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QUALITY AUGMENTATION OF GROUNDWATER OVER RAIN WATER REPLENISHING - A CRITICAL STUDY

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Abstract

Now days, artificial recharging of groundwater with rainwater is the most popular methodology observed towards the elevation of quality and quantity of groundwater , however still it is a puzzle for the researchers and technocrats to endow the exact quantification of quality and quantity improvement of groundwater by recharging with rainwater due to variations in allied factors affecting the groundwater quality like topography , hydro geological phenomena , rainwater availability , land use pattern etc. in the study area. An attempt is made here to extract the improvement of groundwater quality by introducing the collected rainwater of known quality parameters to the developed aquifer strata in laboratory with the controlled laboratory setup and under the likely developed resembled conditions of study area aquifer.

Keywords: Groundwater, Quality, TDS, Hardness, Chlorides and Rainwater

1. Introduction

The quality and quantity of groundwater fluctuates invariably in its own which reflects the time to time status of groundwater as a whole for the region. The exploration of groundwater quality and its improvement in the said study area needs the supportive verification at some extent with the conceptual phenomena of groundwater recharging. To obtain such verification various approaches ranging from conventional laboratory experiments to the sophisticated experimental setups may be applied depends upon the preciseness of verification. Groundwater quality itself is the collective term made of its allied quality parameters which vary as per the study area however researches can be focused to governing groundwater quality parameters of the projected study area which are acknowledged under the consideration by available researches and studies. for e.g. if the study are is found affected much with TDS, Chlorides then the quality of groundwater under the observation in experiment is tested for TDS and Chlorides rather than considering all groundwater quality parameters. The experimental set up prepared in laboratory should represent reasonably the field aquifer state and conditions however it is quite cumbersome to replicate the exact aquifer conditions in laboratory. This developed aquifer setup is enriched by the groundwater collected from the aquifer from the study area and allowed to stabilize for some time so the entire aquifer mass of experimental setup can be saturated with the supplemented groundwater. Here by introducing real aquifer water to the developed aquifer mass the groundwater quality of field can be resembled at considerable extent.
Such saturated aquifer of setup is diluted with controlled quality and volume of rainwater preferably the fresh rainwater and allowed to dilute for the considerable time. There after

such diluted samples are tested again in laboratory and concentration of groundwater quality parameters under considerations are compared with the same aquifer water before dilution and the respective improvement of groundwater quality is recorded. As numerous factors are involved in hydro geological phenomena of mixing rainwater to aquifer water during recharging therefore it is somewhat difficult to get exact chemistry involved during mixing process improvement in groundwater quality can be timidly projected by considering conventional dilution procedure which can be alleged as theoretical improvement of groundwater quality.

2. Experimental Setup

Present study was carried out to determine the reduction in concentration of governing parameters essentially Total Dissolved Solids (TDs), Chlorides, Hardness by recharging with rainwater. Here the dilution phenomena of prevailing groundwater quality with rainwater are applied where improved quality of groundwater is computed. This task is accomplished by developing the experimental setup in laboratory which resembles the aquifer conditions of study area. Projected experimental work is the study part of research work of groundwater quality improvement by artificial recharging process so the experiments were carried to two municipal zones- West Zone and South West Zone of Surat city in Gujarat state in western part of India. Surat city is situated 16 kms away from the costal bank of Arabian sea at 21°15'N latitude and 72°52'E longitude and bounded by the area 335 Sq.kms with the population of 4-4.5 million.

To resemble to aquifer conditions an experimental setup was developed in laboratory as per shown in Figure 1. Where transparent water tight metallic structure with suitable dimensions (1.05 m(L) x.75m(B) x 0.45m(H)) and necessary provisions are provided for the inflow of rainwater to aquifer material and to collect the water sample from the setup. Two PVC pipes of different diameters with control valves were provided to intrude the groundwater sample collected from bore wells in study area and two pipes were placed to enter the rainwater in measured quantity where such pipes are acting as different diameter recharge wells of field. Such recharge well pipes were placed in such a configuration that homogeneous mixing of rainwater and existing water of aquifer mass could take place for the dilution.

Figure 1 Experimental Setup for the Components and Sample Collection Point

Setup was filled with the computed quantity of aquifer material (Mixture of Silty and coarse grain sand) collected from study area and it was packed in layers the height of such material has been changed for various cases under study. Four locations of the study area were considered for the experimental purpose .To get the exact aquifer groundwater conditions in

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setup the water samples of the aquifer situated in the said area were collected and the aquifer material in setup was saturated with such collected water samples of the same aquifer and the sufficient time was given to saturate the mass. To control the flow rate necessary valves were provided in setup and thorough mixing of aquifer water in aquifer material was observed.

3. Results And Discussion

As mentioned in previous sections that four well locations of study area were selected and respective aquifer material were collected from these sites to feed in experimental setup, however such aquifer materials were collected from drilling sites of bore wells in vicinity of well location so perfect undisturbed sample could not be received. Groundwater samples from the same four locations were collected from bore wells to saturate the aquifer material and to fetch the reasonably picture of real field aquifer in laboratory. There were two locations selected from South West zone and remaining from West zone of Surat city and tests were given codes A1, A2 for South West zone samples and B1, B2 for West Zone Samples.

The groundwater samples collected from designated locations bore wells were tested by collecting from sample collection point of experimental setup after feeding to the same. The feeding quantity of such groundwater samples to setup was computed by considering the average porosity of setup material .Rainwater collected were tested before the feeding to experimental setup .All such tests were carried for the parameters of pH, TDS, Chlorides, Electrical Conductivity (EC) and Hardness. Porosity of aquifer materials was considered by averaging the porosity observed for each sample of each zone. It is to be noted herewith to avoid septic condition and proper circulation of air aquifer water is added in less quantity than available pore space in material of experimental system. Rainwater used in experiments was collected from open terrace in huge vessel type pan fitted with conventional mesh. The details of Volume of aquifer (by adjusting the thickness of material pack in experimental setup), Considered Porosity, Available pore space obtained by multiplying the volume of aquifer material to porosity, Actual added aquifer water in litre and finally quantity of Rainwater added to experimental setup are shown in Table 1.

Table 1 Computed Details and its Elements

Test ID	Volume of aquifer Material Feeded in Setup (Mt^3)	Porosity (%)	Available Pore Space (Litre)	Aquifer water Added to setup (Litre)	Rainwater Added (Litre)
A1	0.75 x 1.05 X 0.32 ≈ 0.250	30	75	50	10
A2	0.75 x 1.05 X 0.16 ≈ 0.125	30	37.5	25	7.5
B1	0.75 x 1.05 X 0.16 ≈ 0.125	30	37.5	20	10
B2	0.75 x 1.05 X 0.16 ≈ 0.125	30	37.5	20	8

It is to be noted that rainwater act as solute and water entrapped in aquifer mass acts as solvent during recharging process therefore it is essentially to know the concentration of both before their mixing and recharging process takes place. Table 2 represents the concentration of pH, TDS, EC, Hardness of Rainwater collected and Table 3 shows the concentration of pH, TDS, EC, Hardness of water stored in experimental aquifer at both stage before and after

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recharging. Table 4 illustrates the comparative scenario of theoretical and experimental groundwater quality improvement by using the methodology mentioned in preceding sections by using the available data, actually this is exercised to reach to the association of theoretical computation and experimental result of concentration for the said groundwater quality parameter after recharging. However, such association between theoretically computed concentration and experimentally obtained concentration is computed here using statistical term of R2 which is tabulated in Table 5. The graphical representation of % reduction of groundwater quality parameter concentration after recharging phenomena both theoretically as well as experimentally based on Table 4 is presented in Figure 2.

Table 2 Rainwater Quality

Test ID	Concentration of Rainwater Quality Parameters				
	pH	TDS (mg/lit)	Chlorides (mg/lit)	EC (mS/cm)	Hardness (mg/lit)
A1	7.8	135	107	0.46	122
A2	6.4	164	148	0.36	134
B1	7.3	108	76	0.355	68
B2	6.8	125	88	0.225	72

Table 3 Groundwater Quality Feeded

Test ID	Concentration of Groundwater Quality Parameters (*Collected from Experimental Setup Aquifer material*)									
	Before Recharging*					After Recharging with Rainwater*				
	pH	TDS	Chloride	EC (mS/cm)	Hardness	pH	TDS	Chlorides	EC (mS/cm)	Hardness
A1	7.7	2850	2375	5.4	336	7.3	2365	2038	4.64	301
A2	7.4	2680	2375	5.26	342	7.2	2235	1950	4.24	294
B1	7.3	1245	876	2.88	286	7.1	1062	745	2.56	205
B2	7.4	1062	695	1.82	286	7.2	864	572	1.52	224

* Except pH and EC, all parameters are in mg/lit

Table 4 Comparison of Theoretical and Experimental Groundwater Quality Improvement

Location	A1		A2		B1		B2	
Parameter	*Reduction in Concentration*							
	Exp**	Th.**	Exp**	Th.**	Exp**	Th.**	Exp**	Th.**
TDS	17.018	27.22	16.604	21.665	14.699	30.442	18.644	25.209
Chlorides	14.189	27.28	17.895	21.639	14.954	30.441	17.698	24.954
EC (mS/cm)	14.074	26.14	19.392	21.498	11.111	29.225	16.484	25.039
Hardness	10.417	18.20	14.035	18.065	28.322	25.408	21.678	21.379

** Th= Theoretical Exp= Experimental

Table 5 Value of R2 between Theoretical and Experimental Reduction

Location	R^2 Value	Location	R^2 Value
A1	0.786	B1	0.730
A2	0.732	B2	0.813

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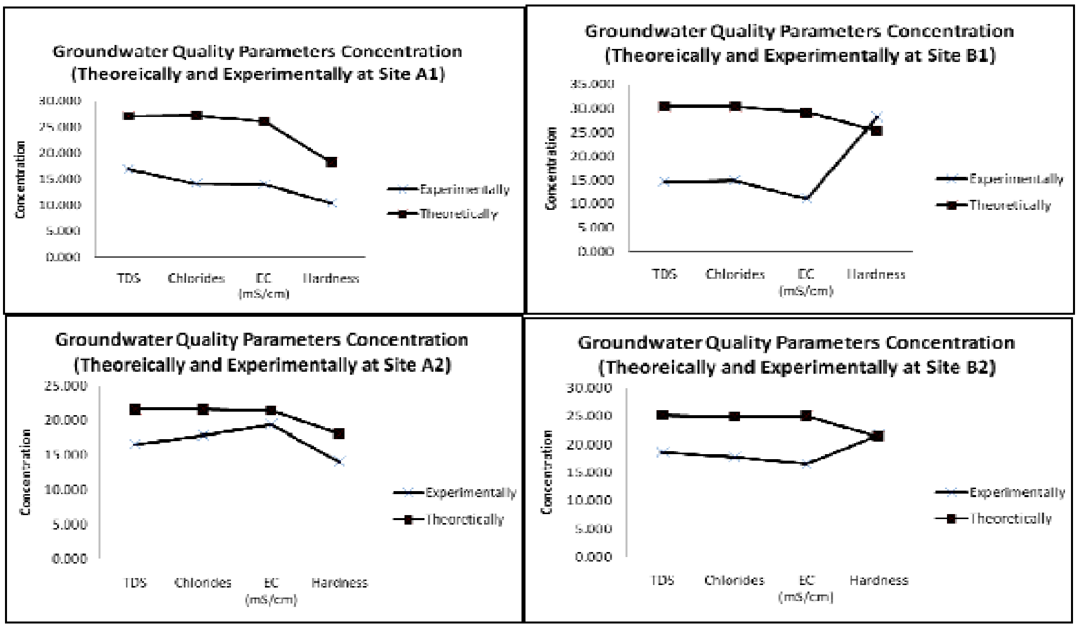

Figure 2 Theoretically Computed and Laboratory Tested Percentage Reduction in Concentration of Groundwater Quality Parameters after Recharging

4. Conclusion

Groundwater recharging is complex phenomenon in its own as it is circumscribed by numerous static and variable aspects like geo hydrological setup, lithology, topography, rainfall pattern, surrounding establishments etc. due to which exact prediction or analysis of groundwater studies is difficult than the surface water. In this regard, present study was attempted to prepare pilot experiment for the analyzing the behaviour of groundwater recharging phenomena and examining the improvement of groundwater quality by recharging the real field aquifer groundwater feeded to experimental setup by rainwater.

- Experimental results of groundwater quality improvement by the reduction in concentration after recharging process for the parameters TDS, Chlorides, EC and hardness were found 17.0%, 14.2%, 14.1% and 10.42 % for site A1 - 16.6%, 17.9%, 19.3% and 14.03 % for site A2 - 14.7%, 14.95%, 11.1% and 28.32 % for site B1 - 18.6%, 17.7%, 16.5% and 21.7 % for site B2.
- By the using standard equations and dilution equations same improvement was found theoretically which was computed as 27.2%,27.3%, 26.1% and 18.20 % for site A1 - 21.7%, 21.65%, 21.50% and 18.06 % for site A2 - 30.44%, 30.44%, 29.22% and 28.41 % for site B1 - 25.2%, 24.9%, 25.0% and 21.38 % for site B2.
- To correlate these two observation i.e. Theoretical and Experimental, co-efficient of determination (R2) was found for the sites A1, A2, B1 and B2 as 0.786, 0.732, 0.73 and 0.813 respectively.
- As the average R2 was found 0.765 however, zone wise means for A category sites situated in south west zone and B category sites situated in west zone such R2 were computed 0.759 and 0.771 respectively.

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