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EVALUATING THE IMPACT OF RAIN WATER HARVESTING IN PAZHAYAR WATER SHED

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ABSTRACT : Groundwater is a valuable resource and if it is exploited in excess, it results in water level declination and water quality deterioration in urban areas. Artificial recharge techniques such as Rain Water Harvesting (RWH) are essential for urban areas, in order to improve the groundwater level and quality. Rainwater Harvesting (RWH) means "catch the rain water where it falls" . It is the activity of direct collection of Rainwater. The rain water collected can be stored for direct use or can be recharged into ground water for later use. This paper narrates a study for evaluating the ground water storage before and after implementation of RWH system in Nagercoil (Pazhayar Water shed) using the data collected from PWD(Ground Water Division), Government of Tamilnadu. The groundwater contours were plotted to identify the trend and spatial distribution of groundwater levels. The groundwater level follows an increasing trend after the implementation of RWH structures in the study area though the rainfall in the study area shows the decreasing trend. The results show that the implementation of RWH has increased the groundwater storage even though the extraction is increased due to increase in population.

1. INTRODUCTION

As the world population increases, the demand increases for quality drinking water. Surface and groundwater resources are being utilized faster than they can be recharged. Rainwater harvesting is an old practice that is being adopted by many nations as a viable decentralized water source. Individual rainwater harvesting systems are one of the many tools to meeting the growing water demand.Rainwater Harvesting (RWH) means "catch the rain water where it falls" It is the activity of direct collection of Rainwater. The rain water collected can be stored for direct use or can be recharged into ground water for later use.

1.1 Benefits of rain water harvesting system:

- Rainwater is a comparatively clean and totally free source of water.
- Rainwater is improved for scenery plants and gardens because it is not chlorinated.

- It can supplement other sources of water supply such as groundwater or municipal water connections.
- It lower the water supply cost.
- It can provide an excellent back-up source of water for emergencies.
- It is socially acceptable and environmentally responsible.
- It uses simple technologies that are inexpensive and easy to maintain.
- Reduced flood flows and topsoil loss.
- It is free; the only cost is for collection and use.
- It reduces the contamination of surface water with sediments, fertilizers and pesticides from rainwater run-off resulting in cleaner lakes, rivers, oceans and other receivers of storm water.
- It is used in those areas which face insufficient water resources.
- It is good for laundry use as rainwater is soft and lowers the need for detergents.
- It can be used to recharge groundwater.
- It minimizes the runoff which blocks the storm water drains.

1.2 Need for Rainwater Harvesting:

1. As water is becoming scarce, it is the need of the day to attain self-sufficiency to fulfill the water needs.
2. As urban water supply system is under tremendous pressure for supplying water to ever increasing population.
3. Groundwater is getting depleted and polluted.
4. Soil erosion resulting from the unchecked runoff.
5. Health hazards due to consumption of polluted water.

2. RAINWATER HARVESTING SYSTEMS AND ITS FEATURES

Rainwater Harvesting is a simple technique of catching and holding rainwater where its falls. Either, we can store it in tanks or we can use it to recharge groundwater depending upon the situation.

2.1 Importance of Rainwater Harvesting

Rainwater harvesting (RWH) acts as an important measure to conserve, to develop and to utilize the natural resources. An efficient conservation and scientific management of harvested water is crucial for optimum utilization of water for crop production, domestic use and industrial purposes.

Technically speaking, water harvesting means capturing the rain from where it falls or capturing the runoff in one's own field or house. Thus RWH is defined as collecting the rainwater falling on house-tops, collection in ponds, lakes and checking the rain water that gets wasted as runoff and also conserving it by recharging the ground water or by storing it.

The major works of RWHS adopted in the watershed are check dams, farm-ponds, nalabunds, contour bunds, vegetative covers, sunken ponds *etc.*, which play major role in managing and conserving the soil and recharging the ground water.

Recently, environmental concerns have increased the appeal of green building practices, including rainwater harvesting systems, in urban areas. Rainwater harvesting is especially appealing as it combines the benefits of water reuse with runoff reduction and groundwater recharge.

2.2 Advantages of Rainwater Harvesting

1. To meet the ever increasing demand for water. Water harvesting to recharge the groundwater enhances the availability of groundwater at specific place and time and thus assures a continuous and reliable access to groundwater.

2. To reduce the runoff which chokes storm drains and to avoid flooding of roads.

3. To reduce groundwater pollution and to improve the quality of groundwater through dilution when recharged to groundwater thereby providing high quality water, soft and low in minerals.

4. Provides self-sufficiency to your water supply and to supplement domestic water requirement during summer and drought conditions.

5. It reduces the rate of power consumption for pumping of groundwater. For every 1 m rise in water level, there is a saving of 0.4 KWH of electricity.

6. Reduces soil erosion in urban areas

7. The rooftop rainwater harvesting is less expensive, easy to construct, operate and maintain.

8. In saline or coastal areas, rainwater provides good quality water and when recharged to groundwater, it reduces salinity and helps in maintaining balance between the fresh-saline water interfaces.

9. In Islands, due to limited extent of fresh water aquifers, rainwater harvesting is the most preferred source of water for domestic use.

10. In desert, where rainfall is low, rainwater harvesting has been providing relief to people.

In cities, due to shrinking of open spaces, rainwater can be harvested and recharged as ground water. From 2001, the concept of rainwater harvesting has been actively promoted by the Tamil Nadu Government. The Government's determination to execute RWH was translated into policy direction as below:

- Implementation of RWH in all Govt. offices, schools, hospitals and residential buildings made compulsory.
- RWH structures made mandatory for all buildings proposed for construction.
- RWH became a prerequisite for obtaining new water and sewage connection.
- RWH made an in-built component for all rural and urban water supply schemes.

2.3 Methods of Rainwater Harvesting:

- Rainwater stored for direct use in above ground or underground sumps / overhead tanks and used directly for flushing, gardening, washing etc. (Rainwater Harvesting)
- Recharged to ground through recharge pits, dug wells, bore wells, soak pits, recharge trenches, etc. (Ground water recharge)

3. SCOPE OF THE STUDY

The study on RWHS and its impact is very important as it is related with water scarcity and the measures to overcome the scarcity. The study is expected to identify water problems encountered, so that possible measures are taken when these interventions are replicated. Besides, being an empirical study it will help to add to the empirical literature that uses the combination of both quantitative and qualitative approach in assessing the impact of RWH technology interventions on ground water recharge and agriculture production.

4. STUDY AREA

4.1 Location

Kanyakumari district is one among the 32 districts of Tamilnadu and itlies between North latitudes $8^{0}04'00$ and $8^{0}35'00$ and East Longitudes: $77^{0}05'30$ and $77^{0}35'30$. The district is bounded on the north and east by Tirunelveli district, south and southeast by Arabian Sea, Indian ocean and Gulf of Mannar and in the West by Kerala State. Total geographic area of the district is about 1672 sq.kms.

The district is part of the composite east flowing river basin," Between Pazhayar and Tamirabarani" as per the Irrigation Atlas of India. Valliyar, Pazhayar, Tamirabarani, and Aralvaimozhi are the important Sub-basins / Watersheds.

The present study area is the Pazhayar watershed of Agastheeswaram taluk, Kanyakumari district. The Pazhayar River originated at an altitude of 1300 m amsl in the Mahendragiri hills and the river water taken away through channels for irrigation. The river is benefited by both SW-NE monsoons. It completes its 20 km journey after joining the Arabian Sea. Its creek can be seen near Manakudi, 12 km south of Nagarcoil.

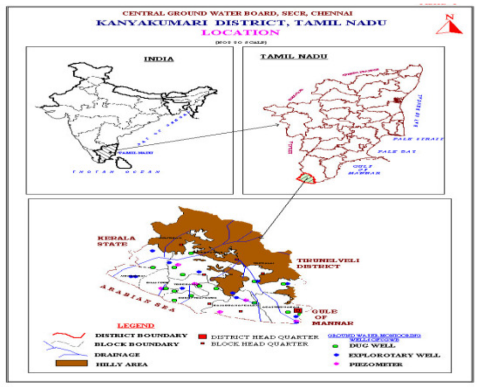

Figure 1. Location of study area

4.2 Regional Climate

The Kanyakumari district received the rain under the influence of both southwest and northwest monsoons. The southwest monsoon chiefly contributes to the rainfall in the district. Most of the precipitation occurs in the form of cyclonic storms caused due to the depressions in Bay of Bengal. The normal annual rainfall over the district varies from about 826 to 1456 mm. It is the minimum around Kanyakumari in the southeastern part of the district. It gradually increases towards west, north and northwest and attains a maximum around Thackalay.

The highest humidity is generally recorded in May with the value of 95 percent whereas the minimum of 45 percent is recorded during February. The maximum wind speed of 17.74 km/hr is recorded during August and the minimum wind speed of 5.53 km/hr is recorded during December. Wind velocity is low from October to December.

The Sun Shine Hours is March-April forms the average bright sunshine hours. The maximum of 12.74 hrs/day has been recorded during April and the minimum of 5.74 hrs/day is recorded during November. The temperature data indicate higher and lower temperatures prevailed during monsoon period. The average maximum temperature during May is 35.93^{o} C. The average minimum temperature recorded is 23.85^{o} C during January. The annual mean minimum and maximum temperatures are 23.78 and 33.95^{o} C respectively.

4.3 Geomorphology

Kanyakumari district is bordered by Western Ghats (Ridge and valley complex) in the West. Western Ghats form an elevation of 200 m amsl from these foothills in the west.

The areas gently slope to southeast towards the Gulf of Mannar attaining an elevation of 25 to 30 m amsl. The eastern and central tracts are quite barren, but there are a few isolated knife edged hillocks. The coastal tracts are occupied by the marshy swamps and number of sand dunes (Teri sands).

The prominent geomorphic units identified in the district through interpretation of Satellite imagery are 1) Structural Hills 2) Bazada 3) Valley Fill, 4) Flood Plain 5) Pediment, 6) Shallow Buried Pediments, 7) Deep Buried Pediments, and 8) Coastal Plain.

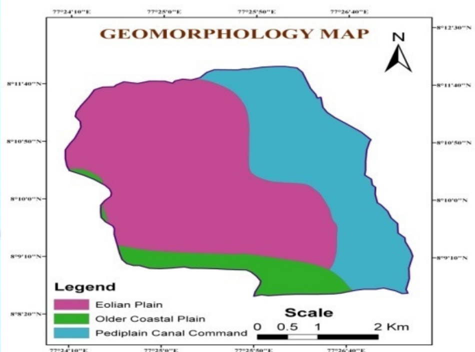

Figure 2. Geomorphology map of study area

4.4 Hydrogeology

Kanyakumari district is occupied by two major groups of rocks namely khondalite (garniferous silimanite gnesis and garnitiferous Biotite gnesis) and charnockites. The coastal region is characterized by presence of marine sediments , fluviomarine sediments and fluvial sediments 9 sub recent origin). Aeolin sandy deposits are also noticed as a narrow belt. Tertiary sediments are also deposited as thin cappings which are identified as the warkali sandstone. Hydrogeological provinces in India can be grouped into three main divisions; hard rock regions (nearly 65% of India), alluvial regions of major river basins (mostly in the northern parts of India) and consolidated sedimentary formations (about 5% of India).

4.5 Soils

The soils of Kanyakumari district can be classified into i) Red Soil, ii) Red lateritic soil, (iii) Brown soil and iv) Coastal sand. The soils are mostly in-situ in nature, lateritic, earthy and pale reddish in colour. They are derived from laterisation of gneisses. The soils derived from gneisses are mostly brownish. The thickness of soils in the mounts is almost negligible whereas in the valleys it is around 2 m.

The lateritic type of soil occurs in Thiruvattar, Munchirai, Kurunthancode, Rajakkamangalam, Killiyur, Thuckalay and Melpuram blocks. The mixed type of Red and alluvial soils, occur in Agastheeswaram and Thovala blocks. The coastal sand occurs in the western side of the district. The coastal alluvium sand is of high fertility.

The district is part of the composite east flowing river basin between Pazhayar and Tamirabarani as per the irrigation Atlas of India. Valliyar, Pazhayar, Tamirabarani and Aralvaimozhi are the important sub-basins/watersheds.

The pazhayar river originated at an altitude 1300 m amsl in the Mahendragiri hills and the river water taken away through channels for irrigation. the river is benifitted by both SW-NE monssons. It completes its 20 km journey after joining the Arabian sea. Its creek can be seen near Manakudi,12 km south of Nagercoil.

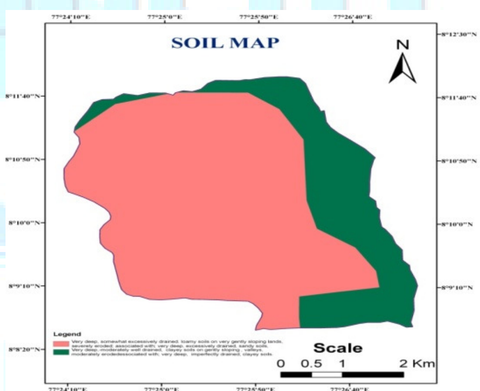

Figure 3. Soil map of study area

The chief irrigation sources in the area are the Canals, tanks, wells and tube/bore wells and other sources. Irrigation is higher in Agastheeswaram, Thovala and Rajakkamangalam blocks followed by Thuckalay, Kurunthancode, Killiyur, Melpuram, and Munchirai blocks. The block-wise and source-wise net area irrigated (Ha) is given below.

Table. 1 Block-wise and Source-wise net area irrigated (Ha)

S. No.	Block	Net area irrigated by					Total Net Area irrigated
		Canals	Tanks	Tube/ Bore wells	Ordinary wells	Other Sources	
1	Thovala	4685	260	28	59	18	5050
2	Agastheeswaram	5215	449	0	315	0	5979
3	Rajakkamangala	2335	638	494	577	0	4044
4	Thiruvattar	588	1112	0	12	94	1806
5	Thuckalay	1021	2529	0	19	3	3572
6	Kurunthancode	813	2199	0	185	4	3201
7	Munchirai	254	554	0	31	12	851
8	Killiyur	667	1058	0	35	52	1812
9	Melpuram	335	983	0	6	55	1379
	Total	**15913**	**9782**	**522**	**1239**	**238**	**27694**

(Source: Department of Economics & Statistics, Govt. of Tamil Nadu)

4.6 Land Use

The various landuse categories identified in the block are. Agricultural lands which includes mostly plantations. Forest lands, water bodies, settlements, problem soils etc. The southern end of the district covering blocks Agastheeswaram, Rajakkamangalam, Kurunthancode, Tiruchuli, Killiyur, Munchirai, are predominantly covered with agricultural lands mostly plantations. The major portions of the blocks Thovala, Thiruvettar are covered under forest lands. Forest lands are also conspicuous in Melpuram block. Salt pans are identified in parts of Agastheeswaram and Rajakkamangalam blocks. The land use abstract table for the district is given in table 2.

Table 2 Land use abstract for Kanyakumari district

Sl.No	Name of the block	Agricultural lands		Forest lands		Waste lands	
		Area in sq.km	% of the total block area	Area in sq.km	% of the total block area	Area in sq.km	% of the total block area
1	Agastheeswaram	100.65	72	4.73	3	7.12	3
2	Rajakkamangalam	114.57	82	5.36	3	-	-
3	Kurunthancode	86.56	77	9.66	8	5.97	-

4	Thackalay	99.94	72	33.62	24	-	5
5	Killiyur	78.09	94	-	-	-	-
6	Munchirai	68.20	94	-	-	-	-
7	Melpuram	171.67	61	89.85	32	7.68	6
8	Thiruvattar	112.34	32	200.48	58	-	-
9	Thovalai	108.42	29	128.97	62	22.61	5

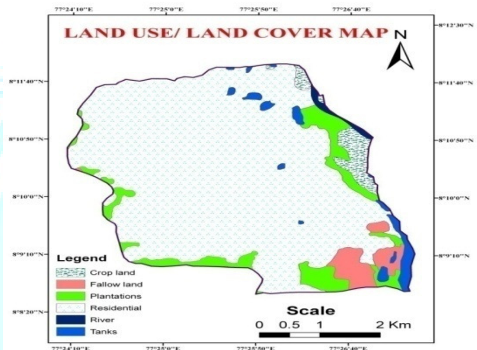

Figure 4. Land Use map of study area

4.7 Ground Water Quality

The chemical characteristics of ground water in the phreatic zone in Kanyakumari district has been studied using the analytical data of ground water samples collected from Network Hydrograph Stations of Central Ground Water Board. The study of quality of ground water in deeper aquifers in the district has been attempted using the data collected from exploratory bore/tube wells constructed in the district.

Ground water in phreatic aquifers in Kanyakumari district, in general, is colourless, odourless and slightly alkaline in nature. The specific electrical conductance of ground water in phreatic zone (in Micro Seimens at 25^{O} C) during May 2006 was in the range of 150 to 2240 in the district. It is between 750 and 2250 µS/cm at 25^{O} C in the major part of the district. Conductance below 750 µS/cm has been observed in ground water in parts of Marthandam, Attur, Villukuri and Chettiyarmadam.

It is observed that the ground water is suitable for drinking and domestic uses in respect of all the constituents except total hardness and Nitrate in more than 90 percent of samples analysed. Total Hardness as $CaCO_3$ is observed in all samples have with in the permissible limits analysed whereas Nitrate is found in excess of 45 mg/l in about 25 percent samples. The incidence of high total hardness is attributed to the composition of litho units constituting the aquifers in the district, whereas the Nitrate pollution is most likely due to the use of pesticides and fertilizers for agriculture.

With regard to irrigation suitability based on specific electrical conductance and Sodium Adsorption Ratio (SAR), it is observed that ground water in the phreatic zone may cause high to very high salinity hazard and medium to high alkali hazard when used for irrigation. Proper soil management strategies are to be adopted in the major part of the district while using ground water for irrigation.

4.8 Hydrology

The district is underlain by both porous and fissured formations (Plate-II). The important aquifer systems in the district are constituted by i) unconsolidated & semi-consolidated formations and (ii) weathered, fissured and fractured crystalline rocks.

The depth to water level in the district varied between 5.27 and 16.70 m bgl during pre-monsoon (Plate-III) and varied between 2.47 and 11.32 m bgl during post monsoon (Plate-IV). The seasonal fluctuation shows a rise in water level, which ranges from 3.71 to 7.06 m bgl. The piezometric head varied between 2.66 to 20.06 m bgl during pre monsoon (May 2006) and 1.19 to 14.57 m bgl during post monsoon (January 2007).

5. DATA COLLECTION AND METHODOLOGY

The monthly water level data for 5 observation wells were collected from the PWD (Ground Water Division), for the periods of before and after implementation of RWH structures along with the lithology data. Using this monthly water level data, groundwater hydrograph was plotted in order to identify its trend. Also, with the application of ArchInfo-GIS software, groundwater contours for the study area were drawn. This will give the spatial variation of groundwater levels within the selected areas. "Groundwater Estimation Committee (GEC) Norms" was used to estimate the change in storage. Ground water potential assessment was carried out by water level fluctuation method for the years 2000 (Pre implementations of RWH) & 2006 (Post implementation of RWH). The influencing area of each well was delineated and calculated based on Thiessen polygon method with the capabilities of ArchInfo software and

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presented in Figure 2. Based on geology of the study area and recommendations of GEC norms, the specific yield values were taken. Using the change in water level, specific yield and area of influence, change in storage was estimated for the years 2000 and 2006.

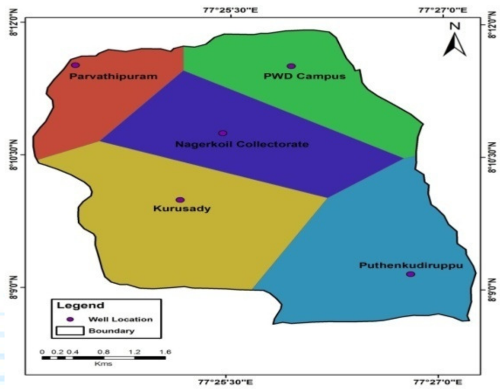


Fig.5. Theissen Polygon Map of the study area

The rainfall observed from Nagercoil Raingauge Station for the years 2000 & 2004 were plotted here. It can be observed that there is comparatively less rainfall in 2004, when compared to the rainfall in 2000. Rainfall observed from Nagercoil Raingauge Station for the years 2000 & 2006

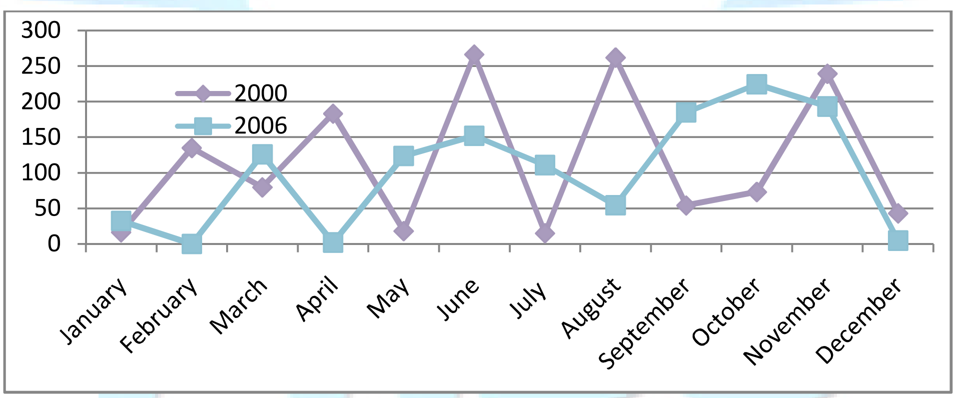


Fig.6. Observed Rainfall Datas

6. Ground Water table contours

From the observed monthly water level data, there is an increase in water level in each well after implementing RWH structures. To know its spatial variation, water table contours were drawn for both periods using the Arc GIS.9.3. The water table contours for the months

January & May 2000 and January & May 2006 are presented in Figures. It is clearly observed that the water table has increased from its level in pre-implementation to that of post implementation period.

Fig 7.Variation of ground water table in Jan 2000

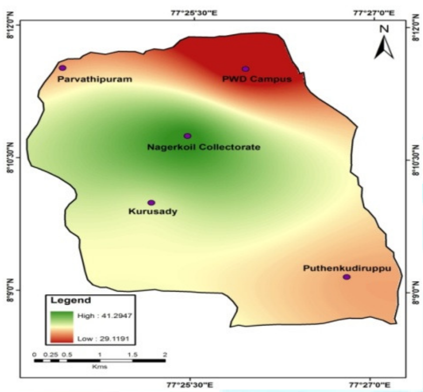


Fig 8.Variation of ground water table in May 2000

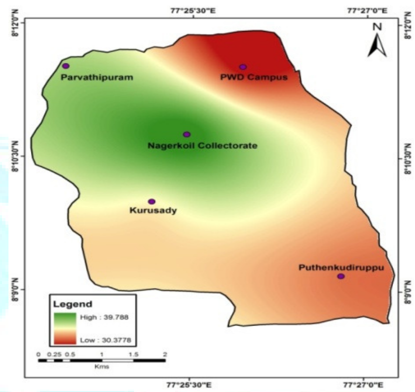


Fig 9.Variation of ground water table in Jan 2006

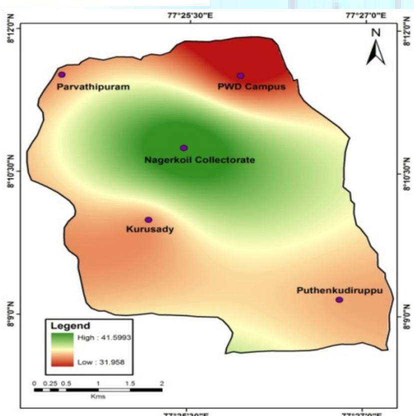
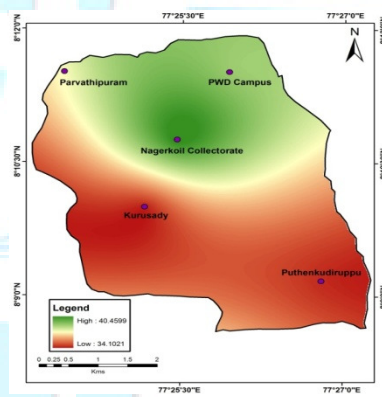


Fig 10.Variation of ground water table in May 2006



In the study area, before the implementation of RWH structures, water table varies from 29.11 - 41.29 m (All water levels refer to the heights above the mean sea level) just after the monsoon (January)and the same varies to 30.38 m to 39.78m during summer month (May). The spatial variation shows that major portion of the study area has water table in the range of 32 m to 40 m meaning that the groundwater levels are falling. After the implementing RWH structures, water table contours vary from 31.96 m to 41.60 m during post monsoon period (January) and 34.1 m to 40.46 m during summer (May) in the study area. Major portions of study area persist with the water table in the range of 35 m to 40 m meaning that the groundwater levels are rising. Hence, the implementation of RWH structures improved the groundwater level in the study area to a great extent.

These results are correlated with variation of Rainfall through a hyetograph shown in Figure 9. Trend line of annual rainfall indicates that the rainfall in the study area shows the decreasing trend.

7. CONCLUSION

The spatial variation of water table contours drawn using ArcGIS shows that many of the urban areas have lower groundwater levels before implementation of RWH. Majority of the study area have raised groundwater levels during the post RWH period. After implementing the rain water harvesting, show positive change in groundwater storage. Hence, it is concluded that ground water storage is in increasing trend after provision of RWH structures in the study area.

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