Applications of Infiltration Studies for Effective Management of Water Resource in a Coastal Belt

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Abstract: Surface water bodies are the water on the surface of the planet such as in streams, river, lake, wet land, or oceans. Non saline surface water is replenished by precipitation and by recruitment from ground water. It is lost through evaporation, seepage and abstracted by mankind for agriculture, living, industry etc. The present study deals with applications of infiltration studies for effective management of water resources in costal belt - Gara Mandal of Srikakulam District. The rainfall data between the years 1995 – 2010 has been collected and rainfall intensity was observed by collecting monthly rainfall data. The collected rainfall data is analyzed to understand the characteristics of rainfall data such as statistical parameters and frequency parameters. The trend is determined with the help of moving average curves. Based on the moving average curves developed for the study area it is observed that the rainfall trends are decreasing for the months of January, February, April , May, September, October, November , December. For the remaining months rainfall trend id fluctuating. From the infiltration curves it is found that, at 3 locations the rate of infiltration obtained is in the range of 300 to 800mm/hr and other remaining locations are below 100mm/hr. It is also observed that in future there may be less rainfall in potential months. So, Ground water levels in the study area may decrease and may cause salt water intrusion because of costal belt.

Introduction: Water is the most important natural resource and is vital for all life on earth. The well-being and the development of our society are dependent on the availability of water. This most precious resource is sometimes scarce, sometimes abundant and is always very unevenly distributed, both in space and time. The oceans which cover 71% of the surface area of earth and which have an average depth of 3.8 km hold as large as 97% of the earth's water, while 2% is-frozen in ice caps. The deep ground water accounts for 0.31%. This 99.31% of water is of no use to man. The' remaining 0.69% which is of the order of 4.374×10^6 km^3 represents the fresh water resources with which the man has to deal. Application of remote sensing in Water resources is not new, in fact it is used by other countries. Runoff and Mean annual rainfall is usually calculated by taking the simply average of total rainfall of several consecutive years. Great variations are recorded in the annual rainfall at the same station, and a rainfall record for considerable no of years is necessary tom get reliable estimate of mean annual rainfall at any place. The greater is the number of years considered, the more correct will be the mean value so obtained. From the study of rainfall records of a large number of different places extending over many years, it has been found that 35years rainfall records are required for reliable estimate of the mean annual rainfall of any place.

Study Area: Gara mandal which is located at a distance of 10kms from city of Srikakulam in Andhrapradesh (India) is located between between 18^0 20'51" and $18^0$15'49" Latitudes and 84^0 0'16.67" and 84^0 7'59" Longitudes. Agriculture is the main occupation in this area. The people here suffer from saline water intrusion into ground water. People here mainly depend on ground water for agriculture and partly on monsoons. This area is bounded with river

Vamsadhara at north direction of Gara Mandal.

Tools and Methods used in present study: For carrying out the infiltration studies in the study area the following tools are used:

(a) Double ring infiltrometer and other accessories
(b) Core cutter and other accessories
(c) Casagrande apparatus
(d) Geographical Positioning System (GPS)
(e) Curve Expert Software
(f) Microsoft Excel Software

Methods:

Infiltration Test Using Double Ring Infiltrometer:

- Select a relatively flat test area so that the double-ring infiltrometer will not be placed
- at an angle.
- Cut the grass to a height of between two to five centimeters.
- Mark the dimensions of infiltrometer with the help of scrapper.
- Gently drive the infiltrometer into the ground.
- Inspect the soil seal around each ring to make sure that it is even and smooth.
- Measure adequate quantity of water for a constant height of 1cm for both rings, now Pour the water first in inner ring and then in outer ring. Maintain a level in the outer ring approximately equal to the level in the inner ring.
- Now start stop watch and measure the depth of water levels for known intervals.
- Add more water to both rings when the level in the inner ring has dropped a measurable amount.
- For most soil types this should be less than an inch.
- Repeat this step until the rate the water level drops begins to decline.
- Continue the experiment until we get constant infiltration rate.

Determination of plastic limit test: Plastic limit may be defined as the water content at which a thread made by rolling a ball of soil crumbles, when it is rolled down to a diameter of approximately 3 mm

- Take about 20g of the air-dried soil passing 425 micrometer IS sieve. Add water to it to attain a consistency that enables it to be molded into a ball.
- Take a small portion of the ball and roll it on the glass plate with fingers, using just sufficient but uniform pressure to make it into thread of uniform diameter over its entire length. When the diameter of the soil thread has reduced to 3mm, knead the specimen together and roll it again. Continue the process until the thread just crumbles at 3mm diameter.
- Collect the crumbled soil thread in a pre-weighed moisture can, close the lid and determine its moisture content.
- Repeat the test for 2 to 3 times and take the average values

Mathematical And Statistical Analysis: The mathematical equations used in the present study and the procedure of determination of their parameters is described in this section. And also the determination of statistical parameters is also described.

Determination of statistical parameters:

The mean, standard deviation, coefficient of variation are determined as follows:

Mean: $\text{Mean} = \frac{\text{Total Rainfall}}{\text{No.of Days}}$

Standard Deviation:

Standard deviation $= \sqrt{((x-\bar{X})^2 \div (n-1))}$

Coefficient Of Variation: Coefficient of variation = $\frac{\text{Mean}}{\text{Standard Deviation}} * 100$

Determination of frequency analysis:

Frequency: The probability of occurrence of an event expressed as a percentage is known as frequency (f).thus

F = 100p = (1/Tr)*100

In irrigation and water resources engineering the term frequency is loosely used to represent the recurrence interval and the probability.

- The available rainfall data, from a record of n years, is arranged in descending order of magnitude.
- The rank of each rainfall is determined. it is equal to its position in the series. In other words, the highest rainfall will have m=1, the second highest m=2, and so on of course the lowest rainfall will have m=n. The rank is also known as plotting position.
- Now the recurrence interval for any rain fall of the rank m is calculated by

Frequency = (m / n)*100

Determination of Mathematical Equations: The regression analysis is used to find the parameters of the Horton's and kostiakov's equations which are described below.

Horton's Equation: $f = f_c + (f_o - f_c)\, e^{-kt}$

Where fo = initial infiltration

f_c = minimum infiltration

t = total time infiltration.

Kostiakov's Equation: $F = at^n$

Where F=cumulative depth of infiltration

The equations of the models are developed using the regression analysis. The regression analysis procedure is as follows:

The logarithmic transformation of the standard equations is done.

The variables are formulated as

$(Y-\bar{y}) = b\,(T-\bar{t})$

$y = \sum y/n$

$\bar{t} = \sum t/n$

$S_y = \sqrt{(\sum (Y-\bar{y})^2 /n)}$

$S_x = \sqrt{(\sum (T-\bar{t})^2 /n)}$

$r = \Sigma(Y-y)\,(T-\bar{t})/n) / (S_x * S_y)$

$b = (r*Sy)/Sx$

Where x and y are the variables to which the relation is to be obtained.

Methodology: For the observation of rain fall variation in the study area, the rain fall data was collected from the collector office of the Srikakulam district during the years 1995- 2010. The rain fall intensity was observed by collecting the monthly rain fall data of the Lost ten years and count the number of rainy days during the every month and add the number of days for the year also estimate the total rain fall depth of the entire year. Finally estimate the rain fall intensity.

Runoff Estimation:

Mean Annual Rainfall: Mean annual rainfall is usually calculated by taking the simply average of total rainfall of several consecutive years. Great variations are recorded in the annual rainfall at the same station, and a rainfall record for considerable no of years is necessary to get reliable estimate of mean annual rainfall at any place.

Run-off Coefficient: In the present study the runoff estimation was calculated by using the Run-off formulae and tables. The run-off and the rainfall can be inter-related by run-off coefficient, by the expression.

R = k P

Where R =run-off in cm, P = rainfall in cm, k =run-off coefficient.

The run-off coefficient naturally depends upon all the factors which affect the run-off. This method is used only for small water, control project, and should be avoided for the analysis of major storms .The-customary values of *k* are given below:

Area	k
Urban residential Single Houses	0.3
Garden apartments	0.5
Commercial and Industrial	0.9

Forested areas, depending on soil	0.05-0.2
Parks, farms land, pasture	0.05-0.3
Asphalt or concrete pavement	0.85

Table: 1 Customary Values of *K*

Data Collection: The data required has been collected for preparation of Land Use / Land Cover which includes the base map (hard copy), satellite digital data and Ground control points. The base map was collected from the Srikakulam municipality office and later it was scanned. Satellite digital data was collected from Google earth and also identified ground control points.

The Satellite Data Collection: The following steps are involved in satellite data collection and processing:

- Acquisition of Satellite Data
- Georeferensing of satellite data
- Mosaicing of georeferenced images

The satellite digital data was collected from the Google Earth by the following procedure. Initially the prepared Gara mandal boundary has been imported on to the Google earth. Later the downloaded image clips were imported into the Arc GIS.

Figure 1: Study area boundary on the Google Earth

Step by Step Procedure of Mosaic using ERDAS: All the rectified images clips are imported into the ERDAS.

→Select the Data prep tool from that click on mosaic images and then click on mosaic tool → Click EDIT and ADD IMAGE. Add all the clipped images → In the mosaic tool dialogue box, select the rectified images for mosiacing → Images are imported into the Mosaic tool → Then click PROCESS and RUN MOSAIC → Then a new image file withal clipped images included is obtained.

Figure 2: Mosaiced Image

Land use land cover map generation:

Image interpretation process: The process consists of a set of image elements or characteristics like color/tone, texture, pattern, size and shape which help in the recognition of various land use/land cover classes. In this project visual interpretation process has been used to extract the land use/ land cover information of rajam by applying previsual interpretation, ground truthing and postal visual interpretation of mosaic image.

Production of GIS output: The digitized eight layers from satellite digital image have been imported to ArcInfo as coverage. Each layer has been edited, cleaned and topology was created. Later each layer was projected to polyconic projection. Then land use land cover of Gara mandal was prepared I Arc GIS at scale 1:50000. Land use land cover map of study area are shown below.

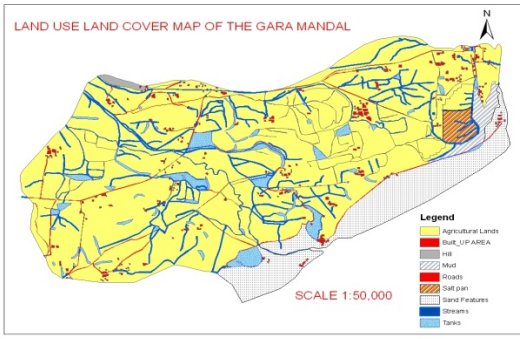

Figure 3: Land use/Land cover map of study area

Results and Discussions:

Rain fall variation: The following results were observed after preparation of the graphs i.e. rain fall in y-axes and months in x-axes from the years 1995-2010. The rain fall variation of lost 15 years was observed

from the graphs of monthly data, it is concluded that the rain fall is maximum in the monsoon seasons and the remaining period the rain fall was almost all nil. The following results were observed by preparing the graph between yearly rain fall in the y-axis and the year in the x-axis.

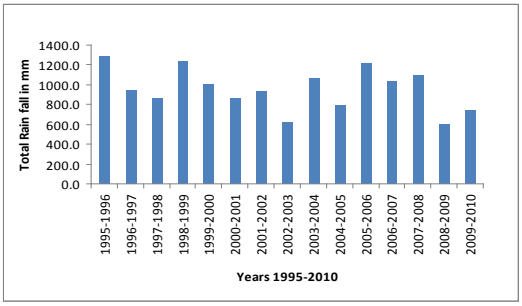

Figure 4: Bar Diagram representing total rainfall and years

Infiltration data: Infiltration tests were conducted with the help of Double ring Infiltrometer for 14 locations in study area. The variations in rate of infiltration are represented in the following graph with respect to time. It is observed that at 3 locations the rate of infiltration in the range of 300-800 mm/hr are obtained and in the remaining locations they are below 100 mm/hr.

Table 2: Observed Rain fall from 1995-2010

Year	Total Rainfall
1995-1996	1295.1
1996-1997	946.5
1997-1998	865.5
1998-1999	1246.7
1999-2000	1007.3
2000-2001	866.5
2001-2002	938.9
2002-2003	631
2003-2004	1068.8
2004-2005	792.6
2005-2006	1228.9
2006-2007	1043.8
2007-2008	1096.8
2008-2009	611.4
2009-2010	756.4

Conclusions: The collected rainfall data is analyzed to understand the characteristics of rainfall data such as statistical parameters and frequency parameters. The trend is determined with the help of moving average curves. The present study shows that the rainfall is Maximum in the monsoon season and the remaining period the rainfall was almost nil. The rain fall intensity variation was zig zag treand from year to year but in the obseravathion of monthly rain fall intensites, the intensity is maximum in some months and the remaining months the rain fall intensith is very less It indicates that in the period of low rain daye thers is no ground water recharged but in the heavy rainey days the maximum rain was converted in to direct runoff because the ground water was recharged only up to the maximum limit. So the direct run off is directly reaches to coast. Based on the frequency analysis made for monthly rainfall, the dependable rainfall in a year for 25% frequency is 1435.5mm and for 50% frequency is 650mm and for 75% frequency is 322.5mm. The infiltration curve show that, at 3 locations the rate of infiltration obtained is in the range of 300 to 800mm/hr and other remaining locations are below 100mm/hr.

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