Annals of Arid Zone 39(1): 15-20, 2000

Some Observations on Rainfall-Water Table Relationship in a Micro-watershed near Faridabad

Saon Banerjee, K.K. Nathan and H. Chandrasekharan
Indian Agricultural Research Institute, New Delhi 110 012, India

Abstract: A study was carried out to understand the effects of rainfall on water table fluctuation (represented by the thickness of water column in a dug well) in a degraded environment for over eight years (1991-1998). The investigated area falls in the semi-arid tract of Aravalli hill range near Anangpur village, Faridabad, Haryana. During summer months, the water table in the area declines considerably and at times, the dug wells become dry. As expected, the thickness of water column increases with the onset of monsoon. However, the rate of increase is gradual in the beginning and is more during the later two monsoon months (August-September). A time lag of about a month was observed between the rainfall and corresponding thickness of water column. Analyses of the data yielded two sets, each comprising three types of regression equations, between the rainfall and thickness of water column, with and without the lag period. The characteristics of the equations are discussed. It is envisaged that such studies may help to identify the period of excess water utilization and/or otherwise. Knowledge on these aspects is of paramount importance for water resources development and management.

Key words: Rainfall, water table, lag period, water management.

Sustainable development of a watershed is governed by a complex interaction of natural resources and their proper conservation, utilization and management. The most vital resource being water, its management planning needs the information on time variant availability of water in a particular watershed. As the problem of availability of water for domestic, irrigation and other uses is increasing, a study was carried out near Faridabad to understand the effect of rainfall on water table fluctuations. The rainfall infiltration is the only source of groundwater recharge in the area. Even in a canal command area (like Sarda Sahayak Canal Command, Uttar Pradesh), where the canal system causes significant addition to the groundwater recharge, fluctuation of groundwater level in response to the natural variation in precipitation is seen (Singh and Singh, 1983). The water table depth study for estimating initial storage capacity prior to storm rainfall is helpful in predicting runoff (Troch *et al.*, 1993). The present study aims at locating the period for excess water utilization in the micro-watershed, governed by the rainfall status throughout the year.

Materials and Method

The area under investigation is a part of the highly degraded Aravalli hill system with two small valleys and is situated at the outskirts of Anangpur village, Faridabad district, Haryana. The region has a hot semi-arid and tropical steppe type of climate. Hot summer prevails during April-June and cold winter during November-March.

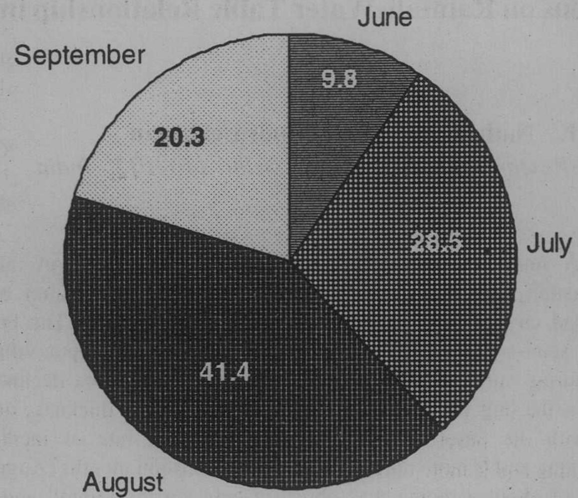

Fig. 1. Average percentage of rainfall distribution during the monsoon period in the study area (1991-98).

South-west monsoon period is between July and September. The annual rainfall is about 564 mm. About 80% of the annual rainfall occurs during south-west monsoon period in 27 rainy days. The long-term climatic data (for 70 years) indicate the average drought frequency to be 21% (Singh *et al.*, 1993).

Two main parameters taken into account for the study were monthly rainfall (1992-98) and depth of water column in a dug well for the same time period. The rainfall data were obtained from the rain gauge installed in the experimental site. Water table depth of a dug well, which is about 7.3 m deep with 2 m diameter located near the rain gauge, was regularly monitored to carry out the study.

Results and Discussion

The mean monthly rainfall data for July to September (for eight years since 1991) indicate that the maximum rainfall (about 41% of the total annual rainfall) occurs in the month of August, followed by July, September and June (Fig. 1). While the highest annual rainfall (774 mm) occurred in 1998, the standard deviation (144) of monthly rainfall for 1995 and the monthly rainfall (521 mm) for August 1995 were the highest. There was considerable decline in the water table during summer months and, at times, the dug wells were completely dry during such periods (Fig. 2). Measured data also show that the thickness of water column (representing the fluctuations in water table) in the dug well varied from completely dry in November 1991, June 1993 and June 1998 to 5.5 m in September 1995. This could be attributed to the very low rainfall during 1992-1993 (Table 1) and the highest rainfall in August 1995 (Fig. 2).

Variations of monthly rainfall and the corresponding thickness of water column during 1991-98 reveal that there is a time

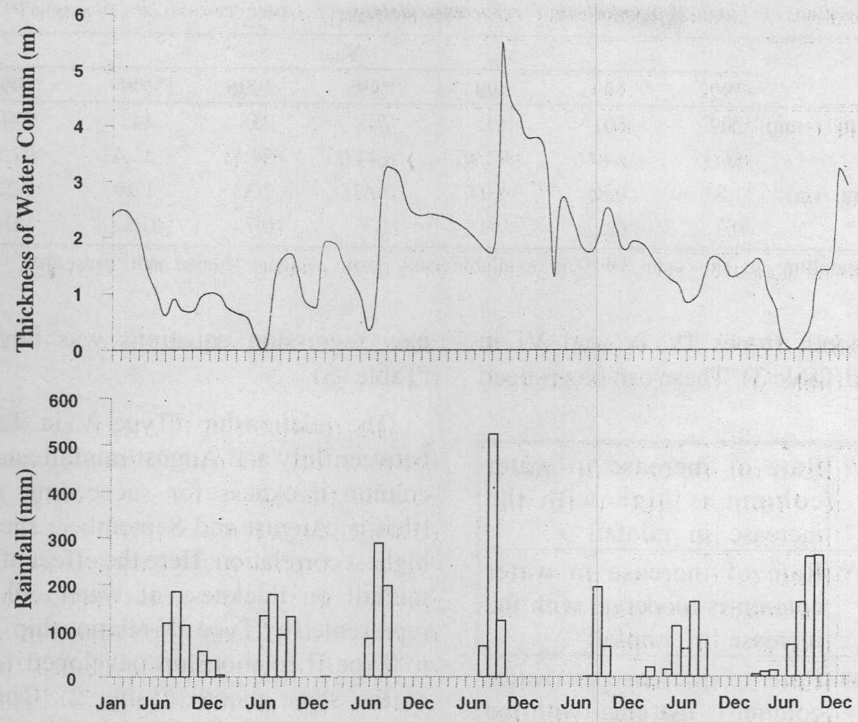

Fig. 2. Variation of monthly rainfall and thickness of water column at the study location during 1991-98

lag of about a month between the highest rainfall month in a year and the largest thickness of water column and that both do not happen in the same month. This is largely due to the time taken by rainfall water to actually recharge the phreatic aquifer.

Accordingly, the thickness of water column was relatively more during February to March in 1992 and 1993 than in other months. This indicates that there is significant recharge to the ground water due to the winter rainfall as it undergoes least evaporation during that time in a year. Although there was no rainfall during winter months of 1995, similar observation could be made for January, 1996, due to the highest rainfall amount (640 mm) during August-September, 1995. The thickness of water column was the largest during August-September for the remaining years. Thus, the day-to-day changes in the rainfall amount are responsible for the variation in the thickness of water column with a time lag of about a month or more.

An attempt was made to work out a specific relationship from which the thickness of water column can be computed if the rainfall amount is known. Ignoring the rainless months, three types of relationship can be obtained between rainfall amount and water column depth in the same month (Types I, II and III in Fig. 3a, and Table 2) and with a time lag of

*Table 1. Variations in annual rainfall and respective depths of water column in a dugwell**

Parameter	Year						
	1992	1993	1994	1995	1996	1997	1998
Annual rainfall (mm)	209	501	532	708	258	443	774
SD_r	56.33	64.46	91.96	144.00	54.51	51.43	97.79
Water column (m)	1.31	0.86	1.94	3.61	2.33	1.29	1.22
SDWC	0.7	0.5	0.9	1.3	0.7	0.3	1.0

*Data corresponding to the year 1991 is available only from August, hence not presented.

about a month (types IV, V and VI in Fig. 3b, and Table 3). These can be grouped as follows:

Type-I and IV:	Rate of increase in water column is high with the increase in rainfall
Type-II and V:	Rate of increase in water column is moderate with the increase in rainfall
Type-III and VI:	Rate of increase in water column is marginal with the increase in rainfall

Type-I relationship represents the water column and rainfall mainly of September when the cumulative rainfall for the earlier few months is high in a year. Type-III relationship, on the other hand, represents the rainfall at the onset of monsoon (during June-July) wherein the soil evaporation loss is high. Effect of winter rainfall on water column is illustrated in Type-II relationship (Fig. 3a).

Since water table responds to the rainfall after a short interval of time, a set of new regression equations was developed (Table 3).

The relationship (Type V in Table 3) between July and August rainfall and water column thickness for succeeding months (that is, August and September) shows the highest correlation. Here the effect of winter rainfall on thickness of water column is represented by Type-IV relationship, similar to Type-II relationship developed for data of the same month (Table 2). This may indicate that the replenishment of groundwater by the winter rainfall is slow, hence the shift from Type-II (with moderate slope) to Type-IV (with a steep slope) equation. Similarly, the shift of Type-III equation to Type-V equation can be explained for high rainfall months. However, as an exception, the effect of July rainfall on thickness of water column (with the time lag) gave better correlation for a non-linear equation (Type-VI in Table 3).

The above discussion shows that, in general, the effect of rainfall on water table

Table 2. Regression equation between monthly rainfall (R) and corresponding thickness of water column (D) during 1992-1998

Equation type	Equation	df	R^2-value
I	$D = 0.037 R + 0.36$	3	0.93
II	$D = 0.007 R + 0.65$	6	0.76
III	$D = 0.002 R + 0.33$	8	0.71

Table 3. Regression equation between monthly rainfall and depth of water column (D) for the subsequent month during 1992-1998

Equation type	Equation	df	R-value
IV	D =0.028 R + 0.128	4	0.88
V	D = 0.009 R + 0.914	8	0.97
VI	D =(R)/0.27R + 124.9)	10	0.84

fluctuation (represented by water column thickness in a dug well) has a time lag of about a month. Although we get significant correlation between the two parameters expressed through three equations each, with and without time lag, the former set of equations is suggested to determine the status of water table from the given rainfall data. Such determination would be helpful for optimum groundwater

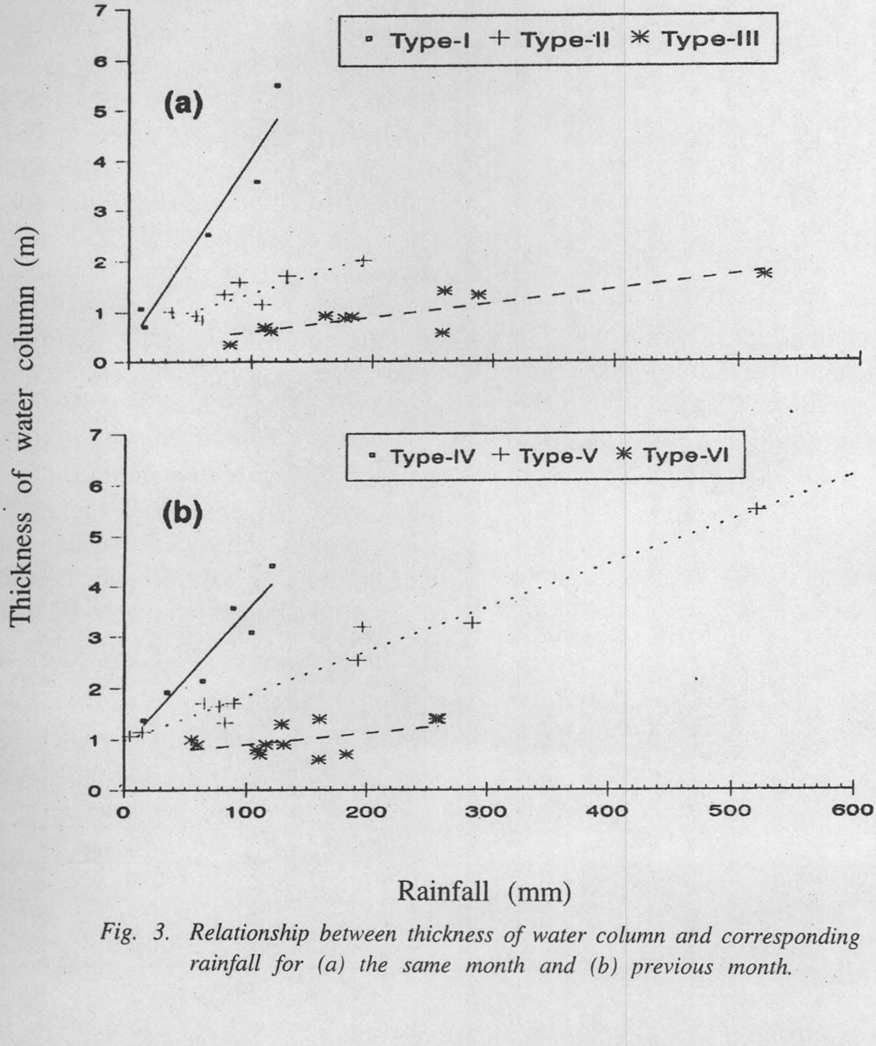

Fig. 3. Relationship between thickness of water column and corresponding rainfall for (a) the same month and (b) previous month.

utilization and better water management in similar areas.

Acknowledgement

Authors are thankful to the Project Director, WTC (IARI) for providing the required facilities and Prof. A. Singh, WTC, for fruitful comments.

References

Singh, A., Chandrasekharan, H. and Singh, R.P. 1993. *Water Resources Development - A Case Study at ABSS Ashram, Anangpur (Faridabad), Haryana.* Tech. Report, Water Technology Centre, IAR1, New Delhi, 37 p.

Singh, L. and Singh, M. 1983. Analysis of changes of ground water level in parts of Sarda Sahayak canal command area of Uttar Pradesh. In *Proceedings of Seminar on Assessment, Development and Management of Ground Water Resources.* April 29-30, 1983, New Delhi.

Troch, P.A., Torch, F.P. de and Brutsaert. W. 1993. Effective water table depth to describe initial conditions prior to storm rainfall in humid regions. *Water Resources Research* 29: 427-434.