SURFACE WATER (WETLANDS) QUALITY ASSESSMENT IN COIMBATORE (INDIA) BASED ON NATIONAL SANITATION FOUNDATION WATER QUALITY INDEX (NSF WQI)

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Abstract. All Water quality index (WQI) is a unique rating to depict the overall water quality status in a single term to address the issues. The present work aims at assessing the water quality in terms of National Sanitation Foundation Water Quality Index [NSF WQI] in the four wetlands namely Ukkadam, Kurichi, Singanallur and Perur in Coimbatore, India. The surface water samples were subjected to compressive physio-chemical analysis. For calculation of NSFWQI nine parameters, DO, FC, BOD, pH, Phosphate, Nitrate, Turbidity, Total Solids and Temperature were considered. It is apparent from NSFWQI values that surface water in Ukkadam wetland falls under bad category. The water quality in Kurichi, Singanallur and Perur belongs to medium category.

Key Words: Surface Water, Wetlands, Water Quality, NSFWQI, Coimbatore.

1. Introduction
Water is the basic component of economic and social infrastructure and is vital for healthy society and sustainable development. River, wetlands, ponds and other water bodies have played a vital role in the human development. Nowadays wetland natural resources receives waste water and urban runoff and are under massive pressure due to pollution, dumping of waste and urbanization. Lakes and wetlands, valued for their water resources, groundwater recharges and habitats of wide range of fauna and flora, are facing erratic degrees of pressure and consequent fall in ecological goods and services they offer. Such degradation is caused by the urban, industrial and agricultural effluent discharges and hydrogeomorphic changes of canals and river linking these lakes (Prusty et al. 2010). The pollutants such as oxygen-demanding organic pollutants, nutrients and heavy metal to siltation, play a major role in the degradation of wetlands. These pollutants affect their auto regulating capacity, buffering capacity and biotic inhabitants (Rachna et al. 2010). Wetlands located in the within the cities undergo rapid degradation due to various factors related to city development, waste dumping, effluent discharges from industries and local bodies, and change in land use pattern. Coimbatore is the second largest city of the state, one of the most industrialized cities in Tamil Nadu, known as the textile capital of South India or the Manchester of the South India, the city is situated on the banks of the
river Noyyal. Many wetlands were dug around the Coimbatore city in ancient times to reserve the water from Noyal river. There are around 24 wetlands in and around the city which are largely fed by the Noyal river. These wetlands serve as system tanks and are main recharge sites of groundwater. In a municipal ecosystem, these wetlands remain the major life-supporting element with high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species. The Coimbatore urban wetlands harbor more than 125 species of resident and migratory birds, with August – October being the peak season. Spot-billed Pelican, Painted Stork, Open Billed Stork, Ibis, Spot-billed Duck, Teal, Black Winged Stilt are a few species of the migratory visitors (Murali et al. 2013). Regardless of the ecological services offered by these wetlands, many of them are under pressure due to pollution. The present study was undertaken to compute the WQI of four wetlands situated in Coimbatore and highlight its importance as a tool to assist policy makers and NGOs to strategize actions which can lead to improvements in environmental conditions of the lakes.

2. Materials and Methods
Coimbatore also known as Kovai is an important city in the South India is located between 10055’ N and 76050’E at an altitude of 410 m approximately. Four wetlands were selected during January 2019 to carry out our work. Sampling stations (Figure 1) include four locations each at the Ukkadam wetland (L1), Kuruchi wetland (L2), Singanallur wetland (L3) and Perur wetland (L4).

![Figure 1. Sampling Locations](image)

Ukkadam wetland (L1) having the largest water spread area, takes a registered ayacut of 231 acres in the catchment area of 1.90 sq. km is situated close to bus stand and fish market. The full lake level is 14.8m. The area is extremely urbanized and receives municipal and industrial sewage. Earlier the solid waste were dumped here, but now the lake is protected by a boundary wall. The Ukkadam wetland, is known to attract several migratory birds. Kurichi wetland (L2) has a registered ayacut of 452 acres in the catchment area, 6.272 sq. km of free and 12.162 sq.km of combined area. This wetland holds the least water storage capacity because of its shallowness. This wetland receives municipal sewage and is a site for garbage dumping from inhabitations around the locality. Singanallur lake has a Wetland (L3)
spread over an area of 1.153 sq. km. The capacity of the lake is 1.48 Mm³. The registered irrigated area is 337.1 ha. The lake is partly affected with eutrophication on the northern side. This lake was earlier used for recreational boating, but due to the discharge of domestic waste, it was affected with eutrophication, and now the boathouse has shut off its working. Perur wetland (L4) is located in the village Perur. It has a registered ayacut of 866 acres in the catchment area, 2.227sq. km of free and 5.888 sq. km of combined area. The full lake level is 14.8m. The lake is surrounded by small villages and agricultural lands. All these wetlands supports flora and fauna in diverse.

Water samples from wetlands were collected from five locations in pre-cleaned bottles and transferred to the ice box after labelling. The samples were taken to the laboratory and analysed immediately. Hydrogen ion concentration (pH), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Calcium (Ca²⁺), Magnesium (Mg²⁺), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Sodium (Na⁺), Potassium (K⁺), Chloride (Cl⁻), Sulphate (SO₄²⁻), Nitrate (NO₃⁻), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb), and Copper (Cu) concentrations were analyzed as per the standard procedure of American Public Health Association (APHA 1995) and Trivedy and Goel (1986).

3. Water Quality Index (WQI)
A water quality index provides a single number (grade) that expresses overall water quality at a certain location and time based on several water quality parameters. WQIs is a simple and powerful method to evaluate water quality status in water bodies that allows the changes in water quality over time and space to be examined (Roohollah Noori, 2019). Since, Horton (1965) proposed the first WQI, several other indices have been formulated. Different WQIs such as the National Sanitation Foundation WQI (NSFWQI) (Brown et al., 1970), the British Columbia WQI (Zandbergen and Hall, 1998), and the original Oregon WQI (Cude,2001), Bhargava method (Bhargava, 1983), Canadian Council of Ministers of Environment (CCME) WQI (CCME, 2001), Overall Index of Pollution (Sargaonkar & Deshpande, 2003) have been developed. The NSFWQI is an important technique for classification of surface water based on their water quality parameters. This index consists of nine parameters including percentage of dissolved oxygen (DO) saturation, pH, total solids (TS), biochemical oxygen demand (BOD5), turbidity (Turb), total phosphate (TP), nitrate (NO3), temperature change (T), and fecal coliform (FC). Each of these parameters has an individual weight proportional to their impact and importance in the development of the NSFWQI model (Brown et al., 1970). Results obtained from tests on these nine parameters are transferred to a weighting curve chart where a numerical value (Q-value) is obtained. Then for each parameter, the Q-value is multiplied by a weighting factor which is based on the significance of the particular parameter in determining the water quality (Table 1). The sum of all weights used for determining the WQI is 1. The nine resulting values are then added to arrive at an overall WQI. The highest score a water body can receive is 100. Quality of water in a surface water body is categorized from bad to excellent depending on the WQI score. Mathematically NSF WQI can be represented as:

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\text{NSFWQI} = \sum_{i=1}^{p} W_i I_i
\]

where, \(I_i\) is the subindex (Q-value) for the ith water quality parameter, \(W_i\) is the weight (in terms of importance) associated with the water quality parameter and \(p\) is the number of water quality parameters.
Table 1. NSF WQI parameters and assigned weights (Brown et al, 1970).

| No. | Parameter       | Desirable Unit | Weight assigned |
|-----|----------------|----------------|-----------------|
| 1   | DO             | % Saturation   | 0.17            |
| 2   | FC             | Colonies/100 ml| 0.16            |
| 3   | pH             | -              | 0.11            |
| 4   | BOD            | mg/l or ppm    | 0.11            |
| 5   | Temperature    | °C             | 0.10            |
| 6   | Total Phosphates| mg/l or ppm   | 0.10            |
| 7   | Nitrates       | mg/l or ppm    | 0.10            |
| 8   | Turbidity      | NTU            | 0.08            |
| 9   | Total Solids   | mg/l or ppm    | 0.07            |
|     | Overall Weight |                | 1.00            |

4. Results and Discussions

The results of physio-chemical analysis of water are presented in Table 2. The water quality parameters of selected wetlands shows a varied relative pollution and urbanization in its surroundings. The pH value of water collected from wetlands varied between 7.50 to 8.60, which is possibly related to the human activities as well as natural processes such as groundwater leaching the carbonate minerals (Rachan et al. 2009). The highest pH was observed in Ukkadam (L1), which exceeds the WHO (1997) permissible limits (6.5-8.5). The rise in pH level indicates increased pollution level in Ukkadam wetland. The total solids in the selected samples varied between 541 mg/l to 1242 mg/l respectively. This parameter is seen to be highest in Ukkadam (L1) and Singanallur (L3) wetlands. The high total solid concentration is due to discharge of wastewater from industries into the water bodies. Dissolved Oxygen level was found to vary from 4.80 to 5.80 mg/l. The lowest value was observed in Kuruchi wetland (L2). The discharge of sewage from the surroundings have led to low DO content. BOD in water varied from 3.82 to 5.20 mg/l. BOD was highest in Kurichi wetland (L2). BOD value of 1-5 mg/l exhibits moderate water quality. The faecal coliform (FC) in the wetland samples ranged from 85 to 150 Colonies/100ml. The highest was recorded in Kurichi wetland (L2). The faecal coliform of 10 colonies/100ml and above reveals the poor water quality. Higher FC values show free flow of sewage into the wetlands and illegal dumping of septage. The nutrients phosphate and nitrate were in the rage of 1.40 to 2.20 mg/l and 3.35 to 5 mg/l respectively. The high phosphate and nitrate values were recorded in Ukkadam (L1) and Perur (L4) wetlands respectively. Phosphate concentration in clean water ranges from 0.01 to 0.1 mg/l. The results shows high concentration of phosphate in all wetlands. The nutrient loading are primarily from agricultural runoff, animal waste and discharge of sewage in wetlands. The augmented concentration of phosphate and nitrates in wetlands resulted in enhanced phytoplankton productivity (Jeyaraj et al. 2016). Turbidity in wetlands ranged between 7.50 to 13.50 NTU, Ukkadam wetland (L1) recorded the highest value. The permissible limit specified by WHO (1997) is 5 NTU. The results shows high value of turbidity in all wetlands.
Table 2. Physio-chemical parameters of the wetlands studied

| Parameters               | Ukkadam (L1) | Kuruchi (L2) | Singanallur (L3) | Perur (L4) |
|--------------------------|--------------|--------------|------------------|------------|
| DO (mg/l)                | 5.10         | 4.80         | 5.30             | 5.80       |
| FC (Colonies/100 ml)     | 135          | 150          | 85               | 90         |
| pH                       | 8.60         | 7.67         | 7.77             | 7.50       |
| BOD (mg/l)               | 4.00         | 5.20         | 3.82             | 4.50       |
| Temperature (°C)         | 30.5         | 30           | 30               | 28.8       |
| Total Phosphates (mg/l)  | 2.20         | 1.40         | 2.10             | 1.80       |
| Nitrates (mg/l)          | 4.75         | 3.35         | 4.20             | 5.00       |
| Turbidity (NTU)          | 13.50        | 9.20         | 11.40            | 7.50       |
| Total Solids (mg/l)      | 1242         | 646          | 1010             | 541        |

4.1. WQI Assessment

Based on the results of the water quality parameters, the NSFWQI index was computed for four wetlands in Coimbatore. Table 3 presents the wetland wise Q or Quality value range of the nine parameters. These Q-values were estimated by converting the observed concentration value of each parameter using the online tool developed by NSF. The Q-values were then multiplied by a weighting factor (Table 1) to get the WQI for a particular parameter. The WQI for each parameter was then summed up to get the overall WQI for four wetlands which is presented in Table 4.

Based on the index value, water quality is categorized as: excellent (91–100), good (71–90), medium (51–70), bad (26–50) and very bad (0–25). The highest value was observed in Perur (L4) wetland and the lowest value at Ukkadam (L1) wetland. The water quality in Ukkadam wetland falls in bad category and other three wetlands namely Kurichi (L2), Singanallur (L3) and Perur (L4) fall under medium category. However, the NSFWQI obtained for the wetlands clearly indicates that the water quality is poor.

Table 3. Q Values of the wetlands studied

| Parameters               | Ukkadam (L1) | Kuruchi (L2) | Singanallur (L3) | Perur (L4) |
|--------------------------|--------------|--------------|------------------|------------|
| DO (% Saturation)        | 60           | 55           | 64               | 75         |
| FC (Colonies/100 ml)     | 41           | 40           | 46               | 45         |
| pH                       | 63           | 91           | 90               | 93         |
| BOD (mg/l)               | 61           | 55           | 62               | 58         |
| Temperature (°C)         | 10           | 10           | 10               | 11         |
| Total Phosphates (mg/l)  | 26           | 33           | 26               | 29         |
| Nitrates (mg/l)          | 66           | 83           | 69               | 65         |
| Turbidity (NTU)          | 69           | 78           | 73               | 81         |
| Total Solids (mg/l)      | 20           | 20           | 20               | 20         |
Table 4. Summary of NSFWQI

| Wetland       | NSF WQI |
|---------------|---------|
| Ukkadam (L1)  | 48      |
| Kuruchi (L2)  | 52      |
| Singanallur (L3) | 53   |
| Perur (L4)    | 55      |

5. Conclusion

Wetland ecosystems are important in supporting diverse and distinctive habitats, speeded across various parts of Coimbatore district. They play a vital part of hydrological cycle and are highly productive systems in their natural forms. In Coimbatore, wetlands play an important role for irrigation, fisheries, recreation and recharge of groundwater. Wetland management has received insufficient attention in the water sector agenda at national, state and regional level. Wetlands in Coimbatore are subjected to anthropogenic pressures and quality of water is deteriorating. The assessment of individual water quality parameters covering a numerous factors is often not possible due to cost and time restrictions. Water Quality Indices consider several parameters simultaneously, and are often a more suitable tool for the assessment of water quality. Therefore, this study aimed to investigate the water quality of four lakes in Coimbatore using NSFWQI. The current study shown that water quality in all wetlands are of poor quality. The poor WQI in Ukkadam, Kurichi, and Singanallur wetlands are mainly due to discharge of domestic and industrial wastes into the lakes. The underground sewerage system in the city is not maintained properly and in many areas it was absent, hence both domestic and industrial wastes, reaches the wetlands. Installation of combined sewage treatment plant may reduce pollution loads to wetlands.

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