AWARENESS OF GROUND WATER RECHARGE & ITS IMPACT ON QUALITY OF WATER

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Abstract : *The fundamental goal of water quality monitoring and assessment is to determine if water is suitable for drinking, horticulture, and other uses. On the basis of some key properties of the water, the appropriateness of surface and groundwater for drinkable applications in terms of chemical quality must be interpreted and described. It is also necessary to study the impact befallen on the groundwater regime before and after the implementation of any kind of project to notice the changes occurring due to physical, chemical and biological interactions. With respect to their geochemical features, water bodies are constantly susceptible to dynamic state changes. Such changes are difficult to assess in case of groundwater as it is a hidden resource, and due to this feature, it is mandatory for us to observe such changes within the approachable time. Increasing groundwater withdrawals have resulted in freshwater shortages in many parts of the world as a result of rapid industrial expansion, urbanisation, and increased agricultural productivity. In view of this, greater emphasis is needed on the studies focusing on the sources and impact of groundwater recharge. The present study was taken up with the objective of assessing the groundwater recharge and its impact on the groundwater quality of water.*

Keywords: *Groundwater Recharge, Water, Water Quality, Artificial Recharge etc.*

1. INTRODUCTION

Groundwater is located in the soil capillaries or in the pores and cervices of the sub-surface rocks. It is stored in underground aquifers. Groundwater is a vital and finite resource. It is part of hydrological cycle and is seasonally recharged through rainfall and other sources. It is an important source of drinking water in many regions of the world including India, more particularly in the regions with scarcity of surface water such as Rajasthan. It is more suitable to drinking purposes because of its stable quality than surface water and does not require any treatment. This is due to the fact that aquifers are frequently well protected by layers of soil and silt, which filter rainwater as it percolates through them, eliminating particles, numerous chemical elements, and pathogenic microbes. As a result, it is widely believed to be a relatively safe supply of drinking water.

Groundwater has been termed the "hidden sea", because of its large volume and invisibility. Because of this, its replenishment occurs slowly. Therefore, the importance of groundwater has increased phenomenally in our daily life.

It is assessed that around 65% of groundwater is utilized for drinking, 20% for agricultural and 15% for industrial purpose in the world. As per the United Nations Environment Program (UNEP), 33% of the total common people depend upon groundwater for drinking especially in India and China. The total population raises generally at the rate of 80 million every year. Because of the expansion in population, different style of water utilization was increased in the last 50 years. Consistently freshwater demand increased by 64 billion cubic meters. The lifestyle and sustenance style of individuals around the earth is the dominant fact in charge of the expansion in water utilization per capita.

Increased population, industrialization, urbanization, and agricultural growth have all had a significant impact on natural ecosystems and water quality in recent decades. As a result, increasing water contamination as a result of increased industrial, household, and agricultural activity is a serious concern in practically every developing country. Agriculture is the leading source of non-point source pollution in surface and groundwater around the water. Excessive use of fertilizers, herbicides, and pesticides, as well as the accompanying loss of water quality, are to blame for health issues. In developing Asia, distilleries are the most significant source of biological oxygen demand (BOD), followed by the textile and food industries.

2. WATER CONSERVATION STRATEGIES FOR OPTIMIZATION OF GROUNDWATER

The management of water resources has profound impact on society with regard to quality of life. Water conservation is the process of collecting and storing water from its different forms like rain, run-off, storm-water which otherwise goes waste for the later productive use. Since it is a low-cost solution to the water issue, water conservation has piqued academicians', institutions', professionals', and non-professionals' interest in recent years.

Techniques such as Rain Water Harvesting (RWH) and Artificial Recharge (AR) to groundwater are useful tools in water management since they directly assist society by alleviating the current and future generation's water problems to some extent. Rainfall harvesting is the process of collecting rainwater directly for beneficial use or recharging it into the ground to boost groundwater storage in the aquifer. Rain water harvesting has been done from the days of ancient civilizations in India and have had improvised methods with locally available materials.

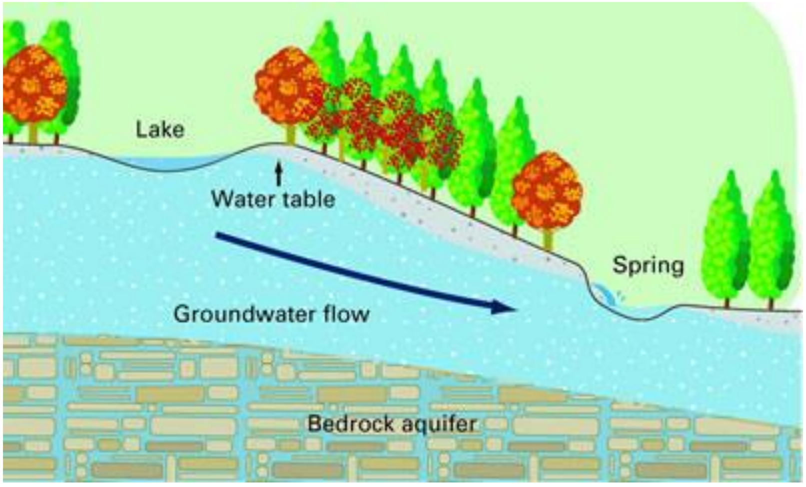

Figure 1: Groundwater Movement

The essential components of the hydrologic cycle and the link between climate, surface water, and groundwater are depicted in Figure 1.1. When rain falls and reaches the ground level, some water runs along the land surface as surface run off to streams or lakes; some water evaporates into the atmosphere, some is taken up by plants, and some seeps into the ground as part of the natural hydrological cycle. The word "groundwater" is appropriately pragmatic within this saturated zone. Groundwater is stored in aquifers, which are interconnected openings of saturated rock/soil beneath the land surface. Aquifers can be confined, which are generally bounded above and below by confining beds and occur at significant depth below the ground surface, or unconfined, also known as a water-table aquifer, which has the water table as its upper boundary and occurs near the ground surface.

Land use, as areas become urbanized, gets shielded with impermeable soil cover such as asphalt and concrete foundation, which tends to increase the surface runoff. The drainage of precipitation from catchments, which flows out through its natural drainage system, is known as runoff. Excess rainwater runs out through small natural channels on the ground surface to the main drainage channel after infiltration and other losses from the precipitation. Most water resources applications use runoff as one of the most essential hydrologic variables.

Many waters management and development challenges require accurate predictions of the quantity and rate of runoff from the land surface or any other source, particularly in metropolitan areas where difficulties such as water logging, storm-water drainage, and water scarcity are prevalent.

Percolation replenishes the groundwater supply naturally. However, due to indiscriminate city expansion and rapid urbanization, the exposed area for soil has been severely reduced, resulting in a reduction in rainwater percolation and depletion of groundwater resources. When the urban pressure exceeds recharge and the discharge is at its minimal, unlike the natural conditions when recharge and discharge are at par, the unsustainable groundwater conditions prevail.

For a given rainfall event, urban growth usually increases the volume and peak of direct runoff. Because storm water disposal is hastened, its travel time is minimized, resulting in shorter lag periods and concentration times. However, by increasing the area's storage capacity and delaying the flow of water, these effects can be reversed, and the peak of direct runoff can be reduced while the time it takes to occur can be increased. This can be done by installing detention storage or altering the terrain and sizing storm drains.

3. IMPORTANCE OF GROUDWATER RECHARGE IN INDIA

India is predominantly an agricultural country. Besides the introduction of high yielding crop varieties and use of fertilizer, the increased irrigation especially through shallow tube wells has played a pivotal role in enhancing the agricultural productivity and overall agricultural production of the country. A comparison of pre-monsoon 2014 groundwater status with decadal mean data (2004-2013) indicates that around 39 % of the wells are showing decline in groundwater levels in different parts of the Country.

Groundwater recharge is one of the water management techniques by which run-off water or excess water can be put into aquifer itself. It replenishes the groundwater reservoir. For recharging groundwater, one may use variety of methods such as well, ponds and pits. There are thousands of dug wells / bore wells / tube wells which are installed in alluvial area either gone dry or the water levels have declined considerably. Unused water well is also known as abandoned well, poses one of the greatest threats to groundwater as it provides a direct route for pollutants to reach an aquifer and under groundwater supply. However, these dry wells can be used as structures to recharge groundwater.

A. Artificial Recharge to Groundwater

Artificial recharge is the practice of increasing by artificial means the amount of water that enters a groundwater reservoir. Artificial Recharge is a practice done for replenishing water in the aquifers in any area where water is available in bounteous amounts in the form of runoff or where groundwater is depleting fast due to excessive groundwater development. Artificial recharge conducted for recharging groundwater is carried out from many years. Different kind of recharge structures are proposed in different areas by considering various factors including topography of that area, soil formations, geology and aquifer characteristics and quantity of water available for recharge. In general, any technique adopted to increase water in sub-surface zone by implementing recharge structures in the area is an artificial recharge system. Artificial recharge (sometimes called planned recharge) is a way to store water underground in times of water surplus to meet demand in times of shortage.

In the broadest sense one can define artificial recharge as any procedure, which helps to accelerate the process of natural recharge through percolation of either stored or flowing water which otherwise was not allowed to percolate in sub-surface regime due to increased paved structures or any other natural/manmade hindrance caused to the environment. Artificial recharge is beneficial in the regions where groundwater overdraft is more or in such areas where surface run-off is generated in large amounts; also, when available groundwater supply is insufficient to fulfill the demand of that particular area.

Source of water for artificial recharge could be rain water falling directly on the area; it can be run-off generated in any area or storm-water drainage accumulating in that area. But a quality factor of water being recharged is a matter of big concern. In such cases where qualitative aspect of water is not adequate or not known, there water is recharged by transferring from any other source or area

Assessment of the available sources of water would require consideration of the following factors:

- Quantity of water available for recharge
- Duration for which the water would be available
- Qualitative features of water to be recharged
- System required for bringing the water to the recharge site.

RESULTS & DISCUSSION

Estimation of groundwater recharge and its availability around the year is very important activity for efficient and sustainable groundwater resource management in a given area. The area designated as excellent for an artificial recharge zone has a high storability, a deep-water table, and sufficient water holding capacity for the construction of an artificial recharge structure. The thickness, depth of occurrence, and hydraulic characteristics of subsurface hydro geological units reveal the presence of unconfined and semi-confined in the research area. Because the discharge through a recharge well is a function of hydraulic conductivity, the thickness of different strata, radius of impact, well radius, and aquifer shape all play a role in determining the artificial recharge system's potential. Permeability of the surface and subsurface strata is required to maintain a high rate of infiltration during the artificial recharge phase. Both unconfined and confined aquifers can be found in the research region. Ability of recharge structure to store water is dependent on its working efficiency which is dependent on various factors to be considered while designing the artificial recharge structure.

A. Impact of Artificial Recharge Structures in Study Area: Quantitative Aspect

The depth to ground water table recorded over the period of project implementation compared with quantum of ground water recharge through the hydrographs and trend graphs and contour map representing changes in groundwater level trends of the study area. This interpretation was carried out by selecting 15 recharges well (representative observation wells) sites on the basis of their functioning and location in the study area. These wells revealed a stronger link between ground water table rise and ground water recharge initiatives. The purpose of the groundwater trend study was to determine the effectiveness of artificial ground water recharge activities on ground water levels and to get a better understanding of how recharge wells work. When calculating the influence of ground water recharge activity, the changes in stages of ground water development and consumption were also taken into account. As a result, conclusions were reached about the efficacy of artificial ground water recharge, which was found to be useful for replenishing ground water aquifers in the face of rising ground water tables. An assessment of changes in groundwater levels or monthly groundwater level was also done w.r.t rainfall to have proper insight of groundwater response to rainfall through implementation of these artificial recharge wells.

The impact of AR structures, as assessed through a few approaches in this study, is not uniform in all areas because of vast variation in hydro-geological setup in the study area, location of recharge wells and also mainly due to their maintenance. In places where the recharge structures are not well maintained, the recharge is minimal and also leads to water logging near recharge structures.

B. Water Level Trend

Trend analysis of groundwater levels was done by drawing hydrographs for the implementation periods and for the operational period of RWH and AR to know the fluctuation and its general trend. During the implementation period that is 2017, the slope is negative for all the sites indicating the declining trend of ground water levels and during the post implementation period that is 2018-2019, the value is positive indicating the rising trend/improvement of ground water level. Mapping was done for having clear picture of groundwater level trend in different zones of the study area between the pre and post implementation periods of the recharge structures.

C. Hydrograph showing Groundwater Level Trend

The perusal of above three groundwater level trend maps clearly indicates the positive impacts of artificial recharge measures adopted in study area. Year-wise groundwater level trend with their respective areas is given in Table 1

Table 1 Showing Change in Study Area and Percentage in Water Level Trend (2017-2019)

S. NO.	WATER LEVEL TREND (m/month)	YEAR 2017		YEAR 2018		YEAR 2019	
		AREA (sq km)	%AGE	AREA (sq km)	%AGE	AREA (sq km)	%AGE
1	-2.66 – -2.26	0.08274	5.30	-	-	-	-
2	-2.26 – -1.86	0.11897	7.62	-	-	-	-
3	-1.86 – -1.46	0.2798	17.91	-	-	-	-
4	-1.46 – -1.06	0.4758	30.46	0.009499	0.61	-	-
5	-1.06 – -0.66	0.31481	20.15	0.07755	4.96	0.03555	2.28
6	-0.66 – -0.26	0.2039	13.05	0.277424	17.76	0.51995	33.28
7	-0.26 – 0.00	0.08599	5.50	0.54845	35.11	0.6211	39.76
8	0.00 – 0.14	-	-	0.3389	21.70	0.2554	16.35
9	0.14 – 0.54	-	-	0.2814	18.02	0.13021	8.33
10	ABOVE 0.54	-	-	0.02878	1.84	-	-

D. Impact on Water Quality

Prior to study the Impact Assessment of any project, it is essential to identify the levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of such project. Various water quality parameters like pH, EC, TDS, Cl^-, F^-, NO_3^{2-}, Mg^{2+}, Na^+, K^+ were analyzed prior to the construction of artificial recharge project in the study area (Table 2). Around 7 water samples were taken from the working tube wells sourcing water to the study area.

Water quality analysis revealed that all the groundwater samples taken from tube wells present in and around the Panjab University Campus before the construction of artificial recharge structures were well within the permissible limits as per BIS, 2012 guidelines followed. As discussed in earlier chapter, there were no such voluminous variations occurred/observed in groundwater chemistry due to implementation of this project in the study area (Table 3).

After the analysis of water samples from the research area it was found that paltry impact is envisaged on the groundwater hydrology due to the construction of the project. Apart from domestic sources, there are no other sources of pollution observed in the project area. In order to have minimum impact on groundwater hydrology, the system should be suitably designed for such waste water if discharged in and around the campus. Adequate water supply for drinking or other usage to the students, faculty and residents is required at the project site.

Table 2: Results of Water Sample Analysis Collected from the Study Area (pre project)

LOCATION	Source	pH	EC	TDS	Cl	CO_3	HCO_3	Ca^{2+}	Mg^{2+}	TH	SO_4	NO_3	F	Na	K	PO_4
Nursery Sector	TW	6.40	429.00	270.00	3.23	0.00	52.50	39.87	21.75	137.00	3.93	7.42	0.16	4.50	47.10	0.07
Botanical Garden	TW	6.29	738.00	478.00	1.24	0.00	124.50	81.92	36.88	249.00	5.07	1.71	0.14	3.40	35.00	0.02
Swimming Pool	TW	6.49	454.00	168.00	3.23	0.00	36.50	34.82	18.33	117.00	2.06	1.38	0.15	6.70	53.00	0.05
Tube well	TW	6.57	259.00	362.00	2.93	0.00	97.00	42.53	29.04	163.00	4.18	3.82	0.55	6.40	25.50	0.01
Student Centre	TW	7.10	455.00	521.00	3.24	0.04	135.00	45.20	27.10	255.00	4.12	4.90	0.43	6.21	37.20	0.13
Minimum	-	6.29	259.00	168.00	1.24	0.00	36.50	34.82	16.14	111.00	2.06	1.38	0.05	3.40	18.50	0.01
Maximum	-	7.10	738.00	521.00	4.22	0.04	135.00	81.92	36.88	255.00	5.07	7.42	0.55	7.10	53.00	0.13
Average	-	6.66	446.43	330.86	2.90	0.01	92.07	45.82	25.37	170.71	3.90	3.82	0.22	5.66	36.43	0.05

Table 3: Result of Groundwater Quality Analysis for Pre-Project and Post-Project Period

S. No.	Parameters	BIS (2012) IS: 10500		PRE-PROJECT			POST- PROJECT		
		Desirable limit	Permissible limit	Average	Minimum	Maximum	Average	Minimum Value	Maximum Value
1	pH	6.5 – 8.5	6.5 – 8.5	6.66	6.29	7.10	6.60	6.13	7.07
2	EC	1500 µS/cm*			259	7.38	415.7	252	647
3	TDS	500 mg/l	2000 mg/l	330.86	168	5.21	266.33	162	414
4	TH	200 mg/l	600 mg/l	170.71	111	255	153.22	101	249
5	Ca2+	75 mg/l	200 mg/l	45.82	34.82	81.92	55.76	38.10	91.92
6	Mg2+	30 mg/l	100 mg/l	25.37	16.14	36.88	21.08	10.45	35.83
7	Na+	200 mg/l			3.40	7.10	5.50	-0.20	15.70
8	K+	12 mg/l		36.43	18.50	53.00	39.36	16.60	64.80
9	HCO_3-	500 mg/l*		92.07	36.50	135.00	50.90	25.25	71.25
10	-	250 mg/l	1000 mg/l	2.90	1.24	4.22	8.66	6.24	12.20
11	F-	1.0 mg/l	1.5 mg/l	0.22	0.05	0.55	0.10	-0.08	0.55
12	NO32-	45 mg/l		3.82	1.38	7.42	4.54	1.38	11.41
13	SO42-	200 mg/l	400 mg/l	3.90	2.06	5.07	4.13	1.80	8.26
14	PO43-	-		0.05	0.01	0.13	0.05	0.01	0.18

E. Social Survey on Panjab University Campus

A semi structured questionnaire having 15 multiple choice question was prepared keeping in view the objective of knowing public awareness of AR structures constructed, water quality and quantity changes, future management perspective of these structures from the residents and students (Table 4). The people and students were also informed about the working and significance of water recharge structures and how it is associated with groundwater quality and quantity. The data of the survey conducted were processed and the results were prepared using Microsoft Excel. Statistical analysis was done using different statistical techniques

Survey Results/Findings

- Total 927 people participated in survey positively and out of which 430 were residents and 497 were students of different educational level.
- For household survey, 475 residents were interacted and out of them 430 gave the proper response. Residents were categorized in 3 groups: Faculty/teaching staff, technical staff and non-teaching/lower working class and their population is given in form of pie-chart in Figure 2.

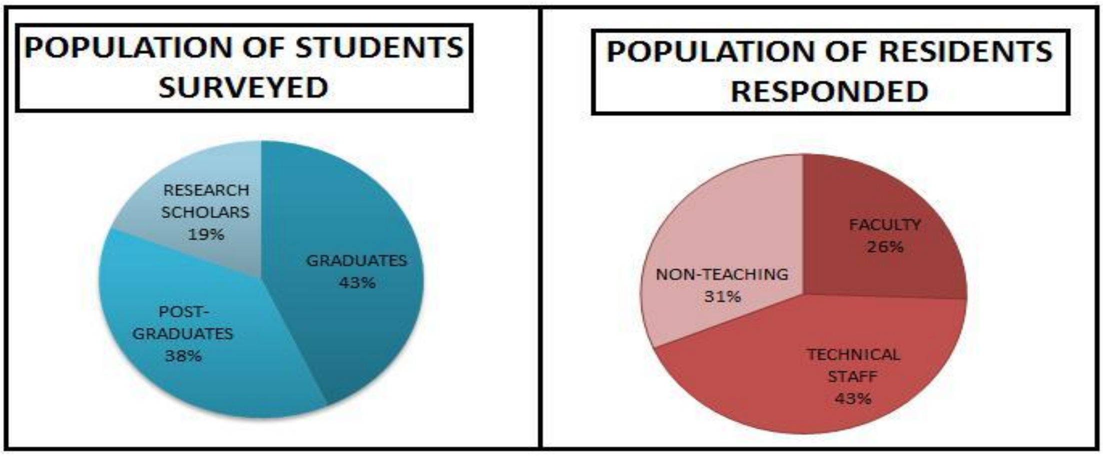

Figure 2: Percentages of Resident Population Surveyed

While 70 graduates out of the total student's population, who took the survey, were having only concept awareness, 67.4% were not at all familiar with this technology. Among the post-graduates (188), the 28.1% were having concept awareness and 71.8% of students were unaware about the prevailing structures in campus, its technique and even unknown about benefits. 94 research scholars were interacted, only 24.4% was aware and 75.5% failed to give positive response against the expected result. Figure 3.34 gives the details of the literacy percentages in the survey population.

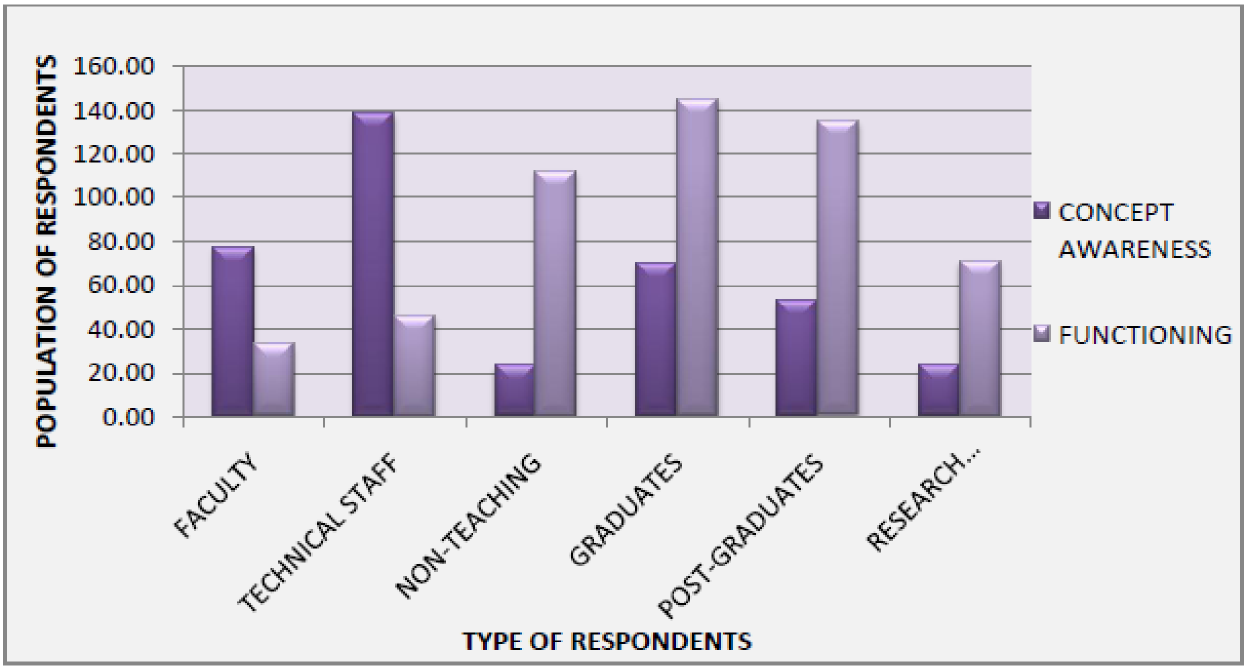

Figure 3: Distribution of Respondents on the Basis of Knowledge Regarding AR

Table 4 Details of the Survey Conducted with respect to AR

S. No.	Type of Question/ Problem	YES	NO	NIL
1	People who were aware about the source of their household drinking water supply. Tube well /Municipal Corporation/Groundwater.	899	11	17
2	People who mentioned about inefficient water supply/water crisis problem.	922	-	5
3	People who mentioned about an objectionable taste/odor in the drinking water supply in past 3 years.	8	919	-
4	People who were aware about AR scheme implemented in your area	314	560	53
5	People who were aware that rainwater and water recharged by AR is fit for drinking.	217	419	291
	People who Were aware about the functioning/technique and benefits from AR scheme adopted.			
	People who mentioned that water logging problem is resolved in their area.	777	47	103
8	People who consider AR implementation in houses are very expensive.	813	63	51
9	People who were in favor that AR scheme adopted can resolve the water scarcity/water logging problem.	577	154	196
10	People who believe that responsibility of maintenance and management of AR structures built in campus is of construction office and also of every resident.	336	442	149
11	People who were aware about the future perspectives of AR scheme.	325	391	211
12	People who accepted that such water conservation techniques should be adopted Nationwide and can resolve water shortage problem.	456	189	282

The following conclusions were made from the survey conducted:

- Most people (96.98%) knew about the source of their drinking water supply, while 3.02% did not know about the source.
- Around 99.46 % people who mentioned about inefficient water supply/water crisis problem and only 0.54% didn't responded.
- Around 0.86% people complained about objectionable taste/odour in the drinking water supply in past 3 years.
- Only 23.41% of the people were aware about AR scheme implemented in Panjab University, Chandigarh and 60.41% were not aware about this project implementation and around 5.72% failed to respond.
- Only 23.41% respondents who accepted that rainwater and water recharged by AR is fit for drinking. Others 45.2% and 31.39% had concerns about the quality of water alterations and health of their families hence denied this aspect.
- Only 34.63% people who were aware about the functioning/technique and benefits from AR scheme adopted and 46.82% and 18.55% were lacking much information.
- Out of 927 respondents 83.82% people who mentioned that water logging problem is resolved in their area and other 5.07% and 11.11% found this is not a major problem.
- Almost 87.70% population considers that AR implementation in houses involve high expenses and 12.3% was not having any estimate regarding economic aspect.
- 62.24% respondents were in favor that AR scheme adopted can resolve the water scarcity/water logging problem in the area and 16.61% opposed this fact and 21.14% were not clear.
- Only 36.25% respondents who believe that responsibility of maintenance and management of AR structures built in campus is of construction office and also of every resident and 63.75% consider it to be maintained by relevant authority only.
- Out of total population only 35.06% population was aware about the future perspectives of AR scheme and major portion of people surveyed were lacking such knowledge.

- Only 49.19% people who accepted that such water conservation techniques should be adopted Nationwide and can resolve water shortage problem and rest of 50.81% respondents due to lack of awareness and doubts about the scheme answered in opposite manner.
- More than half of the population surveyed was not having accurate information about this project and even there was lacking basic concept awareness among residents and students. There is need of awareness programme for successful and sustainable functioning of AR scheme in the campus.

CONCLUSION

In the present study an attempt has been made to provide a complete assessment of the prevailing groundwater and environmental conditions along with the suggestions and recommendations in order to evaluate the impacts of RWH and AR scheme on existing water regime of Panjab University campus. During the course of research, it was observed that the impact of such project is sustaining the groundwater scenario and helping to arrest the problem of declining water levels in the study area. While making any conclusions from this study, it would be essential to take into account the fact that the study was limited by time and the resources available. However, there have not been many studies to evaluate the impacts of RWH and AR, especially in urban environments. There is a need to develop a methodology to assess the impact of RWH and AR in urban environment. The study should have been conducted over a much longer period of time in order to get more input data to assess the environmental impacts of such type of projects in such an urbanized micro watershed.

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