HYDROLOGICAL STUDY FOR THE REHABILITATION OF CHETPET TANK IN CHENNAI

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ABSTRACT

An attempt is made to study the hydrology of Chetpet tank located in Chennai and to recommend designs for rehabilitation. A topographical survey was carried out to study the Cooum river influence. The level difference between the Chetpet tank and Cooum river bed is 5.025 m, which is safe depth upto which the pond can be excavated preventing Cooum river water seepage. The catchment area and existing capacity of the tank was surveyed. Runoff was estimated by SCS method using 22 years of rainfall data, which yields 0.28275 Mm^3 of runoff. Soil samples were collected and tested to obtain the permeability factor for the analysis of recharge mechanism. The proposed pond depth is 3.4 m upto the layer of sandy-clay with gravel with a recharge rate of 71.594 m^3/day. It is suggested to provide 8 numbers of recharge trenches cum shaft for enhancing the recharge rate. The proposed pond, after the rehabilitation will be having the recharge rate as 481.76 m^3/day, which is 6.73 times higher.

INTRODUCTION

India has more than 250 million city – dwellers even though the rate of urbanisation is among the lowest in the world. In most of the cities, the water availability is faced with a number of problems and constraints. The reduced recharge, increase in demand, more extraction of ground water, etc. lead to depletion of ground water level. This causes water problems in quantity and quality aspects, often to unsustainable levels. In urban areas, reduction in pervious surface and conversion of water bodies to built-up areas reduce natural recharge and surface storages, which leads to the draining of rain water as a waste. A simple answer to this problem is to capture and store large quantities of rain water, either during the monsoon or through short intermittent spells as surface water or ground water. The surface storages could be used for any use, if the volume is larger. Otherwise, the stored water will only be evaporating. These could be converted as percolation ponds. Percolation ponds are small storage earthen structures usually constructed across natural watercourse to retain the rainwater for a longer time thereby recharging the ground water. It has neither sluice nor direct command. These ponds help to improve the water table in the vicinity and facilitate the development of ground water.

When tank rehabilitations are attempted, most of the times, the tank is desilted to increase the storage capacity without the botheration of any attempt on the source of water and the means by which the water could be harnessed towards the tank through supply channels. The sufficiency of the catchment area also plays a vital role in this. The rehabilitation will be sustainable if the implementations are backed by a hydrological study of any tank. An attempt is made in this study, to find the way of rehabilitation of an urban tank through rainwater

harvesting, to investigate the possibilities of converting tank into a percolation pond and to study the effectiveness.

DETAILS OF STUDY AREA

Most river courses within Chennai city have became drains for sewage and industrial effluents, causing pollution of surface and subsurface water. There is an overall shortage of water for drinking and domestic in Chennai city. The city receives an annual average of rainfall of 1200 mm; it often faces acute water shortages. The city water supply is depending on the storages of Red hills, Cholavaram, Poondi and Chembarambakkam reservoirs. There had been 73 tanks within Chennai city limits. Many of these have disappeared and others have shrunk in areas. The Chetpet tank, located in the heart of the city is the area of study. The longitude is 80° 15' 00" N and latitude is 13° 03' 15" E. The location of study area is presented in Figure 1. The Chetpet tank was established as tank in early 1930. It is rainfed and receives storm water from the adjoining areas through the storm water inlets. The inlets are in deteriorated condition and the sewerage disposal also habituated. River Cooum is the one of the most polluted river in India, which is converted as the dumping yard for the urban pollutants, is flowing 643 m away from the Chetpet tank.

The annual rainfall of the study area is 1205 mm, within which 80% comes from Northeast and Southwest monsoons, 14% from winter and 6% from summer. The hottest and driest part of the year is April –May when the temperature is as high as 40° C. Humidity ranges from 65 to 80% and average monthly evaporation rate is 156 mm. The general soil type of Chetpet tank is sandy clay.

ENGINEERING SURVEY AND LITHOLOGY

An engineering survey was conducted with the help of a Digital Theodolite and EDM in order to delineate the catchment area, contours and to estimate the present capacity of tank. Also, a survey was conducted to locate the Cooum River and its' bed level. The reference level from the Chetpet railway station has been considered as benchmark. The contour map of Chetpet tank is presented in Figure 2. For the purpose of determining the lithology under the tank bed area, trial pits were undertaken to collect soil samples at different depths. The samples were analysed through sieve analysis for soil classification and permeability in the Geotechnical laboratory of Public works Department. The determined soil lithology is presented in Figure 3.

G.L			G.L
	Clay,sandy	6m	
	Clay sandy with gravel	4.6m	
	Sand	4.6m	
	Clay, sandy	1.56m	
	Sand	2.04m	
	Clay	5.2m	
	Sand	2.4m	
	Sand with clay shale	0.6m	

Figure 3 Soil Lithology

SUMMARY OF SURVEY WORKS

Chetpet railway station level	:	+6.900m (M.S.L)
Highest elevation on Gurusamy bridge	:	+12.345 m
Proposed Weir level in side the tank	:	+ 6.010 m
Deepest bed level of the tank	:	+ 3.790 m
Level at Cooum bridge deck slab	:	+ 7.365 m
Cooum River bed level	:	- 2.735 m
Distance between Chetpet tank and Cooum	:	645 m
Deepest bed level of the tank	:	(+)3.790 m
Bed level of Cooum River	:	(-)2.735 m
Difference of level	:	6.525 m
Maximum depth of Cooum River	:	1.500 m
The level difference between tank and river	:	5.025 m

INFILTRATION TEST AND RUNOFF ESTIMATION

The infiltration test was conducted at three locations within the tank water spread area, using a double ring infiltrometer, to evaluate the infiltration rate. The assessment of surface water potential of the study area is done using SCS method for the rainfall data collected from Nungambakkam IMD raingauge station. The daily rainfall for the period from 1980 to 2001 has been analysed and found that the average annual runoff arrived as 0.28275 M m^3. The maximum and minimum annual runoff computed were 0.5668 M m^3 in 1996 and 0.1344 M m^3 in 1982 respectively. Frequency analysis was carried out using Weibul's method to determine

the 50%, 75% and 90% dependable runoff yields of the catchment. These values are presented in Table 1.

Table 1Result of rainfall and probability yield

Sl. No.	Probability %	Rainfall mm	Yield (Mm^3)
1	90	920.35	0.1584
2	75	1145.8	0.1806
3	50	1423.3	0.2944

DESIGN OF POND

The 75% dependable surface runoff to the tank is 0.1806 Mm^3, which is taken as the design runoff. The pond capacity was analysed for various depths at which it can hold the maximum design runoff as presented in Table2. The depth is determined as 3.4 m at which the pond can hold the capacity of water about 176976.90 m^3. The pond's effective water spread area is reduced to 52,800 m^2 from its original water spread area of 75,078 m^2. The level difference between Chetpet tank bed to Cooum River water level is arrived as 5.025 m. It indicates that the Chetpet tank could be excavated upto 4.525 m in order to convert the tank into percolation pond. This will prevent the seepage from Cooum river.

Table 2 Capacity of pond for various depths

Depth (m)	Area (m^2)	Volume (m^3)
0.85	198.94	45767.35
1.70	399.33	87852.60
2.55	601.16	132255.75
3.40	804.44	176976.80

ESTIMATION OF RECHARGE RATE OF PROPOSED PERCOLATION POND

The recharge rate is derived from the Darcy's formula ; $Q = kiA$
Permeability (k) for Sandy clay with gravel type soil = $1.44*10^{-3}$ m / day
The recharge rate = $1.44*10^{-3} * 49718.24 = 71.594$ m / day.
If the pond is excavated to 3.4 m upto the sandy-clay with gravel layer, which is not favorable for the effective recharge of 71.594 m /day. Hence, it is suggested to provide recharge shafts inside the pond area to increase the recharge rate.

DESIGN OF RECHARGE TRENCH WITH SHAFTS

The general soil type in the Chetpet tank area is sandy clay loam, which has low recharge rate. The construction of recharge trench with shafts will increase the recharge rate. The designed trench with shafts is presented in Figure 4. Recharge size is 5m x 2m and depth of 1.5m. The shafts are bore hole of 150 mm diameter to a depth of 30m, from the bed of recharge trenches. The shaft will be fastening through two sandy layers, one layer at 19.8 m depth and other at 27.4m. According to Darcy's law, the recharge rate of one recharge trench with shafts is computed as 60.22 m^3/day (first sand layer is 27.68 m^3/day and second is 32.54 m^3/day). It is suggested to provide eight number of recharge trench with shafts inside the bed of tank to increase the recharge rate , which is worked out as 481.76 m^3/day.

CONCLUSIONS

The level difference between Chetpet tank bed to the Cooum water level is 5.025m, which is lower from tank bed. Hence, the Cooum River water will not seepage towards the Chetpet tank. The Chetpet tank can be excavated to a safer depth of 3.40 m from the existing condition in order to convert to percolation pond. The pond capacity was analysed for various depths and concluded that the depth of 3.40m can hold the quantum of 176976.80 m^3. The proposed pond depth of 3.40m upto the layer of clay with gravel , which is not favourable for effective recharge as the recharge rate is 71.594 m^3/day. The construction of 8 number of recharge trench with shafts will increase the recharge rate from 71.594 m^3/ day to 481.76v m^3/ day , which is 6.73 times higher than the present condition. Construction of surplus weir of 1.5m height for a length 600m at down stream side is necessary.

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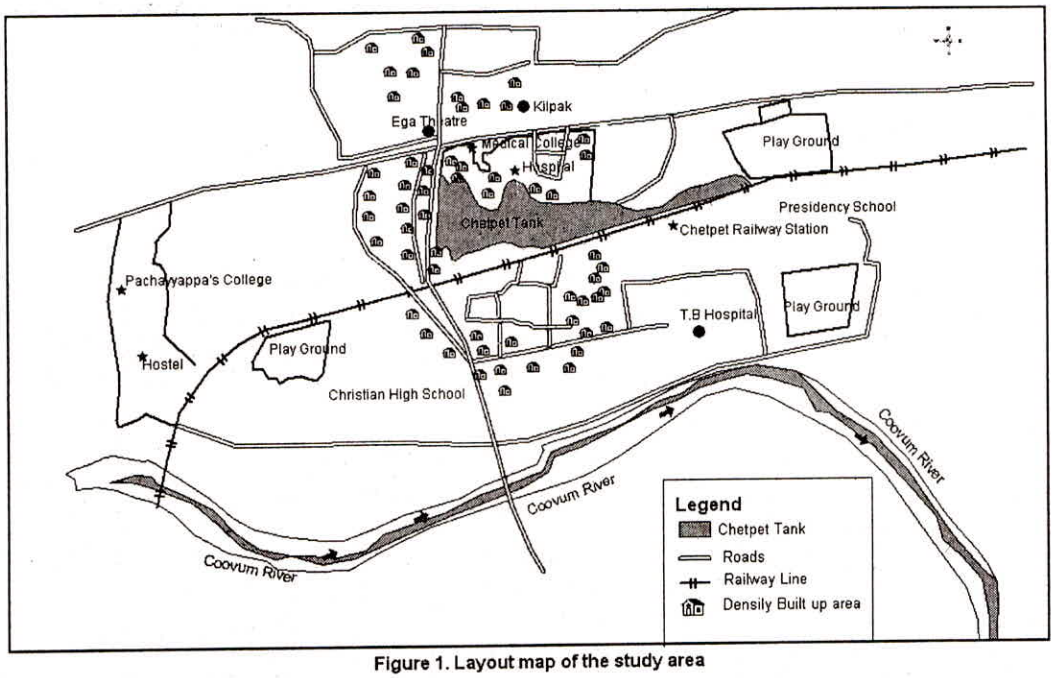

Figure 1. Layout map of the study area

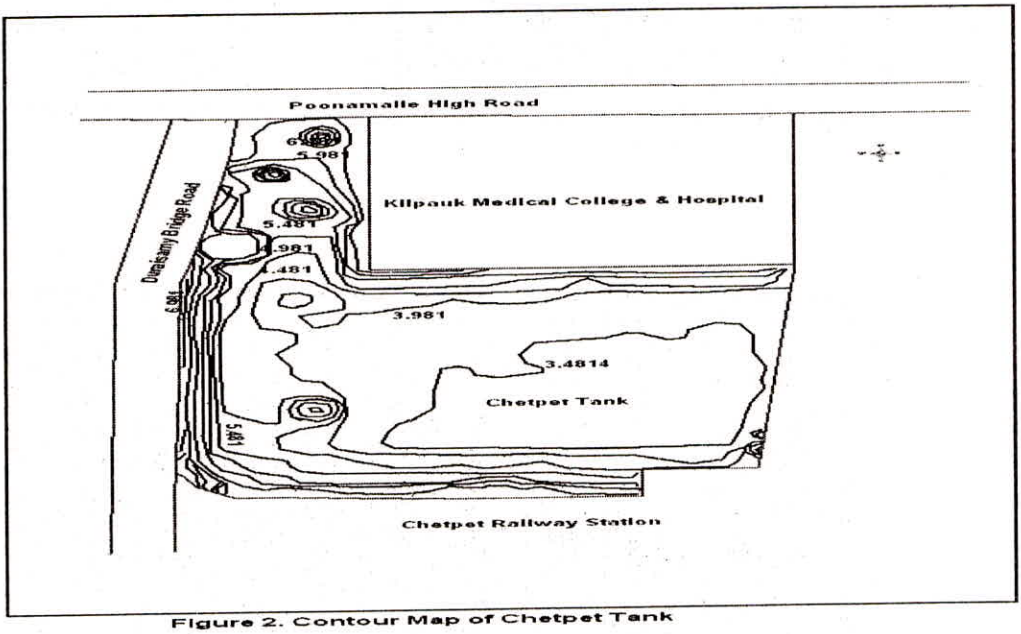

Figure 2. Contour Map of Chetpet Tank

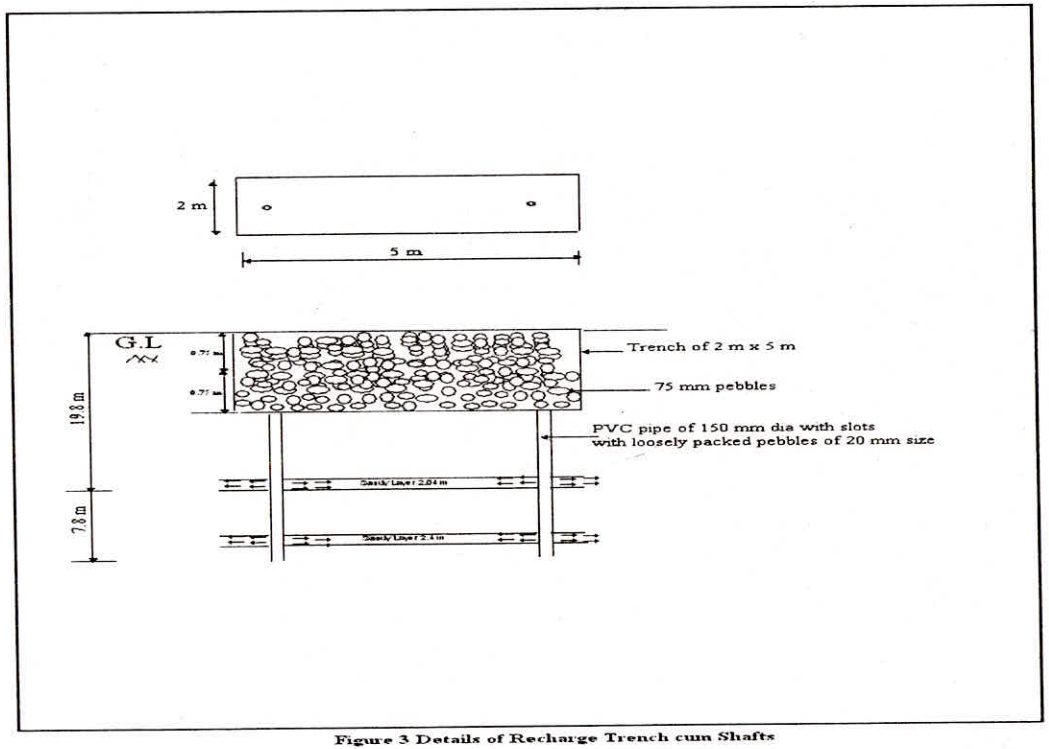

Figure 3 Details of Recharge Trench cum Shafts