RESEARCH PAPER:

Studies on suitability of under ground water for irrigation as influenced by effluents flowing in Khari cannel around area of Nawagam-Vatava region of Gujarat (India)

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SUMMARY

A study was conducted to determine the suitability of under ground water for irrigation as influenced by effluents flowing in Khari cannel around area of Nawagam-Vatava region of Gujarat (India). Twenty - twenty samples of tube well were collected from both contaminated and uncontaminated locations where effluent canal is passed. The samples were analyzed for irrigation quality parameters, micronutrient and heavy metal contents. The pH of tube well water of uncontaminated area was in the range of 7.10 to 9.36, neutral to alkline while tube well water of contaminated area was highly acidic (pH 6.40) to alkaline (pH 8.56) in reaction. The EC of the ground water of non-contaminated area was comparatively less saline than contaminated area. Among different cation and anion concentrations of Na+, Cl-, $CO3^{2-}$ and $HCO3^{-}$ ions were 73, 30, 73 and 46 per cent higher in tube well water sample of contaminated area as compared to uncontaminated area. While K^{+} and Ca^{2+} + Mg^{2+} were higher in tube well water of uncontaminated area as compared to contaminated area. The sodium absorption ratio and residual sodium bicarbonate were also calculated. The SAR (18.0) and RSC (4.5) values were also higher in tube well water from contaminated area than their corresponding values in well water of uncontaminated area. This indicated that the quality of ground water in contaminated area was inferior to that of non-contaminated area. The water soluble and total micronutrients (Fe, Mn, Zn and Cu) and heavy metals (Cd, Ni, Cr, Pb and Co) were comparatively higher in tube well water of contaminated area except water soluble Fe, which was higher in tube well water of uncontaminated area. This indicated that the ground water contamination was laterally extended below ground even up to about 1.5 to 2.0 km away from the open channel carrying mix industrial effluents into Khari river.

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The main source of irrigation in Nawagam area is open well, bore well and village ponds. The village ponds are receiving effluent water through Khari canal/channel, which carries industrial effluents discharged from the industrial area of Naroda and Vatva. These effluents may or may not be biodegradable. It was also observed that there were approximately 1600 units of which, about 525 units generate effluents. These units include dyes intermediates, process house, chemical industries, pigment manufacturers etc., which discharge chromium as one of the metals in their effluents. Therefore, there are possibilities of the contamination of surface and ground water and soils of the area by heavy metals present in the wastewater released by the industry. Farmers in Nawagam area use effluent diluted with fresh canal water for irrigation purpose as and when required. The wastewater contains beneficial elements such as N, P, K, S etc. as well as toxic metals such as Cd, Pb, Ni, Cr, Co etc. In our country, most of the wastewater is a mixture of domestic, commercial and industrial activities. Therefore, although a large proportion of this wastewater is organic in nature and contains essential nutrients but in many cases toxic elements too are present in appreciable amounts (Kansal, 1994; Venkateswara Rao *et al.*, 1996; Srinivasachari, *et al.*, 1998; Siddaramaiah *et al.*, 1998; Patel *et al.*, 2003 and Maliwal *et al.*, 2005).

MATERIALS AND METHODS

The twenty-twenty tube well water samples were collected in the clean plastic bottle from uncontaminated areas like Shrijipura (2), Chitrasar (2), Dharoda (2), Kathwada (1), Chalindra (1), Bareja (2), Bherai

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(1), Bakodara jara (1), Vadala (4), Dhathal (1) Nayaka (3) as well as contaminated areas like Chalinra (1), Pinglaj (2), Nawagam (3), Pansholi (2), Malarpur (1), Kanera (1), Girmatha (1), Lambha (1), Sarasa (1), Lali (2), Umiyapura (2), Bidaj (1) Nayaka (2). The tube well water samples were collected directly from the outlet point. Two to three drops of toluene were added to the samples to prevent microbial growth and preserved under low temperature condition in the laboratory for further analysis. Ground water quality for agricultural purpose was assessed for water samples of contaminated well water in comparison to the samples of adjoining non-affected area. The water samples were analyzed for pH, salinity, sodicity and concentrations of trace and heavy metals. Micronutrients (Fe, Mn, Zn and Cu) and heavy metals (Pb, Ni, Cd, Cr and Co) were determined directly in filtered sample and after wet digestion with 1: 2 mixtures of $HClO_4$ and HNO_3. The analytical methods used for different parameters, micronutrients and heavy metals are given in Table 1.

from 13.4 to 43.6 me l^{-1} with mean value of 25.2 me l^{-1} as against Na^+ content in tube well water of uncontaminated area (ranging form 4.0 to 25.4 me l^{-1} with mean value of 14.6 me l^{-1}). While in case of K^+ and $Ca^{++} + Mg^{++}$, tube well water of uncontaminated area recorded slightly higher mean values of 8.2 and 7.6 me l^{-1} as compared to contaminated area. (Table 1). The data also highlighted that the CO^{3-}, HCO^{3-} and Cl^- were higher in tube well water of contaminated area with mean values of 1.9, 6.0 and 29.3 me l^{-1}, respectively than those recorded in tube well water of uncontaminated area. Similarly, mean of SAR (18.0) and RSC (4.5 me l^{-1}) values were also higher in tube well water from contaminated area than their corresponding values in well water of uncontaminated area. This indicated that the quality of ground water in contaminated area was inferior to that of non-contaminated area.

In general, the overall quality of tube well water of uncontaminated area was medium to poor while that of contaminated area was poor for irrigation purpose.

Table 1 : Methods adopted for tube well water analysis

Sr. No.	Parameters	Analytical method	Reference
1.	pH, EC	Potentiometry	
2.	Calcium (Ca^{2+}) and Magnesium (Mg^{2+})	Complexometric tritation	
3.	Sodium (Na^+) and Potassium (K^+)	Flame photometric	Trivedy and Goel (1984)
4.	Chloride (Cl^-)	Mohr's titration	
5.	Soluble and total Fe, Mn, Zn, and Cu, Pb, Ni, Cd, Cr and Co	AtomicAbsorption Spectroscopy (Analysed on AAS Model: PE 3110) and Analyst 100 with graphite furnace 800)	APHA (1989) (Isaac and Kerber, 1971)

RESULTS AND DISCUSSION

The quality of tube well water (ground water) from contaminated and uncontaminated areas was assessed by analyzing different parameters *viz.*, pH, EC, cations, anions, SAR, RSC and total content of micronutrients and heavy metals like Fe, Mn, Zn, Cu, Cd. Co, Cr, Ni and Pb.

The pH of tube well water of uncontaminated area ranged from 7.10 to 9.36 while tube well water of contaminated area was highly acidic (pH 6.40) to alkaline (pH 8.56) in reaction (Table 2). The EC varied from 2.20 to 6.80 dS m^{-1} with an average value of 3.80 dS m^{-1} in tube well water of contaminated area indicating high level of salinity. The tube well water of uncontaminated area ranged form 1.80 to 4.40 dS m^{-1} with mean value of 2.21 dS m^{-1}, which indicated that the ground water of non-contaminated area was comparatively less saline than contaminated area.

The results of survey indicated that Na^+ was higher in tube well water of contaminated area which ranged

Therefore, the ground water of the area was found as saline as well as sodic in nature. Since, the mix industrial effluents containing high soluble salts are passing through the area in open channel, it is expected that there could be a leaching of soluble salts downwards with ground water. The results also indicated that the salts are of mainly chlorides, carbonates and bicarbonates of Na^+. Therefore, the water was found as saline (EC-3.80) as well as sodic (pH- 7.80) in nature to render its quality poor for irrigation purpose.

Further, it was noticed that the water of contaminated area was containing appreciable quantity of salts and heavy metals as well.

The tube well water samples were also analyzed for water soluble and total micronutrients and heavy metals. The water soluble and total micronutrients (Fe, Mn, Zn and Cu) were comparatively higher in tube well water of contaminated area except water and total Fe and Zn and total Mn, which were higher in tube well water of

Table 2 : Chemical composition of tube well water in Nawagam - Vatava region

Sr. No.	pH	EC	Cations			Anions			SAR	RSC
			Na^+	K^+	$Ca^{2+}+Mg^{2+}$	Cl^-	CO_3^{2-}	HCO_3^-		
			Me/l							
1.	8.09	2.00	14.0	6.5	6.2	20.5	1.0	2.0	11.3	-0.1
2.	8.29	2.30	13.3	10.0	6.4	20.5	1.0	3.0	10.5	0.8
3.	8.43	5.40	15.0	13.6	22.0	38.5	0.8	5.0	6.4	-5.2
4.	8.52	2.70	21.3	5.8	7.0	20.5	1.0	7.0	16.1	4.5
5.	7.65	2.78	7.2	12.3	6.8	16.5	1.4	2.2	5.5	0.2
6.	7.96	2.08	4.0	10.0	5.8	11.5	0.6	3.0	3.3	0.7
7.	8.00	3.74	21.9	7.2	6.2	32.0	2.0	6.0	17.6	4.9
8.	7.57	2.85	24.6	1.0	5.0	22.5	4.0	4.0	22.0	5.5
9.	8.40	2.80	20.2	4.3	4.2	20.5	1.6	7.5	19.7	7.0
10.	7.67	4.48	25.4	8.7	9.6	36.5	1.0	3.0	16.4	-0.8
11.	8.53	3.48	10.5	11.7	8.6	25.0	0.6	3.0	7.2	-0.7
12.	7.20	2.18	13.9	5.5	2.8	12.5	1.0	9.0	16.6	8.6
13.	8.30	4.36	14.0	13.9	9.6	29.0	0.6	7.7	9.1	3.5
14.	9.36	3.00	5.1	9.5	10.2	20.0	0.0	2.0	3.2	-3.1
15.	7.93	3.16	11.0	6.3	9.0	21.5	0.0	2.6	7.4	-1.9
16.	8.69	2.00	14.4	5.5	3.6	14.0	1.6	5.5	15.2	5.3
17.	7.97	3.47	11.2	11.1	9.0	25.0	0.8	1.3	7.5	-2.4
18.	8.51	1.80	10.3	4.3	5.2	14.0	1.0	3.0	9.1	1.4
19.	7.10	3.26	16.1	7.2	8.4	29.5	1.0	4.0	11.1	0.8
20.	7.25	2.16	20.1	10.2	7.1	21.5	0.6	2.0	9.1	7.0
Min	7.10	1.80	4.0	1.0	2.8	11.5	0.0	1.3	3.2	-5.2
Max	9.36	4.40	25.4	13.9	22.0	38.5	4.0	9.0	22.0	8.6
Mean	8.07	2.21	14.6	8.2	7.6	22.6	1.1	4.1	11.2	1.8
1.	7.40	2.57	13.4	5.6	4.0	13.0	2.0	7.0	13.4	1.1
2.	8.07	2.21	17.0	8.8	3.0	32.0	0.6	2.0	19.6	3.2
3.	7.60	3.19	19.1	6.4	5.6	24.0	1.0	5.0	16.2	6.1
4.	8.56	3.60	26.2	6.6	2.8	31.0	2.0	5.5	31.3	1.5
5.	7.20	4.65	37.8	1.3	15.0	30.5	2.0	7.0	13.9	5.7
6.	7.65	2.51	22.4	2.6	6.6	12.0	3.0	6.0	17.4	7.5
7.	7.20	4.26	24.4	7.7	5.0	33.5	2.0	8.0	21.8	4.4
8.	8.11	5.30	33.2	8.4	5.4	36.5	1.6	5.5	22.1	0.7
9.	8.29	3.80	26.7	7.6	7.8	32.5	1.6	3.0	19.2	8.1
10.	8.31	3.20	22.5	5.1	2.8	20.5	1.6	7.9	26.8	3.9
11.	8.11	3.22	23.7	7.8	6.4	25.0	2.0	5.1	18.7	3.0
12.	8.20	3.30	18.0	5.0	5.0	23.0	0.0	5.5	16.1	5.7
13.	8.29	4.60	29.9	7.6	4.4	41.0	2.0	5.9	21.8	3.7
14.	7.35	4.01	31.4	2.4	12.6	33.5	4.0	6.0	11.6	5.5
15.	8.21	4.80	34.2	8.8	6.4	30.5	2.8	5.9	14.1	5.7
16.	8.14	6.80	43.6	10.8	8.4	52.5	2.0	7.9	11.3	5.5
17.	7.90	3.21	18.9	6.4	5.0	29.0	2.0	6.0	16.9	6.4
18.	7.50	3.74	23.2	7.6	5.2	29.0	3.0	6.0	20.4	6.3
19.	7.55	2.20	16.4	0.3	5.4	16.0	2.0	7.0	14.1	1.3
20.	6.40	4.79	22.9	8.0	13.4	40.0	1.0	7.0	12.5	4.7
Min	6.40	2.20	13.4	0.3	2.8	12.0	0.0	2.0	11.3	0.7
Max	8.56	6.80	43.6	10.8	15.0	52.5	4.0	8.0	31.3	8.1
Mean	7.80	3.80	25.2	6.2	6.5	29.3	1.9	6.0	18.0	4.5

Table 3 : Water soluble content of the tube well water of Nawagam-Vatava region

Sr. No.	Micronutrient					Heavy metal			
	Fe	Mn	Zn	Cu	Cr	Cd	Co	Ni	Pb
					ppm				
1.	0.030	ND	0.030	0.010	0.050	0.010	0.070	0.010	ND
2.	0.020	ND	0.030	ND	0.040	ND	0.030	ND	0.020
3.	0.020	0.010	0.050	ND	0.060	0.010	0.050	0.010	ND
4.	0.040	0.200	0.060	0.010	0.044	0.010	0.030	0.020	0.080
5.	0.050	0.030	0.050	0.010	0.024	ND	0.030	0.020	0.040
6.	0.010	0.010	ND	ND	0.028	0.010	0.030	0.050	0.040
7.	0.040	0.010	0.050	0.010	0.024	0.010	0.040	0.010	0.030
8.	0.030	0.010	0.020	ND	0.046	0.010	0.040	0.020	0.040
9.	0.020	ND	0.030	0.010	0.018	ND	0.020	ND	ND
10.	0.040	0.010	0.110	0.010	0.004	ND	ND	ND	ND
11.	0.040	0.010	0.030	0.010	0.030	0.010	0.050	0.030	0.040
12.	0.040	0.010	0.030	0.010	0.026	0.010	0.030	0.010	0.010
13.	0.020	0.050	0.010	0.010	0.008	0.010	ND	ND	0.080
14.	0.020	0.010	0.030	0.010	0.014	ND	0.040	0.010	0.120
15.	0.130	0.010	0.050	0.020	0.020	0.010	0.050	ND	0.050
16.	0.030	0.020	0.040	0.010	0.042	ND	ND	0.020	0.010
17.	0.070	0.010	0.040	0.010	0.022	0.010	ND	0.020	0.040
18.	ND	ND	ND	ND	0.016	0.010	ND	0.070	0.060
19.	0.020	0.010	ND	ND	0.018	0.010	0.030	0.050	0.080
20.	0.050	0.010	0.030	0.010	0.028	0.010	0.030	ND	0.050
Min	ND	ND	ND	ND	0.004	ND	ND	ND	ND
Max	0.130	0.200	0.110	0.020	0.060	0.010	0.070	0.070	0.120
Mean	0.036	0.021	0.035	0.008	0.028	0.007	0.029	0.018	0.040
1.	ND	0.010	0.010	0.010	0.080	ND	0.060	ND	ND
2.	0.040	ND	0.040	0.020	0.050	0.010	0.070	ND	0.050
3.	0.050	0.060	ND	ND	0.050	0.010	0.030	0.090	0.020
4.	0.060	0.090	0.010	0.010	0.100	0.002	0.060	0.050	0.060
5.	ND	0.040	ND	0.010	0.080	ND	0.060	0.030	0.040
6.	0.010	0.010	ND	0.010	0.050	0.002	0.050	0.050	0.040
7.	ND	0.010	ND	0.010	0.040	0.030	0.020	0.030	0.040
8.	0.020	0.020	0.020	0.100	0.060	0.010	0.010	0.030	0.060
9.	0.100	0.060	ND	0.010	0.040	ND	0.040	0.040	0.050
10.	0.020	0.020	ND	0.020	0.060	0.010	0.050	0.040	0.060
11.	0.020	0.030	ND	0.010	0.020	0.010	0.010	0.040	0.060
12.	0.010	0.010	ND	0.010	0.060	0.020	0.070	0.070	0.020
13.	0.030	0.020	ND	ND	0.040	0.040	0.060	0.030	0.050
14.	ND	0.020	ND	0.010	0.060	0.010	0.050	0.030	0.100
15.	0.020	0.010	ND	0.010	0.060	0.010	0.080	0.050	0.050
16.	ND	0.010	ND	0.010	0.070	0.010	0.030	0.010	0.020
17.	ND	0.010	ND	0.010	0.060	0.010	0.050	0.020	0.040
18.	0.020	0.040	0.010	0.010	0.080	ND	0.020	0.060	0.060
19.	0.030	0.020	0.020	0.010	0.090	0.010	0.010	0.030	0.050
20.	0.010	0.030	0.010	0.010	0.080	ND	0.020	0.050	0.060
Min	ND	ND	ND	ND	0.020	ND	0.010	ND	ND
Max	0.100	0.090	0.040	0.100	0.100	0.040	0.080	0.090	0.100
Mean	0.022	0.026	0.006	0.015	0.062	0.010	0.043	0.038	0.047

ND: Not detected

Table 3: Total content of micronutrient and heavy metals in tube well water of Nawagam-Vatava region

Sr. No.	Micronutrient				Heavy metal				
	Fe	Mn	Zn	Cu	Cr	Cd	Co	Ni	Pb
					ppm				
1.	0.500	0.050	0.060	0.010	0.070	0.010	0.060	0.020	0.070
2.	0.430	ND	0.040	0.010	0.080	0.020	0.070	ND	ND
3.	0.800	0.010	0.200	0.020	0.064	0.020	0.060	0.010	0.080
4.	1.320	0.590	0.120	ND	0.048	0.020	0.070	0.040	0.100
5.	0.640	0.270	0.200	0.030	0.044	0.020	0.040	0.400	0.080
6.	0.540	0.070	0.050	ND	0.038	ND	0.070	0.060	0.060
7.	3.490	0.120	0.300	0.030	0.024	0.010	0.060	0.020	0.070
8.	0.630	0.080	0.070	0.010	0.050	0.010	0.100	0.030	0.080
9.	0.270	0.020	0.030	0.020	0.028	0.020	0.060	ND	0.100
10.	0.470	0.020	0.200	0.010	0.040	0.020	0.040	ND	0.080
11.	0.490	0.250	0.150	0.030	0.062	0.010	0.070	0.050	0.080
12.	0.520	0.120	0.010	0.020	0.036	0.020	0.120	0.030	0.030
13.	0.300	0.130	0.500	0.010	0.038	0.020	0.050	0.030	0.090
14.	0.820	0.040	0.070	0.020	0.060	0.020	0.050	0.020	0.140
15.	1.010	0.200	0.100	0.020	0.044	0.020	0.080	0.010	0.150
16.	0.800	0.200	0.030	0.020	0.070	0.010	0.030	0.030	0.040
17.	0.350	0.030	0.050	0.020	0.050	0.010	0.100	0.060	0.090
18.	0.190	0.050	0.040	0.020	0.030	0.020	0.080	0.700	0.090
19.	0.160	0.040	0.050	ND	0.042	0.010	0.070	0.080	0.130
20.	0.070	0.030	0.030	0.010	0.048	0.020	0.120	0.010	0.200
min	0.070	ND	0.010	ND	0.024	ND	0.030	ND	ND
max	3.490	0.590	0.500	0.030	0.080	0.020	0.120	0.700	0.200
Mean	0.690	0.116	0.115	0.016	0.048	0.016	0.070	0.080	0.088
1.	0.370	0.050	0.040	0.020	0.090	0.020	0.080	0.030	0.020
2.	0.560	0.010	0.060	0.040	0.050	0.010	0.080	ND	0.070
3.	0.220	0.080	0.060	0.010	0.120	0.020	0.078	0.080	0.100
4.	0.190	0.410	0.050	0.020	0.120	0.020	0.100	0.120	0.120
5.	0.100	0.070	0.340	0.010	0.090	0.010	0.090	0.080	0.050
6.	0.060	0.060	0.030	0.020	0.060	0.020	0.080	0.100	0.500
7.	0.490	0.060	0.070	0.020	0.100	0.080	0.100	0.040	0.080
8.	0.260	0.030	0.500	0.190	0.090	0.020	0.020	0.900	0.060
9.	0.750	0.080	0.020	0.030	0.070	0.020	0.060	0.080	0.060
10.	0.180	0.090	0.010	0.030	0.070	0.010	0.190	0.080	0.090
11.	0.400	0.090	ND	0.030	0.040	0.020	0.050	0.090	0.070
12.	0.310	0.040	0.010	0.020	0.090	0.030	0.080	0.070	0.060
13.	0.160	0.360	0.030	0.050	0.120	0.060	0.070	0.050	0.170
14.	0.500	0.030	ND	0.020	0.080	0.010	0.120	0.030	0.170
15.	0.340	0.030	0.010	0.020	0.080	0.010	0.110	0.200	0.090
16.	0.060	0.040	ND	0.020	0.070	ND	0.080	0.070	0.040
17.	0.760	0.020	ND	0.010	0.070	0.020	0.100	0.070	0.050
18.	0.180	0.090	0.010	0.020	0.080	ND	0.020	0.080	0.070
19.	0.120	0.080	0.020	0.010	0.090	0.020	0.010	0.050	0.090
20.	0.110	0.090	0.040	0.020	0.100	0.020	0.030	0.060	0.120
min	0.060	0.010	ND	0.010	0.040	ND	0.010	ND	0.020
max	0.760	0.410	0.500	0.190	0.120	0.080	0.190	0.900	0.500
Mean	0.306	0.091	0.065	0.031	0.084	0.021	0.077	0.114	0.104

ND: Not detected

uncontaminated area. Further, the water soluble and total heavy metals (Cd, Ni, Cr, Pb and Co) were also higher in tube well water of contaminated area than in uncontaminated area (Table 3 and 4).

This indicated that the ground water contamination was laterally extended below ground even up to about 1.5 to 2.0 km away from the open channel carrying mix industrial effluents into Khari river. Similar observations on ground water contamination along the ECP channel in vadodara district has been reported by Maliwal *et al.* (2005). Thus, the results of survey study stressed on the possible risk of contamination of ground water not only in the affected but near by surrounding/adjoining areas also.

Conclusion:

The tube well water along the canal was saline-sodic in nature and contained appreciable amount of trace and heavy metals. Also, the tube well water in adjoining area was medium to poor in quality and found contaminated with heavy metals; although the level of contamination was comparatively less than that noticed in contaminated area. This indicated that the ground water was about possibly contaminated even at a distance to about 1.5 to 2.0 km away form the open effluent carrying canal.

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