Evaluating The Impact of Hydrogeological set up on Percolation Tanks in Wagholi and Nerpingalai , Amravati District, Maharashtra.

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ABSTRACT

In India, percolation tank are known to have the potential to serve as one of the important type of artificial recharge structure. Despite water harvesting measures supported on a massive scale, groundwater levels are declining. New programmes are being implemented to improve artificial percolation whilst the impact of former measures on groundwater recharge is still undefined. Downstream impact of upstream watershed development becomes a key question for future programmes.

The present study focuses on integrated geological, geomorphological, hydrogeological and geophysical investigations were carried out at Wagholi and Nerpingalai percolation tanks in Amravati district Maharashtra. Geological studies indicated the usually the structure covers a single flow or sometimes spread over two flows. All the flows are simple AA flow and overlain by thin alluvium. The depth of weathering varies from 0.25 – 6.05m.

Geomorphological studies have been done on 1:50,000 scale using Survey of India toposheets and linear, aerial and relief aspects have been determined for each basin and interpreted for their controls of percolation tank sites. About 7-15 dug well has been selected around each structure and monitored for studying hydrogeological condition and determining the effective area by groundwater fluctuations. At each structure three vertical electrical sounding with AB/2 = 35 m have been carried out and interpreted by IPI2WIN software for layers and their resistivity. The mean resistivity for first layer at each site has been determined on upstream and downstream side. Ultimately an attempt has been made to integrate the collected data to determine the efficiency of percolation tank in the Deccan trap. It was found that low values of first layer resistivity on the upstream side in collaboration with high weathered zone, high drainage density, high drainage frequency, low length of overland flow and high ground water fluctuation favored the feasibility of percolation tanks in Amravati district, Maharashtra.

• INTRODUCTION

Groundwater has emerged as important resources to meet the water requirement of various sectors. Ground water tables are declining from 4-15 m below ground level in some parts of the state. The occurrence, movement and storage of groundwater within rock aquifers is quite complex and depends on several factors like geological, geomorphological and hydrological conditions. Though there is good rainfall, large amount of it is lost through runoff. The varied hydrogeologic conditions may prevent rapid infiltration into groundwater reservoir. There is thus an imbalance between recharge and groundwater development (Raju K.C.B, 1998) resulting in declining groundwater levels. This over extraction of groundwater resources has affected the agricultural economy and rural development. Realizing this many artificial recharge projects have been undertaken up by central and state groundwater department, in an attempt to recharge the depleted aquifers by spending huge amounts. To make the expenditure viable and have the sustainable development, it is essential that the sites and structures should be planned on sound scientific basis.

National Water Policy (2002) has identified conjunctive use of surface and groundwater as one of the thrust areas for sustained management of water resources in the country. In turn with the policy augmenting natural infiltration of rain water/surface water into underground storages by construction of conventional artificial recharge structures (like percolation tanks, kolhapur type weirs, underground bandhara, checkdams etc.) is being undertaken in different parts of the state by investigating mammoth revenues.

Effective groundwater management in any watershed or basin is purely based on the fact that how best one understands the natural environment in which groundwater occur and moves. Diverse physical conditions, including geological settings, geomorphological set up, hydrological and hydrogeological set up and geophysical conditions etc make generalization rather difficult. Such, integrated studies can provide useful information sustainability of artificial recharge structures.

• STUDY AREA

With the above aim in mind two percolation tanks, were selected from Amravati taluka, District Amravati, Maharashtra to evaluate their efficiencies in different hydrological, geomorphological, geological, hydrogeological and geophysical conditions in the region. Amravati District is situated in the northern part of the State and lies between north latitudes 20032' and 21046' and east longitudes 76037' and 78027' and falls in Survey of India degree sheets 55 G, 55 H, 55 K and 55 L.

• GEOLOGICAL SETTING OF THE AREA

To design a system for artificial recharge of groundwater requires permeable soil surface, greater infiltration rates of the soil and good unsaturated zone with adequate permeability. Knowledge of these conditions requires field investigations and hence geology of area where artificial recharge structures need to be constructed.

The study geological set up of Amravati district was undertaken by Geological survey of India in their operation Maharashtra programme, GSI (2001) and the district resource map provided by them.

The main formations in the Amravati Taluka are Archeans, Deccan Traps, Gondwana and Alluvium. Deccan Trap covers 75% of the area while 25% area is covered by Purna alluvium. Most of the area is covered by Deccan trap flows and Alluvium mainly occurring along the river channels and in the Purna river basin (Bhai and Saha (1989). The selected structures occur over Deccan trap formation. The Deccan trap formation consist number of lava flows varying in age from upper Cretaceous to lower Eocene period 65 +/-10 Million years ago.

Based on observation of lithologs and well sections, depth of weathering varies from 2.20 to 10.20 m. Geological studies indicated that usually the structure covers a single flow or sometimes spread over two flows. All the flows are simple AA flow and overlain by thin alluvium. The depth of weathering varies from thin about 0.5 m to 8.5 m. Numbers of field traverses were taken to evaluate the geological conditions at the artificial recharge sites and the geological map of Two percolation tanks were slightly modified after GSI (2001) and presented in figure No.1.

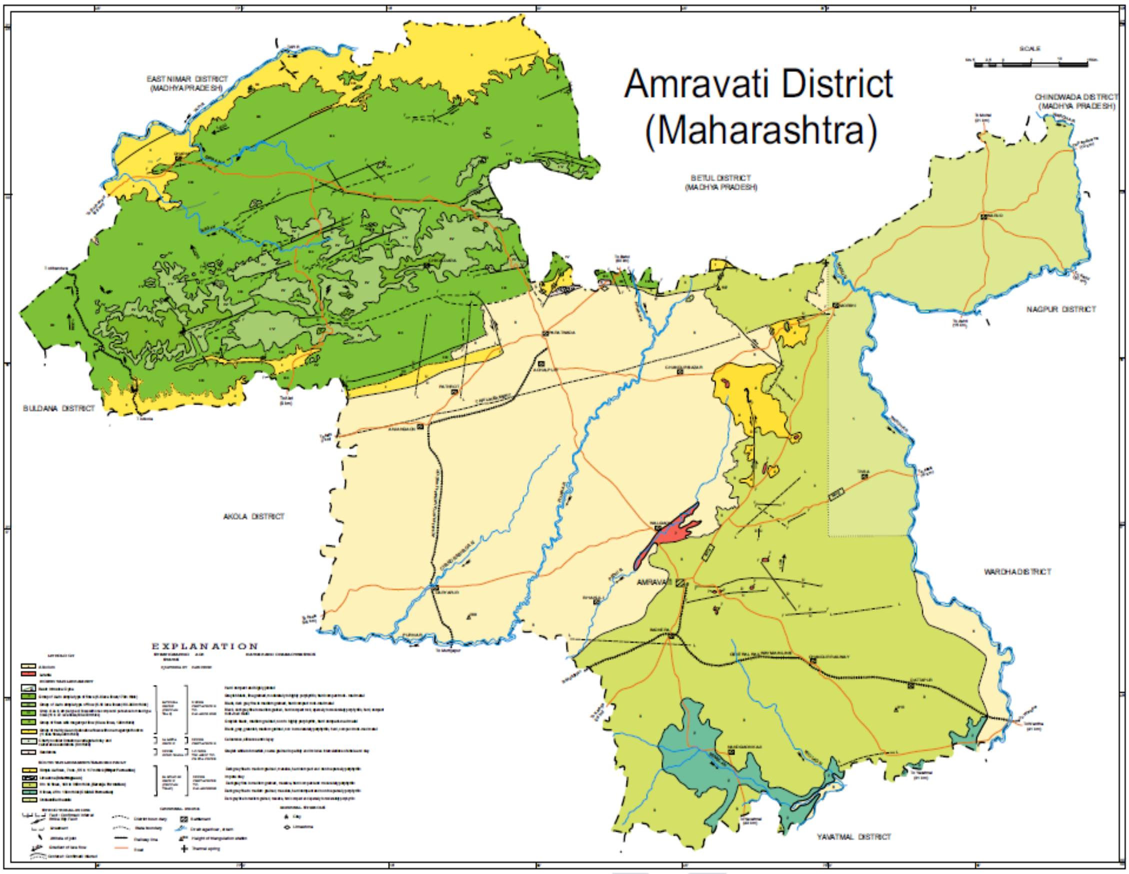

Figure No. 1. Geological Map of the Amravati district, Maharashtra (After GSI, 2001)

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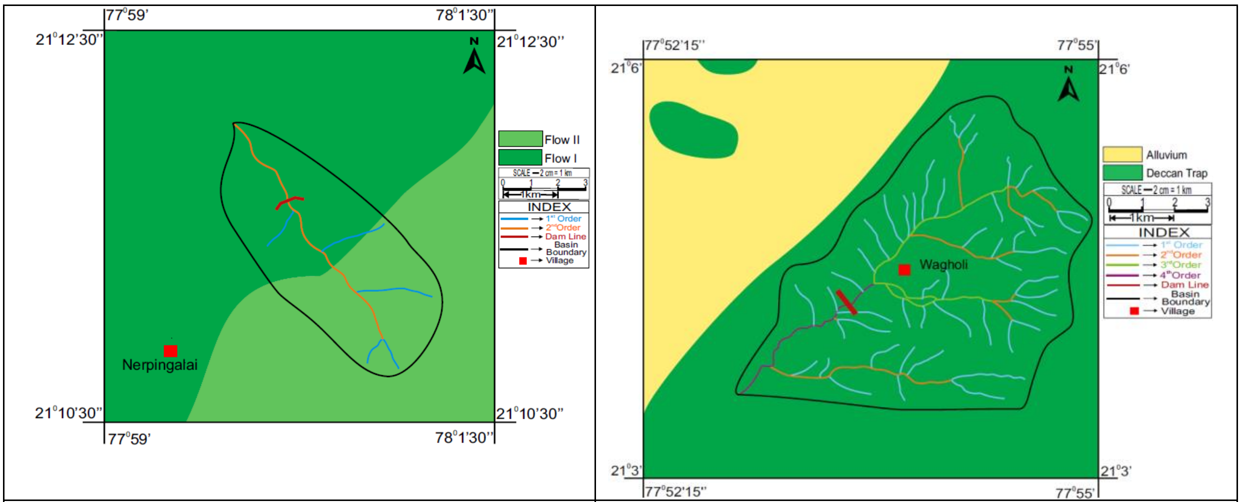
Nerpingalai percolation tank

Two Deccan trap basalt flow found in the catchment area, north western part consists of flow I while southeastern constitute the flow II (Tiwari and Bhai, 1994), (Fig. No.1.1). Flow I is dark grey, fine grained, sparsely porphyritic with fragmentary and vesicular top while flow II is massive. The weathering varies from place to place. It is thin to rocky. The depth of weathering varies from 0.2m to 6.05m

Wagholi percolation tank

One Deccan trap basalt flow found in area, north western part there is alluvium (Tiwari and Bhai, 1994), (Fig. No. 1). Flow is dark grey, fine grained, sparsely porphyritic with fragmentary and vesicular top. Alluvium consists of top clayey zone followed by pebble and boulder bed. The depth of weathering is 4.51m



Nerpingalai Percolation tank	Wagholi Percolation tank

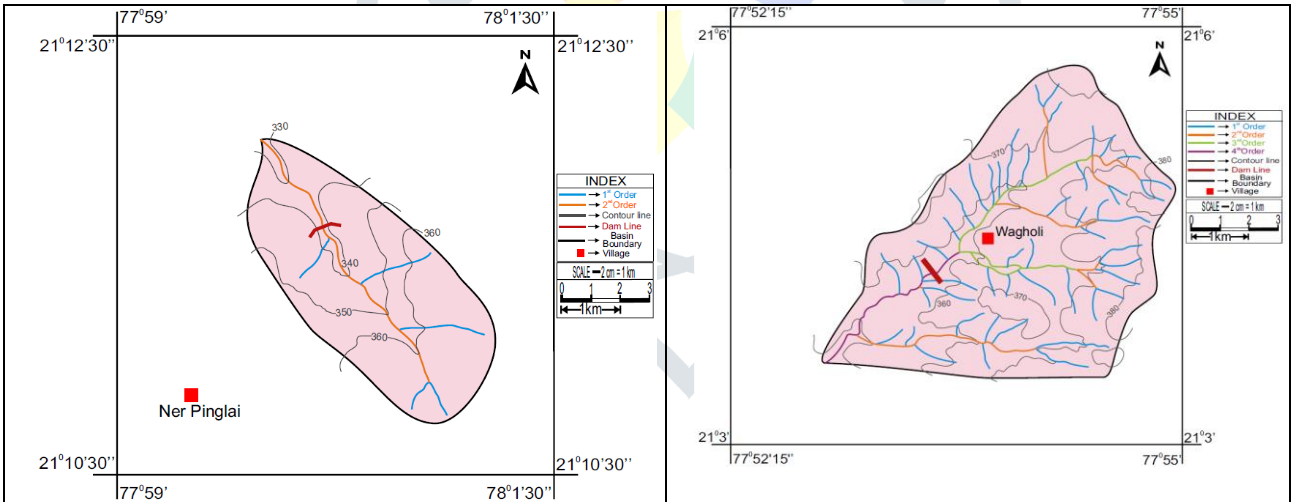
Figure No.2
Geological Map of Percolation tanks with geology and drainage

•Geomorphological and Morphometric analysis

Geomorphological studies throw light on the lithology, structure, relative infiltration, runoff erosional aspects and on the stage of maturity of the basin. A strong mutual relationship exists between morphologic variables and hydrologic characteristics and can be applied to both surface and groundwater regimes.

Morphometry incorporates quantitative study of the area, altitude, volume, slope of the land and drainage basin characteristics of the area concerned (Savindra Singh, 1972). Morphometric studies in the field of hydrology were first initiated by Horton (1945) and Strahler (1957). Their studies on the geo-hydrological behavior of drainage basin and the prevailing climate, over geomorphology, structural aspects of the catchment and their relationship between drainage parameters and other factors were well recognized by many workers like Horton R.E. (1945), Strahler A.N. (1957), Melton M.A. (1958).

Drainage map has been prepared from Survey of India toposheets on 1:50,000 scale for all the percolation tanks (Figure No.3) and used for morphometric analysis. Morphometric study includes the analysis of linear, aerial, and relief aspects of basin Table No. 1.



Nerpingalai Percolation tank	Wagholi Percolation tank

Figure No.3
Map of Percolation tanks with drainage order

The linear aspects include stream order, stream number, stream lengths, bifurcation ratio, length of overland flow, constant of channel maintenance etc. and the observations presented in Stream ordering and numbering has been carried out based on the method proposed by Strahler (1969). The percolation tank of Nerpingalai and Wagholi are situated on second and fourth order stream respectively. The total stream length varies from 6.9 km and 41.35 km respectively. The Avg. bifurcation ratio for percolation tanks Nerpingalai and Wagholi located on second and fourth order streams was found to be 5 and 4 respectively. For Nerpingalai Length of overland flow is 0.28 while Wagholi it is 0.15.Nerpingalai has high value of constant of channel maintenance than Wagholi.

Table No.1.
Salient features of Morphometric analysis of Percolation tanks, in Amravati district.

Sr. No.	Geomorphological Parameters	Artificial recharge structures	
		Nerpingalai P.T	Wagholi P.T
1	Order of stream	2	4
2	Number of streams	6	69
3	Length of streams (km)	6.9	41.35
4	Avg. Bifurcation ratio	5	4
5	Length of overland flow	0.28	0.15
6	Constant of channel maintenance	0.57	0.51
7	Total area (sq.km)	3.92	12.54
8	Mean area	0.65	0.213
9	Drainage frequency	1.53	4.7
10	Drainage density	1.76	3.297
11	Form factor	0.25	0.46
12	Texture ratio	0.57	3.692
13	Infiltration Number	2.69	15.51
14	Relief Ratio	9.75	6.92
15	Ruggedness Number	129.15	232
16	Hypsometric Integral (%)	66.75	21

Aerial aspects include study of basin area, mean area, drainage frequency, drainage density, form factor, texture ratio and infiltration number etc. Total area of stream at Nerpingalai and Wagholi ranged from 3.92 sq.km to 12.54 sq.km. Drainage density of stream at Nerpingalai and Wagholi had 1.76 and 3.297 respectively Drainage frequency of stream at Nerpingalai was 1.53 and at Wagholi it was 4.7. Basin of Wagholi have relatively high stream frequency value indicating less permeable rocks which facilitates greater runoff, less infiltration and steep slopes as compared to Nerpingalai. Form factor of stream at Nerpingalai and Wagholi was found to be 0.25 and 0.46 respectively. The values of form factor indicate these basins are more or less in circular shape . Infiltration number of Nerpingalai and Wagholi were 2.69 and 15.51 respectively.

Relief aspects includes relief ratio, ruggdness number slope and hypsometric analysis i.e. area and altitude analyses etc. Relief ratios and Ruggdness number of stream at Nerpingalai was 9.75 and 129.15 respectively. For Wagholi it was 6.92 and 232 respectively. Hypsometric integral of stream at Nerpingalai and Wagholi had 66.75 and 21 respectively.

•HYDROLOGICAL AND HYDROGEOLOGIC STUDIES

Hydrologic and Hydrogeological studies integrate a variety of hydraulic and geological data, in the delineation, evaluation and management of groundwater. Rainfall data for 10 years has been collected from agriculture department, Government of Maharashtra and trend analysis of rainfall of both percolation tanks has been determined and presented in fig. no.4 and 5 and table no.2. Typically 7-8 observation wells has been selected on the downstream and upstream side of the percolation tanks and monitored for monthly groundwater levels along with tank water level. Hydrograph has been plotted (fig. no. 6) and correlation coefficients determined. With cutoff value of 0.60 for each structure wells directly depended were determined. Based on the benefitted wells area benefited were determined and its average fluctuations determined and presented in table no 2.

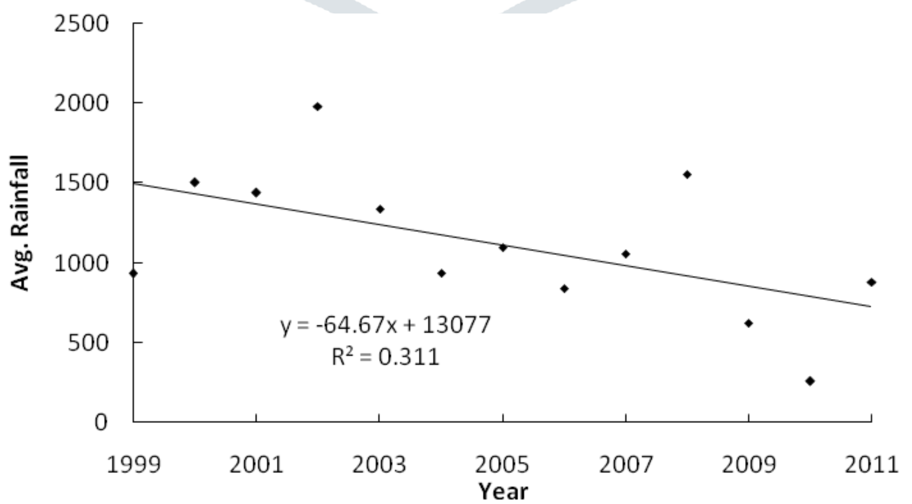


Fig. 4 Long term trend analysis for rainfall data (1999-2011)
For Wagholi Percolation tank

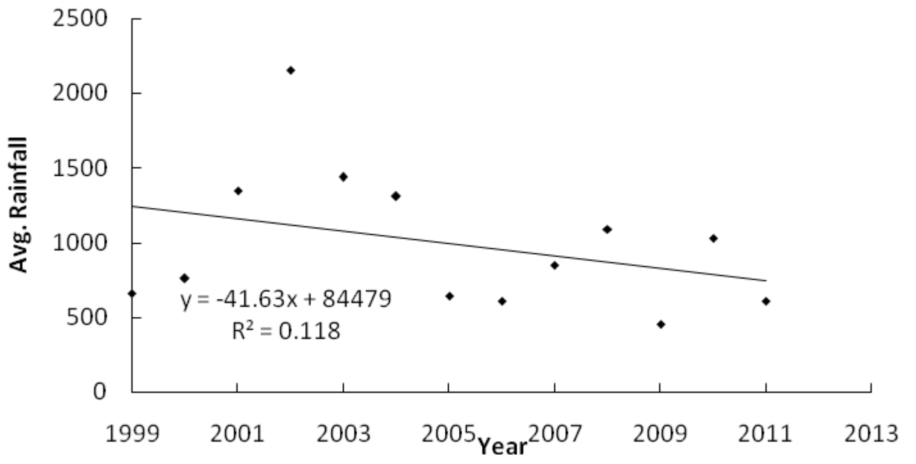


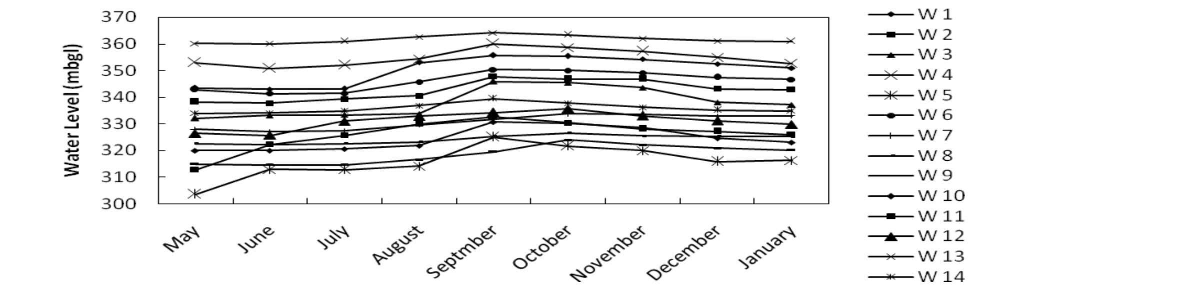
Fig. 5Long term trend analysis for rainfall data (1999-2011)
For NerpingalaiPercolation tank

Table No.2
Salient features of Hydrological and Hydrogeological analysis of Percolation tanks, in Amravati district, Maharashtra

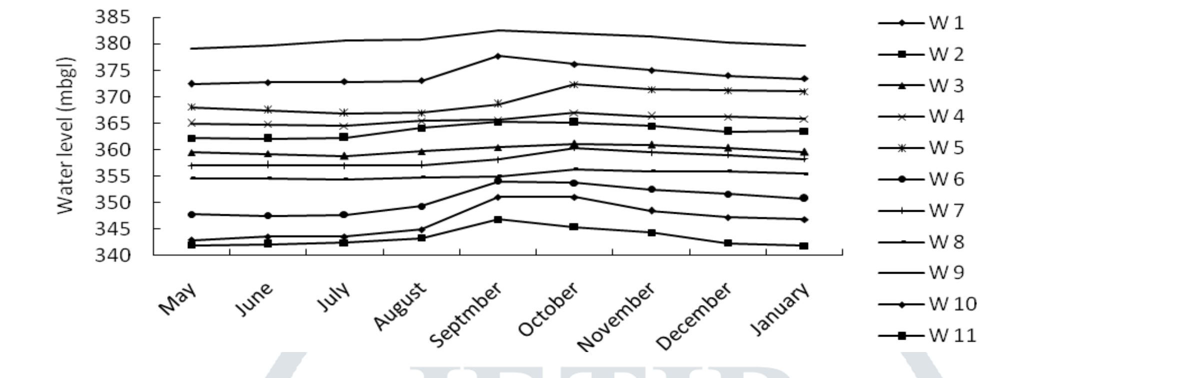
Sr. No.	Hydrological and Hydro geological parameters	Percolation Tank	
		Nerpingalai	Wagholi
1	Aquifer	Deccan trap	Deccan trap
2	Thickness of weathered zone (m)	6.05	4.51
3	Zone of aeration	3.79	3.79
4	Decline in Water level (Rain fall)	$y = -64.67x + 13077$ $R^2 = 0.31$	$y = -41.63x + 84479$ $R^2 = 0.118$
5	Average rainfall	1090.55	1047.15
6	Avg. fluctuation in the total area	8.42	3.57
7	Avg. Fluctuation in Structure	7.7	3.66
8	Area benefitted	5.31	7.76
9	Avg. fluctuation in the benefitted area	8.42	3.75
10	Specific Yield	0.02	0.02
11	Groundwater added (tcm)	0.8942	0.582

In Deccan basalt aquifers, hydrogeological map represents the mapping of the physical state of ground waters within their geological framework and includes the lithological boundaries between basalt flows, fracture zones and the weathered zone dispositions, Kulkarni and Deolankar, 1989. The hydrogeological study requires the study of water level, its long term behavior and evaluation of aquifer parameters, to understand the water yielding capacity of the formation (Todd, 1980, Karanth, 1999). Groundwater occurrence and its movement, and hydrodynamic condition in the basin with the relative transmissivity and storage behavior of different litho units can be very well assessed through hydro geological investigations.

Ground water in Deccan Trap Basalt occurs mostly in the upper weathered and fractured parts down to 15-20m depth. Based on the groundwater levels observed during monthly monitoring groundwater level contours had been superimposed on geological map (figure no. 7) and area benefited is shown in figure no.8. The upper weathered and fractured parts form phreatic aquifer and ground water occurs under water table (unconfined) conditions. At deeper levels, the ground water occurs under semi-confined conditions. At places potential zones are encountered at deeper levels in the form of fractures and inter-flow zones.

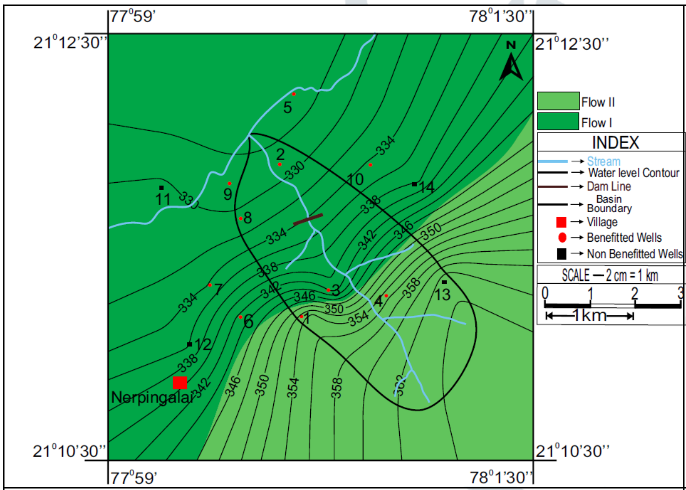


Nerpingalai Percolation tank.

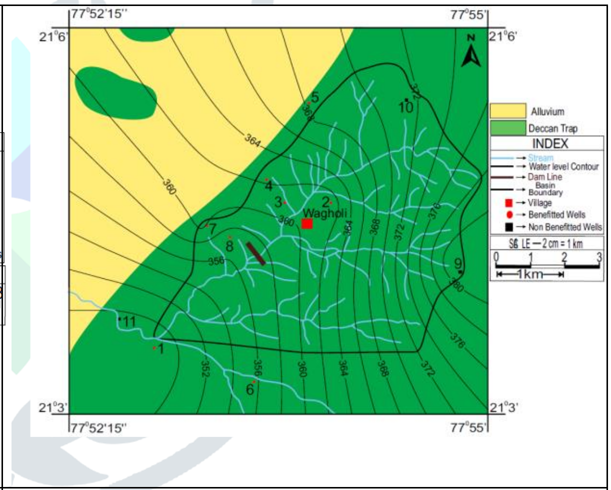


Wagholi Percolation tank.

Figure No.6
Hydrographs of Observation wells at percolation tanks in Amravati District, Maharashtra.

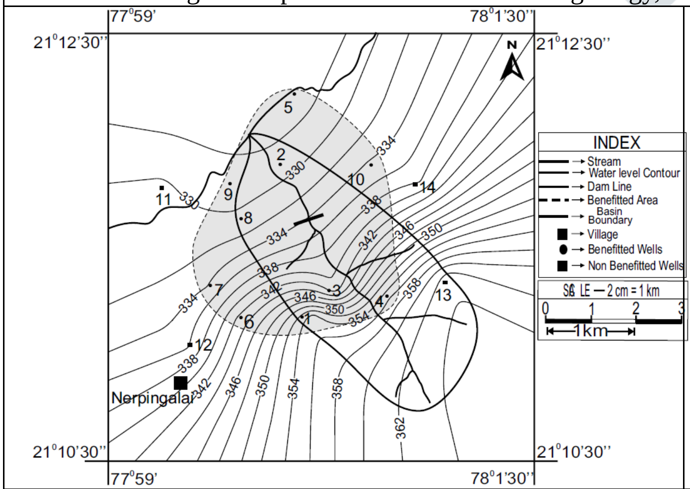


Nerpingalai Percolation tank

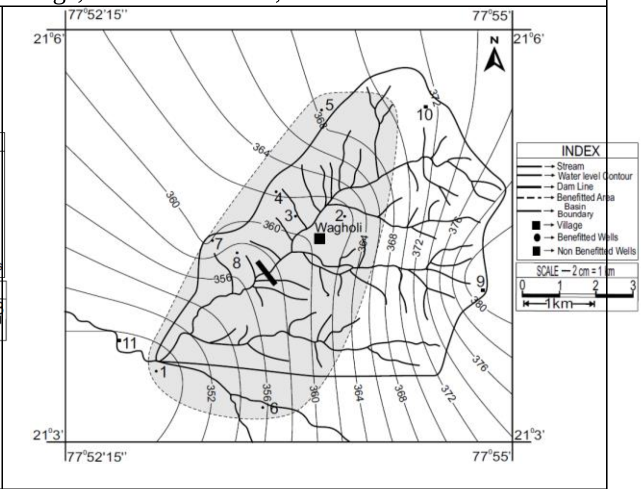


Wagholi Percolation tank

Figure No.7
Geological Map of Percolation tanks with geology, drainage, observation wells, water level contours



Nerpingalai Percolation tank



Wagholi Percolation tank

Figure No.8
Map showing benefitted area.

- **SUMMARY AND CONCLUSION:**

Integrated geological, geomorphological, hydrological and hydrogeological, geophysical studies of the two percolation tanks in the deccan trap area was found to be very useful for determining the efficiencies of the percolation tanks.

Geological studies indicated the usually the structure covers a single flow or sometimes spread over two flows. All the flows are simple AA flow and overlain by thin alluvium. The depth of weathering varies from thin about 0.25-6.05. Percolation tank located on the inter flow zone or those having catchment area in the interflow zone where more efficiency as compared those on highly weathered rock. The efficiency of structure located on simple AA flow depends on extent of weathering and fracturing.

Geomorphological studies carried on linear, aerial and relief aspects have indicated that drainage density, drainage frequency, length of overland flows, bifurcation ratios, hypsometric integral are the controlling parameters in location of percolation tanks. The percolation tank located on third order basin where more effective as those located on second order. Low drainage density indicated a poor condition as compared to those with moderate drainage density. They have their controls on the efficiencies of percolation tank sites.

Hydrogeological condition in the basin indicated that all the structures unconfined groundwater situation. Based on the correlation coefficient effective are of percolation tanks and the mean fluctuation determined. The average fluctuation varies from 7.7-3.66 m in catchment area but in benefited area it varies from 3.57-8.42 m. The zone of benefit in case of percolation tank varies from 5.31-7.76 sq. km.

Ultimately an integrated studies indicated that presence of high weathered zone, high drainage density, high drainage frequency, low length of overland flow and high ground water fluctuation favored the feasibility of percolation tanks in the Deccan trap of Amravati district, Maharashtra.

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