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Comprehensive hydrogeological Survey of Upper Sina River of (SA-2) in the in Ahmednagar District, Maharashtra, India

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***Abstract*:- Groundwater has been the primary source of water supply for domestic, agricultural and industrial uses in Maharashtra. The population increase in demand for water for competing uses, it is difficult to meet the entire demand from a single source and it is a challenge to plan and manage the different water resources. Among the two major water resources surface and groundwater, it is the groundwater source needs carefully, especially in drought prone areas. The hydrogeological features such as sub soil structure, rock formation, lithology and location of water play a crucial role in determining the groundwater. To assess the improve groundwater potential, a suitable and accurate technique is required for a meaningful and objective analysis. The main objective of present study is to implement the artificial recharge structures how to increase the groundwater recharge through observation wells data measuring. Here we are taken five years water level data collected from ob wells and recording and monitoring. The proposed Artificial recharge techniques are used to improve groundwater level to replenish the groundwater resources which exploited by pumping for irrigation and drinking purpose.**

An artificial recharge structures are practiced in the Deccan trap basalts of Maharashtra for groundwater restoration and management. The observation wells data monitoring and collected every year for recording water fluctuation rising and falling.14 observation wells marked in the miniwatershed for each village. The effectiveness of recharge structures in improving the recharge process has been evaluated for different recharge structures, namely, recharge shaft, recharge trench, check dams and percolation tank. Natural recharge, depth of increase in groundwater is 2.0 m whereas the areas having artificial recharge structures the increase in groundwater table is 6.0 m to 8.0m bgl.The recharge shaft in along the nala and percolation pond was found to be more effective in recharging the groundwater. In this paper Remote sensing Land use land cover and water level scenario was observed how to impact groundwater level increased after implementation of the artificial recharge structures in the period 2019 to 2020.To estimate the water level fluctuation, average water level fluctuation, fluctuation between the lowest and highest water levels over five years and fluctuation in monsoon seasons. The results of this study help in accurate prediction of groundwater level, which in turn may avoid groundwater over exploitation and help restore the aquifer system.

Keywords: Trench, Lithology, Shaft, fluctuation and groundwater level.

INTRODUCTION

In view of increasing demand of water for various purposes like agricultural, domestic, industrial etc., a greater emphasis is being laid for a planned and India is mostly agriculture based country where about 85 % of the population depends on groundwater for irrigation and domestic needs. Extraction of groundwater for irrigation where it is slowly renewed is the main cause for depletion (Hertig and Gleeson, 2012). Agricultural activities mostly depend on the use of groundwater especially in deccan trap basalts, Maharashtra. Groundwater depletion and its impact are more obvious at the regional scale in agriculturally important parts of India. Artificial recharge is a technique used to prevent over exploitation of groundwater resources. Artificial recharge is the progression of replenishing groundwater by augmenting the natural infiltration of rainwater or surface water into sub surface aquifers through several methods depending on the slope, Geomorphology, geology and soil conditions. Artificial recharge structures are practiced in the deccan trap basalts of Maharashtra for groundwater restoration and management. The previous studies showed that the most commonly used method for natural recharge estimation is the mass balance approach (Rushton et al., 2006; Sophocleous, 1991; Stone et al., 2001). The influence of percolation pond in artificial recharge of a semi-arid region of India was observed that 30-35 percent of the impounded water was recharged through the pond (Sukhija et al., 1997).The response of two percolation ponds in Tamilnadu, India was studied to assess their potential influence zones. They observed that the strongly influenced wells were located within 400m from the ponds whereas moderately influenced wells were located up to 800m from the ponds (Jothiprakash et al., 2002). In the present study, the drainage pattern artificial recharge structure in upper Sina River miniwatershed was selected to assess the impact of artificial recharge structures in improving the groundwater level.

STUDY AREA:

The Upper Sina River miniwatershed study area (SA-2) is located at a distance of about 10km to from the Ahmednagar district Head quarter in the north direction. The Ahmednagar is largest district and central part in Maharashtra. The study area lies between latitude N19^{0} 00′10″ to N 19 ^{0}15′15″ and longitude E 74°40′00″ to E 74^{0}53′15″ and falls in the Survey of India Toposheet No.47 I/12 and 47 I/16. The location map of the study area as shown in Fig.1. The miniwatershed have spread around 180 sq.km covered fourteen villages as shown in Fig.1. (Pimplegaonmalvi, Pokardi, Shendi, Jeur, Manjarsumba, Dongargaon, Imampur, Burhanagar, Nagapur, Dangarwadi, Pimplegaon Ujjini,Vadagaon Gupta,Bahirwadi and Sasewadi).

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The miniwatershed is located in the Sina River basin of Ahmednagar district, Maharashtra, India. The area is mostly covered with basaltic hard rock terrain and drought prone area. The entire catchment is a sub basin of Sina River which is a tributary of Bhima River that drains eastwards to Krishna River.Fig.2. The area is located on moderately sloping terrain. It is bounded by hilly ranges towards north, north east and east, while rest of the area shows relatively plain surface. The southern boundary is marked by Sina River which meets Bhima River that further goes to Krishna River. The elevation ranges are 668 to 820 m mean sea level (MSL). The drainage shows typically dendritic pattern of Deccan volcanic province. The River flows is from upper regions in the north towards low lying area in the south west.

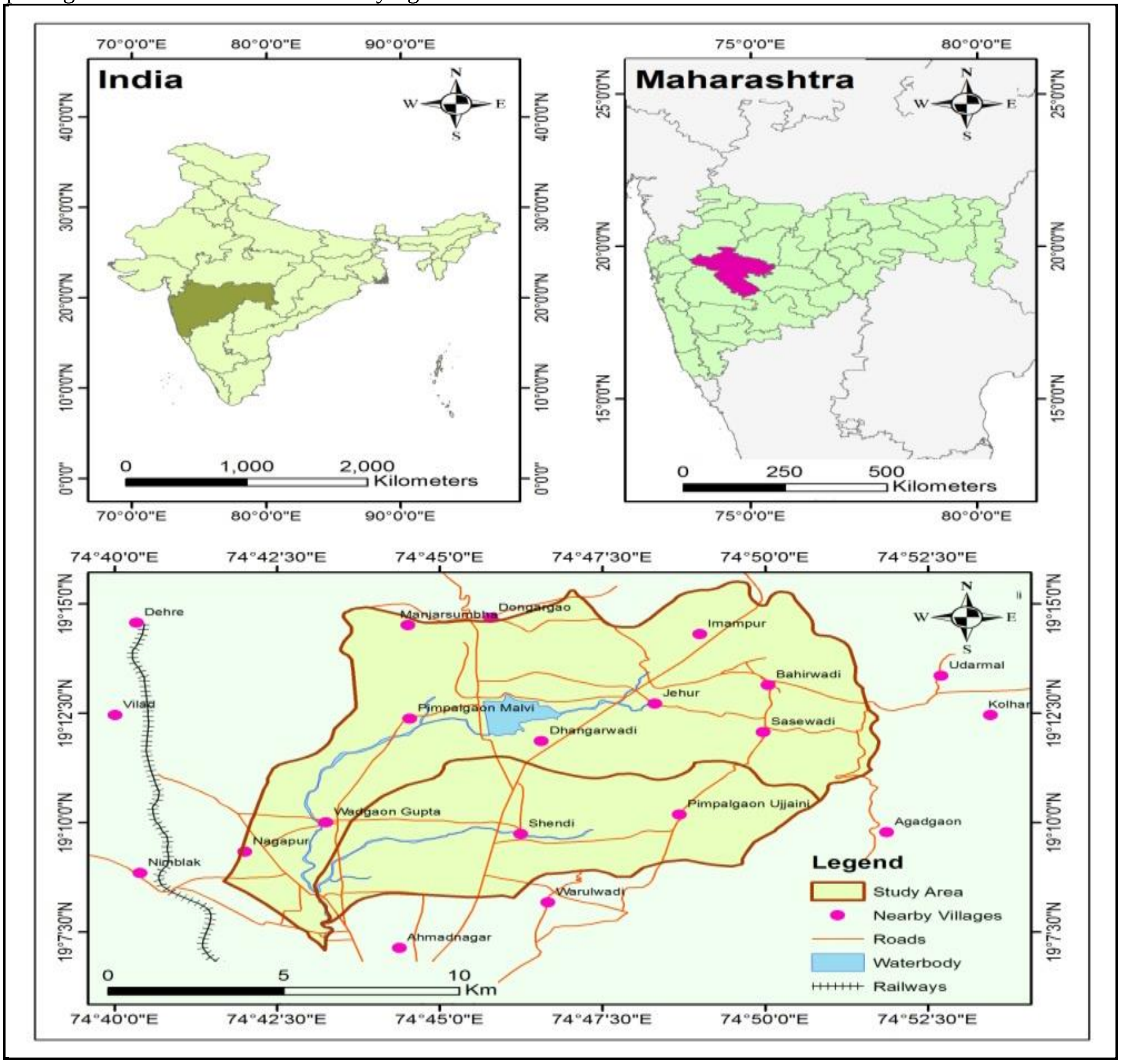

Figure. 1. Location Map of the study Area

RAINFALL PATTERN

Climate of this district is characterized by hot tropical climate with extreme summer, mild winter season and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. As per agro-climate zones of the agriculture department, Ahmadnagar district falls under moderate rainfall zone. The normal annual rainfall in the Ahmadnagar district varies from about 484 mm to 879 mm. It is minimum in the north eastern part of the district around Kopargaon and Sangamner and it gradually increases towards southeast and reaches a maximum around Jamkhed. The average annual rainfall over the district is about 801 mm. It is the minimum in the eastern part of the district and increases west wards towards Kopargaon and Sangamner. The study of negative departures of the annual rainfall over normal reveals that north western and south western parts of the district experienced moderate and severe drought conditions for more than 20 % of years. Hence this parts occupying almost entire Kopargaon, Sangamner and Jamkhed talukas can be categorized as drought area. The average annual rainfall of last ten years in the district varied form 645 mm (Shahada) to 1192 mm (Jamkhed).

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Table 1: Taluka wise Annual Normal rainfall data in Ahmednagar District

Sr No	Taluka	Year	Normal RAIN FALL (MM)	MONSOON RAINFALL (MM)
1	Ahmednagar	2012	479.80	174.00
2		2013	479.80	434.40
3		2014	479.80	377.10
4		2015	479.80	301.40
5		2016	479.80	478.10
6		2017	479.80	669.00
7		2018	479.80	254.40
8		2019	479.80	472.30
9		2020	479.80	827.40
10		2021	479.80	557.00
11		2022	479.80	581.20

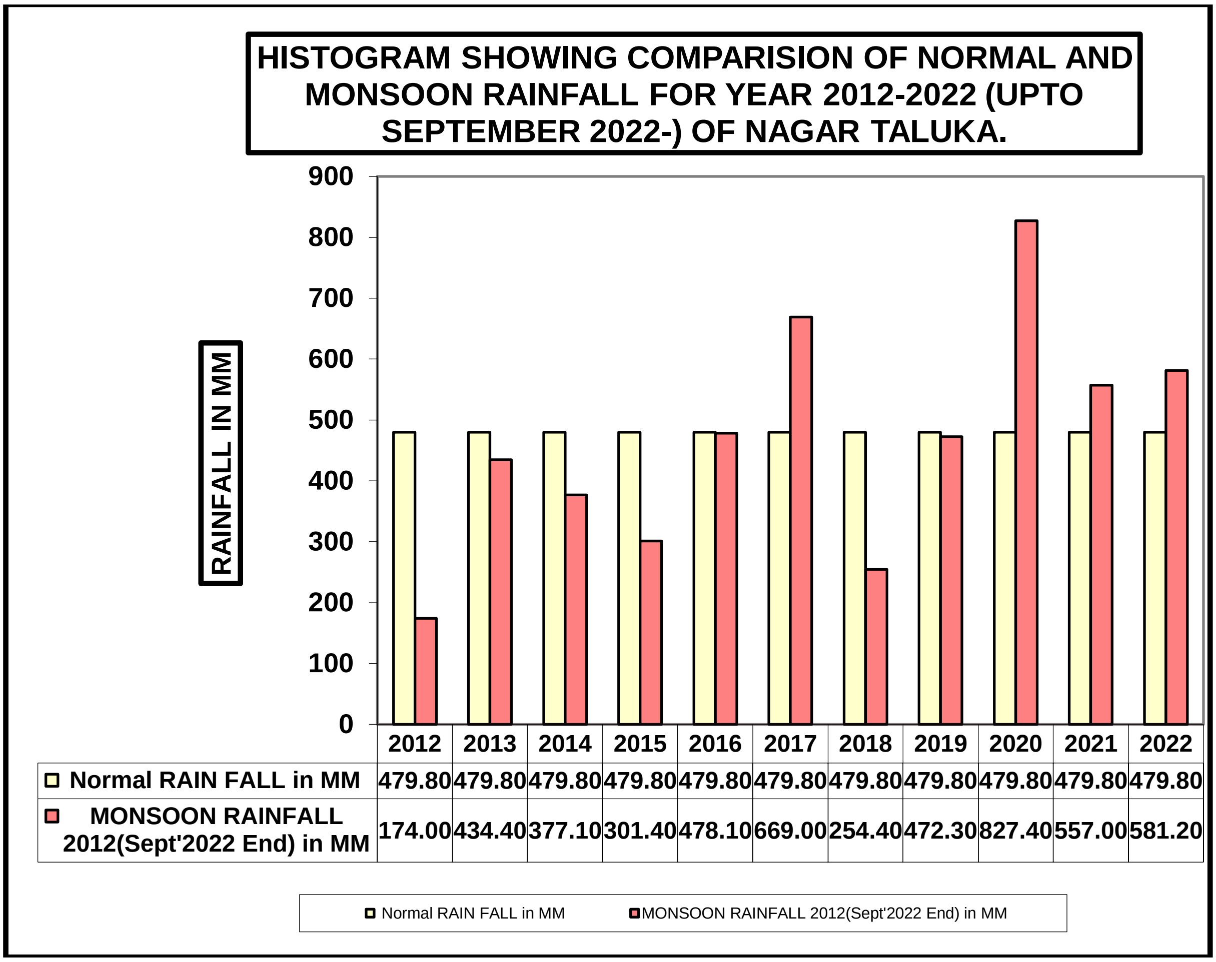

Figure.4.Histogram of Normal Rainfall Year 2012-2022

GEOLOGY:

Geologically, the most important rock types of Ahmednagar district are basaltic lava flows (Deccan Traps), other major geological formations are Archean's, Precambrian (Purana) formations and Alluvium. The major hydrogeological groups such as unconsolidated, semi-consolidated, and consolidated, and nine different types of hydrogeological sub-groups based on geological age and hydrogeological characters. Deccan trap basalt of late Cretaceous to Eocene age is the major rock formation in the district covering almost entire district. The watershed and fractured part of basalt occurring in topographic lows from the main aquifer in the district. Groundwater occurs under phreatic, semi-confined and confined conditions. Generally, the shallower zones down to the depth of 35 m bgl from phreatic aquifer. The water bearing zones occurring between the depths of 9 and 35 m are weathered interflow or shear zones and yield water under semi-confined conditions. Deeper semi-confined to confined aquifers occur below the depth of 35 m as the borewells drilled have shown presence of fractured zones at deeper depths at places. The vesicular portion of different lava flows varies in thickness from 5 to 24 m and forms the potential aquifer zones. However, the nature and density of vesicles, their distribution, inter connection, depth of weathering and topography of the area are the devise factors for occurrence

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and movement of groundwater in vesicular units. The massive portion of basaltic flows are devoid of water, but groundwater occurs in weathered, fractured, jointed or contain weaker zones in it. The field of the dugwells ranges from 10 to 100 m^3 /day, whereas borewells yield is restricted upto 2.5 lps when favorably located.

Table 2: Geological age, Stratigraphic, Rock formation and Hydrological characters

Geological age	Stratigraphic unit	Rock formation	Occurrence and Hydrogeological characters
Unconsolidated formations			
Recent to Sub-recent	River alluvium (Other Rivers)	Silt, Clay, Sand, Gravel and occasionally Cobble beds	Ahmadnagar district. Very productive if thick (>10m) and extensive.
Semi-consolidated formations			
Cretaceous	Infra-trappean bagh beds, lametas	Sandstone, limestone and Clay	Ahmadnagar district. Hydrogeologically not very important due to limited occurrence.
Consolidated formations			
Upper cretaceous to eocene	Deccan traps	Basalt, Dolerite and other acidic derivatives of Basaltic magma	Ahmadnagar districts. Basaltic lava flows consist of two types. (a) vesicular/amygdaloidal basalt and (b) massive basalt. Vesicular basalt possesses primary porosity and permeability if vesicles are interconnected and can be productive but when vesicles are found filled with secondary minerals such as zeolites, quartz, calcite etc. the primary porosity of the rock is reduced to almost nil. The weathered, jointed and fractured parts of the vesicular/amygdaloidal/massive basalt formation constitute the promising water bearing horizons.

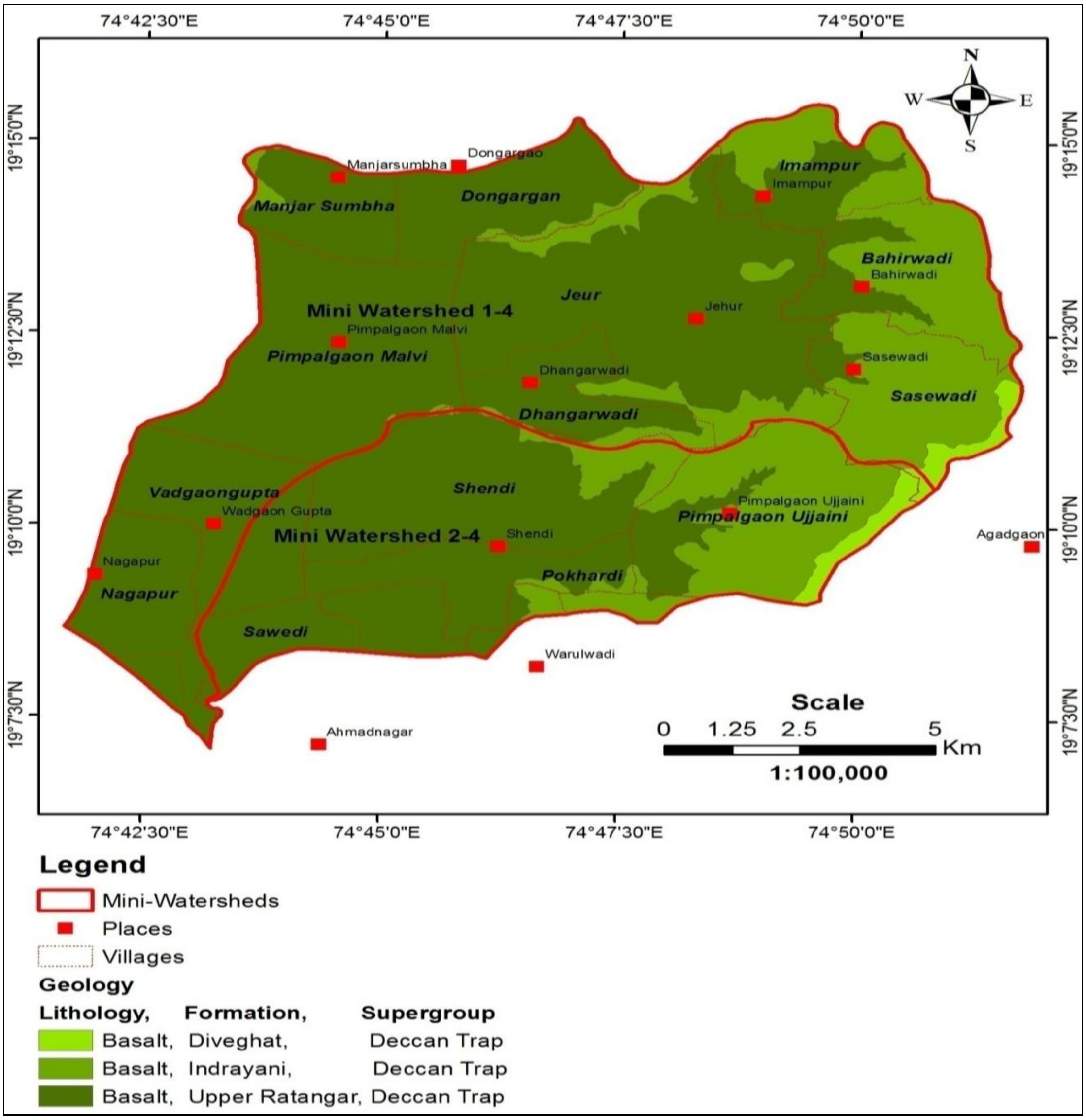

Figure.2.Geology of the Miniwatershed (SA-2) of the study area

DRAINAGE

The drainage system of the miniwatershed is the part of Sina River. The Sina River flows through the district Ahmednagar district eastern. It is tributary of Bhima River which goes to Krishna River.

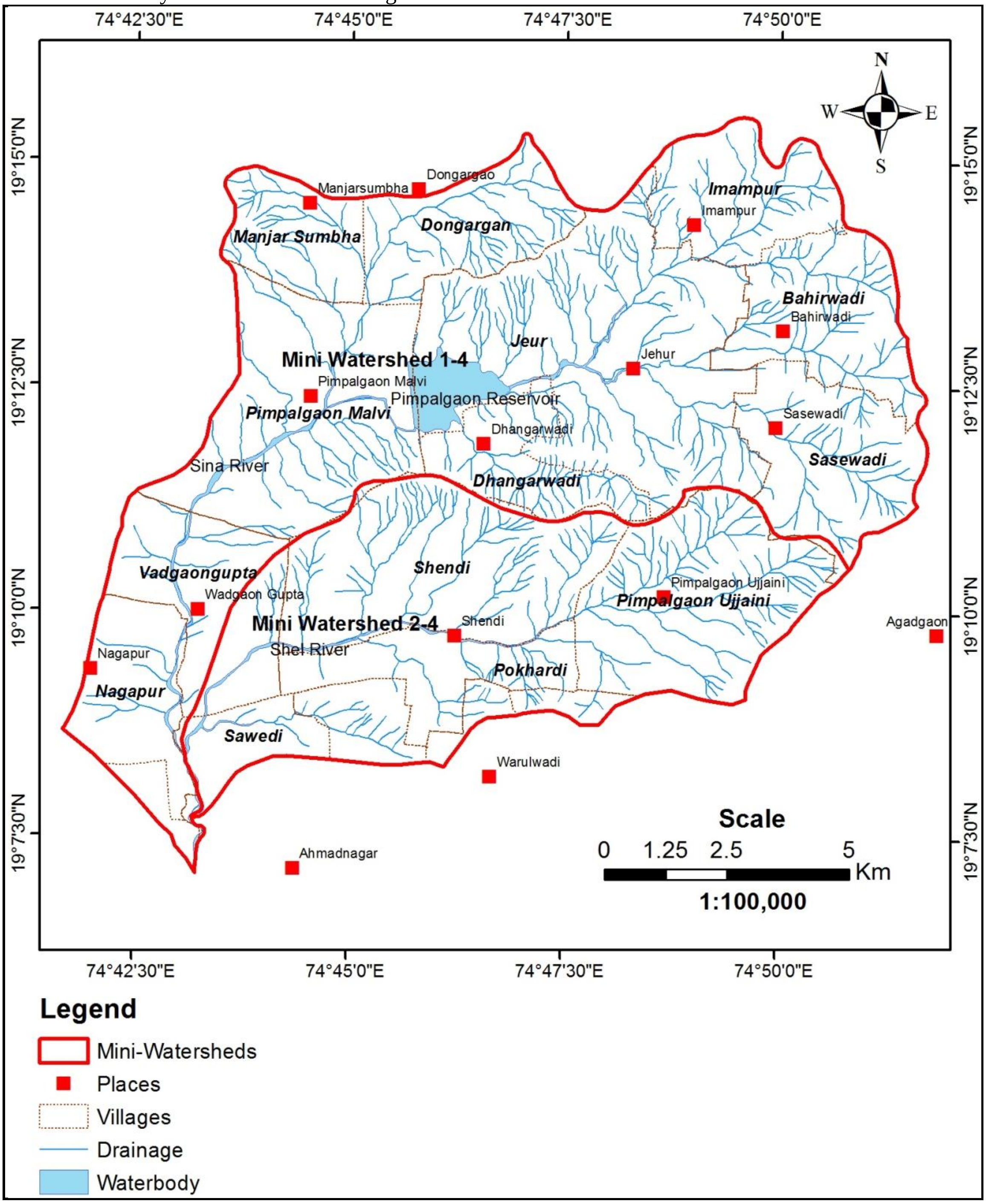

Figure .3. Drainage map of the Miniwatershed (SA-2) of the study area

RESULTS AND DISCUSSION

Water Level Scenario

The study area each village selected one observation well has been monitored with the help of community. Each observation well represents the hydrological conditions of the respective village. The groundwater levels of every month collected from the well. The hydrological year starts from June and ends May month of next calendar year. Since the aquifer saturation is maximum in October (the post monsoon month) and minimum in May (the pre monsoon month), often resulting into dry of wells, the present paper is based on the water level fluctuation between October and May for each hydrological year.(Groundwater estimation committee 2015). Further the consistent series of water table statistics is produced which enabled with the help of GIS mapping. The water level data from 2014 to 2020 has been integrated with well inventory. The water level fluctuation data has been recorded as below.

Change in Groundwater Levels
a) Depth to water level of Aquifer
Study area periodically monitors 14 groundwater monitoring wells times a year 2014-2020 i.e., in, May (pre monsoon) and September (Post monsoon). These data have been used for preparation of depth to water level maps of the study area. Pre monsoon and post monsoon water levels along with fluctuation during long term water level trends (2014-2020).

Table 3: Water level of Groundwater monitoring wells 2014-2020

Sr. No.	Village	Depth	Pre-monsoon water level (in bgl)	Pre-monsoon water level (in bgl)	Pre trend (m/year)		Post trend (m/year)	
					Rise (m)	Fall (m)	Rise (m)	Fall (m)
1.	Dangar wadi	10	6.3	2.5	0.0	0.1	0.21	0.0
2.	Jeur	10.2	7.8	3.5	0.0	0.31	0.0	0.41
3.	Pimplegaon Malvi	7.5	7.5	2.3	0.0	0.02	0.0	0.1
4.	Sasewadi	11.2	11.2	3.8	0.0	0.15	0.0	0.23
5.	Vad gaon	17.5	17.5	7.9	0.0	0.2	0.69	0.0
6.	Gupta	9.3	9.1	2	0.12	0.0	0.08	0.0
7.	Imampur	11	9.8	1.5	0.0	0.18	0.0	0.02
8.	Manjarsumba	10.5	10.5	8.0	0.0	0.2	0.0	0.3
9.	Nagapur	11.3	11.3	7.6	0.0	0.04	0.25	0.0
10.	Dongargan	11.3	7.4	1.2	0.0	0.17	0.0	0.25
11.	Polardi	9.0	6.8	5.0	0.0	0.32	0.0	0.08
12.	Shendi	10.9	9.8	5.0	0.0	0.24	0.0	0.01
13.	Pimplegaon Ujjini	10.4	8.4	3.5	0.0	0.31	0.0	0.23
14.	Burha nagar	12	9.1	2.6	0.19	0.0	0.0	0.01

. Table.5 Pre monsoon and Post monsoon water Level 2014-15 and 2019-2020

Location	Post_ Monsoon (Sept- 2014)	Pre_ Monsoon (May-2015)	Fluctuation in meters 2014-15	Post_ Monsoon (Sept-2019)	Pre_ Monsoon (May-2020)	Fluctuation in meters 2019-20	Well depth in m
Shendi	4.9	8.2	3.3	4.3	7.4	3.1	15
Pokhardi	5.0	7.5	2.5	3.8	6.5	2.7	9.8
Pimpalgaon Ujjani	6.3	11.1	4.8	4.8	8.4	3.6	16.2
Dongargan	7.2	11.6	4.4	5.3	9.7	4.4	17.5
Manjarsumba	6.9	13.5	6.6	5.6	9.4	3.8	19.1
Pimpalgaon Malvi	5.9	10.6	4.7	4.7	7.9	3.2	13.8
Dhangarwadi	6.5	11.7	5.2	4.9	8.8	3.9	18.9
Bahirwadi	11.9	18.6	6.7	7.9	14.3	6.4	24.5
Sasewadi	4.0	7.8	3.8	3.5	6.6	3.1	12.8
Imampur	5.2	9.8	4.6	4.8	8.9	4.1	12.5
Jeur	7.5	11.5	4	5.7	10.5	4.8	12.85
Burhanagar	7.0	12.1	5.1	6.7	9.4	2.7	14.2
Wadgaon Gupta	4.2	7.5	3.3	3.7	5.8	2.1	18.2
Nagapur	3.3	4.9	1.6	2.9	4.1	1.2	7.6

Change in groundwater Levels:
The summary of data pre monsoon and post monsoon groundwater levels monitored in fourteen villages from 2014-2015 and 2019 to 2020 is tabulated in table 5. Groundwater levels of each month are given in annexure 1. The pre monsoon depth to water table in 2014-15 and 2019-20 shows a considerable change to 8.97 to 7.08m respectively. Similarly, the post monsoon depth to water table in 2014-15 and 2019-20 varies from 5.91 to 4.67m respectively. A significant difference in mean annual groundwater level is also goes up from 7.44m to 5.90m.The time series plot of mean pre monsoon and post monsoon groundwater levels in figure 5 shows the highest recording in the year 2019-20.The pre monsoon groundwater levels which used to reach to the depth of the wells 9.92m in 2017-18,has retained more water column in the wells even in the late summer 7.08m groundwater level has been recorded in the 2019-20.Similarly the post monsoon depth groundwater table has been recorded closer to the ground surface i.e upto 4.67m.More over the slope of the line shows pre monsoon and post monsoon seasons clearly shows rising trends.These results impact as positive groundwater levels has increased satisfactorly both pre and post monsoon seasons.It is observed that the mean fluctuation in the aquifer remains the range of 2.40 to 3,20m except the outliers of 2017-18 year.

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Table 6. Summary of Groundwater levels of 2014 to 2020.

Year Groundwater level in m (bgl)	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Monsoon (June to Sept)	7.98	8.24	8.85	8.61	7.48	6.75
Pre monsoon (Feb to May)	8.97	9.84	11.72	8.44	7.78	7.08
Post monsoon (Oct to Jan)	5.91	6.68	6.59	5.99	5.08	4.67
Annual Average	7.62	8.25	8.45	7.68	6.78	6.16
Fluctuation	3.06	3.16	5.15	2.85	2.70	2.41

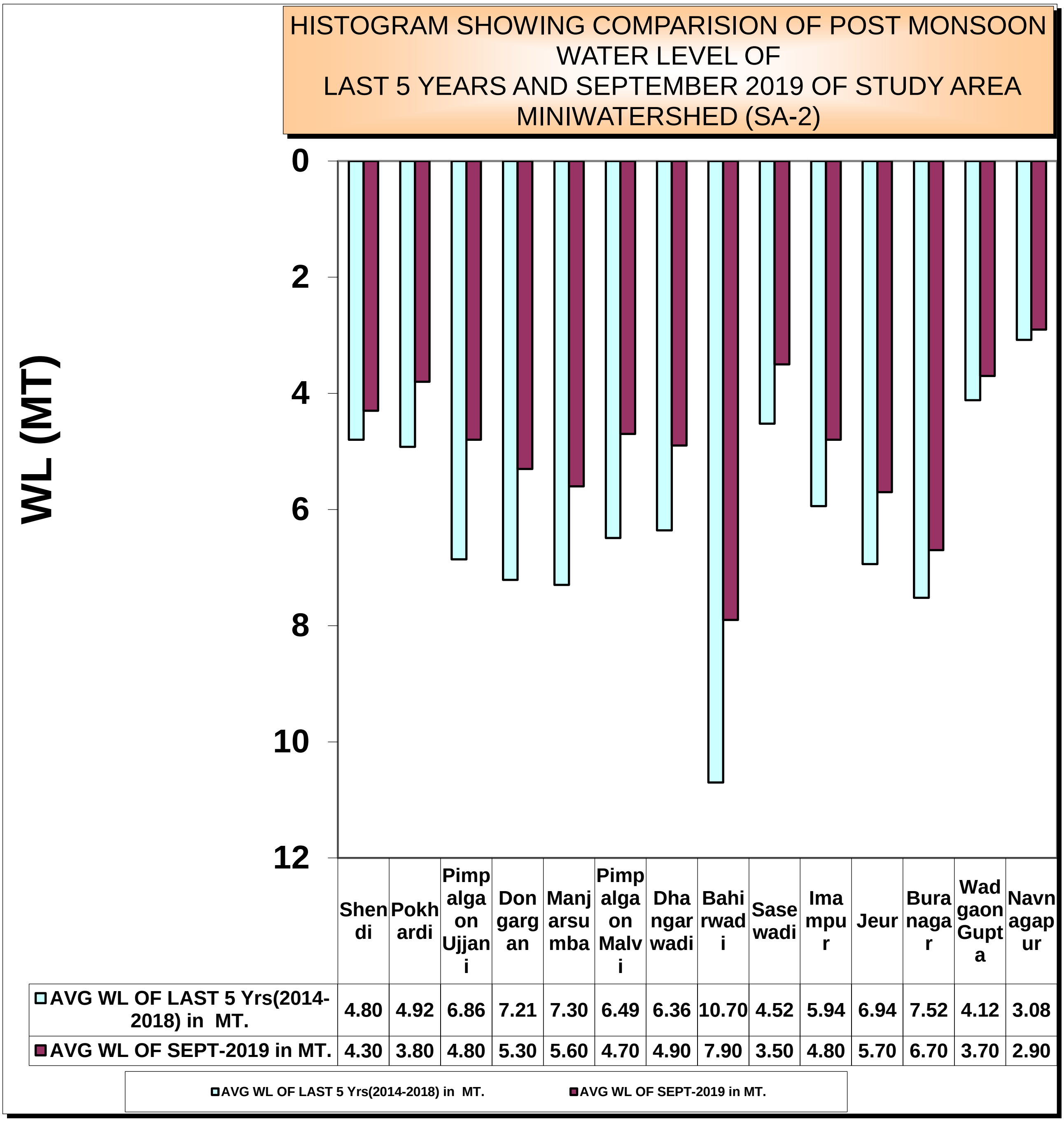

Figure.5.Histogram of Post monsoon Water Levels Year 2014-2019

The pre monsoon season of 2014 to 15 figure shows groundwater levels > 10m in the central and eastern part of the miniwatershed area,where as southeastern part of the area shows groundwater levels <6m.The Central part shows premonsoon groundwater levels between 8 to 10m,while the remaining part shows groundwater levels between 10m to 12m.imapct after implementation of groundwater recharge structures in 2019-20 (figure) remarkebly shows raised premonsoon groundwater levels from 6to 8m in 70% of the area,and between 8 to 10m 20% of the area and only 10% of the area shows groundwater levels above 6 m.

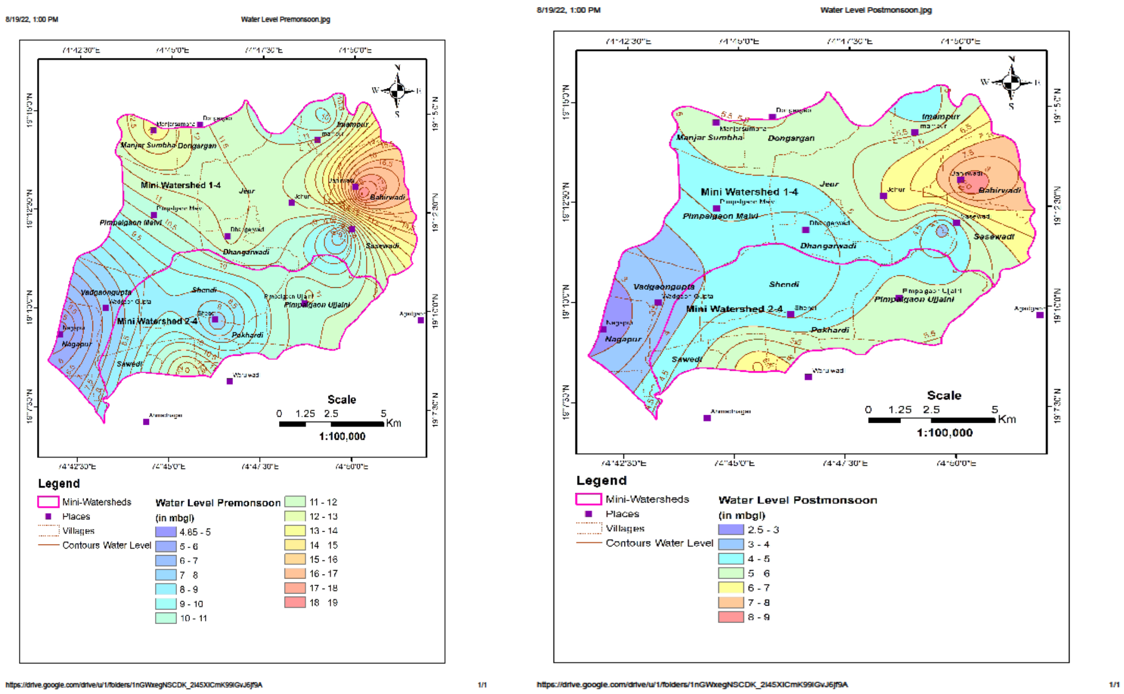

Fig.6 (a) Map shows water level (Pre-Monsoon)Fig.6 (b) Map shows water level (Post monsoon)

The post monsoon season of 2014-15 shows figure 4(a) groundwater levels <4m in south west and below 7.0m in north-eastern part of the area, where as remaining part of the area shows groundwater levels 4 to 7m and in the far eastern part goes to >8m.Impact of recharge structures in 2019-20 (figure 4b) shows 15% of the area having post monsoon levels <3.5m.About 75% of the area shows water levels upto 5.0m bgl and only 10% of the area falls between 5 to 6m.The groundwater level fluctuation in (from post to pre monsoon) in 2014-15 is illustrated in table 6. The range of groundwater fluctuation is observed between 8 to 10m in 90% of the area.A very small portion of south western part of the area shows groundwater fluctuation between 0 to 2m.Groundwater fluctuations are during year 2019-20.i.e after implementation of recharge structures. It distinctly shows the fluctuation in most part of the area between 6 to 8m. The south west part shows fluctuation less than 2m and a very small patch a southern part nagapur and vadagaon gupta,the groundwater level fluctuation between 1.0 to 2 m.The raised groundwater levels are impact of after artificial recharge structures.The average annual rainfall of the area is 622mm.Analysis of data indicates that there is no pattern in the rainfall during last five years occurrence randomly.The lowest rainfall recorded in 2018-19 is 265mm,where as the highest rainfall 827.40mm has been recorded during 2019-20.Rainfall is the major source in the shallow aquifer deccan trap basalts in the area.

CONCLUSIONS

The premonsoon season of 2014 to 15 figure shows groundwater levels > 10m in the central and eastern part of the miniwatershed area,where as southeastern part of the area shows groundwater levels <6m.The Central part shows premonsoon groundwater levels between 8 to 10m,while the remaining part shows groundwater levels between 10m to 12m.imapct after implementation of groundwater recharge structures in 2019-20 (figure) remarkably shows raised premonsoon groundwater levels from 6to 8m in 70% of the area,and between 8 to 10m 20% of the area and only 10% of the area shows groundwater levels above 6 m. Assessing the potential zone of groundwater level is extremely important for the management of groundwater system. Various techniques are available to proposed artificial recharge structures like recharge shaft, recharge trench (Shown in the Figure No.7) percolation tank and check dams at first order, second order and third order streams along the drainage system. In this paper the four recharge structures are impacted rising water level in the year 2019-2020.The starting 2014-2015 year the water level are very low after completion recharge structures last year water levels are slowly rising. The impact of water level are measured and showed. Recharge trench and shafts are artificial recharge structures commonly used for recharging shallow phreatic aquifers, which are not in hydraulic connection with surface water due to the presence of impermeable layers. They do not necessarily penetrate or reach the unconfined aquifers like gravity head recharge wells and the recharging water has to infiltrate through the vadose zone. In areas where phreatic aquifer is overlain by poorly permeable strata, the recharge to ground water storage by water spreading method becomes ineffective or has very low efficiency. This situation also occur in ponds/depressions where due to siltation an impermeable layer or lens is formed which affects hydraulic connection of surface water and phreatic aquifers. Recharge shaft is an artificial recharge structure which penetrates the overlying impervious horizon and provides affective access of surface water for recharging the phreatic aquifer. These structures are ideally suited for areas with deep water levels. In areas where low permeable sandy horizon is within shallow depths, a trench can be excavated to 3 m depth and back filled with boulder and gravel. The trench can be provided with injection well to effectively recharge the deeper aquifers.

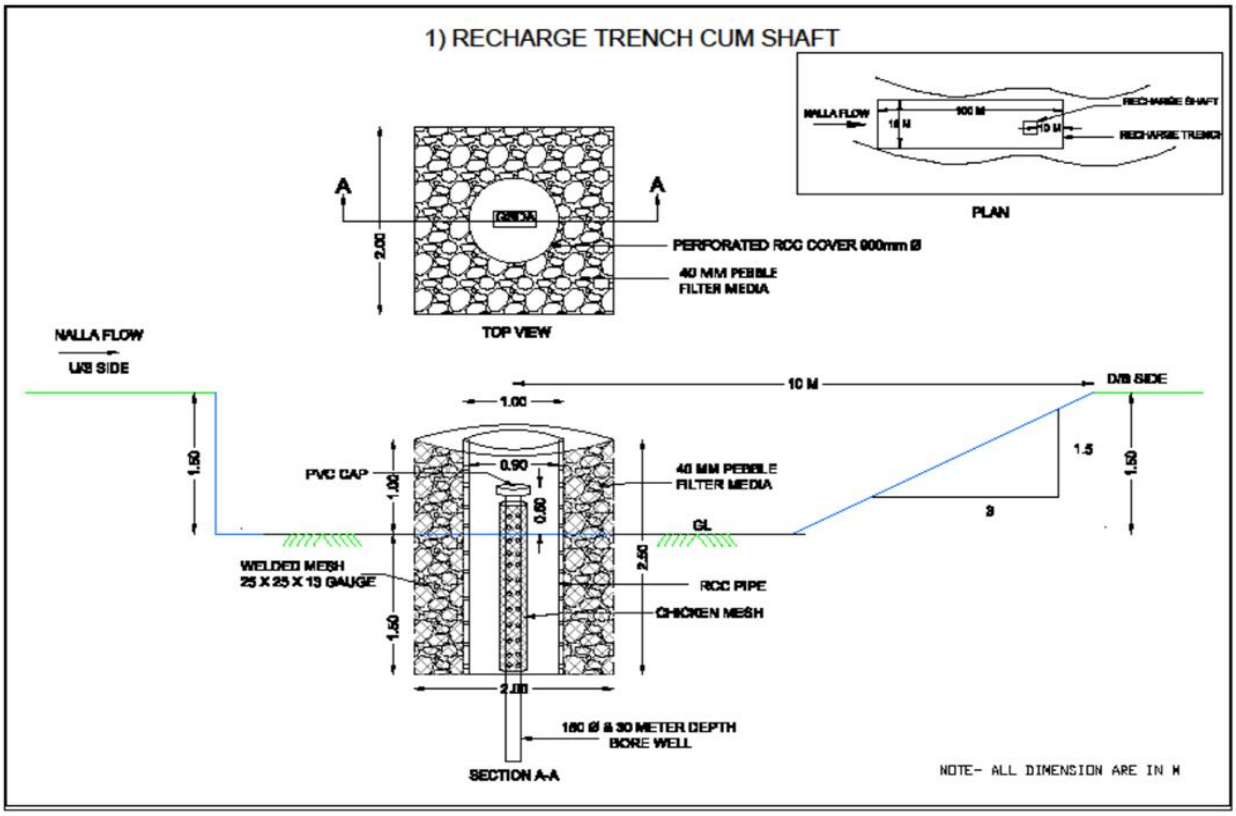

Fig. 7 The diagram of Recharge Trench Cum Shaft i.e. Aquifer Recharge Shaft System after GSDA

INTEREST OF CONFLICTS

The authors do not have interest of conflicts for this study.

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