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Seasonal water quality indexing (WQI) on surface storage and subterranean dispersion at Ukkadam Periyakulam tank in Coimbatore City

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ABSTRACT

Water quality Indexing helps understand the impulse-response patterns of the water quality parametric changes in relation to the interconnectivity of rainfall-storage-dispersion at any multipurpose tank site. The pre-monsoon, monsoon and the post monsoon fluctuations in the values of water quality index parameters were analyzed in accordance with standard operating procedures.On an invariably uniform gradation range of 1 to 5 weightage, the mean water quality indices were found to be 2.25 to 2.64 for surface water and 2.06 to 2.17 for the ground water, spanning over the seasons. The overall hazard rating could be categorized under medium to high vulnerabilities. By these quality standards, perspective planning to improve upon the water quality in storage as well as under dispersion is to be devised. The prospects of in- situ treatments to control the contamination levels are to be explored through the strategic prospects for dilution by rainwater harvesting and the usage of appropriate filtration system to improvise upon physic- chemical water quality criteria. Eventually, the ecological buffering has been suggested around the tank system to keep off such maladies as eutrophication and deoxegenation resulting from point source and distributed pollution along the contributing system connecting the tank.

Key words : *Water Quality Index, eutrophication, deoxegenation, parametric changes, ecological buffering*

Introduction

Surface water reserves such as the tanks, ponds, lakes and groundwater aquifers drilled with bore wells and dug wells store the rainwater for the di- versified usage in the proximity viz., irrigation, drinking and industrial water supplies in an inge- nious way of rotational distribution through open channels and pipeline networks (Brown *et al.,* 1970). The urban and suburban pockets of Coimbatore City has been provided with eight PWD controlled system tanks originally intended for catering to the agricultural and allied irrigation needs in their sur- rounds (Vsanthavigar *et al.,* 2010). However, over the recent past decades this city has witnessed dras- tic changes by way of extensive urbanization and intensive industrialization coupled with intrusive migrations from rural areas for livelihood (Chang *et al.,* 2010). Consequently, the area under agriculture shrunk paving way for industrial estates, commer- cial complexes and dwelling enclaves thereby esca- lating the water requirements for industrial and do- mestic sectors rather than irrigation (Crossland *et al.,* 1995). Hence the paradigm shift of transforming ag- ricultural requirements of the water towards domes- tic water supplies has become inevitable. Mostly we resort to a conjunctive use of surface and groundwa- ter storage that is also responsible for spatial and

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temporal water quality variations. However, these changes have also brought in lot of point source and distributed pollutions in and around the water sources causing an ecological imbalance by way of eutrophication in storage ponds and de-oxygenation of the running streams (Gridharan *et al.,* 2010). Be- sides, percolations from surface storage as well as seepage from pollutant laden streams also have con- tributed for the subterranean groundwater contami- nations to greater extents. This situation necessitates revamping the quality criteria for domestic con- sumption and industrial usage getting diverted from the original irrigation planning. However, a qualitative scrutiny of the water in storage and that reaching the groundwater aquifers is indispensible (Greymore *et al.,* 2009). 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 suit- able mechanical filtration systems and disinfection schedules assured domestic water supplies at desir- able 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 inves- tigated. System tanks or non-system tanks do con- tribute to the aquifer recharge covering a certain ra- dius of influence both on the downstream side and upstream side of storage indicated the well water level fluctuations. Water Quality Indexing (WQI) is by far the best recognized quality control criterion to assess the suitability of untreated waters requiring filtration for multi-purpose usage (Debels *et al.,* 2005). 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 (Kakaraya and Evrendilek, 2010). This is construed as an essential pre-requisite in order to arrive at the water quality indices, repre- senting range of less hazardous to severely hazard- ous status (Kannel *et al.,* 2007). Based on these qual- ity indices the appropriate filtration and disinfection units can be designed.

Ecology plays a vital role in regulating the de- mand-supply equilibrium of all these sorts f water storage and distribution. Appropriate filtering units are to be designed in preventing the undesirable contaminants entering the streams or ultimately set- tling at the ponds or lakes triggering the chances for eutrophication and associated problems (Subramani *et al.,* 2005). With respect to these interdependent system tanks and the network of streams contribut- ing to the other non-system tanks detailed survey should be done for locating the treatment units as precaution before distribution. Disinfectant strategise shall also have to evolved for controlling the outbreak of diseases particularly during the monsoon rains contributing enormous storm water run-off as part of the distributed pollutions directly to stream flows and storage ponds (Voral and Davraz, 2015). Studies governing the de-oxygen- ation and re-aeration prospects along streams and the contaminant depositions at ponds need the Wa- ter Quality Indexing as an essential prerequisite (Horton, 1965). 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 Groundwa- ter Board (Romanelli *et al.,* 2012). Hence, the water quality monitoring is a significant process related to all our surface and groundwater resources in arriv- ing at an evaluation indicator termed as the Water Quality Index (WQI) (Sener *et al.,* 2017)

Methodology

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 re- lated to all our surface and groundwater resources in arriving at an evaluation indicator termed as the Water Quality Index (WQI) (Kazi *et al.,* 2009). By and large, the water quality indexing involves as- signment 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 con- sidering 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 paramet- ric considerations for 5 samples per parameter. The results were compared with the drinking water stan- dards / 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 in- dices (Simsek and Gunduz, 2007). The relative se- verity 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.

Results and Discussion

Lab Assessment on Water Quality Parameters

Table 3.1.1,3.1.2,3.1.3 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 physio-chemical charac- teristic variations between the monsoon season con- taminant dumps and the post-monsoon season re- siduals were not so distinct. However, marked dif- ferences 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 agree- able by the IS or WHO guidelines. Hence the weights for these two parameters were reckoned as unity without much error.

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.

Parametric Water Quality Indexing (WQI) for Turbidity

Table 3.1.1,3.1.2,3.1.3 summarizes the weighted mean values of the parametric pre-monsoon (WQI) values for the surface water at 3.4 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 (Pre-Monsoon)

S. No.	Parameter	Surface Water	Ground water
1	Turbidity	3.4	3.6
2	Total Dissolved Salts	1.2	1.4
3	EC	2.1	1.8
4	pH	1	1
5	Total Alkalinity	4.1	3.9
6	Total Hardness	3.5	3.4
7	Chlorides	2	2.4
8	Sulphates	1	1
9	Dissolved Oxygen	5	5.2
	Overall Index	2.64	2.06
	Overall Hazard Rating	High to severe	Medium to high

Table 2. Summary of Parametric Water Quality Indices (Monsoon)

S. No.	Parameter	Surface Water	Ground water
1	Turbidity	3.8	3.2
2	Total Dissolved Salts	1	1
3	EC	1.2	1.1
4	pH	1	1
5	Total Alkalinity	3.4	3.1
6	Total Hardness	3.7	3.4
7	Chlorides	1.5	1.5
8	Sulphates	1	1
9	Dissolved Oxygen	4.3	4.2
	Overall Index	2.25	2.17
	Overall Hazard Rating	Medium to High	Medium to High

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

Table 3.1.1,3.1.2,3.1.3 summarizes the weighted mean values of the parametric pre-monsoon $(WQI)_t$ values for the surface water at 1.2 and that for the groundwater at 1.4. The same for monsoon and post-monson quality rating were registered respec- tively at 1.

Table 3. Summary of Parametric Water Quality Indices (Post-Monsoon)

S. No.	Parameter	Surface Water	Ground water
1	Turbidity	3.2	2.5
2	Total Dissolved Salts	1	1
3	EC	1.3	1.8
4	pH	1	1
5	Total Alkalinity	4.5	3.1
6	Total Hardness	3.9	3.6
7	Chlorides	1.6	1.8
8	Sulphates	1	1
9	Dissolved Oxygen	5.4	5.1
	Overall Index	2.4	2.06
	Overall Hazard Rating	Medium High	Medium to to High

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 lim- ited in the EC range of 3 to 15 mg/L. 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 follows:

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

On this gradation criterion, the WQI during pre-monsoon period was reckoned as 2.1 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 ground- water. However, during the post-monsoon season the WQI values were obtained as 1.3 for surface water and 1.8 for groundwater.

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 sea- sons for the surface and groundwater sampling.

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

Upon browsing through the tabulation the level of contaminant concentration in surface and ground- water sampling irrespective of the monsoon are con- tained well within the IS prescribed TA range of 200 - 600 mg/l. However, the tested values of TA were found to fluctuate widely even within this relatively wider range. Hence, the weight ranges were stipu- lated as follows:

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

On this gradation criterion, the WQI during pre-monsoon period was reckoned as 4.1 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 ground- water. However, during the post-monsoon season the WQI values were obtained as 4.5 for surface water and 3.1 for groundwater.

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 simi- lar to that of TA, but some sample values exceeding upto 900 mg/L.

TH, 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 3.5 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.

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:

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 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 ground- water. However, during the post-monsoon season the WQI values were obtained as 1.6 for surface water and 1.8 for groundwater.

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-mon- soon, monsoon and post monsoon situations indi- cated 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 .

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

According to Thomann and Miller (1987) the satu- rated solubility of Oxygen in water at 1 atm. pres- sure 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 re- verse grade order was made:

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 was reckoned as 5 for surface wa- ter and 5.2 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. How-ever, during the post-monsoon season the WQI val- ues were obtained as 5.4 for surface water and 5.1 for groundwater.

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.

Conclusions

- Barring the colour and odour remaining quanti- fiable 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 pa- rameters 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 requir- ing attention for amendments.
- By resorting to appropriate rainwater harvesting measures at the catchment level and incorporat- ing suitable filtration and disinfection systems at the storage point, the hazards can be minimized and sustainability can be infused for prolonged domestic water supplies deviating from the pri- mary irrigation distributions.

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