

Original Article

# Assessment of Solid and Liquid Waste Inside the Temple Complex and Tanks of Kumbakonam Town in India

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**Abstract** - *Worshipping is a way of life in India; the state of Tamilnadu in India, being called the Land of Temples, is a prominent religious destination due to the presence of more than 30000 temples, where people visit and make different offerings to the deities, in the form of oil and organic products, with floral offerings being the most common. As a result, temple garbage contains various types of unsegregated wastes which make their way into municipal waste or are abandoned as waste, either into water bodies or left out in the open, generating a variety of environmental concerns. Hence there is a pressing need to address these unorganized waste-handling methods practised in temples in general. Kumbakonam, a significant pilgrim town in Tamilnadu, has been identified to analyze the accumulation and disposal of waste in fourteen temples and five temple tanks. A survey of the wastes accumulated during average days over one month was conducted, and the data of the number of visitors, quantity of offerings for performing daily pujas and the amount of waste disposed of during the same day at night or the next day early morning have been collected, analyzed and recommendations for safe segregation and disposal of wastes have been discussed.*

**Keywords** - Temple wastes, Liquid wastes, Floral wastes, Oil wastes, Kumbakonam town, Environmental pollution.

## 1. Introduction

In India, worship is a way of life. Despite variations, externalities, and religious strife throughout time and geography, Indian Hindu temples considerably impacted the social, economic, and political development of Indian cultures [1]. The trip began with single-cell development in central India's Gupta period, 300 AD and reached its full maturity as a temple city in south India's Nayaka period, 1700 AD [2]. Due to multifaceted changes taking into account styles, migrations, location, economy, and externalities, the evolution of temple building in India has grown complex [3].

For more than 15 centuries, South Indian civilization highly regarded temples, and 36,000 were registered with the state-owned Hindu Religious and Charitable Endowment Department (HRCE), which oversees all the Hindu temples in Tamil Nadu [4]. The majority religion in the Indian subcontinent is Hinduism, the oldest alive religion in the world and dates back to the Iron Age [5]. Hinduism believes in offerings made to god as a form of worship. The offerings commonly include flowers, fruits, coconuts, sweets, shells, milk, oil, curd, clothes and food [6].

### 1.1. Offerings to the Deity and their Residues as Wastes Contaminating Temple Complexes

India is a country that celebrates several festivals, resulting in an accumulation of solid waste throughout the year [7-9]. During festivals and rituals in Hindu temples, which happen daily, weekly, fortnightly and monthly, as in Table 1, the devotees offer flowers in temples, which are later left unused and hence become a waste. This percentage of garbage is frequently overlooked and must be addressed [10].

These floral wastes decompose both aerobically and anaerobically, releasing poisonous gases, unpleasant odours, and solid and liquid wastes that pose serious health risks to anyone nearby. Around 80,000 tonnes of discarded flowers are thrown into Indian rivers yearly [11]. Due to our religious beliefs, many refrain from throwing away flowers and other items needed for prayers. Instead, we put them in plastic bags and dump them directly into bodies of water or under sacred trees, leaving the city of temples with 3.5 to 4 tonnes of rubbish.[12]. Other offerings include fruits, coconuts, sweets, shells, milk, oil, curd and other offerings stacked up and subsequently discarded only in water bodies, posing severe health and environmental risks.



Table 1. Festivals and rituals in hindu shaivate temple, Tamilnadu

Daily	Weekly	Monthly	Yearly	Festivals
Ustha Kaalam (Before Dawn)	Adhivaram Pooja is on Sunday	Shivrathri occurs every month, the 14 <sup>th</sup> day of every lunar month	Thiruvathirai or Aarudira Darshinam	Maha Deepam
Kaala santhi Uchichi Kaalam (Mid-day or Noon)	Somavaram Pooja on Monday	Pournami & Chitra Pournami also the full moon	Paguni Uthram & Vaikasi Brahmavotsam	Paguni Ther, Aadi Pooram, Navarathri
Sayaratchai – (Evening)	-	Aani Thirumanjanam in Aani Masam(June-July).	Maha Shivarathri – Great night of Shiva.	Shanipeyarchi Festival.
Irاندam Kaalam (Three hours after sunset)	Pardosham - Forth nightly	-	Anna Abhishekam	Maasi Magam float Festival
Artha Yaamam (before Midnight)	-	-	-	-

Source: HR&CE, Thanjavur District, Tamilnadu, 2022

Different types of waste accumulated in the temple complex are diagrammatically represented in Figure 1. Flowers, leaves, coconut shells, incense stick remains, fruits, and other organic garbage can be degraded naturally; several biological treatment solutions are available, including vermicomposting as an alternative to open dumping or other ecologically hazardous waste management techniques [13, 22, 23]. In addition, hundreds of followers in Shiv, Hanuman, Maruti, and Shani temples offer oil to idols for various mythological and theological reasons. Once poured,

the oil cannot be used again and is eventually squandered [14]. Temple tanks, in recent times fallen into disrepair. The tanks have been contaminated and tarred by liquid waste from the temples, preventing ground water from seeping [15]. Today, sewage flows into the temple tanks as devotees and the broader population wash their clothes and bodies with detergents and soap for cleaning or other cleansing purposes and conduct other rituals in and around the temple tank [6].

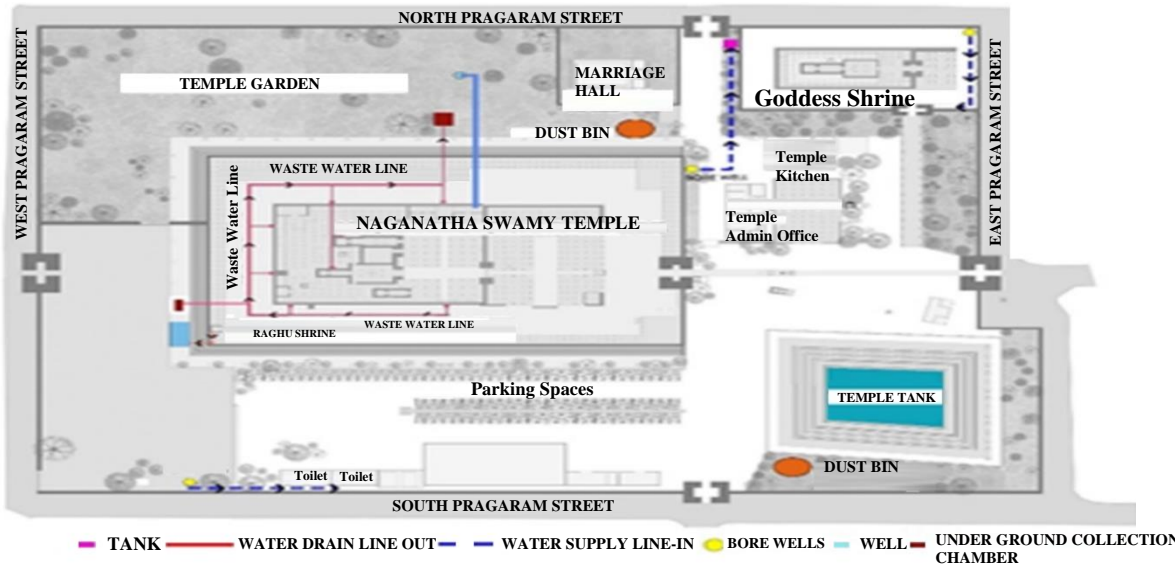


Fig. 1 Solid and liquid waste disposal system in a temple complex of thirunageswaram naganatha swamy temple, Kumbakonam district

1.2. Contamination of Temple Tanks due to the Wastes Generated in Temples

Temple tanks are called Theerthem or Teppakkulam in Tamil Nadu [16]. Temple tanks were used as an ancient technology to recharge the aquifer, which was later extracted through personal wells. These tanks acted as a gauge for the city's underground resource, displaying its fluctuating level. Water tanks were used to store water, also needed for temple rituals. Water stored in this manner increased groundwater

levels and replenished community water supplies. In water-stressed areas, temple tanks are typically fed by precipitation and groundwater. [17]. during the monsoon season, these temple tanks have inlets that funnel excess precipitation into the tanks. Every hamlet in South India has a tank and a temple, while towns and cities have several.

Due to the state's lack of water, all residences had to be constructed to face the tank and were either square or

rectangular so that rainwater would drain onto the tank from the sloping roofs and the roads. Tamil Nadu being a low-level rain-fed state, is heavily reliant on its temple tanks where one would utilize water from the tank to drink, store groundwater, wash one's hands and feet before entering the temple, apply oil occasionally and take a holy plunge in the water in the hope that it would wash away all of their sins and occasionally to irrigate temple grounds [18].

Additionally, worshippers and the general public use detergent and soap for washing or other cleansing purposes [19, 20]; sewage is now flowing into the temple tank, which leaves oil and chemical wastes harming the aquatic life [21] and the quality of water, which can be observed in Mahamagam temple tank in Kumbakonam [9]. It is renowned for hosting the nationwide Mahamagam festival (Kumbhamela of South India), which draws visitors nationwide. One of the most prominent temple tanks in the city wherein every 12 years, the populace uses it for a sacred bath.

The effects of water pollution not only have a devastating effect on people but also harm animals, birds and fish. Due to the restricted groundwater infiltration and certain decreasing aquifer levels, several temple tanks have dried up. Saline water has also entered several groundwater sources due to overuse resulting in changes in the physicochemical parameters of water. The researchers have suggested several suggestions to raise awareness of the harmful effects of water pollution in the ponds, conduct awareness campaigns in the city's surrounding areas, lay appropriate input and outflow lines and frequent refilling with freshwater [11].

### **1.3. Accumulation and Disposal of Wastes across the Temples in India**

#### **1.3.1. Floral Wastes**

Offering flowers to god is considered auspicious & sacred because they are not thrown along with other wastes; instead, the floral and organic wastes are disposed of in temple water tanks, water bodies, left around corners of the temples or open spaces, leading to environmental contamination [24]. As seen in Figure 2, devotees visit the city and the countryside to offer flowers to God and the Goddesses. Following this, tonnes of flower gifts are produced daily, most of which are discarded in open landfills or discharged into bodies of water, where they develop disease-causing germs and emit terrible odours.

According to reports, the nation's temples, mosques, and gurudwaras get almost 800 million tonnes of flowers as donations, including roses and yellow marigolds. Compared to the breakdown of kitchen trash, the degradation of flower

waste is a relatively slow process. [14]. Therefore, a thorough and environmentally friendly technique is required to treat flower waste. The discarded Marigold flower waste was collected from several Varanasi, India, temples and extensively used for textile dyeing. Marigold flowers and other flower varieties were collected from numerous temple trash cans. The materials were separated, cleaned, and dried in a hot air drier at 50°C. The crusher broke apart the blossoms.

To achieve maximal colour extraction, methylol (10 ml/g of crushed materials) was added to the crushed flower petals, and the pH was subsequently corrected to 2.0 using diluted sodium hydroxide and hydrochloric acid. Other materials, such as plant leaves released after extraction, were typically used to prepare biochar and compost [25]. Non-scented flowers and leaves were converted to vermicomposting; after collecting flower waste from temples, the non-biodegradable part was removed by hand.

The biodegradable wastes, namely garlands and flowers, were segregated and shredded into small pieces. The separated floral waste was air-dried for 48 hours by spreading it out on Paper. Because of their thermophilic character, which assists in mass reduction and pathogen reduction, the air-dried samples were pre-composted for ten days to make them acceptable for the vermicomposting process [26, 27]. *Eisenia foetida*, an earthworm, was chosen for composting. Due to its widespread dispersion, tolerance to extreme temperatures, and ability to persist in organic wastes with various moisture levels.

With 1.2 m x 3.0 m in size and green colour, the High-Density Poly Ethylene (HDPE) portable Vermi Bed is a cutting-edge technological idea for earthworm farming. It is portable, water-resistant, and UV-stabilized. In addition, it is also flexible, mobile, cost-effective, and simple to handle and install [28].

#### **1.3.2. Organic and Plastic Wastes**

Worship is an integral part of Indian culture, with people offering various organic products such as fruits, sugars, jaggery, milk and milk products, with non-scented flowers and coconut being the most common. In India, vast quantities of flowers and coconut are utilized in religious ceremonies which grow by the day and are discarded the next. [27]

The increasing amount of waste contributes to pollution and health risks. When this waste is disposed of or dumped on open land or in bodies of water, it causes a variety of problems that are biodegradable and contain elements necessary for the growth of microorganisms [29].



Fig. 2 Different types of floral wastes generated in a typical sarangapani temple, Kumbakonam



Fig. 3 Temple priest performing abhishekam (pouring milk over the sanctum) for lord ganesha



Fig. 4 Accumulation of waste and people bathing in the Kumbakonam mahamagam temple tank





Fig. 5 Tamilnadu state map



Fig. 6 Kumbakonam city map

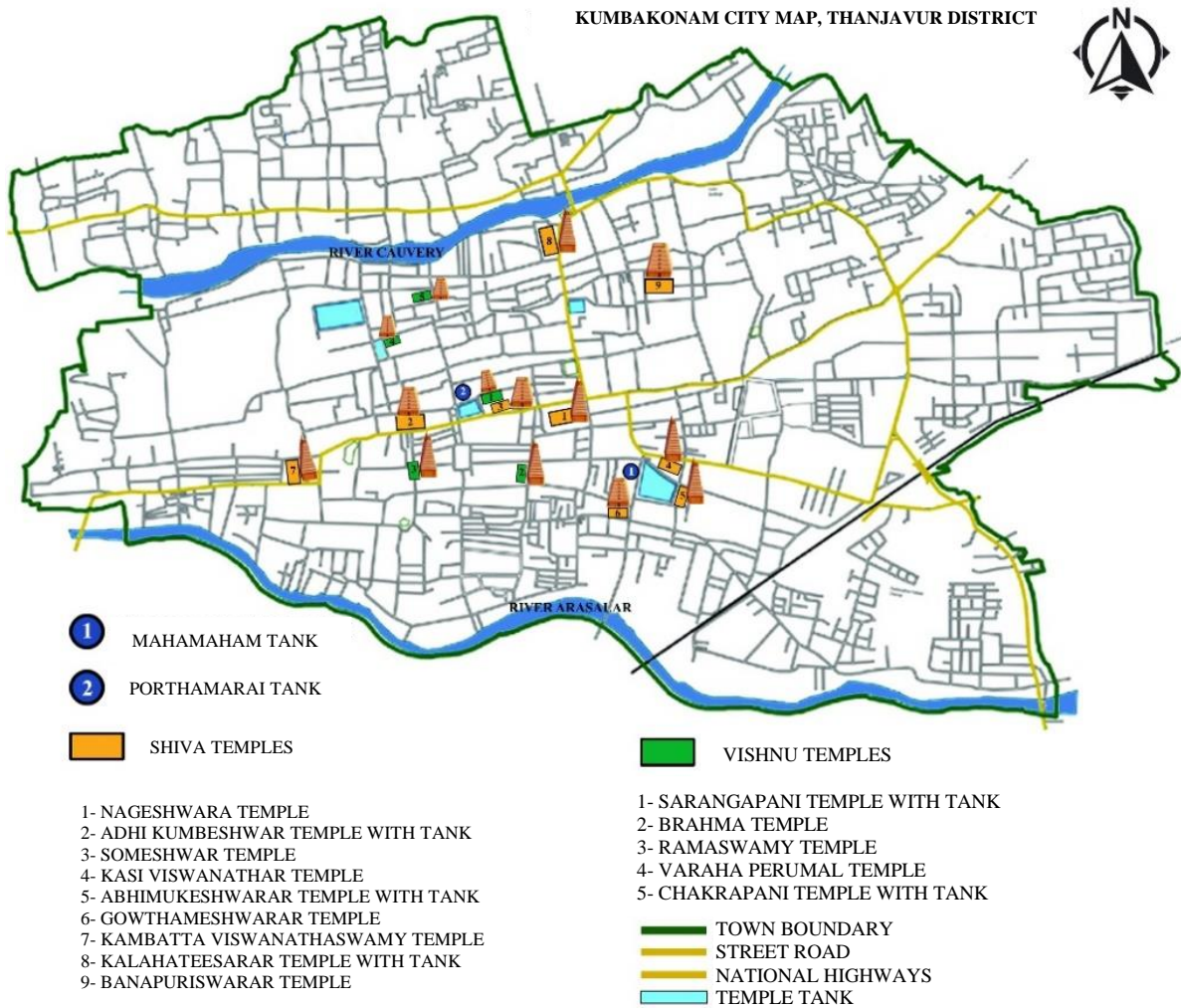


Fig. 7 Temples in and around Kumbakonam city



Fig. 8 Around 10 lakh devotees gather yearly at Kumbakonam for a holy dip in the mahamagam temple tank



Fig. 9 Marigold flowers segregated in sarangapani temple



Fig. 10 Night market around abhi mukeshwara temple tank

Because of this, the temple wastes are released into water bodies or dumped at convenient locations, which causes severe environmental pollution and health risks [25]; their research used organic waste independently to anaerobic digestion inoculated with cattle dung on a laboratory scale for the production of biogas [30-32].

They used 2 kg of flower waste, 5 kg of cow dung, 30 litres of water, and methanogenic bacteria in alkaline form for biogas generation. Shani Shingnapur temple in Maharashtra uses waste temple oil to make biodiesel gathered using the transesterification method. In addition to the production of biodiesel, soaps were also produced with the addition of sodium and potassium hydroxide. [12].

Various plastics and paper wastes in most of the temples are generated in the form of carry bags, Polyethylene

terephthalate (PET) bottles, Oil plastics cans, milk packets, and cardboard which are collected, crushed and or shredded to reduce the volume for easy transportation for the nearby recycle units or dumped along with municipal waste without segregation.

Apart from the floral and organic wastes, the other form of liquid wastes which is generated are milk, curd (yoghurt), ghee, honey, sugar, coconut water, rose water, and sandalwood, which is offered to the main deity in the main sanctum (garbhagriha) as shown in Figure 3 and also ancillary gods within the temple complex [33-35].

### 1.3.3. Wastes in Temple Tanks

Water is essential for all living organisms' existence and flourishing. Water is the most essential component of any ecosystem. Because of the rapid growth of human population

and urbanization, it gets contaminated; the many sources of water to the temple tanks are rainfall, feeding from neighbouring channels, seepage, and agricultural drainage, or the river, if any, flows along the temples, which significantly affects the quality of the water in Mahamagam tank of Kumbakonam as shown in Figure 4. In India, now a day's water pollution is a significant problem [36]. Toxic organic and inorganic pollutants contaminate the surface water and groundwater reservoirs; temple tanks are ancient rectangular rainwater storage buildings constructed in India quite close to the temples for communal usage. Usually, the temples and the temple tanks are surrounded by homes. Today, devotees and the general public wash their clothing and bodies with detergents and soap for cleaning or other cleansing purposes [37, 38]. Solid and liquid wastes from the temple complexes have been deposited in the tank, and sewage flows into the temple tanks. Due to the restricted groundwater infiltration and certain decreasing aquifer levels, several temple tanks have dried up. After bathing and cleaning, the water may be contaminated or polluted by adding dust, oil, detergents, and other substances [39].

In addition, domestic and industrial effluent and municipal wastewater are changing the physicochemical properties of freshwater resources, rendering them unsuitable for animal feed, residential use, and other purposes. Overuse of water extraction has resulted in many of them drying up, inlets being blocked by construction operations, and some being drained and used for other purposes due to population pressure; the physicochemical properties of the temple are significantly affected by anthropogenic activities [40]. Thousands of devotees pour oil on the idols in Shaivite temples for numerous mythical and theological reasons. Once poured, the oil cannot be reused and is thus squandered. Waste temple oil from these temples is used to make biodiesel with the help of *Pseudomonas aeruginosa* cells immobilized with sodium alginate [41]. Used temple oil is also an alternative to automobile biodiesel [42].

## 2. Data Collection and Analysis

### 2.1. Study Area - Kumbakonam

One of the temple cities in Tamilnadu is Kumbakonam, as shown in Figure 5- 7, located in the Thanjavur district, covering a land area of 12.58 sq. Km of land, which stands as a representation of our cultural heritage against all invaders from the beginning of time. It is one of the political centres of the Chola kingdom that still struggles to preserve its rich cultural legacy, situated along the Cauvery River and in the delta formed by the Cauvery and its tributary Arasalar [43]. It is a multicentered temple town with 14 significant temples and five temple tanks.

The magnificent structures and temples in Kumbakonam are evidence of Tamil Nadu's splendour.

Millions of devotees visit these temples leaving behind excess, unmanageable amounts of solid and liquid wastes unattended, as shown in Figure 8, posing severe environmental issues.

This study aims to identify the types of temple wastes accumulated inside the fourteen temples of the Kumbakonam region and five temple tanks and their effective disposal methods for a sustainable built environment. The scope of the research is limited to surveying waste accumulated and disposed of during regular days; waste accumulated during festivals is not taken for the study.

### 2.2. Accumulation and Disposal of Floral Waste in Fourteen Temples of the Kumbakonam Region

A survey was carried out for floral waste accumulation inside fourteen temples of the Kumbakonam region during regular days, excluding festival days, as the footfall was multifold. Starting from 6.00 am to evening 8.00 pm during the visiting hours, the number of visitors visiting each temple during regular days was tabulated, amount of flower sales outside the temple complex was estimated, the number of flowers used for decoration was also approximately calculated, and visitors carrying their flowers without buying from outside the premises of the temple were roughly identified and finally, overall flower waste accumulated at the end of the day at around 9.00 pm and morning 5.00 am were weighed for the study.

Marigold flowers and rose petals from Sarangapani and Chakrapani temples were segregated and sent to non-governmental organizations, as shown in Figure 9, for incense sticks, perfumes, and biochar production [44]. The floral wastes from the 12 temples were mixed with other organic and plastic wastes and finally mixed with municipal waste.

### 2.3. Accumulation and Disposal of Organic and Plastic Waste inside the Fourteen Temples of the Kumbakonam Region

Quantity of coconuts, bananas, betel leaves and nuts, turmeric, camphor, Vilvam leaves or Aegle marmelos commonly known as Bael, Kumkum (red turmeric powder), Vibhuthi which refers to sacred ash used in Hindu ritual made from the white ash of wood burnt in the homam (sacred fire) and cow dung, the thread used for lighting the lamps, cloth material, plastic bottles, sachets, oil cans, curd, milk, water, honey, tender coconut, ghee and sandalwood paste sold per day outside the temple complex, visitors carrying organic items other than the ones sold outside were estimated from morning 6.00 am to evening 8.00 pm. The author has also considered the quantity of organic items used daily by the temple priest for the sanctum or deity.

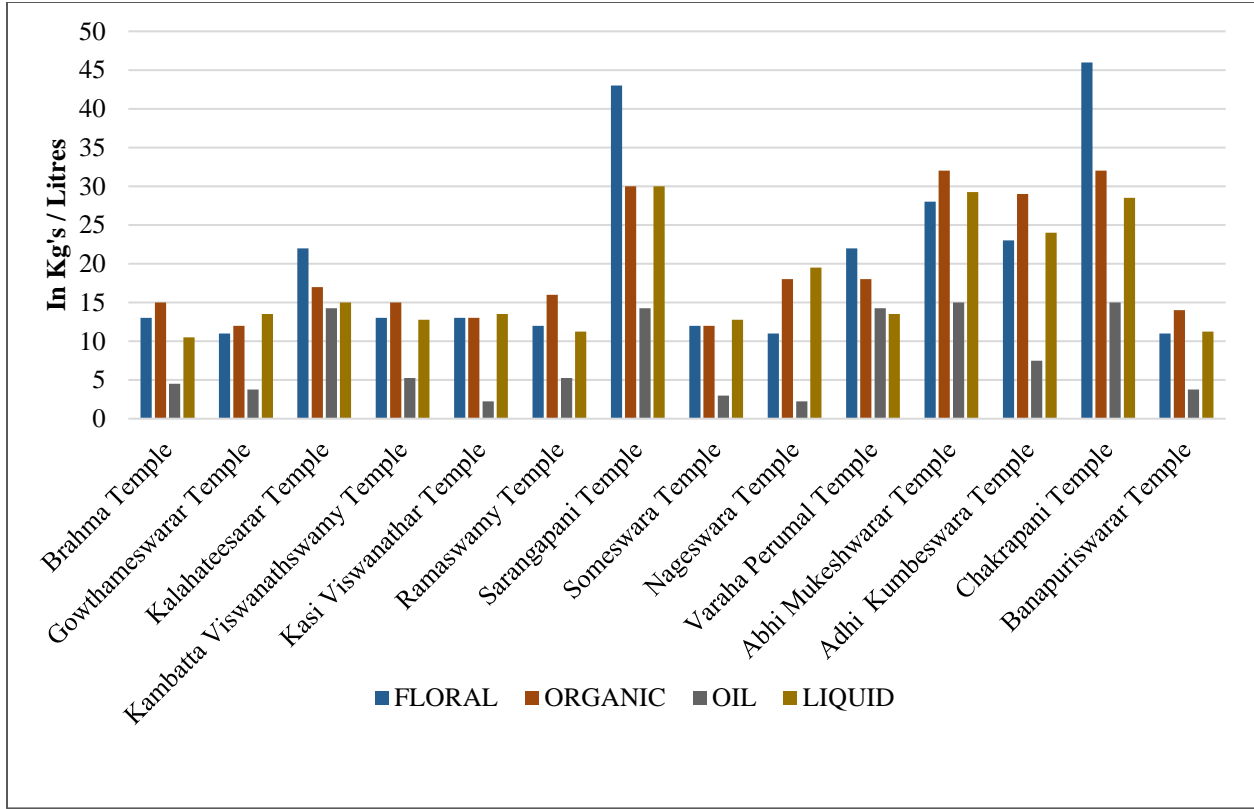


Fig. 11 Generation of waste in 14 temples in Kumbakonam on regular days

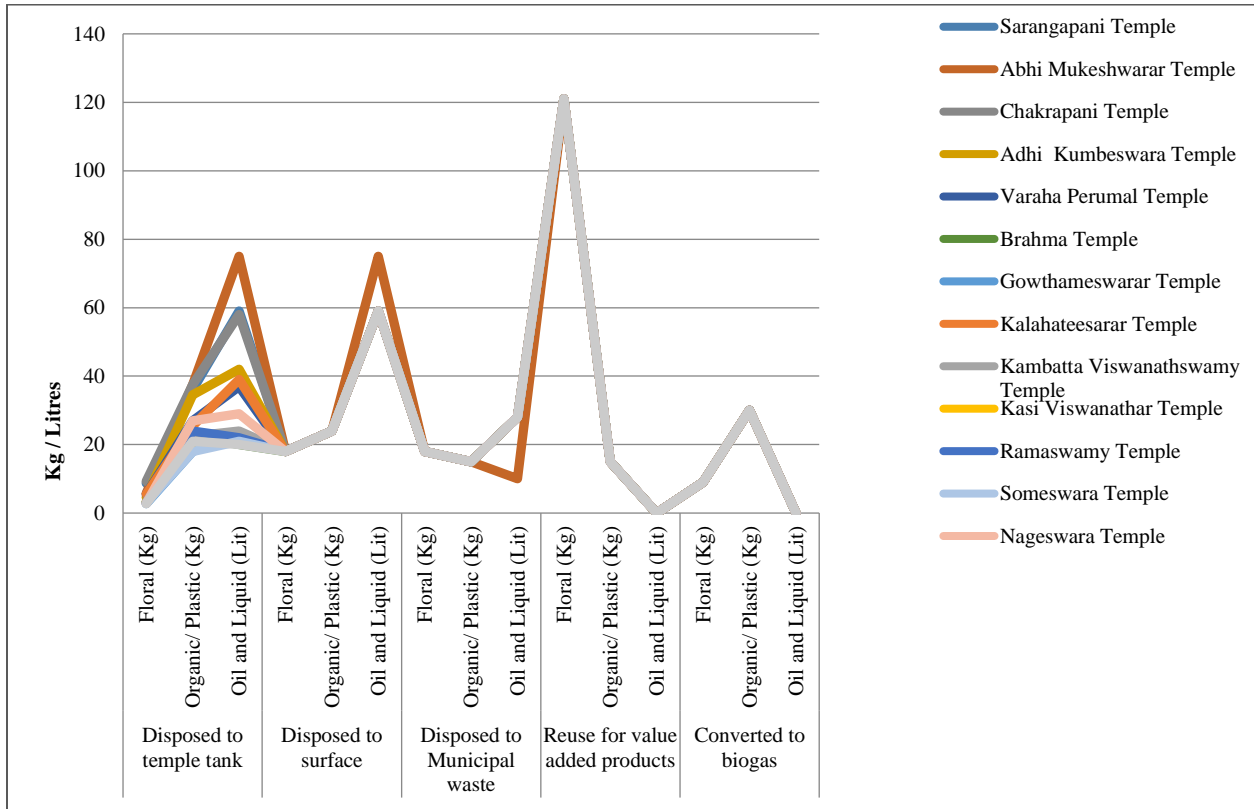


Fig. 12 Disposal of waste in 14 temples in Kumbakonam on regular days



Most Indian temples are built as energy centres, and there are several ways to energize the temple, one of which is Abhishekam. Priests perform Abhishekam by pouring libations on the deity while Chanting Vedic mantras. Depending on the type of Abhishekam performed, various offerings, such as milk, curd (yoghurt), ghee, honey, sugar, coconut water, rose water, and sandalwood paste, are poured.

Post Abhishekam, the organic matter in the form of semi-solids like squeezed fruits are collected separately in a container and distributed to the deities in the form of prasadam, coconut shells, plastic wastes in the form of sachets containing oil, kumkum, turmeric, vibhuthi, camphor, milk are collected in a separate bin and are disposed along with the municipal waste. Fruits, vegetable peels, and palm leaf cups from Abhimukeshwar and Sarangapani temples are sent to the biogas digester plant to produce biogas. The liquid wastes coming out after the process of Abhishekam from the main sanctum in the temples of Ssarangapani, Abhimukeshwara and Chakrapani are collected in a separate filter drain and subsequently led to the main drain. The liquid wastes from the ancillary deities within the temple complex had been directed to the nearby temple garden (nandavanam) or rainwater drain directed to the temple tanks. Among the fourteen temples Thenupuriswarar Temple in Patteshwaram and Abhi Mukeshwarar temple, the liquid wastes from the primary and ancillary deities are led directly to the temple tank within the temple complex without the process of filtration, biological treatment or oil separation.

#### **2.4. Accumulation and Disposal of Wastes in Five Temple Tanks of the Kumbakonam Region**

Several deities entering for the holy dip inside the tank per day were considered for the study. The quantity of floral, organic waste, oil waste, clothes, and plastic sachets left after performing the rituals during the non-peak season was monitored. Several deities were observed washing clothes, bathing, and lighting lamps inside the temple tank. The floating wastes in the five temple tanks are moved to one corner and are removed using casuarina wooden logs leaving behind the floating oil waste and water-insoluble compounds. The Mahamaham temple tanks are thoroughly cleaned only once a year before the maasi Mahamaham festival, which happens yearly once. Before the festival, the water inside the tank is completely drained and refilled with fresh water from the river Arasalar [47], leaving the oil to settle in the Soil and contaminate the groundwater soil and water.

### **3. Results and Discussions**

Wastes accumulated and disposed of in the form of floral, organic, plastic and liquid inside the fourteen temples and five temple tanks of the Kumbakonam region were monitored. It was observed that the Sarangapani and Chakrapani temples of the Vishnu deity generated a

maximum of around 175-185 kg of floral waste during regular days without consideration of any festivals, as presented in Figure 11. Wastes from only these two temples were segregated and sent to the Private Non-governmental organization for the manufacturing of dried flowers, essential oil extraction, and creating Holi colours and incense sticks and supplied to the nearby cities for effective use as presented in Figure 12. Temple flower waste is also a suitable sustainable raw material supply for handmade paper manufacture. In the remaining twelve temples, it has been observed that there is a lack of organized handling of floral wastes.

The organic waste, along with some proportion of cow dung from Abhimukeshwar and Sarangapani temple, which accounts for the highest, around 125kg, is used to produce biogas used to operate the kitchen in the temple complex. In contrast, organic wastes have not been dealt with in other temples. Plastic waste is mixed with municipal waste in all fourteen temples and five temple tanks without segregation [45]. The wastes collected in the temple tanks are cleaned manually with the help of casuarina wooden logs leaving behind the solid and oil wastes settled at the bottom of the tank.

A report suggested using a melamine formaldehyde sponge denoted as PTFPMS, with hydrophobic coating and flame retardant, a labour-saving, cost-effective and environmentally friendly sponge to clean up the floating oil and water-insoluble components [46]. Water analysis was carried out regarding Total Dissolved Solids (TDS), turbidity, alkalinity and hardness for five temple tanks of the Kumbakonam region. The result indicated high pH values and an excess magnesium level in the tanks resulting in phytoplankton growth. It decreases light transfer and makes it unsafe for holy dipping. Of the five temple tanks Varaha Perumal temple tank is primarily affected by total dissolved solids, followed by the Chakrapani temple tank [47].

Additionally, a night market shown in Figure 10 around the Abhi Mukeshwarar temple tank is prone to community waste due to the lack of a proper curb/compound wall around the tank. Coconut is offered as a gift at a temple; the shell is often discarded after removing the edible portion. These shells eventually end up in water bodies, open areas, or places, producing environmental difficulties. These shells in powder form can be an excellent replacement to aggregate up to 15% and aid with the low cost and lessen the dead weight of the structure [48].

Temples under the control of the Archaeological Survey of India avoid entirely using plastics inside the temples in India [49]. Plastic waste management rules, 2016 framed by the Government of India, encourage local bodies to use plastic waste for the construction of roads according to Indian Road Congress guidelines, energy conversion from

waste to oil [50] confirming to IS 14534:1998 as per Central Pollution Control Board [51]. All the fourteen temples under Hindu Religious and Charitable Endowments department do not segregate plastic waste; instead, they dispose along with municipal waste causing environmental degradation and contamination [52]. Thus the study indicates that only three significant temples, namely Abhimukeshwara, Sarangapani and Chakrapani temples had proper segregation and collection of organic wastes.

However, all fourteen temples' liquid and oil waste were unattended [53]. After a few hours, these oil wastes form a thin layer on the tank's upper surface, contaminating the water and Soil below and significantly affecting aquatic life and human health [54]. The present study also observed an increased temperature surrounding the water tank, leaving no room for the deities' safe use.

#### 4. Recommendations

The present study focuses on the accumulation and disposal of waste from fourteen temples and five temple tanks in the Kumbakonam district, hosting millions of Hindu devotees. Various wastes generated from the temple in the form of floral, organic, plastic and liquid has to be appropriately collected, segregated and disposed of at regular intervals. However, proper management is not currently happening as a sad ground reality causing environmental contamination. A few temples in Kumbakonam, under the purview of the Archaeological Survey of India, like the Darasuram (Airavatesvar Shiva temple), had taken strict measures to restrict waste generation inside the temple and the temple tanks.

The Fourteen temples and the five temple tanks taken for the study come under the HRCE Department of the Government of Tamilnadu. It has been observed from the

study that they have not been following proper waste accumulation and disposal strategies despite regulations laid down by the local municipal authorities. The significant deficiencies which lead to improper waste management are no restrictions on the offerings to the deity, no proper segregation of organic and inorganic wastes, no onsite waste reuse strategies implemented, and above all, lack of systematic monitoring by any of the authorities involved. Hence the need of the hour is to take serious steps to impose restrictions over misuse of the temple premises and temple tanks for a cleaner and healthier environment; thereby, they remain comparatively clean.

The public works department and Tamilnadu Water Supply and drainage board must take serious measures to avoid mixing liquid and other wastes into the water bodies and temple tanks. In addition, awareness programs among the various stakeholders about the detrimental effect of waste inside the temple premises and temple tanks have to be conducted by either government or non-governmental organizations for cleaner temples. Further, the study can be focused on the wastes generated and their disposal methods in all the fourteen temples and tanks individually about their context with more viable disposal and recycling process to improve the environmental quality. Recycling these wastes can offer increased employment opportunities and improve the economic status of the local community.

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