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Research Article

STUDY ON SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF GROUNDWATER AT DOHNAVUR FELLOWSHIP AREA IN NAGUNERI TALUK, TIRUNELVELI DISTRICT, TAMILNADU

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A R T I C L E I N F O

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A B S T R A C T

There was a mounting concern on providing adequate water for Dohnavur Fellowship to support its orphanage, school and hospital, targeting 1500 inhabitants. Groundwater is the primary source of water for drinking, domestic and agriculture at the Dohnavur fellowship that covers 350 acres of land. The project area lies at the latitude of 8°27'N and longitude of 77°35'E in Nanguneri taluk of Tirunelvelli district in Tamil Nadu. The average annual precipitation is 840 mm. The Terrain comes in the catchment area of Nambiyar river basin, underlain by crystalline rock formation, consisting of the Archaean age of Gneisses, covered with Kankar formation. The whole area depends solely on ground water, extracted through open well and bore wells. Most of the open wells are abandoned due to increased number of bore wells in their surroundings. Increasing withdrawal of groundwater from neighborhoods and erratic monsoon resulted in lowering the water table in the fellowship area. The water level varies from 18 m to 21m at pre-monsoon period and 4 to 5 m depth at post-monsoon period. The Fellowship was struggling to provide water to its 750 school students, 500 orphans and about 200 patients in their hospital. The agricultural activities in 100 acre of land also started suffering water scarcity. Electrical resistivity survey was carried out (profiling and VES) to identify the potential zones based on which the recharge and discharge zones are identified. The thickness of layers and fractured pattern were identified. Based on all these findings, different artificial recharge measures are proposed with appropriate design. The water extraction and usage method have been modified and recharge measures are adopted in the entire campus area. All the bore wells and open wells are supported with appropriate recharge measures. Three of the abandoned open well has been converted into recharging wells. To reduce the overall water requirement of agriculture organic farming is adopted. Drip irrigation is being followed for plantation crops. Presently, System of Rice Intensification is being practiced to further reduce the irrigation requirement. As a result of minimizing water requirement, judicial extraction and maximization of recharging, the sustainability of groundwater is maintained.

INTRODUCTION

General

Hydrologic cycle - evapotranspiration, recharge and run-off

Water is one of the key elements that sustain all life on earth. Land plants access this water through the soil, but the rooting zone holds <1% of the globes water resources, the bulk being in the oceans (97%) and in ice (approximately 2%). Fortunately water continually moves freely between these pools via evaporation, condensation, precipitation, runoff and deep drainage, such that water lost from the rooting (vadose) zone by plant transpiration, evaporation or deep drainage is replaced annually by precipitation and recharge. On a global scale, about 65% of annual precipitation is returned to the atmosphere via evapotranspiration, the remainder contributing to recharge of aquifers or returned to the sea via runoff and lateral flows. For crops or vegetation systems, these processes can be considered in a "water balance". For example,

Precipitation (P) = Evaporation (transpiration + evaporation) + Runoff(R)+

Deep drainage (D) + change in soil water storage (ΔS).

Water, though occupies three fourth of the earths surface; the availability, safety, and judicial utility of groundwater has always been a challenge for the sustenance of the ecosystem and the humanity. The increasing need of the water has generated a strong demand for groundwater, especially in crystalline rocky terrains. Freshwater is the most important

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resource of life. Population growth in water scarce regions will only increase the value of the existing water. Groundwater constitutes only a small fraction of the total volume of water on Earth; yet it is of immense importance as the source for more than half of the global need of potable water. It is one of the components of the hydrological cycle, stored underground in geological layers called aquifers; it is a result of infiltration of rainfall and surface water, with which it maintains a close relationship. Aquifers present the advantage of having large to huge volume storage capacity with a very low flow and are easily accessed through dug-wells or bore holes, either pumped or flowing (artesian wells) or through springs. The importance of aquifers depends on the geological nature of the layers: for example, sedimentary formations represent good aquifers while hard rocks have a limited capacity for storage.

Need of the Study

The vagaries in monsoon and insufficient surface water flow conditions have lead to increase of agricultural and domestic extraction (Aravindan *et al*. 2004). The increase of human population and the economic activities has grown in scale; the demand for large scale supplies of freshwater from various competing end users has increased. In this existing scenario, an attempt has been made to understand the complexity of groundwater management with sustainability in the study area. The hundred year's old charitable organisation Dohnavur Fellowship covers 360 acres in Nanguneri taluk of Tirunelveli district in Tamilnadu has been selected to have a holistic picture.

Objectives

- To assess the availability and augmentation of water resources in the fellowship campus area.
- To understand the availability of water for agriculture purpose during water stress period.
- To generate a sustainable water supply and management system through proper rechargeable measures.

METEOROLOGY

The average rainfall is 847mm that precipitates in 56 rain days (from 13 years of data). The maximum of the precipitation with 60 to 65 % is received during the months of October and Novermeber as North-East monsoon. In South-west monsoon (July-August) period with 144 mm of rain is received which, contributes 18 % whereas the rest is received during the summer as convection rain (Fig.2.2). In summer 193mm is received, which is 21 % of the total rainfall. The area is drought prone, though it comes under foothills of the Western Ghats. From this it is clear that the rainfall is generally wide spread of distributional pattern. Normally the tanks were filled in twice in a year from North-East monsoon and convectional rainfall. For the past three consecutive years, there is monsoon failure and tanks are not filled to the required level. Depending on the rainfall, a range of recharge techniques has to be developed to harvest every possible form of water and recharge the aquifer effectively without any loss of water.

METHODOLOGY

Well inventory of existing wells

Inventory of existing well forms the basic procedure to be adopted to understand the past and present condition of the water level. Also helps to have over all idea about the terrain topography and its implications over the water level. Observation of the open wells and bore wells exhibits that there is a directly proportional relationship between the season and static water level in the study area.

Geophysical Resistivity Survey

Geophysical electrical resistivity method with Schlumberger electrode configuration was adopted for Profiling and Vertical Electrical Sounding so as to delineate groundwater potential zone. Vertical Electrical Soundings (VES) have been carried out with ABEM SAS 300B instrument (Fig. 3.1). The Schlumberger electrode configuration method was adopted for conducting the VES with a maximum spread of AB/2 = 100 to 200 m. The apparent resistivity of the sub-surface formation was determined. The spread is parallel to the strike of the rock and fractured pattern. The obtained field curves were interpreted by using Orellana and Mooney two layers Master curves and Auxiliary Charts method (partial curve matching). The resistivity sounding survey was carried out in the study area which covering major litho units.

VES Interpretation Procedures

Matching the measured curves with a set of theoretically calculated master curves was done by curve matching. The basic advantages of this method are; 1) the data can be plausibly referred to the number of layers for which the master curves are calculated.

Curves have been calculated for the electrode configuration in question. Except for the two layer case the master curves cannot be presented as single diagram covering all possible combination of the thickness and the resistivity parameters. Master curves are calculated assuming $\rho 1 = 1\Omega m$ and $h_1 = 1m$ are plotted double logarithmically.

Pump Test

The analysis of groundwater movement will be greatly simplified if the vertical flow components are neglected and the groundwater is assumed to move primarily in a lateral direction. Accordingly the following assumptions are made in the theory of groundwater movement.

1. The flow is horizontal and uniformly distributed in a vertical section.
2. The velocity of flow is proportional to the tangent of the hydraulic gradient instead of sine of the hydraulic gradient.

The above two assumptions are called Dupuit-Forchheimer assumptions. In addition, the derivation of the steady flow discharge equation generally assumes the following;

3. The well is pumped at a constant rate.
4. The well fully penetrates the aquifer (Equations can be derived for partially penetrating wells also).

Interpretation Procedure

Vertical Electrical Sounding (VES) or Depth Probing

The properties of the sub surface may be explored by two main procedures often called as electrical sounding (or drilling) and electrical mapping (or trenching). The objective of sounding is to determine the variation of electrical conductivity with depth. It is meaningful in areas where conductivity merely varies with depth and without lateral variation. It is assumed that the conductivity varies with depth only, due to this face the distance between current and potential electrode is increased; the current filaments passing across the potential electrodes carry the current fractions that returns to the surface after reaching increasingly deeper levels.

RESULT AND DISCUSSION

Geophysical electrical resistivity method is the most widely used geophysical tool for groundwater exploration in hard rocks so as to determine productive ground water zones at varying depth. Thickness of weathered zone estimation and depth of bedrock studies were carried out by using inverse slope and curve matching techniques in comparison to lithology data and the curve matching was found to give fruitful results (Sankaranarayana and Ramanujachary, 1967). Curve matching is adopted here with the objectives to delineate the thickness of the aquifer zones. The data analyzed by curve matching techniques for 37 locations have been compared. The layer parameters like apparent resistivity (ρa) and thickness (h) of different layers are arrived. Minor deviations due to subsurface discrepancies and the error in the field data is corrected by smoothening the field curve to have easy interpretation. More importance was given for thickness and resistivities of various layers. The values obtained by the manual curve matching were used for further studies since, the deviation was lesser. A maximum of 4 layers was identified in few regions; the major part of the study area is dominated mainly by 3 layers.

Groundwater Management

RESULT AND DISCUSSION

The safe yield may simply be taken to be amount of water that enters the groundwater basin every year.

Table No. 1 Water requirement at Dohnavur Fellowship
A) Domestic Water Requirements

Sl. No.	Area	Nos.	Litres per person per day	Total litres per day
1.	Fellowship inmates	450	150	67,500
2.	Residential School	750	135	1,01,250
3.	Residential staff	50	150	7,500
4.	Hospital bed	60	340	20,400
5.	0utpatients	350	10	3,500
6.	Separate washing & laundry	-	-	10,000
7	Construction and renovation works	--	--	5,000
8	Common Kitchen purposes	3	--	15,000
9.	Diary farm	70	50	3,500
10	Fodder trees	-	-	15,000
Total Requirement for domestic purposes per day				2,48,650

When the withdrawals exceed the long term mean annual recharge to the basin, the excess must come from the storage within the aquifer. Such permanent depletion is often referred to as mining of groundwater. In most basins the quantity of water in storage is many times the annual recharge. Therefore, in any one year the draft can exceed the recharge without causing permanent depletion. But on a long-term basis, if the draft exceeds the average annual recharge it becomes over draft.

Irrigation Water Requirement:

Total cultivable area – 110 acre
Cultivated area under Paddy – 50 acre
under Horticultural crops – 25 acre

Irrigation requirement of Paddy (Variety: ADT-36)-100 mm
Average Annual Rainfall -840 mm
Average Rainfall during Crop Growth Period - 570mm
Effective rainfall for irrigation (60% of total rainfall) -340 mm
Shortage of irrigation requirement -760 mm

Dependency on ground water for Paddy
(760 mm x 50 acre) = 15.2 ha-m **=152000 Cum**

Irrigation requirement of Horticultural crops -1200 mm
Average Annual Rainfall -840 mm
Average Rainfall during Crop Growth Period -840 mm
Effective rainfall for irrigation (60% of total rainfall)-500 mm
Shortage of irrigation requirement -700 mm

Dependency on ground water for Horticultural crops
(700 mm x 25 acre) = 7 ha-m **=70000 Cum**

Total Groundwater dependency extraction

Total Domestic Requirement met through Groundwater Sources

1.5 lakh L per day x 365 days = = **54750 Cum**

Total Irrigation Requirement met through Groundwater Sources
15.2 + 7) ha-m = 32.2 ha-m = **222000 Cum**

Total Groundwater Extraction = 276750 Cum
(50+25 acres)

25 acres are fallow

Availability Vs Demand

The details of groundwater availability through the existing sources and new sources and groundwater requirement for cultivation are given below:

Availability of Ground water safe yield condition (Cum per year)

Existing sources - 162207 Cum
New Sources - 63510 Cum

Total Available (presently) - 225717 Cum

Extraction of Ground water (Cum per year)

AVAILABILITY = 2,25,717 CUM for domestic

75 acres of traditional cultivation
Requirement = 2, 76,750 cum

CONCLUSION

The present study has the potential of being considered as an admixture of both experimental and experiential learning that could be replicated in order to ensure optimum utilization of available resources. This eventually would contribute to the development, application and management of water resource more scientifically and judicially to ensure sustenance of the ecosystem and humanity. There is potential for widespread drought to occur in conjunction with groundwater declines. If the impacts of intensive use are incremental, so too is recovery, but only if systems can be relaxed.

Recommendations

The results of this study suggest two broad avenues for future work. The first avenue involves the development of a detailed research programme to gather groundwater data directly from governments and other sources in order to develop an improved picture of groundwater use and conditions. This type of picture is a prerequisite for developing: (i) more informed assessments of the implications of groundwater conditions for food security; and (ii) scientifically founded courses of action for managing the resource base. The **second** avenue focuses on the development of adaptive responses to water problems and policy approaches that reflect and respond to uncertainty, change and the absence of real understanding of systems and their interactions. Inherent limitations in the nature of scientific information in conjunction with the dynamic process of social and institutional change occurring in many parts of the world make this second avenue at least as important as the first.

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