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Evaluation of Water Quality for Irrigation Purposes in Dye Affected Soil in the River Noyyal Region

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ABSTRACT

Water is vital to the existence of living organisms, but this valued resource is increasingly being threatened as human population grown which increases the demand for high quality water for domestic purposes and economic activities (UNESCO, 2003). Tiruppur is fast growing 'industrial city' known for its hosiery industries in Coimbatore District of Tamil Nadu. It is an Indian textile town which constitutes many dyeing and bleaching units situated in the upstream of Noyyal River and serves as one of the major exporters of textiles. The industrial pollution has affected not only the surface water but also the soil and ground water. In recent decades, the ecosystem, particularly the water and land resources of the Noyyal river basin have been affected due to heavy discharge of industrial effluents. In the present investigation water samples (A, B, C and D) were collected from various sites near the Orathupalayam reservoir of Noyyal River to study the level of penetration of polluted water into the aquifer system. The physio-chemical properties of water samples were analyzed and studied. The pH of water samples taken from different location did not show much variation in its ranges. However, the concentration of Chloride, Calcium, Magnesium, Sodium, Potassium and Sulphate in the water samples was found to be increasing towards the dead-end of the discharge system. It is highly recommended that water samples B and D are poorly suitable (PS) and A and C are very poorly suitable (VPS) for irrigation purposes.

Key Words: Industrial City, Tiruppur, Noyyal River, Orathupalayam Reservoir.

Introduction

Most of the rivers in urban areas especially in developing countries are the ultimate ends of effluent discharge from industries and sewage. Asian countries experiencing population growth, rapid industrial growth with improper management of effluent, pollution has become a devastating problem in these countries including Pakistan. This results in

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abnormal concentration of hazardous wastes in the natural environment (Peters, and Meybeck, 2000). Effluents from the industries contaminate surface water, as well as soil and groundwater due to the presence of soluble solids, suspended solids, organic matter, heavy metals and toxic constituents (Prabakaran *et al.,* 2002). This necessitates treatment of the discharged waste water.

Textile industries consume large quantities of water and produce large volumes of wastewater. The three major components of this industry are: Yarn and Fabric Production (i.e. spinning and weaving), Chemical Processing (i.e. scouring, bleaching, dyeing, finishing of fabrics) and Garments (i.e. manufacturing and finishing of garments). Chemical processing and garment finishing involve highly effluent-generating processes and the effluents are water-based (PWD, 2003). Both the huge volume of effluents and the high concentrations of chemicals in the effluents need to be considered when looking at the environmental effects of the industry (Furn, 2004).

Even after aerobic or anaerobic treatment, disposal of the industrial wastes and effluents contain toxic substances to be leached and seep into the soil and affect the groundwater course (Madhusudana *et al.,* 2001 and Jain and Nidhi, 2004). Therefore, regular monitoring of groundwater pollution in an industrial area assumes paramount importance to maintain environmental safety .Water quality is dependent on several parameters. There exist strong correlations among different parameters and a combined effect of their inter-relatedness indicates the water quality. In general, groundwater quality in the industrial areas is determined by measuring the concentration of some physico-chemical parameters and comparing them with drinking water standards. The number of such parameters necessary to fully specify the quality of water, however, is quite large.

pH

pH is a standard variable and is a measure of the hydrogen ion concentration, which indicates the degree of acidity (Yadav and Khera, 1994).

Electrical conductivity (EC)

The amount of total soluble salts in a sample solution is generally expressed in terms of electrical conductivity since EC increases as the amount of soluble salts in a solution

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increases. (Hounslow, 1995). EC is a good estimator of Total Dissolved Solids (TDS). The major constituents, i.e. $Na^{+,}$ K^{+}, Ca^{2+}, Mg^{2+}, Cl^{-}, SO^{4-}, HCO^{3-}, CO^{3-} constitute the bulk of the mineral matter contributing to TDS.

Hardness

Hardness in water is caused by dissolved calcium and to a lesser extent magnesium. It is usually expressed as the equivalent quantity of calcium carbonate (WHO, 2nd ed.).

Sodium Adsorption Ratio (SAR)

SAR indicates the degree to which Na^{+} in water replaces the electrostatically adsorbed Ca^{2+} and Mg^{2+} ions on negatively charged soil clay and organic matter surfaces (Hounslow, 1995).

Residual Sodium Carbonate (RSC)

Carbonate and bicarbonate ions present in excess of calcium and magnesium ions in irrigation water may cause harmful effects on crops and are given as RSC.

In recent decades, the ecosystem particularly the water and land resources of the Noyyal river basin have been affected due to industrial effluents. The bleaching and dyeing unit effluents contain a variety of dyes and chemical (acids, salts, wetting agents, soaps, oil etc.). The loss of ecosystem is due to the accumulation of effluents in the ground water and soil. The objective of the present study is to analyse the ground water quality located at the nearest of Orathupalayam reservoir.

Materials and Methods

The main objective of the present investigation is to study the effect of pollutants due to chemicals used in dying and bleaching on the water quality.

Water Sampling

In the present investigation the dye affected ground water samples (A, B, C and D) were collected from four different region (distance of 150 m, 300 m, 450 m and 600 m from the source) around Orathupalayam reservoir, Tirupur District, Tamil Nadu, in order to study the level of penetration of polluted water into the aquifer system. The water from the four spots

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(four directions) of the same locations is to be mixed to obtain one bulk sample. Mixing water from several spots is a method used to create an average sample or composite sample. It is a common procedure, but should be used judiciously to avoid skewing results. The water samples were collected during morning in the polythene bottles which were cleaned with distilled water, followed by rinsing twice with sample water. It was immediately covered tightly after collection of water samples and transported to the laboratory for chemical analysis. The physic-chemical properties of water samples were analyzed in the Mobile Soil Testing Laboratory, Tamil Nadu Government Agricultural Department, Palladam, Tiruppur District. To find out the quality of water through analyzing the physico-chemical properties (pH, EC, Carbonate, Bicarbonate, Chloride, Sulphate, Calcium, Magnesium, Sodium, Potassium, SAR, RSC, etc.) and comparing the physio-chemical parameters with respect to WHO standards.

Statistical Analysis

The water quality parameters of different samples were examined and compared. The statistical analysis, like One-way ANOVA test was used for analyzing the significant difference between different water samples.

Results and Discussion

Physico-chemical Analysis of Water Samples

The result of the physico- chemical analysis of four water samples in the present study was presented in the Table-3 and Fig-1. The water samples were odourless, colourless and slightly turbid. The pH of water (7.20 - 7.60) did not show much variation in its ranges. It indicated that they were in range of water quality parameter's permissible limits (Table-1). Maximum EC value (11.63ds/m) was recorded in sample D and minimum in sample A (7.36ds/m). Carbonate was present only in sample "A" and totally absent in other samples. 1-2mg/l of bicarbonates were present in the water samples. Sodium Absorption Rate (SAR) ranges from 10 to 20mg/l. Residual Sodium Carbonate (RSC) was completely absent in all other samples.

The suitability of irrigation water depends on amount and nature of salts in the water, the soil to be irrigated, climatic conditions and the crop species. These conditions change

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from place to place and therefore the classification of irrigation water is based on the amount and nature of salts in the irrigation water (Natarajan *et al.*, 1988). This finding is in accordance with present observations that water samples B and D are poorly suitable (PS) and A and C are very poorly suitable (VPS) for irrigation purposes. Alkalinity of water could be expressed as RSC, the Residual Sodium Carbonate value. There is a potential alkalinity hazard if there is an excess of carbonate and bicarbonate ions compared with calcium and magnesium ions. But in the current study RSC value is nil in all the cases.

The level of chloride ranged from 13 to 20mg/l. The sulphate concentration in the samples was found to be more in sample D (94.70mg/l) and low in A (59.40mg/l). The level of sodium concentration was higher in sample C (71.33mg/l) and lower in A (41.64mg/l). The amount of potassium varied from 0 to 3mg/l in the samples. High calcium (18.20mg/l) and low magnesium content (6.80mg/l) was found in sample C.

A point of interest is that in the present study, the concentration of chloride, calcium, magnesium, sodium, potassium and sulphate were found to be increasing towards the dead - end of the discharge system. The nature of salts present in the entire sample was sodium sulphate. It is highly recommended that samples B and D are poorly suitable (PS) and A and C are very poorly suitable (VPS) for irrigation purposes (Table-3).

Table-1 Water quality parameters with respect to the WHO standards

S. no	Parameter	WHO
1.	pH	7.0–8.5
2.	Electrical conductivity (EC) (μS/cm)	1400
3.	Total dissolved solids (mg/L)	1000
4.	Bio chemical oxygen demand (BOD) (mg/L)	5
5.	Chemical oxygen demand (COD) (mg/L)	100
6.	Sodium (mg/L)	200
7.	Lead	0.01

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Table- 2. USDA Quality Rating for Irrigation Water

C	S
LOW SALINITY WATER (C1) can be used for irrigation with most crops on most soil.	LOW SODIUM WATER (S1) can be used for irrigation on almost all soil with little danger of harmful levels of exchangeable sodium.
MEDIUM SALINITY WATER (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases.	MEDIUM SODIUM WATER (S1) will present an appreciable sodium hazard in fine-textured soil having high cation-exchange capacity. It may be used on coarse textured or organic soil with good permeability.
HIGH-SALINITY WATER (C3) cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required. Plants with good salt tolerance should be selected.	HIGH SODIUM WATER (S3) may produce harmful levels of exchangeable sodium in most soil and will require special soil management with good drainage, high leaching and organic matter. Amendments may not be feasible with waters of very high salinity.
VERY HIGH SALINITY WATER (C4) is not suitable for irrigation under ordinary conditions. It may be used occasionally but the soil must be permeable, drainage adequate, irrigation applied in excess. Very salt-tolerant crops should be grown.	VERY HIGH SODIUM WATER (S4) is generally not good for irrigation purposes except at low and perhaps medium salinity.

Table- 3. Comparative study on Physico-chemical analysis of water samples

Physical and Chemical Properties	A	B	C	D
pH	7.20	7.30	7.20	7.60
EC (ds/m)	7.36	9.63	9.83	11.63
Carbonate (mg/L)	5.70	0.0	0.0	0.0
Bicarbonate (mg/L)	1.20	1.60	1.10	1.40
Cl (mg/L)	13.0	16.80	14.0	20.20
SO_4 (mg/L)	59.40	77.90	83.20	94.70
Ca (mg/L)	10.6	11.60	18.20	17.0
Mg (mg/L)	21.6	15.0	6.80	32.20
Na (mg/L)	41.64	68.24	71.33	64.86
K (mg/L)	0.96	1.46	1.97	2.24
SAR	10.58	18.71	20.18	13.08

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RSC	-	-	-	-
Classification	$C_5S_2R_1$	$C_5S_2R_1$	$C_5S_2R_1$	$C_5S_2R_1$
Mg : Ca	2.1	1.29	0.37	1.89
Salt Nature	Na_2SO_3	Na_2SO_3	Na_2SO_3	Na_2SO_3
Recommendation	VPS	PS	VPS	PS

SAR - Sodium Adsorption Rate
RSC - Residual Sodium Carbonate
VPS - Very Poorly Suitable
PS - Poorly Suitable

Fig.1 Comparative studies on chemical properties of water samples

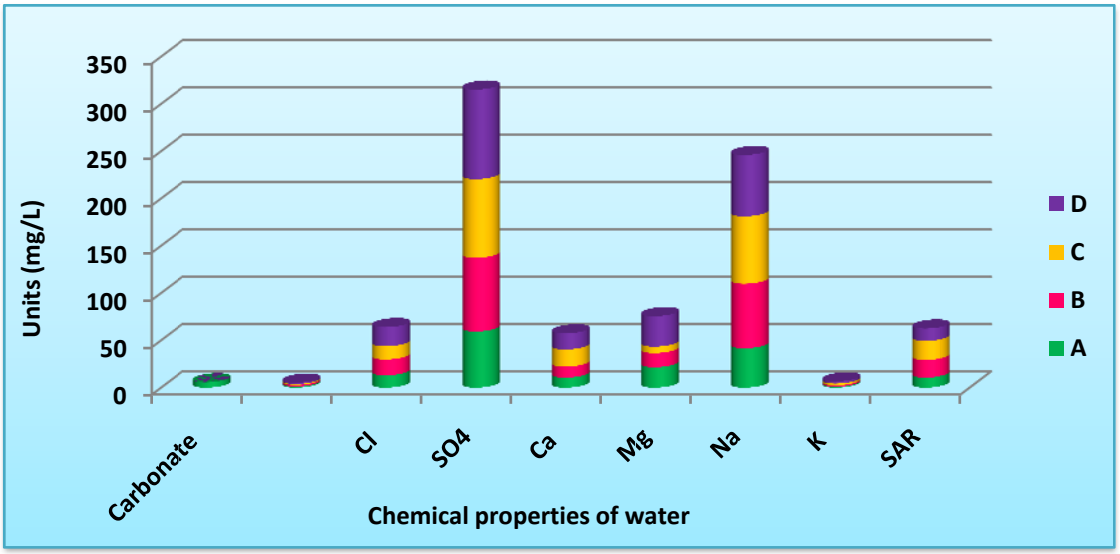

Table- 4. Tamil Nadu Classification of Irrigation Water Ratings on soil reaction (pH) and EC

pH		EC	
Rating	**Status**	**Rating**	**Status**
Below 6.0	Acidic	Below 1.0	Normal
6.0 to 8.4	Normal	1.0-3.0	Critical
8.5 to 8.9	Tending to alkaline	3.0 and above	Injurious
8.9 and above	Alkaline		

In Tamil Nadu, water intended for agricultural purposes is first analyzed for pH and electrical conductivity (EC) with the ratings given in Table-4. From the table, it was clear that the pH of the water is normal (7.20 to 7.60) in all locations where the water samples were

collected (Table–3). According to the USDA system, EC > 0.5 dS/m implies medium salinity, and EC > 0.75 dS/m implies high salinity water. But the EC values (amount of total soluble salts in water) of the water samples were in the injurious state (7.36 to 11.63ds/m). It indicated that it was not suitable to grow crops.

Irrigation waters are usually classified in terms of salinity hazard (estimated from EC or TDS) and sodium hazard (SAR), in order to determine its subsequent effects on soil. The classification with respect to SAR is based primarily on the physical effects on soil but sodium-sensitive plants may suffer injury as a result of sodium accumulation at lower levels (Natarajan *et al.*, 1988). TDS and SAR are used in the USDA System for irrigation water (Table - 2) (Richards, 1969).

Conclusion

The pH of water samples taken from different location does not show much variation in its ranges. The concentration of Chloride, Calcium, Magnesium, Sodium, Potassium and Sulphate in the water samples are found to be increasing towards the dead-end of the discharge system. It is highly recommended that water samples B and D are poorly suitable (PS) and A and C are very poorly suitable (VPS) for irrigation purpose.

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