IMPLICATIONS OF TEXTILE DYEING AND PRINTING EFFLUENTS ON GROUNDWATER QUALITY FOR IRRIGATION PURPOSE PALI, RAJASTHAN

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The dyeing and printing of cotton and synthetic fabrics constitute highly specialized industries at Pali. Pollution of surface water stream has always implicit effect on groundwater quality and river Bandi is no more an exception. The primary and foremost cause is the release of untreated effluents in the river by the industries at Pali city. The sodium salts of chloride carbonate, bicarbonate and sulphate are the major pollutants which have increased significantly in polluted groundwaters besides dyes and organic substances. The application of polluted groundwater (salinity >8000 µS cm^{-1} and SAR >30) in agriculture fields has reduced the yields of crops considerably. The majority of well waters (67.92 %) are characterized (Group V classes) with very high to excessive salinity and sodium hazard (C5S3, C5S4 and C5S5).

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Introduction

During last two decades the problem of quality of groundwater has become more acute moreover it has become contaminated due to several anthropogenic activities. Dramatic increase in population, rapid growth in industrial sector, extensive use of fertilizers, and uncertainty in monsoon has further increased the exploitation of this precious natural resource all around the world.[1]

Groundwater is the promising source of irrigation in western Rajasthan where the surface water resources are scanty and often remains dry due to frequently occurring droughts. Generally the water levels are very deep and the occurrence is often restricted to certain geological formations. Not only the inherent groundwater in western Rajasthan is saline and alkaline but they also contain the constituents like fluoride, nitrate, sulphate, chlorides, and heavy metals etc which are considered as potential health hazards.[2] The use of such waters only adds to the sufferings of local agricultural based population by severely affecting crop productivity and quality of food product.

The burning question in such regions is not the availability of water but its chemical quality. Shortage of irrigation water especially in the arid regions necessitates use of even poor quality of water. The present paper embodies the results of study on the quality of groundwater for irrigation purposes and emphasizes the need for appropriate soil and water management for the utilization of waters even of poor quality.

Experimental

Study Area

The study area is part of Pali and Rohat blocks of Pali district located in the southwestern part of the Rajasthan state. Situated on the bank of river Bandi, Pali city lies between 25.77° N latitude to 73.33° E longitude.

Bandi river is a major tributary of Luni river and flows in almost east to west direction and passes through south of Pali city. The river lies between 25° 42'43" to 25° 55' N latitude and 72° 50' 45" to 73° 28' 30" E longitude (Fig.1).

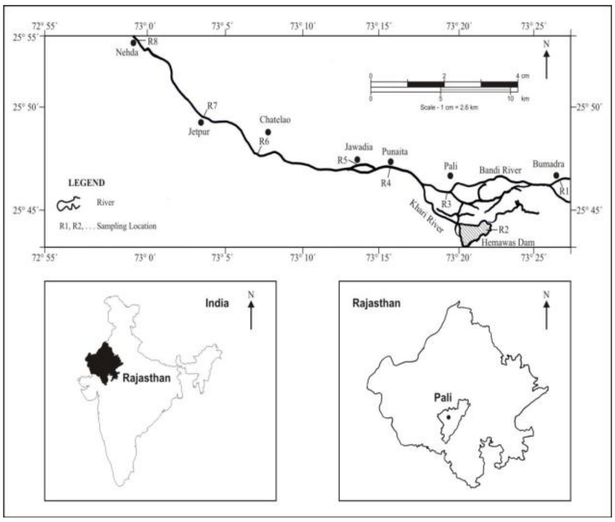

Figure 1. Study Area and sampling sites

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Materials

Groundwater samples from 108 were collected from wells situated on both side of river bank from Bumadra (R1) village on upstream to Nehda (R8) village downstream along the river course during the year (Fig. 1). pH of wastewater was measured by potable pH meter (ELICO), electrical conductivity was also measured by potable EC meter (ELICO) in the field. Major ionic constituents were measured by standard methods.[3] The analytical results are given in (Table 1).

Table 1. Ionic constituents in groundwater

Chemical Constituents/Parameters	Range of Variation		
	Minimum	Maximum	Average
Electrical conductivity µS cm^{-1}	740	33000	9130
pH	6.7	9.1	-
Total dissolved solids, mg L^{-1}	437	23900	5820
Sodium, mg L^{-1}	220	8260	1710
Potassium, mg L^{-1}	2	375	24.8
Calcium, mg L^{-1}	6	1020	226
Magnesium, mg L^{-1}	9	630	146
Chloride, mg L^{-1}	71	8970	2390
Sulphate, mg L^{-1}	16	4460	910
Carbonate, mg L^{-1}	0	564	13.5
Bicarbonate, mg L^{-1}	146	2370	675
Nitrate, mg L^{-1}	1	380	64
Fluoride, mg L^{-1}	0	11.2	2.35
Total alkalinity, mg $CaCO_3$ L^{-1}	120	2270	580
Total hardness, mg $CaCO_3$ L^{-1}	52	5140	1170
Sodium absorption ratio (SAR)	2.63	95.85	22.85
Percent sodium	37.20	94.44	74.68
Residual sodium carbonate, meq L^{-1}	0	25.46	2.97

Results and discussion

Electrical Conductivity (EC)

Dissolved inorganic substances are present in the ionized form in groundwater and as such contribute to electrical conductance which is directly proportional to the concentration of ionized substances in water i.e. salinity. It is also a function of temperature and charge of ions present in water at 25 ^{0}C. It is seen that slightly saline well waters (24.7 %) have electrical conductivity less than 4000 µS/cm whereas 27.77 %, 16.67 % and 31.48 % waters fall in the salinity ranges of 4000-6000, 6000-8000 and above10000 µS cm^{-1} respectively. Fresh groundwater is not available in the study area. Well waters (8.33 %) having salinity less than 2000 µS/cm are observed around surface water bodies of Pali city or near river bed as localized patches (north, east) in the upstream areas. The groundwater in the rest of the region is brackish to saline.

Highly saline groundwater is seen in east of Hemawas dam, south and south west of Pali city covering textile industrial areas, west, south and northern parts excluding few patches in north-east and around Nehda-Dholeria section, localised patches at Jetpur, Jawadia, Mandia, Rupawas, Mandawas and Diwandi villages where salinity have exceeded 8000 µS cm^{-1}. In general, salinity increases from north-western region of Pali city to central part, east, south, north-west and west of the study area. The central parts covering Kerla-Chatelao and Rupawas-Mauliawas-Sukarlai sections have exceptionally high salinity extending up to Gadwara-Jetpur section. Similarly Sajji, Sonai Lakha and Sonai Lakha Dhani in north-west also have higher salinity. However, groundwater around Hemawas dam has lower salinity but the salinity increases with distance from dam in east and south-west. The increase in salinity is supported by the arid climate, a very prominent feature of the region, adds up to overall salinity in soils and groundwater of the study area. Moreover, the regular flow of untreated alkaline-saline textile effluents in the river further enhance the salinity in groundwater downstream from Pali city.

Total dissolved solids (TDS)

Theoretically dissolved solids are anhydrous residues of the soluble salts in water. Like electrical conductance, total dissolved solids in groundwater also show wide variations i.e. from 437 mg L^{-1} to 23880 mg L^{-1} with an average value of 5820 mg L^{-1}. The ground water in north-east is more or less fresh to slightly saline with respect to rest of the area. Sodium salts of chloride, sulphate and bicarbonate usually make up the bulk of dissolved solids up to the range of 2000 mg L^{-1}. While sulphate and chloride salts of calcium and magnesium also contribute significantly to the bulk of dissolved solids with the rise in salinity of groundwater.

A graph of electrical conductivity and total dissolved solids of well waters (Fig. 2) indicating the increase in conductance with the increase in dissolved solids in groundwater. The ratio of electrical conductivity to dissolved solids varies from 0.60 for waters of low dissolved solids to more than 0.65 for waters with dissolved solids more than 3000 mg L^{-1}. The total dissolved solids to electrical conductivity ratio increases with rise in salinity.

Much natural groundwater contains dissolved solids in concentrations exceeding 1000 mg L^{-1}, such water is classed as saline. According to salinity classification by Davis and De Wiest[4] 5.55 % of the samples fall under fresh water category, 28.70 % of the samples fall under slightly saline category, 50 % of the samples fall under saline category and 15.74 % under very saline category.

Total Hardness (TH)

According to Rao[5] water with hardness below 500 mg L^{-1} are recommended for drinking purpose. But for agricultural purpose, more than 1000 mg L^{-1} of hardness is also accepted. Based on the hardness classification of Ragunath[6] more than 67.59 % of samples fall under very hard category, 19.44 % fall under moderately hard category and 12.03 % fall under slightly hard category.

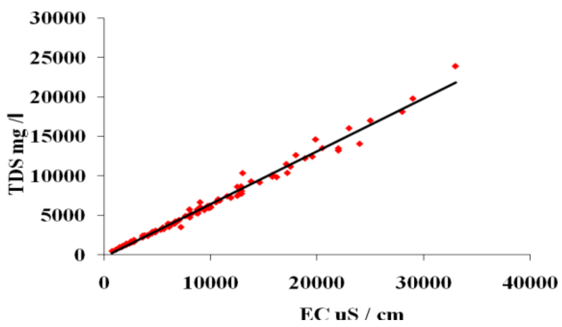

Figure 2. Variation of EC and TDS in groundwater. Relation of EC and TDS in groundwaters: TDS range: 0–1000, 1000–3000 and more than 3000 mg L^{-1} and TDS/EC ratio are 0.60, 0.62 and >0.64, respectively.

Suitability of groundwater for agriculture

The degree of salinity and alkalinity of groundwater is a key factor in water quality ratings for irrigation. Soil type, drainage and local conditions are other important parameters which affect the crop output. A brief discussion have been made on the quality of ground water that can be used safely for irrigation using different criteria's for rating irrigation water. Irrigation waters having dominant sodium ions are responsible for effecting the soil characteristics and crop productivity. Thus, the sodium adsorption ratio is considered to be the best indication of quality of ground water for irrigation purposes. Based on U.S. salinity diagram[7] ground water has been classified to know the suitability and groups of various classes (Table 2).

Table 2. Classes of groundwater for irrigation suitability based on U.S. S. L. diagram

Group	Classes	No. of samples in each class	No. of samples in each group	Type of crop to be grown on sandy soil w.r.t. each group.
I	C2 S1	1	9	Salt-sensitive
	C2 S2	-		
	C3 S1	-		
	C3 S2	8		
	C4 S1	-		
II	C3 S3	3	8	Semi-tolerant
	C4 S2	5		
III	C3 S4	1	13	Tolerant
	C4 S3	12		
IV	C4 S4	4	4	High salt-tolerant
V	C5 S3	2	74	Not even high salt - tolerant
	C5 S4	3		
	C5 S5	69		

It is found that 8.49 % well waters fall under group-1 classes are considered suitable for irrigation on various soils. Further 23.58 % samples covered under group II (7.55 %), III (12.26 %) and IV (3.77 %) can be used for growing most of the semi tolerant to tolerant crops on the sandy soils. The majority of the well waters (68.51 %) are characterized (Group V classes) with very high to excessive salinity and sodium hazard (C5 S3, C5 S4 and C5 S5).

The occurrence of these waters in major parts and could be attributed to pollution of groundwater along river course due to textile industrial effluent flowing regularly in river.[8-9] The crop production in this area has declined to a great extent and soils have become hard and even barren owing to use of polluted groundwater.

Residual sodium carbonate (RSC)

Alkalinity in irrigation water creates sodicity problems in soils. The excess alkalinity termed as residual sodium carbonate is a measure of sodium hazard. It adversely affects the soil texture and the soils become hard and compact due to reduction in permeability. The unfavourable condition so developed inhibits the intake of essential nutrients to the plants and affect the agricultural yield. The water analyses indicate that 31.13 % well waters have residual sodium carbonate above 2 meq L^{-1}. The villages located along the river course i.e. Jawdia, Mandia, Giradara ki Dhani, Kerla, Sukarlaie, Jetpur, Gadwara Dholeria jagir and Dholeria shasan have considerable residual sodium carbonate Some of the groundwater in north-east around Akeli-Nayagaon section also has considerable residual sodium alkalinity. The 64.15 % ground water has percent sodium above 70. Higher percent sodium (> 80) in ground water are encountered in north-east to south i.e. from Bumadra-Utwan to Mandia-Giradara-Dayalpura section and Sukarlai-Chatelao section to Dholeria Jagir-Sonaie Dhani also show higher sodium contents. It is clearly observed that ground waters all along the river course from Pali city to Dholeria Jagir are characterized by high sodicity.

Table 3. Tolerant and semi–tolerant crops with respect to salinity

Semi-tolerant crops EC = 4000-8000 μS cm^{-1}	Tolerant crops EC = 8000 – 16000 μS cm^{-1}
Jowar	Sugarbeet
Rice	Tobacco
Maize	Barley
Oat	Turnip
Wheat	Dhaincha
Senji	Spinach
Berseem	Datepalm
Tomato	Guava
Bajra	
Mango	
Pomegranate	

Thus, high alkalinity as well as soluble sodium contents is the main hindrances inspite of sandy soils available in the study area i.e. favourable for irrigation and good crop yields. Since, plants are relatively more sensitive at the germination stage and salt-tolerances also differ with the stage of growth as such farmers can go for various crops with relative salt tolerances Table 3. The agriculture can be enhanced by giving due consideration to soil-water-plant relationship and adequate leaching of salts through soils.

Conclusion

The application of polluted groundwater (salinity >8000 μS cm^{-1} and SAR >30) in agriculture fields has reduced the yields of crops considerably. The suspended and colloidal matter have clogged the pores of the soil and reduced its permeability due to use of river water for irrigation. The high alkalinity and sodicity of polluted waters have been detrimental to several crops and impaired their growth due to hard and barren soils [9]. Thus, there is an economical loss for riverain population of more than forty villages from Pali to Nehda village. Since these soils are located in arid environment where good quality of groundwater is not available, the reclamation of such type of affected soils is a big problem. Considering the above problem and limitation, the alternate remains is to utilize rainwater by proper collection in the field through construction of strong earthen bunds on field boundary. Deep ploughing should be done before onset of monsoon to increase the infiltration and percolation rate process as this will help in leaching of the soluble salts from upper horizons thus improving the physical condition of soil. The application of gypsum with organic manure to the soil is also beneficial.

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