Study of Discharge Variations with Increased Impermeable Cover – A Case Study of Vignan's Institute of Information Technology, Visakhapatnam

G.Venkata Rao, M.Leela Priyanka, K.Raghavendra, Md.Sirajuddin

Department of Civil Engineering VIIT, Duvvada, Visakhapatnam, India

Abstract: **- The analysis of the change in the flood run-off phenomena due to urbanization of the drainage basin is an important problem in the actual flood control project. As with all aspects of the water cycle, the interaction between precipitation and surface runoff varies according to time and geography. In the present study the runoff is estimated with existing surface layers. The imperious surface area is 37325.362 m^2 and the surface discharge is 14250.823 m^3. The study is also focused on how much amount of discharge increases with increase of every 5% impermeable cover. The increased discharge with impermeable is 14% for 10-20% ,27% for 35-50% and 36% for 75-100%.The ground slopes of the VIIT Study area is prepared by using Arc GIS technique.**

***Key words*: Impermeable cover, slope map, discharge, Rain fall and permeable cover**

I. INTRODUCTION

Water in inevitable thing for life .Life can't be imagined without water .The population of world is increasing day by day so is the consumption of water with .With the increase in population the occupancy of land is also increasing which results in destruction of trees and forest area .Rain is not happening in time due to pollution and other human needs .Thus the concept and practice of rainwater harvesting comes into play

The lands covered by trees, plants, grass or through which water can percolate into soil are called previous (vegetative) lands. And the lands other than the vegetative are called impervious land (i.e. the water can't percolate into it).

As rainfall occurs first the water percolates down into the soil due to its permeability nature but with increase in duration and intensity of rainfall the percolation stops and rainwater flows over the surface as flood which causes erosion of soil .But as the percolation doesn't happen in impervious layer this rainwater flows on pervious layer which increase the flow of water on the previous layer .The more the increment of impervious layer the more will the runoff volume.

II. STUDY AREA

Location

The VIIT Campus lies in Duvvada (Gajuwaka mandala, Visakhapatnam) at 17.7106*N longitude and 83.1638*E latitude.The campus is at a distance of 1.8 km from duvvada railway station. The campus has wide open area and has hill in north side at 5 km distances .There is no lakes or river in the range of 1km of the campus .The surrounding climate is warm and humid .The soil found in the campus area is red, gravel, and sandy.

Description

The campus has seven buildings. The total area of college is 152186.922sq.m.(impermeable area is 37325.362sq.m. and vegetative area is 114861.56sq.m.). Nearly 6000 students are studying in this campus. The precipitation on the campus area is being drained out into drains which ultimately find its way into sea. The precipitated water cause erosion of the soil. Thus, to utilize the water for recharging the ground water table and prevents the erosion of soil, pits or trenches are being constructed. The location of VIIT campus as shown below fig.1.

Figure 1. Map of study area.

III. METHODOLOGY

1. Digital Elevation Model (DEM).

DEM is used to make clear study of the area it gives detailed study information of selected area.DEM is the 3-D representation of the terrain surface, DEMs are typically used to represent the bare-earth terrain, void of vegetation and manmade features.

For creating DEM map

- Open ArcGIS, go to tools option and enter XY data.
- For XY data we specify create a file in MS excel in format of File in CSV.
- In excel, the first column for X data (Latitude), second column for Y data (Longitude), and the third column for the Altitude.
- The Altitude values are taken from the Reduced Level values.
- Open the save excel file and select the file in CSV format and then click ok.
- Now the Altitude points are added to screen.
- By using this altitude points we are going to prepare the contour lines.
- What we are done in arc map is required everything in shape file.
- Right click on file and there is option data (export data), click ok then then the shape file while be created.
- Go to spatial analyst option, selected the interpolate to raster and select the kriging technique for the further process.
- By using the kriging technique, the raster in the form of 3D will be added.
- Then the formation of DEM map is completed.
- Now for contour lines, go to spatial analyst again click surface analysis and we have an option contour.
- For that we place the input surface, and contour intervals also.
- Finally, we got contour line in DEM map.
- Similarly, we create the slope map by using surface analysis in Arc GIS.

2. Measurement of college area:

The area of campus has been computed by using Google map and tape. The vegetative layer and impermeable layer have been measured separately b) Identification of impervious & vegetative layer: A field survey was conducted for identification of impervious & vegetative layer. Several photos were taken of whole campus area for this purpose c)Rainfall data : The rainfall data has been collected from Jilla Parisad and irrigation department of Visakhapatnam d) Calculation of run-off & run-off discharge : Run-off has been calculated by using the run-off coefficient formula ; $R = K * P$

Where, R = run-off in cm, K = run-off coefficient and P = precipitation or rainfall in c.

The rain fall value which has been taken for the study is peak precipitation of a month of a particular year. The rain fall data as shown in table 1.

Table 1. rain fall data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1970	3.679	8.002	34.315	7.238	111.854	298.752	178.065	316.347	119.742	73.677	0.85	0.04
1971	0.029	36.693	10.949	102.016	58.902	65.82	89.711	208.633	203.86	183.531	0.85	0.04
1972	0	16.094	0	35.63	14.566	72.495	136.035	125.072	211.664	155.303	117.124	1.342
1973	0	0.042	7.842	5.677	49.712	90.698	193.368	205.083	93.457	180.368	18.207	0.04
1974	0	2.517	19.961	27.085	24.365	120.97	127.897	193.438	151.966	273.796	60.597	0.04
1975	0.001	1.737	1.141	0.716	55.447	251.231	203.831	232.588	240.545	282.098	59.672	0.191
1976	0	3.209	1.322	76.964	28.78	79.201	204.708	298.648	121.865	84.329	303.358	3.991
1977	2.257	0	1.732	63.923	74.653	140.21	194.718	175.307	183.886	156.794	175.067	5.337
1978	22.307	27.1	1.133	38.757	31.516	261.517	276.223	329.38	170.096	96.983	53.529	8.247
1979	5.199	23.555	0.392	29.381	82.077	100.828	103.307	110.362	238.101	47.549	209.925	33.463
1980	2.445	0	4.146	12.833	25.363	268.139	218.025	243.059	141.401	107.595	93.974	11.266
1981	11.708	0	25.912	19.272	38.479	115.724	213.757	153.324	334.257	112.957	35.857	9.942
1982	0	0.727	0.094	70.066	26.313	117.363	260.471	145.413	180.016	321.502	32.877	0.529
1983	0.782	9.422	0.094	0.584	19.42	218.939	206.88	200.052	146.163	289.436	14.287	23.51
1984	10.438	12.764	3.363	5.509	49.991	124.156	219.407	158.398	138.17	84.962	22.825	6.2
1985	26.266	0	0.665	2.02	14.868	196.132	188.903	201.674	138.566	312.852	35.201	12.976
1986	22.016	24.558	1.61	36.683	32.863	124.985	137.403	424.257	145.163	138.521	202.148	18.405

1987	3.737	0	43.386	60.534	40.541	66.577	102.256	219.341	86.725	171.637	209.287	11.345
1988	0	4.628	0.525	34.599	53.067	87.224	378.824	243.349	330.38	84.15	28.186	11.227
1989	0	0	30.425	2.964	46.333	105.432	420.642	193.876	196.164	45.521	8.375	1.253
1990	0.77	70.821	60.453	21.952	125.561	125.401	149.233	358.011	170.065	249.286	75.448	21.704
1991	6.809	0	2.721	8.574	35.523	332.709	181.256	144.682	323.267	179.975	101.84	12.353
1992	3.818	0.199	0	2.786	48.132	120.157	225.788	255.519	234.605	143.066	233.118	0.04
1993	2.189	0	2.878	22.501	51.56	90.094	139.249	155.277	205.773	316.673	3.403	1.972
1994	4.708	7.653	10.331	20.024	48.502	66.832	346.869	194.851	123.558	225.443	153.943	0.046
1995	14.815	0.598	12.973	15.712	44.176	86.548	246.603	151.738	209.589	419.306	67.967	0.04
1996	1.733	1.982	1.868	37.507	21.819	319.146	157.682	190.327	171.032	261.746	48.03	15.21
1997	7.431	1.024	32.23	45.267	5.361	42.192	251.523	163.414	289.707	73.698	154.552	40.206
1998	15.711	35.276	0.422	36.634	36.908	110.179	251.776	194.88	263.615	267.06	181.704	0.04
1999	0.217	0	0	2.276	56.495	147.084	110.456	255.325	134.977	164.574	3.126	0.825
2000	0	41.441	0	13.864	43.201	306.308	168.055	312.672	134.718	144.511	2.897	0.048
2001	0.232	0	1.496	26.45	66.507	101.618	108.7	300.458	162.769	170.687	134.315	3.66
2002	19.054	0	1.346	63.912	23.661	111.031	116.604	272.423	48.552	129.709	49.242	0.04
2005	28.1	41.80	42.5	37.7	46.1	143.2	334.1	190.1	206.9	99.3	27.2	11.2
2006	17.7	11.9	35.6	32.7	75	141.8	287.6	281.3	178.6	51.8	34.6	13.1
2007	1.7	36.7	35.2	30.6	46.8	192.5	286.2	257.4	206.8	55.7	14.4	15.3
2008	18.4	19.3	41.2	29.5	43.7	202	245	265.8	165.1	51.6	25.5	11
2009	12	12	14.2	25.1	56	85.7	280.7	192.5	139.4	71.4	53.7	11.1
2010	7.5	17	14	39	73.8	138.1	300.7	274.7	197.7	69	61.4	22.7
2011	6.8	25.8	22.4	41.1	53.1	183.5	246	284.9	186.9	38.1	20.1	7.6
2012	26.5	12.7	11.3	47.5	31.7	117.8	250.2	262.4	193.5	58.7	30.7	11.7
2013	0	0	0	0	0	219.8	310	254.7	152.7	0	0	0
2014	0	0	0	0	0	95.2	261.1	237.4	187.9	0	0	0

Run-off volume has been calculated by using formula Q = A * R Where, Q = discharge or runoff volume in cubic meter, R = run-off in m and A = area in sq. m.

IV. RESULTS AND DISCUSSION

DEM Map is prepared with the help of Reduced Levels and latitude & longitude of the various locations in the study area. In this map the ground slopes presented apart from the contours. This map gives the low laying area of the college and also helps to Identification of Rain water harvesting pit locations in the college. The map is shown in figure 2 and Locations are shown in table 2

Table 2.Co-ordinate values for DEM map

Latitude (x)	Longitude(y)	Altitude(z)
17.709	83.165	34.4
17.711	83.167	34.2
17.711	83.167	34.2
17.709	83.167	35.3
17.709	83.165	36.4
17.712	83.165	36.4
17.713	83.165	38.2
17.713	83.165	39.7
17.709	83.168	38.3

17.711	83.168	38.9
17.710	83.165	36.7
17.710	83.166	39.3
17.711	83.164	38.6
17.711	83.164	36
17.711	83.164	36.1
17.711	83.164	38
17.711	83.164	37.7
17.713	83.164	36.4
17.714	83.164	38.7
17.713	83.166	39.1
17.711	83.166	38.4
17.713	83.166	36.6
17.712	83.166	38.4
17.712	83.166	38.6
17.711	83.165	38.7
17.711	83.166	36.1
17.711	83.166	36.1
17.712	83.167	37.7
17.710	83.166	34.1
17.718	83.131	32.7
17.710	83.166	35.2
17.711	83.168	32.9
17.709	83.166	33.9
17.709	83.166	34.4

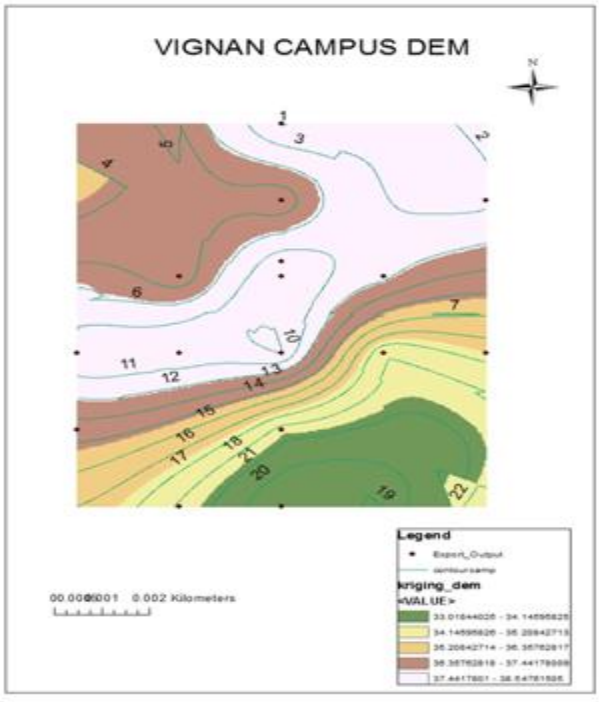

Fig.2. the slope of the VIIT Study area

a) Increasing of Impervious Layer

The actual (In the figure denoted by Natural ground cover) existing surface area of the campus is taken for the estimation of discharge. The increased run off is estimated for the impermeable surface area increased up to 100% of the existing impermeable area at an interval of 5% hike. The discharge rates are presented in the table 3. The increase run off with impermeable cover is presented in figure 3.

Table3. Run off rate s with Impermeable cover

Increased area (%)	Impermeable Layer (Sq. M.)	Discharge from Impermeable Layer (Cu. M.)	Vegetative Layer (Sq. M.)	Discharge From Vegetative Layer (Cu. M.)	Increased Discharge	Discharge Hike (%)
Actual area	37325.362	14250.823	114861.56	16563.037	-----	
5	39191.6301	14963.360	109118.482	15734.885	115.615	0.375
10	41057.8982	15675.900	103375.404	14906.733	231.227	0.75
15	42924.1663	16388.446	97632.326	14078.581	346.833	1.125
20	44790.4344	17100.987	91889.248	13250.429	462.444	1.500
25	46656.7025	17813.529	86146.170	12422.277	578.054	1.875
30	48522.9706	18526.070	80403.092	11594.125	693.665	2.251
35	50389.2387	19238.611	74660.014	10765.97	809.729	2.626
40	52255.5068	19951.152	68916.936	9937.822	924.886	3.001
45	54121.7749	20663.693	63173.858	9109.67	1040.497	3.376
50	55988.043	21376.234	57430.78	8281.518	1156.108	3.751
55	57854.3111	22090.569	51687.702	7453.366	1269.754	4.120
60	59720.5792	22803.168	45944.624	6625.214	1385.478	4.496
65	61586.8473	23515.767	40201.546	5797.062	1501.031	4.871
70	63453.1154	24228.366	34458.468	4968.911	1616.583	5.246
75	65319.3835	24940.965	28715.390	4140.759	1732.136	5.621
80	67185.6516	25653.564	22972.312	3312.607	1847.689	5.996
85	69051.9197	26366.163	17229.234	2484.455	1963.242	6.371
90	70918.1878	27078.762	11486.156	1656.303	2078.795	6.746
95	72784.4559	27791.361	5743.078	828.151	2194.348	7.121
100	74650.724	28503.960	0	0	2309.900	7.490

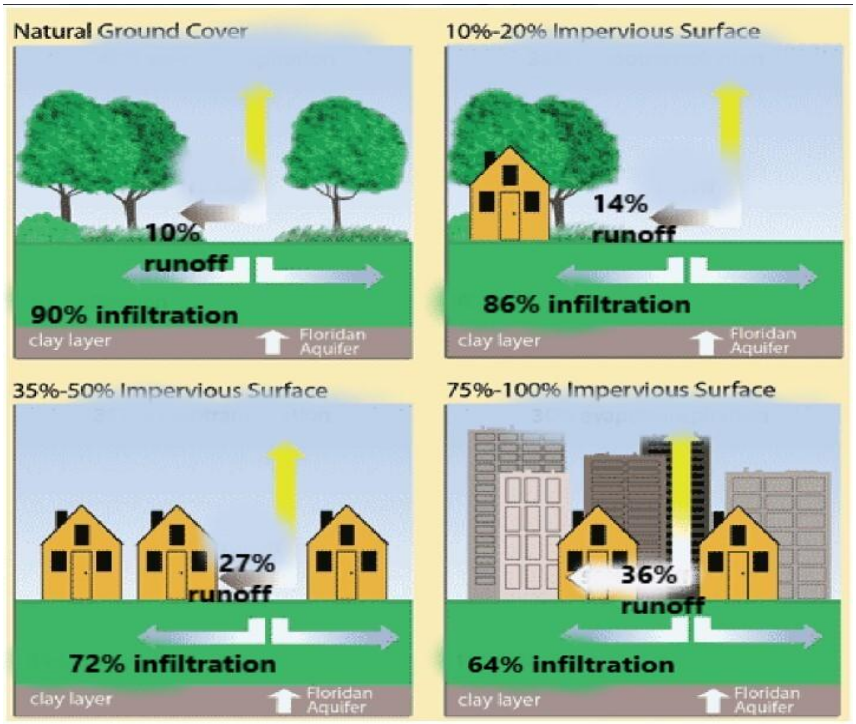

Fig.3 Relation between run off and impermeable cover of VIIT.

V. CONCLUSION

The maximum and minimum elevation s with mean sea level are 38m and 33m.The Present impermeable cover and corresponding discharges is 37325.362 m^2 and 14250.823 m^3. It is concluded that for 50% hike of impermeable cover the run off increases to 3.75%, for 75% hike of impermeable cover the run off increases to 5.621% and for 100% hike of impermeable cover the run off increases up to 7.5 %.

REFERENCES

[1]. Bedient, P.B. and Huber. W.C. (1992): Hydrology and Floodplain Analysis. Massachusetts: Addison Wesley Publishing Company

[2]. Ward, A.D and Trimble S. W. (2003): Environmental Hydrology, Second Edition. CRC Press

[3]. Arnold pacey with Adrian Cullis (1986) RAINWATER HAVERSTING,The collection of rainfall and run-off in rural areas. Intermediate Technology Publications, IT publications, UK.

[4]. Water Resources Engineering", mays L. W., Wiley India Pvt. Ltd, (2013)

[5]. Maladies water and sanitary authority; (2005);" a pilot study conducted in LAAMU ATOLL GAN"

[6]. B.C. Punmia, pande B.B. Lal, Ashok Kumar Jain, Arun Kumar Jain (2009), "Irrigation and water power engineering", 16th edition, Laxmi publication 113, Golden house, Daryaganj, New delhi-110002, India.

[7]. Shittu O.I, okareh O.T and Coker A.O;(2015), "Development of Rainwater harvesting Technology For Securing Domestic Water Supply In Ibadan, Nigeria" In International Research Journal Of Engineering Science, Technology And Innovation(IRJESTI), volume 4(1), 2015.

[8]. Agarwal, A. And Narain, S. (1997) Dying Wisdom: Rise, fall and Potential of India'sTraditional Water Harvesting Systems, Centre for Science and Environment, New Delhi.

[9]. Brar, T.S. (2002), 'Urban Planning and Development Strategies With Respect To WaterResources in Patiala', Guru Ramdass School of Planning, Guru Nanak Dev University, Amritsar

.