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# Effect of Textile and Dye Industrial Pollution on Irrigation Water Quality of Noyyal River Basin of Tamil Nadu

**K.M. Sellamuthu*, C. Mayilswami, A. Valliammai and S. Chellamuthu**
Water Technology Centre
Tamil Nadu Agricultural University, Coimbatore-641 003

**CTo assess the quality of ground water and its suitability for irrigation, a study was carried out during pre and post monsoon seasons of 2006-2007. In the present study, the ground water samples from open wells, bore wells and dug cum bore wells were collected in the Noyyal river basin that encompasses the urban and industrial stretch of Tirupur. The values of EC ranged from 0.41 to 15.95 dSm$^{-1}$ and pH ranged from 7.61 to 8.61. Sodium dominated among the cations and chloride among the anions. The sequence of cations found to be $Na^+$ >$Mg^{2+}$ >$Ca^{2+}$ >$K^+$ and anions followed the sequence of $Cl^-$ > $SO_4^{2-}$ >$HCO_3^-$ >$CO_3^{2-}$. Salinity and sodicity classes were assessed as per Richards (1969). Very high salinity category (C4) dominated (56.90 per cent) and low sodium ($S_1$class) (74.14 per cent) category recorded the major classes of salinity and sodicity respectively. Residual sodium carbonate and Residual Sodium Bicarbonate content classified under satisfactory with 68.9 per cent (<1.25 m.e L$^{-1}$) and 87.93 per cent (<5 m.e L$^{-1}$) respectively. Classification of the samples based on salinity and SAR indicated that 68.97 per cent of samples did not pose infiltration problem to the soils and 31.03 per cent will result in slight to moderate infiltration due to irrigation. It was found that 50 per cent of samples having slight to moderate (0.7 t0 3.0 dSm$^{-1}$) salinity problem followed by 43.01 per cent under severe salinity (>3.0 dSm$^{-1}$). Sodium and chloride toxicity were found in majority of the samples. Slight to moderate toxicity of sodium (SAR>9) was recorded by 67.24 per cent of samples which may cause accumulation of sodium over a long period.**

**Key words**: Irrigation water quality, Noyyal river basin, Tamil Nadu.

Water used for irrigation may vary greatly in quality aspects depending upon type and quantity of dissolved salts. Salts present in irrigation water may be of small but it will add significant amount of salt load to the irrigated fields. The suitability of water for irrigation is determined not only by the total amount of salt present but also by the kind of salt present in the irrigation water.

Deterioration of irrigation water quality is mainly anthropogenic through variety of industries. In India only 24 per cent of wastewater is treated (primary only) before use in agriculture and disposal into rivers (Minhas and Samra, 2004). Contamination of the river has increasingly become a serious problem in many of the river basins of the State. River basins like Palar, Tamirabarani, Cauvery, Noyyal, Bhavani and Amaravathy face serious pollution problems due to industrial effluents. There are about 10,000 garment manufacturers and 2100 bleaching and dyeing industries in India. Majority of them concentrated in the states of Tamil Nadu, Punjab and Gujarat. An estimate shows that textiles account for 14% of India's industrial production and around 27 per cent of its export earnings (Ministry of Textiles, 2004). Many textile processing units in Tamil Nadu use a number of unclassified chemicals that are likely to be from the Red List Group which is said to be harmful and unhealthy (Ravikumar and Dutta, 1996). Balakrishnan *et al.* (2008) observed that there is no immediate threat for irrigation water quality due to dyeing and printing of textile industry of Kancheepuram but increase in salinity, sodicity, and presence of heavy metals like mercury, arsenic, lead and chromium in groundwater found to pose significant threat to the consumers.

The Noyyal river is the major source for irrigation, drinking water and other activities of the people living on both sides of the river. This river is the only source for around 30 tanks, 20 minor canals and two reservoirs in the river basin irrigating about 14,700 ha of land (Govindarajalu, 2003). The industrial effluent released by dyeing and bleaching factories in Tirupur, a major hosiery centre in South India, has become a serious issue because it has had severe impact on water bodies. The Noyyal River, a seasonal river, is a tributary of the Cauvery River passes through Tirupur. Tirupur has more than 9319 hosiery and garment industries and 702 processing industries which discharge about 83.1 million litres per day of effluent into the Noyyal river and

*Corresponding author email: kmsella75@yahoo.com

accumulate in the Orathupalayam dam located 30km downstream of Tirupur Nelliayat (2005). Sodium and chloride are the dominating ions due to the main chemicals used in the cotton processing *viz.*, sodium hydroxide, sodium hypochlorite, sodium sulphide, hydrochloric acid etc. with an yearly input of chloride to the Noyyal basin in the order of 23 g $m^{-2}$ (equivalent amount of sodium chloride) and about 60 per cent of this emanates from the production of knitwear in the town of Tirupur (Jacks *et al.,* 1994).

Though there are proper regulations for effluents from industries, surface and groundwater is receiving partially treated or untreated effluents from the various sources. After semi-treatment or without treatment, the effluents are released into Noyyal river at various points. Jacks *et al.* (1994) have observed an increase in TDS concentration due to accumulation of sodium chloride in Orathupalayam dam and possible impact on Sodium Adsorption Ratio of ground water. Kristina Furn (2004) studied the water and soil quality changes due to polluted water in Orathupalayam dam area and reported EC values up to 18.3 $dSm^{-1}$. Ramesh Mathan, (2006) evaluated the groundwater quality of Orathupalyam dam and found high level of salinity, sodium, BOD, COD and chloride. Though there are variety of industrial pollution led to degradation of groundwater quality of Noyyal river, textile, dyeing and bleaching industries located in the banks of the river and clusters in other areas of the basin found to cause the major source of pollution. Hence, an assessment of irrigation water quality was made during 2006-2007 (Aug. 2006, Dec. 2006, Apr. 2007 and Sept. 2007) to evaluate the irrigation water quality parameters in Noyyal river basin.

## Materials and Methods

***Study area***

In Tamil Nadu, there are about 34 river basins, which are grouped into 17 major river basins, all are flowing eastwards from the Western Ghats and Deccan Plateau. Out of 17 river basins, many basins are water deficient and some have surplus water (ENVIS, 2007). The major and minor rivers flowing in Tamil Nadu were the major source for surface and ground water. The Noyyal river basin is located between latitude of 10º56' and 11º19' N and longitude of 76º41' and 77º56' E. The Noyyal river originates at the Vellingiri hills in Western Ghats and passes through the Coimbatore, Erode, Tirupur and Karur district in Tamil Nadu and confluences with river Cauvery at Kodumudi. It flows over a distance of 170 kilometers with the catchment area 3510 $km^2$ (Sankararaaj *et al.,* 2002). The area is characterized by an undulating topography with a gentle slope from west to east. Open wells, dug cum bore wells and bore wells are the groundwater extraction structures in the area. The general gradient of water table in the area is 2.2 m $km^{-1}$ towards East.

## Methodology

Fifty eight water samples were collected from open wells, dug cum bore wells and bore wells and analysed for various chemical parameters. The water samples were analysed for quality parameters as per the standard procedure given by Richards (1969). Heavy metals were analysed for total elements and estimated in Atomic Absorption spectrometer (GBC make). Classification of quality of irrigation water was done as per standard procedures. Residual Sodium Carbonate (RSC) was classified as per Eaton (1950) and Wilcox, *et. al.* (1954) and salinity and sodicity classes were classified as per Richards (1969). Residual Sodium Bicarbonate was calculated and classified based on Gupta and Gupta (1987). The results were also interpreted as per Ayers and Westcot (1994) where the quality of irrigation water based interpreted on the degree of salinity, salinity and SAR to judge infiltration problems on soils and toxicity of ions.

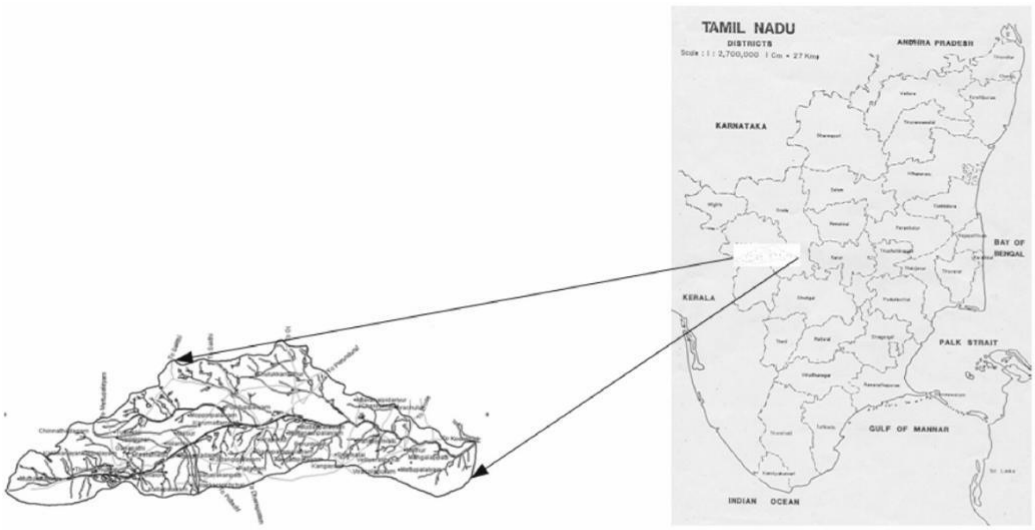


**Fig.1. Locations of water sampling in the Noyyal basin**

*EC and Sodium Adsorption Ratio (SAR)*

EC and SAR were classified based on salinity and sodicity classes as per Richards (1969). SAR is calculated as follows.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Where $Na^+$, $Ca^{2+}$, $Mg^{2+}$ are concentrations of respective ions in m.e $L^{-1}$

*Sodium to calcium activity ratio (SCAR)*

Application of SAR to groups of waters with EC >5 $dSm^{-1}$ and Mg/Ca >1 is questionable and for higher EC waters, SAR is calculated as Na / $Ca^{2+}$ and expressed as sodium to calcium activity ratio would perhaps better correlated with ESP of irrigated soils (Gupta and Gupta, 1987). Critical limits for SAR and SCAR remains the same.

*Residual Sodium Carbonate (RSC)*

RSC was calculated as per Eaton (1950).

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

Where $CO_3^{2-}$, $HCO_3^-$, $Ca^{2+}$, $Mg^{2+}$ are concentrations of respective ions in m.e $L^{-1}$.

Wilcox *et. al*, (1954) classified the water based on RSC values as Satisfactory (< 1.25 me $L^{-1}$), Marginal (1.25 - 2.5 me $L^{-1}$) and Unsatisfactory (> 2.5 me $L^{-1}$).

*Residual Sodium Bicarbonate (RSBC)*

RSBC was calculated as $HCO_3$ - Ca and classified as satisfactory (< 5 me $L^{-1}$), marginal (5-10 me $L^{-1}$) and unsatisfactory (> 10 me $L^{-1}$) as per Gupta, (1983). When rainfall is appreciable, the effective salt balance is zero. High values of EC and SAR would reduce the suggested permissible limits. Higher water table and poor drainage which may also reduce the permissible limits.

*Permeability index*

Permeability index or Doneen's Permeability Index was calculated as per Doneen, (1966) as follows.

$$\text{Permeability Index} = \frac{Na^+ + (HCO_3^-)^{1/2}}{Ca^{2+} + Mg^{2+} + Na^+} \times 100$$

Where $HCO_3^-$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$ are concentrations of respective ions in m.e $L^{-1}$.

The index varies with soils having different initial permeability.

*Magnesium hazard*

Magnesium hazard was calculated by $Mg^{2+}$ to $Ca^{2+}$ ratio (Richards, 1969). If the value is <1.0, classified under non hazardous and the value exceeds 1.0 will cause magnesium hazard.

*Puri's Salt Index*

Puri (1949) established an index to interpret quality of irrigation water. The value varies from -24.5 to 0 for good waters and 0 to + ve for poor quality waters.

PSI = (Total $Na^+$ -24.5) - ((Total Ca-calcium in $CaCO_3$) x 4.85)

## Results and discussion

*EC and pH*

The values of EC ranged from 0.41 to 15.95 $dSm^{-1}$. The highest value of EC was observed at Padiyur, near Anaipalayam. The pH values ranged from 7.61 to 8.61, maximum value was noticed at Muthur. Salinity found to be the major problem in the basin. Movement of salts along the recharge of waste waters lead to salinisation of ground waters.

*Soluble anions*

$CO_3^{2-}$ content varied from 0.28 to 7.77 m.e $L^{-1}$. Bicarbonate content ranged between 2.2 to 11.65 m.e $L^{-1}$. The highest values of carbonate and bicarbonate were noticed at Arthanaripalyam. $Cl^-$ concentration varied from 1.83 to 123.66 m.e $L^{-1}$. $SO_4^{2-}$ concentration varied from 0.53 to 46.55 m.e $L^{-1}$. The highest $SO_4^{2-}$content was noticed at Neelambur and $Cl^-$ at Padiyur. Accumulation of $Cl^-$e was noticed between Tirupur and Orathuplayam dam. The sequence of anions followed the order of $Cl^- > SO_4^{2-} > HCO_3^- > CO_3^{2-}$.

*Soluble cations*

$Na^+$ concentration in the water samples ranged from 2.01 to 114.0 m.e $L^{-1}$. $Na^+$ content of the water samples varied between 0.15 and 16.35 m.e $L^{-1}$. The highest values of $K^+$ was observed at Padiyur and potassium at Chinnapidariyur. $Ca^{2+}$ content of water samples ranged from 0.56 to 22.4 m.e $L^{-1}$. $Mg^{2+}$ concentration in water samples ranged from 1.03 to 29.68 m.e $L^{-1}$. The highest value of $Ca^{2+}$ was recorded at Orathupalayam and magnesium at Padiyur. The sequence of cations found to be in the order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$.

*Heavy metals*

Heavy metals like Fe, Zn, Cu, Mn, Pb, Ni and Co were estimated (Table 5) in selected wells. The results revealed that Fe, Mn, Ni and Co concentration ranged from 2.8 to 4.4 $\mu gmL^{-1}$ , 0.1 to 0.5 $\mu gmL^{-1}$, 0.1 to 1.0 $\mu gmL^{-1}$ and 0.1 to 0.2 $\mu gmL^{-1}$ respectively. Other heavy metals were below detectable limits. The highest concentration of Fe concentration was observed at Padiyur and Ni at Veerapandi (Tirupur).

*Classification of quality of irrigation water*

The classification of quality of irrigation water is presented in Table 1-4.

*Salinity*

Salts contribute to salinity problem in soil are water soluble and readily transported by water. Accumulated salts during the previous irrigations

**Table 1. Results of analysis of irrigation water (Mean values of Aug. 2006, Dec. 2006, Apr. 2007 and Sept. 2007)**

| | | | Soluble anions (m.e. $L^{-1}$) | | | | Soluble cations (m.e. $L^{-1}$) | | | | Puri's Salt index | RSBC | RSC | Mg/Ca | SAR/ SCAR | Permeability index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sa. No | EC ($dSm^{-1}$) | pH | $CO_3^{--}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{--}$ | $Na^+$ | $K^+$ | $Ca^{++}$ | $Mg^{++}$ | (m.e $L^{-1}$) | (m.e $L^{-1}$) | (m.e $L^{-1}$) | | | % |
| 1 | 1.07 | 8.43 | 1.66 | 3.85 | 5.32 | 1.20 | 9.24 | 0.15 | 1.05 | 1.35 | -15.3 | 2.80 | 3.11 | 1.29 | 8.44 | 96 |
| 2 | 4.03 | 8.05 | 3.15 | 5.69 | 25.30 | 7.16 | 22.44 | 1.21 | 9.42 | 7.64 | -10.5 | -3.73 | -8.23 | 0.81 | 7.68 | 63 |
| 3 | 0.84 | 8.04 | 1.99 | 2.52 | 2.50 | 1.41 | 4.45 | 0.56 | 1.29 | 2.12 | -20.4 | 1.23 | 1.10 | 1.64 | 3.41 | 77 |
| 4 | 3.07 | 8.02 | 1.86 | 4.24 | 21.81 | 2.80 | 17.69 | 1.49 | 5.22 | 5.93 | -11.1 | -0.98 | -5.06 | 1.14 | 7.49 | 68 |
| 5 | 2.56 | 8.32 | 3.08 | 5.38 | 16.18 | 2.38 | 18.84 | 0.92 | 3.40 | 3.46 | -8.1 | 1.98 | 1.59 | 1.02 | 10.17 | 82 |
| 6 | 2.64 | 8.51 | 3.16 | 5.07 | 15.29 | 3.59 | 18.99 | 1.90 | 2.28 | 3.85 | -6.8 | 2.80 | 2.10 | 1.69 | 10.85 | 85 |
| 7 | 4.74 | 8.08 | 1.50 | 8.51 | 29.37 | 8.13 | 30.13 | 0.99 | 7.29 | 8.74 | -0.7 | 1.22 | -6.02 | 1.20 | 10.64 | 72 |
| 8 | 2.76 | 8.35 | 2.61 | 5.31 | 17.20 | 4.38 | 22.20 | 1.43 | 1.66 | 4.00 | -3.0 | 3.65 | 2.25 | 2.41 | 13.19 | 88 |
| 9 | 5.17 | 8.05 | 2.83 | 8.86 | 34.48 | 5.43 | 38.28 | 1.51 | 3.10 | 8.41 | 11.7 | 5.75 | 0.17 | 2.71 | 12.35 | 83 |
| 10 | 2.28 | 8.44 | 1.71 | 5.67 | 11.89 | 4.07 | 15.17 | 0.36 | 2.70 | 4.57 | -11.1 | 2.96 | 0.11 | 1.69 | 7.96 | 78 |
| 11 | 2.48 | 8.37 | 3.30 | 7.27 | 10.96 | 4.89 | 17.47 | 2.30 | 1.99 | 4.04 | -8.1 | 5.28 | 4.54 | 2.03 | 10.05 | 86 |
| 12 | 1.67 | 8.50 | 2.57 | 5.34 | 9.55 | 1.00 | 10.44 | 0.44 | 1.83 | 5.25 | -14.9 | 3.51 | 0.83 | 2.87 | 5.55 | 73 |
| 13 | 1.59 | 8.61 | 2.77 | 4.99 | 8.45 | 1.45 | 11.10 | 2.34 | 0.96 | 2.81 | -13.4 | 4.03 | 3.99 | 2.92 | 8.08 | 90 |
| 14 | 1.46 | 8.00 | 1.72 | 3.69 | 8.20 | 1.60 | 8.25 | 0.31 | 3.06 | 3.26 | -18.3 | 0.62 | -0.92 | 1.06 | 4.64 | 70 |
| 15 | 2.94 | 8.22 | 3.44 | 4.88 | 20.76 | 2.03 | 22.88 | 0.63 | 2.82 | 4.61 | -3.5 | 2.06 | 0.90 | 1.64 | 11.87 | 83 |
| 16 | 0.66 | 8.04 | 0.28 | 2.52 | 3.09 | 1.32 | 4.26 | 0.18 | 1.67 | 1.03 | -20.9 | 0.85 | 0.10 | 0.62 | 3.67 | 84 |
| 17 | 7.83 | 7.90 | 2.76 | 5.64 | 24.20 | 46.55 | 31.65 | 2.50 | 21.51 | 22.87 | -13.4 | -15.87 | -35.98 | 1.06 | 1.47 | 45 |
| 18 | 3.32 | 8.13 | 4.26 | 6.67 | 17.79 | 7.29 | 22.99 | 2.13 | 4.16 | 6.52 | -4.7 | 2.51 | 0.24 | 1.57 | 9.95 | 76 |
| 19 | 3.04 | 8.05 | 4.02 | 4.72 | 19.90 | 2.85 | 17.50 | 1.21 | 5.30 | 7.15 | -11.3 | -0.58 | -3.71 | 1.35 | 7.01 | 66 |
| 20 | 6.07 | 8.07 | 2.19 | 6.78 | 37.75 | 16.88 | 45.89 | 1.00 | 5.33 | 10.78 | 17.0 | 1.45 | -7.14 | 2.02 | 8.61 | 78 |
| 21 | 1.28 | 7.83 | 1.94 | 3.03 | 6.29 | 1.50 | 6.08 | 0.26 | 3.30 | 2.86 | -20.8 | -0.27 | -1.19 | 0.87 | 3.46 | 64 |
| 22 | 12.64 | 7.85 | 2.08 | 4.59 | 98.75 | 22.68 | 88.75 | 3.21 | 15.61 | 20.07 | 49.6 | -11.02 | -29.01 | 1.29 | 5.68 | 73 |
| 23 | 7.46 | 8.13 | 4.44 | 6.99 | 53.68 | 9.92 | 57.48 | 0.75 | 6.91 | 9.66 | 27.0 | 0.08 | -5.14 | 1.40 | 8.32 | 81 |
| 24 | 2.11 | 8.23 | 2.64 | 4.01 | 12.70 | 1.92 | 10.22 | 0.77 | 4.36 | 5.76 | -17.7 | -0.34 | -3.46 | 1.32 | 4.54 | 60 |
| 25 | 2.74 | 8.17 | 3.69 | 5.47 | 10.24 | 8.60 | 15.53 | 3.99 | 3.15 | 5.12 | -11.2 | 2.32 | 0.89 | 1.62 | 7.64 | 75 |
| 26 | 5.45 | 8.57 | 5.83 | 11.35 | 30.80 | 8.68 | 33.62 | 11.25 | 3.22 | 8.07 | 6.9 | 8.13 | 5.89 | 2.51 | 10.44 | 82 |
| 27 | 0.92 | 8.25 | 1.38 | 2.64 | 4.53 | 1.34 | 5.01 | 0.60 | 1.16 | 2.82 | -19.7 | 1.48 | 0.05 | 2.42 | 3.55 | 74 |
| 28 | 5.50 | 8.39 | 6.36 | 10.23 | 29.50 | 13.18 | 47.23 | 0.88 | 2.37 | 8.07 | 21.3 | 7.86 | 6.14 | 3.41 | 19.93 | 87 |
| 29 | 1.67 | 7.99 | 2.36 | 5.02 | 9.30 | 1.87 | 11.08 | 1.05 | 2.06 | 3.68 | -14.5 | 2.96 | 1.64 | 1.78 | 6.54 | 79 |
| 30 | 1.61 | 8.36 | 3.05 | 4.41 | 8.46 | 2.04 | 9.66 | 2.64 | 1.55 | 3.50 | -15.4 | 2.87 | 2.41 | 2.27 | 6.08 | 80 |
| 31 | 10.14 | 8.24 | 4.30 | 9.36 | 63.78 | 20.39 | 72.20 | 1.23 | 4.90 | 19.35 | 43.8 | 4.46 | -10.59 | 3.95 | 14.74 | 78 |
| 32 | 0.88 | 7.68 | 1.94 | 2.75 | 3.95 | 0.53 | 6.42 | 0.30 | 1.19 | 1.14 | -18.3 | 1.56 | 2.36 | 0.96 | 5.95 | 92 |
| 33 | 0.65 | 8.04 | 0.83 | 2.75 | 3.65 | 0.87 | 4.20 | 0.29 | 1.17 | 1.41 | -20.5 | 1.58 | 0.99 | 1.21 | 3.70 | 86 |
| 34 | 0.41 | 8.29 | 0.28 | 2.20 | 1.83 | 0.58 | 2.01 | 0.18 | 1.11 | 1.12 | -22.6 | 1.10 | 0.25 | 1.01 | 1.91 | 82 |
| 35 | 2.84 | 8.18 | 3.58 | 7.48 | 11.95 | 7.34 | 22.68 | 0.97 | 2.72 | 3.57 | -3.6 | 4.76 | 4.77 | 1.31 | 12.79 | 88 |
| 36 | 0.86 | 8.39 | 1.11 | 3.30 | 2.55 | 0.64 | 4.78 | 0.41 | 1.61 | 2.18 | -20.4 | 1.69 | 0.62 | 1.36 | 3.47 | 77 |
| 37 | 1.43 | 7.88 | 2.77 | 4.55 | 6.00 | 2.33 | 7.52 | 0.97 | 3.01 | 3.88 | -19.0 | 1.54 | 0.44 | 1.29 | 4.05 | 67 |
| 38 | 3.59 | 8.24 | 3.01 | 9.76 | 16.28 | 6.83 | 20.75 | 1.57 | 4.96 | 7.97 | -7.7 | 4.79 | -0.17 | 1.61 | 8.16 | 71 |
| 39 | 1.31 | 8.10 | 1.94 | 3.86 | 5.72 | 2.79 | 8.45 | 0.60 | 2.35 | 2.21 | -17.4 | 1.51 | 1.24 | 0.94 | 5.60 | 80 |
| 40 | 1.51 | 8.21 | 1.94 | 3.86 | 7.78 | 2.42 | 10.16 | 0.82 | 1.94 | 2.89 | -15.3 | 1.92 | 0.97 | 1.49 | 6.54 | 81 |
| 41 | 5.85 | 8.02 | 3.51 | 4.25 | 43.35 | 9.87 | 38.96 | 0.97 | 8.32 | 12.43 | 7.1 | -4.07 | -12.98 | 1.49 | 4.68 | 69 |
| 42 | 1.67 | 8.27 | 2.53 | 5.29 | 7.63 | 1.85 | 7.94 | 1.18 | 3.47 | 4.35 | -19.1 | 1.83 | 0.00 | 1.25 | 4.02 | 65 |
| 43 | 1.06 | 7.61 | 1.11 | 3.58 | 5.24 | 1.73 | 6.71 | 0.57 | 2.42 | 1.58 | -19.2 | 1.15 | 0.68 | 0.65 | 4.74 | 80 |
| 44 | 1.56 | 8.32 | 2.50 | 5.10 | 5.62 | 2.65 | 8.92 | 1.26 | 2.71 | 2.37 | -17.3 | 2.38 | 2.51 | 0.87 | 5.60 | 80 |
| 45 | 3.86 | 8.59 | 4.55 | 7.70 | 18.85 | 8.03 | 29.20 | 1.88 | 2.46 | 5.17 | 3.2 | 5.24 | 4.62 | 2.10 | 14.95 | 87 |
| 46 | 7.31 | 8.46 | 4.43 | 7.02 | 51.72 | 11.38 | 62.26 | 1.07 | 4.27 | 6.58 | 34.5 | 2.75 | 0.60 | 1.54 | 14.57 | 89 |
| 47 | 15.95 | 8.22 | 3.89 | 7.73 | 123.66 | 25.88 | 114.00 | 1.18 | 15.86 | 29.68 | 74.6 | -8.14 | -33.94 | 1.87 | 7.19 | 73 |
| 48 | 13.15 | 8.27 | 3.19 | 8.25 | 103.87 | 18.06 | 101.52 | 1.51 | 11.46 | 18.33 | 66.5 | -3.22 | -18.35 | 1.60 | 8.86 | 80 |
| 49 | 11.67 | 7.92 | 3.75 | 6.30 | 84.37 | 24.96 | 79.69 | 1.38 | 19.72 | 17.12 | 36.4 | -13.43 | -26.79 | 0.87 | 4.04 | 71 |
| 50 | 10.28 | 8.17 | 4.00 | 6.95 | 72.05 | 20.88 | 74.45 | 2.97 | 13.24 | 12.92 | 37.7 | -6.29 | -15.22 | 0.98 | 5.62 | 77 |
| 51 | 14.30 | 8.13 | 3.52 | 6.75 | 107.87 | 24.42 | 94.43 | 2.16 | 22.40 | 23.12 | 48.5 | -15.65 | -35.26 | 1.03 | 4.22 | 69 |
| 52 | 0.85 | 8.37 | 2.08 | 3.82 | 5.68 | 1.21 | 8.11 | 0.52 | 1.48 | 2.33 | -16.9 | 2.34 | 2.08 | 1.57 | 5.88 | 84 |
| 53 | 0.50 | 8.15 | 0.28 | 3.03 | 1.88 | 0.78 | 2.74 | 0.16 | 1.11 | 1.55 | -21.9 | 1.92 | 0.65 | 1.40 | 2.38 | 83 |
| 54 | 2.07 | 8.04 | 3.70 | 5.85 | 10.92 | 1.57 | 13.68 | 3.35 | 2.11 | 2.93 | -12.0 | 3.74 | 4.51 | 1.39 | 8.62 | 86 |
| 55 | 2.06 | 8.05 | 0.74 | 5.30 | 11.48 | 4.84 | 12.29 | 0.28 | 4.30 | 5.01 | -15.5 | 1.00 | -3.28 | 1.17 | 5.69 | 68 |
| 56 | 7.64 | 8.44 | 7.70 | 11.65 | 49.98 | 10.18 | 54.53 | 12.46 | 3.57 | 8.73 | 27.4 | 8.08 | 7.05 | 2.44 | 15.26 | 87 |
| 57 | 5.43 | 8.03 | 2.36 | 6.05 | 32.00 | 14.98 | 27.93 | 16.35 | 5.98 | 4.62 | -1.6 | 0.07 | -2.19 | 0.77 | 4.67 | 79 |
| 58 | 3.29 | 8.40 | 5.38 | 8.45 | 18.43 | 4.99 | 29.99 | 1.00 | 2.19 | 3.65 | 4.3 | 6.26 | 7.98 | 1.67 | 17.55 | 92 |

reached down if more water infiltrates the soil than the crop use. Since, leaching is the key factor that controls salinity, salt removed must be equal or exceed the salt accumulation through the irrigation water to avoid salt build up to injurious levels to crops.

The samples analysed for EC and SAR were classified based on United States Salinity Laboratory Staff classification (Richards, 1969). Among the salinity classes, very high salinity class (C4) was dominated (56.9 per cent) followed by high salinity class (C2) (21.0 per cent) (Table 2). High salinity water can be used for irrigating soils with very good drainage whereas very high salinity water is not suitable for irrigation for many of the soil groups.

***SAR and SCAR***

Presence of Na salts and their concentration in water decide the quality of irrigation water. The SAR

**Table 2. Classification of quality of irrigation water based on EC and SAR**

| EC ($dSm^{-1}$) | Category | No of samples | Frequency (%) | SAR /SCAR | Category | No.of samples | Frequency |
|---|---|---|---|---|---|---|---|
| <0.25 | Low Salinity Class ($C_1$) | 0 | 0.00 | <10 | Low Sodium Class ($S_1$) | 43 | 74.14 |
| 0.25-0.75 | Medium Salinity Class ($C_2$) | 4 | 6.90 | 10-18 | Medium Sodium Class ($S_2$) | 15 | 25.86 |
| 0.75-2.25 | High Salinity Class ($C_3$) | 21 | 36.21 | 18-26 | High Sodium Class ($S_3$) | 0 | 0.00 |
| >2.25 | Very High Salinity Class ($C_4$) | 33 | 56.90 | >26 | Very High Sodium Class ($S_4$) | 0 | 0.00 |

classification suited upto 5 $dSm^{-1}$, beyond 5 $dSm^{-1}$ SCAR was used. The classification of irrigation water with respect to SAR is based on the abundance of exchangeable $Na^+$ particularly on the physical condition of the soils(Table 2). Most of the samples come under $S_1$ class (74.14 per cent) followed by $S_2$ class (25.86 per cent). Irrigation waters with $S_2$ class will produce appreciable Na+ hazard in fine textured soils. Therefore, proper soil management practices have to be adopted while irrigating on the fine textured soils. Chemical amendments like gypsum have to be applied to the soils while irrigating with sodic water.

***Magnesium toxicity***

Most of the samples showed potential for magnesium toxicity. Out of 58 samples 48 samples (87.2 %) found to have a Mg/Ca ratio of >1 (Table 1). Major areas of dye industry polluted water have shown potential for magnesium toxicity.

***RSC and RSBC***

Water samples containing $CO_3^{2-}$ and $HCO_3^-$ in excess of $Ca^{2+}$ and $Mg^{2+}$ are harmful. $CO_3^{2-}$ and $HCO_3^-$aggravate the Na+ hazards by precipitating the $Ca^{2+}$ and $Mg^{2+}$ ions.

**Table 3. Classification of quality of irrigation water based on RSC and RSBC**

| RSC ($m.e.L^{-1}$) | No. of Samples | Frequency (%) | RSBC ($m.e.L^{-1}$) | No. of Samples | Frequency (%) |
|---|---|---|---|---|---|
| <1.25 | 40 | 68.97 | <5 | 51 | 87.93 |
| 1.25-2.5 | 7 | 12.07 | 5-10 | 7 | 12.07 |
| >2.5 | 11 | 18.97 | >10 | 0 | 0.00 |

Eaton (1950) established the concept of RSC and Wilcox, *et al*.(1954) classified the waters on the basis of RSC values as suitable (<1.25 $m.e.L^{-1}$), moderately suitable (<1.25-2.5 $m.e.L^{-1}$) and unsuitable (>2.5 $m.e.L^{-1}$) for irrigation (Table 3). RSC content showed that 68.9 per cent of samples comes under satisfactory (<1.25 m.e $L^{-1}$), 12.07 per cent under marginal (1.25 to 2.5 m.e $L^{-1}$) and 18.96 per cent under unsatisfactory (>2.5 m.e $L^{-1}$) as per Wilcox, *et. al.* (1954). Continuous application of waters with RSC >2.5 m.e $L^{-1}$ will induce accumulation of $CO_3^{2-}$and $HCO_3^-$ in soils and impair crop growth. Special precautions are needed to prevent lime accumulation and possible soil alkalization. More frequent irrigation is necessary to prevent soil drying and leaching has to be done at frequent intervals under these situations. RSBC was found to dominate (87.93 per cent) with satisfactory (<5 m.e $L^{-1}$) and 12.07 per cent under marginal (5-10 m.e $L^{-1}$) as per Gupta (1983).

***Puri's Salt Index (PSI)***

PSI values varied from -22.62 to 74.60. Out of 58 samples 42 samples showed negative values (72.4 %) and 16 sample showed positive values (27.6 %). Positive values indicate free $Na^+$ ions in the irrigation water. Free $Na^+$ ions prevalent in many samples. Continuous irrigation with the water with free $Na^+$ will lead to $Na^+$ accumulation in soils.

***Permeability Index***

Permeability Index is used to assess probable influence of water quality on physical properties of soils. It is the most important single soil physical property reflecting soil texture and soil structure, as well as chemical characteristics. High level of $HCO_3^-$in irrigation water will affect the permeability of soils.

**Table 4. Degree of restriction on use for irrigation to crops**

| Parameter | None | | | Slight to moderate | | | Severe | | |
|---|---|---|---|---|---|---|---|---|---|
| | Limits | Frequency (No) | % of samples | Limits | Frequency (No) | % of samples | Limits | Frequency (No) | % of samples |
| Salinity | | | | | | | | | |
| ECw (limits in $dSm^{-1}$) | <0.7 | 4.00 | 6.90 | 0.7-3.0 | 29.00 | 50.00 | >3.0 | 25.00 | 43.10 |
| Infiltration problem based on SAR | | | | | | | | | |
| SAR | ECw $dSm^{-1}$) | Frequency | % of samples | ECw ($dSm^{-1}$) | Frequency | % of samples | ECw ($dSm^{-1}$) | Frequency | % of samples |
| 0 -3.0 | >0.7 | 1.00 | 1.72 | 0.21-0.7 | 3.00 | 5.17 | <0.2 | NIL | NIL |
| 3.1-6.0 | >1.2 | 15.00 | 25.86 | 0.31-1.2 | 8.00 | 13.79 | <0.3 | NIL | NIL |
| 6.1-12.0 | >1.9 | 18.00 | 31.03 | 0.51-1.9 | 5.00 | 8.62 | <0.5 | NIL | NIL |
| 12.1-20.0 | >2.9 | 7.00 | 12.07 | 1.31-2.9 | 2.00 | 3.45 | <1.3 | NIL | NIL |
| >20.1 | >5.0 | 0.00 | 0.00 | 2.91-5.0 | 0.00 | 0.00 | <2.3 | NIL | NIL |
| Specific ion toxicity | | | | | | | | | |
| Sodium (SAR) | <3.0 | 3.00 | 5.17 | 3.1-9.0 | 39.00 | 67.24 | >9.0 | 16.00 | 27.59 |
| Chloride (m.e $L^{-1}$) | <4.0 | 7.00 | 12.07 | 4.1-10.0 | 15.00 | 25.86 | >10.0 | 36.00 | 62.07 |

Permeability index varied from 44.76 to 96.26. Effect of individual water type on irrigation depends on the initial permeability of soils. Irrespective of initial permeability, the Permeability Index of the samples come under class 2 and 3.

***Degree of restriction on use for irrigation to crops and infiltration of soils***

The total quantity of salts present in irrigation water and $Na^+$ content relative to $Ca_2^+$ and $Mg_2^+$ are the two major water quality indices that influence the infiltration rate. In the few centimeters of the soil surface due to low $Ca_2^+$ relative to $Na^+$ which causes structural instability of the soil surface that leads to crusting of seed beds, nutritional disorders, rotting of seeds drowning of crop etc. Ayers and Westcot (1994) interpreted the quality of irrigation water based on salinity and SAR to judge the infiltration problems on soils. It was found that 50 per cent of samples having slight to moderate (>3.0 $dSm^{-1}$) salinity problem followed by 43.0 per cent under severe salinity (0.7 to 3.0 $dSm^{-1}$) and 6.9 per cent under salinity (<0.7 $dSm^{-1}$) category (Table 4).

Classification of the samples based on salinity and SAR indicated that 68.97 per cent of samples does not post infiltration problem to the soils and 31. 03 per cent will result in slight moderate infiltration due to irrigation.

***Toxicity of ions***

Crop damage or yield reduction due to toxicity of specific ions as a result of irrigating with poor quality water is a common phenomenon. Accumulations of ions at high concentration in plant system cause damage to crop plants. The degree of damage depends on the uptake and sensitivity of the crop plants. The ions of primary concern are chloride, $Na^+$ and boron.

As per Ayers and Westcot (1994) classification, the limits for toxicity of ions were established. $Na^+$ and $Cl^-$ toxicity were found in majority of the samples (Table 4). Slight to moderate toxicity of $Na^+$ (SAR 3-9) was recorded at 67.24 per cent followed by severe category (SAR >9.0) at 27.59 per cent. Severe $Cl^-$ toxicity (>10 m.e $L^{-1}$) was noticed in 62.07 per cent of samples followed by slight to moderate category (4.1-1.0 m.e $L^{-1}$) at about 25.86 per cent and 10.3 per cent under no severe $Cl^-$ toxicity (<4.0 m.e $L^{-1}$). Following an irrigation, the most readily available water is in the upper root zone where low salinity persists. Importance must be given to maintain high soil-water availability and the leach the accumulated salts from the rooting depth before it get exceeds the tolerance limit of the crop. Hence frequent irrigation to maintain soil moisture levels and leaching the salts beyond the root zone is important in utilizing high salinity water.

**Table 5. Heavy metal concentration in selected well waters**

| Sa.No. | Source | Cu | Zn | Fe | Mn | Pb | Ni | Co |
|---|---|---|---|---|---|---|---|---|
| | | μ mL-1 | | | | | | |
| 2 | Poondi | BDL | BDL | 3.20 | BDL | BDL | BDL | BDL |
| 5 | Somanur | BDL | BDL | 2.80 | BDL | BDL | 1.00 | 0.10 |
| 6 | Sulur | BDL | BDL | 3.70 | 0.10 | BDL | 0.70 | 0.10 |
| 8 | Veerapandi- Tirupur | BDL | BDL | 3.70 | 0.30 | Traces | 1.00 | 0.20 |
| 9 | Padiyur pirirvu | BDL | BDL | 4.40 | 0.20 | BDL | 0.10 | 0.20 |
| 11 | Anaipalayam | BDL | BDL | 4.20 | 0.20 | BDL | BDL | BDL |
| 13 | Orathupalayam Dam | BDL | BDL | 4.10 | 0.50 | BDL | BDL | 0.10 |
| 15 | Anjur | BDL | BDL | 3.10 | 0.30 | BDL | BDL | BDL |
| 17 | Kodumudi | BDL | BDL | 3.30 | 0.30 | BDL | BDL | BDL |
| | Min | 0.00 | 0.00 | 2.80 | 0.10 | 0.00 | 0.10 | 0.10 |
| | Max | 0.00 | 0.00 | 4.40 | 0.50 | 0.00 | 1.00 | 0.20 |
| | Wave length (nm) | 324.7 | 213.9 | 248.3 | 279.5 | 217.0 | 232.0 | 240.7 |
| | Sensitivity of AAS (g $mL^{-1}$) | 0.025 | 0.008 | 0.050 | 0.020 | 0.060 | 0.040 | 0.050 |

## Conclusions

The present study envisages the appraisal of irrigation water quality of Noyyal basin. The results are the average values for the four seasons during 2006-2007. Salinity due to $Cl^-$ was noticed in most of the areas. Among the cations, $Na^+$ was dominated followed by $Mg^{2+}$, $Ca^{2+}$ and $K^+$. Among the anions, Cl- was dominated followed by $SO_4^{2-}$, $HCO_3^-$ and $CO_3^{2-}$. The dominant salinity and sodicity classes in the basin were very high salinity class ($C_4$) with 56.90 per cent and low sodium ($S_1$ class) with 74.14 per cent respectively. RSC (68.97 per cent) and RSBC (87.93 per cent) have shown satisfactory classes. Classification of the samples based on salinity and SAR indicated that 68.97 per cent of samples does not pose infiltration problem to the soils and 31.03 per cent will result in slight moderate infiltration irrigation. $Na^+$ and $Cl^-$ toxicity were found in majority of the samples. Slight to moderate category of sodium toxicity dominates with 67.24 per cent. Severe chloride toxicity (>10 m.e $L^{-1}$) was noticed in

62.07 per cent of samples. Salinity is the main problem posed by the irrigation waters in Noyyal basin. Movement of salts along the recharge water accumulates in ground waters. Since, the soils in the basin are well drained, most of the salts added through the irrigation water get drained into the ground water and contaminate the ground water by recycling. Optimum use of water, conjunctive use of good quality water, leaching of salts during rainy period, cultivating salinity tolerant crops, applying sufficient organic manures and green manures, integrated nutrient management and stress management techniques will be useful for better management and prevent the yield loss.

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