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The temple tanks of Madras, India: rehabilitation of an ancient technique for multipurpose water storage

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Abstract: There are 39 temple tanks in the city of Madras, most of which have been dry for the past one decade due to rapid urbanization and continuous withdrawal of groundwater. Out 39 temple tanks one tank belongs to Mylapore Temple which is within Madras city and second one belongs to Thirupporur Temple which is out of city have been selected to compare the status of the temple tanks. Thirupporur Tank has been taken to find the reason for having water throughout the year. Then the Mylapore tank (within the city) has been taken and studied in detail. The study found the reason for the dryness of urban tanks. It also revealed the methods to rehabilitate and thus to re-establish the hydrological role and possible multiple use of the tanks. The study analysed both the quantity and quality aspects of the tanks.

Keywords: Temple tanks, rainwater harvesting, groundwater recharge, SCS method & public participation.

Introduction

In India, traditionally settlements are located in and around temples. The temple complex includes a tank which is as an important site for cultural actions and the temples and tanks are inseparable. Temple tanks occupy a prime position in the day to day living of the people. For instance in Kancheepuram, there are seven temple tanks corresponding to the days of the week and each tank has its own significance (Cox, 1894). They are still places of socio-religious and cultural activity. These temple tanks are located in the very centre of the village and are the repository of age old rituals. Further the temple tanks are also used for Float Festivals every year. These are normally held on a full moon day, and are celebrated at the end of the monsoon. If the locality falls in the influence of the south west monsoon, the festival is celebrated in July and August. In regions, which get rain from the north east monsoon it is celebrated during January and February. The people celebrate this festival to thank the Almighty for giving sufficient rain. The festival creates awareness among people regarding the need to store rainwater. It can be simply summarised that the temple tanks are meeting places of the social and ritual activities. Thus, temple tanks need to be properly maintained to provide a sublime atmosphere.

Apart from the sanctity attached to them, the tanks help to recharge the wells in and around the area. That was one of the reasons for the ancient rulers to allot funds for their maintenance. In India the word "tank" normally refers to a dug-out reservoir which has steps on all sides reaching down to the water. The best examples of such tanks are called kulam in South India. Traditionally, where the rainfall was relatively low, every effort was made to retain all the water that fell on the ground through appropriate water retention and conservation strategies such as at the *erys*, temple tanks and ponds. Traditionally, temple tanks seem to have played three hydraulic roles:

- as a storage, which acted as insurance against low rainfall periods and also recharges groundwater in the surrounding area,
- as a flood control measure, preventing soil erosion and wastage of runoff waters during the period of heavy rainfall, and
- as a device which was crucial to the overall eco-system.

In south India at least one tank is attached to every temple. In Madras city alone, there are 39 temple tanks. The surface area of tanks varies from half an acre to seven acres (2000 m^2 to 30,000 m^2). Most of the temple tanks have been dry during recent decades due to urbanization, continuous withdrawal of groundwater and blockage of inlet systems. Most of the temple tanks were served by inlet systems in the olden days. In recent years, due to mushrooming of commercial and residential apartments in the catchment areas, the inlet systems are totally blocked and precious rainwater runs into sewers and reaches the sea (Cudworth & Bottorf, 1969). Over-extraction of groundwater has occurred due to population growth in the tanks' catchment areas. Groundwater recharge has been reduced due to the increase in impervious surface from asphalting or concreting of roads and backyards. This has led to a lowering of the water table surface and has caused failures in groundwater wells.

A study has been made to evaluate appropriate strategies to conserve the rainwater in the existing urban temple tanks. It also deals with the recharging capacity of the tanks, effects of the surrounding land use pattern and water inlet systems. This includes studying the runoff characteristics of the catchment areas of temple tanks and suggesting methods to improve their storage potential.

Structural features in temple tanks

Temple tanks are either square or rectangular in plan, and are truncated trapezoidal in section, being staggered from top to bottom as shown in Fig. 1. Often, temples have two tanks: one inside and the other outside the temple building. Granite slabs are used for constructing the steps on all sides. Normally, each step has a tread of one foot and a rise of half a foot (GOI, 1961). At every tenth step there is a landing of two foot width, having the same rise of half a foot as shown in Fig. 1. This gives stability to the structure.

In Madras (now Chennai) the major inlets are usually placed in the south west or the north west corner of the tank as shown in Fig. 2. The land slopes from west to east. The major inlet is connected to its own catchment area or another water resource through storm drains. Apart from this inlet there are a few other slots like inlets on all sides of the tank. These help to link the water table and the tank laterally. Most of the temple tanks also have an inlet from the temple area. It has been observed from the original layout of tanks in Madras City, there was series of inter linkages among the tanks to allow excess flow of water to decant into the neighbouring tank. This design provided for both inlet and outlet drainage. There is a structure known as a Neerazhi Mandapam situated in the centre of the tank. The main purpose is to house the deity during the Float Festival. It is constructed with granite stone (Fig. 1).

Most of the tanks are having wells in their bed. Their presence is relevant in the present context and one can visualize a certain functional role for them. The wells link the aquifer and tanks and are supposed to serve for natural recharge. Wells in the tank are shown in Fig. 3. Thus the design of the temple tanks is ideal from the point of view of harvesting, storing rainwater and recharges the aquifer.

Study area: Mylapore tank

After a preliminary survey of the temple tanks in Madras city, the Mylapore Tank has been selected for the case study. This tank serves as storage for rainwater from the surrounding urban landscape and also as a recharging medium for groundwater within a radius of 500 metres. To estimate the yield from the catchment area, the Soil Conservation Service Curve Number Technique was used. This tank belongs to Sri Kapaleeswarer Temple at Mylapore which is situated in the heavily urbanized and densely populated area of the city. It is said to be 330 years old. The Fig.4 shows the location of the present study area and Fig. 5 gives the plan of the Mylapore Tank. In ancient times the temple and tank were surrounded by coconut groves. The entire average rainfall of 1200 mm soaked into the soil and flowed into the tank. The piezometric level then was only 1 metre to 2 metres below the ground level. The present urban development of the Mylapore area, namely Mandaveli, Mandavelibakkam, Alamelumangapuram, Ammaniammal Street, Narayana Swamy Garden, Abiramapuram, R.A. Puram, were non-existing. Now, the groundwater depth is 10 metres or more below ground surface. In 1991 groundwater withdrawal in this area was estimated to be in the order of 10,000 m^3 per day.

The geology in the locality comprises alternate layers of coastal alluvial sand and clay of recent formation, deposited over a bed of Archean rock. The Adyar river and Buckingham canal are drainage channels 10 metres to 12 metres below the ground level. At this depth there is a potable water bearing zone. Below 15 metres the groundwater becomes brackish. Areal photographic survey of the Mylapore-Mandaveli locality shows that the built-up area occupies about 90 percent and open space occupies some 10 percent. The soil group of the open space is classified under Group 'B' known as sandy loam. The slope of the paved area from north to south of the tank is 1:1875 over a distance of 750 metres. The natural catchment of the Mylapore Tank is intercepted by the Buckingham canal, constructed in 1901. This reduces the original catchment area and also takes away rainwater to the sea. The canal also intercepts subsurface flow towards the tank. The main catchment area of the tank today is a Higher Secondary School and its playground. It covers nearly 51,000 m^2. This area helps to provide nearly 1 metre of water to the tank. But the runoff from this area was blocked by an unauthorized shopping complex constructed over the storm drain leading to the tank. This blockage of storm drains was removed in 1972 through a tank renovation project.

Problem inventory of the Mylapore tank

In 1974, rainfall in Madras city, was 900 mm which was below the normal value. Hence, the tank did not get sufficient water. The authorities felt that silting of the tank over the years had blocked springs supplying the tank and that the blockage would be removed if the tank could be de-silted. By 1975, the time they could start de-silting the tank, there was a heavy rainfall of 1500 mm and the tank was filled. So the idea of de-silting the tank was given up. Each year until 1987 there was enough water in the tank for celebrating the Float Festival. (Murthy,1991)

In April 1987, the Tamil Nadu Construction Corporation started de-silting work, and removed 1.5 metres of alluvial soil that lay over the sandy bed. This work was completed in December 1988. From that date the tank completely lost its retaining capacity, and no water stood in the tank for celebrating the Float Festival. But it was observed that the water level in the adjoining wells improved very quickly during the rainy season. For example, though there was exceptionally heavy rainfall, of 180 mm in one day, on 4^{th} June 1991, no water was found in the tank the next morning. This state of affairs continued till June 1992. By then, the authorities had begun to feel that the tank required some arrangements to retain water.

Strategies for improvement of tank hydraulics

The strategies for improving tank hydraulics concentrated on forcing water storage and on observing water quality.

Concreting the tank bed: Accordingly, the tank beds of the Madurai Meenakshi Temple, Thiruvallur Veeraragava Swami Temple and Triplicane Parthasarathy Temple (Fig. 6) were concreted (Ramji Satyaji Rao, 1992). But this approach was not appreciated by the public. Our fore-fathers, who could excavate such large tanks and construct the steps with neatly dressed granite slabs, should have had some reason for not paving the tank beds with granite slabs. The purpose of the temple tanks is not only the retention of water for celebrating the Float Festival, but also includes some larger purpose. As already explained, the temple tanks actually served two major purposes: the first being to recharge the surrounding aquifers by allowing water percolation, and the other being to retain water for social and cultural activities. Further, the natural tank bed permitted the growth of water plants such as lotus and lily, and water creatures such as fish and frogs. The Executive officers of the Triplicane Parthasarathy temple and Madurai Meenakshi temple concluded that concreting the tank bed would arrest the percolation of water.

The drawbacks of concreting the tank bed are:

- during the rainy seasons when the tank receives a copious flow of runoff water, concreting the bed of the tank will prevent the natural replenishing and build-up of groundwater resources,
- with very little natural circulation the stagnant water will deteriorate in quality. Stagnant water carries less oxygen and hence becomes less pure. Perhaps this explains why the sastras also insist that water should be in active contact with the land,
- reduced oxygen levels due to stagnancy, together with the great warming of water during summer, will render the tank an ecologically impossible habitation for fish populations,
- algal blooms are widely noticed in tanks with cement flooring.

Lining the tank bed with clay: To avoid the draw-backs of concreting, an alternate method of flooring with clay was suggested. The clue for this method was inspired from the famous PORAMAMULLA ERY Inscriptions of 1291 A.D. (Poramamulla is situated in Cuddapah District in the state Andhrapradesh). One of the important criteria for locating the site is that the ground should be adorned with good clay. This method was tried at the small Madhava Perumal Temple tank.

Sri Madhava Perumal temple tank is situated within the premises of Sri Madhava Perumal temple in Thyagarajapuram near Mylapore tank (Fig. 7). This tank has an area of 480 m^2. As stated earlier, this tank could not retain any water before its renovation. Renovation commenced in June 1990. The tank bed was covered with puddle clay to a depth of one foot. Over this, half a foot depth of silt sand was laid. A bore was sunk at the centre of the tank. Water pumped from this bore was used to fill the tank to a height of two meters yielded about 13 m^3 per hour. Daily evaporation from the tank is compensated by pumping water from the bore for one hour daily. The open well situated at the centre of the tank is closed with a concrete slab during summer seasons and is opened during rainy seasons.

An expert committee appointed by the Government of Tamil Nadu, to suggest methods for retaining water in the Mylapore Tank, has recommended the method of covering the tank bed with puddle clay to a depth of two feet with a thin layer of sand over it. This was accepted by the government and the work was executed in July and August, 1992. After this, the tank became capable of retaining the water. However, the neighbouring community complained that there is no rise in water level in their wells, though the tank is full. This made us realize that covering the tank bed with puddle clay was not advisable since it does not serve the purpose of recharging the surrounding aquifer.

There are 39,000 *Erys* in Tamil Nadu used for storing water for irrigation. They occupy areas varying from 30 m^2 to 1 km^2. They are capable of both retaining water and recharging the surrounding aquifer. A study of these *Erys*, revealed that their beds are covered with alluvial soil. This made us realize that the temple tanks can serve their twin purposes of retaining water and recharging the surrounding aquifer if their beds are covered with alluvial soil. Temple tanks accumulated alluvial soil at their beds when they obtained their water supply from free catchment areas as the *Erys* do (GOI, 1871 & 1873). Fortunately, the temple tanks which were not renovated have not lost their alluvial soil. If the blockages of their inlet systems are cleared, they will get enough water and the alluvial soil bed will help them to retain water as well as to recharge the surrounding aquifer. The temple tanks which were renovated have lost their alluvial soil bed. The remedy lies in filling their beds with alluvial soils transported from the *Ery* beds.

Water Quality: Water samples were collected from the Sri Parthasarathy (Fig. 6), Mylapore and Sri Kandaswamy temple tanks. The quality of water was evaluated for a "limited human exposure" category because the temple tanks are intended to serve only as a water conservation pond apart from their traditional function as a place where the Float Festival is conducted. The age old practice of using these tanks for bathing and washing of clothes no longer arises, as they have surrounded by the development of commercial activities. Table 1 gives details about the measured water quality in the tanks. It also shows that the water quality is suitable for the intended present purpose.

Enhancement of Water Potential

As mentioned earlier, the Mylapore Tank was served by a storm water drainage system in ancient times. All the inlets serving the Mylapore Tank are now blocked and destroyed. A survey of the entire area was conducted with the help of a digital theodolite to find out its original catchment area and the reduced levels of the locality. It was found that the High School ground, Ramakrishna Mutt Road and Venkateswara Agragaram Street are the main catchment of the tank. This area covers 140,000 m^2 which is not sufficient to fill the tank full. In the above area storm drains are available. But to fill the tank to its full capacity, an additional area of about 400,000 m^2 and new storm drains would be needed. This area was identified and surveyed from Cutchery Road to Mandaveli Road. For this additional area new storm drains should be constructed and connected to the Mylapore tank.

SCS Rainfall-Runoff Model: In the above mentioned study area a rainfall-runoff analysis was made using the Soil Conservation Service (SCS) Curve Number Technique (Mc Cuen, 1982). The technique is used to estimate runoff from the suburban and urban catchment. The SCS runoff equation is given below (SCS 1985 & 1986):

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

where

$$S = \frac{25400}{CN} - 254(\text{mm})$$

Q = actual runoff (mm)

P = rainfall (P>Q) (mm)

S = potential maximum retention after runoff begins (mm)

CN = curve number, which depends on hydrologic soil group, land use pattern and treatment, hydrologic condition and antecedent moisture conditions.

Rainfall-Runoff Analysis: A rainfall-runoff analysis (Warren Viessman *et al*., 1977) was undertaken for Mylapore tank in 1992 considering two different areas:

existing catchment - 140,000 m^2

proposed catchment - 520,000 m^2.

Runoff from the existing catchment area, as well as the additional area, are shown in Table 2; Fig. 8-9.

Storage capacity of the tank: 115,000 m^3

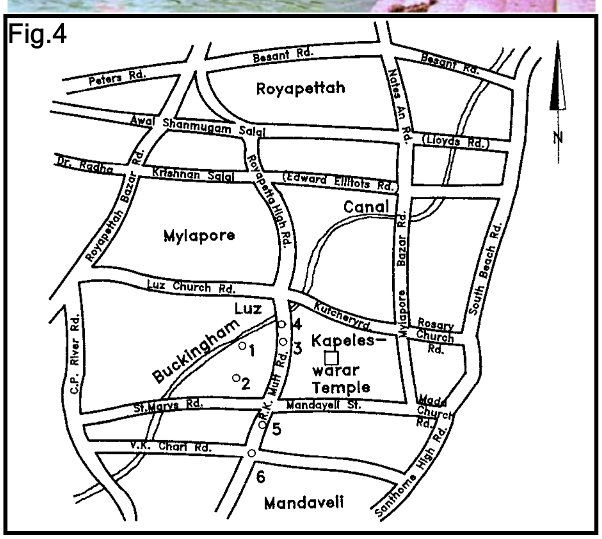
Total rainfall of the year: 1,015 mm

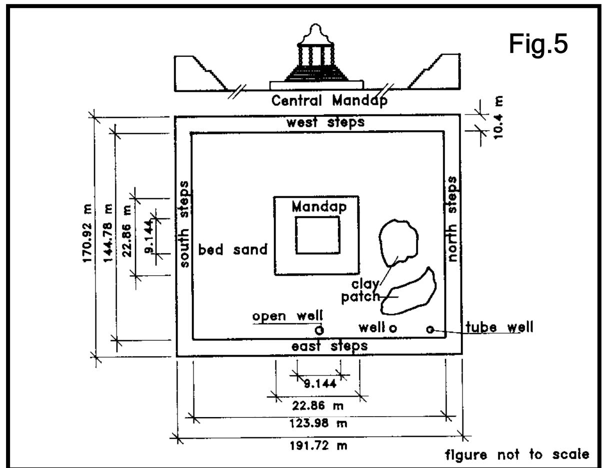
Depth of the tank: 4.72 m (15.5 feet)

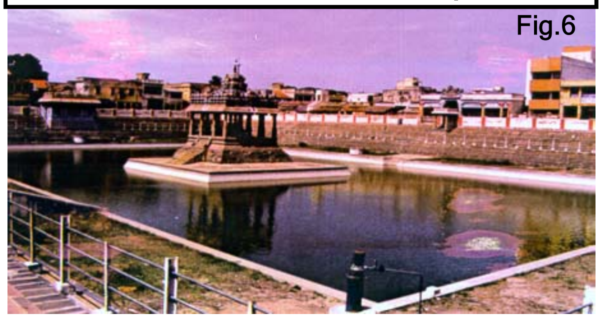
The existing catchment area of 140,000 m^2 can bring 2.5 metres of water on an average rainfall year as shown in Fig. 10. This 2.5 metres of water is not sufficient to meet the annual evaporation and percolation losses. The Mylapore tank can be filled to its full capacity only when about 520,000 m^2 catchment area is connected through a system of storm drains, during the monsoon. With expected evaporation and percolation loss of 2.6 metres, only 2 metres of water remains in the tank for direct use at the beginning of the next monsoon.

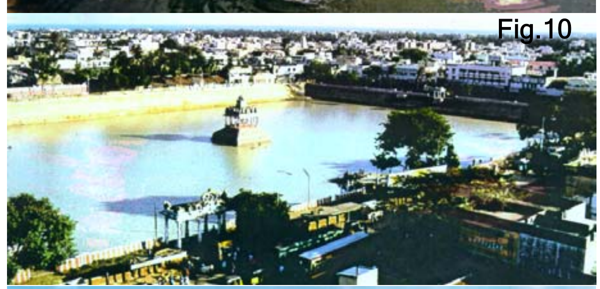
Public Involvement and Implementation

The recent experience of drought and scarcity of drinking water in Madras have made people to realize the importance of the rainwater harvesting and conservation. The urgent need to recharge the groundwater and the role of tanks in recharge has now been recognized. The various agencies such as Public Works Department, Madras Metropolitan Water Supply and Sewerage Board, and the Madras Metropolitan Development Authority, have disseminated information on rainwater harvesting, conservation and recharging of groundwater to improve the drinking water situation of the city. The bitter lesson learnt by the people themselves due to shortage of drinking water has made them more responsive to the efforts taken by various Government and Non-Government agencies.









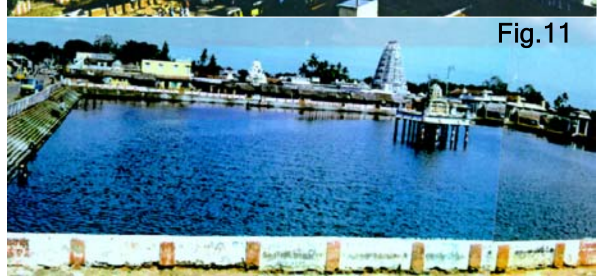


Fig.1.Various features of temple tank including Neerazhi Mandapam; Fig. 2. View of the major inlet situated in the south west corner of the Mylapore temple tank; Fig. 3.View of well inside the tank; Fig. 4.Location of the study area- Mylapore; Fig.5.Plan & section of the Mylapore tank; Fig. 6. View of concrete bed at Sri Parthasarathy temple tank; Fig.7.Sri Madhava Perumal temple tank, Mylapore; Fig. 10.View of Mylapore tank after renovation- 1992; Fig.11.View of Thirupporur temple tank.

Some successful examples of temple tank renovation such as at Madhava Perumal temple, have created much interest. In this particular case, finance for tank renovation also came through contributions from residents of the area. Similar successful renovations are being carried out in other temple tanks, the latest one being the Maruntheeswarer Temple tank. The work was carried out by the Rotary Club of Madras and the finance was fully met by them. The work was completed in December 1993 and it has been handed over to the public for carrying out maintenance.

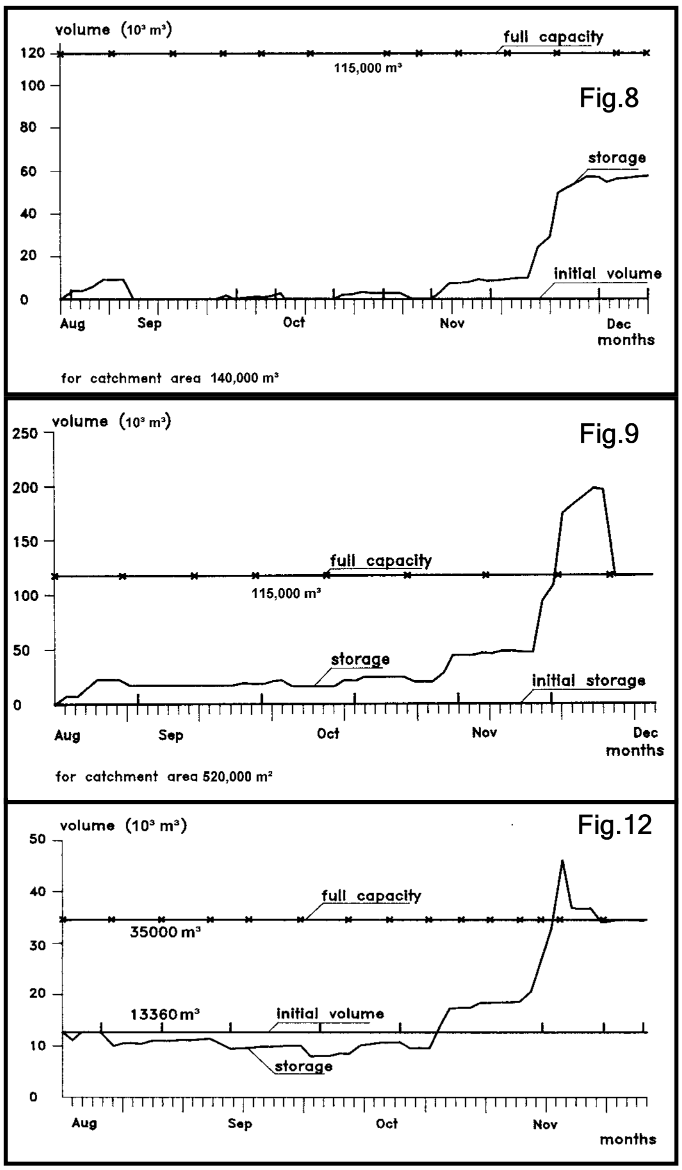


Fig. 8 & 9. Storage variation of Mylapore temple tank in 1992; Fig. 12. Storage variation of Thirupporur Temple Tank in 1992

There is another temple tank known as Chitrakulam which occupies an area of about 5560 m^2 in the vicinity of the Mylapore tank. This tank was renovated by a national spiritual and cultural organization known as the Janakalyan in February, 1990. The tank was deepened by 1.4 metres with the help of bulldozers. Since then, the tank does not retain any water. Further, it is found that the piezometric level is 6 metres below the level of the tank bed.

Tamil Nadu State Government is very interested in bringing the temples and their tanks back to their days of glory, as they are the only available cultural link with the past. There are nearly 1000 temple tanks in Tamil Nadu. The State Agricultural Engineering Department has programmed to complete the renovation work of the tanks in a phased manner in the next two years. The renovation work has six components, i.e. cleaning the inlet and outlet channels, bailing out contaminated water, removing weeds and slush and desilting, spreading of clay and sand, repairing of steps and parapet wall and rearing of fish in temple ponds. This trend will go a long way in rain-water harvesting, conserving and also recharging of groundwater in the city.

Water Storage in Suburban Temple Tanks

After a preliminary survey of the temple tanks in the suburban area, the Thirupporur temple (Fig. 11) tank was selected for the purpose of further study. The tank is situated 40 km from Madras. It is underlined by a hard rock and red soil which is in the Palar Boundary Basin. This tank survives without much change and its catchment has not been encroached upon by the public. Hence this tank contains more water throughout the year as shown in Fig.11. This tank meets the daily use of the public for bathing, washing the clothes and for other religious activities. Thus water in the tank keeps the environment very stable.

The 15 metres height of Kailasanathar Hillock located in the western side of the tank is its catchment. With the help of a digital theodolite the catchment area was determined as 61,286 m^2. The full capacity of the tank is 35,000 m^3. A daily rainfall-runoff analysis was performed for the years 1974, 1976 and 1977, as they represented a dry, average and wet year respectively. The computed value was verified by observing the actual fluctuation in the water level and overflow from the tank on November 16th to 19th and also on December 5th and 6th of the year 1992.

Table 3 & Fig. 12 show that the existing catchment area is sufficient to fill the tank to its full capacity in an average rainfall year. The study

Table 1. Quality of the waters in the temple tanks

Parameters	Parthasarathy temple tank	Mylapore tank	Kandarkottam tank
PH	7.74	7.40	6.81
T.D.S. (mg/L)	383	91.9	208
E.C. (10^{-6} Siemens)	766	183.8	689
Total Hardness (mg/L)	1904	2304	1760
Carbonate (mg/L)	72	8	-
Bicarbonate (mg/L)	120	100	140
Nitrate (μg/L)	0.022	0.036	0.039
Nitrate (μg/L)	-	-	4
Ammonia (μg/L)	0.044	0.136	0.02
Phosphate (μg/L)	150	-	100
Total coliform (MPN/100 ml)	1700	23	92

Table 2 . Runoff from the existing and proposed catchments of the Mylapore tank

Catchment Area m^2	Jan. 1st to June 30th			July 1st to Sept. 30th			Oct. 1st to Dec. 31st		
	Rainfall mm	Depth m	Volume m^3	Rainfall mm	Depth m	Volume m^3	Rainfall mm	Depth m	Volume m^3
140,000	7	-	-	334.6	-	-	678.9	2.40	55,800
521,663 (Total catchment to fill the tank)	7	-	-	334.6	0,74	16,500	678.9	4.48	109.500

Table 3 .Storage variation of Thiruppour temple tank

Year	Total Annual Rainfall	Jan. 1st to June 30th			July 1st to Sept. 30th			Oct. 1st to Dec. 31st		
		Rainfall mm	Depth m	Volume m^3	Rainfall mm	Depth m	Volume m^3	Rainfall mm	Depth m	Volume m^3
1974	719.4	65.4	1.330	11,500	358	1.970	18,000	237.3	2.11	16,800
1976	1,439.3	41.9	1.302	11,400	342	1.600	15,100	1,101.9	3.417	33,000
1977	1,932.4	60.5	2.427	22,500	303.8	3.033	29,000	1,574.6	3.49	33,700
1992	1,039.4	2.0	1.260	11,000	150.9	1.010	8,500	8,500.0	3.49	33,700

further shows that as the catchment is a hillock, and no further changes in land use are expected, the catchment will continue to yield sufficiently.

Storage capacity of the tank: 35,000 m^3
Depth of the tank: 3.6 m (12 feet)
Catchment area: 61,286 m^2

Conclusion

A major conclusion of the study is that the bed material of the tank should be alluvial soil, that will help to retain water as well as recharge the surrounding area. The only water resources available to the temple tanks in the urban locality are rain water from roof tops, roads and platforms. In fact, the area was originally 70 % to 80 % open space through which rain water recharged into the ground. Now 90 % of the urban area around the temple is impervious surface. Hence the entire rainfall should be collected through storm drains and stored in the temple tanks.

Chennai city alone has 39 temple tanks, having an average depth of 4.5 metres. Through these 39 tanks it is possible to harvest and conserve about 1,300,000 m^3 rain water. The catchment area required to fill a temple tank located in urban surrounding has to be at least 10 times the surface area of the tank. Taking the normal rainfall as 1200 mm, the tank could get water to a depth of 0.6 metres by direct rainfall. The rest has to be collected from the identified catchment area. Incidentally, the quality of waters in the temple tanks has been found fit for the limited exposure category.

This study has shown that the tanks of Chennai, act as water conservation structures, apart from serving their traditional function. They can be filled to their capacity by having storm drains from the surrounding urban area directed to the tanks. A full tank has an aesthetic value, and the quality of water is also good for a limited exposure use category. It can be seen that strategies for rehabilitation of the temple tanks have integrated a number of uses such as traditional functions, rain harvesting structures, aesthetic value and limited exposure use for the public.

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