidity Unit

All of the samples, were discovered to be clear and colourless. The odour of water samples gathered for this study was found to be consistent and pleasant. The pH of the water after various treatments ranges from 5.99 to 6.85. High pH was found in the water that was not given any purification treatment (6.85), leading packaged drinking water (6.64), boiled water (6.52), membrane filtered water (6.4), and RO water (5.99) had low pH value.

Mohanan *et al.* (2017) suggested that water with a pH value greater than 9 or less than 4.5 was inappropriate for most living forms and other applications. The desirable pH range of drinking water was 6.5-8.5. Among the physical parameters, turbidity ranged between 2.24 – 0.59 NTU, which was less than the acceptable limit. Feroz and Bahnemann (2022) defined electrical conductivity as an indirect indicator of the concentration of dissolved particles in water. In this part of the study, **drinking water quality after common purification methods** electrical conductivity value ranged between 0.04 μS/cm – 0.27 μS/cms.

Figure: 27 portrayed the level of TDS identified in water after undergoing the common water purification methods.

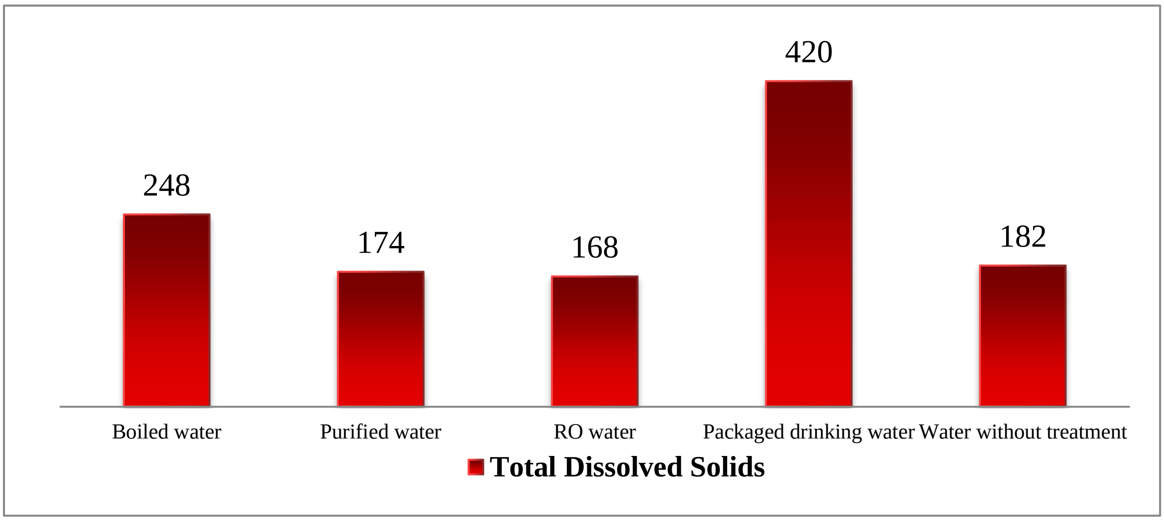
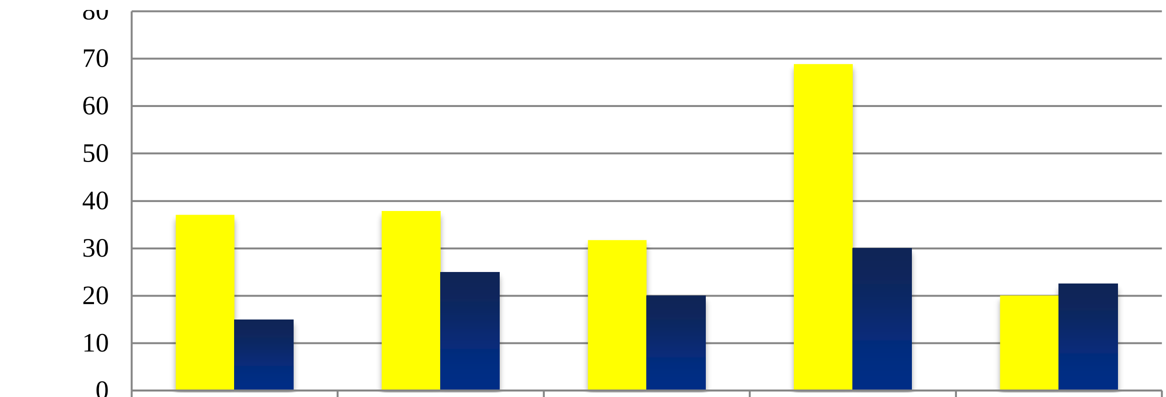


Figure 27: Total Dissolved Solids in Common Purification Methods

Leading packaged drinking water had high TDS value (420 mg/l), while low TDS was shown in RO water (168 mg/l). TDS was useful for determining the level of turbidity and hardness of water. Having low TDS, water might not have good taste. TDS was discovered to be higher may increase the taste of the water, which also caused an increase in EC of 0.27 μS/cms in premium packaged drinking water. Conductivity was used as a stand-in for dissolved solids measurement (Hargesheimer *et al.* 2002). All of the samples that were taken were found to be free of suspended solids.

The hardness of the water samples identified in different purification methods were portrayed in Figure 28. It ranged from 20.09 to 68.84 mg/l.



	Boiled water	Purified water	RO water	Packaged drinking water	Water without treatment
Hardness	37.07	37.85	31.77	68.84	20.09
Alkalinity	15	25	20	30	22.5

Figure 28: Hardness of Water Analyzed in Common Purification Methods

Sengupta (2013) concluded that the proportion of calcium and magnesium found in the water was another important aspect that helped determine its hardness. Groundwater usually acquired hardness when it percolated through minerals containing calcium or magnesium. Since hardness entered the water in this way, the hardness of groundwater was often higher than that of surface water.

The greatest hardness rating was discovered in packaged drinking water, which may be due to the company's reliance on an underground water source. In contrast, water that was not purified by any of the procedures had a low hardness rating.

The range of other parameters included: bicarbonate (15 – 35 mg/l), iron (0.004 – 0.007mg/l), calcium (7 – 12 mg/l), chloride (14.18 – 27.70 mg/l), copper (0.002 – 0.003 mg/l), fluoride (0.001 – 0.002 mg/l), magnesium (1.22 – 1.82 mg/l), manganese (0.001 mg/l), nitrate (4.27 – 6.18 mg/l), sulphates (58.05 – 99.7 mg/l), and silica (5.18 – 7.21 mg/l) that seemed to be to be less than the acceptable limit.

The water obtained from a RO (reverse osmosis system) had the lowest value of all physical and chemical characteristics as it removed critical minerals and resulted in excessive water wastage. All the selected samples were found to be free from E.coli and coliforms. Overall results indicated that the physical and chemical parameters were found to be within the permissible limit set by WHO and Indian Standard Drinking Water Specification (2012). The total plate count was used to measure the overall bacteriological quality of drinking water in public, semi-public and private water systems as shared by Mohannan *et al.* (2017). In the collected water samples, the membrane purified water was found to have 240 CFU/ml of total plate count which was more than the acceptable limit in drinking water. Membranes could also eliminate germs by restricting their entrance to the finished water.

Microorganisms may be removed almost completely as long as the membranes were intact; nevertheless, certain bacteria could grow through the membrane, as quoted by Cotruvo *et al.* (2010). Duration exceeded to change the membrane filters could be a reason for a high number of total plate count in the selected samples. Changing the filter membranes within the time frame specified may help to lower the number of bacteria identified in the drinking water.

C. Monitoring and Assessing the Quality of Water Stored in Different Containers

i. Physical properties of stored water

The method of storage was essential in maintaining water purity and safety for drinking purposes. According to the results of the research, the water in the chosen city was circulated every five, ten, fifteen and twenty days, depending on its location. It also revealed that people used a variety of containers made of various materials such as aluminium, brass, copper, mud pots, plastic, and stainless steel, to preserve drinking water for later use.

As drinking water was not supplied on a daily basis, people commonly stored the supplied water from a minimum of 5 days to a maximum up to 20 days. During summer, the frequency may extend even up to 25 days. The researcher attempted to investigate the effect of different types of storage vessels such as aluminium, brass, copper, mud, plastic and steel on water quality which was commonly used for water storage among the selected households from the West zone of the selected city. The physical, chemical and biological parameters of the water collected during water supply and after storing the water in different vessels for a maximum of 20 days was analysed.

Table. 23 showed the average change of water colour supplied in the West zone, on the day of supply (actual) and the quality of stored water in different containers at four intervals (after change) on the 5^{th} day, 10^{th} day, 15^{th} day and 20^{th} day.

Table 23: Analysis of Physical Parameters of Stored Water at Different Intervals in Different Containers

Parameter	Types of water storage containers	Day 1		Day 5		Day 10		Day 15		Day 20		Changes Reported							
												Day 5		Day 10		Day 15		Day 20	
		Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Colour	Aluminium	.22	.05	.26	.06	.40	.12	.42	.07	.36	.04	.04	.01	.18	.11	.20	.05	.14	.03
	Brass	.22	.05	.41	.08	.40	.14	.43	.16	.45	.14	.19	.04	.18	.09	.21	.13	.22	.09
	Copper	.22	.05	.38	.23	.42	.06	.36	.24	.35	.15	.16	.28	.19	.11	.13	.22	.12	.12
	Mud	.22	.05	.21	.04	.38	.16	.39	.17	.53	.16	-.01	.09	.15	.13	.17	.12	.31	.15
	Plastic	.22	.05	.33	.22	.32	.06	.27	.13	.37	.18	.11	.27	.09	.10	.05	.16	.14	.21
	Stainless steel	.22	.05	.26	.13	.35	.06	.30	.02	.50	.08	.04	.09	.13	.02	.08	.04	.28	.12
pH	Aluminium	6.67	.13	6.75	.08	6.73	.10	6.71	.02	6.65	.10	.08	.09	.06	.14	.04	.14	-.02	.20
	Brass	6.67	.13	6.34	.43	6.42	.36	6.44	.34	6.49	.32	-.33	.54	-.26	.48	-.23	.45	-.18	.43
	Copper	6.67	.13	6.51	.20	6.56	.16	6.59	.20	6.58	.10	-.16	.32	-.11	.28	-.08	.33	-.09	.22
	Mud	6.67	.13	6.66	.06	6.73	.16	6.82	.16	7.03	.03	-.01	.11	.06	.29	.14	.28	.36	.16
	Plastic	6.67	.13	6.49	.26	6.74	.12	6.66	.07	6.75	.13	-.18	.35	.06	.23	-.02	.06	.07	.25
	Stainless steel	6.67	.13	6.60	.20	6.70	.14	6.66	.14	6.72	.15	-.07	.33	.03	.26	-.02	.12	.04	.16
Turbidity	Aluminium	.47	.25	.42	.25	.45	.14	.45	.10	.32	.13	-.06	.31	-.02	.17	-.02	.26	-.15	.12
	Brass	.47	.25	.30	.10	.27	.10	.22	.08	.28	.06	-.17	.34	-.21	.34	-.25	.18	-.19	.26
	Copper	.47	.25	.40	.14	.32	.06	.29	.15	.29	.08	-.08	.39	-.16	.27	-.18	.37	-.18	.31
	Mud	.47	.25	.23	.08	.33	.21	.34	.07	.51	.01	-.25	.30	-.14	.37	-.13	.20	.04	.25
	Plastic	.47	.25	.39	.29	.33	.17	.24	.08	.28	.18	-.08	.54	-.14	.42	-.23	.31	-.20	.33
	Stainless steel	.47	.25	.40	.10	.42	.04	.32	.05	.39	.07	-.07	.26	-.05	.27	-.15	.30	-.08	.31
Electrical Conductivity	Aluminium	.070	.036	.030	.017	.113	.085	.097	.038	.073	.050	-.040	.044	.043	.078	.027	.072	.003	.078
	Brass	.070	.036	.093	.051	.070	.020	.073	.040	.093	.042	.023	.045	.000	.052	.003	.068	.023	.078
	Copper	.070	.036	.051	.054	.087	.015	.070	.044	.110	.056	-.019	.026	.017	.045	.000	.072	.040	.062
	Mud	.070	.036	.023	.006	.080	.060	.143	.111	.250	.052	-.047	.042	.010	.095	.073	.140	.180	.082
	Plastic	.070	.036	.097	.071	.127	.070	.043	.025	.123	.133	.027	.035	.057	.085	-.027	.035	.053	.120
	Stainless steel	.070	.036	.050	.020	.093	.031	.031	.028	.130	.095	-.020	.056	.023	.057	-.039	.060	.060	.075
Total Dissolved Solids	Aluminium	223.33	95.04	113.33	2.89	201.00	107.50	194.00	22.72	176.33	50.82	-110.00	95.00	-22.33	38.08	-29.33	113.53	-47.00	143.42
	Brass	223.33	95.04	204.67	51.47	164.67	26.86	165.67	17.56	204.00	60.10	-18.67	53.00	-58.67	101.79	-57.67	104.20	-19.33	136.47
	Copper	223.33	95.04	181.33	46.50	184.67	36.61	204.00	69.40	225.67	67.80	-42.00	105.73	-38.67	109.87	-19.33	119.20	2.33	160.18
	Mud	223.33	95.04	206.33	78.05	286.33	107.45	298.33	70.57	416.33	40.99	-17.00	31.76	63.00	178.47	75.00	155.91	193.00	102.36
	Plastic	223.33	95.04	185.33	54.60	244.67	72.53	170.33	4.04	247.33	171.28	-38.00	92.24	21.33	85.85	-53.00	91.50	24.00	232.13
	Stainless steel	223.33	95.04	152.00	7.00	199.67	13.05	173.33	16.17	252.67	103.93	-71.33	100.51	-23.67	92.52	-50.00	101.73	29.33	135.43

Plate 11:

Pitting in Aluminium Container **Storage of Water in Aluminium Containers**

The acceptable level of drinking water colour was 5 Hazen units which would be clear to our vision, the permissible limit was 15 Hazen units may be cloudy and above 25 units the water remains murky (Indian Standard Drinking Water Specification, 2012). It was noticed that the colour of water on day 1 was 0.22, and the water stored in mud container showed reduction in colour where as the other containers ranged from 0.26 - 0.41 on the 5th day of water storage. Pitting was found in the aluminium container where a layer of scaling material was floating made the colour change (Plate 11).

It was noticed that the average change in the mud pot was much higher (0.31) on 20th day compared to other containers. The least change was found in aluminium container (0.14) and plastic container (0.14) on 20th day. Overall result showed that all the samples were found to be clear and colourless and within the prescribed limits given by Indian Standard Specifications for Drinking Water and WHO (2012).

Even if the homemakers stored drinking water for more than up to 20 days also it was within the permissible limit. Hence the repeated measures of ANOVA found that the difference in water colour across sample containers was not significant ($F= 0.476$, $P>0.05$, NS). Furthermore, the water colour did not change over a period of maximum 20 days stored ($F= 2.801$, $P>0.05$, Ns) and the interaction between days stored and sample containers did not show any significant difference.

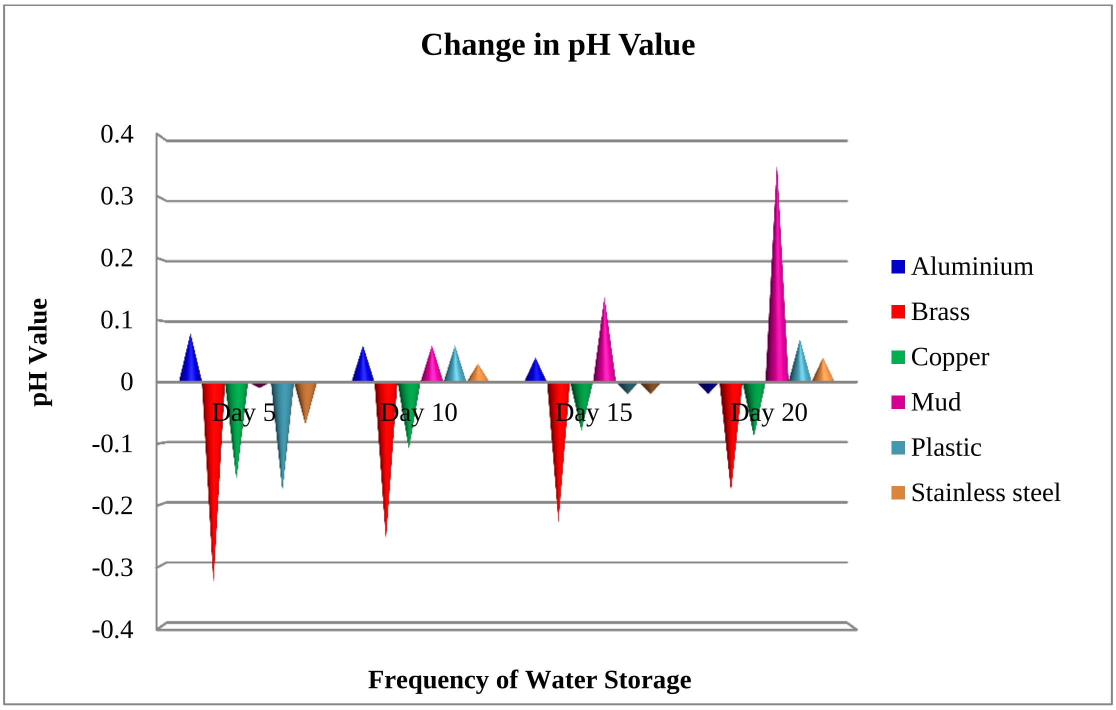


Figure 29: Comparison of pH Values of Water Stored in Different Containers

Figure: 29 exhibited the comparison of pH values of water stored in different containers. Summers (2020) explained that the pH of water was a significant metric in evaluating its acid-base balance. It also indicated whether the water is acidic or alkaline. The WHO and Indian Standard Specifications for Drinking Water (2012) suggested a pH range of 6.5 to 8.5. The present investigation's average value fell between 6.34 and 7.03. The water held in brass containers had the lowest pH value, whereas, water stored in mud containers had the highest.

Table 24: Repeated Measures ANOVA for the Physical Properties of Stored Water

Repeated Measures ANOVA for the Physical Properties of Water							
Parameter	**Source**	**Sum of Squares**	**df**	**Mean Square**	**F**	**Prob.**	**Sig.**
Colour	Sample	.069	5	.014	.476	.788	Ns
	Error(A)	.346	12	.029			
	Days	.125	3	.042	2.801	.054	Ns
	days * Sample	.201	15	.013	.899	.572	Ns
	Error(B)	.538	36	.015			
pH	Sample	1.055	5	.211	.713	.625	Ns
	Error(A)	3.549	12	.296			
	Days	.187	3	.062	5.525	.003	**
	days * Sample	.257	15	.017	1.517	.151	Ns
	Error(B)	.407	36	.011			
Turbidity	Sample	.162	5	.032	.093	.992	Ns
	Error(A)	4.161	12	.347			
	Days	.022	3	.007	.627	.602	Ns
	days * Sample	.227	15	.015	1.272	.269	Ns
	Error(B)	.428	36	.012			
Electrical Conductivity	Sample	.021	5	.004	.443	.810	Ns
	Error(A)	.112	12	.009			
	Days	.052	3	.017	4.596	.008	**
	days * Sample	.083	15	.006	1.478	.166	Ns
	Error(B)	.135	36	.004			
Total Dissolved Solids	Sample	131361.667	5	26272.333	.617	.689	Ns
	Error(A)	510657.833	12	42554.819			
	Days	59632.444	3	19877.481	4.089	.013	*
	days * Sample	61811.222	15	4120.748	.848	.622	Ns
	Error(B)	175012.833	36	4861.468			

Ns Not Significant ($P>0.05$)　***** Significant at 5% level ($P < 0.05$)　****** Significant at 1% level ($P < 0.01$)

The pH level of water showed an increasing face, when water was stored for 20 days in mud pots. Gradual increase of pH level had been noted with the increase in number of storage days. Stainless steel, brass and copper containers were well suited for long duration maintaining the pH level throughout the water storage period.

The pH levels of the samples kept in various containers were not significantly different (F= 0.713, P>0.05, Ns). Over the course of being stored, the pH level of the water varied (F= 5.525, P0.01, significant at 1% level). The number of water storage days was not significantly influenced by water storage containers.

Turbidity's physical characteristic was defined by the transparency of the water (Li and Liu, 2019). Natural waterways become turbid due to suspended materials, including colloids, organic matter, silt and clay particles, tiny organisms, and organic matter. After five days of water storage, the turbidity of the water in every container had decreased as all the suspended materials got sedimented at the bottom level of the stored container without any disturbance. On the 20th day of storage, the turbidity value of the water held in mud pots ranged high (.51). After the fifth day of storage, the level of turbidity in other containers fluctuated (decreased and increased), and on the twentieth day, it was discovered to be lower than the first day of water collection since many of the particles may got deposited and dissolved in the stored water.

The statistical analysis showed that the difference in water turbidity across sample containers was not significant (F= 0.093, P>0.05, Ns). Also, the degree of turbidity did not alter over period of days stored (F= 0.627, P>0.05, Ns). The relationships between sample containers and days stored were likewise not substantially different.

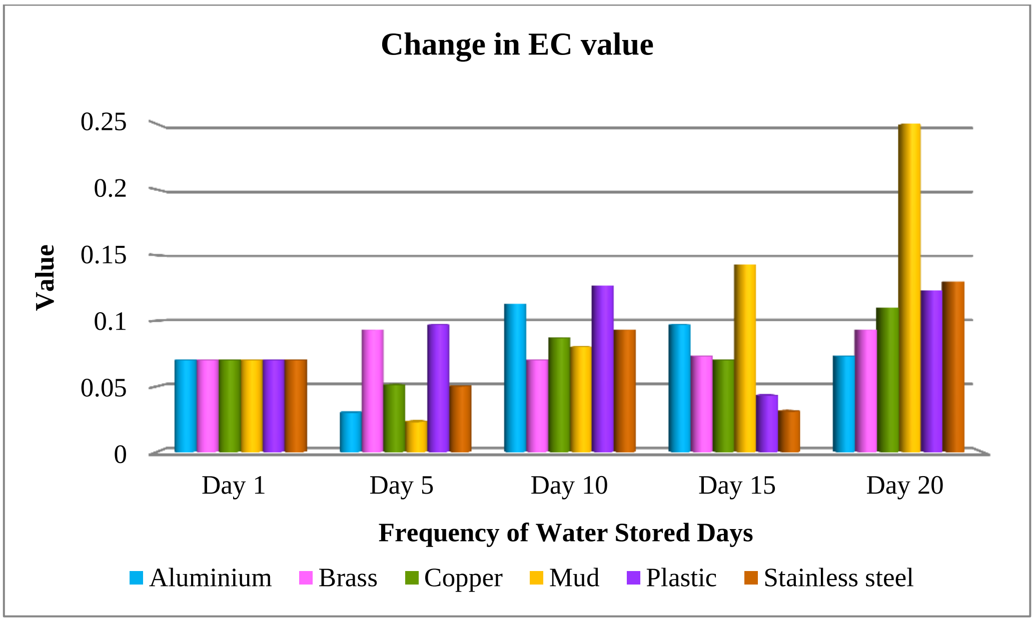


Figure 30: Variations in Water EC Values Stored in Different Containers

Figure: 30 displayed the variation in EC value during the storage period in various containers. According to the current study, after 10 days of storage, the average EC value of water stored in plastic containers decreased and then climbed on the 20th day. In water held in mud pots, the EC value gradually increased. These data clearly show that the ideal water storage period of drinking water, regardless of the material of the container used for water storage, was within a week, as the graph indicates an inclination of the average EC value from the 10^{th} day of water storage.

In the case of electrical conductivity, the difference between sample containers was not significant (F=.443, P>0.05, Ns). The concentration of EC also varied over time (F= 4.596, P0.01, significant at 1% level), and the interaction between days stored and sample containers based on electrical conductivity was not significant.

The amount of total dissolved solids helped in determining the turbidity and hardness of the water. Average level of TDS in water on the sample collection day was 223.33 mg/L. The water held in mud pots (416.33 mg/L), stainless steel containers (252.67 mg/L), and plastic containers (247.33 mg/L) had high mean TDS values on day 20 of storage, whereas water in aluminium vessels (176 mg/L) had low TDS. From the 15^{th} day of storage, except water in aluminium container all other sample containers showed a significant rise in total dissolved solids.

Repeated ANOVA demonstrated that the difference in total dissolved solids across sample containers was not significant (F=.617, P>0.05, Ns). TDS levels also altered during the course of water storage (F= 4.089, P<0.05, significant at 5% level). The relationship between the number of days the water was stored and the number of sample containers with TDS was not significantly different.

With regard to TDS, based on the results it was advisable to consume water that had been stored within 10 days, particularly in brass and copper vessels. Table: 24 summarised the repeated measures ANOVA analysis to determine the relationship between the physical qualities of the stored water, container and number of water storage durations.

The results demonstrated that the suggested ***Hypothesis*** H_04.***(a), which stipulated that "The physical properties (i.e) colour and turbidity of water in different containers that has been stored during distribution cycle would not meet the quality standards set for its use", was rejected.***

H_04.*(b) "The physical properties (i.e.,) pH, electrical conductivity and total dissolved solids of water in different containers that has been stored during distribution cycle would not meet the quality standards set for its use" was accepted.*

ii. Chemical properties of stored water

"Hard" water included a high concentration of naturally occurring dissolved calcium and magnesium. Total hardness was the total of calcium and magnesium concentrations, both reported in milligrams per litre (mg/L) as calcium carbonate. In the current investigation, an increase in the average difference in hardness was detected in water stored in mud containers.

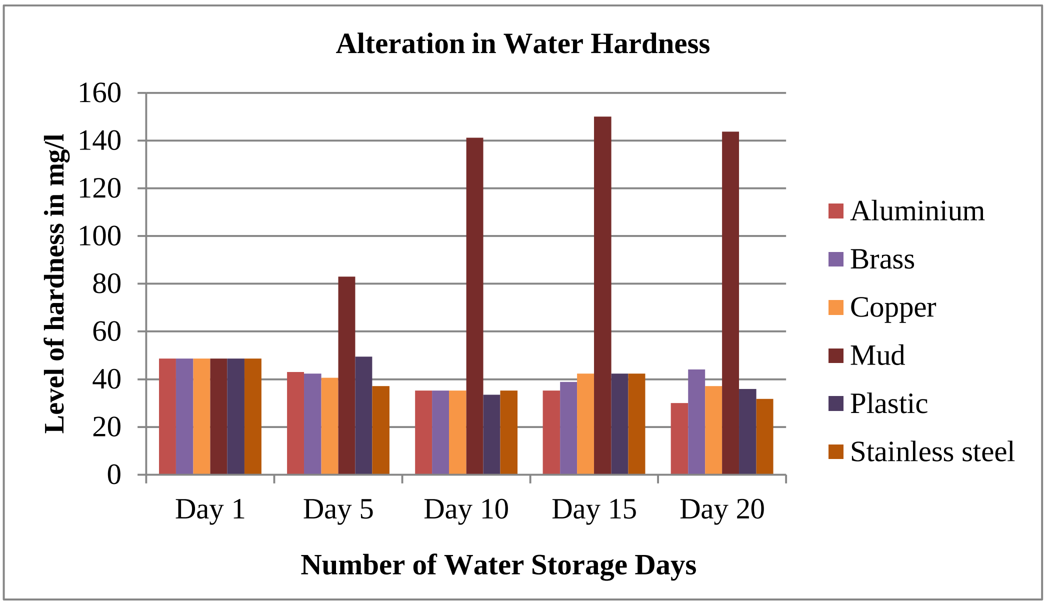


Figure 31: Level of Water Hardness in Transition from Container to another Container

Statistical analysis showed that there was a substantial variation in hardness (Figure: 31) between sample containers (F= 114, P<0.01, significant at 1% level). It was also recognised that the hardness level did not vary during water storage (F= .368, P>0.05, Ns). The interaction between the days the water was stored and sample containers were also was not significantly different.

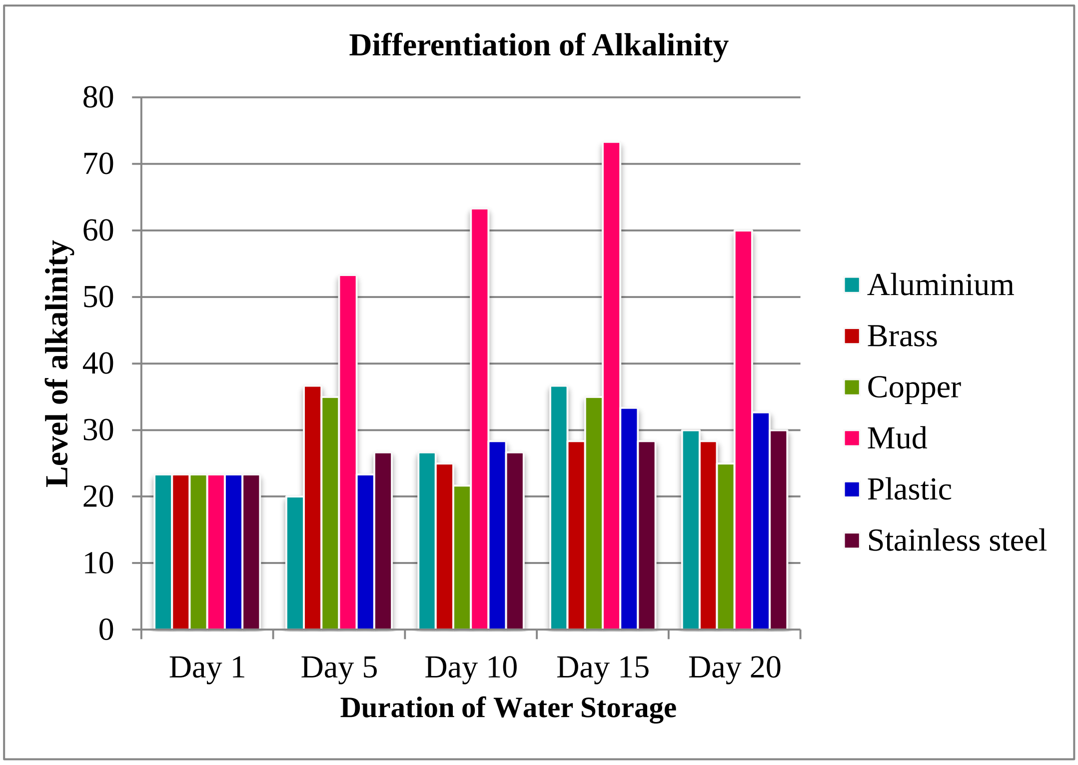


Figure 32: Differentiation of Alkalinity in Water Stored in a Variety of Selected Containers

Figure 32 depicted the mean values of total alkalinity in stored water. Water stored in plastic, brass, and stainless steel containers showed a gradual rise in alkalinity. Notable raise could be seen in water stored in mud containers. With regard to the alkalinity in the analyzed samples, it was concluded with the support of the ANOVA result that alkalinity of the water varied with different water storage containers (F= 7.380, $P<0.01$, significant at 1% level) as well as with the number of days the water was stored (F= 3.857, $P<0.05$, significant at 5% level). There was no significant difference in the interface between the containers used for storing water and the number of days the water was stored.

Table 25: Analysis of Chemical Parameters of Stored Water at Different Intervals in Different Containers

Parameter	Types of water storage containers	Day 1		Day 5		Day 10		Day 15		Day 20		Changes Reported							
												Day 5		Day 10		Day 15		Day 20	
		Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Hardness	Aluminium	48.62	6.80	43.03	10.65	35.30	3.06	35.30	13.32	30.01	8.09	-5.60	4.33	-13.32	4.73	-13.32	6.91	-18.62	2.65
	Brass	48.62	6.80	42.36	5.30	35.30	13.32	38.83	13.32	44.13	18.59	-6.26	5.55	-13.32	6.91	-9.79	6.53	-4.50	14.95
	Copper	48.62	6.80	40.56	8.08	35.30	11.02	42.36	10.59	37.07	10.59	-8.06	2.60	-13.32	4.44	-6.26	3.93	-11.55	8.46
	Mud	48.62	6.80	82.96	42.80	141.20	42.80	150.03	53.56	143.74	74.70	34.34	36.29	92.58	45.01	101.40	59.31	95.12	75.84
	Plastic	48.62	6.80	49.42	15.29	33.53	3.05	42.36	9.16	35.97	7.27	.80	10.68	-15.09	4.16	-6.26	3.93	-12.66	2.84
	Stainless steel	48.62	6.80	37.07	19.09	35.30	11.02	42.36	10.59	31.77	15.89	-11.56	15.97	-13.32	4.44	-6.26	14.64	-16.85	9.18
Alkalinity	Aluminium	23.33	10.41	20.00	5.00	26.67	2.89	36.67	7.64	30.00	8.66	-3.33	7.64	3.33	7.64	13.33	2.89	6.67	15.28
	Brass	23.33	10.41	36.67	12.58	25.00	5.00	28.33	14.43	28.33	2.89	13.33	18.93	1.67	7.64	5.00	5.00	5.00	10.00
	Copper	23.33	10.41	35.00	8.66	21.67	2.89	35.00	8.66	25.00	5.00	11.67	17.56	-1.67	7.64	11.67	11.55	1.67	7.64
	Mud	23.33	10.41	53.33	10.41	63.33	15.28	73.33	7.64	60.00	.00	30.00	.00	40.00	21.79	50.00	8.66	36.67	10.41
	Plastic	23.33	10.41	23.33	5.77	28.33	7.64	33.33	10.41	21.67	2.89	.00	5.00	5.00	10.00	10.00	.00	-1.67	11.55
	Stainless steel	23.33	10.41	26.67	7.64	26.67	2.89	28.33	2.89	30.00	8.66	3.33	2.89	3.33	11.55	5.00	8.66	6.67	17.56
Iron	Aluminium	.0067	.0012	.0060	.0010	.0060	.0017	.0063	.0021	.0063	.0015	-.0007	.0006	-.0007	.0015	-.0003	.0021	-.0003	.0021
	Brass	.0067	.0012	.0063	.0015	.0063	.0015	.0047	.0006	.0043	.0015	-.0003	.0025	-.0003	.0021	-.0020	.0010	-.0023	.0021
	Copper	.0067	.0012	.0053	.0012	.0047	.0006	.0060	.0010	.0057	.0006	-.0013	.0012	-.0020	.0010	-.0007	.0006	-.0010	.0010
	Mud	.0067	.0012	.0080	.0000	.0083	.0012	.0070	.0010	.0083	.0012	.0013	.0012	.0017	.0023	.0003	.0015	.0017	.0023
	Plastic	.0067	.0012	.0060	.0020	.0060	.0010	.0053	.0006	.0040	.0010	-.0007	.0012	-.0007	.0015	-.0013	.0015	-.0027	.0021
	Stainless steel	.0067	.0012	.0053	.0006	.0057	.0006	.0047	.0006	.0050	.0010	-.0013	.0006	-.0010	.0017	-.0020	.0010	-.0017	.0006
Calcium	Aluminium	15.87	6.99	10.67	4.16	11.33	2.31	9.33	3.06	9.33	3.06	-5.20	8.17	-4.53	8.81	-6.53	7.90	-6.53	7.90
	Brass	15.87	6.99	13.33	1.15	11.33	5.03	13.33	3.06	12.67	2.31	-2.53	6.20	-4.53	5.66	-2.53	7.90	-3.20	5.54
	Copper	15.87	6.99	12.00	2.00	11.33	2.31	14.00	3.46	11.33	3.06	-3.87	7.80	-4.53	8.81	-1.87	7.05	-4.53	4.39
	Mud	15.87	6.99	20.67	9.02	47.33	16.29	50.67	13.32	47.33	19.63	4.80	6.16	31.47	18.42	34.80	16.81	31.47	25.17
	Plastic	15.87	6.99	13.33	7.57	10.00	.00	12.67	1.15	11.33	1.15	-2.53	13.15	-5.87	6.99	-3.20	7.87	-4.53	6.82
	Stainless steel	15.87	6.99	11.33	6.43	10.67	2.31	14.00	3.46	8.67	3.06	-4.53	9.12	-5.20	6.84	-1.87	8.49	-7.20	4.85

(Contd…)

Parameter	Types of water storage containers	Day 1		Day 5		Day 10		Day 15		Day 20		Changes Reported							
												Day 5		Day 10		Day 15		Day 20	
		Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Chloride	Aluminium	24.83	9.41	17.14	1.03	21.27	1.77	21.86	5.12	21.86	1.02	-7.70	9.12	-3.56	9.89	-2.97	14.47	-2.97	8.40
	Brass	24.83	9.41	18.91	4.09	24.82	.01	16.54	3.69	24.82	1.78	-5.93	13.45	-.02	9.41	-8.29	8.41	-.02	9.89
	Copper	24.83	9.41	24.22	2.05	24.22	3.69	27.18	4.46	32.66	10.29	-.61	10.26	-.61	5.72	2.35	13.57	7.83	19.14
	Mud	24.83	9.41	28.36	13.84	34.86	9.09	43.72	30.97	43.55	17.10	3.53	5.29	10.03	12.84	18.89	35.87	18.72	22.06
	Plastic	24.83	9.41	18.32	5.41	21.86	3.69	24.23	6.71	24.81	4.69	-6.52	14.35	-2.97	12.85	-.61	14.24	-.02	12.43
	Stainless steel	24.83	9.41	23.64	5.12	23.63	2.71	20.68	5.12	21.27	1.77	-1.20	14.46	-1.20	9.79	-4.15	13.33	-3.56	9.89
Sulphate	Aluminium	140.04	70.82	44.50	4.12	96.40	64.49	98.33	17.63	97.23	56.38	-95.54	74.94	-43.64	22.14	-41.71	86.99	-42.81	126.41
	Brass	140.04	70.82	111.24	54.48	76.08	25.48	84.05	31.15	117.28	52.35	-28.80	20.70	-63.96	94.38	-55.99	96.49	-22.76	108.61
	Copper	140.04	70.82	84.16	46.92	105.75	35.12	98.06	51.62	117.28	49.92	-55.88	77.43	-34.29	92.20	-41.98	84.44	-22.76	118.26
	Mud	140.04	70.82	72.79	48.43	103.00	73.21	104.10	30.40	173.56	31.92	-67.25	35.18	-37.04	128.46	-35.94	100.80	33.52	78.28
	Plastic	140.04	70.82	88.17	40.02	131.83	43.55	73.89	8.00	109.59	77.71	-51.87	73.44	-8.21	92.80	-66.15	76.29	-30.45	138.74
	Stainless steel	140.04	70.82	67.30	19.52	110.69	24.78	73.06	15.20	132.66	41.62	-72.74	88.10	-29.35	71.95	-66.98	56.17	-7.38	61.50

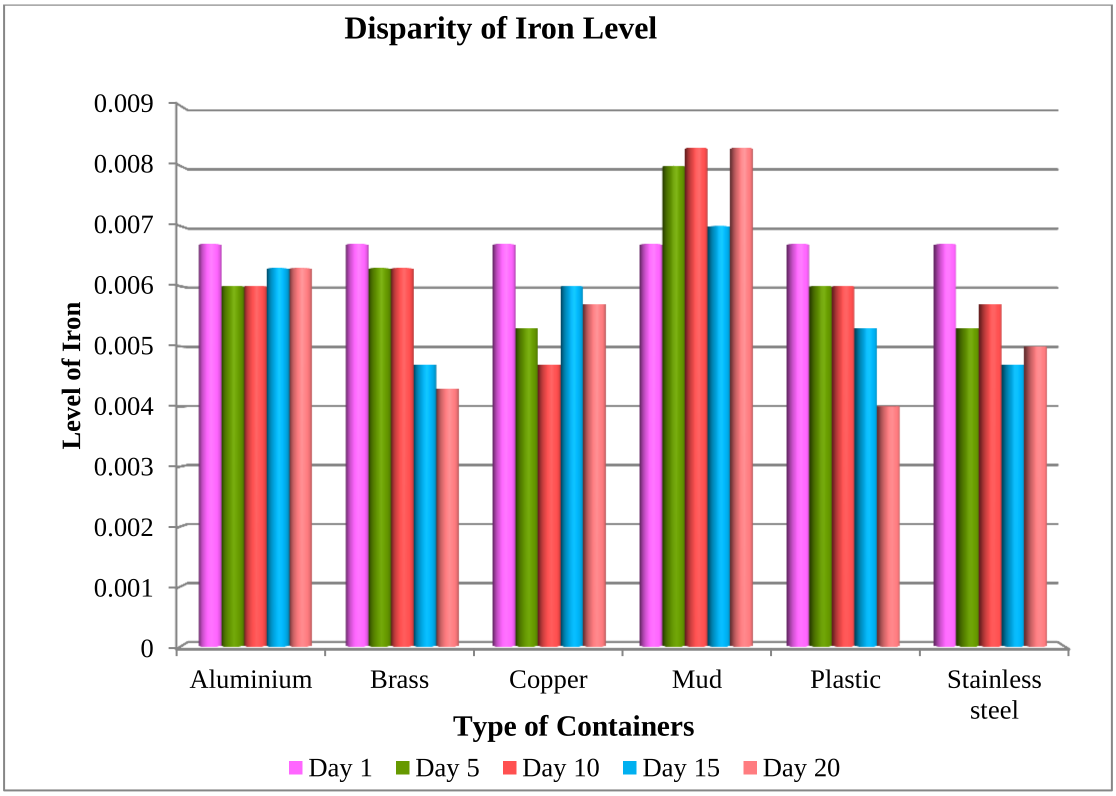


Figure 33: Disparity of Iron Level in Water Saved in Chosen Containers

Apart from water stored in mud pots, all water samples indicated a negative difference in iron concentration when compared to the first day's water samples as seen in Figure 33. Although iron does not cause health issues, even at extremely low concentrations, it gave a noticeable bitter taste to drinking water, quoted Summers (2020). Water stored in mud containers had a modest increase in iron concentration, but it was still within the allowed range set by the Indian Standard Drinking Water Specification and the World Health Organization (2012). The kind of water storage containers or the frequency with which water was kept, and their interaction, had no effect on the quantity of iron contained in the studied samples since it was not significant (F= 1.826, P>0.05, Ns; F= 1.754, P>0.05, Ns; F= 1.510, P>0.05, Ns).

Table 26: Repeated Measures ANOVA for the Chemical Properties of Stored Water

Repeated Measures ANOVA for the Chemical Properties of Water							
Parameter	**Source**	**Sum of Squares**	**df**	**Mean Square**	**F**	**Prob.**	**Sig.**
Hardness	Sample	83215.095	5	16643.019	114.411	.000	**
	Error(A)	1745.603	12	145.467			
	Days	798.877	3	266.292	.368	.776	Ns
	days * Sample	9103.034	15	606.869	.839	.631	Ns
	Error(B)	26041.623	36	723.378			
Alkalinity	Sample	11736.111	5	2347.222	7.380	.002	**
	Error(A)	3816.667	12	318.056			
	Days	637.500	3	212.500	3.857	.017	*
	days * Sample	1341.667	15	89.444	1.624	.116	Ns
	Error(B)	1983.333	36	55.093			
Iron	Sample	.000066	5	.000013	1.826	.182	Ns
	Error(A)	.000086	12	.000007			
	Days	.000005	3	.0000017	1.754	.173	Ns
	days * Sample	.000022	15	.0000014	1.510	.153	Ns
	Error(B)	.000035	36	.0000010			
Calcium	Sample	8985.167	5	1797.033	7.190	.003	**
	Error(A)	2999.093	12	249.924			
	Days	273.944	3	91.315	1.660	.193	Ns
	days * Sample	1579.056	15	105.270	1.914	.055	Ns
	Error(B)	1980.000	36	55.000			
Chloride	Sample	2542.267	5	508.453	.945	.487	Ns
	Error(A)	6457.648	12	538.137			
	Days	375.275	3	125.092	1.378	.265	Ns
	days * Sample	570.797	15	38.053	.419	.963	Ns
	Error(B)	3266.969	36	90.749			
Sulphate	Sample	5389.979	5	1077.996	.043	.999	Ns
	Error(A)	300125.319	12	25010.443			
	Days	22111.002	3	7370.334	3.435	.027	*
	days * Sample	20461.294	15	1364.086	.636	.826	Ns
	Error(B)	77246.650	36	2145.740			

Ns Not Significant ($P>0.05$) ****** Significant at 1% level ($P < 0.01$) ***** Significant at 5% level ($P < 0.05$)

Except in mud containers, the mean average value of calcium was shown to decrease with the number of days the water was stored compared to the water evaluated prior to the procedure of water storage.

Calcium levels in water varied with storage container ($F= 7.190$, $P<0.01$, significant at 1% level). It did not change with the number of days the water was stored ($F=1.660$, $P>0.05$, Ns). There was no significant difference in the level of calcium with the interface between the containers used for storing water and the number of days the water was stored.

The significance of the difference in the means based on the chloride content presented in water stored in various water storage containers was computed. Based on the statistical findings, there was no significant relationship between the water storage containers, (F=.945, P>0.05, Ns) the number of days the water was stored (F=1.378, P>0.05, Ns) and the chloride concentration in the drinking water. The interaction between the water storage containers and the amount of days the water was stored with the chloride level was similarly not significant (F=.419, P>0.05, Ns).

It is inferred from the study result that we could see the level of sulphate decreased in all the storage containers on the 5^{th} day of storage and then it steadily increased with the number of days the water was stored for its consumption. The ANOVA to test the significance difference was initiated and revealed that there was no significant difference in the materials of water storage container and sulphate content in the sampled water. The degree of sulphate present caused a significant variation in the frequency of water storage (F= 3.435, P<0.01, significant at 1% level) with the level of sulphate present was obtained. It was also noted that the interaction between the number of days the water was stored and sample containers based on sulphate content was not significantly different (F= .636, P>0.05, Ns).

As a result, the ***Hypothesis*** H_04.***(c), which asserted that "The chemical properties such as iron and chloride content of water in different containers that has been stored during distribution cycle would not meet the quality standards set for its use", was rejected .***

H_04.***(b) The chemical properties such as hardness, alkalinity, calcium and sulphate content of water in different containers that has been stored during distribution cycle would not meet the quality standards set for its use", was accepted.***

iii. Biological properties of stored water

Biological parameters of the drinking water were assessed to determine the effect of different water storage vessels on the purity of water that was portrayed in Table. 27.

Table: 27. Analysis of Biological Parameters of Water Quality Stored in Different Containers

Parameter	**Types of water storage containers**	**Acceptable limits**	**Day 1**			**Day 5**			**Day 10**			**Day 15**			**Day 20**		
			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Total Plate Count (37 degree for 24 hrs)	Aluminium	< 20 CFU/ml	20	65	80	100	14	180	4	10	120	70	60	450	120	110	3900
	Brass					-	-	-	-	-	-	-	15	-	4	20	18
	Copper					-	-	-	-	-	-	-	-	-	18	16	18
	Mud					150	210	80	330	220	210	350	225	1000	800	240	1100
	Plastic					35	60	150	40	80	160	110	90	1000	2500	260	2400
	Stainless steel					25	18	32	65	70	340	580	90	1800	700	120	3600
E.Coli (37 degree for 24 hrs)	Aluminium	Absence	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
	Brass					-	-	-	-	-	-	-	-	-	-	-	-
	Copper					-	-	-	-	-	-	-	-	-	-	-	-
	Mud					-	-	-	-	-	-	+	-	+	+	+	+
	Plastic					-	-	-	-	+	-	+	+	+	+	+	+
	Stainless steel					-	-	-	+	-	-	+	+	+	+	+	+
Coliforms	Aluminium	Absence	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
	Brass					-	-	-	-	-	-	-	-	-	-	-	-
	Copper					-	-	-	-	-	-	-	-	-	-	-	-
	Mud					+	+	+	+	+	+	+	+	+	+	+	+
	Plastic					-	+	+	-	+	+	+	+	+	+	+	+
	Stainless steel					-	-	-	+	-	-	+	+	+	+	+	+

Primary Data; - indicates absence + indicates presence T1 – Trial 1 T2 – Trial 2 T3 – Trial 3

The purpose of the presence-absence test was to determine if an organism was present or absent rather than to quantify the concentration of microorganisms in a sample, particularly in a sample of drinking water. The test was used to evaluate samples (100 ml in a single culture container) collected every 5 days and stored at home for a total of 20 days to determine biological parameters. The same mode was followed with the analysis during the multiple storage trials. Overall, three experiments were conducted using storage water analysis to evaluate the presence of microorganisms.

Water for consumption could become polluted at the source or during storage. Despite the fact that water storage was a suggested technique of water purification, contamination of treated or disinfected water could occur during storage owing to inappropriate management. As a result, maintaining the quality of drinking water throughout storage was critical for safety as opined by Mohanan *et al.* (2017).

Mahajan, Pate and Sharma (2022) highlighted the practice of storing water in a copper vessel overnight and consuming it in the morning for various health advantages recommended by Indian Ayurveda. Copper has antimicrobial, anti-inflammatory, antioxidant, and anti-carcinogenic properties. Brass containers was used to store water for millennia, and doing so is also believed to be healthy. The zinc and copper found in brass are thought to promote immunity and protect against sickness. People nowadays keep water in containers made of plastic, steel and other materials that lack antibacterial and purifying qualities. The usage of traditional storage containers such as copper and clay pots was decreasing. People tend to rely on sophisticated techniques and processes for water purification rather than simple and inexpensive traditional methods. Therefore, this analysis was intended to determine the impact of different storage vessels on the purity of water and there by protect and promote the human health.

In accordance with the findings of this investigation, the quality of water held in brass and copper was superior to other containers like as aluminium, mud, and stainless steel. As a result the predicted ***Hypothesis*** $H_0$4.***(e), which claimed that "The biological properties of water in different containers that has been stored during distribution cycle would not meet the quality standards set for its use", was accepted.***

D. Water Consumption Analysis by Micro Components

The descriptive analysis findings (Table: 28) revealed that 66.69 per cent (483.57 ± 236.83L) of total water use was utilized for activities such as laundry, bathing, and toilet flushing. About 19.33 per cent of available water was used for cooking and washing utensils. Other fundamental tasks such as drinking and brushing utilised just 2.90 per cent (19.82±8.96L) of the water. The remaining water (10.94%) was used for outside home activities such as gardening, vehicle washing, and other reasons.

Table 28: Descriptive Analysis of Water Usage

Activities	N	Minimum	Maximum	Mean	Std. Deviation
Cooking (litres/head/day)	30	1.32	12.50	4.5687	2.22262
Drinking (litres/head/day)	30	1.67	7.50	3.7058	1.56474
Bathing (litres/head/day)	30	20.80	59.23	38.3161	8.79153
Brushing (litres/head/day)	30	.50	2.38	1.4114	.44334
Toilet flushing (litres/head/day)	30	11.88	80.00	42.1661	15.80437
Washing clothes (litres/head/day)	30	6.92	120.00	46.2562	25.28857
Washing utensils (litres/head/day)	30	4.58	56.40	31.5382	14.86783
Gardening (litres/head/day)	23	.50	100.00	15.4772	22.76670
Washing vehicles (litres/head/day)	10	2.40	15.00	7.5733	4.06712
Pets care (litres/head/day)	8	.10	1.67	.9500	.58905
Others (litres/head/day)	30	.33	30.00	8.4633	7.04226
Total Water spent per head/per day (in litres)	30	65.92	378.00	191.0695	55.23153

The findings showed that the highest quantity of water was consumed in bathrooms and toilets. It was evident that higher consumption of water for bathing indicated that the households used overhead showers in a majority of the houses. Leakages in pipelines or in showers could result in wastage of water. Hence, people using overhead showers must adopt a cautious attitude. To minimise water waste, pipes must be monitored for leaks on a regular basis. Similarly, toilets consumed a lot of water. Leakage in flush tanks could result to substantial amounts of water being wasted. As a result, water-saving devices and fittings were advised.

The study showed that a considerable quantity of water was used for washing the clothes manually and it was necessary to buy water-efficient washing machines. Based on the findings, it was proposed that individuals be made aware of the need of utilising water-efficient equipment. Water conservation techniques, such as reducing shower times, limiting the quantity of water spent on gardening and vehicle washing, and establishing systems for rainwater collection, must be disseminated to the general people.

Table 29: Difference in Water Consumption between Traditional Method and using Labour-saving Devices for Performing Selected Activities

Activities	Mode of Usage	N	Mean±Std	F	p
Washing Machine (L)	Hand	10	204.8±88.98	8.972	0.001**
	Semi-automatic	13	195.077±74.43		
	Fully automatic	7	66.271±31.57		
Washing Machine (%)	Hand	10	25.602±5.09	25.567	0.000**
	Semi-automatic	13	28.025±5.58		
	Fully automatic	7	10.636±5.27		
Flush (L)	Traditional	8	104.563±49.22	-3.301	0.004**
	Western	22	182.648±75.16		
Flush (%)	Traditional	8	14.907±5.4	-4.657	0.001**
	Western	22	25.16±5.14		
Type of Flush (L)	Manual	8	104.563±49.22	3.579	0.042*
	Single flush	16	181.109±75.56		
	Dual flush	6	186.75±81.05		
Type of Flush (%)	Manual	8	14.907±5.4	14.355	0.000**
	Single flush	16	23.903±4.95		
	Dual flush	6	28.51±4.36		

** - Significant at 1% level (P < 0.01) * - Significant at 5% level (P < 0.05)

The ANOVA results (Table. 29) illustrated that there exists a significant difference between the consumption of water using traditional techniques and labor-saving devices (p<0.05). The result demonstrated that traditional hand washing consumed more water (M= 204.8±88.98 L) when compared to semi-automatic (M=195.077±74.43L) and fully automatic (M=66.271±31.57L) washing machines and the difference was significant (F=8.972, p<0.01). This highlighted the need for efficient, fully automated washing machines to reduce water waste when washing clothes. When compared to water consumed by western flush systems, traditional flushing dramatically reduced water usage in toilets (F=-3.301, p<0.01). Significant difference was also observed in the consumption of water while cleaning manually, using single flush, and dual flush (F=3.59, p<0.05). It was found that the consumption of water was the least in the manual method and the most in the dual flush method. This result confirmed the higher consumption of water in western flush systems as the need arises to flush twice or thrice to flush out the solid waste.

Based on these results, it could be inferred that manual flushing consumed lesser quantity of water per head when compared to single flush and dual flushes. Fully automatic washing machines consumed lesser quantity of water when compared to manual and semi-automatic machines. Based on these findings, ***Hypothesis 5, "The amount of water consumption differed for selected activities using traditional (manual) methods and labor saving devices", was accepted.***

Table 30: Difference in the Usage of Water between Paid Assistant and Homemaker

Major Water used Household Activity	Paid assistant (N=16)	Homemaker (N=14)	t	p
Washing Clothes	204.613±100.65	170.146±105.2	0.895	0.379 Ns
Washing Utensils	199.625±65.56	153.915±81.55	1.637	0.115 Ns

Ns – Not Significant (P>0.05)

Plate 12: The Juxtaposition of the Two Scenarios - Water Usage by Paid Assistant and Homemaker

The findings of the t-test (Table. 30) demonstrated that there was no significant difference between the homemakers and paid servants with the amount of water consumed for washing clothes and utensils (P>0.05), thereby suggested that water consumption for household chores did not vary between homemakers and paid assistants. Hence, ***Hypothesis 6, "There was no significant difference between the quantity of water used for household chores by homemakers and paid assistants", was accepted.***

Phase III: Knowledge Germination and Dissemination

Ordonez and Serrat (2017) described knowledge dissemination as the process of communicating information to various target audiences in order for that information to be used in a way that brings about change. Water demand management interventions took the form of public notices published on websites and in news articles, urging the general public to use water responsibly (Rola *et al*. 2018). The following is a discussion on the implementation of the programme for the distribution of knowledge entitled "Community Vision on Water Management Practices" and the findings that were acquired during this part of the research:

A. Effectiveness of the knowledge dissemination programme on residential water management, and
B. Comparison of behavioural attitude scores before and after the knowledge dissemination programme

A. Effectiveness of the Knowledge Dissemination Programme on Residential Water Management

Conduct of the Knowledge Dissemination Programme

The knowledge dissemination session was planned and conducted in Coimbatore city. Ward Number 35 and 42 from the West zone were selected for the knowledge dissemination programme. Amid an increase in COVID 19 cases throughout the nation, the awareness session was carried out through virtual mode.

Based on the willingness the homemakers expressed during the household survey (purposive sampling), contacted, and requested their consent to find their willingness to participate in the water management knowledge dissemination program. Out of the contacted homemakers, 101 individuals expressed a strong interest in taking part in the programme. Only 65 individuals were able to engage in the online knowledge dissemination programme, because, the remaining 37 were either unavailable or unable to devote any time to it. Besides, some of the homemakers were not aware of the procedure involved in attending through virtual mode. It was planned that the programme to disseminate knowledge on effective domestic water management would take place for two sessions, each of which would last for three hours on a day that was convenient for the homemakers.

Behavioural Change after Knowledge Dissemination Programme

The effectiveness of the knowledge dissemination programme for the transmission of information was determined by analyzing the response of homemakers to a series of questions about their behaviour in matters pertaining to the use of water within the context of a household. In order to find awareness on effective residential water management a checklist was developed, which consisted of 14 questions using 5 point Likert scale ranging from Strongly Agree (5 points) to Strongly Disagree (1 point) along with seven general questions.

Additional research was conducted to assess the level of awareness regarding water conservation and behavioural attitude towards water management among the selected homemakers based on the total score obtained from the statements not only before the execution of the programme, but also three months after the programme had been put into action.

Exhibit 4: Written Material - ***Brochure Developed***

The responses of the homemakers both before and after the intervention programme on the topic "Community Vision on Water Management Practices" are listed in Table: 31**.**

Table 31: Homemaker's Responses before and after the Knowledge Dissemination Programme

Awareness Statements		**Attitude Scale (N=65)**					
		SA	**A**	**U**	**DA**	**SDA**	**T**
1. The provided drinking water was of excellent quality.							
Before	No. (%)	3 (4.6)	33 (50.8)	23 (35.4)	5 (7.7)	1 (1.5)	65 (100.0)
After	No. (%)	3 (4.6)	33 (50.8)	23 (35.4)	5 (7.7)	1 (1.5)	65 (100.0)
2. It was necessary to purify the provided drinking water before consumption.							
Before	No. (%)	12 (18.5)	28 (43.1)	13 (20.0)	12 (18.5)	-	65 (100.0)
After	No. (%)	12 (18.5)	28 (43.1)	13 (20.0)	12 (18.5)	-	65 (100.0)
3. The quantity of drinking water supplied was adequate.							
Before	No. (%)	14 (21.5)	38 (58.5)	6 (9.2)	5 (7.7)	2 (3.1)	65 (100.0)
After	No. (%)	14 (21.5)	38 (58.5)	6 (9.2)	5 (7.7)	2 (3.1)	65 (100.0)
4. Excessive use of water for domestic activities.							
Before	No. (%)	8 (12.3)	29 (44.6)	15 (23.1)	12 (18.5)	1 (1.5)	65 (100.0)
After	No. (%)	-	1 (1.5)	4 (6.2)	43 (66.2)	17 (26.2)	65 (100.0)
5. Children at home were known to waste water irresponsibly.							
Before	No. (%)	14 (21.5)	36 (55.4)	15 (23.1)	-	-	65 (100.0)
After	No. (%)	2 (3.1)	-	6 (9.2)	33 (50.8)	24 (36.9)	65 (100.0)
6. Water was in great demand in homes with young children and senior citizens.							
Before	No. (%)	12 (18.5)	37 (56.9)	11 (16.9)	5 (7.7)	-	65 (100.0)
After	No. (%)	12 (18.5)	37 (56.9)	11 (16.9)	5 (7.7)	-	65 (100.0)
7. Due to the assistance of hired labour, excessive amounts of water was utilised							
Before	No. (%)	8 (12.3)	19 (29.2)	20 (30.8)	7 (10.8)	11 (16.9)	65 (100.0)
After	No. (%)	8 (12.3)	19 (29.2)	20 (30.8)	7 (10.8)	11 (16.9)	65 (100.0)
8. Installing water flow control devices could conserve water.							

Awareness Statements		Attitude Scale (N=65)					
		SA	A	U	DA	SDA	T
Before	No. (%)	11 (16.9)	30 (46.2)	13 (20.0)	10 (15.4)	1 (1.5)	65 (100.0)
After	No. (%)	16 (24.6)	43 (66.2)	6 (9.2)	-	-	65 (100.0)
9. The replacement of high-tech appliances with older ones may be a way to save water.							
Before	No. (%)	6 (9.2)	20 (30.8)	32 (49.2)	7 (10.8)	-	65 (100.0)
After	No. (%)	6 (9.2)	20 (30.8)	32 (49.2)	7 (10.8)	-	65 (100.0)
10. Regular efforts were made to save water at household level.							
Before	No. (%)	2 (3.1)	13 (20.0)	14 (21.5)	23 (35.4)	13 (20.0)	65 (100.0)
After	No. (%)	21 (32.3)	31 (47.7)	13 (20.0)	-	-	65 (100.0)
11. Rainwater was collected for later use.							
Before	No. (%)	2 (3.1)	15 (23.1)	5 (7.7)	28 (43.1)	15 (23.1)	65 (100.0)
After	No. (%)	2 (3.1)	15 (23.1)	5 (7.7)	28 (43.1)	15 (23.1)	65 (100.0)
12. There were plumbing leaks in the water points and fixtures.							
Before	No. (%)	23 (35.4)	21 (32.3)	6 (9.2)	14 (21.5)	1 (1.5)	65 (100.0)
After	No. (%)	-	-	6 (9.2)	40 (61.5)	19 (29.2)	65 (100.0)
13. House water leakages will be repaired once identified.							
Before	No. (%)	4 (6.2)	15 (23.1)	7 (10.8)	27 (41.5)	12 (18.5)	65 (100.0)
After	No. (%)	24 (36.9)	35 (53.8)	6 (9.2)	-	-	65 (100.0)
14. Participating in these sessions will be beneficial for acquiring water conservation information							
Before	No. (%)	31 (47.7)	31 (47.7)	3 (4.6)	-	-	65 (100.0)
After	No. (%)	24 (36.9)	35 (53.8)	6 (9.2)	-	-	65 (100.0)

SA – Strongly agree; A – Agree; U – Undecided; DA – Disagree; SDA – Strongly disagree; T - Total

The results of the homemakers' reviews on the quality of drinking water distributed, the need for water purification, the method of water purification adopted, the sufficiency of water supplied, and the water usage behaviour when employed paid assistants to take up household chores did not show any difference between before and after their participation in the programme, as showed in Table: 30. It can be seen that among the total number of 65 homemakers, 1.5 per cent of the homemakers strongly disagreed that water was wasted before the knowledge dissemination programme. Similarly 44.6 per cent of people agreed water was wasted. However, after their participation in the programme, just 1.5 per cent of people believed that they were wasting water.

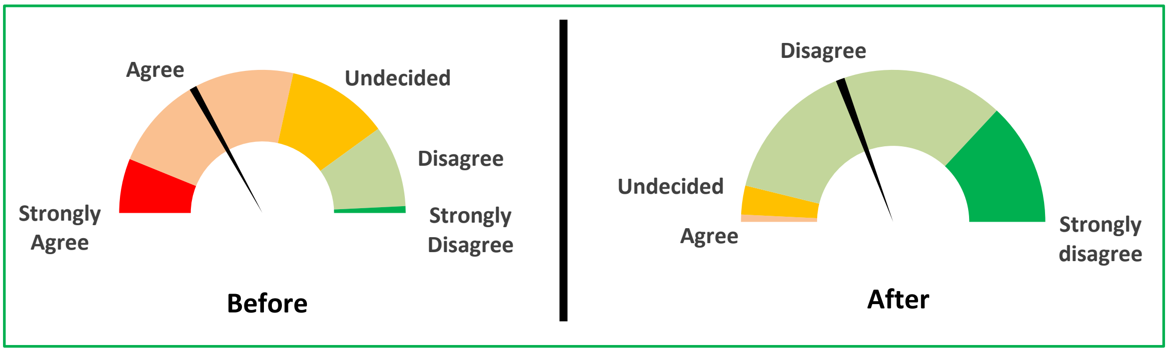


Figure 34: Water Wastage at Home Reported before and after the Knowledge Dissemination Programme

Figure 34 provided a graphical representation of the comparison between the reported water waste before and after the knowledge dissemination programme. During the pre-programme evaluation, a total of 21.5 per cent of the homemakers strongly agreed, while 55.4 per cent of homemakers agreed that the children in their homes wasted water while brushing their teeth, taking bath, and playing with water, which all contributed to the wasting of water. In contrast, only 3.1 per cent wastage was discovered after the programme due to the fact that the intervention took place through online platform made children also contribute towards resource conservation. This statement of review was shared by the benefited homemakers.

In response to the knowledge dissemination effort, 47.7 per cent of the homemakers agreed and 32.3 per cent strongly agreed that they were concerned with conserving water through minimising water waste. Presence of water leakages in the plumbing fixtures at home had reduced and moreover attending immediately to any reported water leakages was also the major water conserving behaviours acknowledged by the homemakers at the conclusion of the knowledge dissemination programme.

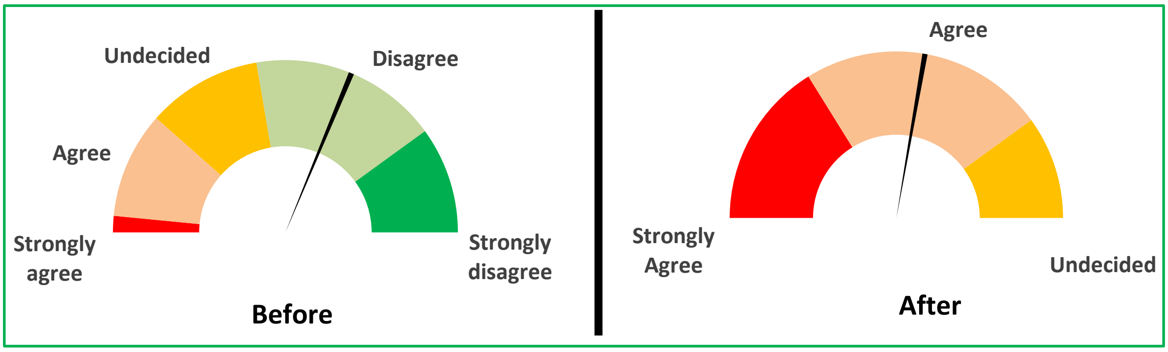


Figure 35: Habit of Saving Water Reported before and after the Knowledge Dissemination Programme

B. Comparison of Behavioural Attitude Scores before and after Knowledge Dissemination Programme

The ratings given by the homemakers were added to form the attitude scores for each homemaker, before and after intervention. Figure: 35 indicated the habit of saving water reported before and after the knowledge dissemination programme. The higher these scores are, the more favourable positive behaviour among the homemakers (participants). The descriptive analysis of the behaviour scores that were computed for each homemaker both before and after the knowledge dissemination programme may be seen in Table. 32.

Table 32: Comparison of Behavioural Attitude Scores before and after the Intervention Programme

			(N=65)
Description	**Mean**	**S.D**	**No.**
Behaviour score - Before knowledge dissemination programme	36.86	3.83	65
Behaviour score – After knowledge dissemination programme	42.40	3.21	65

The significance of the difference between the means was determined using a paired t-test. Behaviour scores before and after intervention with the help of checklist was analyzed. It was identified that the average score for behaviour before knowledge dissemination programme was 36.86, with a standard deviation of 3.83. After the intervention, the average score was increased to 42.40, and the standard deviation was 3.21. This point to the fact, that there was a shift for the betterment in the homemakers' behaviours related to water conservation. Based on the findings, it was concluded that there was a positive behaviour change among the homemakers who participated in the knowledge dissemination programme on the subject "Community Vision on Water Management Practices".

The pinpointing topics addressed by providing essential information regarding the fundamental facts on understanding water source, water's travel history till it reaches the containers, useful ideas on monitoring daily water consumption and minimising water usage resulted a shift in behavioural change. The result of the statistical study could be found in Table. 33.

Table 33: Paired Sample t-Test

Paired Sample t-Test (N=65)			
t-value	**df**	**Prob.**	**Sig.**
14.368	64	.000	**

** - Significant at 1% level (P<0.01)

It was obvious, based on the data showed in Table. 32, that there was a favourable shift in behaviour among the homemakers. This indicated that the participated homemakers obtained better awareness on water conservation behaviour and attitude after attending the knowledge dissemination programme. The level of awareness gained by the homemakers was significantly higher. There was a statistically significant difference in the behaviour scores before and after knowledge dissemination programme, as indicated by the derived t-test value of 14.368, which was found to be significant at a level of 1%.

From the result ***Hypothesis 7, which stated that "The knowledge dissemination session did not result in any noticeable changes in water-conscious behaviour among the sampled homemakers", was rejected.***

Phase IV: Designing the IoT Enabled AI System for Devising Water Conservation

The outcomes (design and the operational aspects) of this experimental research program were compiled and discussed under the following heads:

A. Conspectus Minutiae of the Invention
B. Invention's Detailed Picture
C. Block Diagram Representing the Thorough Architecture of the Invention
D. Novelty and Highlights of the Invention and
E. Honour of the Invention Acknowledged

A. Conspectus Minutiae of the Invention

The efficient management of water in the residential sector was a monumental problem for the general public. The main supply source was wasted and water waste was increasingly prevalent in houses. Consumers in today's society were always looking for new ways to make their lives easier. Monitoring the amount of water available was essential to safeguard the health of the planet and its continued viability over the long term. After engaged in this study and coming to the conclusion that water conservation should serve as the primary focus of efforts to alleviate water shortage, the researcher made the decision to develop an IoT Enabled AI system for devising water conservation. *Therefore, a mechanical prototype assembly, **"Jalaflux Espy",** was developed to monitor on a daily basis water consumption in each water outlet with the help of LCD and mobile application to compare data with the previous day water consumption as well.*

The prototype was designed to monitor and compare the water usage in the bathroom and kitchen. By employing the same technology, it may be able to monitor water use at all water outlets in a house. Using a web browser, it was possible to monitor the flow of water throughout the whole house and the water distribution network from any location.

Additionally, the mobile application had other features that allowed for the determination of the amount of water used at any given time and also enabled us to set a daily water usage limit. The user may choose a daily water usage limit, and when the limit was reached, the alarm triggered to indicate water leakage and alert the relevant personnel to get the taps fixed.

B. Invention’s Detailed Picture

The most important components to develop the prototype of the invention were as follows:

The ATmega328P is the basis of the ***Arduino Uno*** micro controller board had 14 digital input and output pins, six analogue inputs, a connection for USB, a power connector, an ICSP header, and a reset button. Additionally, it had a quartz crystal that operates at 16 MHz. The Arduino Uno was capable of communicating with a computer, another Arduino board, and other micro controllers.

As mentioned by Poonia *et al.* (2019), a ***solenoid valve*** was an electro mechanically controlled valve that controlled and measured water flow. Quick and secure switching, excellent medium compatibility of employed materials, long service life, low control power, high reliability and a compact design were all benefits of solenoid.

The connection of a 16-character, 2-line alphanumeric LCD was accomplished by the use of a single 9-way D-type connector. Because of this, the device was able to connect to the more number of the E-I/O Block's ports. In addition, the display called for a power source that was 5V. It was imperative to take precautions to avoid exceeding 5V, since doing so rendered the device inoperable. Either a 5V fixed and regulated power supply or E-blocks Multi programmer was optimized to generate the necessary 5V.

Significant use of both of these ***relay*** factors wereemployed during the course of this project. One was the trigger Voltage. This was the voltage necessary to activate the relay and switch to contact from Common $\rightarrow$ NC to Common $\rightarrow$ NO. The relay had a trigger voltage of 5V. Load Voltage and Current are the other factors.

Since the relay has a 5V trigger voltage, a +5V DC supply to one end of the coil and the other end to ground through a switch was used.

The 7805 IC ***Voltage Regulator*** was a circuit that changed the alternating current (AC) power source into a steady direct current (DC). Because the whole circuit was designed to operate on the 5V DC supply, the researcher needed to utilize an IC regulator rated for 5V DC.

An infrared sensor could measure an object's temperature and track its movement. All items emit heat radiation in the infrared spectrum. An infrared sensor was able to detect these sorts of radiations, which are invisible to the human eye (https://robu.in/ir-sensor-working/).

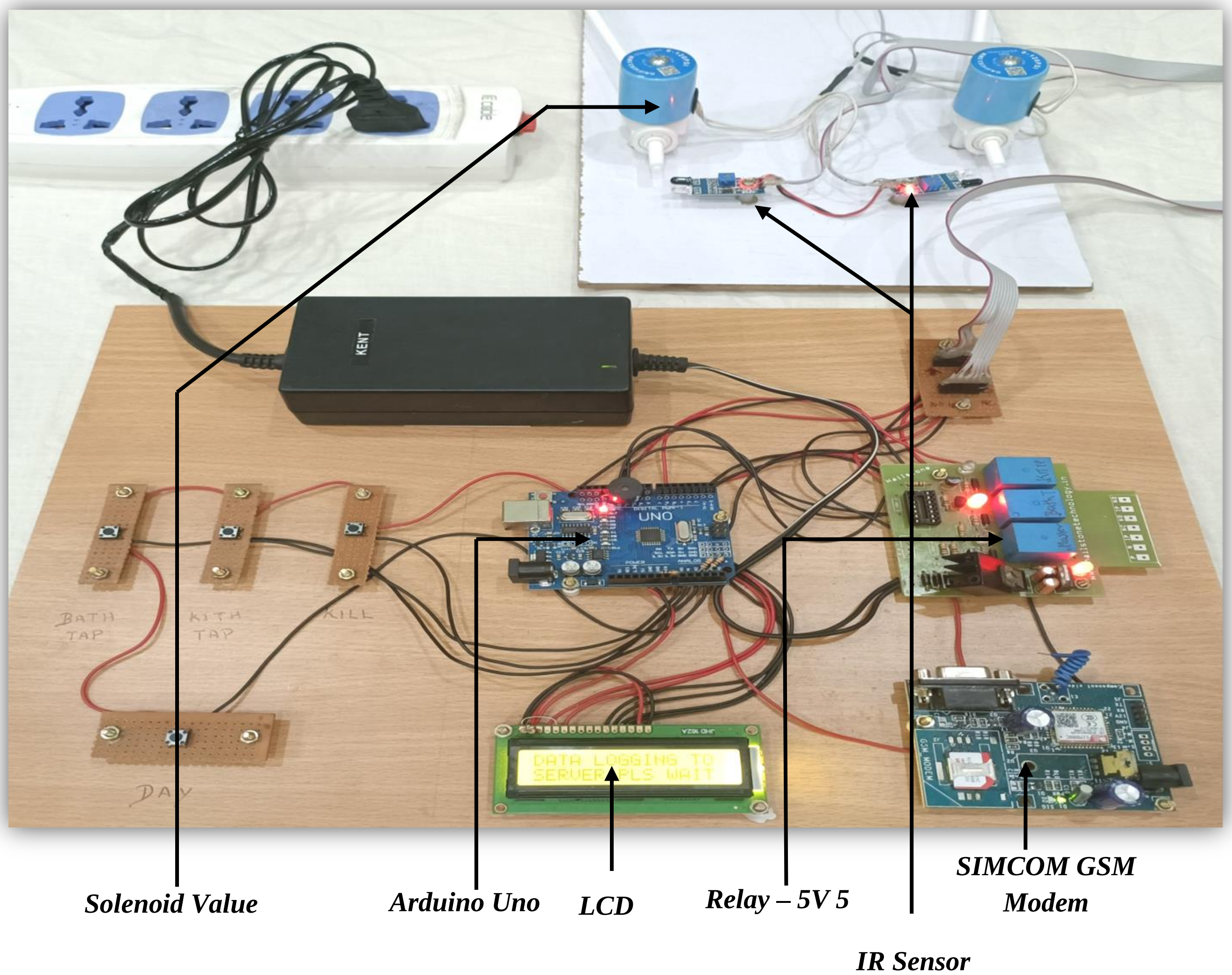


Plate 13: Components of the Mechanical Prototype - Jalaflux Espy (PATENT PUBLISHED)

This ***GSM Modem*** was capable of working with any SIM card that was issued by a GSM network provider, just as a mobile phone would with its own specific phone number. The ability to communicate and build embedded programmes was made possible by this modem's RS232 interface, which was one of the advantages of utilising this modem. Using this, it was simple to create applications such as SMS control, data transmission, remote control, and logging. It was also possible to use it in GPRS mode so that it may be connected to the internet and run a variety of programmes that record data and control devices.

The ***piezo buzzer*** created a buzzing sound that alerted the user to signal shut off water flow, that there was an overflow, or there was a leakage.

C. Block Diagram Representing the Thorough Architecture of the Invention

The schematic presentation of the block diagram that was built to depict the architecture of the system could be seen in Figure 36.

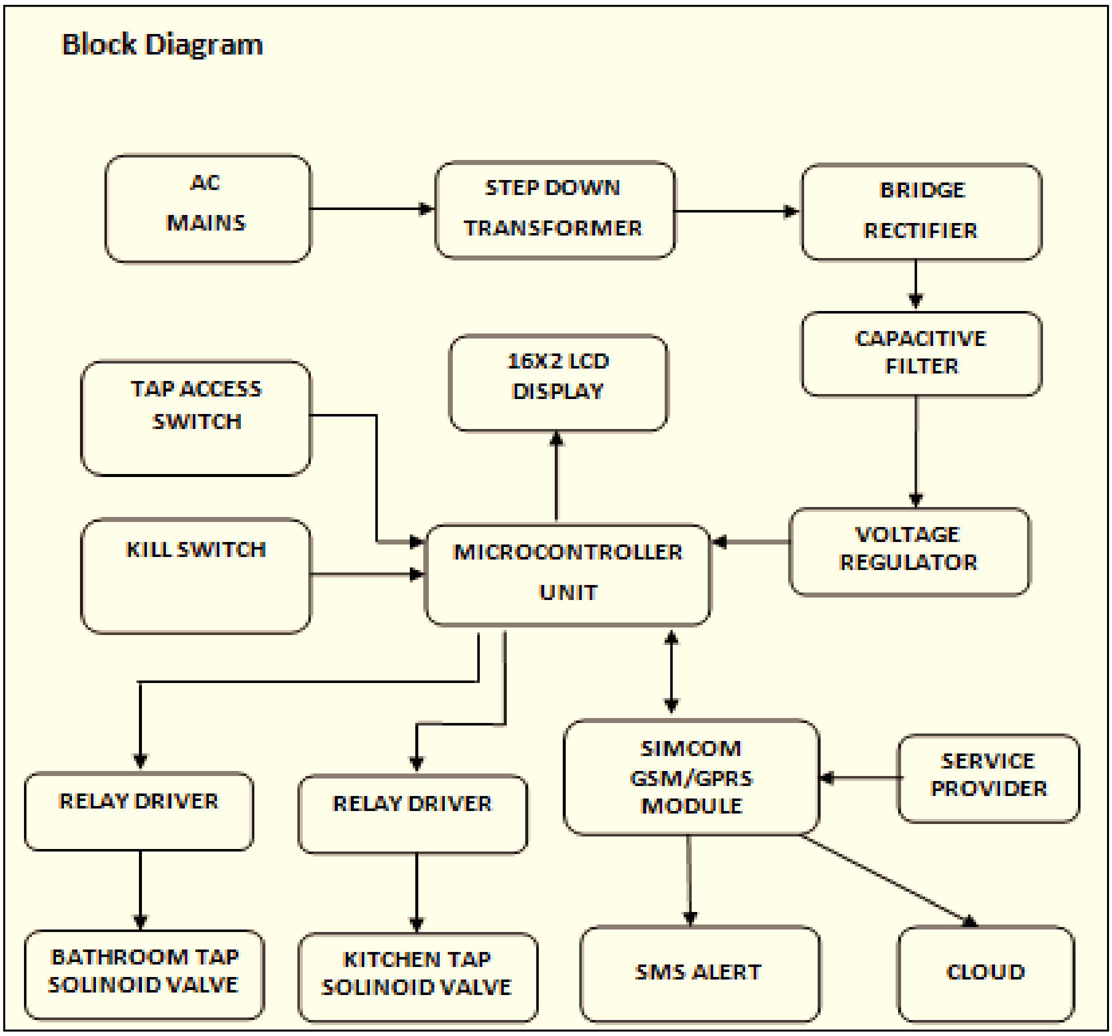


Figure 36: Block Diagram Representing the Thorough Architecture of the Invention

D. Novelty and Highlights of the Invention

IoT Enabled AI system for Devising Water Conservation was a mechanical assembly called **“Jalaflux Espy”,** in which the daily live water consumption in each water discharge pipe was monitored (Plate: 13). In addition to the feature of monitoring, comparing, detecting, and managing the water flow, this system acted as a good decision maker to auto cut off the water flow during unnoticed water flow or leaking from the taps. All the readings were displayed on the LCD screen at all times (Plate: 14). It also compared the data and the previous day’s water consumption rate (Plate: 16 & 17). Compared to daily water usage, the water pipes with the highest water usage would be notified by SMS and LCD to the registered mobile number and LCD (Figure: 37). When it was discovered that the water was discharging beyond the prescribed time, it would begin to buzz. If a continuous discharge of water is required, (Plate: 15) it is necessary to press the kill switch. Otherwise, unnoticed water discharge, even after sending the water wastage notification alert through mobile message and LCD, it would not wait until the individual sets right the water leakage (Plate: 19). Still, it would make the decision to cut off water dispensing, detecting the flow as water leakage adds to the uniqueness of this overall system. Although there were inventions in the IoT-enabled water management systems, this innovation had influenced artificial intelligence in deciding to shut off the water supply, preventing water loss.

- **Highlights of the Invention**

Many existing innovations would reduce water wastage, estimated the flow of water and track the quality of water. The data collected in the cloud provided real-time data/information of the current water usage, know the amount of water currently being utilized; also the total amount of water used per day and wastage of water could be noticed.

The existing systems could detect or monitor the daily water usage, or if any leakage was detected, it would give just the information. Until any personnel involvement, the leakage issue continues, resulting in considerable water wastage.

In addition, ***"Jalaflux Espy"*** was capable of monitoring the daily water consumption in each of the water outlet pipes, displayed the data in LCD and a mobile application, and the data collected (Figure: 38) could be compared with the water consumption from the day before as well. After providing the water wastage warning alert through mobile message and LCD, the system would not wait for the person to remedy the water leakage but would make the choice to shut off water dispensing, identifying the flow as water leakage, and therefore boosting the efficiency of the whole system.

Objectives of the Invention:

I. To keep track of how much water each water outlet uses every day,

II. To alert the user by tracking the comparative data (days/months) of water expenditure through SMS/alarm/display in LCD, and

III. Identify the water leakage in any water outlet, thereby activating the water supply's auto-cut-off mode.

Alert Warnings Displayed

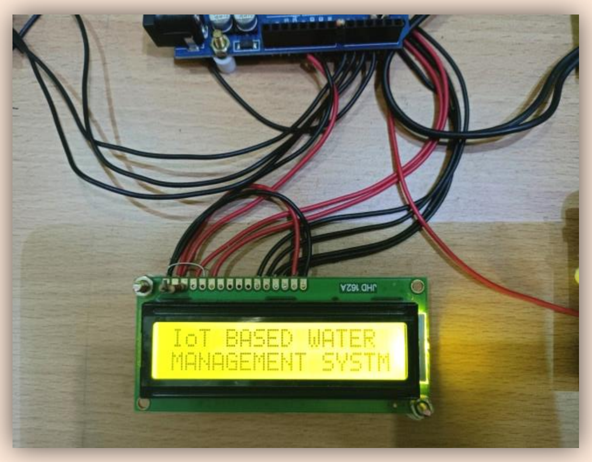


Plate 14: Welcome Message IoT Based Water Management System

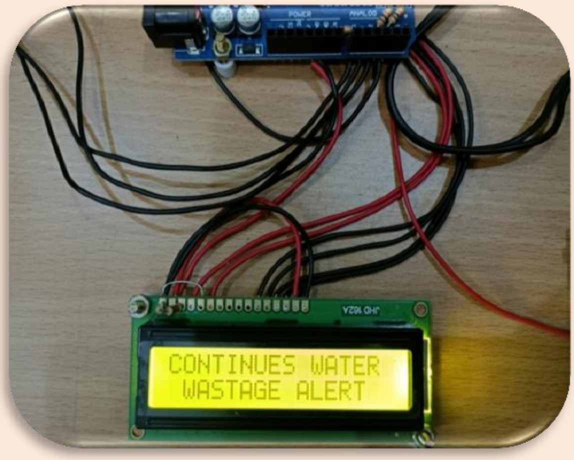


Plate 15: Continuous Water Wastage Alert

Plate 16: Day 2 Water Usage Data in Bathroom and Kitchen

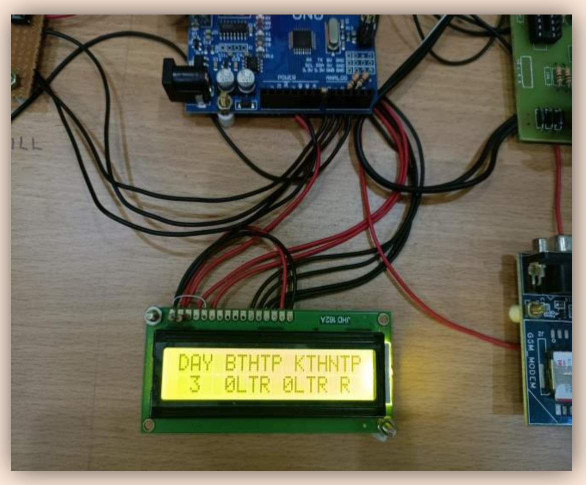


Plate 17: Day 3 Water Usage Data in Bathroom and Kitchen

Alert Indication Displayed

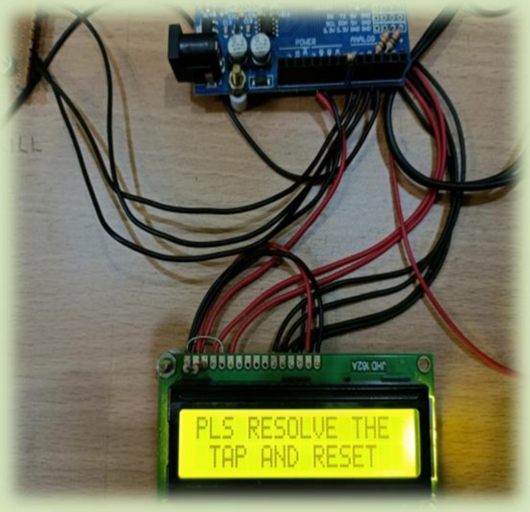


Plate 18: SMS Alert Sent Successfully **Plate 19: Pls Resolve the Tap and Reset**

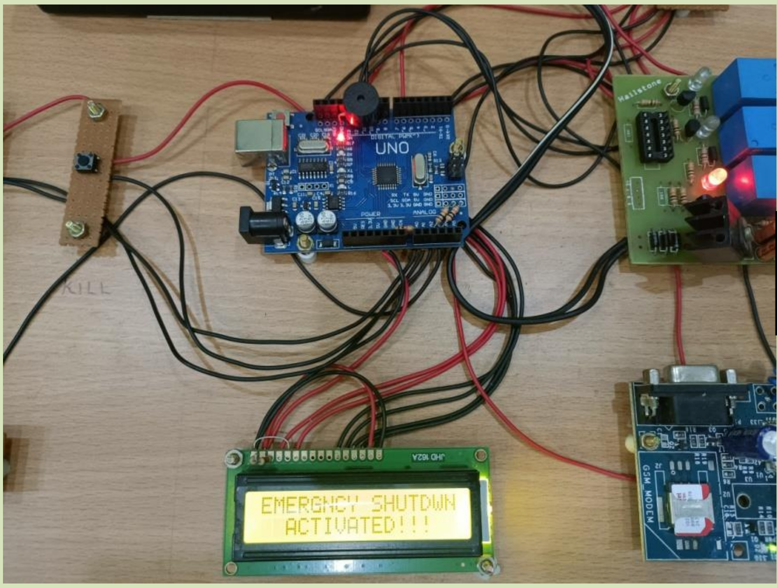


Plate 20:
Emergency Situation Activated

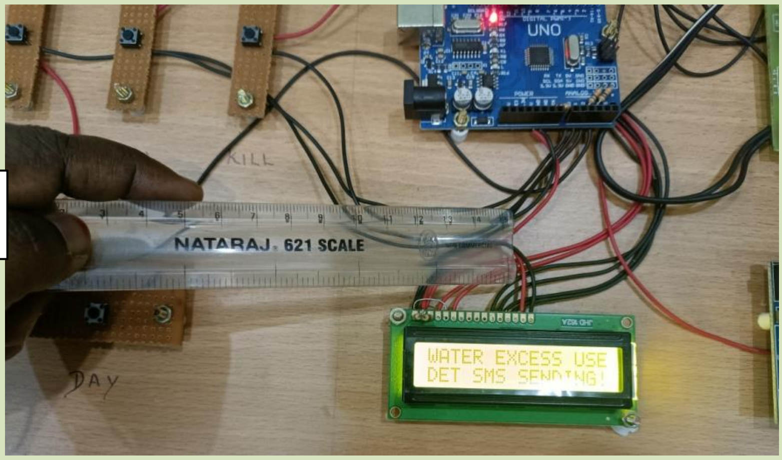


Plate 21:
Water Excess Use Detected

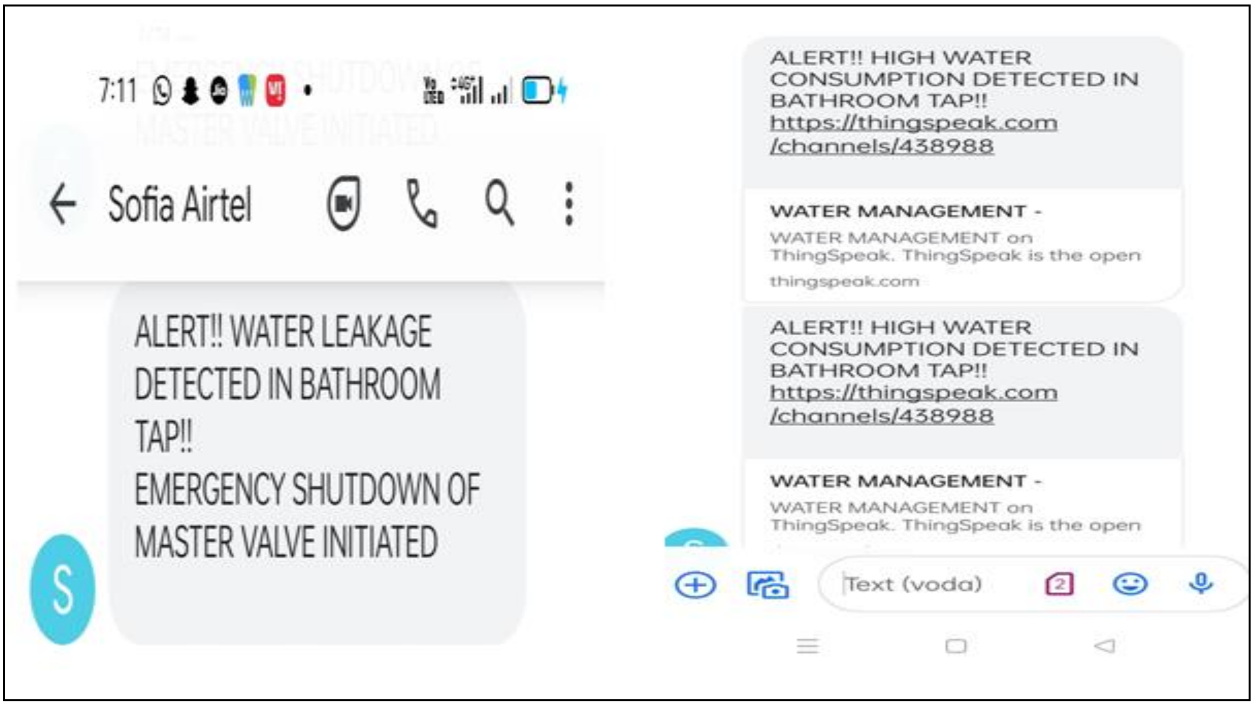


Figure 37: Alert through SMS

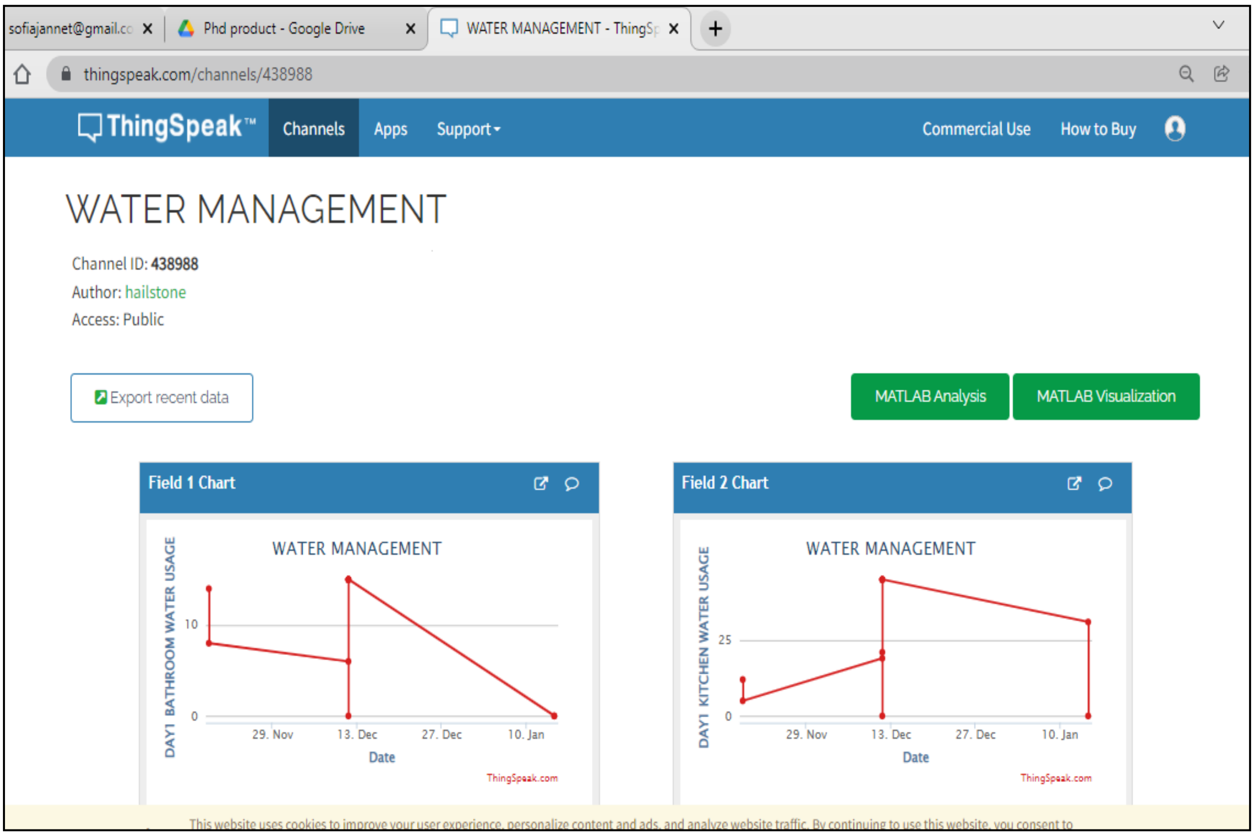


Figure 38: Data Stored in Cloud

E. Honour of the Invention Acknowledged

This invention has had one more feather in its cap after it was published for the approval of PATENCY by the Ministry of Commerce & Industry. This was evident from Figure 39.

4/17/22, 9:57 PM Intellectual Property India

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Figure 39: Honor of the Invention Acknowledged – Patent Published

Note: Patent Published

Name of the Invention – IoT Enabled AI System for Devising Water Conservation

Inventor: Dr.M.R.Thilakam

Co-Inventor: Mrs.J.Sofia Jannet