Qualitative perspectives on sustainable domestic water usage prospects from Ukkadam Periyakulam tank of Coimbatore City

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ABSTRACT

The premise that the water storage of the system tanks of Coimbatore City within its urban pockets for a partial domestic water supply alongside the primarily intended irrigation supplies needs to be scrutinized for quality standards. The present investigation on water quality indexing has revealed the perspective prospects for such schemes inasmuch as the prescribed quality ranges are not exceeded during rains and post rain periods. However, the domestic water usage warrants quality improvisations by possible filtration and disinfection treatments before distributions. The sustainability of such modified system tank water distribution has been critically analyzed. The qualitative assessment for sustainability was based on 9 identified parameters as suggested by Indian standards and World Health Organization. The overall quality index for both surface and ground water was reckoned in a gradation system of weightage range from 1 to 5, from less hazardous to severely hazardous status. The indices established the values in the moderate range of 2.3 to 3.8, suggesting the feasibility of quality sustained domestic water supplies in the urban zones of Coimbatore.

KEYWORDS

Water Quality Index, *domestic* usage, gradation, pre-monsoon and post monsoons.

1. INTRODUCTION

Surface water reserves such as the system tanks fed by a stream or river network, a non-system tank with its own catchment basin and subterranean aquifers embedded with dug wells and bore wells store the rainwater for the diversified usage in their vicinity. The distribution of water for the purposes of irrigation, domestic and industrial water supplies is executed in an ingenious way of roaster based rotational distribution through open channels and pipeline networks (Brown et al. 1970; Debels et al. 2005; Giridharan et al. 2010; Horton 1965). By and large, the system tanks created at various zones of Coimbatore (8Nos.) were primarily envisaged to cater to the irrigation needs of agricultural crops in their downstream command areas. However, over the past twenty years this scenario has undergone dramatic changes partly due to extensive urbanization and intensive industrialisation as well. Eventually the agricultural land area has diminished drastically and got converted into real estate pockets. In response to this impulse the agricultural needs also got decreased but the domestic and industrial water requirements got exponentially shotup. Hence the paradigm shift of transforming agricultural requirements of the water towards domestic water supplies has become inevitable. Mostly we resort to a conjunctive use of surface and groundwater storage that is also responsible for spatial and temporal water quality changes in accordance with the contaminant solute transport (Kannel et al. 2007; Sener et al. 2017; Subramani et al. 2005; Thomann and Muller 1987). However, a qualitative scrutiny of the water in storage and that reaching the groundwater aquifers is indispensible. Hence it could be impeccable if the existing water distribution schedule can be modified to suit the dominating domestic water needs compared to the barest minimum agricultural water requirements. By way of incorporating suitable mechanical filtration systems and disinfection schedules assured domestic water supplies at desirable quality level can be accomplished.

Besides, the sustainability of extracting and using both surface and groundwater from the system tank storage and dispersion zone shall have to be investigated. System tanks or non-system tanks do contribute to the aquifer recharge covering a certain radius of influence both on the downstream side and upstream side of storage indicated the well water level fluctuations (Chang et al. 2010; Graymore et al. 2009; Crossland et al. 1995; Varol et al. 2015). The present investigation was contemplated to include nodal point water samplings related to the surface storage of water in the tank and well water in the vicinity. This is construed as an essential pre-requisite in order to arrive at the water quality indices, representing range of less hazardous to severely hazardous status. Based on these quality indices the appropriate filtration and disinfection units can be designed.

2. FEATURES OF THE STUDY AREA

The Noyyal river stretch proliferating and meandering through Coimbatore region encompasses 21 Anaikuts and 31 Tanks, of which 8 system tanks are located within Coimbatore city urban viz.,, Narasampathi tank, Krisnampathi tank, Selvampathi tank, Kumarasamy tank, Selvasindhamani tank, Ukkadam periyakulam tank, Valankulam tank and Singanallur tank. The study was however limited only to Ukkadam periyakulam tank only (Fig.1) that is knitted to the downstream reach of the Noyyal River feeding where the concentrated dumping of pollutants and contaminants along the stream flows gushing into the tank water spread pose a severe threat on the surface and groundwater water qualities.

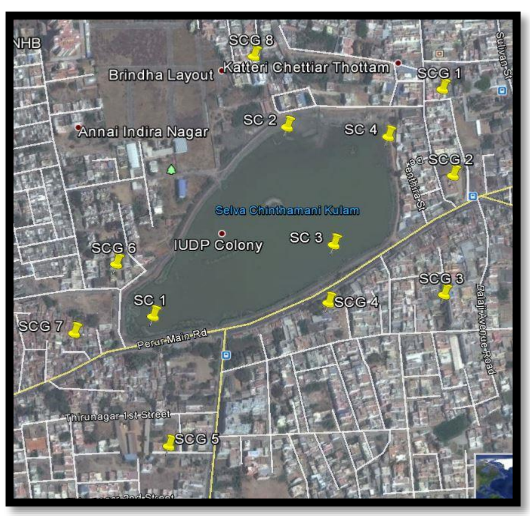

Fig.1 Ukkadam Periyakulam: water sampling nodes

3. METHODOLOGY

3.1. Methodology followed for WQI in the present investigation:

The Primary data collected includes the laboratory analysis results for the water samples collected along the stretch of the Ukkadam Periyakulam tank. Secondary data such as Rainfall data, Water quality data, Groundwater level data, Lithology data, and Aquifer parameters data were obtained from State Surface Water and Groundwater Board. Hence, the water quality monitoring is a significant process related to all our surface and groundwater resources in arriving at an evaluation indicator termed as the Water Quality Index (WQI) (Vasanthavigar et al. 2010; Romanelli et al. 2012; Simsek and Gunduz 2007; Moratalla et al. 2011; Karakaya and Evrendilek 2010; Kazi et al. 2009). By and large, the water quality indexing involves assignment of weights for specified quality ranges of the independent parameters that are going to result in an integrated change upon mutual interactions within the water body. For the present investigation four sampling sites were selected randomly by considering the domestic, agricultural and industrial factions. The ground water and surface water of the pre-monsoon/summer (March-June), monsoon (July-November) and post –monsoon (December-February) seasons were analyzed for various physico-chemical parameters in line with parametric considerations for 5 samples per parameter. The results were compared with the drinking water standards / guidelines by Indian Standards (IS 10500:2012) and World Health Organization (WHO 2008). The water quality indexing was done based on the weights affixed to these parameters and the overall index was taken as a weighted mean value of all the independent parametric water quality indices. The relative severity grading has been done on 1 to 5 grade scale in which <1 is hazard free or low, (>1to 2) is medium, (>2 to 3) is high, (>3 to 4) is severe and (>4 to 5) is critical.

4. RESULTS AND DISCUSSION

4.1. Lab Assessment on Water Quality Parameters:

Table 1 furnishes the Test result of mean parametric values for the ten surface and groundwater water samples at a given nodal spot during pre-monsoon season, monsoon season and post monsoon season in their customary units of measurement. The results were compared with the water utility guidelines of Indian Standard (IS 10500:2012).

The distinctive effects on physical and chemical characteristic variations between the monsoon season contaminant dumps and the post-monsoon season residuals were not so distinct. However, marked differences could be observed during the pre-monsoon water table depletion phase. As regards the colour and odour both surface and groundwater samples exhibited satisfactory appearance from clear to slight grey waters and not much of odour diffusion in the vicinity during the monsoon season and the variations were within the quality criteria as agreeable by the IS or WHO guidelines. Hence the weights for these two parameters were reckoned as unity without much error.

4.2 Water Quality Indices (WQI):

Barring the colour and odour remaining quantifiable parameters were assigned weights and the weighted mean values were used to get at the Water Quality Indices for both surface water and the groundwater samples collected from the nodal points in the vicinity of the tank under study. The hazard rate grading for all these parameters was restricted to a uniform weightage factor range of 1 to 5 as to the relative severity of contaminant impact status.

4.2.1. Parametric Water Quality Indexing (WQI) for Turbidity:

Table 1 summarizes the weighted mean values of the parametric pre-monsoon $(WQI)_t$ values for the surface water at 4.6 and that for the groundwater at 3.6. The same for monsoon quality rating were registered respectively at 3.8 and 3.2. The corresponding values for the post-monsoon sampling were found to be 3.2 for surface water and 2.5 for groundwater.

Table 1. Summary of Parametric Water Quality Indices

Parameter	**Pre - Monsoon**		**Monsoon**		**Post Monsoon**	
	Surface Water	***Ground Water***	***Surface Water***	***Ground Water***	***Surface Water***	***Ground Water***
Turbidity	4.6	3.6	3.8	3.2	3.2	2.5
Total Dissolved Salts	1.9	1.4	1	1	1	1
EC	2.8	1.8	1.2	1.1	1.3	1.8
pH	1.5	1.3	1	1	1	1
Total Alkalinity	4.5	3.9	3.4	3.1	4.5	3.1
Total Hardness	3.6	3.4	3.7	3.4	3.9	3.6
Chlorides	2.6	2.4	1.5	1.5	1.6	1.8
Sulphates	1	1	1	1	1	1
Dissolved Oxygen	5.2	5.2	4.3	4.2	5.4	5.1
Overall Index	3.15	2.75	2.35	2.32	2.42	2.31
Overall Hazard Rating	High to severe	Medium to high	Medium to High	Medium to High	Medium to High	Medium to High

4.2.2. Parametric Water Quality Indexing $(WQI)_s$ for Total Dissolved Solids (TDS):

Table 1. summarizes the weighted mean values of the parametric pre-monsoon $(WQI)_t$ values for the surface water at 1.9 and that for the groundwater at 1.4. The same for monsoon and post-monsoon quality rating were registered respectively at 1.

4.2.3. Parametric Water Quality Indexing (WQI) for Electrical Conductivity (EC):

By and large the level of contaminant concentration in domestic or irrigation or industrial waters are limited in the EC range of 3 to 15 mg/l.

Table 2. Rating and weight of EC

EC,mg/l	< 3	3 - 6	6 - 9	9 - 12	12 - 15
Hazard rating	low	medium	high	severe	critical
Weight	1	2	3	4	5

However, the tested values of turbidity were found to fluctuate from 2 to 6 mg/l close range. Hence, the weight ranges were stipulated as in Table 2.

On this gradation criterion, the WQI during pre-monsoon period was reckoned as 2.8 for surface water and 1.8 for groundwater. By the same token, during monsoon season the values of WQI were obtained as 1.2 for surface water and 1.1 for groundwater. However, during the post-monsoon season the WQI values were obtained as 1.3 for surface water and 1.8 for groundwater.

4.2.4. Parametric Water Quality Indexing $(WQI)_a$ for Total Alkalinity (TA):

Upon browsing through the tabulation the level of contaminant concentration in surface and groundwater sampling irrespective of the monsoon are contained well within the IS prescribed TA range of 200 - 600 mg/l.

Table 3. Rating and weight of TA

TA, mg/l	<200	200 – 300	300 – 400	400 - 500	> 500
Hazard rating	low	medium	high	severe	critical
Weight	1	2	3	4	5

However, the tested values of TA were found to fluctuate widely even within this relatively wider range. Hence, the weight ranges were stipulated as above in Table 3.

On this gradation criterion, the WQI during pre-monsoon period was reckoned as 4.5 for surface water and 3.9 for groundwater. By the same token, during monsoon season the values of WQI were obtained as 3.4 for surface water and 3.1 for groundwater. However, during the post-monsoon season the WQI values were obtained as 4.5 for surface water and 3.1 for groundwater.

4.2.5. Parametric Water Quality Indexing (WQI) for pH:

A perusal of the pH values from the tables suggests that the pH is well within the prescribed range of 6.5 to 8.5 as per IS or WHO guidelines in relation to the relative salinity/alkalinity/neutral levels. Hence, the parametric $(WQI)_{pH}$ is taken as 1 irrespective of the monsoon or post monsoon or pre-monsoon seasons for the surface and groundwater sampling.

4.2.6. Parametric Water Quality Indexing $(WQI)_h$ for Total Hardness (TH):

Even as during the monsoon rains and catchment inflows the surface and ground waters are getting softened, the receding water table during the post monsoon dry spells may again impart hardness to the fluctuating waters. The TH indexing is slightly deviating from TA, with the same permissible range of 200-600 mg/l. The observed test values of the samples are also showing a trend of variations similar to that of TA, but some sample values exceeding upto 900mg/l. The following weights were assigned to the classified sub-ranges as given in Table 4.

Table 4. Rating and weight of TH

TA, mg/l	<200	200 – 400	400 – 600	600 - 800	> 800
Hazard rating	low	medium	high	severe	critical
Weight	1	2	3	4	5

By this gradation criterion, the WQI during pre-monsoon period was reckoned as 3.6 for surface water and 3.4 for groundwater. By the same token, during monsoon season the values of WQI were obtained as 3.7 for surface water and 3.4 for groundwater. However, during the post-monsoon season the WQI values were obtained as 3.9 for surface water and 3.6 for groundwater.

4.2.7. Parametric Water Quality Indexing $(WQI)_{cl}$ for Chlorides (Cl):

Even as WHO sticks on to a limiting value of 250, IS 10500:2012 prescribes the permissible range from 250 to 1000 in units of mg/l. Hence, the following weights were assigned to the classified sub-ranges as shown in Table 5.

Table 5. Rating and weight of Cl

Cl, mg/l	<200	200 – 400	400 – 600	600 -800	> 800
Hazard rating	low	medium	high	severe	critical
Weight	1	2	3	4	5

Based on this gradation criterion, the WQI during pre-monsoon period was reckoned as 2.6 for surface water and 2.4 for groundwater. By the same token, during monsoon season the values of WQI were obtained as 1.5 for surface water and 1.5 for groundwater. However, during the post-monsoon season the WQI values were obtained as 1.6 for surface water and 1.8 for groundwater.

4.2.8. Parametric Water Quality Indexing $(WQI)_{sul}$ for Sulphate (SO_4):

While WHO suggests a limiting value of 500, IS 10500:2012 prescribes the range from 200 to 400 mg/l. A perusal onto the tabulated values for pre-monsoon, monsoon and post monsoon situations indicated less than 200mg/l only. Hence, the parametric water quality $(WQI)_{sul}$ in the study area confined is taken as 1 irrespective of surface or groundwater sampling

4.2.9. Parametric Water Quality Indexing $(WQI)_{do}$ for Dissolved Oxygen (DO):

According to Thomann and Miller (1987) the saturated solubility of Oxygen in water at 1 atm. pressure and an ambient temperature of 20°C is 9.09mg/l with zero chloride concentration. However, it is a bit red-signalling to observe that the contamination levels have impaired both surface and groundwater qualities with DO alarmingly less than 3 mg/l only irrespective of whether monsoon and post monsoon seasons. They have also prescribed optimum levels in the range of 5 mg/l to 8 mg/l for the survival base to fish and other water borne entities. Hence, the following weight factor distribution in the reverse grade order was made and shown in Table 6.

Table 6. Rating and weight of TA

DO, mg/l	<2	2 – 4	4 – 6	6 -8	> 8
Hazard rating	critical	severe	high	medium	low
Weight	5	4	3	2	1

On this gradation criterion, the WQI during pre-monsoon period could be reckoned around 5.2 for both surface water and groundwater. By the same token, during monsoon season the values of WQI were obtained as 4.3 for surface water and 4.2 for groundwater. However, during the post-monsoon season the WQI values were obtained as 5.4 for surface water and 5.1 for groundwater.

4.2.9.1. Parametric Water Quality Indexing $(WQI)_{bod}$ for 5 days Bio-chemical Oxygen Demand $(BOD)_5$:

The values of $(BOD)_5$ had been calculated from the DO values only for a dilution fraction of (10/300) with reference to the saturated DO at 9.09 mg/l. Hence this need not be included in arriving at the final WQI. However, parallel endorsement with this criterion is also mandatory from the pointofview of creating water treatment units and systems for quality restoration.

5. CONCLUSIONS

- Barring the colour and odour remaining quantifiable parameters were assigned weights and the weighted mean values were used to get at the Water Quality Indices for both surface water and groundwater samples collected from the nodal points in the vicinity of the tank under study. The hazard rate grading for all these parameters was restricted to a uniform weightage factor range of 1 to 5 as to the relative severity of contaminant impact status.
- For all the parameters taken into account the overall WQI values were found to be within the prescribed quality criterion ranges pertaining to medium to high status range of hazards requiring attention for amendments.
- By resorting to appropriate rainwater harvesting measures at the catchment level and incorporating suitable filtration and disinfection units or systems at the storage point, the hazards can be minimized and sustainability can be infused for prolonged domestic water supplies deviating from the primary irrigation distributions.
- It is also felt necessary that the temporal and spatial deoxygenation and reoxygenation status should be included in order to keep the stream flow contributing the storage water quality variations can be kept under control.

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