International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2020; 8(1): 2589-2592

Received: 25-11-2019
Accepted: 27-12-2019

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Effectiveness of artificial recharge structures in enhancing groundwater quality

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DOI: https://doi.org/10.22271/chemi.2020.v8.i1am.8659

Abstract
Artificial recharge is a technique used to recharge the groundwater resources which exploited by pumping for irrigation and drinking purpose. An artificial recharge structures are practiced in the hard rock regions of Tamil Nadu for groundwater restoration and also to enhance the groundwater quality. In the present study, an existing recharge structures in Thondamuthur block of was selected to assess the impact of artificial recharge structures in enhancing the groundwater quality. The considerable improvement in groundwater quality was observed due to the effect of artificial recharge structures. The maximum water quality improvement was observed near the artificial recharge structures at downstream side. The standard of irrigation water was improved during post monsoon period. Hence, it is recommended to recharge the groundwater artificially by constructing artificial recharge structures wherever feasible in the study area.

Keywords: Artificial recharge, check dam, groundwater quality, recharge shaft, recharge borewell

Introduction
India is an agrarian 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 [1]. Agricultural activities mostly depend on the use of groundwater especially in southern part of India. Groundwater depletion and its impact is 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 and to enhance groundwater quality. Water quality enhancement through artificial recharge became predominant in the last decade. Quality of water is equally important as that of its quantity. Water stored in the recharge structures are primarily rainfall drained as runoff from different land use of the catchment. Hence, the recharge of this water may change the hydro-chemical characteristics of the groundwater. Several researchers have studied the impact of such structures in enhancing quality of groundwater. Artificial recharge structures improved the groundwater quality and even reduced the concentrations of toxic ions such as arsenic, fluoride and boron because of dilution [2, 3]. However, a few researchers have also highlighted the constraints implicated in using recharge structures for improving the water quality. It is important to maintain the quality of water stored in the recharge structures by taking precautions like preventing discharge from the nearby agricultural lands, dumping of domestic wastes, release of sewage etc. [4]. The response of two percolation ponds in Tamil Nadu, 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 [5]. In the present study, the existing artificial recharge structures in Thondamuthur block of Noyyal sub basin was selected to assess the influence of artificial recharge structures in enhancing the groundwater quality.

Materials and methods
Study area
The location map of Thondamuthur block is shown in Figure 1. It falls within the coordinates of longitude $76^0 40' 00''$ to $77^0 02' 00''$ E and latitude $10^0 56' 00''$ to $11^0 03' 00''$ N of Survey of India top sheet numbers 56B/13, 58B/16 and 58F/1. It has a geographical area of 480 Km^2

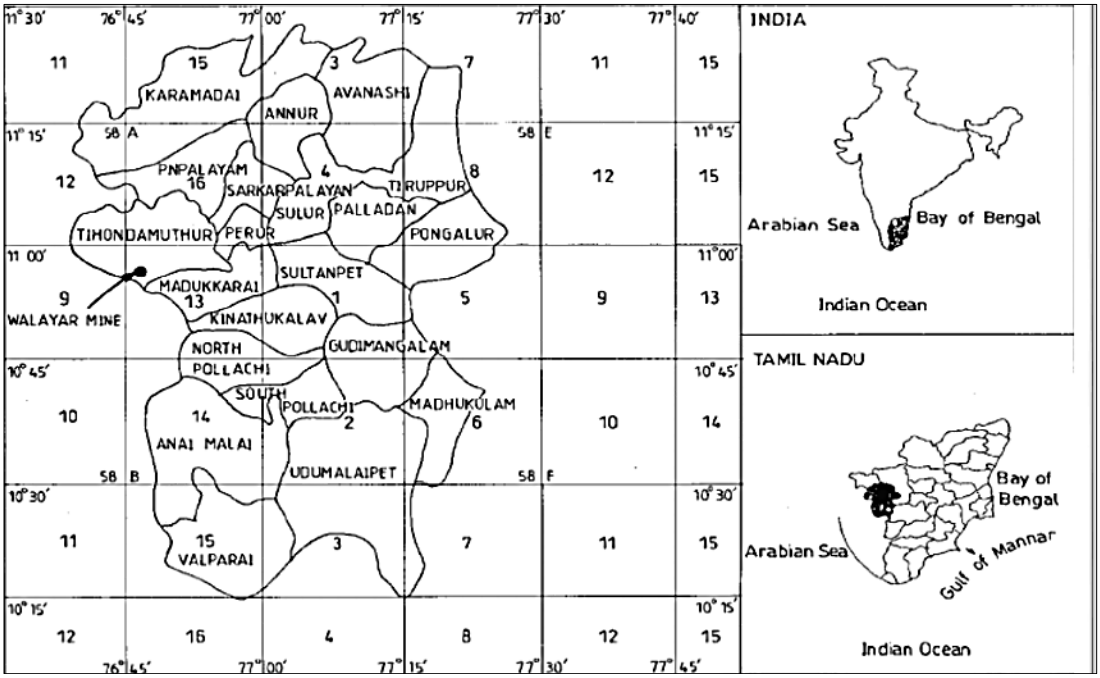

Fig 1: Location map of Thondamuthur block

Five recharge structures were identified in the study area. Three check dams, one recharge shaft in check dam and one recharge bore well was identified for the study. The five observation wells near the structures were also identified for monitoring the water levels. The location of the recharge structures and observation wells were tabulated in Table 1.

Table 1: Location of recharge structures and observation wells

S. No	Observation wells	Structure	Latitude	Longitude	Well depth
1.	Well No. 1	Recharge bore well in check dam	11.007831	76.830701	900feet
2.	Well No. 2	Recharge bore well	11.007163	76.83090	750 feet
3.	Well No. 3	Check dam.1	10.989062	76.79940	900feet
4.	Well No. 4	Check dam.2	10.989979	76.80070	1100feet
5.	Well No. 5	Check dam.3	10.59304	76.79940	1000feet

Water sampling

Regular sampling was done to analyze the quality of groundwater and the changes due to the artificial recharge structures, from observation wells. Five water samples from observation wells were collected and analysed for various parameters. The collected water samples were analysed for pH, EC, Calcium, Magnesium, Sodium, Potassium, Carbonates, Bicarbonates, Chloride, Sulphate, Sodium Absorption ratio (SAR) and Residual Sodium Carbonate (RSC) are calculated by the following equations [6].

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

$RSC\ (meL^{-1}) = (CO_3^{-} + HCO_3^{-}) - (Ca^{++} + Mg^{++})$

All values of cations and anions are in me L^{-1}

Irrigation water suitability as per USSL classification

In the present study, the collected samples of recharged water were classified as per the criteria suggested by the US Salinity Laboratory of the Department of Agriculture (Table 2 to Table 4).

Table 2: Salinity hazard classes based on USSL classification

Salinity hazard class	EC in (dS m^{-1})	Remark on quality
C1	0.1-0.25	Excellent
C2	0.25-0.75	Good
C3	0.75-2.25	Doubtful
C4 and C5	>2.25	>2.25 Unsuitable

Table 3: Sodium hazard classes based on USSL classification

Sodium Hazard class	SAR	Remark on quality
S1	<10	Excellent
S2	10-18	Good
S3	18-26	Doubtful
S4 and S5	>26	Unsuitable

Table 4: Groundwater quality based on RSC (Residual sodium carbonate)

RSC (me L^{-1})	Remark on quality
<1.25	Good
1.25-2.5	Doubtful
>2.5	Unsuitable

Results and Discussion

The potential for water quality improvement of an aquifer is a major criterion for any artificial recharge structure. Water quality parameters were analyzed during pre-monsoon and post monsoon periods before and after artificial recharge.

Table 5: Water quality Parameters analysed pre monsoon

Parameters	W1	W2	W3	W4	W5
pH	7.9	8.1	8.3	8.4	8.7
EC (dsm^{-1})	1.1	1.6	1.5	2.1	2.3
Calcium (me L^{-1})	1.6	1.8	2.2	2.3	2.4
Magnesium	1.5	1.9	1.8	2.1	2.2
Sodium (me L^{-1})	8.6	7.8	8.8	9.2	8.6
Potassium (me L^{-1})	0.4	0.3	0.6	0.5	0.4
Carbonate (me L^{-1})	2.6	2.9	2.9	3.2	3.6
Bicarbonate (me L^{-1})	3.7	3.2	3.9	4.3	5.2
Chloride (me L^{-1})	5.3	4.6	5.6	6.2	5.8
Sulphate (me L^{-1})	0.7	0.6	0.8	0.8	0.9
SAR	6.6	5.4	5.9	5.9	5.4
RSC	2.9	2.2	2.5	2.8	3.8
PI	105.1	95.7	99.2	99.3	104.5

Table 6: Water quality Parameters analysed Post monsoon

Parameters	W1	W2	W3	W4	W5
pH	7.1	7.3	7.5	7.6	7.9
EC (dsm^{-1})	1.0	1.4	1.4	1.9	2.1
Calcium (me L^{-1})	1.4	1.6	2.0	2.1	2.2
Magnesium	1.4	1.7	1.6	1.9	2.0
Sodium (me L^{-1})	7.7	7.0	7.9	8.3	7.7
Potassium (me L^{-1})	0.4	0.3	0.5	0.5	0.4
Carbonate (me L^{-1})	2.3	2.6	2.6	2.9	3.2
Bicarbonate (me L^{-1})	3.3	2.9	3.5	3.9	4.7
Chloride (me L^{-1})	4.8	4.1	5.0	5.6	5.2
Sulphate (me L^{-1})	0.6	0.5	0.7	0.7	0.8
SAR	6.9	5.7	6.2	6.2	5.7
RSC	3.2	2.4	2.8	3.1	4.2
PI	105.1	95.6	99.2	99.2	104.5

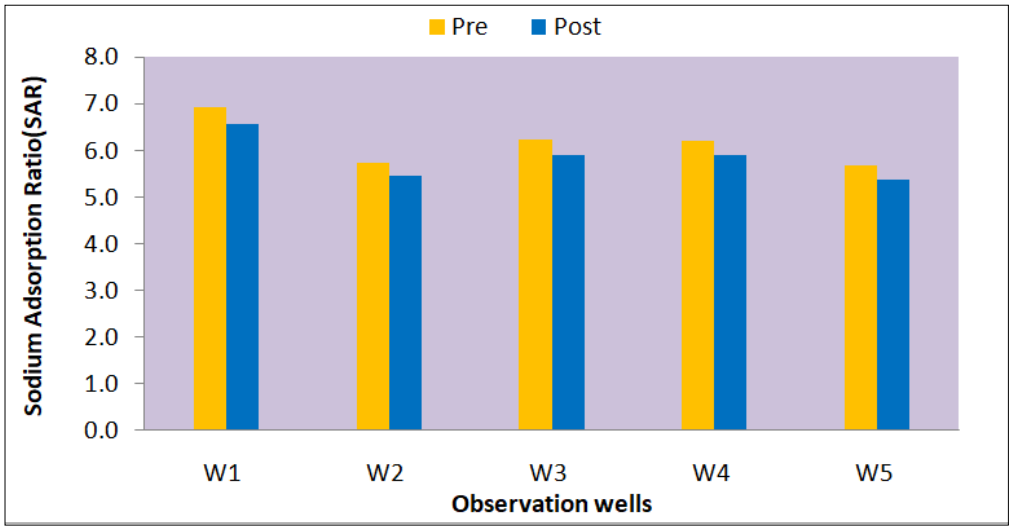

Fig 2: Analysed SAR during Pre and post monsoon seasons

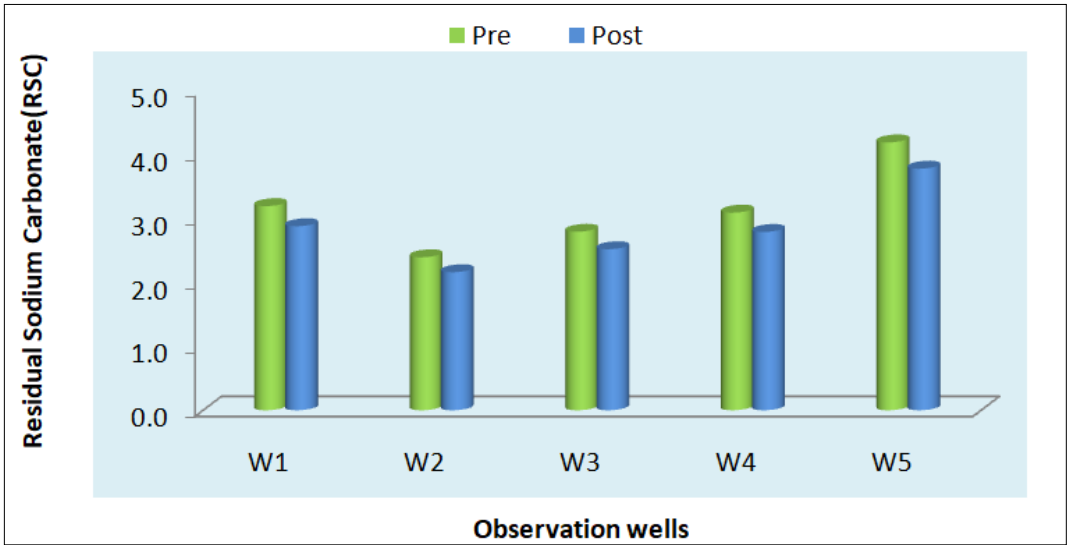

Fig 3: Analysed RSC during Pre and post monsoon seasons

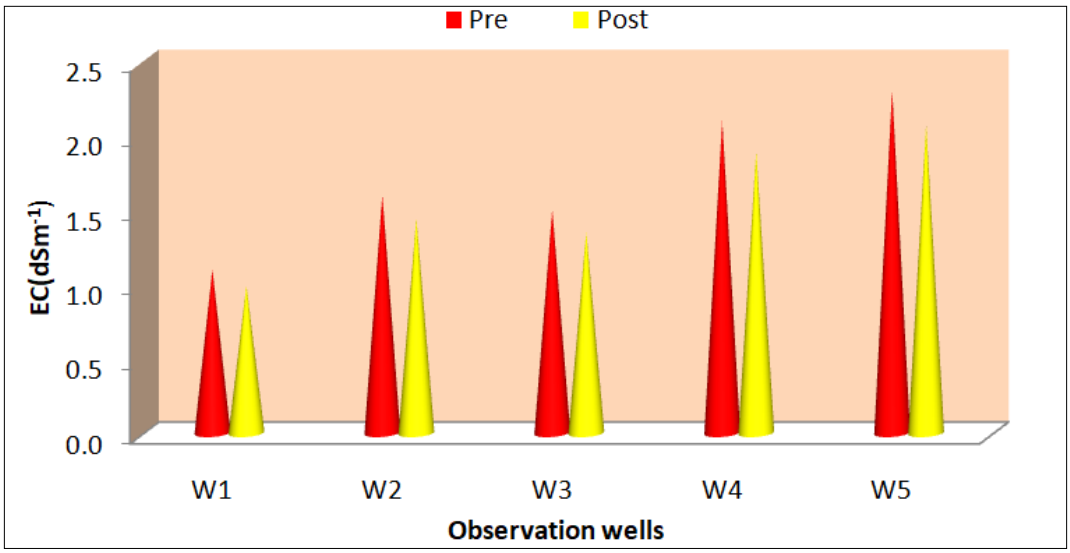

Fig 4: Analysed EC during Pre and post monsoon seasons

There was considerable improvement in the groundwater quality especially in the case of EC and anions after monsoon [7].

Conclusions

The effectiveness of different artificial recharge structures, namely check dam, recharge shaft in check dam and recharge bore well were evaluated and reported in this paper. Water samples were collected from wells within the influence zone and the quality were analyzed before and after monsoon seasons. The considerable improvement in groundwater quality was observed due to the effect of artificial recharge structures. The maximum water quality improvement was observed near the artificial recharge structures at downstream side. The standard of irrigation water was improved during post monsoon period. Hence, it is recommended to recharge the groundwater artificially by constructing artificial recharge structures wherever feasible in the study area.

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