

Chapter-4 RESULTS AND DISCUSSIONS

4.1. Arsenic contamination in District Khairpur Mirs

One thousand one hundred and fourteen (1114) water samples from three Tehsils of district Khairpur were collected to determine the degree of arsenic contamination in groundwater as well as validation of data generated through field arsenic testing kits. About 25% of water samples were found to be arsenic contaminated in Khairpur Mirs district considering 10 ppb as guideline value. However, only 10% samples were found ‘unfit’ when compared with 50 ppb guideline value of PSQCA. The Tehsil-wise situation of arsenic contamination is given in Table-2.

Table-2 Arsenic Contamination in Tehsils of District Khairpur Mirs

S.No.	Tehsil	Total No. of Samples	No. of Samples > 10 ppb	No. of Samples >50 ppb	%age of Sample >10ppb	%age of Samples >50 ppb
1.	Khairpur	420	56	8	13.1	1.9
2.	Gambat	388	209	102	53.35	26.03
3.	Kotdiji	306	10	2	3.27	0.7
	Total	1114	275	112	24.68	10.04

4.1.1 Arsenic Contamination in Tehsil Khairpur:

In total four hundred and twenty samples were analysed from 14 Union Councils of Tehsil Khairpur for validation purpose. Only 13% of samples were found with arsenic concentration above 10 ppb whereas 1.9% samples were found with arsenic concentration above 50 ppb (Table-2). Union Council wise details of Tehsil Khairpur regarding the arsenic contamination is given in Table-2.1.

Table-2.1 Union Council Wise Arsenic contamination in Tehsil Khairpur

S.No.	Name of Union Council	Total No. of Samples	No. of Sample >10 ppb	No. of Sample > 50 ppb	%age of Sample >10 ppb	%age of Sample >50ppb
1.	Bukhari	8	Nil	Nil	Nil	Nil
2.	Jeelani	17	2	Nil	12	Nil
3.	Bhurgri	12	Nil	Nil	Nil	Nil
4.	Shah Lateef	20	Nil	Nil	Nil	Nil
5.	Luqman	20	1	Nil	5	Nil
6.	Baberloi	24	16	4	67	17
7.	Murree	42	12	1	29	2.4
8.	Shadi Shaheed	40	1	Nil	2.5	Nil
9.	Nizamani	30	Nil	Nil	Nil	Nil
10.	Their	13	1	Nil	8	Nil
11.	Mehar Ali	79	4	3	5	4
12.	Wada Machyoon	30	9	Nil	30	Nil
13.	Tando Masti	43	5	Nil	12	Nil
14.	Khan Pur	42	4	Nil	9.5	Nil
	Total	420	56	8	13.3	1.9

Analytical data revealed that all samples of groundwater collected from four Union Councils i.e. Bukhari, Bhurgri, Shah Lateef and Nizmani are found safe for drinking purpose. Whereas water samples of rest of ten Union Council's did not fulfill the criteria of 10 ppb. Water samples from three Union Councils i.e. Baberloi, Mehar Ali & Mori have arsenic concentration more than 50 ppb (17%, 4% & 2% respectively). A comparison of all the Union Councils of Tehsil Khairpur showed that Baberloi had the highest arsenic contamination level for both guideline values of 10 ppb and above 50 ppb as shown in Fig.-1.

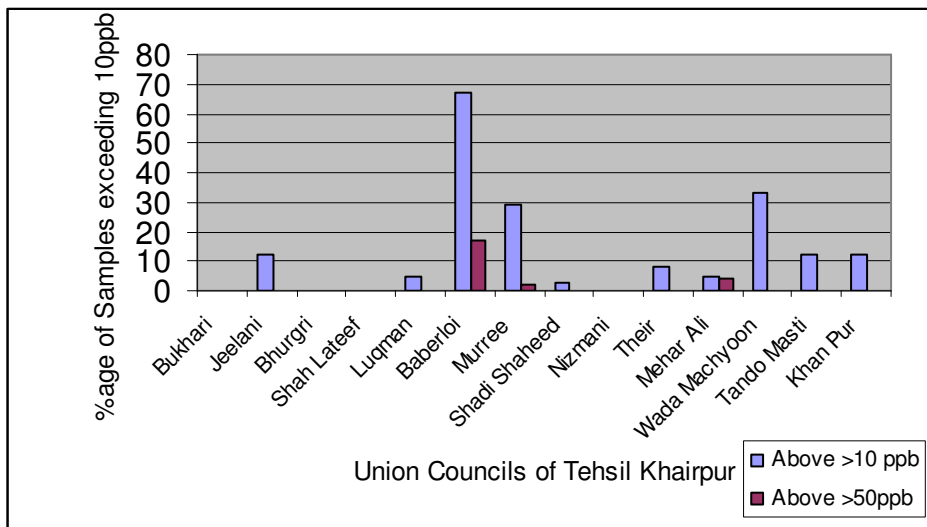


Figure-1 Arsenic Contamination in Groundwater of Tehsil Khairpur

Moreover, out of total 420 samples, 1.19% water samples (5) fell in the range of 50-100 ppb, whereas only 0.71% samples (3) were found with concentration above 100 ppb. The details of this analysis are summarized in Tables-2.2 & 2.3

Table-2.2 Water Samples of Tehsil Khairpur having arsenic (50-100 ppb)

S.No.	U/Council	Village	Source	As (ppb)
1.	Mehar Ali	Ghohno	PHP	88
2.	Beberloee	Muhammad Mithal	PHP	51
3.	Beberloee	Muhammad Mithal	PHP	79
4.	Beberloee	Sikandar Ali	PHP	51
5.	Beberloee	Sikandar Ali	PHP	53

Table-2.3 Water Samples of Tehsil Khairpur having arsenic above 100 ppb

S.No.	U/Council	Village	Source	As (ppb)
1.	Mehar Ali	Ghohno	PHP	173
2.	Mehar Ali	Chohno	PHP	121
3.	Muree	Ghulam Abbas Jatoi	PHP	250

4.1.2 Arsenic Contamination in Tehsil Gambat:

Tehsil Gambat has nine Union Councils. From these nine Union Councils, 388 water samples were collected to evaluate actual situation of arsenic contamination. 54% water samples of Tehsil Gambat exceeded WHO guidelines for arsenic; however 26% can be categorized unfit according to PSQCA standards. Worst situation was observed in Union Council Agra, where 91% of samples exceeded the arsenic concentration level of 10 ppb (WHO guideline) and 75% of samples exceeded the 50 ppb limit of PSQCA (Figure-2).

Table-2.4 Arsenic Contamination in Groundwater of Tehsil Gambat

S.No.	Union Councils	Total No. of Samples	No. of Samples >10ppb	No. of Samples >50 ppb	%age of Samples >10 ppb	%age of Samples > 50ppb
1.	Gambat-1	24	1	Nil	4	Nil
2.	Gambat-II	38	9	3	24	8
3.	Khuhra	66	14	7	21	10.6
4.	Kamal Dero	30	23	14	77	47
5.	Jado Wahan	31	17	9	55	29
6.	Khemia	78	45	17	57.7	21.8
7.	Ripri	44	34	7	77	16
8.	Agra	44	41	34	93	77
9.	Belharo	33	25	11	76	33
Total		388	209	102	53.8	26

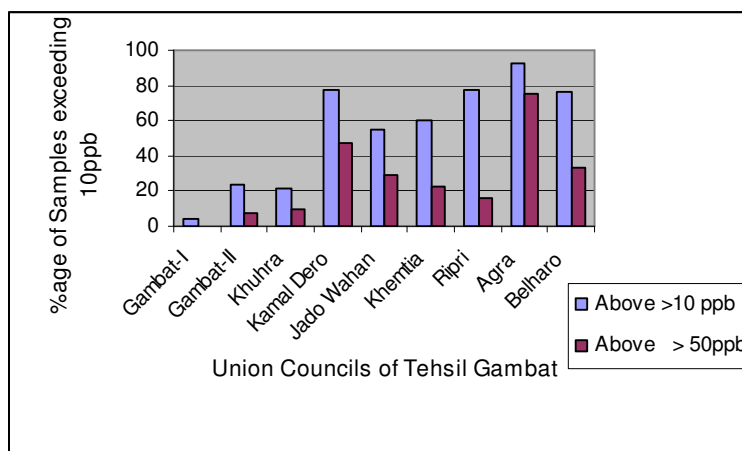


Figure.2. Arsenic contamination in groundwater of Tehsil Gambat

Out of total 9 Union Councils, only Gambat-1 showed the lowest arsenic concentration only (4%) of samples exceeded the 10 ppb limit. Furthermore, data showed that 47 samples (12%) had arsenic concentration in the range of 100–1000 ppb. These 12% contaminated samples are grouped into three sub-groups and are presented in Tables-2.5 to 2.7 whereas Figure-3 shows the %age of water samples falling in these sub-groups.

Table-2.5 Group-I Water Samples having arsenic conc.(100-150 ppb) in Tehsil Gambat

S.No.	U/Council	Village	Source	As (ppb)
1.	Agra	Ali Nawaz Sial	PHP	103
2.	Agra	Ali Dad Sial	PHP	116
3.	Agra	Chehani	PHP	109
4.	Agra	Mahtani	PHP	136
5.	Agra	Razi Dero	PHP	102
6.	Jado Wahan	Mehro Wahan	PHP	150
7.	Jado Wahan	Mehro Wahan	PHP	134
8.	Jado Wahan	Ghulam Bari	PHP	134
9.	Jado Wahan	Jado Wahan	PHP	125
10.	Kamal Dero	Wali Dino Shaikh	PHP	105
11.	Kamal Dero	Daro	PHP	130
12.	Ripri	Khat	PHP	118
13.	Khemtia	Dargha Noor Pur	PHP	126
14.	Khemtia	Lal Bux Bhatti	PHP	134
15.	Khemtia	Lal Bux Bhatti	PHP	138
16.	Khemtia	Badal	PHP	144
17.	Khemtia	Muhammad Lararik	PHP	141
18.	Khemtia	Lal Kumbhar	PHP	140
19.	Belharo	Belharo	PHP	110
20.	Belharo	Belharo	PHP	107
21.	Belharo	Gohram	PHP	138
22.	Agra	Warid Ali	PHP	138
23.	Agra	M. Salih	PHP	101

Table-2.6 Group-II, Arsenic contamination range from 150 ppb-200ppb in Tehsil Gambat

S.No.	U/Council	Village	Source	As (ppb)
1.	Agra	Abdul Raheem	PHP	186
2.	Agra	Shah Muhammad Khoro	PHP	161
3.	Agra	Allah Warayo	PHP	166
4.	Agra	Razi Dero	PHP	196
5.	Agra	Chehani	PHP	164
6.	Jado Wahan	Haji Soof	PHP	200
7.	Khemtia	Muhammad Larik	PHP	160
8.	Khemtia	Nawab Ali	PHP	169
9.	Khemtia	Lal Kumbhar	PHP	188

Table-2.7 Group-III Arsenic contamination range from 200 ppb-1000 ppb in Tehsil Gambat

S.No.	U/Council	Village	Source	As (ppb)
1.	Khuhra	Daloo Khan Ujan	KHP-003	247
2.	Agra	Muhammad Juman	KHP-002	972
3.	Agra	Muhammad Juman	KHP-003	320
4.	Agra	Muhammad Juman	KHP-004	954
5.	Agra	Mehboob Kalhoro	KHP-016	758
6.	Agra	Allah Warago	KHP-009	239
7.	Agra	Allah Warago	KHP-033	311
8.	Agra	Mahtani	KHP-004	247

9.	Agra	Agra	KHP-061	271
10.	Agra	Wali Muhammad	KHP-016	312
11.	Agra	Muhammad Aucher Jati	KHP-008	271
12.	Agra	Muhammad Juman Sheikh	KHP-001	930
13.	Jado Wahan	Bago Shambani	KHP-006	245
14.	Kamal Dero	Saidi Lower	KHP-030	245
15.	Belhero	Kand Gopang	KHP-067	239

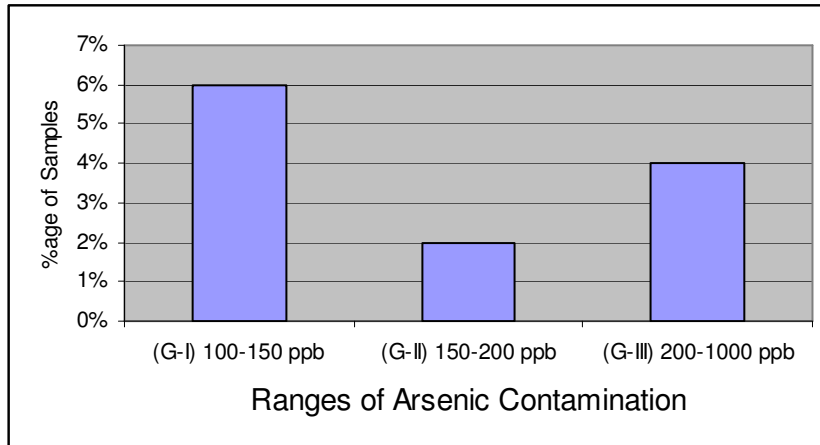


Figure-3 Percentage of samples with arsenic contamination range of 100-1000 ppb

4.1.3 Arsenic Contamination in Tehsil Kotdiji:

Eleven Union Councils of Tehsil Kotdiji were selected to monitor the arsenic contamination in ground water. In total 306 water samples were collected from all these eleven Union Councils. Out of these only 10 samples (3%) samples exceeded the arsenic concentration level of 10 ppb, whereas 2 samples (0.7%) exceeded the arsenic concentration level of 50 ppb. The details are given in Table-2.8. Analytical data showed that water samples of only 5 Union Councils of Tehsil Kotdiji namely kumb, Jhando Mashah, Muhabat Wah, Lyari & Fatehpur had arsenic level beyond 10 ppb (Figure-4).

Table-2.8 Details of Arsenic Contamination in Ground water samples of Tehsil Kotdiji

S.No.	U/Council	Total No. of Samples	No. of Samples >10ppb	No. of Samples >50 ppb	%age of Samples >10 ppb	%age of Samples > 50ppb
1.	Kotdiji	15	Nil	Nil	Nil	Nil
2.	Jiskani	33	Nil	Nil	Nil	Nil
3.	Kumb	27	2	Nil	7	Nil
4.	Jhando Mashah	27	1	Nil	4	Nil
5.	Bapho	24	Nil	Nil	Nil	Nil
6.	Jalalani	32	Nil	Nil	Nil	Nil
7.	Deh Sohu	41	Nil	Nil	Nil	Nil
8.	Muhabat Wah	25	2	1	8	4
9.	Lyari	20	1	1	5	5
10.	Fateh Pur	43	4	Nil	9.3	Nil
11.	Faqeer Abad	19	Nil	Nil	Nil	Nil
Total		306	10	2	3	0.7

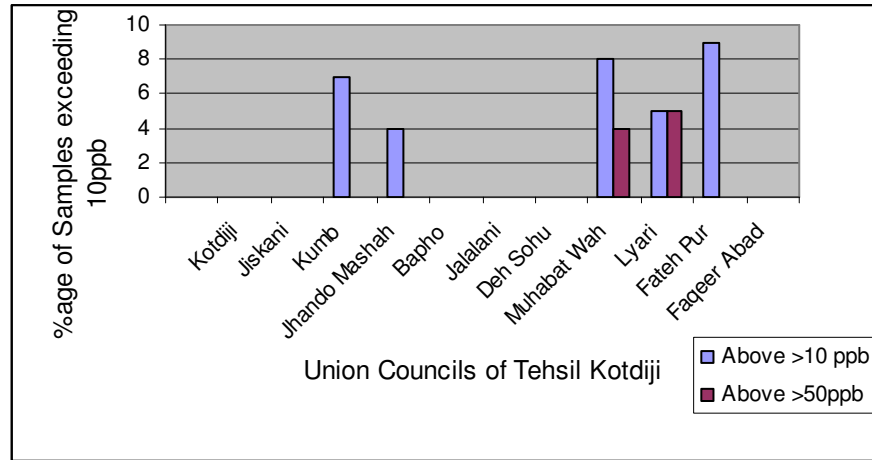


Figure-4 Arsenic contamination in groundwater of Union Councils of Tehsil Kotdiji

Union Council Fatehpur had highest %age of samples (9%) above 10 ppb arsenic level while Union Councils Muhabat Wah and Lyari had one sample beyond 50 ppb arsenic (Table-2.8). Most of the water samples of Tehsil Kotdiji fall in the range of 10-50 ppb (Table-2.9). Only 2 samples were found above 50 ppb, whereas only one sample was found having arsenic concentration above 100 ppb (Table-2.9).

Table-2.9 Samples of Tehsil Kotdiji having arsenic concentration in range of 10-50 ppb

S.No.	Union Council	Village	Source	As (ppb)
1.	Jhando Mashah	Molvi Dino Bhatti	PHP	13
2.	Fateh Pur	Raz M. Tanwari	PHP	37
3.	Fateh Pur	Malhar Kashkeli	PHP	16
4.	Fateh Pur	Ghulam Rasool	PHP	12
5.	Fateh Pur	Qadir Bux	PHP	19
6.	Muhabat Wah	Shah M. Ujjan	PHP	18
7.	Kumb	Kumb City	PHP	25
8.	Kumb	Janib Ujan	PHP	17
1.	Lyari	Haji Allah Wadhayo	PHP	115
2.	Muhabat Wah	Shah M. Ujjan	PHP	55

Graphical presentation of level of arsenic contamination in groundwater of all Tehsils of District Khairpur Mirs had shown that Tehsil Gambat had the highest arsenic contamination of 53% and 26% respectively considering the WHO guideline value of 10 ppb and PSQCA standard of 50 ppb for arsenic in drinking water. Somehow better situation was observed in Tehsil Kotdiji, which has lowest arsenic contamination for both threshold values as shown in Figure-5.

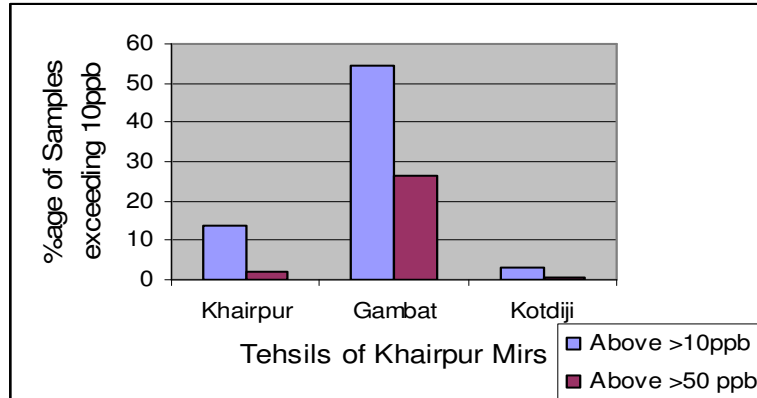


Figure-5 Arsenic contamination in groundwater of District Khairpur Mirs

Moreover out of 1114 water samples 61 were found between 50-100 ppb whereas only 51 samples were found with arsenic concentration more than 100 ppb. Figure 6 shows overall picture of Arsenic contamination in groundwater of District Khairpur Mirs.

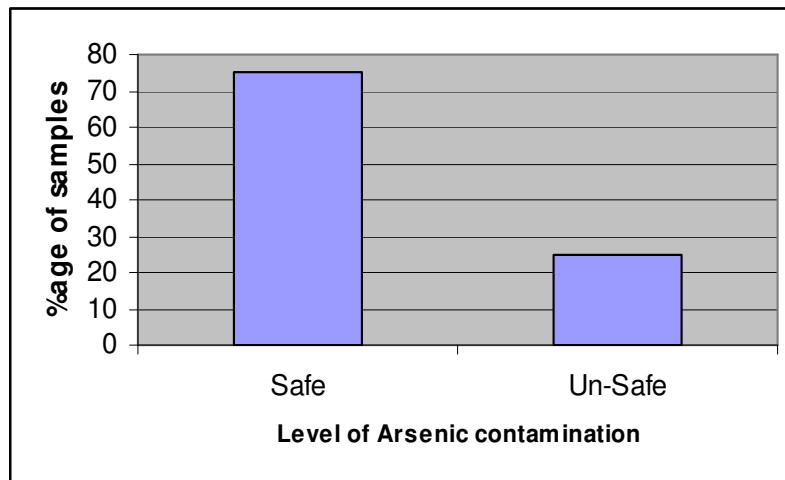


Figure-6 Overall comparison of Arsenic contamination in groundwater of District Khairpur Mirs

4.2 Arsenic Contamination in Dadu District

In total 874 water samples from 3 Tehsils of District Dadu were analysed in PCRWR water quality laboratory for validation purpose. Fifty percent samples showed arsenic concentration more than 10 ppb while 23% sample had arsenic concentration greater than 50 ppb. Tehsil wise detail of arsenic contamination is given in Table-3.

Table-3 Arsenic contamination in Groundwater of Dadu District

Tehsil	Total No. of Samples	No. of Samples > 10 ppb	No. of Samples >50 ppb	%age of Sample >10ppb	%age of Samples >50 ppb
Dadu	595	347	150	58.3	26.55
Johi	140	30	4	21.4	3
Sehwan	139	62	40	44.6	29
Total	874	439	202	50.35	23.2

4.2.1 Arsenic Contamination in Tehsil Dadu:-

From Tehsil Dadu, 595 samples were collected and analysed out of 15 Union Councils to verify the results of field arsenic testing kits. Of these 58% samples exceeded the limits of 10 ppb whereas 27% samples exceeded the arsenic concentration of 50 ppb as presented in Table 3.1.

Table 3.1 Arsenic presence details in water samples of Tehsil Dadu

Sr. No.	Name of Union Council	Total No. of Samples	No. of Sample >10 pps	No. of Sample > 50 ppb	%age of Sample >10 ppb	%age of Sample >50ppb
1.	Dadu-I	46	30	13	65.2	28
2.	Dadu-II	20	17	8	85	45
3.	Dadu-III	58	24	10	41	17
4.	Dadu-IV	36	15	1	42	3
5.	Yar Mohammad Kalhoro	46	35	20	76	43
6.	Mondar	62	45	30	72.6	48.3
7.	Muradabad Channa	45	28	14	62	31
8.	Khuda Abad	37	32	19	86	51
9.	Phulji Station	36	23	8	64	22
10.	Makhdoom Bilalwal	28	14	2	50	7
11.	Piario Station	25	1	Nil	4	Nil
12.	Pat Sharif	51	23	4	45	8
13.	Siyal	29	17	7	58.6	24
14.	Pipri	47	35	19	74	40
15.	Allahabad	29	8	3	27.5	10.3
Total		595	347	158	58.4	26.5

Out of 595 water samples, 347 (58%) samples of Tehsil Dadu exceeded WHO guidelines (10 ppb) while 158 water samples (27%) were found contaminated having more than 50 ppb arsenic concentration (Table 3.1). Two Union Councils, Khuda Abad and Dadu II, showed highest arsenic contents with 86% and 85% respectively above 10 ppb, whereas Union Councils of Khuda Abad and Mondar exceeded the limits of 50 ppb i.e. 51% and 50% respectively. Fourteen union Councils out of 15 showed arsenic contamination. The analyses showed 24 to 86% samples exceeded 10 ppb limit and 3 to 51% exceeded 50 ppb limit. Only the Piario Union Council had lowest arsenic concentration (4%) according to 10 ppb (figure-7).

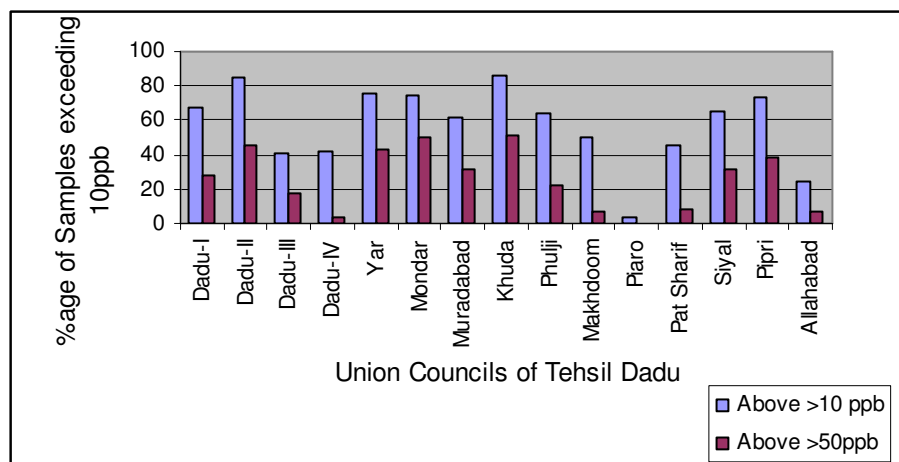


Figure-7: Arsenic contamination in groundwater of Tehsil Dadu

Moreover, it was found that 64 water samples (11%) had arsenic concentration in the range of 100 to 500 ppb. These 11% contaminated samples are grouped into 3 categories. Figure 8 shows the percentage of water sample falling in these sub-groups.

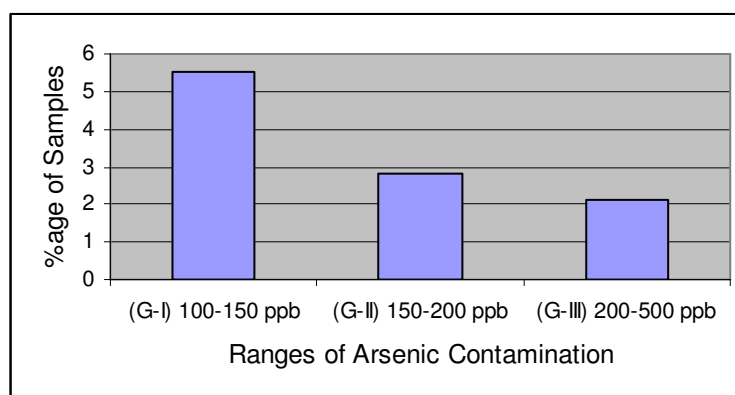


Figure: 8 Percentage of samples with Arsenic contamination (100-500 ppb).

Table 3.2 Group-I Arsenic in groundwater of Tehsil Dadu (100 ppb-150 ppb)

S.No.	Union Council	Village	Source	As (ppb)
1.	Dadu-I	Shahbaz Colony	PHP	117
2.	Dadu-I	Shahbaz Colony	PHP	142
3.	Dadu-I	Nawab Colony	PHP	111
4.	Dadu-II	Surhia Mohalla	PHP	107
5.	Dadu-III	Najam Colony	PHP	104
6.	Pipri	Pechoha	PHP	108
7.	Pipri	Pechoha	PHP	143
8.	Pipri	Nabi Bux Panhwar	PHP	117
9.	Pipri	Pipri	PHP	146
10.	Pipri	Rawat Khan Zonur	PHP	132
11.	Mondar	Gul Mohammad Shahani	PHP	138

12.	Mondar	Mondar	PHP	119
13.	Mondar	Din Mohammad Shahani	PHP	126
14.	Murad Abad Channa	Mohammad Umer Panhwar	PHP	110
15.	Yar Mohammad Kalhoro	Samtani	PHP	115
16.	Yar Mohammad Kalhoro	Hafiz Mir Mohammad	PHP	118
17.	Yar Mohammad Kalhoro	Imam Bux Bhand	PHP	149
18.	Yar Mohammad Kalhoro	M. Saleh Rind	PHP	117
19.	Yar Mohammad Kalhoro	Jurial Bhand	PHP	140
20.	Yar Mohammad Kalhoro	Yaqoob Pirzado	PHP	115
21.	Yar Muhammad Kalhoro	Lutaf Ali Bhand	PHP	147
22.	Yar Mohammad Kalhoro	Lutaf Ali Bhand	PHP	108
23.	Yar Mohammad Kalhoro	Mohabat Jalbani	PHP	107
24.	Sial	Noorjo	PHP	105
25.	Pat Sharif	Setta Village	PHP	138
26.	Pat Sharif	Abdullah Chohan	PHP	137
27.	Allah Abad	Abdullah Panhwar	PHP	149
28.	Khuda Abad	Birmani	PHP	130
29.	Khuda Abad	Mirmani	PHP	143
30.	Khuda Abad	Mirmani	PHP	133
31.	Khuda Abad	Mangneja	PHP	142
32.	Khuda Abad	Mangneja	PHP	140
33.	Khuda Abad	Palio Lohar	PHP	149
34.	Khuda Abad	Union Council Office	PHP	141

Table 3.3 Group-II Arsenic in groundwater of Tehsil Dadu (150 ppb – 200 ppb)

S.No.	Union Council	Village	Source	As (ppb)
1.	Pipri	Pipri	PHP	173
2.	Pipri	Pipri	PHP	170
3.	Pipri	Duaboo	PHP	171
4.	Mondar	Gul Mohammad Shahani	PHP	155
5.	Mondar	Luqman Shahani	PHP	163
6.	Mondar	Mondar	PHP	185
7.	Mondar	Din Mohammad Shahani	PHP	200
8.	Mondar	Fazal Lashari	PHP	166
9.	Murad Abad Channa	Allah Warayo Panhwar	PHP	154
11.	Murad Abad Channa	Umeed Ali Panhwar	PHP	154
12.	Yar Mohammad Kalhoro	Jurial Bhand	PHP	163
13.	Sial	Ghulam Hussain	PHP	154
14.	Khuda Abad	Dhotra Panhwar	PHP	186
15.	Khuda Abad	Khudabad Station	PHP	185
16.	Khuda Abad	Malano	PHP	158

Table 3.4 Group-III: Arsenic in groundwater of Tehsil Dadu (200 ppb-500 ppb)

S.No.	Union Council	Village	Source	As (ppb)
1.	Dadu-I	Nawab Colony	PHP	211
2.	Pipri	Bachal Boak	PHP	269
3.	Mondar	Luqman Shahani	PHP	318
4.	Mondar	Mondar	PHP	412
5.	Mondar	Mondar	PHP	243

6.	Mondar	Karimdad Shedi	PHP	203
7.	Mondar	Gul Muhammad Janwari	PHP	271
8.	Murad Abad Channa	Ghulam Hyder	PHP	250
9.	Murad Abad Channa	M. Umer Panhwar	PHP	220
10.	Phulji Station	Sher Mohammad	PHP	212
11.	Yar Mohammad Kalhoro	Shah Shakar	PHP	224
12.	Allah Abad Kharo	Kharo	PHP	239
13.	Sial	Jeeand Lashari	PHP	227

The analysis of results of Tehsil Dadu revealed that Yar Muhammad Kalhoro, Mondar and Pipri Union Councils showed higher percentage of arsenic contamination (above 100 ppb). Furthermore, 412 ppb was found the highest arsenic concentration in Tehsil Dadu.

4.2.2 Arsenic Contamination in Tehsil Johi:

One hundred and forty groundwater samples were collected in Tehsil Johi from 10 Union Councils. The analysis of results showed comparatively better situation than Tehsil Dadu in respect of arsenic contamination. Out of 140 samples only 4 (3%) showed arsenic concentration above 50 ppb whereas 30 samples (21%) had arsenic concentration more than 50ppb as shown in Table 3.5

Table 3.5. Water Samples of Tehsil Johi Containing Arsenic

Sr. No.	Name of Union Council	Total No. of Samples	No. of Sample >10 pps	No. of Sample > 50 ppb	%age of Sample >10 ppb	%age of Sample >50ppb
1.	Johi City	16	5	Nil	31	Nil
2.	Sawro	10	Nil	Nil	Nil	Nil
3.	Tore	11	Nil	Nil	Nil	Nil
4.	Bahawalpur	21	9	1	43	5
5.	Phulji Village	12	3	1	25	Nil
6.	Kamal Khan	24	13	2	54	8
7.	Tando Rahim Khan	13	Nil	Nil	Nil	Nil
8.	Drigh Bala	12	Nil	Nil	Nil	Nil
9.	Chhini	10	Nil	Nil	Nil	Nil
10.	Pat Gul Mohammad	11	Nil	Nil	Nil	Nil
Total		140	30	4	21	3

Results showed that six Union Councils out of 10, all samples were found within permissible limit of arsenic contents. However, water samples from 4 Union Councils namely Johi city, Bahawalpur, Phuliji Village and Kamal Khan were found having arsenic concentration beyond the WHO guidelines and PSQCA standards (figure-9).

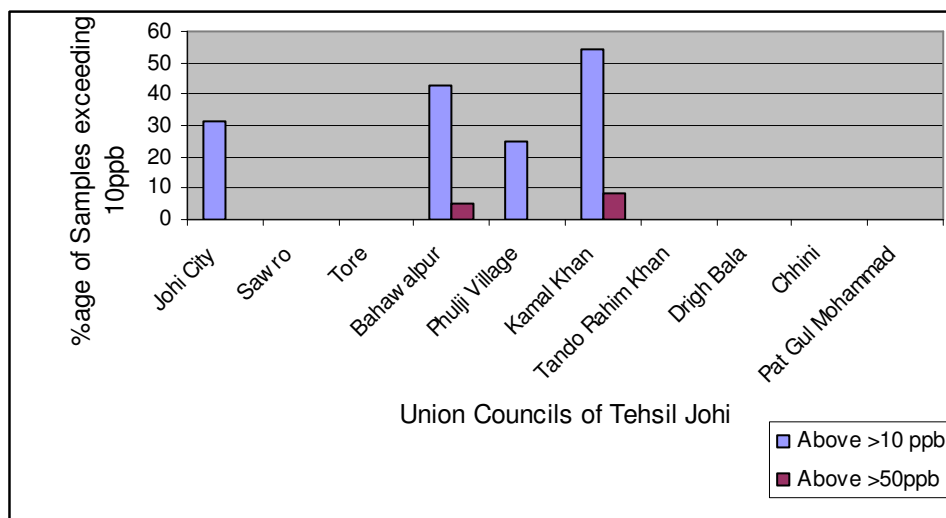


Figure-9: Arsenic Contamination in groundwater of Tehsil Johi

Overall, out of these four, Union Council Kamal Khan had highest percentage of samples in accordance to both guidelines values i.e. 54% samples above 10ppb and 8% samples beyond 50ppb. Whereas Union Council Phulji Village had lowest percentage of samples (25%) above 10ppb as shown in Table 3.5. Only 4 samples (3%) were found above 50ppb as given in Table 3.6.

Table 3.6. Groundwater Samples of Tehsil Johi above 50 ppb

S.No.	Union Council	Village	Source	As (ppb)
1.	Bahawalpur	Chandan Mori	PHP	78
2.	Phuljee	Phuliji Village	PHP	161
3.	Kamal Khan	Dilawar Panhwar	PHP	184
4.	Kamal Khan	Qasim Jamali	PHP	105

Data showed that 184 ppb is the highest arsenic concentration detected in village Dilawar panhwar of Union Council Kamal Khan in Tehsil Johi.

4.2.3 Arsenic Contamination in Tehsil Sehwan:

In total 139 samples were collected from 8 Union Councils of Tehsil Sehwan and analyzed for arsenic verification. Forty four percent samples were identified for containing arsenic contamination above WHO guideline and 29% samples were found greater than 50 ppb (Table 3.7).

Table 3.7 Arsenic contamination in Water Samples of Tehsil Sehwan

S.No.	Name of Union Council	Total No. of Samples	No. of Sample >10 ppb	No. of Sample, > 50 ppb	%age of Sample >10 ppb	%age of Sample >50ppb
1.	Sehwan-I	6	2	Nil	33	Nil
2.	Sehwan-II	5	2	Nil	40	Nil
3.	Talti	41	22	17	54	41
4.	Channa	17	12	7	70.6	41.1

5.	Boobak	15	6	4	40	27
6.	Bhan Sayad Abad	31	14	8	45	26
7.	Dal	19	4	4	21	21
8.	Jhangara	5	Nil	Nil	Nil	Nil
Total		139	62	40	44.6	29

The overall results of Tehsil Sehwan showed that 62 samples (45%) were found unsafe considering the 10 ppb guideline values of WHO whereas 40 samples (29%) were found contaminated, as per PSQCA standard of 50 ppb. Union Council Jhangara did not have any sample contaminated with arsenic, while the maximum number of arsenic contaminated samples were found in Union Council Channa according to WHO guidelines (figure 10).

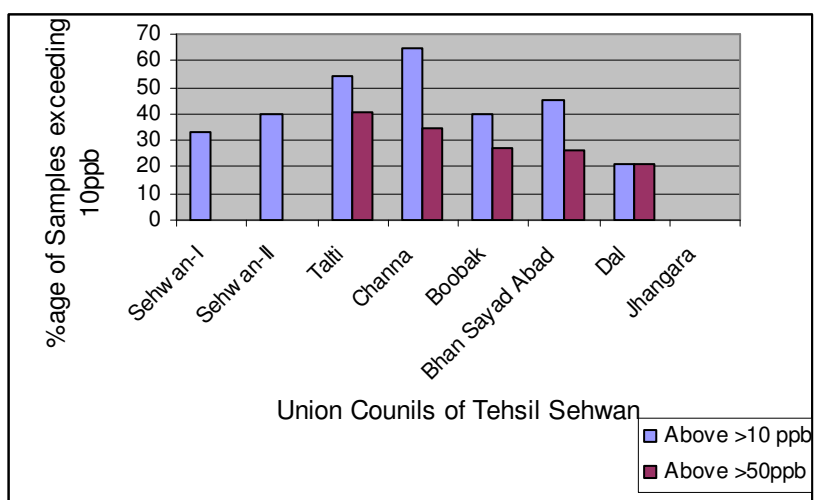


Figure 10: Arsenic presence in groundwater of Tehsil Sehwan.

The analysis revealed that percentage of samples (Sehwan Tehsil) containing arsenic greater than 50 ppb was 64% higher than the samples falling in the range of 10 ppb to 50 ppb arsenic concentration². Water samples of (Tehsil Sehwan) had arsenic concentration above 400 ppb and 20 samples (14%) were found containing arsenic higher than 100 ppb (Table 3.8).

Table 3.8. Arsenic Contamination above 100 ppb in Tehsil Sehwan

S.No.	Union Council Name	Village Name	As (ppb)
1.	Talti	Haji Hashim	207
2.	Talti	Kot Lashari	275
3.	Talti	Gada Jat	145
4.	Talti	G. Mohammad Solangi	223
5.	Talti	Talti	408
6.	Talti	Ali Mohammad Jatoi	495
7.	Dal	Kariani	230
8.	Bobak	Bagal Khan	230
9.	Boobak	Amira	161

10.	Channa	Karam Ali Khoso	115
11.	Channa	Karam Pur	110
12.	Channa	Pacca Channa	208
13.	Channa	Pacca Channa	119
14.	Channa	Sher Khan Solangi	192
15.	Bhan Syed Ababd	Areeb Khan	226
16.	Bhan Syed Ababd	Mohammad Usman Solangi	103
17.	Bhan Syed Ababd	City Circle-II	124
18.	Bhan Syed Ababd	City Circle-I	349
19.	Bhan Syed Ababd	Talib Panhwar	216
20.	Bhan Syed Ababd	Syed Monaka	103

By comparing the results of three Tehsils of Dadu District, percentage of water samples exceeded the limits of 10 ppb (WHO guidelines) were more in Tehsil Dadu whereas Tehsil Sehwan showed higher percentage of samples exceeding 50 ppb Limit (PSQCA standards). Groundwater of Tehsil Johi was found comparatively better (Figure-11).

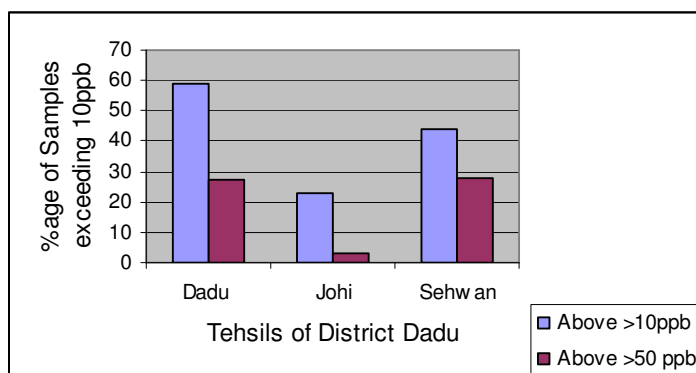


Figure 11: Arsenic contamination in groundwater of District Dadu

Results of District Dadu revealed that 50.6% samples were found unfit with high arsenic contents. The overall picture of Arsenic contamination in groundwater of District Dadu is given in Figure 12.

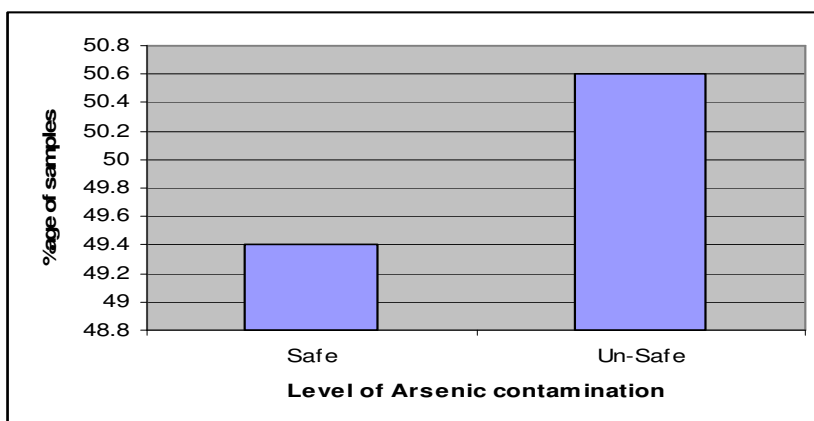


Figure 12: Overall comparison of Arsenic contamination in groundwater of District Dadu

4.3 Arsenic data generated by kits.

Total 20,158 samples were collected and analyzed by SAFWCO team from Khairpur Mirs and Dadu districts. As it was decided earlier that to re-confirm the results of field testing kits, 10% samples (2000 approx.) would be analyzed by using some sophisticated and high-tech instrument like Atomic Absorption spectrophotometer. Now the results of these (10%), 1988 water samples analyzed by using arsenic field testing kits were examined in the light of the guideline values. Overall 28.3% samples exceeded WHO guideline value of arsenic of 10 ppb, while only 7.6% samples exceeded from PSQCA value of 50 ppb (Table-4,5,6).

Table 4. Arsenic levels in Ground water of central Sindh (Field Testing Kits Data)

S.No.	Categories (ppb)	No. of Samples	%age
1.	Nil	1151	57.96
2.	1-10	274	13.77
3.	11-50	411	20.66
4.	51-100	125	6.28
5.	101-500	27	1.35
6.	>10	563	28.3
7.	>50	152	7.6
	Total:	1989	100%

About 58% samples were found arsenic free, fit for drinking and domestic purposes. Data of Dadu district analysed by field testing kits showed that 42.56 percent of the samples exceeded 10 ppb value and 10.5 percent samples exceeded the 50 ppb value (Table-5).

Table-5 District wise Arsenic contamination (Field Testing Kits Data)

S.No.	District	Total No. of Samples	No. of Sample >10 pps	No. of Sample, > 50 ppb	%age of Sample >10 ppb	%age of Sample >50ppb
1.	Khairpur Mirs	1114	191	60	17%	5.38%
2.	Dadu	874	372	92	42.56%	10.5%
	Total	1988	563	152	28.3%	7.64%

Whereas the Khairpur Mirs district data showed that 17.13% and 5.38% of samples exceeded the arsenic contamination guideline values of 10ppb and 50 ppb respectively. Samples of Dadu district showed greater arsenic contamination in all ranges than the Khairpur except in the range of 101-500ppb (Table-6).

Table-6 District wise Arsenic Status (Field Testing Kits Data)

S.No.	Categories (ppb)	Khairpur Mirs		Dadu	
		No. of Samples	%age	No. of Samples	%age
1.	Nil	793	71.2	358	40.96
2.	1-10	130	11.65	144	16.47
3.	11-50	131	11.74	280	32.03

4.	51-100	43	3.85	82	9.38
5.	101-500	17	1.52	10	1.14
6.	>10	191	17.13	372	42.56
7.	>50	60	5.38	92	10.52
	Total	1114		874	

4.4 Comparison of Analytical techniques of analysis used for this study.

Ten percent samples out of all tested samples by field testing kits were analysed on Atomic Absorption Spectrophotometer (AAS) at PCRWR Water Quality Laboratory to evaluate the degree of reproducibility and reliability of field testing kits. Comparison of these results with the results generated by PCRWR on the high-tech and state of art Atomic Absorption Spectrophotometer revealed that analytical data of field testing kits for 14.42% gave the difference of ± 10 ppb, almost equal 7.73% and 6.79% percentage of samples showed the difference of ± 20 ppb and ± 30 ppb while 4.17% samples were found to have difference more than 100ppb (Table-7).

Table-7. Comparison of Data generated by Arsenic Field Testing Kit & AAS

Sr. No.	District	Tehsil	No. of samples having variations (\pm ppb)						
			± 5	± 10	± 20	± 30	± 50	± 100	
1.	Khairpur Mirs	Khairpur	45	23	5	Nil	4	18	15
		Gambat	57	47	38	42	37	2	26
		Kotdiji	59	14	4	2	Nil	Nil	2
2.	Dadu	Dadu	89	82	69	71	65	9	26
		Johi	21	13	8	4	2	Nil	1
		Sehwan	16	6	10	16	14	3	13
		Total	287	185	147	150	123	14	83
	Percentage (%)		14.42	9.30	7.39	7.54	6.18	0.70	3.61

A difference of ± 5 is ignorable when compared the results of AAS with testing kits, whereas a difference of ± 10 ppb is also acceptable under certain conditions. However, a difference of ± 20 ppb and ppb is not acceptable by the Scientific Community.

Comparison of analytical techniques (Atomic Absorption Spectrophotometer and Arsenic Field Testing Kit) revealed that results given by both techniques showed a significant difference for all ranges of Arsenic concentration for samples of both Khairpur Mirs and Dadu District (Table-8).

Table-8 Comparison of analytical Techniques

Sr. No.	Results/Items	Khairpur Mirs			Dadu		
		AAS	Kit	%age Diff.	AAS	Kit	%age Diff
	No. of Samples	1115	1115		874	874	
1.	>10ppb	276	191		442	372	
	%age	24.75%	17.13%	8	50.57%	42.56%	8
2.	>50ppb	112	60		203	92	

	%age	10.04%	5.38%	5	23.22%	10.52%	12.7
3.	50-100ppb	61	43		116	82	
	%age	5.47%	3.85%	2	13.27%	9.38%	4
4.	>100ppb	51	17		87	10	
	%age	4.57%	1.52%	3	9.95%	1.14%	8.8

This variation may be due to the difference of visual sensation of color given by testing kit which varies person to person. Therefore, this difference is ignorable provided the emphasis is placed on careful observation of color indicated by field testing kit for arsenic concentration. There is very less percentage difference between the results of samples exceeding 50 ppb, 50-100 ppb and above 100 ppb analyzed by both the techniques as shown in Figures 13, 14, 15 and 16.

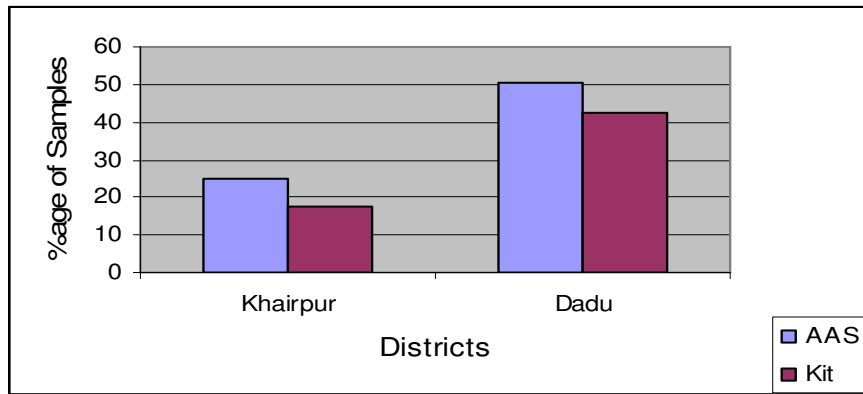


Figure-13: Comparison of Analytical Technique (> 10ppb)

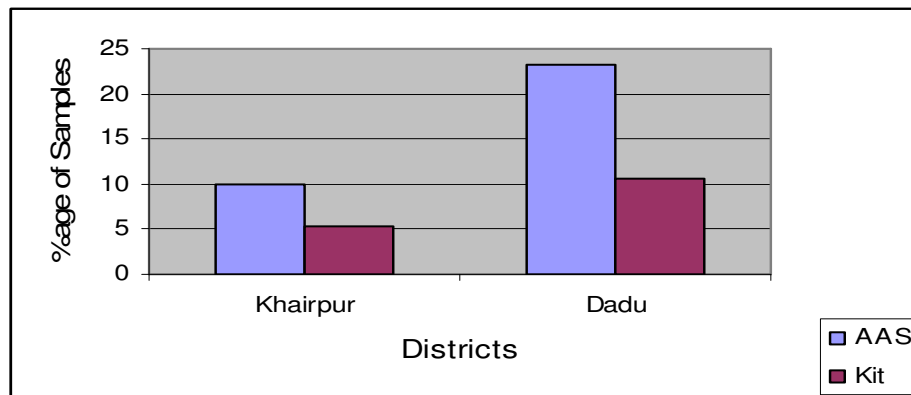


Figure-14: Comparison of Atomic Absorption Spectrophotometer and Arsenic Testing Kit (>50ppb)

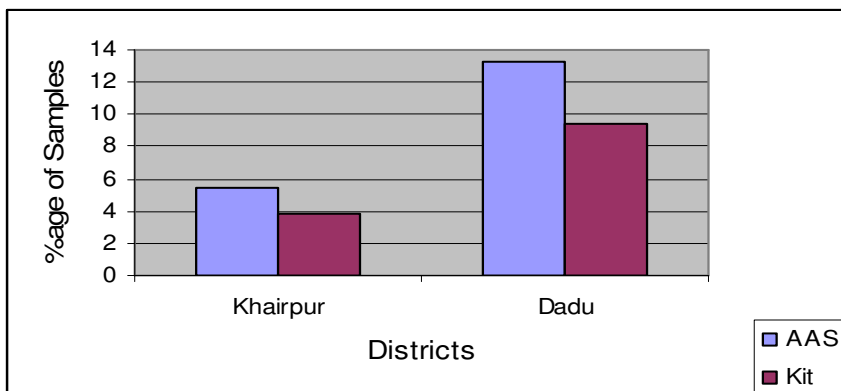


Figure-15: Comparison of AAS and Arsenic Testing Kit (50-100ppb)

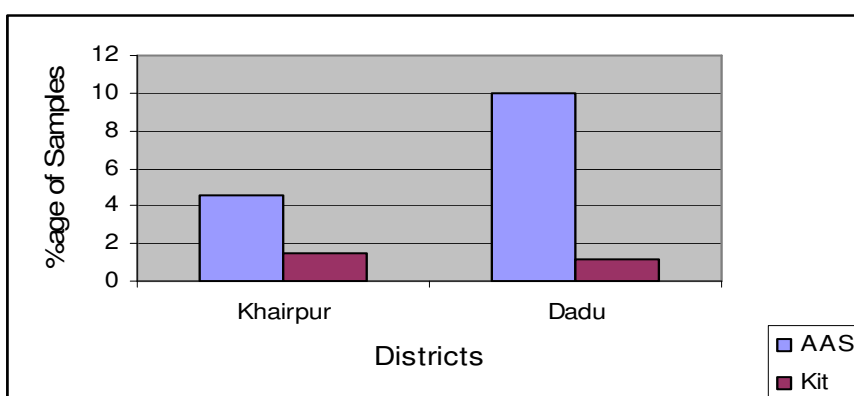


Figure-16: Comparison of AAS and Arsenic Testing Kit (>100ppb)

Furthermore, it is concluded that results of arsenic field testing kit are reliable and considerable for field testing of water samples. To ensure the accuracy, reliability and actual position, it is highly recommended that atleast % water samples must be analyzed on the Atomic Absorption Spectrophotometer (AAS), if this state of the art equipment is available.

4.5. Implications and Possible Causes of Arsenic Contamination in Central Sindh.

Findings of this study have clearly shown the prevailing situation of arsenic contamination in the Central Sindh. The most spectacular example of arsenic poisoning and sufferings is Bangladesh. As compared to Bangladesh as well as other affected areas of the world, percentage of arsenic contamination in the groundwater of Central Sindh is very low. However presence of arsenic contamination in the groundwater is of higher concern.

The presence of arsenic in drinking water can create many diseases associated with arsenic contamination. Generally, if arsenic is present in drinking water, it suggests that arsenic contamination would be taking place through food chain, soil and crops irrigated with arsenic contaminated water. Consumption of these contaminated commodities may cause medical problems

ranging from gangrene of the peripheral organs to skin cancer. Common water sources used in these districts are hand pump, pond, well, and tube well. To know the basic cause of arsenic in groundwater, geological, geo-morphological and geo-hydrological conditions of these affected areas are important to know. Arsenic in higher concentration has been found in those water samples collected from hand pumps installed at the depth of 51 to 100 ft. So it can be concluded that depth for any source (Hand pump or Well) has direct correlation with presence of arsenic. Geology and water chemistry of these areas is not much clear but the possible prediction about cause of the arsenic in groundwater may be the result of the strong influence of water-rock interactions and the greater tendency in aquifers for the physical and geochemical conditions to be favorable for arsenic mobilization and accumulation. The pesticides, fertilizers and chemicals, used for agricultural activities may also be responsible of arsenic contamination.

The characteristic chemical features of groundwater with high arsenic are high iron, manganese, bicarbonate and often phosphorus concentrations and low chloride, sulphate, nitrate and fluoride concentrations with pH value close to or greater than 7 (Pauline, L.S and David, G.K, 2002). Data collected by SAFWCO team shows the presence of manganese and iron in these samples. So the higher arsenic concentration in groundwater may become the reason of other problems caused by increased concentrations of iron, manganese, bicarbonate or phosphorus. Therefore, detailed monitoring is needed to discover the complete picture. How many people are suffering from arsenic related diseases in these affected areas remain to be established? The total area of the affected districts is 34,805 Sq. Km with a population of 18,75,841 individuals. This does not mean that at present all of the 18,75,841 people are drinking arsenic contaminated water and that the whole area of 34,805 Sq. Km. is contaminated by arsenic.

4.6 Arsenic Removal Technologies

Review of arsenic removal technologies has revealed that many technologies have been developed in many parts of the world for the removal of arsenic from large municipal treatments plants or at community or household levels. All of the technologies for arsenic removal rely on a few basic chemical processes such as oxidation-reduction reactions, precipitation, adsorption and ion exchange, solid liquid separation, physical exclusion and coagulation. These technologies remove arsenic but have certain drawbacks such as high cost, energy dependent, post treatment requirement etc. In recent years, a tremendous amount of research has been conducted to identify novel technologies for arsenic removal particularly with low cost.

Presence of excessive levels of arsenic in ground water of areas of Sindh province has attained greater attention as the affected areas of the Sindh province such as Districts of Khairpur Mirs and Dadu have an estimated population of 18, 75, 841 people. Major part of the population is from rural areas where the people are not aware of the health hazards of arsenic contamination in the drinking water. As arsenic is tasteless, colorless and odorless even at higher concentration in many cases damage is done before knowing the cause. The magnitude of complexities of the arsenic problem makes it extremely difficult problem to handle. Added to this, socio-economic situation of the people of these areas is very much important to control this problem. Most of the Central Sindh depends on groundwater for drinking, cooking and other domestic purposes. The presence of excessive arsenic beyond the WHO guideline value in groundwater of such areas has necessitated the need for a simple and low cost techniques for the removal of arsenic from drinking water. Considering the socio-economic background of rural and urban population of these areas, it was highly needed to develop a simple, appropriate and affordable household filtration system to combat the situation. Therefore, PCRWR has developed a low cost technology for the removal of arsenic from drinking water. PCRWR has recently successfully completed the work on three options of arsenic removal technologies. These technologies will be promoted in the affected districts in near future with the coordination of UNICEF.