Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP1: 582-587

Palwinder Singh Brar
Assistant Professor, Department Agriculture, Baba Farid Group of Institutions, Punjab, India

Nikseerat Kaur
Assistant Professor, Department of Agriculture, Baba Farid Group of Institutions, Punjab, India

Rajan Aggarwal
Senior Research Engineer, Department of Soil and Water Engineering, Punjab Agricultural University, Punjab, India

Samanpreet Kaur
Assistant Professor, Department of Soil and Water Engineering, Punjab Agricultural University, Punjab, India

Correspondence
Palwinder Singh Brar
Assistant Professor, Department Agriculture, Baba Farid Group of Institutions, Punjab, India

(Special Issue- 1)
2nd International Conference
"Food Security, Nutrition and Sustainable Agriculture - Emerging Technologies"
(February 14-16, 2019)

Studies on artificial groundwater recharge through abandoned well

Palwinder Singh Brar, Nikseerat Kaur, Rajan Aggarwal and Samanpreet Kaur

Abstract
The Punjab State is facing continues problem of declining groundwater table for last 2-3 decades and as a consequence, most of the wells which were used for withdrawal of water earlier have dried up and become abandoned. With water harvesting gaining momentum in the state, the abandoned wells can be put to best use and boost the water table. During rainy season and winter season irrigation water requirement through canal water reduced sharply. So farmer can use surplus canal water for recharging groundwater. In the present study recharge rate and its impact under different conditions were studied for recharging abandoned well. The recharge rate through abandoned well varies from 0.2l/s to 7.67 l/s for different heads. The recharging of surplus canal water will improve overall quality of groundwater. Recharging abandoned well with gravel pack will improved overall capacity and life of abandoned well. There was negligible effect on rise in water table as limited volume of water for limited time was recharged.

Keywords: Abandoned well, surplus canal water, groundwater recharge

Introduction
Geographical area of Punjab is only 1.57 percent of total area of India, but it contributes more than 25 per cent grains in the central pool. Cultivation is done in more than 83 per cent land of Punjab, whereas in India only 40.34 percent area is under cultivation (Gupta 2009) [6]. Irrigation water demand in Punjab has increased due to shift in cropping pattern of low water requiring crops to rice-wheat system post green revolution. The average annual rainfall is 650 mm and is ill distributed in time and space (Jain and Kumar 2007) [7]. As a result, the number of tube wells has increased from 1.92 lakh to 14.06 lakh for the period 1970 to 2015 (Anon 1975, 2015) [1, 2]. The present condition of groundwater development in Punjab is very serious as more than 80 per cent of monitored wells are overexploited (CGWB, 2012) [5]. The annual groundwater extraction in Punjab (*31.16 billion* m^3) falls short of the groundwater availability (*21.44 billion* m^3). The situation in the state is so alarming that 110 blocks out of 138 blocks are categorised as overexploited, that is groundwater extraction in these blocks exceeds the natural replenishment of groundwater and 4 blocks are critical, 2 blocks are semi-critical and only 22 blocks are in safe category (CGWB 2011) [4]. This has led to water table decline in most parts of state. The long term data (1998-2015) of the monitoring wells indicate an annual decline rate 47.5 (Aggarwal R *et al.* 2016) even after the implementation of sub-soil preservation act in paddy (Singh K 2009) [9]. Also, the area with water table depth > 10 m, has increased from 20 to 58 percent during 1998 to 2006 respectively (Kaur *et al.* 2011) [8], which indicates continuous overexploitation of groundwater resource of the state. As a consequence, many of the wells have deepened and gone dry and the farmers are forced to shift from centrifugal to submersible pumps.

Therefore, considering the insidious and seriousness of the problem, it warrants to develop techniques to arrest this declining trend. Wherever, good quality surplus water is available and geo-hydrological conditions are favourable artificial groundwater recharge should be promoted.

The Central Groundwater Board has already demarcated about 26,650m^2 area in Sangrur, Ludhiana, Moga, Amritsar, Kapurthala, northern parts of Ferozepur, Moga, Patiala, Jalandhar and some parts of Ropar and Nawanshahr districts for artificial groundwater recharge (Gupta 2009) [6]. In Punjab, three fourth of the irrigated area is through tube wells and only one fourth area is canal irrigated. Canal water is supplied to farmers as per their warabandi schedule, mostly on weekly basis. Many a times, canal water is available but not required in the field in the event of a good rainfall. In such cases the farmers usually diverts the available water toward the next field where ultimately it's accumulated at the tail end causing problem of stagnation. It is also pertinent to point out that with changing climate, the rainfall patterns are changing. In recent years (2013-2014, 2014-2015) more rainfall occurred during winter season. Wheat is the major crop of Punjab it covers an area more than 3.5 million hectares in the state. It requires 4 to 6 irrigation. If rainfall occurs frequently, during *rabi* season wheat requires only 1 to 2 irrigation. Under such situations, the surplus canal water can be used for groundwater recharge. Further, in declining water table areas many wells which were dug to install centrifugal pumps have been abandoned as the water table declined and centrifugal pumps have been replaced by submersible pumps. These abandoned wells are as such become an easy choice for waste disposal thereby threatens the underground aquifers by leakage of contaminants directly into the aquifer bed. But if these are properly cleaned and utilized they can offer immense potential to recharge surplus canal water/ excess agricultural runoff. This will help in augmenting the depleted groundwater resource and help in arresting the decline in water table. However, scientific studies of scope of these well for recharging structures and the effect of recharging water on groundwater are lacking.

Material and Methods

Location of abandoned wells

The study was conducted on four abandoned wells located at different locations in Punjab Agricultural University (PAU), Ludhiana (Fig. 1). The region is characterized by sub-tropical and semi-arid type of climate with hot and dry summer from April to June followed by hot and humid period during July to September and cold winters from November to January. Summer temperature however around 38°C and touches 45°C with dry summer spells. Winter experiences frequent frosty spells especially in December and January and minimum temperature dips up to 0.5°C. The average annual rainfall of Ludhiana is 733 mm (Kingra *et al.* 1996) the major portion of which (75%) is received during July to September. In the present research the recharge from four field experiment was conducted from December 2013 to July, 2016.

Fig 1: Location of four sites of abandoned well

Initially, all the selected four wells were filled with agriculture and other waste material. The abandoned wells were cleaned to remove the foreign/extra material from the well. The depth of these four wells was between 6.41 m to 8.31 m (Fig 2). Maximum head at sites 1, 2, 3 and 4 are 7.36, 6.36, 6.40, 5.56 m respectively. These abandoned wells were also at higher elevation, so the filter pits were dug before the well so that most of silt coming along the surplus canal water settles inside the filter pits and overflow from the pit is diverted into the well. The quality of canal water quality varied significantly within the monsoon period with turbidity levels ranging from 85 to 95 NTU (Nephelometric Turbidity Units) sediment load concentration during the study period. The hydraulic conductivity of site 1, site 2, site 3 and site 4 by the inverse auger-hole method (Ritzema, H. P (2006) [10] was computed as 2.08, 3.00, 3.69 and 2.59 m/day respectively.

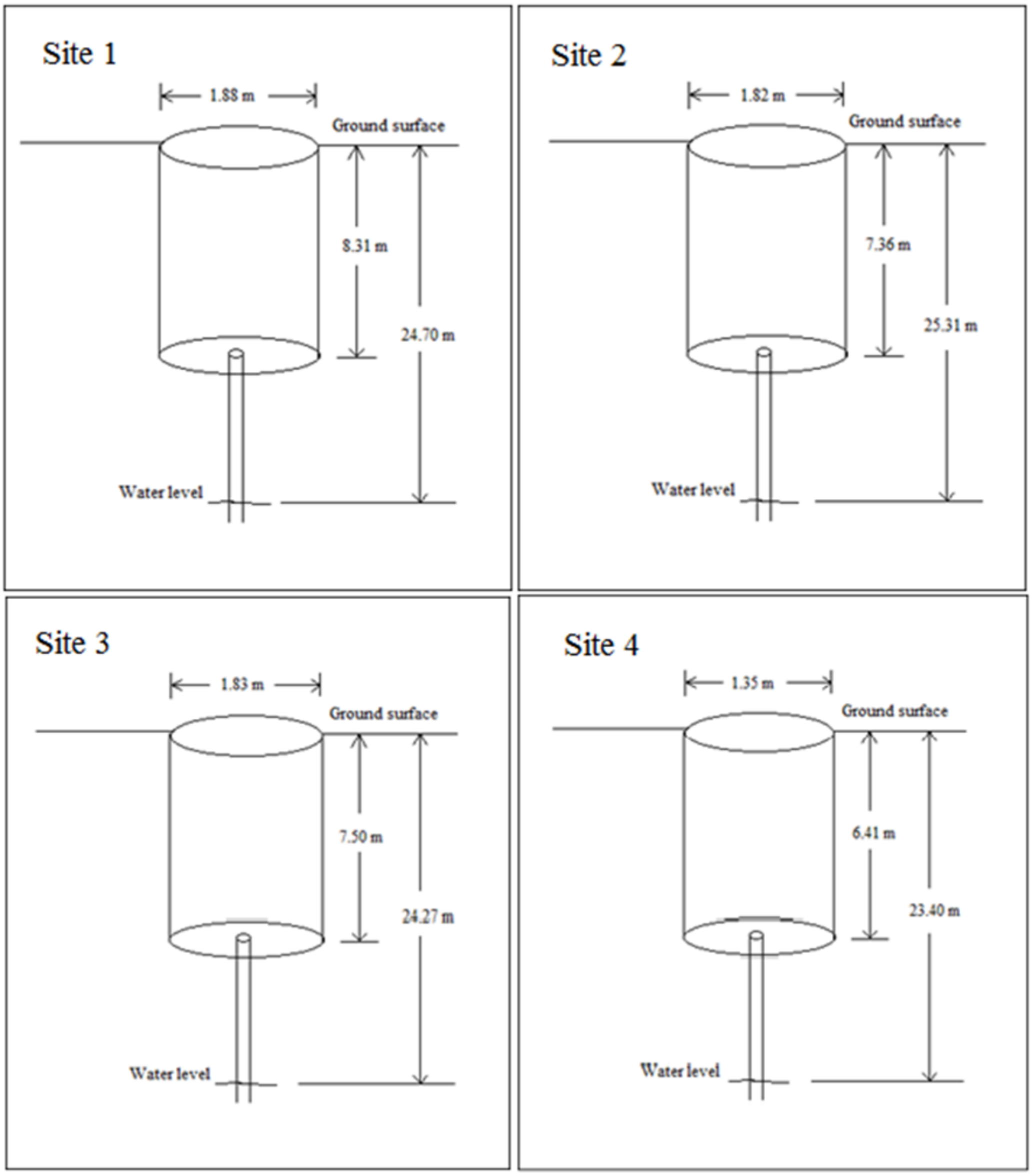

Fig 2: Dimensions of abandoned wells soil farm of Site No 1, 2, 3 and 4.

Observation wells were installed at a distance of 2.4 m to 6 m at different sites near the abandoned wells to determine the effect of recharging on groundwater levels and quality. Well log for different sites was prepared by taking sample during the installation of observation wells. The observation wells were developed occasionally by submersible pump for protecting the blockage of well strainers. There charge rate and groundwater quality under different conditionsi. e. (i) under saturated and unsaturated condition was determined and (ii) with and without gravel pack. The experiment was replicated for 15 times. The canal water and groundwater samples were also collected for testing of pH, EC, RSC, chlorine content, pesticides and herbicides. The turbidity of canal water was also measured throughout the recharging periods.

Results and Discussion

Effect on recharge rate

i) Under unsaturated and saturated conditions

Recharge rate of abandoned wells was reduced due to saturation of soil column in unconfined aquifer. Under unsaturated condition recharges varies from 12 l/min to 460 l/min. The recharge rate was then reduced to half of unsaturated recharge rate.

i) Under unsaturated and saturated conditions

At site 1, the recharge rate was initially high under unsaturated condition for first 100 min as shown in Fig. 3 and then it decreased due to partially saturation of the underlying soil with respect to time. After 10 to 15 times of recharging of the well, the soil underneath was fully saturated. The recharge rate decreased from 390 l/min to 190 l/m due to saturation of the well. At site 2, the recharge rate of well was significantly reduced as shown in Fig.3 The recharge rate were decrease 580 l/m to 210 l/min for unsaturated to saturated condition. Similarly at site 4 and site 5the recharge rate decreased significantly as shown in Fig. 3

ii) With and without gravel pack

Initial recharge from these wells was without gravel pack i.e. the water directly diverted to the wells from filter pits. The results indicated the difference in their time for same volume of recharging water in both cases. Recharging time is reduced by gravel pack. In all these wells, recharging time for same volume of water was reduced by 10 to 20 per cent with the use of gravel pack (Fig. 4)

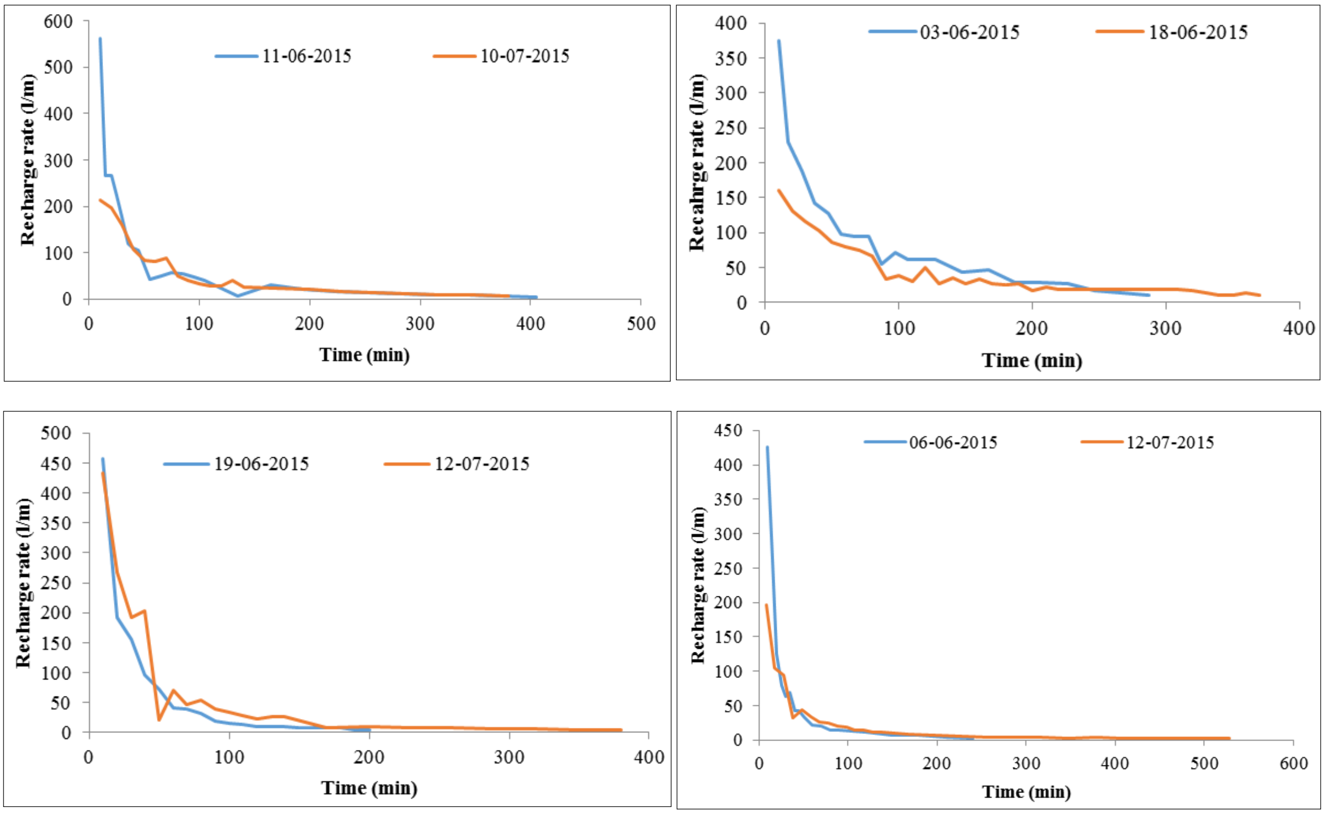

Fig 3: Recharge rate of wells in saturated and unsaturated conditions site1, 2 3 and 4

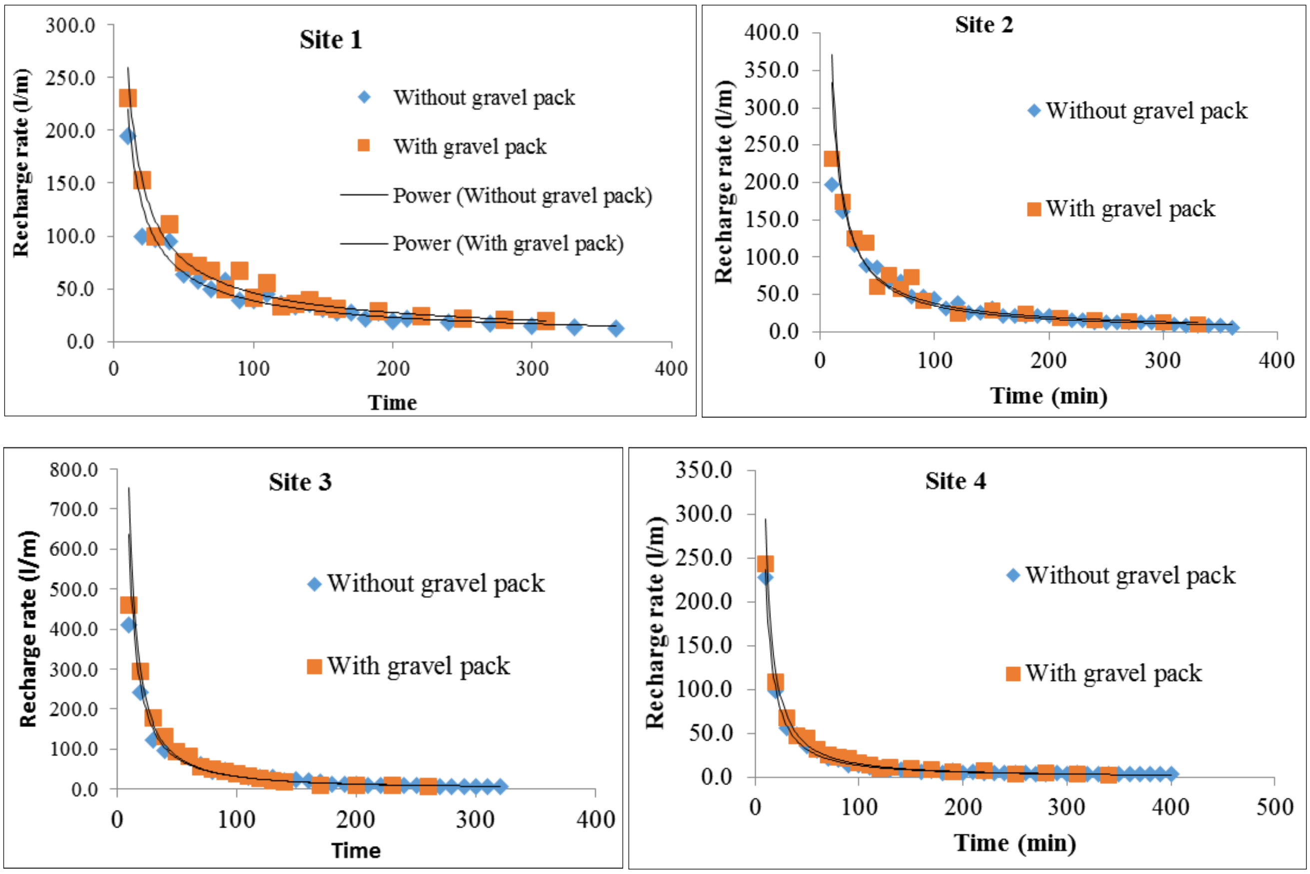

Fig 4: Recharge rate before and after gravel pack at site 1, 2, 3 and 4

Effect on soil texture

The observed change in percentage of sand, silt and clay and consequently soil texture both with and without gravel pack at different sites is given in Table 1. A persual of the table reveals that there was change in percentage of sand, silt and clay with and without use of gravel pack. But the increase of clay and sand was much more without gravel pack in comparison to when water was recharged with gravel pack and decrease in sand percentage.

Table 1: Per cent of sand, silt and clay of abandoned wells located at different sites

Site No	Sample		Sand %		Clay %		Silt %		Texture
			Per cent						
1	Before recharging		81.6	-	11.8	-	6.6	-	Loamy sand
	After recharging	Without gravel pack	77.7	-3.9	14.6	2.8	7.7	1.1	Loamy sand
		With gravel pack	76.5	-1.2	15.2	0.6	8.3	0.6	Loamy sand
2	Before recharging		85.3	-	3.4	-	11.3	-	Sand
	After recharging	Without gravel pack	82.9	-2.4	4.0	0.6	13.1	1.8	Loamy sand
		With gravel pack	82.3	-0.6	4.2	0.2	13.5	0.4	Loamy sand
3	Before recharging		88.2	-	4.1	-	7.73	-	Sand
	After recharging	Without gravel pack	86.5	-1.7	5.6	1.5	7.9	0.2	Sand
		With gravel pack	84.9	-1.6	6.8	1.2	8.3	0.4	Loamy sand
4	Before recharging		84.9	-	3.6	-	11.5	-	Sand
	After recharging	Without gravel pack	75.5	-9.4	10.0	6.4	14.5	3	Loamy sand
		With gravel pack	74.2	-1.3	11.5	1.5	14.3	-0.2	Loamy sand

The pH, EC values and RSC values are shown in Fig. 1, Fig. 2 and Fig 3 respectively. The parameters *viz*., pH and RSC were initially high in monsoon period and gradually decrease at the end of the October. However, EC values gradually decrease in month of June to August but slightly increase in September and October.

Recharge water quality

In all the samples Organochlorines, Organophosphates, Synthetic pyrethroids and Herbicides were found to be below determination limit. The quality of canal water quality varied significantly within the monsoon period. The parameters *viz*., pH and RSC were initially high in monsoon period and gradually decrease at the end of the October. However, EC values gradually decrease in month of June to August but slightly increase in September and October.The salinity remained within the permissible limit during pre-monsoon, post monsoon and during recharging period. In monsoon season (July to September), salinity and RSC values were lowest at four sites. The pH was within normal range throughout the recharging periods and water quality was improved (Fig. 5). At site 1, pH fluctuated more at initial recharging periods in comparison to other sites. EC values of four wells were showed little variance during recharging periods. These were under permissible limits (Fig. 6). RSC values of four observation wells were reduced during the monsoon period (Fig.7).

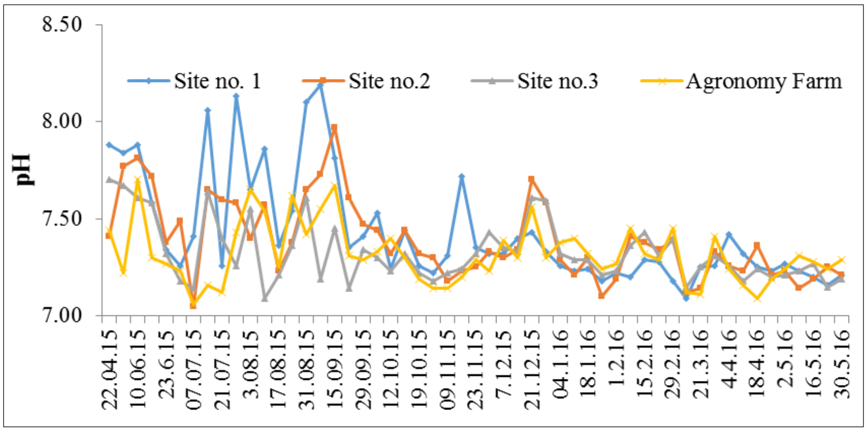

Fig 5: pH values at four sites

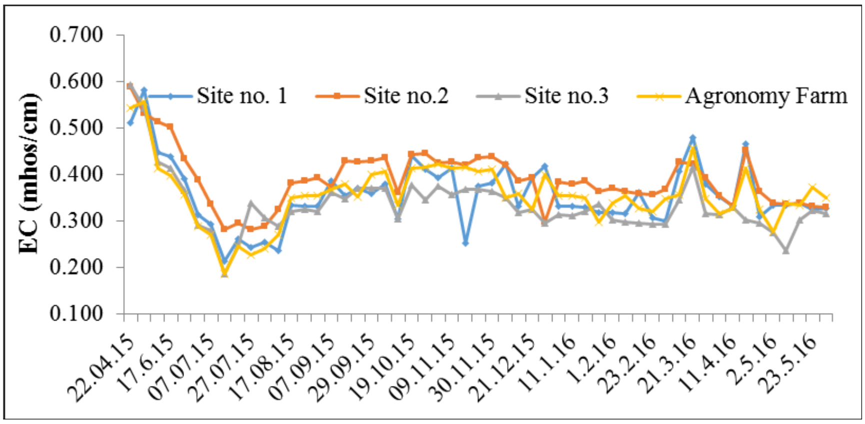

Fig 6: Electrical conductivity (mhos/cm) values at four sites

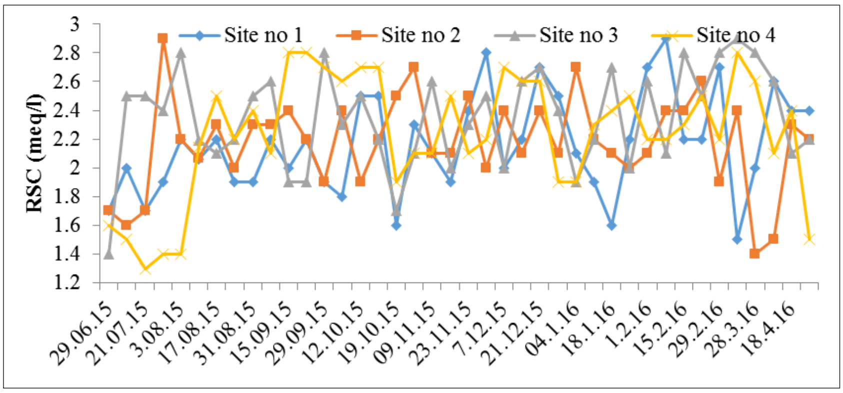

Fig 7: RSC (meq/l) values at four sites

However, the bacteriological analysis of recharged groundwater and canal water revealed that it was not within the permissible limits of drinking water standards (Table 2).

Table 2: Bacteriological quality analysis of water sample

S. No.	Location	Coliform organisms		Faecal Coliform/ E. coli detected/ Not detected
		Present/Absent	Most Probable Number index (<10/100ml)	
1	Site no 1	Present	240	Detected
2	Site no 2	Present	460	Detected
3	Site no 3	Present	240	Detected
4	Site no 4	Present	460	Detected
5	Canal Water	Present	1100	Detected

Conclusion

In Punjab out of 98 percent irrigated area about 75 percent area is irrigated by groundwater and 25 percent by canal water. There has been overexploitation of groundwater in major part of state, which leads to progressive decline of water table. Due to continuous decline of groundwater level the wells, which were used for withdrawal of groundwater have dried up and become abandoned. These abandoned wells can offer a huge potential use for recharging surplus canal water. The use of gravel pack in these wells not only decreases the time of recharge but also improves the life of an abandoned as silt and clay content will be absorbed by the gravel pack. Further no determinal effect on groundwater quality was observed rather there was improvement in groundwater quality. However in the present study there was negligible effect on rise in water table due to canal water recharge as recharging was done with limited volume of water and limited duration. Based on the study, it is suggested government should take initiatives to encourage the public to restructure these unused wells for artificial groundwater recharge instead of abandoning and closing the wells.

References

1. Anonymous. Statistical Abstract of Punjab. Directorate of Economics and Statistics, Government of Punjab, Chandigarh, 1975.
2. Anonymous. Statistical Abstract of Punjab. Directorate of Economics and Statistics, Government of Punjab, Chandigarh, 2012.
3. Aggarwal R, Kaur S, Brar MS. Groundwater Scenario Based Decision Support System for Selection of Pumping Sets, 2016.
4. CGWB. Dynamic Ground Water resources of Punjab State. Water Resources and Management Directorate. Central Groundwater Board, 2011.
5. CGWB. Manual on Artificial Recharge of Ground Water. Ministry of water resources Central Groundwater Board, 2012.
6. Gupta S. Ground water management in alluvial areas of Punjab. J Bhu-Jal News. 2009; 24:74-81.
7. Jain AK, Kumar R. Water management issues – Punjab, North-West India. Indo-US Workshop on innovative e-technologies for distance education and extension/ outreach for efficient water management, ICRISAT, Patancheru/ Hyderabad, Andhra Pradesh, India. www.observerindia.com/cms/export/orfonline/.../ppt/o411-aljain.pdf, 2007. (Accessed on 20-04-2014)
8. Kaur S, Aggarwal R, Soni A. Study of Water-Table behaviour for India Punjab using GIS. Water Sci Technol. 2011; 63:1574-81.
9. Singh K. Act to save groundwater in Punjab: Its impact on water table, electricity subsidy and environment. Agricultural Economics Research Review. 2009; 22:365-386.
10. Ritzema HP, Nijland HJ, Croon FW. Subsurface drainage practices: From manual installation to large-scale implementation. Agricultural water management. 2006; 86(1):60-71.