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A REGRESSION ANALYSIS MODEL FOR ESTABLISHING CORRELATION BETWEEN RAINFALL AND GROUND WATER LEVEL FLUCTUATIONS WITH RESPECT TO APPLICATION ASPECTS

Dr. Rajat Kumar Mehta[1], Dr. Harish Chandra Singh[2], Er. Ramjeet Singh[3], Dr. Pramod Kumar Mishra[4], Dr. S.K. Pandey[5], Er. Ashish Gupta[6]

Professor, Deptt. of IDE, MCAET, Ambedkar Nagar, Uttar Pradesh, India[1]

Dean, MCAET, Ambedkar Nagar, Uttar Pradesh, India[2]

Associate Professor, Deptt. of FMPE, MCAET, Ambedkar Nagar, Uttar Pradesh, India[3]

Assistant Professor, Deptt. of FMPE, MCAET, Ambedkar Nagar, Uttar Pradesh, India[4]

Assistant Professor, Deptt. of Agricultural Engineering, COA, Kotwa, Azamgarh, Uttar Pradesh, India[5]

Guest Faculty, Deptt. of CS&E, MCAET, Ambedkar Nagar, Uttar Pradesh, India[6]

Abstract: The study was made in order to establish correlation between rainfall and ground water fluctuation of Ambedkar Nagar District in Uttar Pradesh through regression analysis. To study the trend in ground water level in eastern U.P. Ambedkar Nagar a model was fitted known as regression model with data for every year from 2008-2017 .The developed model equation is $Y' = -3.59 \times 10^{-3}X + 13.767810$ .The coefficient of correlation between water table and rainfall was observed as − 0.5735. The result of study had been evaluated through r^2, RMSE and EC were found to be -0.574, 1.23 & 96.6% respectively. The above empirical equation may be useful in prediction of water table depth from rainfall for base line for boring of tube well for timely irrigation of crop.

Index Terms: Rainfall, Regression Analysis, Correlation, Groundwater, Fluctuation.

I. INTRODUCTION

In 1959-60 the area underground water irrigation which is less than six million hectare but went up to 18 million hectare in 1980-81 to 33 million hectares in 1999-2000. More than half of the total irrigation is based on ground water, the share of ground water in area increasing from 30% in 1960-61 to 58.77% in 1999-2000. The area underground water is increasing progressively because it the most reliable and cost effective source of irrigation (Joshi, 2002).

The rainfall contributes to the annual increment in the ground water reserve which in turn is reflected in the rise of water table during the post monsoon period. Estimation of water table is needed for planning and developing the resources. With increasing demand for water for both agricultural and industrial use, the need to develop ground water resources to maximum possible extent has gained importance. The main component of recharge of ground water is precipitation. The ground level is an indicator of ground water availability. Ground water is an important resource of irrigation of India. It contributes to enhance agricultural production was better realize during green revolution and miss management has result in several problem likes fluctuation in water table and increasing in depth of wall. In last 10 year out of total monitoring wells 60% showed depletion in water table depth during per monsoon dry session. This leads to associated problem off lowering tube well depth and drying of open dug wells in the areas. Few areas with associated problem of lowering tube well depth and drying of open dug wells has becomes the major issues. This also indicates the decreasing trend of ground water table depth over a period of time. The fluctuation of water table is mainly depending upon the precipitation received in the area. Being insufficient annual rainfall and which is not sufficient to crop production, it is become essential to have the use of ground water. For irrigation purpose the ground water is utilized through tube well, pumping etc. For installation of the tube well is necessary to know the base the depth of table.

The present investigation entitled to "develop the model for the prediction and relationship between rainfall and ground water fluctuation of Ambedkar Nagar District" was carried out with objective to establish correlation between rainfall and ground water fluctuation.

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II. LITERATURE REVIEW

Literatures pertinent to this study have been cited under the heading of rainfall and water table fluctuation geo hydrological feature of the study area.

Chaturvedi (1936) reported that water level fluctuation and rainfall amount in Ganga Yamuna deals 1936 derived an empirical relation to arrive at the recharge as a function of annual precipitation.
$R = 2.0 (P-15)^{0.4}$
R = Net recharge due to precipitation during year (inch) P = Annual precipitation (inch)
The formula was later modified by further work at the U.P. irrigation research institute, Roorkee and modified the formula is: $R = 1.35(P-15)^{0.4}$
The Chaturvedi formula has been widely used for the preliminary estimations of ground water recharge due to rainfall.

C.P. Kumar (1973) derived an empirical relationship to determine ground water recharge from rainfall in upper Ganga canal command area based upon seasonal ground water balance study carried out for a number of years.

Central ground water board (1982) recommended methodologies for estimation of ground water resources potential in India. It was recommended by committee that the ground water recharge should be estimated based on water level fluctuation. However in areas where ground water level monitoring is not being done regularly where adequate data about water level fluctuation is not available adhoc norms or rainfall infiltration may be adopted.
Gupta (1985) reported that water table in Rohtak district has been raising at the annual rate of 0.6 m in deep water table areas. It has been rising of 0.08 m in shallow water table areas following the introduction of canals irrigation. He pointed as years of these areas. This related with high and low rainfall respectively.

Agarwal & Khanna (1983) Studying the water table fluctuation of areas helps us is to understand the relative causes of drainage problems and its surrounding. In Haryana ground water areas (north eastern and south eastern parts) water table is decline constantly while in saline area brackish ground water area (middle east central and south western parts) water table is rising at an alarming rate.

Ministry of water Resources (1984) “ground water estimation methodology”, reported of the ground water estimation committee, ministry of irrigation, government of India, New Delhi.
Singh (1985) studied water table fluctuation for government from at Hansi (Haryana) which is adjacent to study area. In his study it was found that the water level reached to the surface during three to four months period depending on the rainfall during monsoon.

Central Ground Water Board (Nov. 1995) this committee has proposed several improvements in the existing methodology based on the ground water level fluctuation.

Sadeque (1996) reported that in Bangaladesh water level fluctuation are causing shallow wells to go dry particularly during summer, this difficulty for village is obtaining drinking water supplies.

Agarwal & Kumar (1998) reported that nearly 50 percent of the area of Haryana state was affected with serious problem of rise in water table, mostly the area falling in the district of Rohtak, Jhajjar, Jind, Bhiwani, Hisar, Sirsa, Sonipat.

Niak et al., (2003) Ground water recharge amount in to 57 MCM in a year in the lower Koyana river basin vertical percolation of rain water was estimated.

Ramesh Chand etal., (2004) natural ground water recharge is estimated using the injected tracer technique in the Bairasagara watershed of Kolar district Karnataka. An attempt was made to get empirical relationship b/w recharge versus depth to basement, and recharge versus water level fluctuation.

Ramesh Chand et al., (2005) ground water recharge in Hayat Nagar micro – watershed near Hyderabad is estimated from the measurement of soil moisture variation using neutron moisture probe and water level fluctuation.

Marechal et al., (2006) a water budget approach is developed to jointly estimate natural recharge and specific yield in an unconfined aquifer with significant seasonal water table fluctuation. This method is applied for recharge estimation in the granitic Maheswaram watershed.

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Rai et al., (2006) the origin and natural recharge none of ground water in parts of Upper Ganga catchments were investigated using isotope technique. The close resemble in altitude effect of ground water and precipitation only.

Romani, (2006) Reported the annual replenish able recharge from rainfall in the zone of water table fluctuation was estimated as 433 billion cubic meters (BCM), 399 BCM is available for utilization, leaving aside 34 BCM unutilized natural discharge in the form of subsurface flow in to the oceans, rivers, streams.

Bhattacharaya, (2007) Reported that simulation of ground water behavior is Required to predict water table fluctuation in response to varying ground water pumping and recharge conditions. Ground water models are widely used for simulation of ground water behavior.

III. MATERIALS AND METHODS

The study was conducted to develop the model for the prediction and relationship between rainfall and ground water fluctuation of Akbarpur, Ambedkarnagar district (U.P.) through regression analysis and correlation between rainfall and depth of water table. This chapter deals with the detail of experimental material, method and technique relate to analyzing the data collect for present investigation.

3.1 Description of the study area:-

Ambedkarnagar is one of the districts of Uttar Pradesh, India. The district lies between 26°09′ N to 26°40′ N latitude and 82˚12′ E to 83°05′ E longitude. Ambedkarnagar is the district headquarters, and also the administrative centre for the various divisions. With an area of 2,520 square kilometers (970 sq mi), Ambedkarnagar is bound on north by Basti and Kabir Nagar district, on the north east by Gorakhpur district on the south by Sultanpur district ,on the west by Ayodhya district, and on the east by Azamgarh district. The total length of the district from east to west is approximately 75 km and the breadth from north to south is about 42 km.

The district of Ambedkarnagar forms a part of the central Ganga basin. The soil of Ambedkarnagar district is alluvium. The Saryu is the main river and is located at the north boundary of the district. The Tanda, Rajesultanpur, Ramnagar and Baskhari blocks are located along this river and use its water for irrigation.

The climate of the district resembles that of eastern Uttar Pradesh. It is characterized by the rhythm of season, which are produced by south-west and north-east monsoon. The reversal of winds takes place twice a year.

3.2- Collection of hydrologic data:-

The data of ground water for Akbarpur, Ambedkarnagar district for the period of 10 years i.e. (2008-2017) have been collected from ground water department of Akbarpur, Ambedkarnagar district & shown in table 4.1& 4.2

3.2.1- Analysis of data

Under analysis of data, the regression analysis and correlation is done. In the analysis, rainfall (mm) is denoted by "X" whereas depth of water table is denoted by "Y".

3.3- Correlation:-

It is a statically technique which means and analyze the degree or extent to which two or more variable fluctuate with reference to each other. The direction of change is denoted by + and -.
+ve for movement is same direction
-ve for movement in opposite direction

3.3.1 – Type of Correlation:-

1. Positive & Negative - When the variable are in the same direction then they are + ve / direct, when the variable is in opposite direction then they are – ve / inverse.
2. Simple & Multiple - Simple, when the relation is between two variables and multiple when the relation is between more than two variables.
3. Partial & total – Partial is which the relation of two or more variable excluding other variable. Total is when, it's based on all relevant variable, it's not palatable
4. Linear & none. Linear – when the variable in the value of two variables is constant then it's linear. Non liner does not have a constant ratio.

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3.3.2- Method of correlation:-

Following are some algebraic method-

3.3.2.1- Karl Pearson's Method:-This method of calculating coefficient of correlation (r) is based on covariance of the concerned variable.

3.3.2.2- Direct Method:-It is a mathematical method of measuring the intensity or the magnitude of the linear relationship between two series of variables. This measure known as pearsonian correlation coefficient between two variable X and Y usually denoted by 'r' is a number measure of the covariance between X and Y to the product of symbolically.

$r = \frac{\sum xy}{N\delta x.\delta y}$ ………………………………………………………… (3.1)

Where,

$X = X - \bar{x}$

$Y = Y - \bar{y}$

δx = standard deviation of the series X,

δy = standard deviation of the series,

δ = numerical measure of linear relationship,

3.4- Regression analysis:-

Regression is a mathematical measure expressing average of relationship between two or more variables in terms of the original units of data.

Table: 3.1Annual rainfall data of Akbarpur, Ambedkarnagar district

Year	Rainfall (mm) X	Depth Of Water table(m) Y	$\bar{x}$ $(X-\bar{X})$	x^2 mm^2	y $(Y = \bar{Y})$ m	y^2 m^2	xy m^2
2008	980.25	10.92	437.717	191596.17	-1.324	1.752	-0.579
2009	800.21	10.40	257.677	66397.43	-1.85	3.452	-0.476
2010	360.45	11.12	-182.083	33154.218	-1.13	1.276	0.205
2011	550.19	11.92	7.657	58.629	-0.33	0.108	-0.002
2012	446.76	12.10	-95.773	9172.46	-0.15	0.022	0.014
2013	535.40	12.45	-7.133	50.879	0.20	0.040	-0.001
2014	280.25	13.20	-262.283	68792.37	0.95	0.902	-0.249
2015	520.45	13.80	-22.083	487.658	1.55	2.402	-0.034
2016	441.25	13.05	-101.283	10258.246	0.80	0.640	-0.081
2017	510.12	13.54	-32.413	1050.602	1.29	1.664	-0.041
Total	$\bar{X} = \frac{\sum X}{10}$ =5425.33/10 = 542.533	$\bar{Y} = \frac{\sum Y}{10}$ =122.506/10 =12.250		$\sum x^2$ =381018.662		$\sum y^2$ =12.348	$\sum xy$ = - 1.244

3.8- Empirical relationship:-

Empirical relationships can also be developing between ground water recharge and rainfall based on seasonal ground water balance studies. The relation b/w rainfall and recharge is shown by the equation as.

Where,

$R = 1.35(\frac{P}{25.8} - 14)^{0.50}$

R= recharge (mm)

P = precipitation (mm)

Table: 3.2 Ground water fluctuation in Akbarpur, Ambedkarnagar.

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Sl. No.	Pump number	Date	Discharge (/gallon)	Piezometric Pressure (kg/cm^2)	Water Pressure (kg/cm^2)	Pumping Pressure (kg/cm^2)	Motor
1	33AG	25/11/17	32429	23	22	45	CT
2	35	05/10/17	28371	24	20	44	KSB
3	35A	06/10/17	31280	24	22	46	SU
4	36	28/11/17	30367	24	18	42	KSB
5	38	30/01/17	31280	24	21	45	KSB
6	43	08/12/17	31450	23	20	43	WTH
7	44	06/10/17	32429	24	20	44	LB
8	50	07/10/17	28391	24	21	45	KSB
9	54	02/12/17	28391	23	15	38	KSB
10	58AG	03/12/17	32650	21	15	36	KSB
11	63	18/01/18	30367	27	13	40	LB
12	64	15/01/18	32429	26	18	41	LB
13	65	08/12/17	30367	16	26	41	LB
14	66	08/12/17	32429	27	18	45	HCL
15	66A	18/01/18	28371	27	16	44	HCL
16	79	10/10/17	32429	23	21	44	CT
17	88	04/12/17	25210	22	16	38	KSB
18	42	12/10/17	32429	23	20	43	LB
19	98	15/01/18	24609	25	18	43	KSB
20	98A	15/01/18	28371	25	19	44	WTH
21	136	13/10/17	32429	24	20	44	CT
22	149	24/11/17	32429	23	20	43	WPIL
23	152	13/10/17	28371	23	20	43	WPIL
24	61AG	16/01/18	30367	28	14	42	KSB
25	140	16/01/18	28391	26	16	42	KSB
26	160	16/01/18	34609	24	18	42	LB
27	161	16/01/18	30367	23	17	40	CT
28	170	05/01/18	28371	23	18	41	KSB
29	176	16/12/18	28371	21	19	40	WP

Table3.3: Estimation of ground water recharge by Empirical Method

Year	Precipitation (mm)	Recharge (mm)
2008	848.9	151.0
2009	1189.9	197.8
2010	1233.9	201.7
2011	1497.7	223.5
2012	1241.5	204.2
2013	929.9	163.0
2014	1058.00	180.3
2015	1943.9	273.1
2016	1236.2	202.0
2017	1112.7	187.2

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RESULT AND DISCUSSION

The general description of Akbarpur district selected for hydrological investigation, measurement and collection of hydrological data used in the study from ground water department district of Akbarpur, Ambedkar Nagar U.P.
Analysis of hydrologic, formulation number of mathematical model and their development were described previously. The model developed by using Karl Pearson's method has been used for predicting ground water table. Coefficient of efficiency, root mean square error to judge the adequacy of the model, qualitative and quantitative comparison of observed and predicted water table graph are presented and discussed in this section.
On the basic of 10 years data regression equation water table and annual rainfall of Akbarpur, Ambedkar Nagar district was derived by Karl Pearson' s method. The developed equation model which was used is given below:-

4.1 – The developed model equation is given below:-

$Y' = -3.59 \times 10^{-3}X + 13.767810$ …………………………………….. (4.1) Where,
Y'= predicted water table
X = observed rainfall

The coefficient of correlation between water table and rainfall was − 0.5735.
The result of study have been evaluated through r^2, RMSE and EC were found to be -0.574, 1.23 & 96.6% respectively.

4.2 - Quantitative performance of the model in computation of water table:-
The quantitatively performance of model as regard to water computation of water table was compared with one another by determining several statistical measures such as root mean square errors and efficiency coefficient.
4.2.1 – Root mean square error:-
Its yields the residual error in term of the mean square error and is expressed as

$RMSE = \sum_{i=2008}^{2017} (Yi - \bar{Y})^2 / n$ ………………………………… (4.2)
Where;
Y = observed values
$\bar{Y}$ = mean of the observed values
n = number of observation
The values RMSE model is obtain by with the help of equation 4.2 and the value of RMSE is 1.23.

4.2.2 – Efficiency coefficient (EC):-
It is used to assess the performance of the model is given by:-
$EC = [1 - (F/Fo)] \times 100$ ………………………………… (4.3)
Where,
$Fo = \sum(Y - \bar{Y})^2$
$F = \sum(X - \bar{X})^2$
A value of efficiency coefficient of percent generally indicates a very satisfactory model performance while a value in the range 80% - 90% a fairly good model. Value in the range of 60% - 80% would indicate model is fit. The value of EC of model is obtained with the help of equation 4.3 and value of EC 96.6%

The ground water table in Akbarpur, Ambedkar Nagar varies from 10.92 to 12.45. It's evident from the data that the water table changes according to rainfall. The rainfall of Akbarpur, Ambedkar Nagar district varies from 535.40 to 980.25 mm.

IV. CONCLUSION

1. On the basis of 10 year data liner regression equation model between water table and annual rainfall of Ambedkar Nagar district was derived by Karl Pearson's method.
2. The developed equation model which was issued is given below:-
$Y = -0.00359X + 13.767810$
Where,
X = Observed rainfall
Y = predicted water table
3. The value of r^2, RMSE and EC were found to be 0.32,1.234 and 96.6 respectively-
The developed equation model may be adopted for reasonable estimate of ground water table depth at piezometric

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stations based on depth for the effective planning & management of ground water resources of the basin.

The above empirical equation may be useful in prediction of water table depth from rainfall for base line for boring of tube well for timely irrigation of crop.

In order to study the trend in ground water level in eastern U.P. Ambedkar nagar regression model was fitted with data for every year from 2008-2017. The fitted regression model is sketched for water table. These fitted regression model are also used to forecast the future of ground water level in of Ambedkar nagar district.

For most of the fitted models, values of fluctuation determination i.e. R^2 was found to be significant indication their by good fit of model. The model and value of R^2 is Saying that 85% - 95% of prediction is correct and rest 10% - 20% is error.

In order to understand the fluctuation of ground water level in Ambedkar nagar district the regression analysis like water table fluctuation was carried out data for period from 2008 – 2017. It is been found that fluctuation was more as compared and availability is because of fluctuation rainfall we had received. From analysis we conclude that in coming 10 year the ground water will go on depleting if rainfall will occur at same rate what it had occurred from year 2008-2017.

To protect the ground water from further depletion water extraction has to be somehow balanced by the recharge calculated, not only the basis of intensity of modern seasonal rainfall but also by improved direct methods. All such estimation should be revised time to time as reconsidered. Wherever feasible newer approach need to be adopted to recharge through low lying areas where surface rainfall get collect during rainfall intensity, Instead of allowing water to stagnate, legal provisions are needed to be introduced to restrict indiscriminate withdrawal of ground water with emphasis on enhance water use efficiency for various specific purpose. The zone of ground water recharge need to be clearly indentified and revised in relation to land use change in order to restrict on eliminate waste disposal activities in these area.

Ground water recharge is a fundamental component in the water balance of any watershed. However, because it is nearly impossible to measure directly, numerous methods have been used to estimate recharge, and in some cases, base flow has been used as an approximation of recharge. A common recommendation in the literature is that recharge should be estimated from multiple methods and the result compared, but in reality, comparing the result may be difficult because of differences inherited in the method.

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