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Aquifer Management Plan for Sustainable Development in Over Exploited Gangavalli Block of Salem District Tamil Nadu- A Case Study

KEYWORDS: Gangavalli block, Drinking, Agricultural, Artificial Recharge Structures

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ABSTRACT *Groundwater resources estimation has indicated that the Gangavalli block of Salem district is under over exploited category. The block is mainly depending on the groundwater for drinking and agricultural purposes. In view of the above, a study was carried out in this block to manage the groundwater for sustainable development. In the area, the groundwater is available in two major aquifer systems i.e. 1.water table aquifer (weathered / alluvium) and 2.fractured aquifers. The groundwater is abstracted at present mainly from fractured aquifers as its availability in water table aquifers is negligible. In the study area, an attempt has been made to improve the groundwater availability in both aquifer systems by constructing various types of artificial recharge structures and suggesting for the management plan for the sustainable development.*

INTRODUCTION

Gangavalli Block is having the highest groundwater development (221% as per GEC-2004) in Tamil Nadu, thereby indicating that groundwater extraction is twice the annual replenishment and the balance available for future development is negligible. Further, Piezometers tapping the fractures also show a declining trend, there by indicating a greater extraction when compared to the natural recharge. Thus the declining trend and higher groundwater development indicate the need for artificial recharge to supplement the natural recharge to groundwater system and stabilize the prevailing groundwater utilization pattern without further adverse impact on environment and crop yield. In this connection, a study was carried out in this block to improve the groundwater availability and applying the management plan for the sustainable development.

STUDY AREA

The Gangavalli block of Salem district lies between North Latitudes 11° 00' 30" and 11° 58'30" and East Longitudes 77° 39'0" and 78° 50'30" forming part of survey of India topographical maps Nos. 58E and I (fig-1). The total survey geographical area of the block is 410 Sq.km. and has 27 revenue villages and 14 Panchayats.

The block is covered by red in-situ soil, black soil, forest loam and mixed soil. The prominent geomorphic units are 1) Structural hills, 2) Valley fill, 3) Pediments and 4) Buried Pediments. Suvedha Nadhi draining the central part of the block is the major water course controlling the drainage in the block. The area is characterised by dentritic drainage. The block receives the rain under the influence of both southwest and northeast monsoons. The northeast monsoon chiefly contributes to the rainfall in the block. The southwest monsoon rainfall is highly erratic and summer rains are negligible. Rainfall data from two stations over the period from 1901-2003 have been analysed. The normal annual rainfall over the block varies from about 800 mm to about 1600 mm. It is observed that the chances of receiving normal rainfall are minimum (40-50%) around Attur located close north of the of the block and maximum (50-60%) around Pachamalai in the southern part of the block.

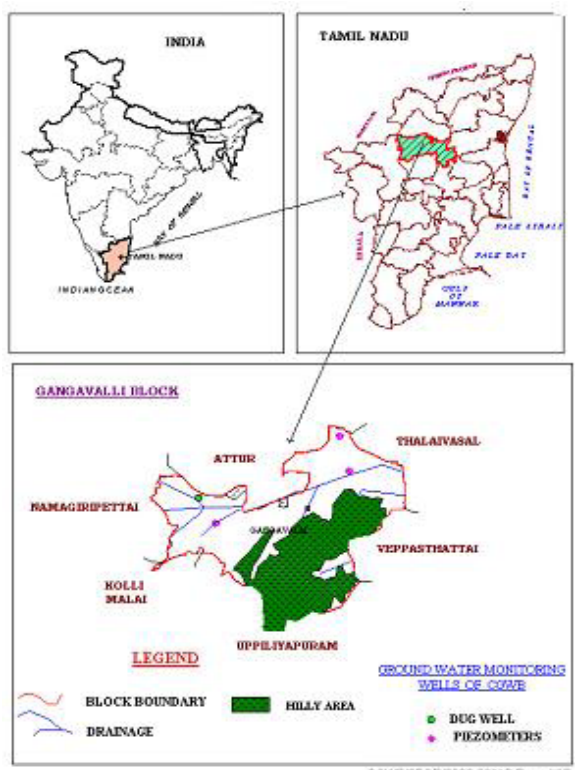

Figure1: Location Map

Geology

Gangavalli block is underlain entirely by Archaean Crystalline formations with Recent alluvium (fig-2). The major part of the block is characterized by Charnockite and Pyroxine Granulite occurs as bands trending NE-SW. Hornblende Biotite Gneiss occur as patches on the north-western part of the block. Recent alluvium is seen along the river courses and in the intermountain valleys.

Hydrogeology

In general, aquifer system can be considered as two types, viz., weathered residuum and deeper fractures. The thick-

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ness of weathered zone in the block ranges less than 1 to 28 m. Based on the exploration it is found that fractures are encountered down to depth 200mts with yield ranging from 10 lpm to 840 lpm. The depth of the dug wells in the area are ranging from 4.00 to 38.00 m.bgl with yield ranging from 35 to 140 lpm and up to 250 lpm in weathered and alluvium formation respectively. The bore wells recorded transmissivity values ranging from 1 m2/ day to 250m2/ day. The Storativity values ranges from 4.3x 10 ¯3 to 9.6x 10¯5.

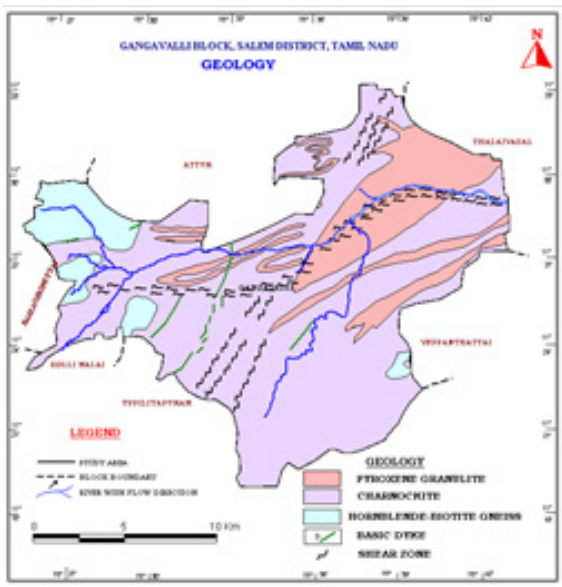

Figure 2: Geology Map

TYPES OF ARTIFICIAL RECHARGE TECHNIQUES

Based on the hydrogeology of the area including nature and extent of aquifer soil cover, slope, water level, chemical quality and availability of surface water, the type of artificial recharge structures are constructed. The types of artificial recharge structures are as follows.

Check Dam

Check dam is constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within a short span of time. The water stored in these structures is mostly confined to stream course and the height is normally less than 2m and excess water is allowed flow over the wall. In order to avoid souring from excess run off, water cushions are provided at downstream side. To harness the maximum run off in the stream, series of check dams are constructed to recharge on regional scale.

Percolation pond/tank

Percolation pond is an artificially created surface water body submerging in its reservoir a highly permeable land so that surface run off is made to percolate and recharge the ground water storage.Percolation tank should be constructed preferably on second to third order streams, located on highly fractured and weathered rocks, which have lateral continuity down streams.The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tank is designed for storage capacity of 0.1 to 0.5 MCM with water column generally between 3 to 4.5m. The percolation tank is mostly earthen dams with masonry structure only for spillway.

Recharge Bore Well

A recharge bore well is one, which admits water from the surface to aquifer. Recharge bore well is ideally suited for those locations where land availability is limited, and/or aquifer is deep and overlying by thick impermeable stratum. In recharge bore well single diameter pipe assembly is used and it should have a provision of slotted pipes against the filter media for entering filter water in to the well. In Gangavalli block the rain water stored in few check dams and percolation ponds are channeled to the bore well under gravity flow condition after proper filtration.

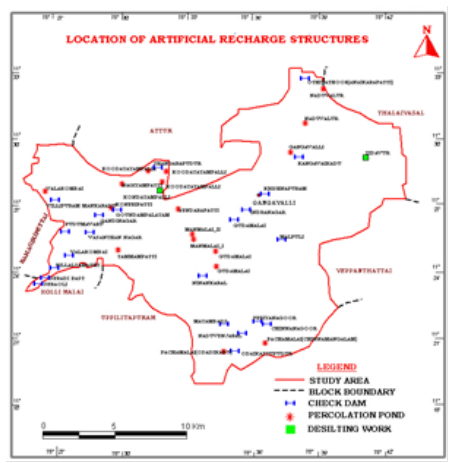

Figure 3: Location of Artificial Recharge Structures

ARTIFICIAL RECHARGE STRUCTURES CONSTRUCTED IN THE AREA

In Gangavalli Block, a total of 41 artificial recharge structures had been constructed (fig-3). 16Nos Percolation Pond, 2Nos De-silting tank and 23Nos Check Dam were constructed in the area during 2007.

11nos of structures were constructed in Gneissic terrain and others were constructed in Charnockites rock formation. Photo – i and ii are showing ARS constructed at Gudamalai and Gangavalli. The details of structures are given in table-1.

RESULTS AND DISCUSSION

Artificial Recharge structures were constructed to recharge the aquifer systems mainly phreatic aquifer in the area (D.S.Thambi, 1998).

If the aquifer is recharged, our tendency is to develop the aquifer in unplanned way without understanding characteristics of aquifers. It is time to proceed in planned way. In this processes, the prime need is to understand the recharge to groundwater.

TABLE -1
TYPE OF THE ARTIFICIAL RECHARGE STRUCTURE

Location	Type of the structure	Longitude	Latitude
Gangavalli	Percolation Pond	78°37'07"	11°29'21"
Kondayayampalli-Perumalkaradu	Percolation Pond	78°31'55"	11°27'06"
Naduvalur- East	Percolation Pond with Recharge BW	78°40'09"	11°32'04"

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Kondayayampalli- South	Percolation Pond with Recharge BW	78°31′05″	11°27′36″
Gudamali-Narikaradu	Percolation Pond	78°34′50″	11°24′24″
Thammampatti	Percolation Pond with Recharge BW	78°24′39″	11°25′17″
Nagiyampatti	Percolation Pond with Recharge BW	78°30′11″	11°27′55″
Koneripatti	Percolation Pond with Recharge BW	78°24′28″	11°26′37″
Sendarapatti- Manmalai-III	Percolation Pond with Recharge BW	78°32′44″	11°26′51″
Gudamali	Percolation Pond	78°35′00″	11°25′57″
Naduvalur- West	Percolation Pond with Recharge BW	78°38′18″	11°31′42″
Manmalai-I (South)	Percolation Pond	78°33′26″	11°25′45″
Manmalai-II (North)	Percolation Pond	78°32′27″	11°25′37″
Odadikadu	Percolation Pond	78°35′57″	11°20′39″
Chinnamangalam	Percolation Pond	78°36′29″	11°20′32″
Valakombai	Percolation Pond	78°28′56″	11°24′45″
Kondayayampalli- East	Check Dam	78°32′43″	11°28′24″
Ullipuram mankaradu	Check Dam	78°27′36″	11°27′00″
Naduvenjarai	Check Dam	78°35′25″	11°20′57″
Chinna Nagoor	Check Dam	78°37′07″	11°22′06″
Periya Nagoor	Check Dam	78°36′33″	11°22′07″
Mayambadi	Check Dam	78°34′31″	11°22′18″
Odalkattu pudur	Check Dam	78°35′35″	11°20′26″
Thagarapudur	Check Dam	78°32′12″	11°27′42″
Pudumavaru	Check Dam	78°25′43″	11°25′33″
74-Krishnapuram	Check Dam	78°37′19″	11°28′12″
Gudamali	Check Dam	78°34′51″	11°27′25″
Othiyathoor	Check Dam	78°38′56″	11°33′59″
Analkarapatti (Indra Nagar)	Check Dam	78°35′36″	11°26′50″
Valakombai	Check Dam	78°27′47″	11°24′55″
Pillalyarmathy	Check Dam	78°26′53″	11°24′16″
Serdi -West	Check Dam	78°25′43″	11°23′06″
Ninankarai	Check Dam	78°33′45″	11°23′41″
Seradi- Eeast	Check Dam	78°26′04″	11°23′40″
Malpulli	Check Dam	78°37′05″	11°25′37″
Thammampatti -Gandhi Nagar	Check Dam with Recharge BW	78°27′43″	11°26′40″
Thammampatti -Vasanthan Nagar	Check Dam with Recharge BW	78°27′49″	11°26′19″
Goundampalayam	Check Dam	78°29′46″	11°26′45″
Kanavaikadu	Check Dam	78°38′15″	11°29′09″
Kondayampalli (Tank)	Desliting of Tank	78°41′25″	11°27′35″
Tidavur (Tank)	Desliting of Tank	78°4125″	11°29′05″

Photo. i Check Dam (Gudamalai)
Water level monitoring

The groundwater level of an area is very important to understand the groundwater recharge and development. The monitoring of groundwater levels during pre and post construction of structures

Photo. ii Percolation Pond (Gangavalli)
were carried out in the area to understand the groundwater recharge. 36 nos of key wells were established near the structures and collected water level from 2006 to 2009. The details of the key wells and water levels are presented in the table given in table.2.

Phreatic (Water Table) Aquifer
The water table aquifer of the area is defined based on the thickness of weathered zone encountered in dug well section established for water level monitoring.

The thickness of weathered zone plays vital role in groundwater recharge and water holding capacity.

The depth of dug wells is ranging from 4.00 m.bgl at Mayambadi to 35.1 m.bgl at Naduvalur-west. The depth of the dug wells and weathered thickness is plotted and shown in plot-1. The thickness of the weathered zone is ranging from 2.5 mts to 10mts.

The depth of dug wells are deep in the central, north and eastern part of the block where as shallow depth dug well are found along the river courses and hilly regions of the block.

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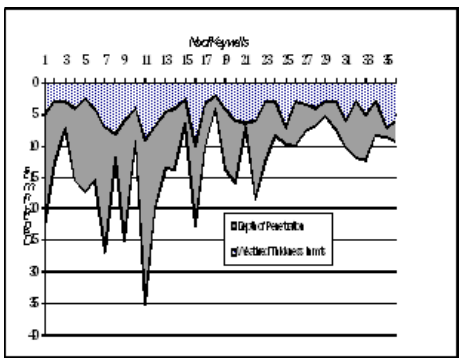
The occurrence of groundwater is mainly depending on the thickness of the weathered zone. The management of the saturated zone of this aquifer is very important for sustainable development in the area. (K.Rajarajan, 2012).



Plot.1.Weathered thickness and depth of dug wells vs no of dug wells.

Water level - pre construction of artificial recharge structures

Based on the key well monitoring. The groundwater level of June-2006 (Pre monsoon) was collected for the pre-construction of artificial recharge structures. The water level is ranging from 1.22 m.bgl at Mayambadi and 21.90 m.bgl at Thamampatti. The water level of post monsoon was also collected for pre-construction of artificial recharge structures in the month of Jan-2007 and it reveals that most of the dug well shows the negative fluctuation. The rising water level is ranging from less than 1m to 8.35 m and the falling water level is ranging from less than –1 to –5.80m.

TABLE-2
WEATHERED THICKNESS AND WATER LEVEL FLUCTUATION

Location	Depth of Dug Wells (m.bgl)	Weathered Thickness (m)	Water Level (m.bgl)		Water Level Fluctuation (m)	Water Level (m.bgl)		Water Level Fluctuation (m)
			Jul-06	Jan-07		May-08	Jan-09	
Gangavalli	23.00	5.00	8.00	11.50	-3.50	9.00	3.80	5.20
Kondayayampalli	12.44	3.00	10.75	8.60	2.15	7.30	5.50	1.80
Kondayayampalli	7.20	3.00	5.15	6.20	-1.05	5.90	5.30	0.60
Naduvalur- East	15.40	4.00	6.80	12.60	-5.80	9.20	8.60	0.60
Kondayayampalli	17.20	2.50	9.25	13.20	-3.95	10.40	N/M	N/M
Gudamali	15.40	4.00	6.80	7.90	-1.10	6.80	6.30	0.50
Thammampatti	26.90	7.00	21.90	13.55	8.35	13.00	9.00	4.00
Nagiyampatti	21.90	7.50	12.10	12.50	-0.40	12.10	6.95	5.15
Koneripatti	11.82	8.00	10.40	10.70	-0.30	6.40	3.55	2.85
Sendarapatti (MM-III)	25.00	6.00	12.90	10.25	2.65	4.15	N/M	N/M
Gudamali	9.12	4.00	6.98	8.70	-1.72	7.20	6.10	1.10
Naduvalur- West	35.10	9.00	19.70	6.50	13.20	17.00	10.10	6.90
Manmalai-1	20.22	7.00	10.10	9.70	0.40	9.00	6.90	2.10
Manmalai-11	13.40	4.5	9.50	9.80	-0.30	9.40	7.15	2.25
Odaikadu	13.60	4.00	9.00	3.80	5.20	2.90	2.30	0.60
Chinnamangalam	6.45	2.50	6.30	7.15	-0.85	3.50	1.80	1.70
Valakombai	22.70	10.00	9.60	13.50	-3.90	15.80	11.40	4.40
Ullipuram	5.60	3.30	3.80	4.50	-0.70	3.70	3.50	0.20
Chinna Nagoor	13.02	3.00	10.20	3.20	7.00	2.85	2.20	0.65
Periya Nagoor	9.98	3.30	4.38	5.50	-1.12	4.00	2.30	1.70
Mayambadi	4.00	2.00	1.22	2.20	-0.98	1.07	1.06	0.01
Odalkattu pudur	13.60	4.00	9.00	3.20	5.80	9.10	2.65	6.45
Thagarapudur	15.70	6.00	6.60	9.20	-2.60	9.00	6.05	2.95
74-Krishnapuram	18.60	6.00	9.60	10.20	-0.60	6.90	4.30	2.60
Gudamali	12.50	3.00	6.90	6.55	0.35	6.02	4.30	1.72
Othiyathoor	8.20	3.00	3.00	7.50	-4.50	6.30	2.90	3.40
Analkarapatti	9.60	7.00	7.30	6.20	1.10	6.10	6.10	0.00
Serdi	6.62	4.00	4.50	3.10	1.40	4.45	2.55	1.90
Ninankarai	5.20	3.00	4.10	6.00	-1.90	2.60	N/M	N/M

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Seradi east	7.44	3.00	5.24	5.50	-0.26	5.90	5.70	0.20
Malpull	10.20	6.00	9.10	6.85	2.25	5.45	2.25	3.20
Gandhinagar	11.75	3.00	7.08	9.20	-2.12	5.20	4.30	0.90
Vasanthan nagar	12.16	5.00	9.60	9.70	-0.10	7.50	5.10	2.40
Goundampa-layam	8.20	3.00	7.78	7.00	0.78	4.50	2.25	2.25
Kanaavaikadu	8.63	7.05	8.34	5.40	2.94	4.80	2.10	2.70
Tidavur (Tank)	9.25	6.00	1.40	4.23	-2.83	3.00	0.30	2.70

Water level - post construction of artificial recharge structures

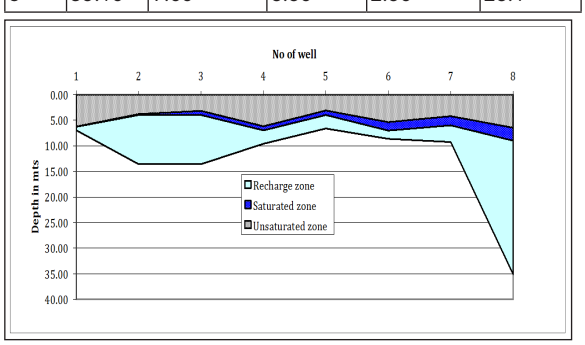
The groundwater levels of May-2008 (pre-monsoon) and January-2009 (post monsoon) were collected for the post-construction of artificial recharge structures. The water level during May-2008 is ranging from 1.07 to 15.80 m.bgl (Valakombai). The post monsoon water level is indicating that most of the dug well are showing rising water level trend. The maximum rising is at Naduvalur- west having the water level of 6.90m.

Saturated thickness in January-2007

The saturated thickness of the area is defined based on the water level collected in Jan-2007 and the thickness of the weathered zone. The saturated thickness is directly indicating the water table aquifer. The aquifer thickness (water bearing zone) is raging from less than 1.00m to 2.50m. Out of 36 dug wells, only 8 dug wells are having saturated aquifers. The recharge zone in the dug well is groundwater contributed from saturated aquifer by means lateral flow and vertical flow to well.

TABLE-3

Sl.No	Depth of Dug Well (m.bgl)	Weathered Thickness (m)	Water level in Jan-2007 (m.bgl)	Zone of Saturation in Jan-07 (m)	Recharge zone (m)
1	6.95	6.30	6.25	0.05	0.65
2	13.6	4.00	3.80	0.20	9.60
3	13.6	4.00	3.20	0.80	9.60
4	9.60	7.00	6.20	0.80	2.60
5	6.62	4.00	3.10	0.90	2.62
6	8.63	7.05	5.40	1.65	1.58
7	9.25	6.00	4.23	1.77	3.25
8	35.10	9.00	6.50	2.50	26.1



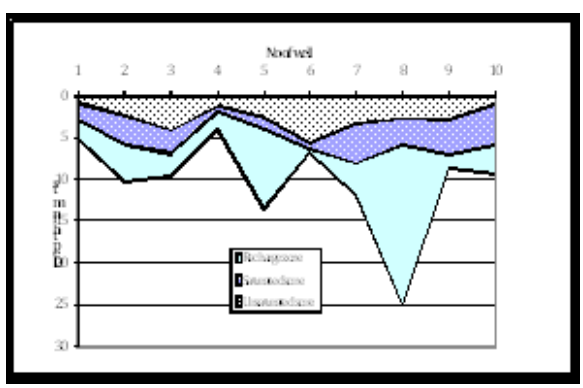
The maximum recharge zone is occurring in Naduvalur-west and minimum is at Pudumavaru having the recharge zone of 0.65 m. The details of the saturated thickness in aquifer is presented in the given below table. The section is prepared to show weathered thickness, saturated thickness and recharge zone in the dug well. The saturated thickness in the area is very thin.

Saturated thickness in Jan-2008

Based on the water level collected in the month of Jan-2008, 10nos of dug well is showing zone of saturation. The maximum thickness of zone of saturation is observed at Tidavur and minimum is at Pudumavaru. The maximum zone of recharge is observed in Sendarapatti where the thickness of recharge is 19.00m. The aquifer thickness is ranging from 0.60 to 5.10m. The section is indicating that the zone of saturation is very board at dug wells where the depth is deep and it is very thin at the shallow dug wells.

TABLE-4

Sl.No	Depth of Dug Wells in (m.bgl)	Weath-ered Thickness in (m)	Water level in Jan-08 (m.bgl)	Zone of Saturation in Jan-08 (m)	Re-charge zone (m)
1	5.20	3.00	0.85	2.15	2.20
2	10.20	6.00	2.3	3.70	4.20
3	9.60	7.00	4.20	2.80	2.60
4	4.00	2.00	1.15	0.85	2.00
5	13.60	4.00	2.45	1.55	9.60
6	6.95	6.30	5.70	0.60	0.65
7	11.82	8.00	3.40	4.60	3.82
8	25.00	6.00	2.75	3.25	19.00
9	8.63	7.05	3.00	4.05	1.58
10	9.25	6.00	0.90	5.10	3.25



Saturated thickness in January-2009

Based on the water level data collected in the month of Jan-2009, 16 nos of dug well is showing the zone of saturation. The zone of saturation is ranging from less than 1.00m to 5.70m. The recharge zone is ranging from less than 1.00m to 13.22m. It is observed that thickness of zone of saturation is high in the central and eastern part of the block. Photo iii and iv are showing water level in below and in zone of saturation.

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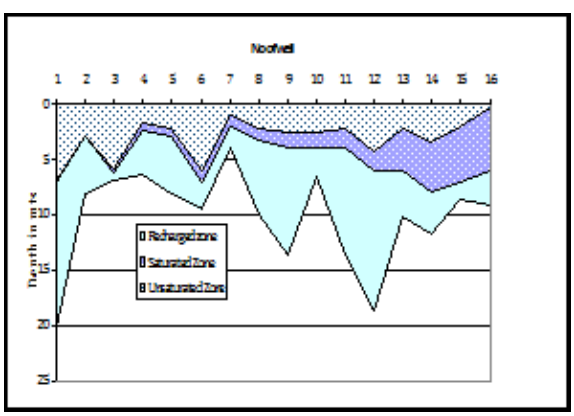
TABLE-5

Sl.No	Depth of Dug Well in (m.bgl)	Weathered Thickness in (m)	Water level in Jan-09 (m.bgl)	Zone of Saturation in Jan-09 (m)	Recharge zone (m)
1	20.22	7.00	6.90	0.10	13.22
2	8.2	3.00	2.90	0.10	5.20
3	6.95	6.30	5.85	0.45	0.65
4	6.45	2.50	1.80	0.70	3.95
5	8.20	3.00	2.25	0.75	5.20
6	9.60	7.00	6.10	0.90	2.60
7	4.00	2.00	1.06	0.94	2.00
8	9.98	3.30	2.30	1.00	6.68
9	13.6	4.00	2.65	1.35	9.60
10	6.62	4.00	2.55	1.45	2.62
11	13.6	4.00	2.30	1.70	9.60
12	18.6	6.00	4.30	1.70	12.60
13	10.20	6.00	2.25	3.75	4.20
14	11.82	8.00	3.55	4.45	3.82
15	8.63	7.05	2.10	4.95	1.58
16	9.25	6.00	0.30	5.7	3.25



Groundwater management plan

In the study area, the groundwater recharge is occurring from 2007 to 2009. The actual groundwater recharge is that the water level should persist over period of time in weathered zone or the water level is under atmospheric pressure in the aquifer. In the study area, the water level had been rebuilt considerably after the construction of artificial recharge structures. It means that the groundwater availability has been improved in the water table aquifer. The groundwater development in this area should be restricted to water column created in the zone of saturation to avoid drying up of dug wells and persisting the groundwater recharge to fracture aquifer. The zone of recharge to groundwater should not be touched for the groundwater developments. The sustainable groundwater development can be achieved in Malpuli, Koneripatti, Kanavaikadu and Tidayur locations where the zone of saturation is significantly high.

CONCLUSIONS

In the study area, Artificial Recharge Structures were constructed to provide sustainability to the groundwater reservoir, since the excessive groundwater development of this area is resulting in depletion of groundwater level and drying up of open wells. The thickness of weathering, zone of saturation in the water table aquifers were analysed and suggested where the groundwater development is possible without damaging the groundwater reservoir.

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