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Physicochemical Parameters and Water Quality Indices of Certain Temple Tanks of Mysore, India

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Abstract:

The study primarily involves the analysis of water in temple tanks of Mysore and its surrounding areas. Water samples from 6 temple tanks (T_1-T_6) were collected to examine certain physicochemical parameters such as temperature, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), salinity, conductivity, resistivity, amount of nitrates, phosphates and turbidity. As per the Pearson Correlation Coefficient, four of the temple tanks have high correlation with respect to the physicochemical parameters. Only two temple tanks have 99% similarity. The samples were also subjected to a microbiological study where the total coliforms were determined. Based on these factors, the samples were analysed for their water quality using the Malaysian Department Of Environment Water Quality Index and the National Sanitation Foundation WQI. On the basis of DOE WQI, the samples ranged from 76 to 88, all of them belonging to class II. Water samples from T_2, T_5, and T_6 were 'Slightly Polluted' and the remaining samples from T_1, T_3 and T_4 were 'Clean'. Results from NSF WQI implied that all the water samples were of 'Medium' quality as their values varied from 52.67 to 68.46. Both the water quality indices used are simple and only a few parameters are involved in its calculation. Thus, the indices serve as important tools in understanding the quality of waters, control of the water pollution and conservation strategies.

Keywords: DOE, microbiological, NSF, physicochemical, temple tanks, water quality.

1.0 Introduction:

Water is inevitably one of the primary requirements for life to sustain. It has numerous purposes in almost all the spheres known to mankind. One of the cultural purposes of water is its use in scared rituals performed at holy places. To uphold this sanctity, water is maintained in separate special tanks, generally found in the premises of temples or other centres of worship. These water tanks are also created with the intention of conserving water during dry spells and to help recharge the ground water.

Khapekar (2012) reported that due to unplanned urbanization and negligence, the conditions of these temple tanks are completely different. Most of the temple tanks are contaminated or enriched with various types of nutrients because of surface runoff, anthropogenic activities like bathing, washing clothes and utensils. Apart from this, there is also the dumping of garbage into these water bodies. Most temple devotees use the holy water for washing their limbs, sometimes they make a holy dip into the water and people believe that it can wash all their sins away (Sulbha and Prakasam, 2006). Shivalingaiah *et al.,* (2009), opined that when the devotees step into the tank for a holy dip, they cause overturns, thus bringing huge biomass to the surface and thereby, disturbing the entire ecosystem of the tank. Also, the seasonal congregation of humans to celebrate festivals often have a severe impact on the tank water. Such activities have significant variations in the physical, chemical as well as the biological characteristics of the water system. And all of the changes are recorded sequentially in this study.

The maintenance of healthy aquatic ecosystem is dependent on the physicochemical properties and biological diversity. A regular monitoring of water bodies with required number of parameters with reference to the quality of water not only prevents the outbreak of diseases and occurrence of hazards but checks the water from further deterioration. (Jalal and Sanalkumar, *2013).*One of the most effective ways to communicate water quality is by determining the Water Quality Index (WQI), where the water quality is assessed on the basis of calculated water quality indices. Quality of water is defined in terms of its physical, chemical, and biological parameters (Almeida, 2007). Horton (1965) proposed the first WQI. A water quality index provides a single number that expresses overall water quality at a certain location on several water quality parameters and turns complex water quality data into information that is understandable and usable by the general people. WQI is a mathematical instrument used to transform large quantities of water quality data into a single number which represents the water quality level while eliminating the subjective assessments of water quality and biases of individual water quality experts

According to Armah *et al* (2012), WQI is important because it arises first from the need to share and communicate with the public, in a consistent manner, the technical results of monitoring ambient water. Secondly, it is associated with the need to provide a general means of comparing and ranking various bodies of water throughout the geographical region. One of the benefits of the index is elimination of jargon and technical complexity in describing water quality. The index strives to reduce an analysis of many factors into a simple statement. Basically a WQI attempts to provide a mechanism for presenting a cumulatively derived, numerical expression defining a certain level of water quality (Miller *et al.,* 1986).

Two of the WQI used in the study are the National Sanitation Foundation (NSF) WQI and the Malaysian Department Of Environment (DOE) WQI, which involve a minimum of five parameters to determine the quality of water. Lumb *et al* (2011) and Hirsch *et al* (1991) have successfully used these water quality indices in determining the surface water quality. There are many researchers who have used such indices. Some of them include: Blanco and Blanco (2012) on river water quality assessment, Hosmani (2010) on phytoplankton diversity, Hosmani (2012) on the applications of the benthic diatom community in lake water quality monitoring, Hosmani and Mruthunjaya (2013) on the impacts of phytoplankton diversity on water quality indices, Hosmani (2013) on fresh water algae as indicators of water quality, Giriappanavar and Patil (2013) on water quality assessment of a reservoir at Belgaum, and Devi Prasad and Siddaraju (2012) have applied the CCME WQI for lakes.

2.0 Materials and Methods:

2.1 Study area

Six temple tanks located in Mysore, Mandya and Hassan districts of Karnataka were selected for the present study. Four of them (T_1 - T_4) are located in Mysore district (12°18'N 76°42'E). The first temple tank (T_1) belonged to Bandanthamma-Kalanthamma temple in Kuvempunagar. The second temple tank (T_2) was from the prominent Chamundi hills (Devi Kere). The third (T_3) was from another iconic religious foundation-GanapathysriSachidanand Ashram. The fourth (T_4) water sample was from Lakshmi-Narasimha temple, located at the heart of Mysore city, in Jayalakshmipuram.

The fifth temple tank (T_5) belonged to Adichunchunagiri temple at Nagamanglataluk (12°18'N 76°75'E) which is about 45km from Mysore. And the sixth temple tank (T_6) was from Hasanamba temple, at Hassan (13°01'N 76°10'E) a neighbouring town that is 119Km from Mysore. The present study is an attempt to determine the Water Quality Index of these temple tanks and to suggest measures of conserving them.

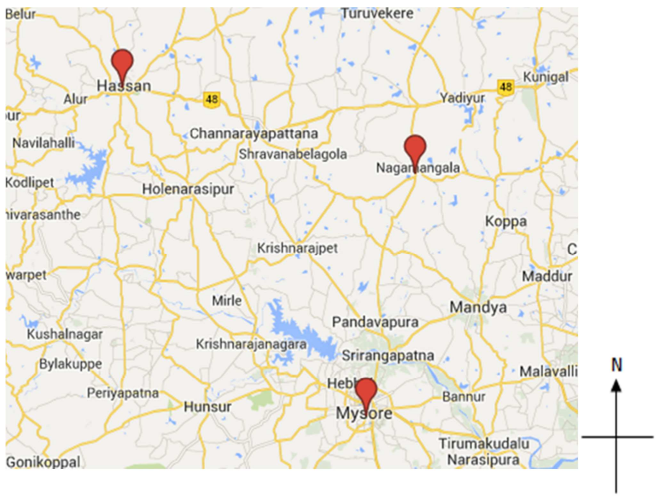

Fig 1 : Map showing the study areas of the temple tanks.

2.2 Sampling

Water samples for the analysis of physicochemical parameters were collected as per the methods described in APHA (1998). Water temperature, pH, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Dissolved Solids, salinity, conductivity and resistivity were determined using HACH kits (USA). Turbidity was determined using a Nephelometer. Nitrates and phosphates were determined as per APHA (1998).

Bacterial counts were made as per Aneja (2001). Coliforms were expressed as CFU/ml.

3.0 Results and Discussion:

The physicochemical and bacteriological parameters of six temple tanks are presented in table 1.

About 12 physicochemical parameters such as temperature, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), salinity, conductivity, resistivity, nitrates, phosphates, and turbidity were analysed. The microbiological analysis of the temple water samples were done in reference to coliforms for their total count. All the analysis was done as per the methods described in APHA (1998).

3.1 Temperature

Temperature is one of the most important factors for determining water quality. It primarily aids in the regulation of all metabolic and physiological activities in the water system. The temperature of the water samples varied from 27.4°C to 28.5°C. The highest (28.5°C) was recorded in T_3 and T_6 and the lowest (27.4°C) in T_1. Water Temperature (as it was recorded in summer), was high due to low water level, high temperature and clear atmosphere (Salve and Hiware, 2008).

3.2 pH

The pH of a solution is the concentration of hydrogen ions, expressed as a negative logarithm. It reflects the acidity or alkalinity of a solution. pH of the water samples ranged from 8.08 to 8.84, T_6 being the minimum (8.08) and T_3 being the most alkaline (8.84) among all the samples taken. The reduced rate of photosynthetic activities reduces the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month (Kamble *et al*., 2009).

3.3 DO

Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. Dissolved oxygen can be expressed either as a concentration (in mg/L or ppm), which is an absolute value, or as percentage saturation, which is an expression of the proportion of dissolved oxygen in the water relative to the maximum concentration of oxygen that water at a particular temperature, pressure, and salinity can dissolve. (Department of Water, Western Australia, 2009). As stated by Agarwal and Rajwar (2010) dissolved oxygen is of great importance to all living organisms. It may be present in water due to the direct diffusion from air and photosynthetic activity by autotrophs. In T_6 the minimum value of DO was recorded as 5.26ppm and the maximum in T_1 as 7.28ppm.

3.4 BOD

BOD is the amount of oxygen required by the living organisms engaged in the utilization and ultimate destruction or stabilization of organic waste. (Hawkes, 1993) BOD of the water samples varied from 0.06mg/L (T_4) to 4.07mg/L (T_5). BOD is clearly an index of organic pollution (Pushpam *et al*. 2013) BOD tests measures only biodegradable fraction of the total potential DO consumption of a water sample. High BOD levels indicates decline in DO, because the oxygen that is available in the water is being consumed by the bacteria leading to the inability of fish and other aquatic organisms to survive in the water body (Pathak and Limaye, 2011).

3.5 COD

COD is also a measure of pollution in aquatic ecosystems. It estimates carbonaceous factor of the organic matter (Agarwal and Rajwar, 2010). In the present study, COD ranged from a minimum value of 0.15 mg/L (T_4) to a maximum value of 10.175 mg/L (T_5). The measure of COD determines the quantity of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water (Faith, 2006).

3.6 TDS

Total dissolved solids consists majorly all of the inorganic and organic substances in the water body that are generally found in the suspended form. The levels of total dissolved solids in the water samples fluctuated from 128.4mg/L (T_4) to 1355mg/L (T_2). In water bodies, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles (Mahananda, 2010). According to Dasgupta and Purohit(2000), a viable reason for high TDS is due to waste disposals around the temple tanks.

3.7 Salinity

Salinity is an important property for both industrial and natural waters. It was originally conceived as a measure of the mass of dissolved salts in a given mass of solution (Singh et al., 2010; APHA 2005). Thus, concentration of salts dissolved in water is the measure of salinity. The dissolved salts maybe sodium chloride, magnesium, calcium sulphates, bicarbonates etc. In the water samples, T_4 has the least salinity of 0.13% and T_2 has 1.37%, the highest salinity.

3.8 EC
Electrical conductivity is a measure of capacity of a solution to carry an electric current. It is a parameter for dissolved as well as dissociated substances and indicates the concentration of dissolved electrolytes (Rai *et al.*, 2012). The unit of measurement for electrical conductivity is expressed in either micro Siemens per centimetre (µS/cm) or milli Siemens per centimetre (mS/cm). EC was maximum in T_5 with a value of 906µS/cm and minimum in T_2 with a value of 2.67µS/cm. These values of electrical conductivity are related to the dissolved ionic matter in the waters and so help in understanding that particular aquatic system. Hence, increasing levels of conductivity and cations are the products of decomposition and mineralization of organic materials (Abida, 2008).

3.9 Resistivity
Resistivity is also a measure of the ability of a fluid to conduct electrical current. The SI unit of resistivity is Ohm.meter (Ω.m). The water samples collected from the temple tanks indicated resistivity ranging from 2.23KΩ.cm in T_1 to 2151 KΩ.cm in T_6. The content of ionic salts in a water body is the major regulator of resistivity.

3. 10 Nitrates
The concentration of nitrates can be used to assess nutrient status in water systems. The main source of nitrates is the decomposition of organic matter, as stated by Dasgupta and Purohit (2000). The minimum value of nitrates were found to be 0mg/L in T_1 and maximum value 0.265mg/L in T_2 and T_5. The amount of nitrates depends on the activity of nitrifying bacteria which in turn is influenced by presence of Dissolved Oxygen (Dubey and Ujjania, 2013). Excessive amounts of nitrate can cause water quality problems and accelerate eutrophication, altering the densities and types of aquatic plants found in affected waterways. (Department of Water, Western Australia, 2009)

3.11 Phosphates
Phosphate content in water bodies is also a significant parameter in determining water quality. Increased amounts of phosphates could be attributed to the domestic activities such as washing clothes, utensils etc, alongside the temple tanks. This could eventually lead to the abundant growth of toxic algal blooms in the water body. The phosphate value varied from 1.66mg/L in T_3 to 2.33mg/L in T_2. Also, phosphate is an important factor for the growth of planktons as well as an important nutrient for maintaining fertility of the water body (Jadhav *et al*, 2013).

3.12 Turbidity
Turbidity of water is actually the expression of optical property in which the light is scattered by the particles present in water (Das and Shrivastva, 2003).It is commonly recorded in nephelometric turbidity units (NTUs). Turbidity in the water samples fluctuates from 0.4 NTU in T_1 to 20.8 NTU in T_2. The increase in turbidity might be due to the growing of aquatic vegetation and also by lowering the volume of water (Suber, 1953). Suspended silt and clay, other organic matter can contribute to turbidity. (Srivastava *et al*., 2011).

3.13 Total Coliform Count
Total Coliforms (TC) were found to be the highest in T_4 i.e., 1220 CFU/ml and the least in T_3i.e., 5 CFU/ml. The biological character of water is of fundamental importance to human health, in controlling diseases caused by pathogenic organisms of human origin and because of the role that they play in decomposition of waste. (Metcalf and Eddy, 2003) Coliforms primarily indicate faecal contamination in the water samples.

3.14 DOE WQI
Department Of Environment (Malaysia) Water Quality Index formulated classes and status for water samples that were analysed for physicochemical properties (Table 3). DOE WQI of T_1 is 88, T_2 is 76, T_3 is 83, T_4 is 88, T_5 is 77 and T_6 is 80. All of them belong to Class II, and their status ranges from 'clean' to 'slightly polluted'. Conservation strategies suggested for these water bodies are by the addition of sensitive aquatic species and practice of Fisheries - Type II. (Table 3.1)

3.15 NSF WQI
National Sanitation Foundation designed the NSF Water Quality Index in 1970. Based on this all the water samples from the temple tanks are classified as 'Medium', since indices range from 52.67 to 68.46 (Table 1). The classes and quality of the NSF WQI are designated as: 90-100 = Excellent; 70-90 = Good; 50-70 = Medium; 25-50 = Bad and 0-25 indicates very bad quality of water.

A Pearson Correlation Coefficient was performed for the physicochemical parameters in all the temple tanks. The results of the same are presented in Table 2. Temple tank T_1 has very high correlations with T_3 and T_4. Similarly, T_3 has very high correlations with T_4 and T_5. Also, T_6 shows very high correlation coefficients as far as the physicochemical parameters are concerned. The rest of the tanks show very low correlations. In order to determine which of the tanks show similarity, the data was subjected to a Bray-Curtis similarity index and a dendrogram was derived (Fig.2). Temple tanks T_3 and T_4 showed highest similarity in the nature of the physicochemical parameters. T_6 had great variations in resistivity while T_2 had great variations in TDS. (Figure 3)

Table 1: Physicochemical, Microbiological and Water Quality Indices of the temple water samples.

Parameters	T_1	T_2	T_3	T_4	T_5	T_6
Temperature (°C)	27.4	27.6	28.5	28.4	28.4	28.5
pH (units)	8.71	8.61	8.84	8.45	8.83	8.08
DO (ppm)	7.28	5.58	6.43	6.56	6.23	5.26
DO (%)	93	72	84	86	81	69
BOD(mg/L)	0.93	0.96	0.18	0.06	4.07	0.61
COD (mg/L)	2.325	2.4	0.45	0.15	10.175	1.525
TDS (mg/L)	217	1355	150.3	128.4	445	225
Salinity (%)	0.21	1.37	0.15	0.13	0.44	0.22
Conductivity (µS/cm)	449	2.67	314	269	906	465
Resistivity (KΩ.cm)	2.23	377	3.19	3.72	1104	2151
Nitrates (mg/L)	0	0.265	0.08	0.08	0.265	0.08
Phosphates (mg/L)	1.79	2.33	1.66	1.73	1.93	1.99
Turbidity (NTU)	0.4	20.8	1.6	0.8	18.4	0.8
TC (CFU/mL)	10	850	5	1220	430	1055
DOE WQI	88	76	83	88	77	80
Class	II	II	II	II	II	II
Status	Clean	Slightly Polluted	Clean	Clean	Slightly Polluted	Slightly Polluted
NSF WQI	68.46	61.29	52.67	61.2	52.78	58.41
Quality	Medium	Medium	Medium	Medium	Medium	Medium
WQI (DO %)	97	78	90	92	88	73
Range	Excellent	Good	Excellent	Excellent	Good	Good

Table 2: Pearson Correlation Matrix

	T_1	T_2	T_3	T_4	T_5	T_6
T_1	1					
T_2	0.313	1				
T_3	**0.998****	0.302	1			
T_4	**0.994****	0.296	0.**999****	1		
T_5	0.588*	0.379	0.579*	0.571*	1	
T_6	0.091	0.259	0.087	0.084	**0.856****	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2 tailed)

T_1 - BandanthammaKalanthamma temple,Kuvempunagar. T_2 - DeviKere, Chamundi hills. T_3 -Ganapathy Sri SachidanandAshram. T_4 - Lakshmi-Narasimha temple, Jayalakshmipuram. T_5 -Adichunchunagiri temple, Nagamangla. T_6 - Hasanamba temple, Hassan.

Table 3: Malaysian Department of Environment Water Quality Index and Classes

Parameter	**Unit**					
Water Quality Classes	Class	Class I	Class II	Class III	Class IV	Class V
Ammonia nitrogen	mg/L	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
BOD	mg/L	<0.1	1-3	3-6	6-12	>12
COD	mg/L	<10	10-25	25-50	50-100	>100
DO	mg/L	>7	5-7	3-5	1-3	>1
pH	units	>7	6.0-7.0	5.0-6.0	<5.0	>5.0
TDS	mg/L	>25	25-50	50-150	150-300	>300
WQI	WQI	>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

Table 3.1: Water quality Classes and Uses

Classes	**Uses**
Class I	Conservation of natural environment, water supply I; practically no treatment necessary; Fisheries I; very sensitive aquatic species
Class II A	Water supply II; Conservation treatment required; Fisheries II; Sensitive aquatic species
Class II B	Recreational use with body contact
Class III	Water supply III-extensive treatment required; Fisheries III-common; of economic value and tolerant species; livestock drinking
Class IV	Irrigation use only
Class V	Cannot be used for any of the above

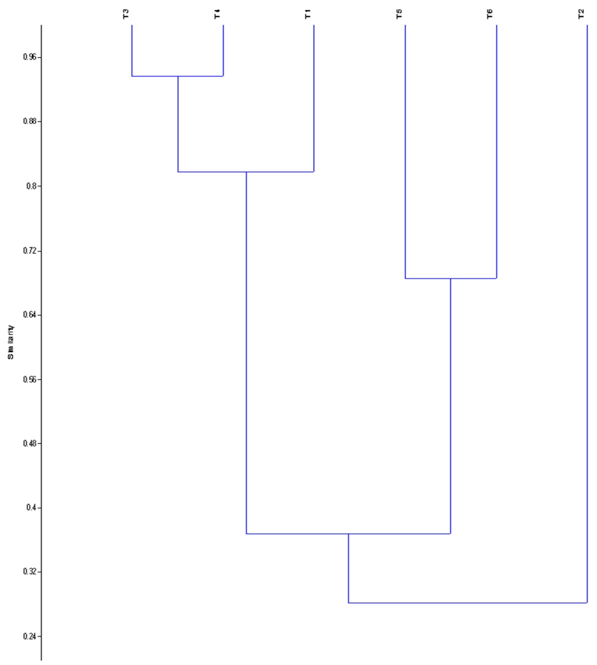

Fig. 2: Bray-Curtis Distance Similarity Index for the temple tanks

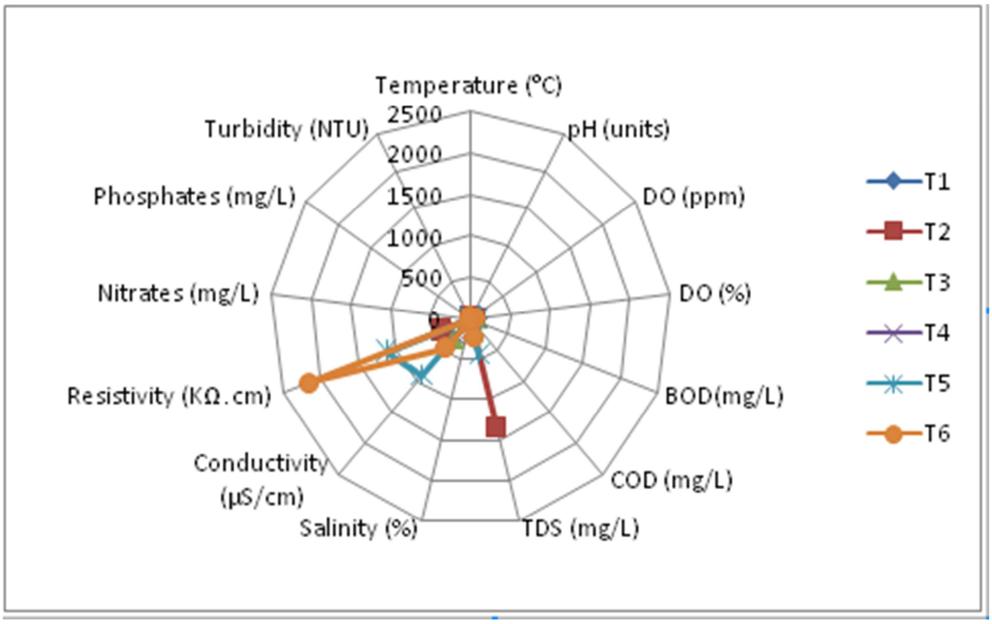

Fig. 3: Radar Graph for Physicochemical parameters

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4.0 Conclusion:

The use of modern tools in determination of WQI is of prime importance. The NSF Water Quality Index and the DOE Water Quality Index can be determined by analysing only a few water chemistry parameters. According to the DOE WQI all the temple tanks belong to Class II and respective conservation strategies are necessary. Also, introduction of type II sensitive fishes are necessary. The status of the water ranges from 'clean' to 'slightly polluted'. According to the NSF WQI all the temple tanks have Medium quality rating. Comparison of the physicochemical parameters in six temple tanks indicates that very high correlation exists between four temple tanks. T1 and T5 have very high similarity.

As comprehended by Jalal and Sanalkumar (2013), the maintenance of a healthy aquatic ecosystem is dependent on the physicochemical properties of water and the biological diversity. This study would help the water quality monitoring and regulation in order to improve the quality of water with better sustainable management. The outcome can be taken into consideration by the authorities concerned to take the needed measures to safeguard the quality of the respective temple tanks. Also the findings of this research paper are expected to convey essential information on the safe use of the waters from the temple tanks.

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