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CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE GROUNDWATER MANAGEMENT IN PUDUCHERRY

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Abstract

Groundwater depletion has become a major issue in many regions of India, including Puducherry. The rapid growth of population and urbanization has led to the over-extraction of groundwater, resulting in a serious threat to the availability of water. In this study, the authors assess the current groundwater scenario in Puducherry, determine the per capita demand for water, evaluate the deficit groundwater, and analyze the key issues and challenges related to groundwater depletion, including the non-availability of sufficient water, lowering of the water table, reduction in other sources of water, deterioration of water quality due to saltwater intrusion, and land subsidence. The authors suggest solutions such as awareness programs for judicious use of water, stronger laws to minimize water wastage, and artificial groundwater recharge techniques based on soil type, hydro-geological factors, and climate. The authors also recommend building percolation shafts, run-off structures, increasing the number of recharging structures, and conducting further studies to deal with groundwater depletion. Without necessary actions, Puducherry may face a zero-day situation where people struggle for potable water. Therefore, an integrated approach is required to conserve and manage groundwater resources effectively.

Introduction

Groundwater is found beneath the Earth's surface. It is present within the pores of soil as well as the fracture and cracks of the rocks. It flows through the shallow as well as deep aquifers. It also seeps out through the springs, lakes, rivers. The groundwater is pushed due to force and moves under gravity in such a way that it enters through one end of the aquifer and exits through the other end. It is a known fact that groundwater is not as polluted as surface water as it passes through different strata of the soil.

The groundwater beneath the surface is classified into three zones namely vadose zone, capillary zone and zone of saturation. The vadose zone is also known as the unsaturated zone or soil-water zone. In the vadose zone, air

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occupies space between soil particles along with water. Hence, it maintains the same atmospheric pressure as outside. It is right beneath the ground and above the water table. The second zone is the named as intermediate zone or capillary fringe. It is right above the water table. Here, the groundwater fills the pores of soil due to capillary action. It also acts as a layer separating the water table and the unsaturated zone/vadose zone. Both the vadose zone and capillary fringe are termed as the zone of aeration as it is n ot completely saturated. The zone of saturation is also known as the
groundwater zone or phreatic zone. Here, all the pores are filled completely with water. The first major source is precipitation. The most common form of precipitation is rain and snow. The first shower of rainfall directly enters into the soil. In the later showers, some amount of rain infiltrates into the soil, some flow as run-off and others are accumulated in depressions.

Importance of groundwater

The importance of groundwater lies in the fact that it is the major source of drinking water, which is the least contaminated. It is the most dependable source of water among others. Groundwater has gained significant importance due to its availability and low cost of treatment. All the industrial sectors rely on groundwater for most of its processes. It fulfills most of the domestic and industrial requirements of the country. The hydrogeology of India is diversified and so is the groundwater behavior. Groundwater is extracted for various purposes such as for domestic use, agricultural use, livestock use, industrial use, and commercial use. Rural as well as urban areas heavily rely on groundwater for its day-to-day needs. In Puducherry, groundwater is utilized mainly for the domestic and agricultural use. Despite being such an important resource, it is being exploited every day. Groundwater is prone to get contaminated as surface water can easily percolate into it. Hence, it is necessary to protect it from being contaminated and depleted.

Groundwater depletion

Groundwater depletion is defined as the process of over-extraction of groundwater without replenishing it immediately. In simple words, it is a reduction in the volume of groundwater without considering its quality. In the case of coastal areas, groundwater depletion can be seen from a different perspective. The groundwater depletion may be defined as the reduction in usable water due to saltwater intrusion. Groundwater depletion has become a major concern over the years. Some regions in India are able to cope up with it while the others are soon going to have a water crisis. Hence, an integrated approach is required to deal with the water depletion and understand its key issues and challenges.

Scope and Objectives

1. To assess the present groundwater scenario.
2. To determine the per capita demand of water for various uses and the amount of water reaching the groundwater table.
3. To evaluate the deficit groundwater based on the water demand and the water recharged to the ground.
4. To analyze the key issues and challenges of groundwater depletion.

Methodology

The methodology consists of all the steps, which were followed, in designing the whole project. It starts with the literature review wherein the whole topic was broken down into segments and the literature was collected accordingly. The study area considered here is Puducherry district; hence all the data related to it such as rainfall, topography, population and so on were collected. Then, the next step was to calculate the water demand of the study area viz Puducherry district.

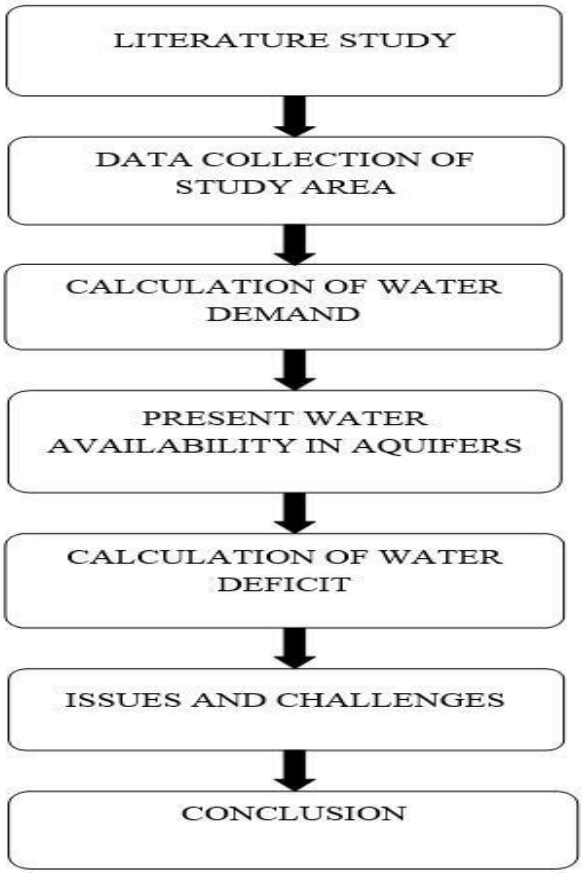

Fig 1: Methodology of the study

This was done using the geometric progression method. Five water demands were take into consideration namely domestic, livestock, agricultural, industrial and commercial. Based on the Government reports the calculation for future water demand was calculated. The calculation for domestic water demand was done using the geometric progression formula. And for the other demands, it was calculated based on the previous year data. Similarly, the present and future availability of water in aquifers were calculated using the previous data. Finally, the deficit was calculated. The key issues and challenges were discussed and the conclusion was drawn. Fig 1 gives the flowchart of methodology.

RESULT AND ANALYSIS

As mentioned in the methodology, the calculation of water demands was done based on the geometric progression formula and previous data.

DOMESTIC WATER DEMAND

Domestic water demand can be calculated by using the projected population. The projected population is calculated using the geometric progression method.

YEAR	POPULATION	GROWTH %	SOURCE
1991	6,08,000	-	1991 census handbook
2001	7,35,332	20	2001 district census handbook
2011	9,50,289	29	2011 district census handbook

Table 1: Population growth percentage in Puducherry The geometric progression formula is given as follows:

$P_n = P (1+ I_g / 100)^n$

Where,

P_n = Population at the end of the nth decade

P = Present population I_g = Geometric mean (%) n = No. of decades

Geometric mean $I_g = (20*29)^{1/2}$

= 2.4%

Using this formula, the projected population is given as follows.

YEAR	PROJECTED POPULATION
2021	11,78,358
2031	14,61,164
2041	18,11,844

Table 2: Year-wise projected population

Considering the water demand as 165 lit/cap/day, the projected domestic water demand is given as follows.

YEAR	PROJECTED DOMESTIC WATER DEMAND (MCM/YEAR)
2021	70.96
2031	87.998
2041	109.118

Table 3: Projected domestic water demand for future

INDUSTRIAL WATER DEMAND

There are 274 industries in and around Puducherry district. And the annual water demand in MCM comes to 0.01419 as per district irrigation plan. Based on the year-wise trend of industrial units registered, the growth percentage was taken as 14.8. The projected industrial water demand is given below.

PROJECTED INDUSTRIAL WATER DEMAN D			
Year	**Growth %**	**Growth factor per year**	**Demand**
2019	14.8	0.148	0.01419
2021	14.8	0.148	0.03
2031	14.8	0.148	0.20
2041	14.8	0.148	0.36

Table 4: Projected industrial water demand

AGRICULTURAL WATER DEMAND

The present agricultural water demand is 137.725 MCM/year. However, based on the yearwise season and crop pattern report, there has being a drastic decline in the cropped area.

Hence, the growth rate is taken as 0% and the present and future demand are taken as same.

LIVESTOCK WATER DEMAND

As we know that agricultural demand showed zero growth, the same can be applied in case of livestock demand. As both the demands are interlinked, the present livestock demand of 1.94 MCM/year is taken as the demand for the future as well.

COMMERCIAL WATER DEMAND

Commercial water demand was ascertained by the Public works department as 4.30 MCM/year. Taking the growth percentage as 2.4 the future demand was determined and it was 13.21, 57.24 and 101.27 MCM/year for 2021, 2031 and 2041 respectively.

The total year-wise demand for 2021, 2031 and 2041 are 223.865, 285.103 and 350.413 MCM/year respectively.

PRESENT STORAGE AND RECHARGE OF WATER

There are 609 ponds, 23 check dams, and 84 irrigation tanks in Puducherry. The rainfall infiltration rate excluding the built-up areas is around 42.62 MCM/year. Based on these details the total recharge of the aquifer was taken as 68.46 MCM/year. Once, the projected demand and recharge was calculated. The water deficit was calculated as follows.

YEAR	TOTAL DEMAND IN MCM/YEAR	TOTAL RECHARGE IN MCM/YEAR	DEFICIENCY IN MCM/YEAR
2021	223.865	68.46	155.405
2031	285.103	68.46	216.643
2041	350.413	68.46	281.953

Table 5: Demand V/s Recharge

From the above table, we can infer that the water demand will increase over the years, but with the current recharging methods, we will have a deficiency.

5.0 ISSUES AND CHALLENGES

The current groundwater scenario poses a number of issues and challenges for both the Government and people of Puducherry. In the near future, the water will become a luxury if the same trend follows. The issues and challenges pertaining to water deficit are as follows, ● Non-availability of sufficient water will lead to a major water crisis.

- Lowering of the water table will occur.
- There will be a reduction in other sources of water as well such as lakes, rivers, and streams.
- The existing water quality will deteriorate due to saltwater intrusion.
- With the increase in demand for water, the cost will also increase and hence time will come where consumers will have to pay more money to get fresh water.
- Land subsidence is the gradual settling of the land due to sub-surface movements. In this case, the depletion of groundwater will lead to sub-surface movements and thereby land subsidence will take place.

To solve the water deficit issue, artificial recharging techniques can be employed. However, even they have certain issues that need to be addressed. Some of them are listed below. ● The artificial groundwater recharge techniques should be employed based on the soil type, hydro-geological factors, and climate. Or else it may lead

to failure of the project. ● The water used for recharge should be pretreated or it may contaminate the groundwater. ● Before recharging, the water used for recharging as well as the native groundwater should be mixed together and tested so that if they react with each other, then the appropriate actions can be taken.

- Economical feasibility should also be taken into consideration
- Cultural and social acceptance needs to be considered before taking up a recharging project.
- The hydro-geology of aquifer should be studied before recharging takes place.

6.0 CONCLUSION

Groundwater depletion has become a major issue in our country. Awareness programs need to be conducted so that the people of Puducherry can understand the importance of water and can use it judiciously. Stronger laws are required in this regard so that minimal wastage of water will occur. Artificial recharging techniques need to be implemented in such a way that it is suitable for Puducherry and is economically feasible at the same time. If necessary actions are not taken then one day, Puducherry will have to face the situation of zero-day wherein the people will have to suffer and struggle for potable water. It is high time that we come up with solutions for the issues and challenges posed by the groundwater scenario in Puducherry. Some of the solutions, which can be provided, are building percolation shafts, run-off structures to conserve excess of water and increasing the number of recharging structures such as ponds, check dams and tanks so as to balance the water deficit. For bore wells greater than 200 feet, recharge shaft method can be adopted and for shallow bore wells, recharge pits can be adopted. Further study is required to deal with groundwater depletion.

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