

Evaluation of the challenges in water governance through citizen's perception and Water Quality Index: a case study of a fast-growing city in India

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ABSTRACT

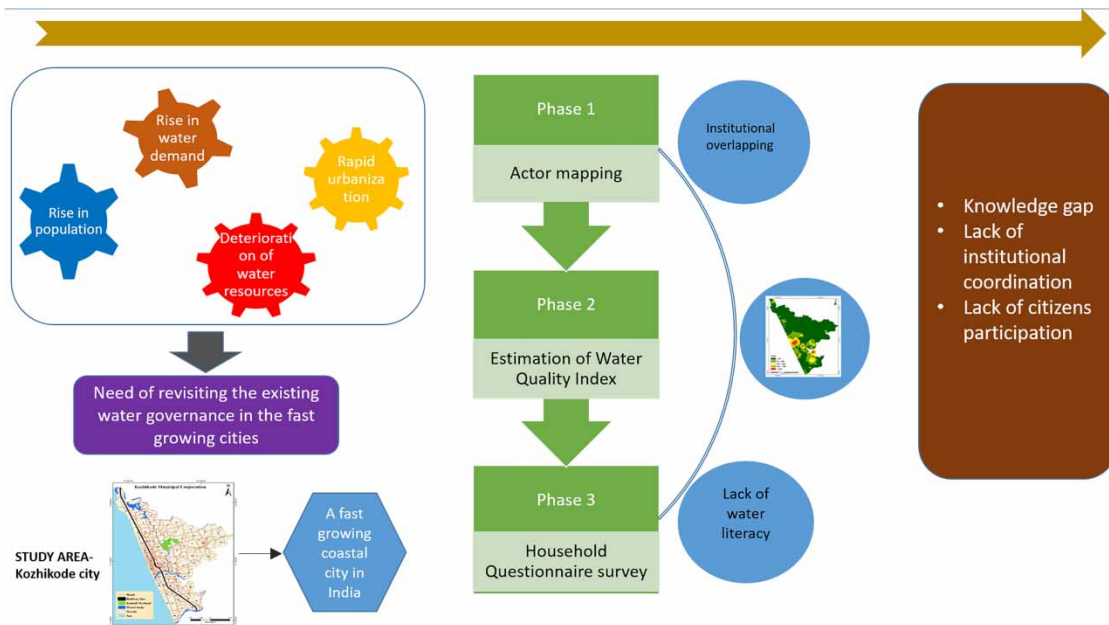
Urban water governance (UWG) plays an important role to ensure safe and sufficient water availability in cities. In developing countries, citizen centric studies, which are important to understand the ground-level scenario and the existing UWG, are often not conducted due to the lack of manpower or infrastructure. Indian cities are rapidly growing, and there is a need to revisit the existing UWG scenario in its cities. Therefore, as a first step, this study evaluates the UWG challenges in Kozhikode, Kerala, based on citizen perception and drinking water quality. The present study reports the findings from face-to-face interviews conducted (using structured questionnaires) to evaluate the knowledge of citizens in the basic areas of water resources management and conservation ($n = 180$) and the analysis of water samples from household sources ($n = 261$). The Water Quality Index (WQI) was computed and analyzed using the geographic information system (GIS). The WQI map identified the vulnerable areas requiring focused intervention to improve water quality. A poor awareness among the respondents, especially regarding the local water resources, was identified from the interviews. However, on a positive note, the citizens are willing to bridge this knowledge gap. Thus, involving citizens and understanding the issues at the ground level will aid in improving the UWG in cities.

Key words: citizen survey, Kozhikode, sustainable development, urban water governance, Water Quality Index

HIGHLIGHTS

- The questionnaire survey and water quality assessment helped to know the citizens' perception of the major water governance challenges.
- Knowledge gap and lack of coordination of multiple stakeholders are the major governance challenges to be addressed.
- Citizens' engagement and stakeholder interaction through effective data transfer strengthen the water governance aspects of a city.

GRAPHICAL ABSTRACT



INTRODUCTION

Urban water governance (UWG) is a rising challenge in the present world where the population is increasingly combating with water crisis (Seijger *et al.* 2018). Rapid urbanization and the rise in population have put our water resources under pressure, and hence, the management of water resources is a serious concern particularly for developing countries showing a higher rate of urban growth (UNESCO 2015). Insufficient access to safe drinking water has a severe impact on public health, even though technological interventions have been made many developing countries still find it difficult to ensure safe drinking water for their citizens (Kayser *et al.* 2015). India is a developing country experiencing rapid urban growth, which has a severe impact on environment, especially the water environment, and the access to safe drinking water is a major governance challenge in such cities. Water governance in India is facing significant challenges due to a myriad of reasons such as inadequate institutional performance and duplication of roles, unclear policies, and lack of water-related expertise of urban local bodies at the ground level (Cronin *et al.* 2016). Several studies point towards the governance pitfalls faced by the growing cities today. A few of such studies include those by Ahmed & Araral (2019), which assesses the water governance in eight Indian cities. The water governance index for each state was calculated and compared with the water law, policies and administration aspects. Although water governance in India has many pitfalls, it was observed that it had improved after the announcement of Sustainable Development Goals. Researchers have also attempted to assess cities based on the 'newer' methods, which focus more on governance. The assessment of Ahmedabad city using the City Blueprint Approach (Koop *et al.* 2017; Aartsen *et al.* 2018) indicated that the lack of stakeholder's engagement, lack of continuous learning and implementing capacities are major constraints of water governance. Challenges of UWG reported for densely populated coastal city such as Trivandrum (the capital city of Kerala) include spatial inequity in service delivery, lack of providing quality service and uncertainties in source sustainability (Chattopadhyay & Harilal 2017).

Water governance is the 'the range of political, institutional and administrative rules, practices and (formal and informal) processes through which and how decisions are taken and implemented; decision-makers are held accountable in the development and management of water resources and the delivery of water services; and, last but not least, stakeholders articulate their interests and have their concerns considered' (OECD 2011). It determines equity and efficiency in allocating and distributing water resources and services, and balances water use among socio-economic activities and ecosystems. The challenges of water governance are enormous and when it comes to complex urban system, researchers have identified a wide range of issues in water governance such as competing interests among different sectors/stakeholders, lack of communication among

organizations and experts, different interpretations of integrated water management, power dynamics, and lack of capacity building among stakeholder (Olsson & Head 2015). Water governance of urban area studied based on several indicators, which are available in plenty, does not assimilate water quality parameters at the ground level and fail to understand the service that is reaching the citizens from the citizen perspective. Insufficient coordination between stakeholders and lack of data sharing affects monitoring, enforcement, and surveillance of drinking water ultimately resulting in the deterioration of water quality provided to the consumers (Kayser *et al.* 2015). Wuijts *et al.* (2018) reviewed the social-economic, legal, and ecological perspective influencing the effectiveness of water quality governance and argued that all the above three perspectives have a major role in water quality governance, and the review also reveals that there is a gap in understanding the role of interaction of the three perspectives in water quality improvement. Developed countries fare better on water governance front with better policies and implementations, whereas the developing countries need to improve their water laws and policies and give more emphasis on public participation (Chattopadhyay 2018). Another setback that the developing countries face as observed by the authors is the lack of studies to understand water governance in the context of water quality at the city level from the perspective of citizens which is very important for proper intervention and to bring about a policy change.

Kozhikode is a fast-growing coastal city located in the southern part of India in the state of Kerala and is one of the cities listed at the fourth position by *The Economist* on the list of fastest-growing cities in the world (Times of India, 2020). The present study mainly focuses on understanding the status of water governance of the city in the context of water quality. Previously, researchers have described the difficulty of assessing water governance in the perspective from water quality (Wuijts *et al.* 2018). Therefore, in this study, the authors have attempted to use a different approach focusing on multiple facets of the problem by involving public perception to know the governance gap at the ground level, and mapping actors involved in drinking water governance. The Water Quality Index (WQI) was used to determine the water quality of the drinking water sources. The WQI was estimated to understand the water quality of the sources that the urban households depend upon, within the city limits of Kozhikode. The local authorities involved in water supply prioritize on providing services, especially in urban areas of developing countries. Hence, the present study is of much importance to bridge the data gap as the local authorities may not have the infrastructure or the manpower to conduct studies which provide a picture of the water situation especially from a citizen perspective. Thus, the present study is first of its kind conducted to provide a focused insight of drinking water quality governance of one of the fast-growing urban coastal cities of India.

MATERIALS AND METHODS

Study area

Kozhikode, a coastal city in northern Kerala, was selected for the study. The study area extends between 11°21'N to 11°9'N latitudes and between 75°44'E to 75°51'E longitudes. Table 1 provides an overview of the study area, and Figure 1 provides the map of the study area.

Methodology

The study is intended as the first attempt in understanding the current scenario of water governance and the quality issues of the drinking water sources. For a comprehensive understanding, the study was conducted at three

Table 1 | Basic details of the study area

District	Kozhikode
Area	118.59 km ²
Number of wards	75
Rainfall (annual average)	3,266 mm
Temperature	Maximum 27–33 °C
District HQ	Kozhikode
Population (2011 census)	608,255
Population density	5,129 persons/km ²
Literacy rate	94%

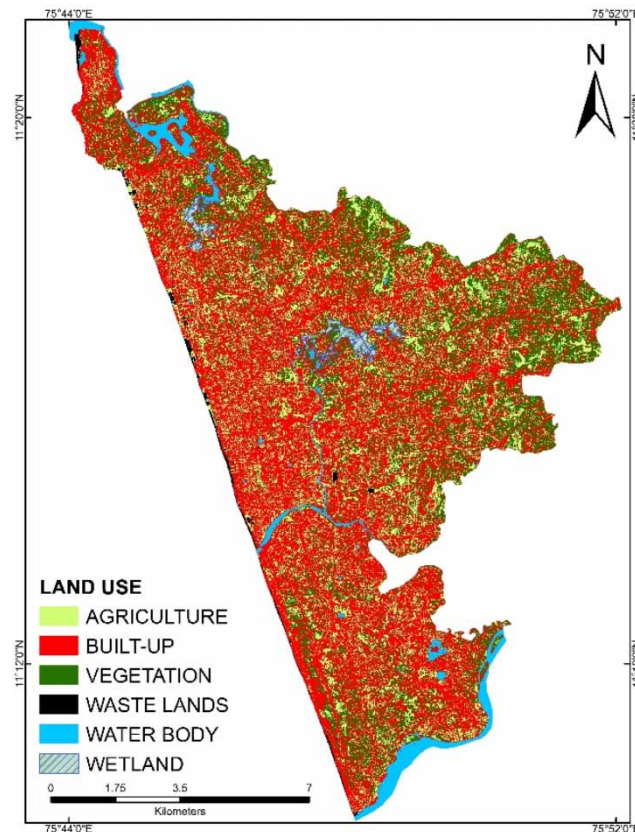


Figure 1 | Land-use map of the study area.

levels and hence is divided into three phases. In the first phase, the identification of different actors and their roles in drinking water quality and governance was mapped. In the second phase, the physio-chemical and microbiological analysis of the household sources of water collected from the study area was carried out. In the third phase, a household questionnaire survey was conducted and the data were analyzed to understand the citizen's perception on different facets of water and water governance. The methodology adopted in each phase is explained in the sections below.

Phase I: Methodology for mapping of actors

The fundamental part of understanding water governance is identifying the important actors involved and the interconnection between them. Mapping the actors in a system will enable us to know the emerging challenges and opportunities in water governance. Actors play a role in implementing policies and understanding the actor map would help to understand the interventions that may be required. The authors have used a methodology of classifying the actors along the vertical axis, i.e., from national, regional, to a local, city level (Lienert *et al.* 2013). This is done through reviewing existing works of literatures, policy documents, and reports.

Phase II: Household water source – sample collection and analysis

Extensive field visits were conducted from November 2020 to February 2021. Sampling locations were selected based on a preliminary survey and the available secondary data collected. Secondary data regarding the local water bodies and water supply schemes were collected, and a land-use/land cover map for the study area was also prepared. For the evaluation of water quality of household sources in the Kozhikode city, a total of 261 household water samples were collected from Kozhikode Municipal Corporation (shown in Figure 2). The sources of water samples collected include: open wells of individual households, common/community wells, household outlets of water supply schemes, and public taps. The collected samples were analyzed for various physio-chemical and bacteriological analyses as per the standard procedure. Portable water quality analyzers were used for *in situ* measurements of pH and electrical conductivity (Eutech Instruments, Singapore). All other parameters were analyzed as per the standard methods for water analysis as given in Table 2 (APHA 2017). For the bacteriological

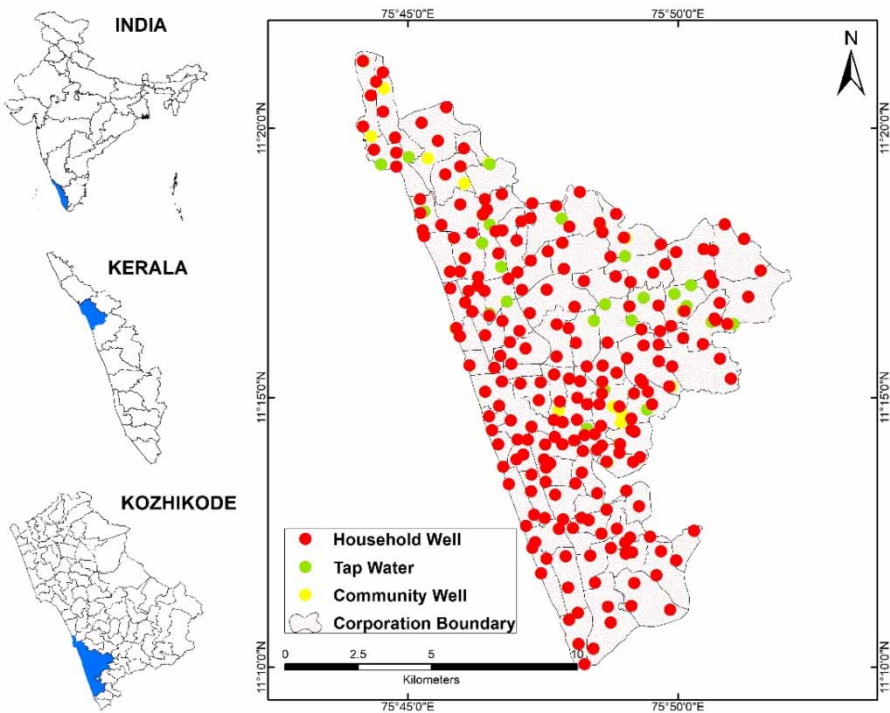


Figure 2 | Location map of the study area showing the sampling stations.

Table 2 | Water quality analysis method

Parameter	Analysis method
Turbidity	Nephelometric method APHA (2130.B)
Total dissolved solids (TDS)	TDS meter
Total hardness	EDTA Titrimetric Method APHA (2340.C)
Total alkalinity	Titration method APHA (2320.B)
Calcium	EDTA Titrimetric Method (3500 Ca. B)
Magnesium	Calculation Method APHA (3500-Mg B)
Sulfate	Turbidimetric Method APHA (4500-SO ₄ ²⁻ E)
Chloride	Argentometric Method APHA (4500-Cl ⁻ B.)
Nitrate	Ultraviolet Spectrophotometric Screening Method APHA (4500-NO ₃ ⁻ B)
Iron	Phenanthroline Method APHA (3500-Fe B.)
Lead	Flame atomic absorption spectrometry APHA (3111-B)
Copper	Flame atomic absorption spectrometry APHA (3111-B)
Total coliform	Multiple-Tube Fermentation Technique APHA (9221)
<i>E. coli</i>	Multiple-Tube Fermentation Technique APHA (9221)

analysis, samples were collected in sterile bottles, transported in ice box, and transferred to the laboratory within 2–4 h (APHA 2017). The collected samples were analyzed for total coliform and *Escherichia coli* as per the standard method (APHA 2017). Furthermore, the Arc GIS software (version 10.8) and the IDW (Inverse Distance Weighted) tool were utilized for the spatial interpolation of each parameter. It is one of the commonly used techniques in the geographic information system (GIS) for the spatial analysis (Malla 2014).

Estimation of the WQI

The data obtained from water quality analysis of household water samples were then processed for statistical analysis using Microsoft Excel 2010. The results were then compared for their suitability with Indian standards

(BIS 2012) and WHO (2017). To understand the quality of water, the weighted WQI was computed for the samples (Abbasi & Abbasi 2012). The Indian Standards were used for computing the WQI. The first step in computing the WQI is to assign weights (w_i) for the parameters selected, which emphasize the importance of the parameters on water quality. Furthermore, the relative weight (W_i) is calculated as per the following equation:

$$W_i = \frac{w_i}{\sum_{i=1}^n w_i} \quad (1)$$

The parameters analyzed in this study, their standards, the weights, and the computed relative weights are given in Table 3.

The next step is to compute a quality rating (q_i) as per the following equation:

$$q_i = \frac{C_i}{S_i} * 100 \quad (2)$$

where C_i is the concentration of the chemical parameter in the i th water sample, mg L^{-1} and S_i is the standard for the chemical parameter, mg L^{-1} .

For computing the WQI, the sub-index SI_i is calculated as per the following equation:

$$SI_i = W_i * q_i \quad (3)$$

Hence,

$$WQI = \sum SI_i$$

Further, the Arc GIS software (version 10.8) and the IDW tool were used to derive the WQI map of the study area.

Household survey

A household survey was conducted among 180 households to ensure a well-represented coverage across all wards of the Kozhikode Municipal Corporation using a structured questionnaire cum interview. The survey was conducted to assess the citizen's perception on water and sanitation aspects of the Kozhikode Municipal

Table 3 | Relative weights of parameters for the WQI^a

Parameter	Weight	Relative weight	Standard
pH	4	0.1	6.5–8.5
Turbidity	2	0.05	1 NTU
TDS	4	0.1	500 mg/L
Total hardness	4	0.1	200 mg/L
Total alkalinity	3	0.075	200 mg/L
Chloride	3	0.075	250 mg/L
Sulfate	2	0.05	200 mg/L
Calcium	2	0.05	75 mg/L
Magnesium	2	0.05	30 mg/L
Iron	4	0.1	0.3 mg/L
Nitrate	4	0.1	45 mg/L
Copper	3	0.075	0.05 mg/L
Lead	3	0.075	0.01 mg/L
Total	40		

^aAdapted from Abbasi and Abbasi (2012).

Corporation. The questionnaire was introduced through face-to-face interaction, and the responses were recorded.

RESULTS AND DISCUSSION

Water governance in Kozhikode city: actor mapping

Water governance mainly involves the practices of coordination and decision-making between different actors around water distribution (Zwarteveen *et al.* 2017). Multiple actors across different institutional levels play important roles in water governance. For understanding the existing governance scenario, multiple actors and their role in water governance have been mapped for Kozhikode city (Table 4).

Table 4 | Actor mapping for the city of Kozhikode, Kerala

Administrative level	Actors (Department/Organization)	Responsibilities/positions/actions
Central	Ministry of Jal Shakti	Overall planning, policy formulation, coordination, and guidance in the water resources sector
	Ministry of Housing and Urban Affairs (MoHUA)	Formulate policies, sponsor, and support program, and coordinate the activities for the urban development in the country
	Ministry of Environment, Forest and Climate Change (MoEFCC)	Planning, promotion, coordination, and overseeing the implementation of India's environmental and forestry policies and programs
	National Disaster Management Agency (NDMA)	Provide for institutional mechanisms for drawing up and monitoring the implementation of the disaster management plans
	Central Pollution Control Board (CPCB)	Role in the abatement and control of pollution in the country by generating relevant data and providing scientific information, and coordination of the state pollution control boards
	Central Ground Water Board (CGWB)	Providing scientific inputs for management, exploration, monitoring, assessment, augmentation, and regulation of groundwater resources
	Central Public Health and Environmental Engineering (CPHEEO)	Technical advice, guidelines, scrutiny, and appraisal of schemes and propagation of new technologies in the field of water supply and sanitation including municipal solid waste management
	Centre for Science and Environment (CSE) National Institute of Urban Affairs (NIUA)	Research and Policy advocacy organization Knowledge support to the MoHUA
Parastatal	All India Institute of Local Self-Government	Capacity building of ULBs for implementing schemes like AMRUT, PMAY, SCM, and SBM
State	Kerala Urban Development Finance Corporation (KUDFC)	Funding and promotion and development of medium- and large-scale projects in the state
	Kerala Institute of Local Administration (KILA)	Promoting governance both in urban and rural areas, and capacity building of LSG
	Irrigation Department	Construction of irrigation and settlement projects for the conservation, diversion, and distribution of water
	Town and Country Planning Department	Preparation of perspective plans for urban development
	Kerala Water Authority	Drinking water, sewage, and wastewater disposal management
	Groundwater Department (Govt. of Kerala) Kerala State Pollution Control Board Central Ground Water Board (Kerala region)	Groundwater management Environmental monitoring and impact assessment Executing the management and plans of CGWB
Local (city)	Kozhikode Municipal Corporation Kozhikode District Administration Academia – NIT-C, University of Calicut, IIM-C, CWRDM	Policy formulation for local self-government activities Interdepartmental coordination Academic research and training
	Civil Society Organizations: OSICA for Rural Water Supply, sanitation, C-Earth, Kudumbasree, Niravu	Activities in the field of water supply and sanitation

As per the Constitution of India, water is a state subject and hence, the responsibility of water resources development and management rests with individual states, i.e., water governance in India is decentralized at the state level. At the highest level, provisioning of urban water supply and sanitation in the city mainly lies under the purview of the Ministry of Housing and Urban Affairs, and the other National Ministries such as the Ministry of Jalshakthi and the Ministry of Environment, Forest and Climate Change also contribute towards urban water and sanitation through formulating policies and providing resources to meet urban demand, which also influences the decision on the allocation of the resources used to meet urban needs (Cronin *et al.* 2016). The Ministry of Water Resources, which now transformed to the Ministry of Jalshakthi, had introduced its first National Water Policy in 1987 and revised twice in 2002 and 2012 (Pandit & Biswas 2019). The actors at the National level perform their role through different policies, missions, and schemes and provide financial resources to the state governments for implementing them. Ultimately, the state government is responsible for executing the national-level policies and development activities in the city. The best example is the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme which is a National level Scheme under the Ministry of Housing and urban affairs that is ongoing in the city and focuses on sanitation, and septage management in the city is executed by the Kerala State Government. Kerala State has different institutions such as Kerala Water Authority (KWA), Irrigation Department, and Public Works Departments to develop and manage water resources. Among these, KWA plays a major role in water supply and management in the city. The major function of the KWA in the city includes preparation, execution, and maintenance of different water supply schemes in the city, such as Japan International Cooperation Agency (JICA) which is one of the largest water supply scheme executed by KWA. KWA is also responsible for the collection and disposal of wastewater in the city and also the fixation and revision of tariffs and charges of water supply and maintenance. The Central Ground Water Board, Government of India, and the State Groundwater Department, Kerala, are actively involved in the monitoring and assessment of groundwater in the city. Those agencies also conduct micro- and macro-level water management studies and involved in exploring different aspects of groundwater sector such as ground water depletion, groundwater contamination, saline intrusion, and water balance. The state groundwater department is also involved in mini-water supply schemes and groundwater conservation activities. Chattopadhyay & Harilal (2017) stated that urban self-governments in Kerala play a minimal role in providing basic water supply and management of drinking water, although a similar environment also prevails in Kozhikode city (such as no separate department for water). The major reason for that is, traditionally in households of the city which expanded over the years, the primary source of water has been open wells at the household level. The citizens still depend on the same even as piped water supply is provided to them. Also, the piped water supply is provided by the KWA which is a statutory autonomous body under the Government of Kerala and thus the role played by the Municipal Corporation is limited. The corporation has been involved in initiating several mini water supply schemes in the city and constructed several common wells and actively involved in the sanitation of the city, which may bring a much-needed change from the base of the administrative pyramids of cities.

Furthermore, upon an analysis of the legal framework, there exists six laws to deal with violations and management issues in water resources in the city which include two central and four state laws (Vinod Kumar *et al.* 2020). The central and state pollution control boards are mainly involved in the prevention, control, and abatement of water pollution, and use the existing water laws as a tool for their action. Civil society organizations such as non-governmental organizations, academic bodies, community support organizations, and general public also contribute to the water governance in the city.

Physico-chemical and bacteriological analysis

The quality of life is directly proportional to the quality of water that is available to its citizens among the other necessities of life. To assess the quality of water at the household level, samples were collected from various sources and assessed for physico-chemical and bacteriological parameters. Furthermore, to understand the spatial distribution of parameters, spatial maps were drawn by IDW method using ArcGIS (ver.10.8). Figure 3(a)–3(j) shows the IDW map of all parameters. From the spatial interpolation of the parameters, it is found that the groundwater quality varies with regard to the geography and population density. This is evident from Figure 3(a), which shows the value of pH ranges from 4.05 to 8.4, in which the coastal belt depicts a higher pH, and at a higher altitude the pH value decreases. This may be attributed to the soil type, which is alluvial in lowlands and laterite in the midland and highland of the city (Vinod Kumar *et al.* 2020). In most of the groundwater samples, values of turbidity exceeded the acceptable limit, which is attributed to a lack of

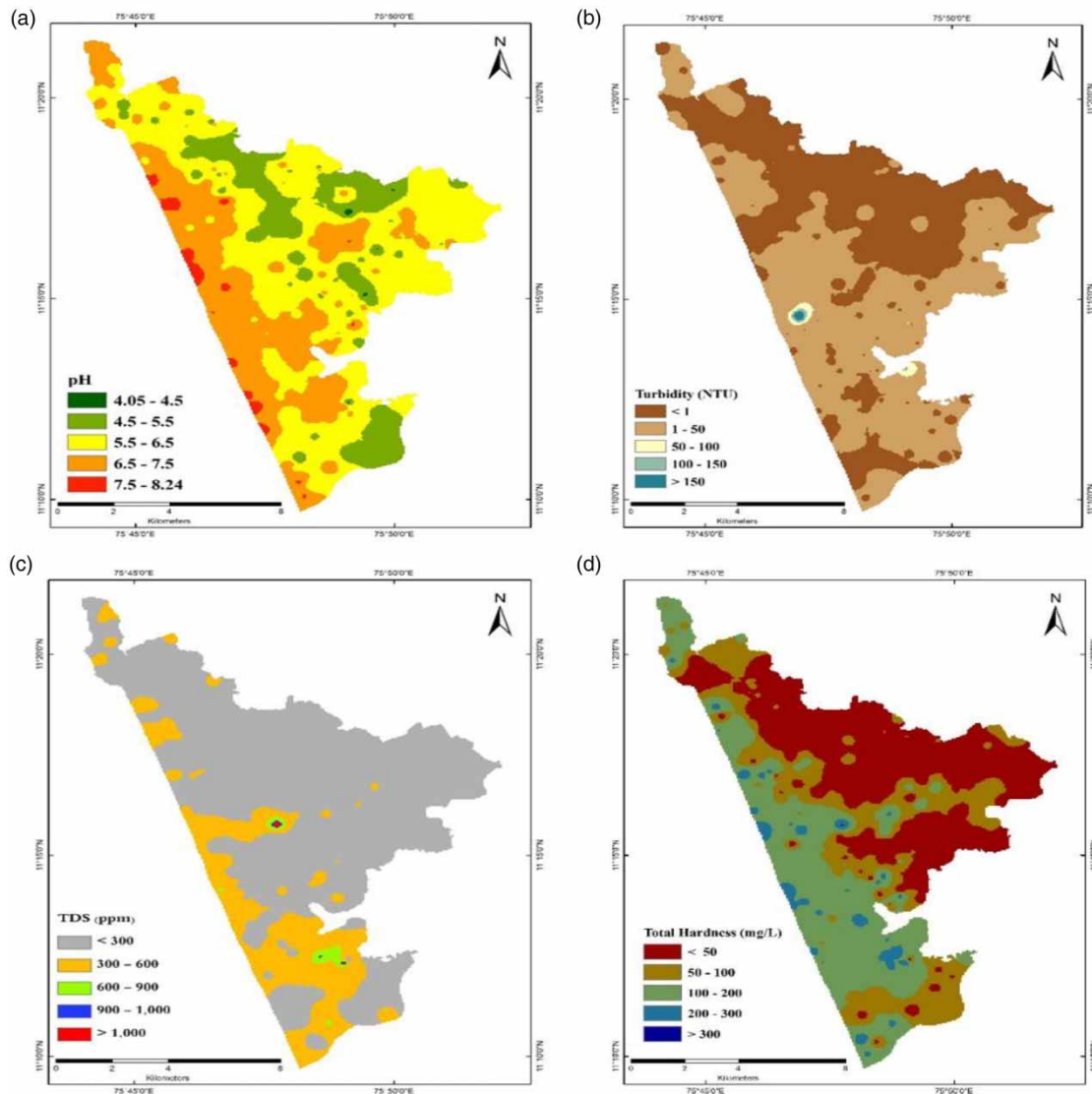


Figure 3 | IDW map showing physico-chemical parameters, pH (a), turbidity (b) TDS (c), and TH (d) in the household water sources of Kozhikode Corporation. IDW map showing physico-chemical parameters: iron (e), salinity (f), chloride (g), nitrate (h), calcium (i), and magnesium (j) in the household water sources of Kozhikode Corporation. (*Continued.*)

maintenance of wells, runoff from the surroundings into the well and phytoplankton growth as shown in Figure 3(b). The total dissolved solids (TDS) of the majority samples reported lies within the limit as per WHO (2017); however, higher values are obtained in some areas which are shown in Figure 3(c). The higher TDS values might be due to the infiltration of household wastewater into groundwater (Khosravi *et al.* 2017). Figure 3(d) shows the distribution of total hardness (TH) in the city. The value lies within the limit for the majority of samples, with only a few samples is having a value greater than 300 mg/L. The spatial distribution of iron concentration in most of the samples analyzed were within the desirable limits, but some samples collected from marshy areas were found to have a higher concentration (Figure 3(e)). The IDW map of salinity shown in Figure 3(f) indicates that there is deterioration of groundwater due to saline intrusion in the city at the places, namely Beypore, Marad, Puthiyappa, and Elathur. These places are characterized by high population density and are very close to the coastline. The spatial maps of other chemical parameters like chloride (Figure 3(g)), nitrate (Figure 3(h)), calcium (Figure 3(i)), and magnesium (Figure 3(j)) are within the limit except for few samples.

Another important aspect that governs drinking water quality is microbial contamination, which is addressed as a major health risk worldwide (Powell *et al.* 2002). Microbiological analysis for the presence of total coliforms

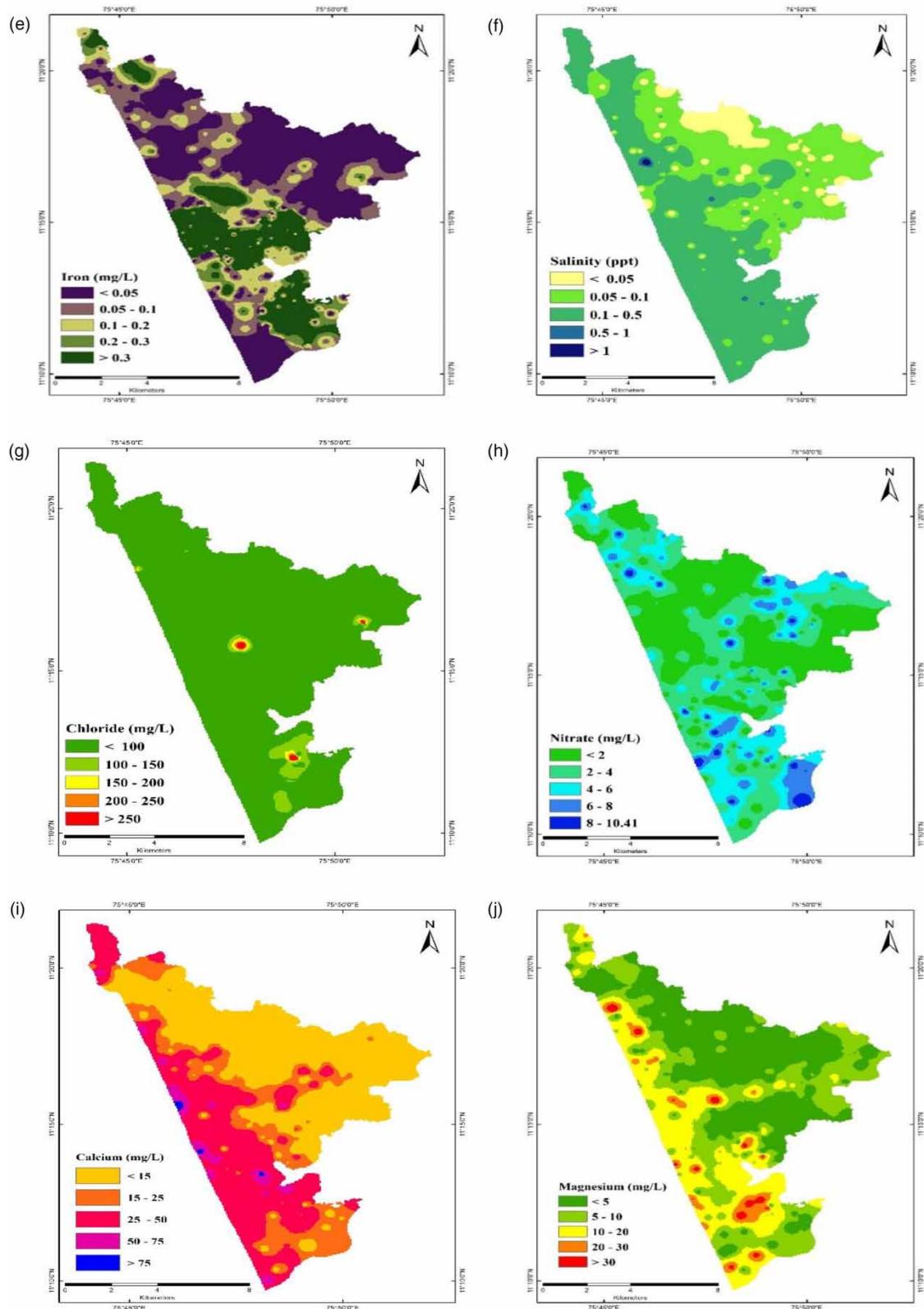


Figure 3 | Continued.

and *E. coli* was performed and found that more than 50% of the water sample is contaminated with total coliforms and the presence of *E. coli* was only detected in less than 10% of samples. Total coliforms give a picture of the general hygiene conditions prevalent in and around the water sources, and Figure 4 represents

the spatial distribution of the presence of total coliforms in the study area. As per the Indian standards, the total coliform count should be 'nil' in drinking water sources (IS: 10500). However, it is evident from [Figure 4](#) that several areas have a reported a count of more than 1,000 MPN/100 mL. Also, the total coliform contamination is higher in regions with a higher built-up area. It may be due to the closeness of the well to the septic tank/leach pit, especially in areas with high population density, which are found to be highly prone to the microbial contamination. This also puts further emphasis on the regular intervention needed to maintain hygienic conditions in and around the water sources, the distribution sources, and other structures in the distribution network ([WHO 2017](#)). This is a growing concern for Kozhikode city, since most people depend on dug wells, which are also used as a drinking water source, as evident from the household survey elaborated in section Household survey and analysis.

Water Quality Index

The WQI map is derived as shown in [Figure 5](#). The computation of the WQI has come as a handy tool and has been used by researchers to interpret the quality of water ([Abbasi & Abbasi 2012](#)). The spatial distribution indicated that while the majority of the sources could be categorized as 'Excellent', there are certain regions that require specific interventions where the water quality fell under the category of not fit to drink. The WQI map of the corporation also suggests that the highly populated areas were more susceptible to a drop in the quality of water, especially in the coastal belt and the highly dense core of the city. The 'very poor' and 'not fit for drinking' can be attributed to the high values of TH, chloride, total alkalinity, calcium, and iron. However, unlike other cities studied by researchers using the WQI, 75% of the samples fell into the excellent category of classification based on the WQI, while in most cities for example Anna Nagar area of Chennai of the 24 samples, only 20.83% could be classified as excellent ([Krishna Kumar et al. 2015](#)). Similar is the case with Visakhapatnam, a coastal city, where only 18–24% of samples could be classified as excellent.

Household survey and analysis

The household survey was conducted among the residents of Kozhikode, and the questions were structured to understand the following:

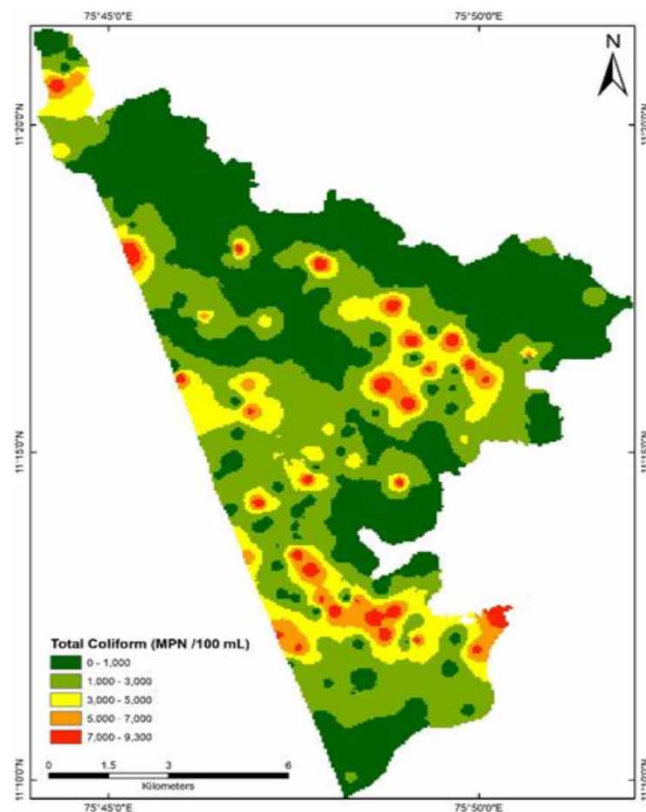


Figure 4 | Spatial distribution of total coliforms in the household water sources of Kozhikode Corporation of Kozhikode.

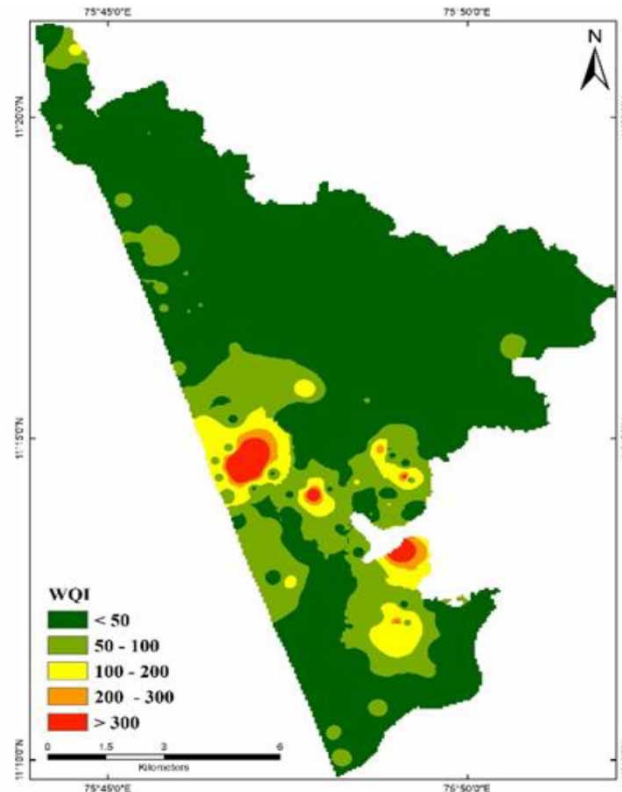


Figure 5 | WQI map of Kozhikode Corporation.

- (a) The water sources available to the citizens.
- (b) The public perception of water and related issues.

India is one of the largest consumers of groundwater in the world. This trend is of great concern, especially in the growing cities, where indiscriminate extraction of groundwater to meet the requirements of the growing population leaves little room for the recharge of groundwater. Traditionally, groundwater has been the source of water for the residents in urban as well as rural areas of Kozhikode, even before the city expanded to its current limits. In the late 1950s till 1960, when the piped water supply to households was in the nascent stages, the supply was utilized only as a standby arrangement to the groundwater source. Later as the city expanded, the need for a more formal and structured arrangement for water supply was felt and several drinking water projects were introduced (Radhakrishnan 2003).

During the household survey, it was found that a large population of the city depends on open wells (60%) for drinking water, especially in regions other than the core city. The abundant rainfall received has aided in depending on groundwater year after year. However, the dependence is of concern, because the city does not have a sewerage system and the households rely on the traditional septic systems. The proximity of household septic tanks and the water sources is a prime reason for the presence of coliforms in water sources as is evident in Figure 4. Other than the groundwater, the citizens depend on the water supplied to the households through piped supply by the KWA. Among the respondents, 5.56% depend on public taps. This is especially the case with the residents in the coastal belt, which is densely populated, and individual household connections are not available. Also, though there are households with open wells, saltwater intrusion forces them to depend on public tap for drinking water in the coastal belt. Concerning the quality of the drinking water, the respondents depending on the piped water supply found it aesthetically appealing, apart from a few who mentioned discoloration and chlorine smell. As for the groundwater, the major concern was salinity which was, however, confined to the respondents from the coastal belt. While studying the scarcity of water faced by households, 66.67% of households have never experienced water shortage. Moreover, those households that have experienced scarcity have experienced the same, particularly in the summer months (April–May), and are mostly located in the elevated areas of the city. As mentioned earlier, the abundance of rains from the southwest monsoons and also from

the retreating monsoons plays a major role in recharging the groundwater sources. Furthermore, Kozhikode Corporation currently receives water from two sources, namely 32 MLD from the Chaliyaar River and 76.4 MLD from the Peruvanamuzhi reservoir (KWA 2021). The individual data regarding the aspects surveyed are detailed in Table 5.

Any administrative body aims to provide resources and services to its citizens without scarcity and at the same time make it affordable to even the economically weaker sections of the society. With this aim, the urban bodies have been exploring new sources of water for supply to the cities. Similar is the case with Kozhikode. Very few respondents have, in their true sense, felt the scarcity of water. Even in the coastal belt, the citizens who depend on public taps responded that they had enough water for their usage. Such a mindset that water is abundant due to continuous availability through the piped water supply leads to a false perception of water abundance (Sheikh 2020). When citizens have access to multiple sources and low-priced water, they become water abundant. This tends to send the wrong message that water is ubiquitous (Hill & Symmonds 2011) and citizens fail to realize the need to conserve water. The second part of the survey led to the understanding that the majority of the citizens (76.67%) were unaware of the water resources in their locality or their status in terms of environmental health. Also, the awareness of the need of protecting the water resources, including the use of water recharge systems at the household level, was not known to the citizens and very few (11.67%) had attended any awareness programs on water and related sources. Even the scarcity of water during a few months of the year was not much of a motivation to learn and implement water conservation strategies. The scarcity is temporary, which is tackled using temporary solutions such as buying water from private players, and abundant rains provide water for a major part of the year. This has been human nature and has been pointed out by Sheikh (2020). A lack of awareness at the household levels, which is the foundation of the society, is alarming as the society will thus lack water literacy. This further expands the dangers as the citizens are not aware of, for example, the basic standards of drinking water standards and a very few (35.56%) have tested the quality of their water source recently. Although the tests done are low, traditional methods of water purification, such as boiling before consumption, still followed may be the reason for few incidents of water-borne diseases. Water illiteracy also contributes to very

Table 5 | Citizen response to questions relating to household water ($n = 180$)

	% response
Source of household water	
Open well	60
Piped household water supply	22.22
Open well + piped household water supply	10
Public taps	5.56
Community water supply	2.22
Quality of household water	
Satisfactory	82.22
Chlorine odor and taste	10
Discoloration	2.22
Salinity	2.78
Others (iron content, hardness, and foul odor)	3.33
Water scarcity	
Frequent	2.22
Occasional	29.44
Never	68.33
Frequency of water supply in the piped system	
Daily	89.47
Alternative days	7.37
Once in 3 days	1.05
Intermittently	2.11

Table 6 | Perception of citizens to water as a resource (*n* = 180)

	% response
Aware about local water resources and its quality	
Yes	23.33
No	76.67
Awareness programs on water	
Attended	11.67
Not attended	88.33
Conducted quality test of available water for domestic use	
Yes	35.56
No	64.44
Water purification method	
Boiling	44.44
Chlorination of open well + boiling	46.67
Filtration	7.78
No method adopted	1.11
Recharge systems	
Installed	3.89
Not installed	96.11
Aware about community-based programs	
Yes	5.6
No	94.4
Willing to take part in water-based activities	
Yes	66.11
No	33.89

few community-based efforts in water conservation and the like, as evident from the survey, in which only 5.6% of respondents were aware of any such programs in their locality. But on a positive note, many of the respondents were willing to take part in activities such as collecting data on water quality (66.11%) and making efforts to become water literate. Table 6 shows the detailed responses to the perception questionnaire of the survey.

CONCLUSION

The present study is a first step in providing a ‘citizen perspective’ and an insight into the existing drinking water quality status of Kozhikode city. The authors identified the common challenges in UWG and a comprehensive understanding of the current state of the city in terms of the quality of the water accessible to the public mainly through citizen’s perception and estimation of the WQI. Thus, to conclude,

1. From the WQI map, it is inferred that even though the majority of the population in Kozhikode Corporation has access to reliable water sources, there are vulnerable regions, especially at the core of the city, which have access to poor quality water, where further intervention is required. It also emphasizes the need to collect reliable data be collected on a real-time basis for effective intervention.
2. Since the majority of the households in the study area depends on the groundwater resources, responsible action must be taken to ensure the protection and sustainable use of groundwater resources and long-term governance of aquifer systems.
3. From the citizen’s perception, it is understood that the residents play a passive role in water quality governance – they are only considered as the consumers of the resources not contributors. The study also revealed that there is limited data sharing between the service providers and the citizens, thereby the water literacy of the people in the city is found to be poor.

4. To improve the existing scenario of water governance, there should be more interaction among the local bodies and the citizens through knowledge sharing. Citizens should be actively involved in decision-making, this can be done if citizens can be used as a source for collecting information at the ground level, and the study also indicated that the majority of people are interested to be a part of the collection of information.

Therefore, to improve the UWG, it is important to empower citizens, bridge the data gap, and interact with them through knowledge transfer making the system more transparent which will ultimately lead to a good water governance system in the city.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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