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Studies on the Ground Water Recharge through Rainfall and Artificial Recharge Structures in Selected Dry Well in Ambedkarnagar District (UP), India

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A B S T R A C T

An experiment was conducted to study the groundwater recharge through rainfall and artificial recharge structures in selected dry well at different locations of Ambedkarnagar District, UP. The results of the study concluded that the autoregressive time series model can be used effectively to predict the pre and post monsoon ground water level the better predictions will help the Farmers and policy makers to optimally utilize the groundwater resources. It is providing the solutions to execute the artificial recharge structure at the appropriate locations with best geological condition to enhance the recharge rate at least cost for control of declining groundwater level. It reveals that the stochastic auto regressive lime series model is an effective tool for management of ground water resource in Ambedkarnagar district of Uttar Pradesh state.

Introduction

We have an image of the world as a blue planet as 70% of the earth's surface is covered with water. The reality, however, is that 97% of the total water on earth of about 1400 Billion Cubic Meter (BCM) is saline and only 3 % is available as fresh water. About 11% of the resources are available as extractable ground water within 800 m depth and about 1% is available as surface water in lakes and rivers. Out of the 113,000 BCM of rain and snow received on the earth, evaporation losses account for about 72,000 BCM, leaving a balance of about 41,000 BCM, out of which about 9000-14000 BCM is considered utilizable. Water is a state matter under India's constitution but the central government provides much of the financing for groundwater development in consequence, there is substantial component for control over funding and the interpretation of groundwater data. Groundwater levels in state networks are generally monitored twice a year, before and after the monsoon. Water scarcity may be severe during droughts or on a seasonal basis even where long-terra trends are absent and water-balance estimation indicate substantial resources are available for development.

Agriculture sector is the major consumer of irrigation water in India. Therefore, it becomes very important to develop a water use plan to ensure more crops per drop, thereby increasing water productivity and achieving sustainability in agriculture. In addition, due to erratic and limited rainfall in semi-arid regions, irrigation is essential for increasing crop production and productivity.

Globally, groundwater depletion has increased from 126 km^3 in 1960 to 283 km^3 in 2000 Ravichandran *et al.,* (2011). In semi- arid and arid areas, the extraction of groundwater for irrigation was the major cause of groundwater depletion Russo *et al.,* (2014). Bouwer (2002) also observed that groundwater pumping must be managed so that it will not exceed the safe yield or the natural recharge rate of the aquifers and found that it should range from less than 1% of average precipitation in arid to semi-arid climates, to 20% of average precipitation in Mediterranean-type climates and 50% in cool and humid climates as in north-western Europe. To control the declining water table. Agarwal *et al.,* (2009) analyzed the problem of declining water table and factors responsible for it in Punjab.

They study and found that due to change in cropping pattern irrigation requirement increases, which resulted in over exploitation of groundwater. They suggested suitable strategies for arresting declining water table. Strategies include rain water harvesting, change of cropping pattern, delay in paddy transplantation, and precision irrigation for artificial groundwater recharge.

Saha and Marwaha (2016) observed a steep decline in groundwater level in western Ganga plains, India. The average decline rate was about 0.15 m/year. Swami and Kulkarni (2016) also observed that pumping rate was higher than natural recharge in southeastern Nigeria. Due to this hydrological imbalance had occurred, which was affecting quality and quantity of groundwater.

Natural recharge takes place naturally without any intervention and human effort. Artificial recharge systems are the engineered systems where surface water is put on or in the ground for infiltration and subsequent movement to aquifers to augment groundwater resources. The work on artificial groundwater recharge started in early fifties. Tripathi *et al.,* (2016) summarized the knowledge on groundwater recharge and reported advances in groundwater recharge estimation technique.

Artificial groundwater recharge began early in last century in the Europe. First infiltration basin for recharging the groundwater was constructed at Goteborg, Sweden in 1897 and subsequently several basins were developed. Infiltration rates' ranging from 7 to 52 feet/day was reported for these basins Jansa (1952). In the Santa Clara river valley in California, floodwaters were stored in the dams and released slowly to get absorbed in stream beds and off channel ponds. Also water was spread over receptive Orchard lands. Thus water that would otherwise be largely wasted in the semi-arid region was conserved by storage in the ground and made available to meet water requirements Todd (1959).

Islam *et al.,* (2014) estimation and forecast of groundwater recharge and capacity of aquifer are essential issues in effective groundwater resource management in Bangladesh. Peera and Kumar (2015) assessment of groundwater resources by whatever method is normally subject to large uncertainties and errors.

The methodology recommended by Groundwater Estimation Committee (GEC) is being adopted to compute the groundwater resources in India. Mansouri and Mezouary (2015) climate change is already a reality affecting, in particular, several countries of the Mediterranean Sea. The impact of this change on water resources is very important; indeed, climate observations highlight periods of droughts and floods, which we call extreme events. To reduce the effect of these two phenomena on the quantitative degradation or lack of water resources due to changes in rainfall, artificial recharge techniques are a solution to adapting to this situation.

Materials and Methods

The study was conducted in the Ambedkar Nagar district UP watershed with code No. 2B2A6d1d, 2B2A6e1a, 2B2A6e1b, 2B2A8a2b respectively having area 6628.00 ha. located in North-East part of Ambedkar Nagar district. The afar said watershed has also been taken up programme implementation comprising of development & management plan during next five years. The total area of watershed is 4955 ha and treatable area is 4708 ha.

First of all we did survey in all 11 block of district Ambedkarnagar and under it village Asupur Bagiya block Tanda and worked on a dry well for 6 months firs of all I got the dry well cleaned and the depth of dry well was measured 3.20 meter. Then after we put small small pieces of bricks inside the dry well, then we filled the dry well with rain water of tubewell water and canal water.

Then in a one month at an interval of 15-15 days both the dry well were worked on separately and every 10-10 minutes the level of the ground water was checked in which we analyzed the different ground water level of both the wells. Time minutes, depth of water meter, depth of well in meter

To evaluate the effectiveness of individual structures and to delineate the suitable sites for constructing recharge structures in the study area, natural groundwater recharge from rainfall was estimated using following empirical formulae based on water level fluctuation and rainfall amount in Ganga -Yamuna doab Chaturvedi in 1936 derived an empirical relationship to arrive at the recharge as a function of annual precipitation.

$R_g=2\ (P-15)^{0.4}$

Where,

R_g is net recharge, in inches; P is annual rainfall, in inches.

This formula is useful for preliminary estimates of recharge due to rainfall. This formula later modified by U.P. irrigation research institute.

$R_g = 1.35\ (P-14)^{0.5}$

Where R_g is net recharge, in inches, P is annual rainfall, in inches.

Results and Discussion

The present investigation was on artificial ground water recharge by reactivating dry wells. For studying the impact, it is necessary to assess the available water resources such as rainfall, groundwater and details of existing RWH structures. For the assessment of groundwater potential, the groundwater level data (1998-2017) of the observation wells situated in the Ambedkarnagar watershed were collected from Ground water department, Ayodhya U.P. The data about the rainfall were collected from Indian Meterological department, Pune.

The main objective of the study is to develop an autoregressive time series model for annual rainfall. The stochastic process of annual precipitation is characterized by an autoregressive model. This chapter discusses about model identification and parameter estimation and evaluation of performance and adequacy of the model by statistical parameters and several other measures such as mean forecast error, mean absolute error, mean relative error, mean square error, root mean square error and integral square error.

Model Identification

The yearly stream flow series Y_t the precipitation was modeled by means of an autoregressive model. The various steps involved are identification, estimation of parameters and validation of model type, sequence and parameters. The general shape of the autocorrelogram and partial autocorrelogram are used as a basis for identification. The autocorrelagram is a plot of autocorrelation function against lag K and partial autocorrelation is a plot of partial autocorrelation function against lag K.

1. By using rain water inside the dry well, our water is not going to waste, it is being recharged underground.
2. The quality of underground water is getting better.
3. There is an observation well near our dry well through which we have checked that the ground is getting recharged and the rate of decreasing depth is decreasing.
4. We had installed an observation well near the dry well, then the observation well is telling that the decreasing rate of the ground water level has decreased and has become stable. We have collected rain water, tube well water or canal water inside the dry well similarly. If we keep collecting rain water inside the dry well for 1-5 years in the future then we can improve the water level of our land by doing this the quality of the ground water level will be good.
5. We had installed an observation well there and there we used to test the sample of water in which we saw that there was a difference in the quality of the ground water level the quality is getting better and the recharge rate of the depth in quality is not decreasing much and it is decreasing rate has come down.
6. We analyzed and saw whether we have to save our underground water level or improve the underground water level or do not water or save water from being wasted or save water.

The observed and predicted groundwater level by developed models in each location with R^2 between observed and predicted values are given in table-1. The different statistical parameters and error of predicted values to evaluate the performance of the developed model are given table-2. Autocorrelation and partial auto correlation coefficient for 95 per cent upper and lower limit upto lag 10.

Table.1 Observation of dry well in Village AsopurBagiya Block Diameter of well =1.60 meter

Time Minute	Depth of Water (M)	Head	time	time interval	Cumulative depth m	incremental depth m	time (hr)	infiltration rate (m/h)	accumulative depth (m)
11:25	0.80	2.50	10	10.00	1.50	0.90	0.17	5.40	0.41
11:35	0.90	2.40	20	10.00	2.40	0.95	0.33	2.85	0.88
11:45	0.95	2.35	30	10.00	3.35	1.00	0.50	2.00	1.21
11:55	1.00	2.30	40	10.00	4.35	1.08	0.67	1.62	1.47
12:05	1.08	2.22	50	10.00	5.43	1.10	0.83	1.32	1.69
12:15	1.10	2.20	60	10.00	6.53	1.14	1.00	1.14	1.88
12:25	1.14	2.16	70	10.00	7.67	1.19	1.17	1.02	2.04
12:35	1.19	2.11	80	10.00	8.86	1.20	1.33	0.90	2.18
12:45	1.20	2.10	90	10.00	10.06	1.25	1.50	0.83	2.31
12:55	1.25	2.05	100	10.00	11.31	1.30	1.67	0.78	2.43
1:05	1.30	2.00	110	10.00	12.61	1.35	1.83	0.74	2.53
1:15	1.35	1.95	120	10.00	13.96	1.36	2.00	0.68	2.64
1:25	1.36	1.94	130	10.00	15.32	1.40	2.17	0.65	2.73
1:35	1.40	1.90	140	10.00	16.72	1.41	2.33	0.60	2.82
1:45	1.41	1.89	150	10.00	18.13	1.43	2.50	0.57	2.90
1:55	1.43	1.87	160	10.00	19.56	1.45	2.67	0.54	2.97
2:05	1.45	1.85	170	10.00	21.01	1.48	2.83	0.52	3.04
2:15	1.48	1.82	180	10.00	22.49	1.50	3.00	0.50	3.11
2:25	1.50	1.80	190	10.00	23.99	1.52	3.17	0.48	3.18
2:35	1.52	1.78	200	10.00	25.51	1.55	3.33	0.47	3.24
2:45	1.55	1.75	210	10.00	27.06	1.56	3.50	0.45	3.30
2:55	1.56	1.74	220	10.00	28.62	1.58	3.67	0.43	3.35
3:05	1.58	1.72	230	10.00	30.20	1.60	3.83	0.42	3.41
3:15	1.60	1.70	240	10.00	31.80	1.62	4.00	0.40	3.46
3:25	1.62	1.68	250	10.00	33.42	1.64	4.17	0.39	3.51
3:35	1.64	1.66	260	10.00	35.06	1.66	4.33	0.38	3.56
3:45	1.66	1.64	270	10.00	36.72	1.68	4.50	0.37	3.60
3:55	1.68	1.62	280	10.00	38.40	1.70	4.67	0.36	3.65
4:05	1.70	1.60	290	10.00	40.10	1.71	4.83	0.35	3.69
4:15	1.71	1.59	300	10.00	41.81	1.73	5.00	0.35	3.73
4:25	1.73	1.57	310	10.00	43.54	1.75	5.17	0.34	3.77
4:35	1.75	1.55	320	10.00	45.29	1.77	5.33	0.33	3.81
4:45	1.77	1.53	330	10.00	47.06	1.79	5.50	0.33	3.85
4:55	1.79	1.51	340	10.00	48.85	1.81	5.67	0.32	3.89
5:05	1.81	1.54	350	10.00	50.66		5.67	0.32	3.89

Table.2 Observation of dry well recharge at Mahamaya college of Agricultural Engineering Block Akbarpur Diameter of well=1.70 meter.

Time Minute	Depth of Water (M)	Head	time	time interval	cumulative depth (m)	incremental depth m	time (hr)	infiltration rate (m/h)	accumulative depth (m)
1:05	0.40	2.8	10	10	0.96	0.60	0.17	3.60	0.04
1:15	0.56	2.64	20	10	1.56	0.65	0.33	1.95	0.44
1:25	0.60	2.6	30	10	2.21	0.67	0.50	1.34	0.79
1:35	0.65	2.55	40	10	2.88	0.70	0.67	1.05	1.06
1:45	0.67	2.53	50	10	3.58	0.71	0.83	0.85	1.28
1:55	0.70	2.5	60	10	4.29	0.73	1.00	0.73	1.46
2:05	0.71	2.49	70	10	5.02	0.74	1.17	0.63	1.61
2:15	0.73	2.47	80	10	5.76	0.75	1.33	0.56	1.75
2:25	0.74	2.46	90	10	6.51	0.77	1.50	0.51	1.87
2:35	0.75	2.45	100	10	7.28	0.78	1.67	0.47	1.99
2:45	0.77	2.43	110	10	8.06	0.79	1.83	0.43	2.09
2:55	0.78	2.42	120	10	8.85	0.80	2.00	0.40	2.18
3:05	0.79	2.41	130	10	9.65	0.81	2.17	0.37	2.27
3:15	0.80	2.4	140	10	10.46	0.82	2.33	0.35	2.35
3:25	0.81	2.39	150	10	11.28	0.83	2.50	0.33	2.42
3:35	0.82	2.38	160	10	12.11	0.84	2.67	0.32	2.49
3:45	0.83	2.37	170	10	12.95	0.85	2.83	0.30	2.56
3:55	0.84	2.36	180	10	13.80	0.86	3.00	0.29	2.62
4:05	0.85	2.35	190	10	14.66	0.87	3.17	0.27	2.69
4:15	0.86	2.34	200	10	15.53	0.88	3.33	0.26	2.74
4:25	0.87	2.33	210	10	16.41	0.89	3.50	0.25	2.80
4:35	0.88	2.32	220	10	17.30	0.90	3.67	0.25	2.85
4:45	0.89	2.31	230	10	18.20	0.91	3.83	0.24	2.90
4:55	0.90	2.3	240	10	19.11				
5:05	0.91	2.29	250	10	19.11				

Figure.1 Diagram of infiltration process and water flow Factors affecting infiltration

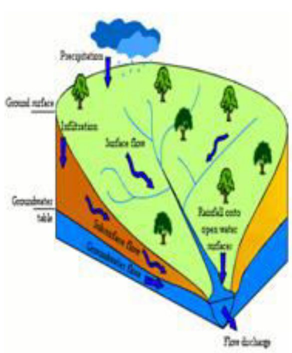


Figure.2 Graph showing the Observation of dry well in Village AsopurBagiya Block.

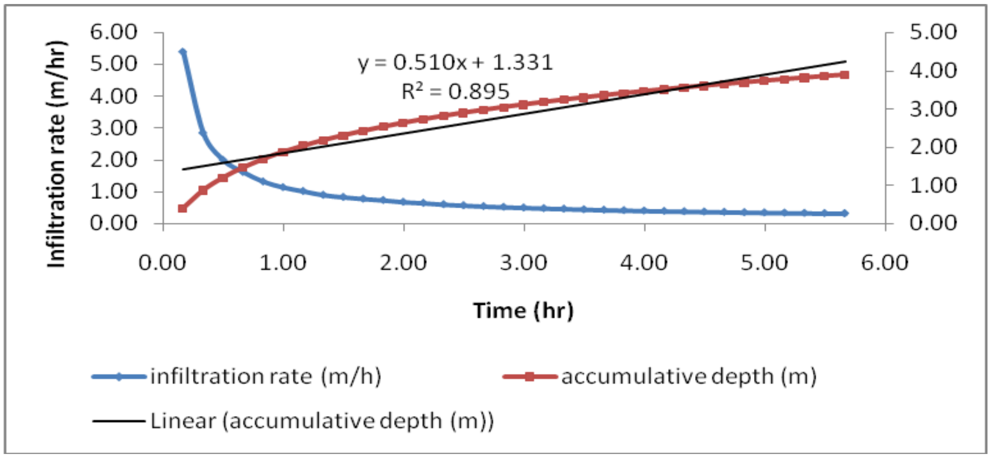
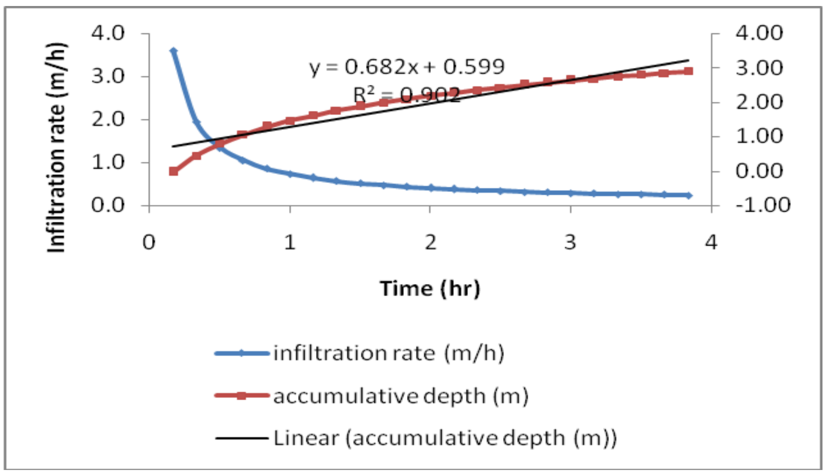


Figure.3 Graph showing the Observation of dry well recharge at Mahamaya college of Agricultural Engineering Block Akbarpur.



The correlation between observed and predicted rainfall is shown in Fig. 1. Tabular values and the graphical representation of the correlation between observed and predicted groundwater levels exhibits strong correlation between observed and predicted which clearly indicates that the auto regressive time series model of order 1 can be used for prediction of groundwater level fluctuations more accurately in Akbarpur Block to adopt the best management strategies within the acceptable limits of errors.

Overall it was concluded that the autoregressive time series model can be used effectively to predict the pre and post monsoon ground water level at different locations of Ambedkarnagar District the better predictions will help the Farmers and policy makers to optimally utilize the groundwater resources.

It is providing the solutions to execute the artificial recharge structure at the appropriate locations with best geological condition to enhance the recharge rate at least cost for control of declining groundwater level. It reveals that the stochastic auto regressive lime series model is a effective tool for management of ground water resource in Ambedkarnagar.

Author Contribution

Sonveer Singh: Investigation, formal analysis, writing—original draft. Arpan Sherring: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

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Ethical Approval: Not applicable.

Consent to Participate: Not applicable.

Consent to Publish: Not applicable.

Conflict of Interest: The authors declare no competing interests.

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