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

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(Received 4th September, 2001, revised 19th February, 2002)

Summary: Ground water samples from existing wells in different agricultural farms of Malir Valley Karachi, (Pakistan) 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. Inspite of high values of TDS, 70,90 and 100% samples were found to be safe with respect to their SAR, ESP & RSC values respectively. Sodium percent (Na%) of 30% samples was found to be good whereas 50% were in permissible range from irrigation point of view. The overall results show that the underground water of Malir Valley can suitably be used for irrigation purposes.

Introduction

Malir Valley Long: 67° 41' East, Lat: 25° 44' North situated in the east of Karachi city, remained very important during last century because of its water supply to Karachi city from Dumloti wells. Now the wells have been dried, Dumloti is serving as pumping station for public water supply from Kanchar lake to eastern part of Karachi. The Malir Valley is still important from its agricultural point of view, particularly for the production of vegetables & fruits. Malir Valley is actually the valley of Malir river which is formed by combination of Khadeji Nadi (rivulet) from Sindh Kohistan & Mole Nadi (rivulet) from Mole hills in the North of Super-Highway. The river then crosses the Super-Highway and passes through the green Malir Valley by receiving several other rivulets in the way. The river only flows during rainy season and brings sand by weathering of northern rocks. The sandy bed of the river adsorbs most of the river water which is stored underground in the valley. This water is used for irrigation purposes through open wells. The irrigation chemistry of well waters of the Valley may differ in different seasons. During rains water table of the valley becomes high with a result that ground water flows from valley to sea, where as in dry seasons water table in the valley goes down and the water flows from sea to valley, increasing the salinity of the underground water in the Valley which adversely affects the crop production. The irrigation chemistry of well water of valley was studied when there was no rain for the last several years.

The quality of irrigation waters depends principally upon the total amount of salts present and on the proportion of sodium to other cations. The salt content of irrigation water adversely affects the crop production *via* osmotic pressure of soil solution whereas higher proportion of sodium to other cations deteriorates the soil structure. 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 waters with regard to sodium is the rating of waters according to the soluble sodium percentage $(Na^+ x100)/(Ca^{++}+Mg^{++}+Na^+ +K^+)$, [1]. Sometimes low salinity and sodium percentage within safe limits may

be hazardous from irrigation point of view due to considerably exess amount of CO_3^{--} + HCO^-_3 than Ca^{++} + Mg^{++}, with the result that calcium and magnesium precipitate as carbonates, thus deteriorating the soil structure. This condition is termed as residual sodium carbonate (RSC), [2].

Recent trend in rating a water sample from irrigation point of view, is to rate it on the basis of its total dissolved salts (TDS), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and exchangeable sodium percentage (ESP), [3] & [4] Well waters of Malir Valley have been analysed for different physiochemical characteristics to calculate their irrigation parameters. Fig(1) depicts the map of Karachi showing Malir Valley with sampling points.

Results and Discussion

The detailed results of the well water analysis are tabulated in Table–1. It shows that pH ranged between 7.06-7.91 and phenolphthalien alkalinity zero, which indicate that hydroxides and carbonates are absent. Thus the total alkalinity which ranges between 188-476 ppm was only due to bicarbonate [5]. Almost all the samples were clear and colourless, had very low turbidity i.e. between 0.25-0.42 NTU. Electrical conductivity varies between 1010-7810 µS/cm. Major anions and cations were Cl^-, HCO_3^-, SO_4^{--} & Na^+, K^+, Ca^{++}, Mg^{++}, respectively.

Statistical analysis of physiochemical characteristics and correlation between different parameters have been tabulated in table-2 and 3.

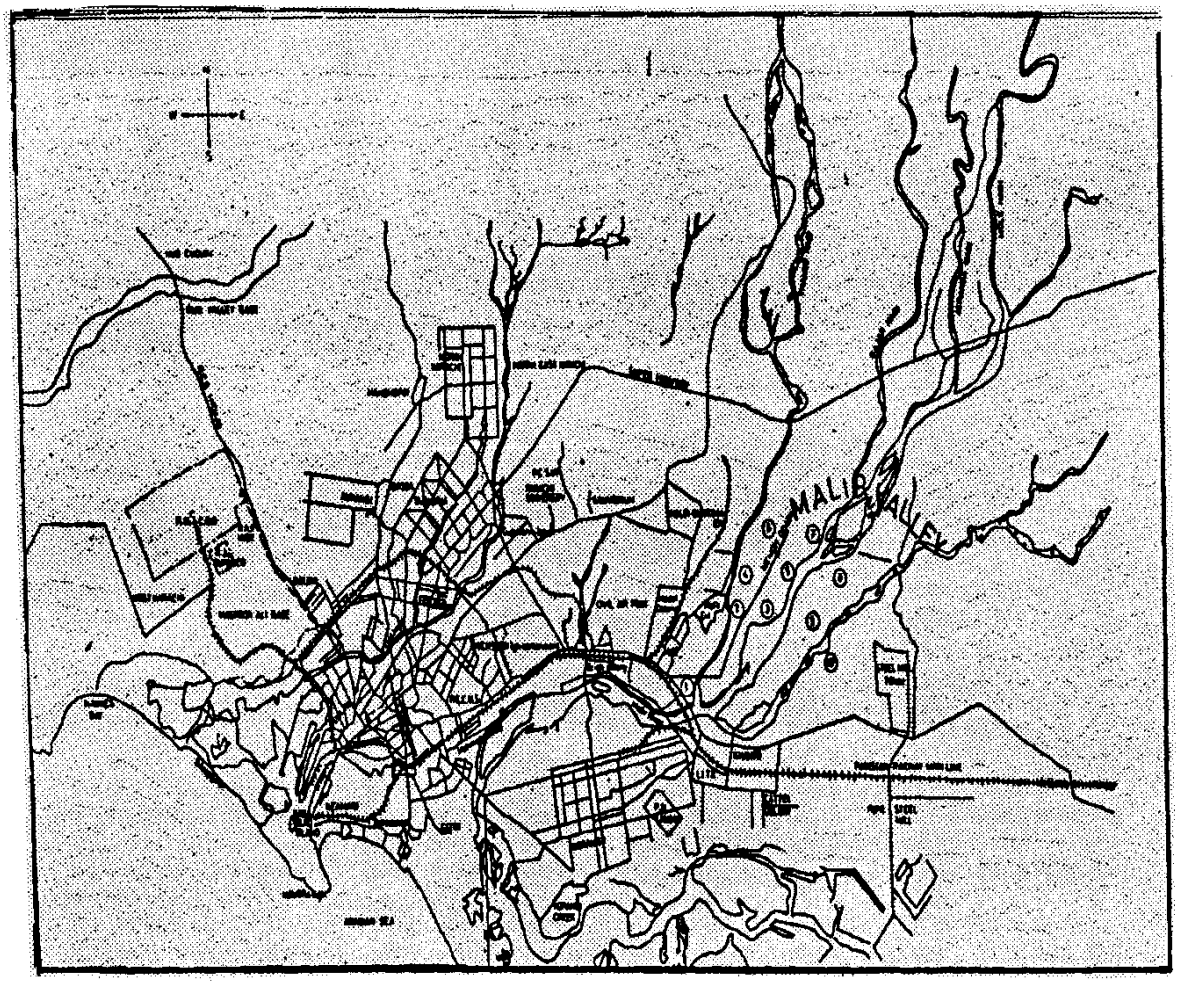


Fig. 1: Map of eastern part of Karachi showing Malir Valley with sampling points.

Table-1 Physiochemical Characteristics of Well Water of Malir Valley

Sample.	PH	Turbidity	Ele. Cond	Anion (ppm)			Cation (ppm)				Methyl Orange Alkalinity
No.		NTU	uS/cm	Cl^-	HCO_3^-	SO_4^{--}	Na^+	K^+	Ca^{++}	Mg^{++}	ppm
1	7.06	0.32	2150	355	549	103	285	10	80	80	450
2	7.17	0.35	6130	1738	381	494	675	10	277	280	312
3	7.40	0.28	1880	372	580	99	225	9	88	80	476
4	7.14	0.27	7810	2482	290	305	475	10	461	413	238
5	7.90	0.37	1010	160	366	41	143	5	44	32	300
6	7.63	0.40	3010	709	305	247	320	9	116	124	250
7	7.91	0.42	1730	355	244	82	170	6	76	88	200
8	7.57	0.33	3800	1064	244	173	250	10	200	199	200
9	7.15	0.27	6455	2056	229	189	340	10	409	331	188
10	7.35	0.25	2670	496	366	239	255	7	116	122	300

Table–2 Statistical Analysis of Physiochemical Characteristics of Well Water of Malir Valley

Characteristics	Mean	Median	Minimum	Maximum	Range	Std. Dev.
PH	7.424	7.375	7.06	7.91	0.85	0.311848
Turbidity	0.326	0.325	0.25	0.42	0.17	0.058727
Ele. Cond	3682.5	2840	1010	7810	6800	2349.233
Cl^-	978.7	602.5	160	2482	2322	825.0518
HCO_3^-	355.4	335.5	229	580	351	123.1171
SO_4^-	197.2	181	41	494	453	133.6569
Na^+	313.8	270	143	675	532	157.5047
K^+	8.6	9.5	5	10	5	1.897367
Ca^{++}	186.7	116	44	461	417	147.8476
Mg^{++}	174.9	123	32	413	381	126.517
Alkalinity	291.4	275	188	476	288	100.9777

Table-3 Correlation between Physiochemical Characteristics of Well-Water of Malir Valley. Marked Correlations are Significant at $p < .05000$ N=10

Characteristics	pH	Turbidity	Ele.Cond	Anion (ppm)			Cation (ppm)				Alkalinity
		NTU	uS/cm	Cl^-	HCO_3^-	SO_4^-	Na^+	K^+	Ca^{++}	Mg^{++}	
PH	1										
Turbidity	0.705										
Ele. Cond	-0.647	-0.406									
Cl^-	-0.594	-0.394	0.992								
HCO_3^-	-0.292	-0.232	-0.40	-0.450							
SO_4^-	-0.514	-0.150	0.738	0.665	-0.181						
Na^+	-0.643	-0.167	0.803	0.741	-0.055	0.941					
K^+	-0.804	-0.394	0.665	0.632	0.088	0.510	0.627				
Ca^{++}	-0.602	-0.472	0.974	0.990	-0.454	0.576	0.656	0.609			
Mg^{++}	-0.604	-0.429	0.990	0.995	-0.462	0.662	0.723	0.632	0.990		
Alkalinity	-0.293	-0.233	-0.405	-0.450	0.999	-0.182	-0.056	0.089	-0.453	-0.461	1

Scofield [6] has suggested a reasonably satisfactory classification of irrigation waters on the basis of their electrical conductivities and sodium percent as given in Table-4.

According to this classification, as may be seen in Fig (2), which shows that 30% of water samples of Malir Valley are of permissible grade, other 30% are doubtful and remaining 40% are unsuitable from irrigation point of view. Table 6 shows that sodium percentage varied between 31-64% and Fig (3) indicates that with respect to sodium percentage 30% samples are good, 50% are in permissible category whereas 20% are doubtful and none was found to be unsuitable for irrigation purposes.

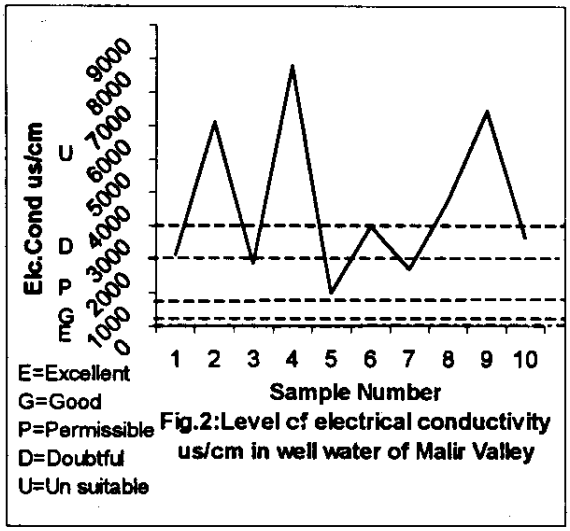


Fig.2:Level of electrical conductivity us/cm in well water of Malir Valley

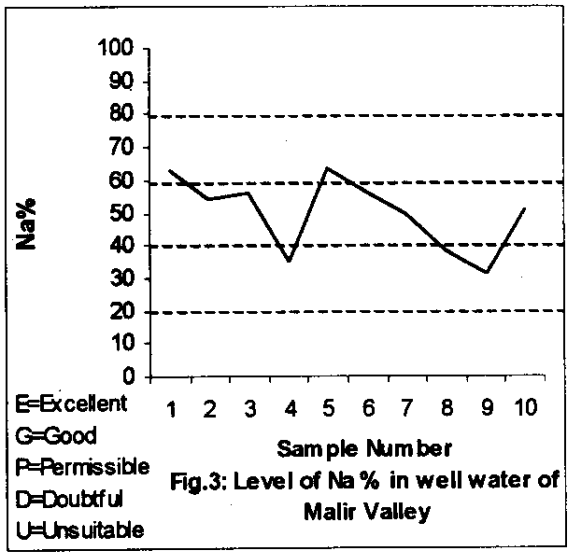


Fig.3: Level of Na % in well water of Malir Valley

Table-4 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

Table –5 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

U.S. Regional Salinity Laboratory Reverside, California [6] has given a graphical representation of cumulative effect of electrical conductivity and sodium percentage of a certain water sample on crop growth. Fig (4) shows this effect which elucidates that 10% samples are within good to permissible range, 20% in permissible to doubtful range, other 20% in doubtful to unsuitable range and remaining 50% were unsuitable for crop growth.

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

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

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

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

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

S.D. Hussain [4] *et al.*, have classified irrigation water as safe, marginal and hazardous on the basis of values of the prior mentioned parameters as tabulated in Table 5.

Different parameters like TDS, SAR, RSC & ESP of Malir Valley well waters have been calculated and are tabulated in Table-6.

Table – 6 Irrigation Parameters of Well Waters of Malir Valley

Sample No.	TDS ppm	SAR	RSC	ESP	Na %
1	1520	5.4	-1.56	6.28	63
2	3909	6.82	-30.93	8.18	54
3	1515	12.53	-1.56	14.67	56
4	4540	3.88	-52.7	4.21	35
5	830	4.00	1.13	4.39	64
6	1905	4.93	-11.13	5.66	56
7	1095	3.15	-7.13	3.28	50
8	2220	3.00	-22.58	3.00	38
9	3745	3.01	-44.28	3.00	31
10	1680	3.94	-9.97	4.39	51

Statistical analysis and correlation between different irrigation parameters have been tabulated in table –7 and 8.

The rating of the water samples on the basis of their irrigation parameters is also graphically

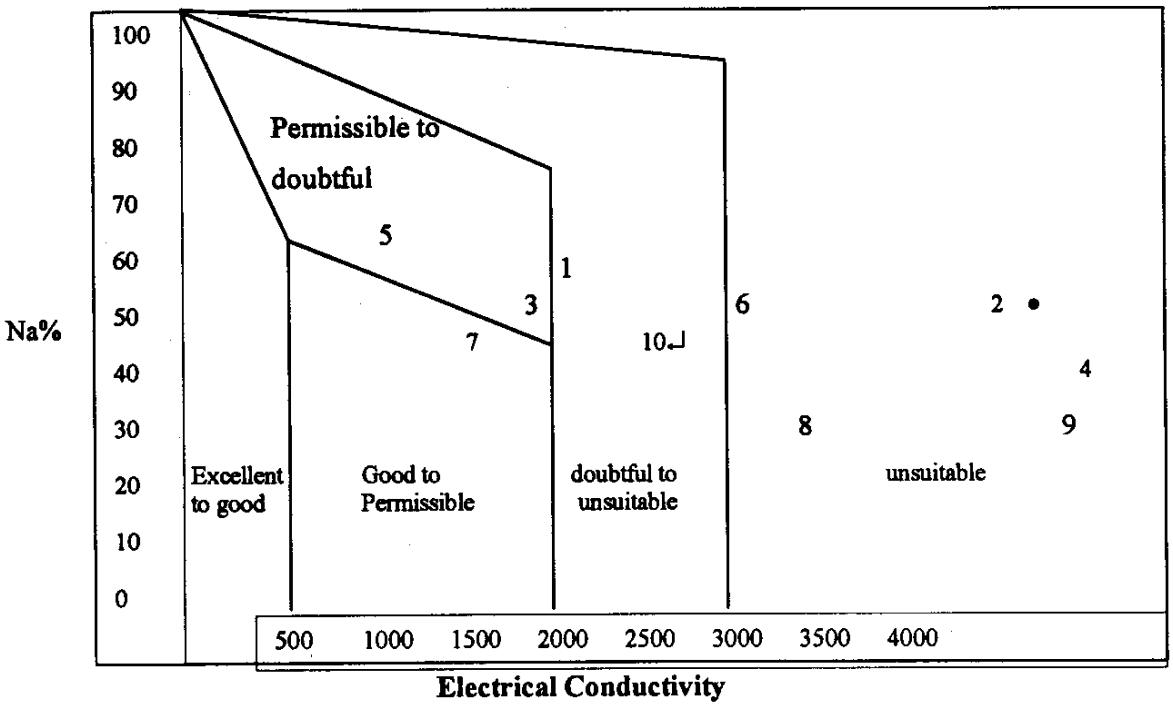


Fig. 4: Cumulative effect of electrical conductivity and sodium percentage on well water of Malir Valley

Table-7 Statistical Analysis of Irrigation Parameters of Well Waters of Malir Valley

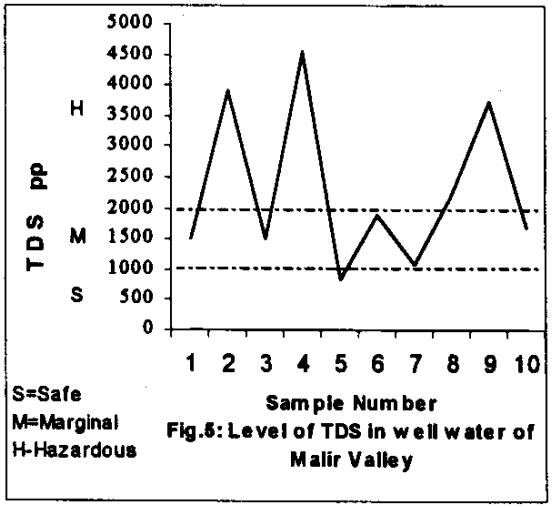
Parameters	Mean	Median	Minimum	Maximum	Range	Std.Dev.
TDS ppm	2296.5	1792.5	830	4546	3716	1295.53
SAR	5.066	3.97	3	12.53	9.53	2.88
RSC	-18.07	-10.55	-52.7	1.13	53.83	18.91
ESP	5.706	4.39	3	14.67	11.67	3.54
Na%	49.8	52.5	31	64	33	11.46

Table– 8 Correlation between Irrigation Parameters of Well Waters of Malir Valley. Marked Correlations are Significant at $p < .05000$ N=10

Parameters	TDS ppm	SAR	RSC	ESP	Na
TDS ppm	1				
SAR	-0.123				
RSC	-0.956	0.323			
ESP	-0.117	0.998	0.327		
Na%	-0.689	0.406	0.846	0.4304	1

Table-9 Percentage Results of Irrigation Parameters of Malir Vally Well Water

Irrigation Parameters	Classification		
	Safe	Marginal	Hazardous
TDS	10%	50%	40%
SAR	70%	20%	10%
RSC	100%	0%	0%
ESP	90%	10%	0%



represented in Figs (5) - (8). Fig (5) shows that 10% samples were safe, 50% marginal and 40% were hazardous on the basis of their values of TDS. Fig (6) shows that 70% of samples were safe, while 20% are marginal and only 10% were hazardous on the basis of their SAR values whereas Fig (7) shows the rating of water sample on the basis of their RSC values.

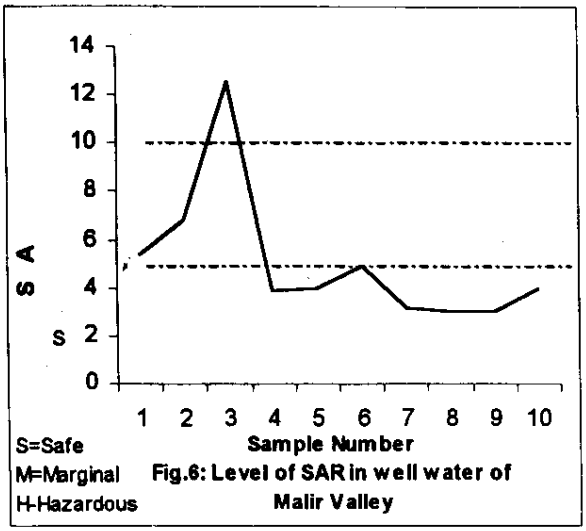


Fig.6: Level of SAR in well water of Malir Valley

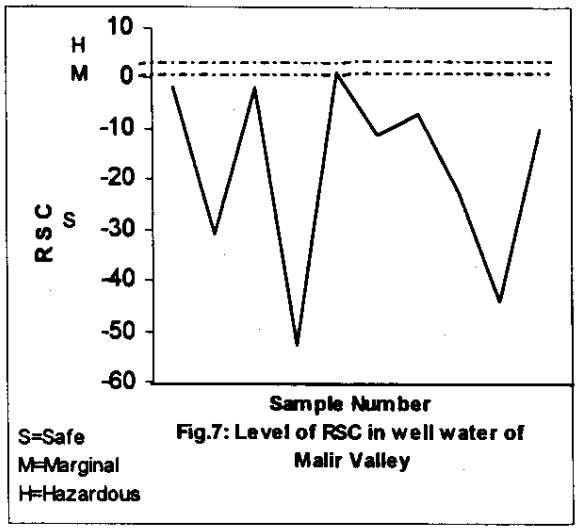


Fig.7: Level of RSC in well water of Malir Valley

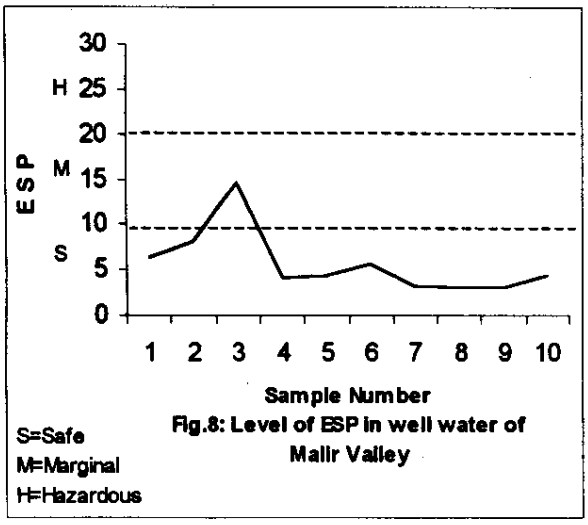


Fig.8: Level of ESP in well water of Malir Valley

According to it, 100% samples were found to be safe. Fig (8) indicates that 90% samples were safe and 10% are marginal on the basis of their ESP.

The above mentioned percentage results have been tabulated in table-9

Another classification of irrigation water on the basis of SAR has been referred by Alam [9] *et al.* 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 90% well waters of Malir Valley can be considered safe for irrigation purposes.

Experimental

Water samples from 10 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 [10].

Conclusions

This study indicates that, the salinity of the well waters of Malir Valley is comparatively on the higher side, but values of other irrigation parameters viz SAR, RSC and ESP are well within the safe range. Hence, the well waters of Malir Valley can suitably be used for irrigation purposes.

Acknowledgement

Sincere thanks to Mr. Muhammad Arif for assistance in statistical analyses.

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