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Permeable Concrete for Storm Water Management and Ground Water Recharge

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Abstract

Development of smart cities in India is primary reason for increase in quantity of impervious surfaces-(surfaces which doesn't let the water to penetrate through them). These impervious surfaces include asphalt streets and highways, concrete footpaths and pavements, parking lots, and highly compressed soil surfaces. Because of these impervious surfaces the runoff produced by these surfaces cause some serious problem to the low lying areas by flooding them. Growth in population leads to the demand for water, as the surfaces water bodies are not sufficient enough to meet the need of people they go after the alternative of ground water, this result in decline in ground water levels. Permeable concrete-(the concrete structure with voids in them which allow the water to penetrate through them) is a modern and environmental friendly material which can be used in construction of pavements, footpaths, and parking lots, where the traffic loads are low. The usage of these permeable concrete structures will reduce the amount of runoff and improve ground water recharge conditions. During the work the amount of area which has been impervious in our area of study was calculated, advantages and disavatages of using permeable concrete structures in place of impervious materials are discussed.

Keywords:

Impervious;
Surface runoff ;
Ground water Recharge;
Permeable concrete;
Benefits;
Drawbacks.

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1. Introduction

There will be more opportunity for living in cities, so people migrate to cities making cities the most populated locations and this result in urbanization. Rapid urbanization creates demand for both land and water. In order to meet the land necessities of urbanization most of the vegetation coat is being substituted with the concrete building and paved streets. Water demand is a huge trouble compared to that of land. Surface waters are not sufficient to meet the requirements of the people in entire city, so people started drawing out of underground water. This leads to decline in the ground water level making it unavailable for future generations. In cities along the seashore decline in ground water level compared to sea water level creates an additional problem of salt water

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intrusion. Though the soils have recharging potential, wrapping it with impervious structures is affecting the infiltration chances of water through soils, creating more runoff and flooding problems. Permeable concrete replacinng impervious materials give the solutions to problems created. Usage of permeable concrete in construction of pavements, footpaths, and parking lots, where the traffic loads are low will reduce the amount of runoff and improve ground water recharge conditions. Permeable concrete is a concrete in which no fine aggregate is used, this generate voids or pores in concrete which helps in infiltration of water all the way through them.

2. Research Methods

In this paper the collected remote sensing data with help of ArcGIS 10.3 software is processed to find the extent of impervious surface cover in Greater Visakhapatnam Municipal Corporation (GVMC) city limits, suggest the use of permeable concrete as an alternative to increase effectiveness in storm water management and to increase the ground water infiltration area.

Four toposheets of Visakhapatnam published under guidance of Surveyor general of India in 1978 were used to create a boundary along the limits of Greater Visakhapatnam Municipal Corporation (GVMC) using ArcGIS 10.3, toposheet numbers used were 65 O/1, 65 O/2 and O/3, 65 O/5 and, 65 O/6. Data sets of Sentinal-2 were downloaded from USGS Earth Explorer website which has a spatial resolution of 10m and these data sets are processed using ArcGis 10.3 to generate false-color composite image of the GVMC region. Supervised classification was performed on false-color composite image using ArcGis 10.3 to find the extent of area covered by each different classe in the study region.

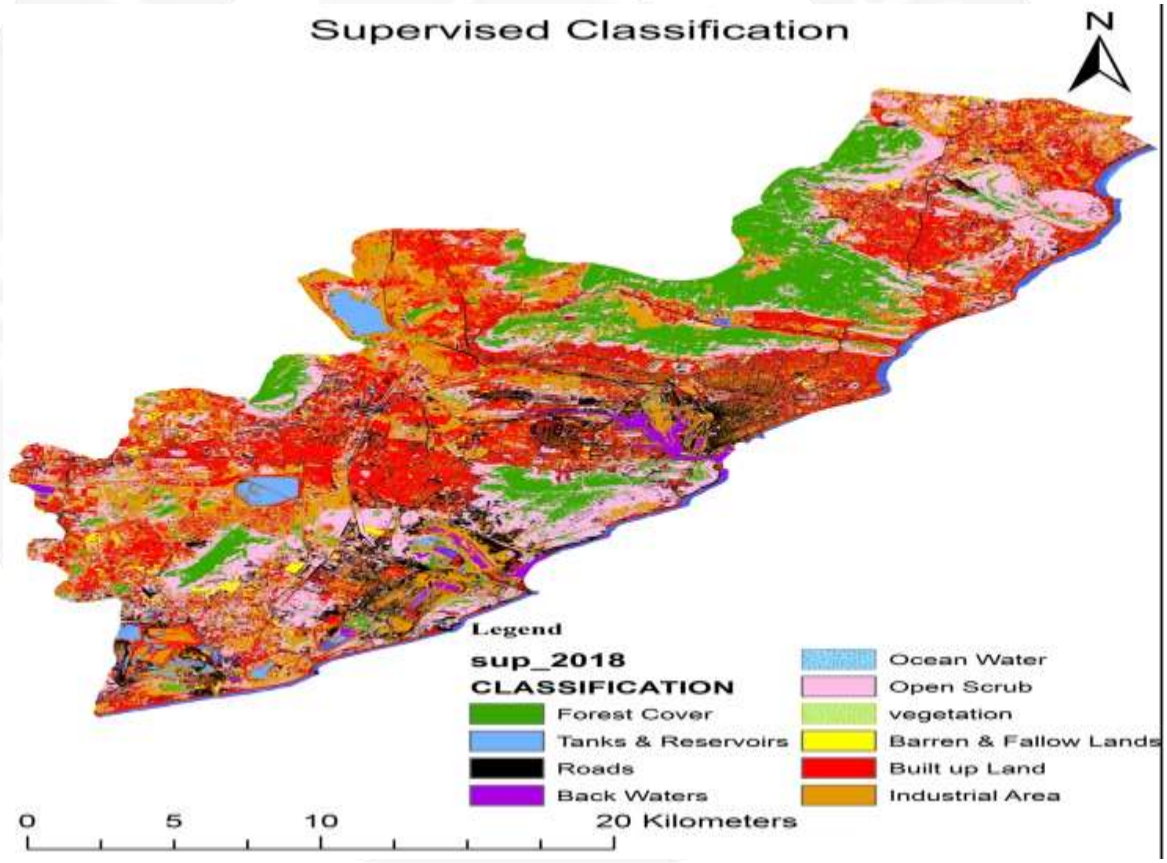

Figure 1. *Supervised classification of GVMC*

Figure-1 shows the supervised classification of the false-color composite image. Study area was classified into ten classes namely forest cover, tanks & reservoirs, roads, back waters, ocean water, open scrub, vegetation cover, barren and fallow lands, built up land and, industrial area.

The study area covers an overall area of 598.780833sq.km, the area covered under each class are shown in table-1 below.

S.No	CLASSIFICATION	AREA (Sq.km)
1	Forest Cover	78.907923
2	Tanks & Reservoirs	10.508936
3	Roads	64.953316
4	Back Waters	7.265568
5	Ocean Water	8.918387
6	Open Scrub	137.714543
7	Vegetation	87.266375
8	Barren & Fallow Lands	21.095634
9	Built up Land	146.923292
10	Industrial Area	35.226859

Table 1. *Area covered under each different classe of GVMC*

Area of each class was converted into percentage and was represented in the form of pie chart for better analysis as shown in figure-2 below.

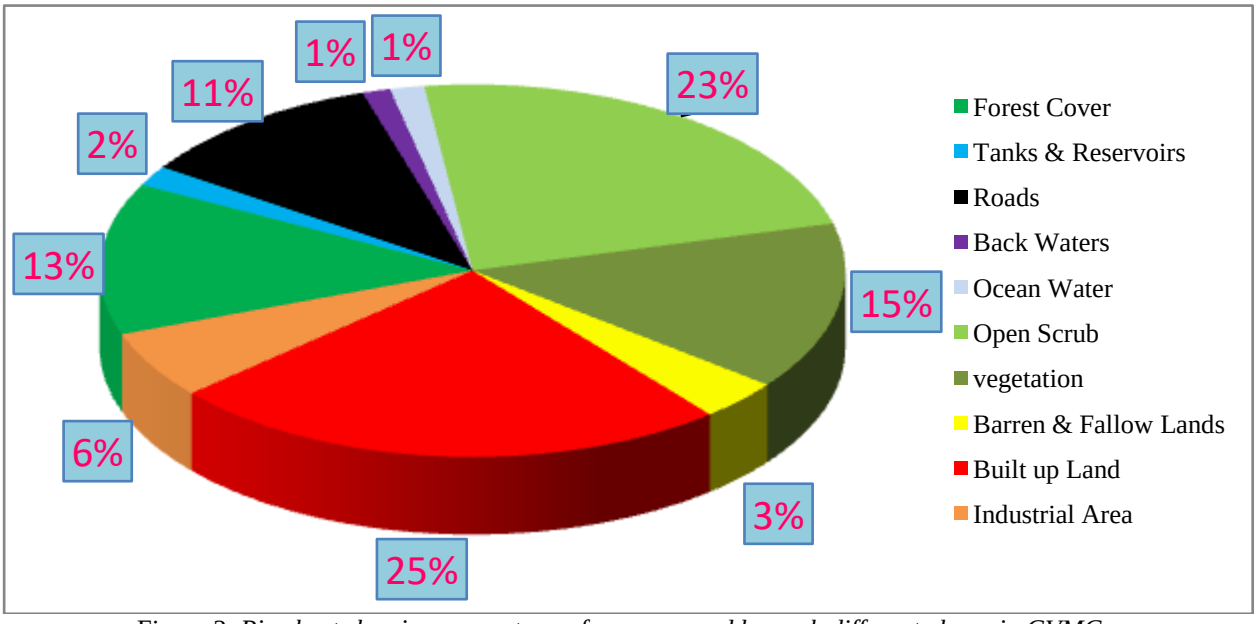

Figure 2. *Pie chart showing percentage of area covered by each different classe in GVMC*

Back waters and ocean water classes were not given importence in the study because they were neither useful for placing permeable concrete over them nor useful for ground water recharge. Classes like built up land, industrial area and, roads, are impervious regions covering 42% of the study area. Though the forest cover is about 13%, the forest cover in GVMC is mostly found on the hills where infiltration chance is very low because of the effect of slope. So the rest of the study area 43% which includes tanks and reservoirs, open scrub, vegetation and, barren and fallow lands are the left over regions where there are chances of infiltration.

Nearly 55% of the study area produce huge amount of runoff causing flood in low elevation region. The study region is along the shore and has got two problems in relation to ground water; they are decline in ground water levels and salt water intrusion. Decrease of ground water levels below the sea water levels will result in the intrusion of sea water into ground water, making the residual ground water unfit for use.

Real time information of decline in groundwater levels in the study area is shown in the table-2 below. The information is gathered from CORE Dashboard of Andhra Pradesh.

Piezometer Location and Month Wise Groundwater Levels (Meters below ground level)										
Sno	**Mandal**	**Piezometer Location (Village)**	**17-Mar**	**17-May**	**17-Nov**	**18-Feb**	**Rise(+)/Fall(-) from current water level and with reference to**			
							17-Mar	**17-May**	**17-Nov**	**18-Feb**
1	Gajuwaka	Visakhapatnam (Gollalapalem)	5.015	5.53	4.472	4.999	-0.302	0.213	-0.845	-0.318
2	Gajuwaka	Visakhapatnam (Kanithi Colony)	6.583	7.707	6.731	8.703	-2.531	-1.407	-2.383	-0.411
3	Gajuwaka	Visakhapatnam (Bhpv)	3.92	4.455	3.524	4.31	-0.456	0.079	-0.852	-0.066
4	Pedagantyada	Visakhapatnam (Steel Plant)	5.109	5.459	5.614	6.483	-1.78	-1.43	-1.275	-0.406
5	Pedagantyada	Palavalasa	2.142	2.07	0.98	1.852	-0.753	-0.825	-1.915	-1.043
6	Pendurthi	Narava	3.46	4.038	1.879	3.694	-0.541	0.037	-2.122	-0.307
7	Pendurthi	Pendurthi	10.578	11.704	8.369	11.618	-1.654	-0.528	-3.863	-0.614
8	Vsp Rural	Visakhapatnam (Gopalapatnam)	8.418	9.326	5.772	9.589	-2.247	-1.339	-4.893	-1.076
9	Vsp Urban	Visakhapatnam (Sivajipalem)	11.226	13.765	11.858	13.975	-5.237	-2.698	-4.605	-2.488
10	Vsp Urban	Visakhapatnam (Apsidc)	4.342	4.911	4.877	5.193	-1.122	-0.553	-0.587	-0.271
11	Vsp Urban	Visakhapatnam (Ysr Park)	14.327	15.47	14.28	16.825	-2.879	-1.736	-2.926	-0.381

Table 2. *Groundwater levels variation in the study area*

Rise or fall from the current waterl level column shows the values almost with the '-'Sign, this clearly indicate the trend of decline of groundwater in the study area. This is not a good sign; a possible solution should be identified to this problem. Use of permeable concrete will be a superior solution.

Permeable concrete is an amalgamation of cement, water and coarse aggregate. No fine aggregate will be used, so these are also known as no fines concrete. As the coarse aggregate size ranges about 10 to 20 mm they give opportunity for the formation of pores in the concrete. These pores in permeable concrete allow the infiltration of water through them. At the same time lack of fine aggregate makes the concrete weak in compression making the concrete unfit to tolerate heavy loads.

Benefits of permeable concrete

Use of permeable concrete decreases the load on storm water system by reducing quantity of runoff formed during storms; thereby prevent the problems like water logging and floods. Allowing water to infiltrate through them into soils help in ground water recharging which help in balancing the dug up ground water. Loss of water from the region can be prevented by use of these permeable concrete. These are environmental friendly and economical too.

Drawbacks of permeable concrete

The main drawback of permeable concrete is strength; they are weak in strength compared to normal concrete and cannot bear any heavy loads. The other shortcoming is blockage of pores in permeable concrete.

3. Results andAnalysis

55% of the study area soil is almost impervious which has very low chances of allowing water to infiltrate and high chances of producing huge amount of runoff. Further development in the GVMC area covering the vegetation

may cause serious problems in managing the storm waters. Also excessive extraction of groundwater without recharging it may lead to water scarcity and salt water intrusion problems.

Recommandations

Use of permeable concrete in location where there will be low traffic loads like footpaths, parking lots and pavements will surely solve the problem of storm water management and helps in groundwater recharge. To have good possibility of groundwater recharge the permeable concrete coating should be positioned over the original layer of soils, because top soils are mostly covered with dust or waste which may decrease the recharging capabilities of soil.

4. Conclusion

In the process of expansion of cities, to cope up with the demand for land and water by eliminating the problems like storm water management and groundwater depletion, the use of permeable concrete is a good alternative. In areas about to be developed the use permeable concrete in location where there will be low traffic loads like footpaths, parking lots and pavements will surely eliminate the future problems. Even in the developed portions of the cities replacement of footpaths with permeable concrete will be more fruitful.

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