Water Irrigation Chemistry of Underground Water in Hub Valley, Karachi (Pakistan)

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Summary: Groundwater samples from existing wells in different farms/villages of Hub valley were collected and analyzed for chemical constituents, viz Na^+, K^+, Ca^{++}, Mg^{++}, CO_3^{--}, HCO_3^-, Cl^- and SO_4^{--} along with their physical properties. The values of total dissolved salts (TDS), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and exchangeable sodium percentage (ESP) of the samples were then calculated to investigate their irrigation chemistry. The overall results show that 44% samples are within safe limit, whereas 38% are marginal and only 18% samples are hazardous from irrigation point of view. A considerable quantity of Hub dam water, which is presently being used for irrigation in Lasbella district, can be saved for drinking purposes by replacing it with well waters of Hub valley within safe to marginal limits. Underground water of Hub valley is some what inferior than the underground water of Malir valley from irrigation point of view.

Introduction

The process of rapid industrialization and urbanization has created problems of water scarcity in the city of Karachi. A dam had been constructed by WAPDA, across Hub river 56 Km from North of Karachi. M.A.A. Beg [1] *et al*, have monitored seasonal changes in composition and quality of Hub-dam water for eight years and found it as good quality raw water for industrial and agricultural purposes and human consumption after simple treatment. The Hub river separates the provinces of Balochistan and Sindh, each of which receives water by a canal from the Hub dam reservoir. Although the stream bed of the Hub River was deprived of its water by Hub River Dam and its real function now is only to provide, after strong downpours of rain that lead to an overflowing of the reservoir, for the rapid draining of the superfluous mass of water. The ground water comes both from these sources and from the seepage losses in the Pleistocene aquifer from the Hub River reservoir.

According to the local population, water is present throughout the year in the wells and the deeper parts of the riverbed. Water samples from twenty wells in the valley were collected to study their irrigation chemistry. Fig. (1) depict the map of Hub Valley with sampling points. The quality of irrigation water depends principally upon the total amount of salts present and on the proportion of sodium to other cations. The most satisfactory method for rating the salt content of irrigation waters involves measuring of their electrical conductivity (E.C). A widely used scheme to evaluate irrigation water with regard to sodium is the rating of waters accordingly to the soluble sodium percentage (Na^+ x 100)/ (Ca^{++} + Mg^{++} + Na^+ + K^+) [2]. Sometimes low salinity and sodium percentage within safe limits may be hazardous from irrigation point of view due to considerable excess quantity of CO_3^{--} + HCO_3^- than Ca^{++} + Mg^{++}, with the result that calcium and magnesium precipitate as carbonate, thus deteriorating the soil structure. This condition is termed as residual sodium carbonate (RSC) [3].

Recent trend in the rating a water sample from irrigation point of view, is to rate it on the basis of its total dissolved salts (TDS), sodium absorption ratio (SAR), residual sodium carbonate (RSC) and exchangeable sodium percentage(ESP), [4-5]. Well waters of Hub Valley have been analyzed for different physiochemical characteristics to calculate their irrigation parameters.

Results and Discussion

The detailed results of the well water analysis are tabulated in Table–1. It shows that pH ranged between 6.59 - 8.26 and phenolphthalien alkalinity zero, which indicate that hydroxides and carbonates are absent. Thus the total alkalinity which ranges between 49 – 344 ppm, was only due to bicarbonate [6]. Electrical conductivity varies between 2583 -

Table-1: Physiochemical Characteristics of Well Water of Hub Valley

Samp No.	pH	Ele. Cond us/cm	Anion ppm Cl^-	HCO_3^-	SO_4^{--}	Cation ppm Na+	K+	Ca++	Mg++	Methyl Orange Alkalinity ppm	Na %
1	6.68	3000	689	240	330	223	4	107	166	196	44.60
2	7.00	5520	1065	298	620	438	12	274	165	245	49.26
3	7.00	3990	965	239	519	527	11	137	95	196	68.44
4	7.00	5110	882	150	659	358	13	207	184	126	46.98
5	6.93	3920	827	179	371	406	14	150	98	147	60.77
6	7.11	2583	554	300	350	312	9	108	82	245	61.05
7	7.05	2711	551	298	292	355	10	70	85	245	68.26
8	6.95	3690	547	269	276	305	10	71	84	221	64.89
9	6.59	3000	550	119	473	222	17	154	92	98	44.77
10	6.65	4610	969	478	597	304	14	344	122	192	38.77
11	7.52	4530	890	180	721	338	17	206	207	147	44.00
12	8.08	2770	319	60	370	205	4	98	63	49	55.55
13	7.88	2790	546	160	406	208	7	136	137	131	42.62
14	7.05	3500	547	179	535	253	14	134	120	147	39.92
15	7.95	2705	191	419	576	180	7	159	123	344	38.37
16	7.64	3440	568	299	742	349	8	103	190	245	53.69
17	7.93	4060	639	359	762	477	8	190	126	294	59.55
18	8.26	3680	958	197	618	486	7	211	137	162	57.78
19	7.40	2680	414	239	372	215	3	128	70	196	51.68
20	7.00	4340	852	178	453	218	9	139	125	147	60.49

5520 µS/cm. Major anions and cations were Cl^-, HCO_3^-, SO_4^{--} & Na^+, K^+, Ca^{++}, Mg^{++} respectively. Sodium percentage varies between 38.37 - 68.44.

Scofield [7] has suggested a reasonably satisfactory classification of irrigation waters on the basis of their electrical conductivities and sodium percent as given in Table-2.

Table-2 Scofield's classification of irrigation water based on E.C. & Na%

Classes of Water		Electrical Conductivity	Sodium Percent
Rating	Grade		
1	Excellent	<250	<20
2	Good	250 - 750	20 - 40
3	Permissible	750 - 2, 000	40 - 60
4	Doubtful	2,000 - 3, 000	60 - 80
5	Unsuitable	>3000	>80

According to this classification, 40 % of water sample of Hub Valley are of doubtful grade and remaining 60 % are unsuitable from irrigation point of view, on the basis of their electrical conductivity. With respect to sodium percentage 15 % samples are good, 50 % are in permissible category v ıereas 35 % are doubtful and none was found to be unsuitable for irrigation purposes.

As already mentioned in prior description, that a recent trend in water irrigation chemistry is to evaluate a irrigation water on the basis of its TDS, SAR, RSC and ESP.

where $SAR = Na^+ / \sqrt{(Ca^{++} + Mg^{++})/2}$

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

$$ESP = \frac{100\ (-0.0126+0.01475\ SAR)}{1+(0.0126+0.01475\ SAR)}$$

all concentrations are in miliequivalent per litre [7-8].

S. D. Hussain *et al*, [5] have classified irrigation water as safe, marginal and hazardous on the basis of values of the prior mentioned parameters as tabulated in Table-3.

Table-3: Recent Trend in Classification of irrigation water (S.D. Hussain)

Water Quality	TDS ppm	SAR	RSC	ESP
Safe	<1000	<5	<1.25	<10
Marginal	1000-2000	5-10	1.25 - 2.5	10 - 20
Hazardous	>2000	>10	>2.5	>20

Different parameters like TDS, SAR, RSC & ESP of Hub Valley well waters have been calculated and are tabulated in Table-4.

The rating of the water samples on the basis of their irrigation parameters is also graphically represented in Figs (2-5). Fig (2) shows that 50 % samples were marginal and other 50 % were hazardous on the basis of their values of TDS. Fig (3) shows that 55 % of samples were safe, while 45 % were marginal on the basis of their SAR values

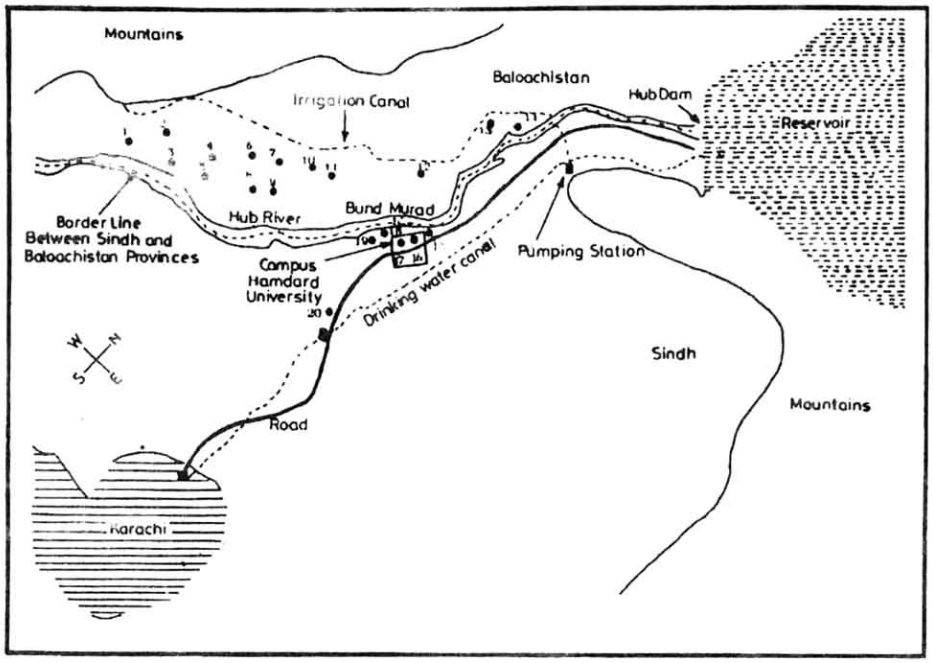

Fig. 1: MAP of Hub River Valley Showing Sampling Points.

Table – 4 Irrigation Parameters of Well Waters of Hub Valley

Sample No.	TDS ppm	SAR	RSC	ESP
1	1800	3.17	-14.70	3.30
2	2940	5.20	-22.07	6.02
3	2569	8.54	-10.53	10.20
4	2525	4.39	-22.61	4.96
5	2110	6.39	-12.41	7.55
6	1730	5.55	-7.05	6.54
7	1703	6.82	-5.42	8.05
8	1608	5.86	-5.86	6.87
9	1650	3.52	-13.11	3.78
10	2900	3.60	-19.13	3.89
11	2610	4.01	-23.91	4.47
12	1169	3.99	-8.96	4.44
13	1659	3.04	-15.14	3.10
14	1809	3.86	-13.37	4.23
15	1695	2.62	-10.93	2.54
16	2300	4.77	-15.45	5.39
17	2590	6.64	-13.70	7.87
18	2689	6.46	-18.28	7.64
19	1470	3.83	-8.09	4.21
20	2215	6.24	-14.04	7.38

whereas Fig (4) shows the rating of water sample on the basis of their RSC values. According to it, 100 % samples were found to be safe. Fig (5) indicates that 95 % samples were safe and 5 % are marginal on the basis of their ESP value.

Scofield's classification (Table-2) can be merged in S.D. Hussain's classification (Table-3) of irrigation water by considering excellent and good grade waters as safe, permissible & doubtful waters as marginal and unsuitable water in Scofield's classification as hazardous in S.D. Hussain's classify-cation. The above mentioned percentage results have

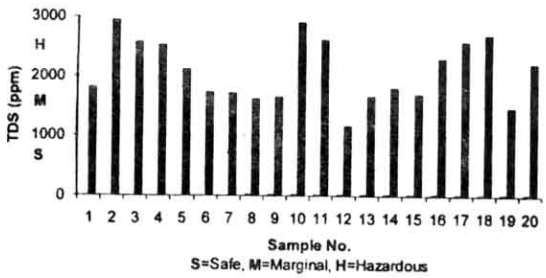

Fig. 2: Level of TDS in Well water of Hub Valley.

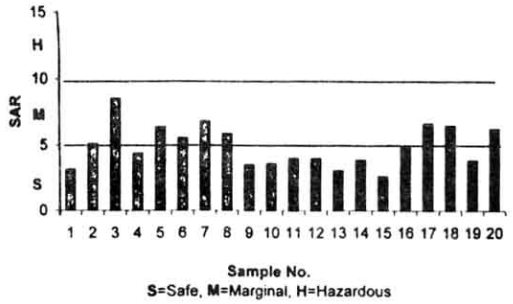

Fig. 3: Leve of SAR in Well water of Hub Valley.

been tabulated in Table-5. The table also shows the average result of these parameters.

Another classification of irrigation water on the basis of SAR has been referred by S. M. Alam *et al* [9]. According to this classification, a water with SAR<10 is considered as low sodium water, between 10-18 as medium, 18-26 as high and >26 very high or poor water from irrigation point of view. If this classification is taken into consideration for rating the results of the irrigation parameters, then 100 % well waters of Hub Valley can be considered safe for irrigation purposes.

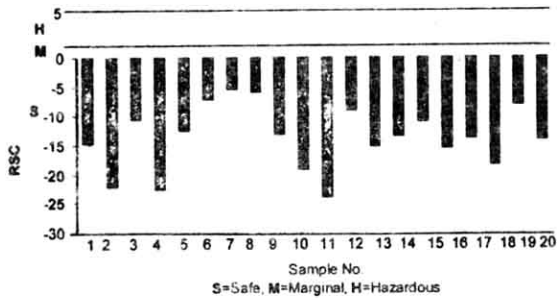

Fig. 4: Level of RSC in Well water of Hub Valley.

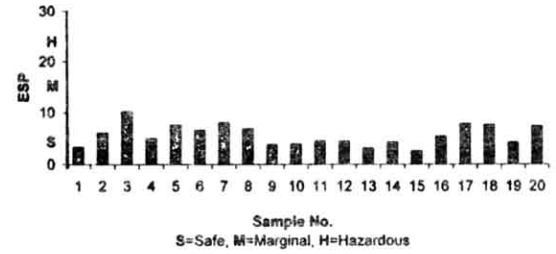

Fig. 5: Level of ESP in Well water of Hub Valley.

If the results of irrigation parameters of Hub valley well waters is compared with the results of Malir valley well water, shown in Table-6 [10]. It appears that the Malir Valley well water is more suitable then Hub Valley well water from irrigation point of view.

Experimental

Water samples from 20 wells were collected in thoroughly washed plastic containers for this study. Each sample was collected in such a way that it is the most representative sample of the area. Analytical grade (A.R) chemicals were used in the preparation of reagents. Physical and chemical analyses were carried out in triplicate for each sample and the average values were recorded. pH was measured immediately after collection of samples using a portable digital pH meter and all other estimations were completed within two days after sampling, SO_4^{--} and TDS were determined by gravimetric methods, Cl^- by argentometric method. Ca^{++} and Mg^{++} were determined by EDTA titration method and Na^+ and K^+ were determined by flame photometer [11].

Conclusions

This study indicates that, the salinity of the well waters of Hub Valley is comparatively on the

Table-6: Percentage results of Irrigation Parameters of Malir Valley Well Water

Irrigation Parameters	Classification		
S.D.Hussain's classification	Safe	Marginal	Hazardous
Scofield's classification	Excellent + good	Permissible + doubtful	Unsuitable
TDS	10%	50%	40%
SAR	70%	20%	10%
RSC	100%	00%	00%
ESP	90%	10%	00%
Elc. Cond.	0%	60%	40%
Na%	30%	70%	00%
Average results	50%	35%	15%

Table-5: Percentage results of Irrigation Parameters of Hub Valley Well Water

Irrigation Parameters	Classification		
S.D.Hussain's classification	Safe	Marginal	Hazardous
Scofield's classification	Excellent + good	Permissible + doubtful	Unsuitable
TDS	0%	50%	50%
SAR	55%	45%	0%
RSC	100%	0%	0%
ESP	95%	5%	0%
Elc. Cond.	0%	40%	60%
Na%	15%	85%	0%
Average results	44%	38%	18%

higher side, but the values of other irrigation parameters viz SAR, RSC, ESP and Na% are well within the safe and marginal ranges. Hence the underground water can be used for irrigation purposes in the area.

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