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EVALUATION OF WATER EFFICIENCY IN RESIDENTIAL BUILDINGS

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Abstract - *Water is a natural resource that is readily available for the sustenance of living beings. The earth is filled with 71% of water, out of which only 3% of it is potable. But the requirement of water is increasing due to growth of population industrialization and urbanization. A report from WHO says that nearly one billion people lack access to clean water. A resource that was considered as plentiful once upon a time is becoming scarce. In order to meet this scarcity, available water must be managed efficiently. The present study mainly focuses on the analysis of water efficiency in existing buildings with a view to conserve water. Water utilization in thirty seven houses from different areas is analyzed to arrive at an index that defines its utilization. The areas are chosen in such a way that they vary from each other by way of availability of water and its utilization. From the analysis made, the following conclusions have been arrived at:*

1. Water savings for the thirty seven residential buildings works out to 10.56% on an average based on Water (conservation) Index and Indian Green building Council (IGBC). On Retrofitting and replacement there is a possibility to achieve even higher efficiency.

Keywords: *Water (conservation) Index, Retrofitting.*

1. INTRODUCTION

Water originating from precipitation of clouds on hills and Plains, melting of glaciers and getting stored in lakes, rivers, ponds and streams are called surface water and that stored below the sub surface is called ground water. Water also gets stored in the fracture of rocks below the sub surface in hard rock region and in void space in sedimentary rock region.

Water is obtained from the sources that could be tapped more easily and utilized for various purposes such as domestic, industrial, agricultural etc. Domestic consumption of water in buildings is for bathing, flushing, cooking, drinking and cleaning. The water consumption in each building depends on the type of fixtures used and it also depends on the usage of each person.

The demand for water varies in tandem with change in seasons, climatic conditions and availability. Wherever industrial areas are located on consideration other than proximal availability of water, water has to be transported over long distances to supply it to the industry and the nearby settlement involving spending of precious energy. The type of distribution and supply of water by the local bodies also leads to variation in the consumption pattern.

The demand level indicates the conservation level of water. To identify the water conserved in buildings. Evaluation of water efficiency in each building is to be carried out in accordance with the "Architecture and Building Research Institute" (ABRI), as this system prioritizes water conservation as one of its factors. This work aims at minimizing water consumption.

2. METHODS AND MATERIAL

2.1 STUDY AREA

The study area for the evaluation of water efficiency is selected from both rural and urban areas in the surroundings of Thanjavur City. KRJ apartment in Tiruchirapalli city with 10 apartments, ABA apartment in Mannarkudi with 7 apartments, Thanjavur city with 10 houses and Panayakottai village with 10 houses. The water efficiency for these 37 houses is evaluated using the WI and the amount of water conserved is calculated and the baseline is as per the Indian Green Building Council (IGBC).

2.2 WATER INDEX

This study is focused on the water conservation measures for buildings with the aim of providing a quantitative procedure for proving water-saving efficiency. The water conservation index is a ranking system for the adoption of water-conserving items, including water closets, urinals, faucets and baths, and for the reuse of rainwater and grey water [1]. The framework of the ranking and evaluation system is shown below in equation,

$$WI = a + b + c + d + e$$

WI: Water index of a green building's water resource indicator system.

a, b, c, d and e are water conserving parameters of water closets, urinals, faucets, baths and of the reuse of rainwater and grey water with the ranking value.

This Index varies between 2-9.

2.3 WATER CONSUMPTION AND CONSERVATION

The water demand and the actual water consumption of buildings are actually quite complex, not only because of the difference in building types, but also because even among buildings of the same type, individual buildings may differ substantially due to factors, such as building age, occupancy, density, etc [4]. This causes difficulty in accurately estimating water consumption. The following estimation procedure is used to calculate approximately.

$$WUI = P_{di} \times Q_{wi} \times F_{ri}$$

WUI= water consumption density per unit area of the buildings (m^3/m^2/year)

P_{di} = person density (person/m^2)

Q_{wi} = yearly water usage (m^3/person/year)

F_{ri} = occupancy rate (%)

Water Consumption evaluation

$$W_{ty} = A_f \times WUI$$

W_{ty} = Annual water consumption for each category of building (m^3 /year)

A_f = The floor area of a building (m^2)

WUI= water consumption density per unit area of the buildings (m^3/m^2/year).

Water Conservation

$W_{st} = W_{ty} \times (WI \div 9)$

W_{st} = the estimated quantity of building annual water conservation (m^3/year)

W_{ty} = annual water consumption for each category of building (m^3 /year)

WI= water index

BASELINE AS PER IGBC:

Table 1: Baseline for IGBC

Fixture type	Maximum flow rate / consumption	Duration	Estimated daily uses per FTE*
Water Closets (Full – flush)	6 LPF	1 Flush	1 for male; 1 for female
Water Closets (Half – flush)	3 LPF	1 Flush	2 for female
Urinals	4 LPF	1 Flush	2 for male
Faucets/ Taps	6 LPM	15 sec	4
Health Faucet	6 LPM	15 sec	1
Shower head/ Hand held spray	10 LPM	8 min	0.1

* FTE (Full Time Equivalent) represents a regular building occupant who spends 8 hours per day in the building. Part-time or overtime occupants have FTE values based on their hours per day divided by 8 [3].

3. RESULTS AND DISCUSSION

This study was carried out in the following manner:

i) Choosing Different cases reflecting different consumption patterns. These are urban apartment houses (10 + 7 = 17 houses), urban individual houses (10 houses) and rural households (10 houses).

ii) In each of these, actual daily consumption of water was calculated based on the plumbing fixtures, spacial area and no of occupants of each household / apartment.

iii) Water Index calculation has been carried out based on the ABRI standards.

iv) Those residences where consumption was on the higher side, suggestion for retrofitting the fixtures and consequent saving in consumption have been given.

v) In all, 37 residential buildings are analyzed from four different localities like Thanjavur, Panayakottai, ABA Apartment and KRJ Apartment. The quantity of water consumed per person will vary based on building category and time.

Table 2: Water Conservation range in m^3/year.

S.No	Area	Ranges of conservation m^3/year
1	Thanjavur	-117.44 to 91.22
2	ABA Apartment	78.6 to 139.5
3	KRJ apartment	-74.30 to 36.94
4	Panayakottai	-89.18 to – 40

Table 2 shows the water conservation ranges for all 37 houses.

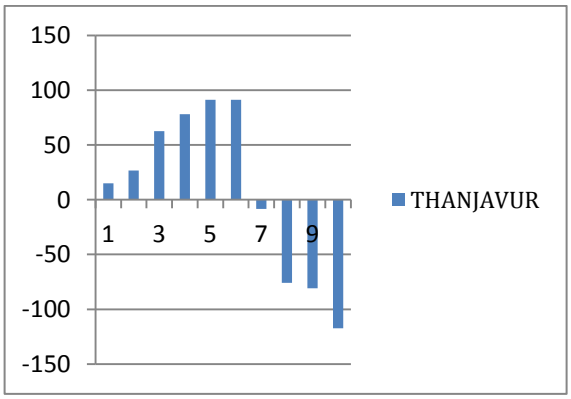

Chart 1: Water conservation for Thanjavur.

The conservation in Thanjavur ranges both in both positive and negative. The reason is based on Age of the building, type of occupants, types of fixtures used.

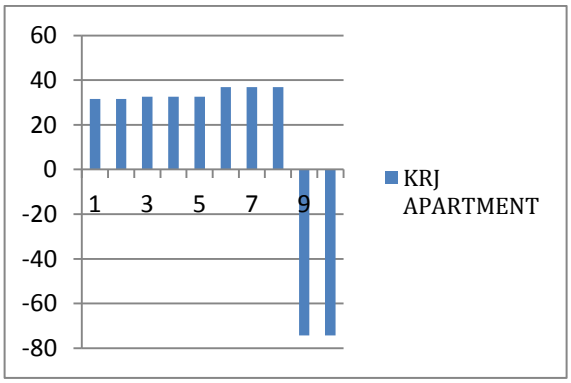

Chart 2: Water Conservation for KRJ apartment

The conservation in KRJ apartment ranging between 2 negative and 8 positive. The ranging is based on the fixtures used.

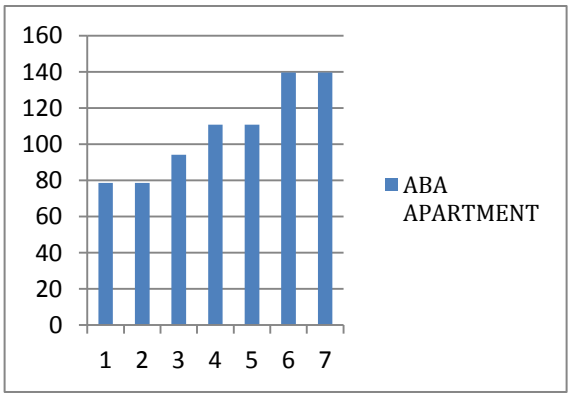

Chart 3: Water conservation for ABA apartment

The conservation in ABA apartment is positive. As it is newly constructed and the fixtures used are efficient.

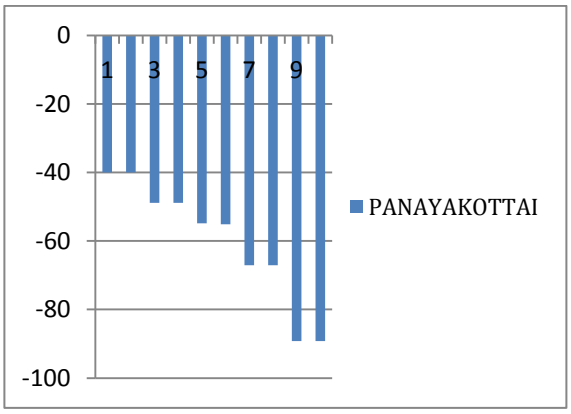

Chart 4: Water Conservation for Panayakottai.

The conservation values are completely negative as there is no consumption and the usage is higher.

Table- 3 Water conservation in %

House no	Quantity of water conservation m^3	Water conservation %
T-1	91.22	55.5
T-3	91.22	55.5
T-6	78.14	68.5
T-9	26.62	25.8
T-10	62.65	38.8
ABA-1	110.8	55.5
ABA-2	139.5	55.5
ABA-3	110.8	55.5
ABA-4	139.5	55.5
ABA-5	78.6	66.6
ABA-6	94.16	55.5
ABA-7	78.6	66.6

Table -3 list the houses where conservation is possible and the values are given both in quantity and percentage.

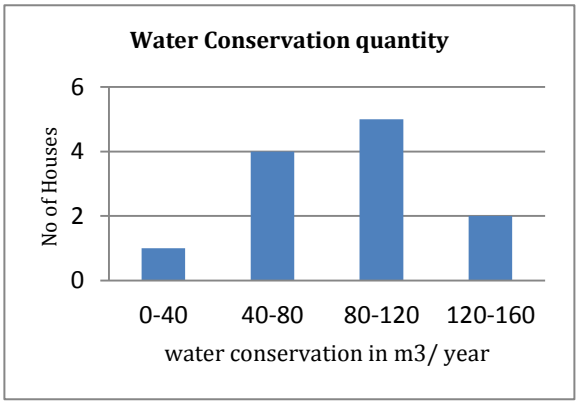

Chart 5: showing water conservation quantity.

Chart shows the water conservation quantity grouping them into four ranges. There is a possibility of conservation for four houses in the range (40 – 80 m^3) and five houses in the range of (80 -120 m^3) From the 37 residential buildings, 12 have a positive water saving system and the remaining 25 are negative. The probable reason for the range is:

i) Age of the building
ii) Type of fixtures used.
iii) Supplementation by ground water.

Table 4: Retrofitting option for water efficient plumbing [5]

Retrofitting option for water efficient plumbing				
Plumbing fixtures	Conventional consumption	1 star	2 star	3 star
Water closet	6 Lpf	4.8 Lpf	< 4.8 Lpf	< 4 Lpf
Urinals	4 Lpf	< 3.8 Lpf	<2.0 Lpf	<1.0 Lpf
Shower heads	10 Lpm	9.5 Lpm	7.5 Lpm	5.7 Lpm
Lavatory faucets	8 Lpm	8 Lpm	5.7 Lpm	5.0 Lpm

Table 5: Water saving % after retrofitting.

Area	1 star retrofit in %	2 star retrofit in %	3 star retrofit in %
Thanjavur	13.1	30.1	42.42
ABA apartment	0	18.6	33.1
KRJ apartment	24.1	39	49.98
Panayakottai	26.4	39.8	48.5

From the above table it shows that there is a possibility of water conservation with innovative fixtures based on the population and usage.

4. CONCLUSION

Water conservation is the main focus of this study as it is in great demand to access. The effective use of water resources is the need of the hour. The actual quantities of water consumed by buildings and their water-saving rate were investigated. According to the results, the average water-saving rate for 37 residential buildings, sampled from areas differing in supply and consumption characteristics was approximately 10.56 %. Further savings can be effected by retrofitting the present fixtures with efficient fixtures like aerators, low flow closets etc.

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