CHAPTER V

RESULTS

" .. When you can measure what you are speaking about and express it in numbers, you know something about it ; but when you cannot express it in numbers, your knowledge is a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of scene, what ever the matter may be. "

Lord Kelvin

GENERAL

The geo-environmental investigation of the Bhadar basin exemplarily depicts that the deteriorated water quality is on account of dyeing and printing units which are situated in and around Jetpur. Other geo-environmental aspects and their controlling factors viz. geology, geomorphology and hydrogeology have already been dealt with. In this chapter, therefore, the thrust has been given on the Jetpur dye industry and its impact on the quality of water in the valley.

To achieve the above objective, the following methodology has been designed and executed. After considering various controlling factors and parameters, the basin has been divided into three distinct blocks (Fig. 5.1) viz. :-

* Highlands / catchment areas (based on the movement of water)
* Bhadar valley proper and
* Coastal region (beyond Kutiyana - representing interplay of coastal dynamics).

Water samples both from surface and sub-surface from the same location, for repetitive seasons, for pre and post monsoons of 1993 to 1995 were collected (Fig. 5.1). More or less equidistance between the locations were maintained, however, at times close sampling was done keeping in mind the extent of the problem. If any station is not mentioned in any one season, it is on account of its dry state. The sampling stations may be grouped as:

→ Control Point - the water of natural source (unaffected by dye contaminants)
→ Point source - the effluent discharge points,
→ Valley samples - surface water after the contamination of the effluents,
→ Sub-surface water - within the limits of Bhadar valley and
→ Coastal zone - both surface and sub-surface water within the transitional dynamic environment.

To understand the extent of dye effluent's impact on the valley, the control points were selected in the upstream or up-highland areas so that correlation would be more effective and practical rather than comparing with WHO, ICMR or ISI standards (Compliment - C). The point source samples were collected intentionally to evaluate the actual elements within them. Also, the effluents

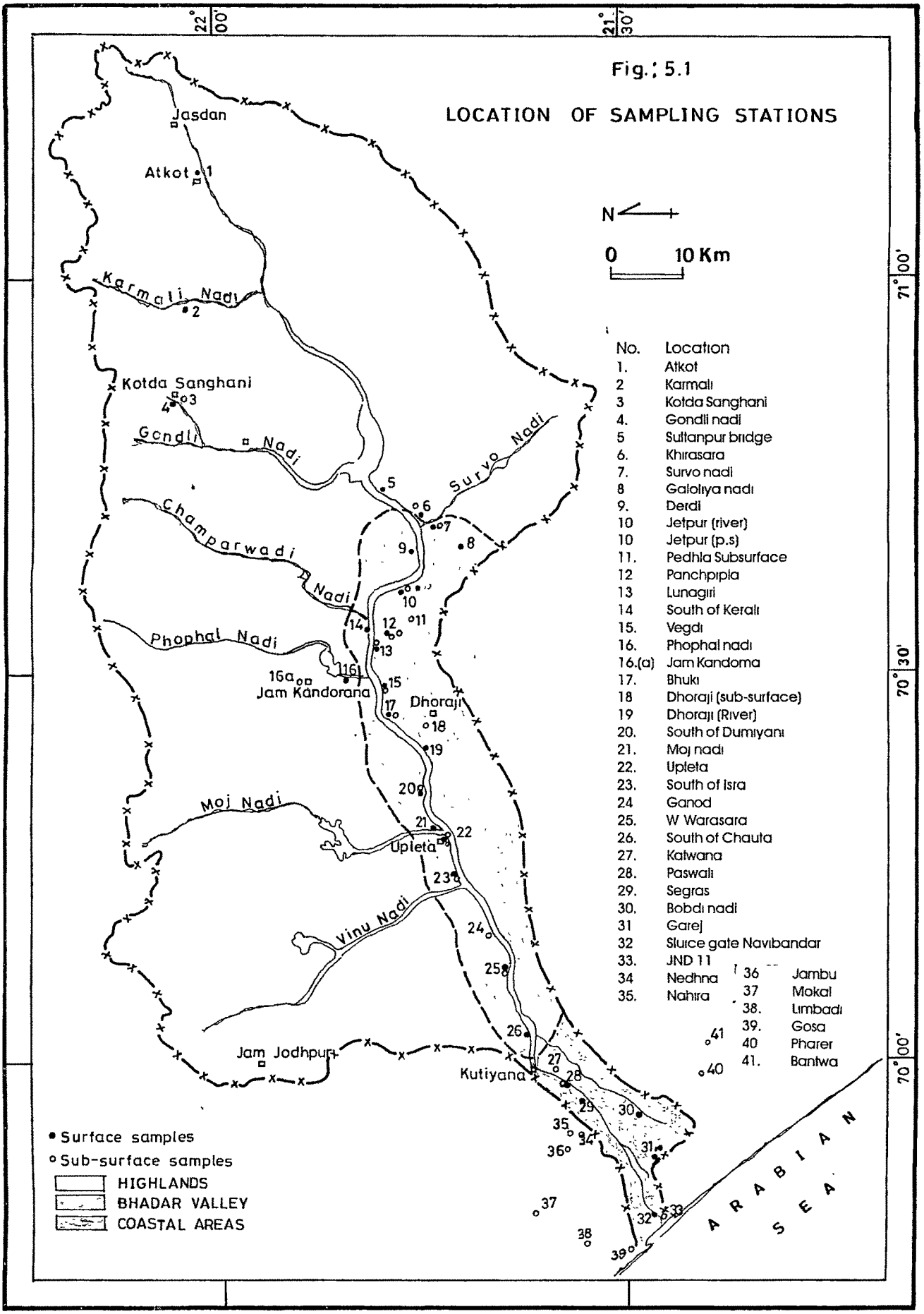
Fig.; 5.1
LOCATION OF SAMPLING STATIONS
22° 00'
21° 30'
71° 00'
70° 30'
70° 00'
N
0 10 Km
Jasdan
Atkot
Karmali Nadi
Kotda Sanghani
Gondli Nadi
Surve Nadi
Champarwadi Nadi
Phophal Nadi
Jam Kandorana
Dhoraji
Moj Nadi
Upleta
Vinu Nadi
Jam Jodhpur
Kutiyana
ARABIAN SEA
No. Location
1. Atkot
2 Karmali
3 Kotda Sanghani
4. Gondli nadi
5 Sultanpur bridge
6. Khirasara
7. Surve nadi
8 Galoliya nadi
9. Derdi
10 Jetpur (river)
10 Jetpur (p.s)
11. Pedhla Subsurface
12 Panchpipla
13 Lunagiri
14 South of Kerali
15. Vegdi
16. Phophal nadi
16.(a) Jam Kandoma
17. Bhuki
18 Dhoraji (sub-surface)
19 Dhoraji (River)
20. South of Dumiyani
21. Moj nadi
22. Upleta
23. South of Isra
24 Ganod
25. W Warasara
26. South of Chauta
27. Kalwana
28. Paswali
29. Segras
30. Bobdi nadi
31 Garej
32 Sluice gate Navibandar
33. JND 11
34 Nedhna
35. Nahira
36 Jambu
37 Mokal
38. Limbadi
39. Gosa
40 Pharer
41. Bantwa
• Surface samples
○ Sub-surface samples
HIGHLANDS
BHADAR VALLEY
COASTAL AREAS

of dyeing and priinting units and that of the washing and processing units were separately considered because both are using very distinct chemicals.

In the proceeding pages, the analytical results of various parameters (physical, chemical and biological) are furnished in table 5.1 to 5.9. The analyses were carried out strictly following standard procedures as suggested by American Public Health Association (APHA, 1980) (Compliment - B).

HIGHLANDS

Considering the location of Jetpur dye industries, the slope, landform, movement of water and the land use pattern, it is quite clear that there is no adverse effect due to human interference in the highlands (Fig. 5.1) other than agricultural and municipal wastes which are generally local. Further, these highlands / catchment areas are not affected by the dye contaminants, as they lie in the up-slopes. The sampling locations in these regions have, therefore, been considered as "control stations". The analytical results of these water is furnished in table 5.1.

BHADAR VALLEY

To assess the impact of the contaminants, the Bhadar valley proper (Fig. 5.1) has been divided into three categories viz. (a) points source, (b) surface water and (c) sub-surface water. The analytical data of these water samples of pre and post monsoons are as tabulated in table 5.2, 5.3, 5.4, 5.5 and 5.6.

COASTAL AREA

The coastal block has unique water quality both in surface and sub-surface. The river Bhadar near the mouth flows in a single effective channel and has the tidal influence. Therefore, water samples from the adjacent areas were also collected and grouped together, with those of basin proper because of the inter-play of various coastal dynamics. The geomorphic, geologic and dynamic processes and also the hydrogeologic conditions of this block are entirely different from those of other blocks.

Supply of drinking water for the villages in this block are made through pipe lines from the Paswali village which is situated on the left hand bank of river Bhadar, near Kutiyana. Here, tube wells, situated near Bhadar, lift the water to high tanks from where it is re-distributed through pipelines. Therefore, water from this station has been considered as 'control point' for sub-surface and rest of the ground water stations have been compared with it. Similarly, near Garej village, a pond, mainly receiving the rain water, has been considered as another 'control point' for the surface water. The analytical results of the water samples in the coastal area are furnished in table 5.7, 5.8 and 5.9.

Table No. 5.1 : Water quality in Highlands

Pre-monsoon										
Station	Sample No.	pH	EC	TSS mg/l	TDS mg/l	BOD mg/l	COD mg/l	PA mg/l	TA mg/l	Hardness
Sultanpur bridge (93)	J-2	7 85	1203 60	23 50	770.30	20 00	50 00	12 50	275.00	240 00
Khirasra (93)	J-3 !	7 67	651 36	23 00	416 87	*	*	0 00	172 50	150.00
Khirasra (94)	J-113 !	8 10	764 64	0 60	489 37	*	*	7 50	205 00	185.00
Karmali Nadi (95)	J-156	8 20	1203 60	0 00	770 30	122 50	720 00	17 50	267 50	230.00
Sultanpur bridge (95)	J-157	8 00	1161 12	0 40	743 12	25 00	30 00	17 50	312 50	210 00
Khirasra (95)	J-158 !	7 86	906 24	3 20	579 99	*	*	20 00	197 50	180 00
Station	Sample No.	Cl mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	OH	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Sultanpur bridge (93)	J-2	134 90	25 00	250 00	0 00	0 00	38 08	35 34	89 00	2.00
Khirasra (93)	J-3 !	53 25	0.00	172 50	0 00	0 00	32 06	17 07	42 50	0.50
Khirasra (94)	J-113 !	67 45	15 00	190 00	115 20	0 00	34 07	24 34	47 00	2 00
Karmali Nadi (95)	J-156	113 60	35 00	232 50	0 00	0 00	36 07	34 13	81.00	3 50
Sultanpur bridge (95)	J-157	124 25	35 00	277 50	0 00	0.00	40 08	26 81	85 00	2 50
Khirasra (95)	J-158 !	81 65	40 00	157 50	0 00	0 00	40 08	19 50	56 00	1 00
Post-monsoon										
Stations	Sample No.	pH	EC	TSS mg/l	TDS mg/l	BOD mg/l	COD mg/l	PA mg/l	TA mg/l	Hardness
Sultanpur bridge (93)	J-34	8 10	1274 40	72 00	815 62	*	*	30 00	337 50	260 00
Khirasra (93)	J-35 !	7 81	1132 80	80 00	724 99	*	*	17 50	287 50	330 00
Atkot (94)	J-114	8 33	1274 40	0 40	815 62	10 00	160 00	15 00	217 50	290 00
Gondli Nadi (94)	J-115	8 42	821 28	24 40	525 62	*	*	25 00	242 50	250 00
Sultanpur bridge (94)	J-117	8 26	807 12	12 00	516 56	10 00	12 20	7 50	160 00	205 00
Phophal Nadi (94)	J-129	8 36	708 00	0 00	453 12	*	*	5 00	142 50	160 00
Moj Nadi (94)	J-150	8 42	920 40	0 00	589 06	*	*	5 00	192 50	200 00
Kotda Sangani (94)	J-116 !	8 06	2548 80	36 40	1631 23	*	*	5 00	155 00	710 00
Khirasra (94)	J-118 !	8 38	1699 20	24 00	1087 49	*	*	17 50	212 50	525 00
Jam Kandorna (94)	J-132 !	8 11	1699 20	12 00	1087 49	10 00	260 00	5 00	160 00	455 00
Stations	Sample No.	Cl mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	OH	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Sultanpur bridge (93)	J-34	156 20	60 00	277 50	0 00	0 00	38 08	40 22	89 00	4 00
Khirasra (93)	J-35 !	106 50	35 00	252 50	0 00	0 00	66 13	40 22	48 00	0 00
Atkot (94)	J-114	170 40	30 00	187 50	0 00	0 00	56 11	36 56	100 00	6 50
Gondli Nadi (94)	J-115	67 45	50 00	192 50	0 00	0.00	50 10	30.47	60 00	5 50
Sultanpur bridge (94)	J-117	110 05	15 00	145 00	0.00	0.00	40 08	25.59	68.00	4 50
Phophal Nadi (94)	J-129	78 10	10 00	132 50	0 00	0 00	32 06	19 50	60 00	3 00
Moj Nadi (94)	J-150	106 50	10 00	182 50	0 00	0 00	52 10	17 06	82 00	20 50
Kotda Sangani (94)	J-116 !	372 75	10 00	145 00	0 00	0 00	112 22	104 82	100 00	13 50
Khirasra (94)	J-118 !	220 10	35 00	177 50	0 00	0 00	104 21	64 59	77 00	2 50
Jam Kandorna (94)	J-132 !	166 85	10 00	150 00	0 00	0 00	76 15	64 60	79 00	1 50

*** Not analysed ; PA Phenolpthalein alkalinity ; TA Total alkalinity ; EC in micromho/cm**

! Subsurface

Table 5.2 Water quality of the point source samples , Bhadar valley

Surface water pre-monsoon 1993								Surface water post -monsoon 1993							
Station	Sample No.	pH	EC	TSS mg/l	TDS mg/l	BOD	COD	Station	Sample No.	pH	EC	TSS mg/l	TDS mg/l	BOD	COD
Derdi	J-5	9 90	5097.60	229 00	3262 46	*	*	Derdi	J-38	9 34	1486 80	288 00	951 55	*	*
Jetpur	J-7	10 61	3450.00	75.50	2265 60	*	*	Jetpur	J-39	11 06	8496 00	288 00	5437 44	*	*
Surface water pre-monsoon 1994								Panchpipla	J-42	9 93	2761 20	32 00	1767 17	*	*
Derdi	J-111	8 82	3964 80	76 00	2537 47	*	*	Lunagiri	J-45	10 90	9204 00	0 00	5890 56	12 50	160 00
Jetpur	J-110	10 53	5522 40	297 40	3534 34	950 00	560 00								
Panchpipla	J-107	8.80	9912 00	573.60	6343 68	*	*	Surface water post-monsoon 1994							
Lunagiri	J-104	9 67	2973 60	39 40	1903 10	780 00	320 00	Derdi	J-122	9 62	3115 20	43 20	1993 73	20 00	280 00
Surface water pre-monsoon 1995								Jetpur	J-123	10.35	4956.00	15 40	3171.84	25 00	520 00
Derdi	J-160	9 98	4814 40	0 00	3081 22	*	*	Panchpipla	J-126	8 52	1104 48	16 00	706 87	*	*
Jetpur	J-164	9 15	3681 60	168 00	2356 22	102 00	520 00								
Lunagiri	J-169	8 32	1090 32	33 20	697 81	780 00	320 00								

Pre-monsoon 1993															
Station	Sample No.	Cl mg/l	CO_3	HCO_3	SO_4 mg/l	OH	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	PA mg/l	TA mg/l	Hardness		
Derdi	J-5	525 40	235 00	790 00	451 20	0 00	N D	N.D	880 00	9 50	117 50	1025 00	40 00		
Jetpur	J-7	266 25	110 00	745 00	158 40	0 00	N D	N D	590 00	12.50	55 00	855.00	20 00		
Pre-monsoon 1994															
Derdi	J-111	237 85	145 00	655 00	177 60	0 00	98 20	0 00	846 00	10 00	72 50	800.00	25 00		
Jetpur	J-110	308 85	224 00	868 00	998 40	0 00	10 02	36 56	1458 00	38 00	112 00	1092 00	65 00		
Panchpipla	J-107	1533 60	165 00	1215 00	595 20	0 00	N D	N D	1776 00	46 00	82 50	1380 00	30 00		
Lunagiri	J-104	248 50	440 00	345 00	0 00	0 00	20 04	0 00	750 00	14 50	220 00	785 00	30 00		
Pre-monsoon 1995															
Derdi	J-160	291 10	765 00	400 00	499 20	0 00	N D	N D	600 00	22 00	382 50	1165 00	50 00		
Jetpur	J-164	266 25	90 00	635 00	604 80	0 00	188 38	N D	534 00	19 00	45 00	725 00	30 00		
Lunagiri	J-169	88 75	40 00	182 50	86 40	0 00	30 06	15 85	94 00	6 50	20 00	222 50	140 00		
Post-monsoon 1993															
Derdi	J-38	78 10	50 00	475 00	148 80	0.00	4 01	7 32	260 00	4 50	25 00	525 00	40 00		
Jetpur	J-39	340 80	285 00	960 00	873 60	0 00	12 02	N D	1456 00	30 00	142.50	1245 00	N.D		
Panchpipla	J-42	177 50	205 00	540 00	0 00	0 00	40 08	N D	462 00	11 00	102 50	745.00	60 00		
Lunagiri	J-45	670 95	2490 00	0 00	874 40	172 50	122 22	N D	846 00	40 00	1417 50	2662 50	75 00		
Post-monsoon 1994															
Derdi	J-122	244 95	480 00	327 50	441 60	0 00	N D	N D	480 00	20.00	240 00	807 50	30 00		
Jetpur	J-123	294 65	1585.00	0 00	81 60	10.00	N D	N D	592 00	33 50	802 50	1595 00	65 00		
Panchpipla	J-126	120 70	35 00	200 00	0 00	0 00	52 10	37 79	79 00	1 50	17.50	235.00	285 00		

PA : Phenolpthalein alkalinity ; TA : Total alkalinity ; EC in micromho/cm
N.D. : Not detected ; * Not analysed

Table 5.3 : Surface water quality of Bhadar river valley (Pre-monsoon)

Pre-monsoon 1993					
Stations	Sample No.	pH	EC	TSS mg/l	TDS mg/l
Survo Nadi	J-4	8 82	1175.28	30.00	752.18
Galoliya Nadi	J-6	8 24	1416.00	40 00	906 24
Jetpur	J-8	8 90	2832.00	22.50	1812 48
S of Kerali	J-14	8 10	2053 20	40.00	1314 05
Vegdi	J-16	7 93	1557 60	29.50	996 86
Bhuki	J-17	8 00	1486.80	26.50	951.55
Dhoraji	J-19	7 80	1557.60	25.00	996 86
S of Dumiyani	J-21	7 78	1486 80	17 50	951 55
Upleta	J-22	7 83	1557.60	21 00	996 86
S. of Isra	J-23	7 96	1486.80	23 00	951 55
W of Warasara	Dry	-	-	-	-
S of Chauta	J-28	7 83	1486 80	78.00	951.55

Pre-monsoon 1994						
Sample No.	pH	EC	TSS mg/l	TDS mg/l	BOD mg/l	COD mg/l
Dry	-	-	-	-	-	-
J-112	9.12	3964 80	414 80	2537 47	1030 00	480 00
J-108	7 83	2973 60	80 80	1903 10	1030 00	560 00
J-105	8 48	2407.20	15 00	1540 61	1030.00	560 00
J-100	8 01	1557 60	14 80	996 86	105 00	120 00
J-97	8 07	566 40	4 00	362 50	105.00	220 00
Dry	-	-	-	-	-	-
Dry	-	-	-	-	-	-
Dry	-	-	-	-	-	-
Dry	-	-	-	-	-	-
Dry	-	-	-	-	-	-
Dry	-	-	-	-	-	-

Pre-monsoon 1995

Stations	Sample No.	pH	EC	TSS mg/l	TDS mg/l	BOD mg/l	COD mg/l
Survo Nadi	J-159	8 20	1416 00	0 00	906 24	*	*
Galoliya Nadi	J-161	8 45	1840 80	13 20	1178 11	95 00	400 00
Jetpur	J-163	8.15	3681 60	284 80	2356 22	102 00	520 00
S of Kerali	J-168	8 62	2690 40	382 80	1721 86	107 00	600.00
Vegdi	J-172	8 36	2194 80	16 80	1404 67	90 00	520 00
Bhuki	J-174	8 13	2053 20	15 20	1314 05	90 00	520 00
Dhoraji	J-176	8 07	2124 00	5 60	1359 36	*	*
S of Dumiyani	J-177	7 96	1982 40	2 40	1268 74	*	*
Upleta	J-178	8 01	1982 40	0 80	1268 74	80 00	520 00
S of Isra	J-180	7 88	2053 20	3 20	1314 05	*	*

EC in Micromho/cm
* Not analysed

(Table continued.....)

Table 5.3 (Continued)

Stations	Sample No	Cl mg/l	CO_3	HCO_3	SO_4 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	PA mg/l	TA mg/l	Hardness
Suface water pre-monsoon 1993												
Survo Nadı	J-4	113.60	25.00	465.00	0 00	52 10	30 47	75 00	2 50	12.50	490.00	255.00
Galoliya Nadi	J-6	152.65	25 00	255 00	0 00	42 08	30 47	132 00	3.00	12 50	280 00	230.00
Jetpur	J-8	234.30	50 00	555.00	48.00	52 10	8 53	364 00	24 00	25 00	605 00	165 00
S. of Keralı	J-14	216.55	75 00	300 00	139 20	64 13	35 34	176.00	6.00	37 50	375 00	305.00
Vegdı	J-16	166.85	30.00	280.00	33.60	54 11	41.44	142.00	4.00	15.00	310 00	305 00
Bhukı	J-17	166.85	30.00	215.00	9 60	54 11	29 25	128.00	3.00	15.00	245 00	255.00
Dhorajı	J-19	177.50	10 00	257.00	33 60	48.10	33 34	128.00	4.50	5.00	267.50	265 00
S of Dumıyanı	J-21	173.95	10.00	217.50	268 80	48.10	30 37	132.00	3.00	5.00	227.50	245 00
Upleta	J-22	188.15	15.00	172.50	81 60	46.09	28.03	136.00	3.00	7 50	187.50	230 00
S of Isra	J-23	188 15	15 00	182.50	81 60	42.08	25.59	136.00	3 00	7.50	197.50	210.00
S of Chauta	J-28	181 05	0.00	215.00	148 80	50.10	19 50	132.00	4 00	0.00	215 00	205.00
Surface water Pre-monsoon 1994												
Galoliya Nadı	J-112	372 75	160 00	625 00	782 40	90 18	0 00	882.00	12 00	80 00	785 00	30 00
Jetpur	J-108	415 35	35 00	347 50	182 40	86 17	51 19	468 00	48 50	17 50	352 50	425 00
S of Keralı	J-105	376 30	345.00	0.00	139 20	14 03	58.52	450 00	6 00	175.00	347 50	275 00
Vegdı	J-100	244 95	0 00	172 50	28 80	40 08	49 98	134 00	6 00	0 00	172 50	305 00
Bhukı	J-97	46 15	25 00	145 00	43 20	32 06	12 19	29 00	2 50	12 50	170 00	130 00
Remaining stations (Dhorajı to South of Chauta) were dry												
Surface water pre-monsoon 1995												
Survo Nadı	J-159	142 00	45 00	232.50	38 40	60 12	35.34	90 00	4 00	22 50	277 50	295 00
Galoliya Nadı	J-161	181 05	40.00	282 50	96 00	30 06	31 69	255 00	6 00	20.00	322 50	205 00
Jetpur	J-163	326 60	0 00	550 00	192 00	102 20	10 95	426.00	35.50	0 00	550 00	300 00
S of Keralı	J-168	287 55	80 00	335 00	465 60	68 14	-	432 00	17 00	40.00	415 00	135 00
Vegdı	J-172	234 30	65 00	252 50	52 80	66 13	32 90	130 00	11 00	32.50	317 50	300.00
Bhukı	J-174	220 10	45 00	242 50	76 80	64 13	34 12	122 00	9 50	22.50	287.50	300 00
Dhorajı	J-176	234 30	40 00	235 00	48 00	60 12	37 78	125 00	8 50	20.00	275 00	305.00
S of Dumıyanı	J-177	230 75	20 00	217 50	57 60	50 10	35 35	125 00	8 50	10 00	237.50	270 00
Upleta	J-178	241 40	15 00	200 00	52 80	48 10	32 90	125 00	8.00	7 50	215.00	255 00
S of Isra	J-180	266 25	25 00	180 00	67 20	50 10	35 35	130 00	7 00	12 50	205 00	270 00

PA : Phenolpthalein alkalinity ; TA : Total alkalinity ; EC in micromho/cm

Table 5.4 : Surface water quality of Bhadar valley (post-monsoon)

Post- monsoon 1993																
Stations	Sample No	pH	EC	TSS	TDS	PA	TA	Hardness	Cl	CO_3	HCO_3	SO_4	Ca	Mg	Na	K
Survo Nadi	J-36	7 83	655 52	76 00	419 53	17 50	255 00	125 00	56 80	35 00	220 00	0 00	24.05	15 85	43 00	2 00
Galoliya Nadi	J-37	8 43	1416 00	116 00	906 24	20 00	337 50	165 00	156 20	40 00	297 50	48.00	38.08	17 06	160 00	4 00
Jetpur	J-40	8 22	4248 00	192 00	2718 72	0 00	700 00	495 00	553 80	0 00	700 00	0 00	110 22	53 62	360 00	64 00
S of Kerali	J-44	8 17	920 40	32.00	589 06	27 50	280.00	170 00	92 30	55 00	225 00	0 00	34.07	20 72	78.00	4 00
Vegdi	J-48	7 98	807 12	32 00	516 57	0 00	200 00	165 00	81 65	0 00	200 00	76.80	34 07	19 50	60 00	4 00
Bhuki	J-50	7.94	863 76	8 00	552 81	15 00	207 50	190 00	88.75	30 00	177 50	580.80	38.08	23 60	60 00	3 00
Dhoraji	J-51	8 06	835 44	16 00	534 68	12 50	217 50	160 00	95 85	25 00	192 50	57 60	34.07	18 28	70 00	3 50
S of Dumiyani	J-52	8 10	821 28	8.00	525 62	7 50	185 00	130 00	99 40	15 00	170 00	19 20	22.04	18 28	74 00	3 50
Upleta	J-55	7 93	849 60	4 00	543 74	7 50	192 50	115 00	102.95	15 00	177 50	62 40	24 05	13 41	96 00	3 00
S of Isra	J-53	8 10	5239 20	8 00	3353 09	5 00	192 50	130 00	106 50	10.00	182 00	14 40	30 06	13 41	84 00	3 50
W of Warasara	J-57	7 86	821 28	12 00	525 62	5 00	190 00	115 00	85 20	10 00	180 00	0 00	36 07	6 09	80.00	5 00
S of Chauta	J-58	7 63	665 52	12 00	425 93	5 00	190 00	120 00	63 90	10 00	180 00	0 00	34 07	8.53	56 00	3 00

Post - monsoon 1994																		
Stations	Sample No	pH	EC	TSS	TDS	BOD	COD	PA	TA	Hardness	Cl	CO_3	HCO_3	SO_4	Ca	Mg	Na	K
Survo Nadi	J-119	8 38	1274 40	22 00	815 62	*	*	7 50	177 50	230 00	142 00	15 00	162 50	0 00	32 06	36 57	101 00	6 50
Galoliya Nadi	J-121	8 45	1557 60	12 00	996 86	20 00	160 00	15 00	200.00	250 00	191 70	30 00	170 00	14 40	40 08	36 57	121 00	8 50
Jetpur	J-124	8 62	1175 28	0 80	752 18	50 00	520 00	20 00	222 50	245 00	134 90	40.00	182 50	0.00	44.09	32 91	101 00	8 00
S. Kerali	J-127	8 55	1416 00	4 00	906 24	25 00	280 00	27 50	262 50	305 00	181 05	55 00	207.50	0 00	64 13	35 34	116 00	8 50
Vegdi	J-130	8 70	1557 60	34 00	996 86	32 50	200 00	15 00	200 00	280 00	195 25	30 00	170 00	0 00	42 08	42 66	121 00	9.50
Bhuki	J-153	8 51	1557 60	0.00	996 86	32 50	200 00	22 50	245 00	325 00	184.60	45 00	200 00	0.00	62 12	41 44	107 00	7 50
Dhoraji	J-152	8 58	1557.60	5 60	996 86	*	*	20 00	237 50	350 00	205 90	40 00	197 50	0 00	72 14	41 44	107.00	8 50
S. Dumiyani	J-151	8 48	1486 80	6 40	951 55	*	*	15 00	217 50	325 00	188 15	30 00	187 50	24 00	66 13	38 99	106.00	8.00
Upleta	J-133	8 57	1416 00	3 20	906 24	27 50	120 00	25 00	242 50	305 00	184 60	50 00	192 50	0.00	64 13	35 34	106 00	7 50
S. of Isra	J-135	8 56	1416 00	0 40	906 24	*	*	20 00	235 00	300 00	177 50	40 00	195 00	0 00	60 12	36 56	109 00	7 00
W. of Warasara	J-137	8 39	1302 72	0 00	833 74	*	*	15 00	220 00	290 00	170 40	30 00	190 00	0 00	56 11	36 56	101 00	7 00
S. of Chauta	J-139	8 39	1175 28	0 60	752 18	*	*	12 50	193 75	260 00	154 43	25 00	168 75	0 00	53 11	31 08	98 00	6 50

PA : Phenolthalein alkalinity ; TA : Total alkalinity ; EC in micromho/cm ; * Not analasyed ; All values expect pH and EC in mg/l

Table 5. 5 : Pre-monsoon sub-surface water quality, Bhadar valley

Stations	Sample No	pH	EC	TSS mg/l	TDS mg/l	PA mg/l	TA mg/l	Hard-ness	Cl mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Pre-monsoon 1993																
Jetpur	J-9	7 60	608 88	114 00	389 68	0 00	172 50	140 00	63 90	0 00	172 50	0 00	42 08	8 53	35 00	2 00
Panchpipla	J-13	7 64	1260 24	37 00	806 55	0 00	185 00	275.00	102.95	0 00	185 00	57 60	44 09	40 22	54 00	3 00
Dhoraji	J-15	7 82	1146 96	23 00	734 05	30 00	357 50	255 00	56 80	60 00	297 50	19 20	48 10	32.91	68 00	1 00
Bhuki	J-18	7 58	3256 80	18 50	2084 35	0 00	190 00	775 00	436 65	0 00	190 00	48 00	214 43	58 47	148 00	5 50
S of Dumiyani	J-20	7 64	1557 60	20 00	996 86	5 00	107 50	280 00	209.45	10 00	97 50	19 20	66 13	28 02	104 00	3 00
Ganod	J-24	7 80	4248 00	21 50	2718 72	15 00	427 50	220.00	575 10	30.00	397 50	350 40	30 06	35 35	680 00	1 00
W of Warasara	J-25	7 62	2371 80	26 25	1517 95	1 25	216 25	455 00	344 35	2 50	213 75	52 80	79 16	62.77	191.00	3 50
Pre-monsoon 1994																
Panchpipla	J-106	8 45	962 88	4 80	616 24	10 00	195 00	200 00	95 85	20 00	175 00	67.20	20 04	36.57	69.00	3 00
Lunagiri	J-102	8 46	1345 20	0 00	860.93	27 50	260 00	285.00	159.75	55 00	205.00	67 20	20 04	57 30	134 00	1 00
Vegdi	J-101	8 30	1557 60	11 40	996 86	30 00	262.50	440 00	205 90	60 00	202 50	48.00	80 16	58 50	77 00	41 00
Bhuki	J-98	8 60	778 80	7 40	498 43	10 00	217 50	125 00	56 80	20 00	197 50	0.00	24 05	15 85	78 00	2 00
E of Bhuki	J-99	7 98	1161 12	0 00	743 12	0 00	172 50	310 00	142.00	0 00	172.50	91 20	56 11	41 44	69 00	1 00
S of Dumiyani	J-76	7 80	1175 28	0 80	752 18	10 00	215 00	190.00	145 55	20 00	195 00	163 20	22 04	32 91	164 00	2 00
Upleta (R bed)	J-77	8 09	1076 16	14 40	688 74	17 50	215 00	185 00	120 70	35 00	180 00	144 00	20 04	32.91	132.00	3 00
Upleta	J-79	8 73	4248 00	23 20	2718 72	72 50	522 50	185 00	692 25	145 00	377 50	552 00	10 02	39 01	792 00	0 00
S of Isra	J-78	8 01	1486 80	4 00	951 55	15 00	320 00	190 00	191 70	30 00	290 00	96 00	36 07	24 37	216 00	2.00
Ganod	J-80	8 80	3256 80	16 00	2084 35	45 00	455 00	125 00	426 00	90 00	365.00	561 60	6 01	26 82	638 00	0 00
W of Warasara	J-81	8 50	1373 52	4 40	879 05	12 50	242.50	215 00	198 80	25 00	217 50	76 80	28 06	35 35	156 00	3 00
Pre-monsoon 1995																
Pedhla	J-165	8 32	1770 00	0 00	1132 80	15 00	287 50	320 00	195 25	30 00	257.50	91 20	60 12	41 44	106 00	2.50
Panchpipla	J-166	8 26	1331 04	0 40	851 87	12 50	280 00	270 00	134 90	25 00	255 00	76 80	42.08	40 22	92 00	1 50
Panchpipla	J-167	8 26	1047 84	0 00	670 62	10 00	235 00	250 00	99 40	20 00	215.00	57 60	48 10	31 68	69 00	6 00
Lunigiri	J-170	8 40	1911 60	0 40	1223 42	37 50	342 50	340 00	163 30	75 00	267 50	110 40	56 11	48.75	111 00	2 50
Vegdi	J-171	7 78	2265 60	0 80	1449 98	82.50	587 50	725.00	248.50	165.00	422.50	48 00	200 40	54 81	91.00	36.00
E of Bhuki	J-173	8.05	1401 84	0 00	897 18	20 00	255 00	325 00	120 70	40 00	215.00	96.00	64 13	40 22	79 00	1 50
Bhuki	J-175	7 89	2124 00	2 80	1359 36	10 00	235 00	480 00	244 95	20 00	215 00	38 40	98 20	57 28	88 00	3 50
Upleta	J-179	8.19	3540 00	0 00	2265 60	87 50	605 00	300 00	355.00	175 00	430 00	614 40	20 04	60 95	184 00	2 50
Ganod	J-181	8 12	3398 40	0 00	2174 98	90 00	590 00	130 00	262 70	180 00	410 00	619 20	28.06	14 62	194 00	2 50
W of Warasara	J-182	8 10	3115 20	2 80	1993 73	37 50	352 50	425 00	422 45	75 00	277 50	158 40	58 12	68 26	159 00	33 50

PA : Phenolpthalein alkalinity ; TA : Total alkalinity ; EC in micromho /cm

Table 5. 6 : Post - monsoon sub-surface water quality, Bhadar valley

Post - monsoon 1993																
Stations	Sample No.	pH	EC	TSS mg/l	TDS mg/l	PA mg/l	TA mg/l	Hardness	Cl mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Panchpipla	J-43	7 99	1274 60	48.00	815 74	25 00	307 50	370 00	110 05	50 00	257.50	105 60	84 17	38 99	59 00	3 00
Lunagiri	J-46	8 06	1770 00	4 00	1132.80	37 50	482 50	420 00	195 25	75 00	407 50	110 40	58 12	67 04	110.00	1.00
Vegdi	J-47	7 94	1840 80	4 00	1178.11	55 00	457 50	615 00	195 25	110 00	347 50	0 00	166 33	48 73	60 00	19 50
Bhuki	J-49	8 37	1416 00	16 00	906 24	15 00	282 50	420 00	149 10	30 00	252 50	81 60	92 18	46 31	60 00	1 00
Upleta	J-54	8 19	906 24	8 00	579 99	95 00	957 50	215 00	624 80	190 00	767 50	201 60	22.04	39 00	765.00	1 00
Ganod	J-56	7 99	4248 00	4 00	2718 72	50 00	600 00	265 00	507 65	100 00	500 00	369 60	48 10	35 34	574 00	0 50
Post - monsoon 1994																
Survo nadi, bank	J-120	8 47	1699 20	26 80	1087 49	15 00	220 00	270 00	220 10	30 00	190.00	0 00	34 04	45 10	131 00	5.50
Panchpipla	J-125	8 49	1161 12	24 00	743 12	10 00	207 50	240 00	117 15	20 00	187 50	0 00	20 04	46 32	89 00	1 50
Lunagiri	J-128	8 19	4248 00	31 60	2718 72	12 50	202 50	655 00	639 00	25 00	177 50	24 00	144 29	71 90	348 00	6 00
Vegdi	J-131	8 45	5239 20	38 80	3353 09	37 50	270 00	1735 00	1114 70	75 00	195.00	0 00	440 88	154 73	129 00	28 00
Bhuki	J-154	8 62	1416 00	0 00	906 24	22 50	232 50	325 00	181 05	45 00	187 50	0 00	68 14	37 78	101 00	7 00
E of Bhuki	J-155	8 07	2336 40	7 20	1495.30	0 00	160 00	610 00	312 40	0 00	160 00	0 00	112 22	80 44	95.00	4 00
Upleta	J-134	8 78	3115.20	15 20	1993 73	65 00	575 00	235 00	457 95	130 00	445 00	244 80	4 01	0 86	363 00	3 00
Ganod	J-136	8 40	4460.40	26.20	2854 66	27 50	388 75	637 50	766 80	55 00	333 75	247 20	101.20	94 35	430 00	5.75
W of Warasara	J-138	8 30	1076 16	2900 80	688 74	20 00	302 50	175 00	95 85	40 00	262.50	0 00	30 06	24 38	111.00	19.00

PA : Phenolpthalein alkalinity ; TA : Total alkalinity ; EC in micromho /cm

Table 5.7 : Surface water quality in the coastal area

Stations	Sample No.	pH	EC	TSS	TDS	PA	TA	Hardness	Cl mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Pre-monsoon 1993																
Garej	J-30	7 62	1486 80	16 00	951 55	2 50	165 00	455 00	223 65	5 00	160 00	0 00	42 08	85 33	138 00	3 00
Garej Pond #	J-31	9 56	821 28	12 50	526 00	0 00	130 00	75 00	110 05	0 00	130 00	0 00	16 03	8 53	90 00	4 00
Navibandar	J-32	7 88	6938 40	22 00	4440 58	5 00	172 00	560 00	1363 20	10 00	162 00	240.00	76 15	90 19	864.00	20 50
Pre-monsoon 1994																
Segras	J-85	7.75	8496 00	65 20	5437 44	10 00	172 50	980 00	1906 35	20.00	152 50	326 40	130 26	159 68	1100.00	19 00
Garej Pond #	J-86	8 20	1302.72	4 60	833 74	7 50	217 50	155 00	216 55	15 00	202 50	0 00	26.05	21 94	154 00	8 00
Navibandar	J-87	7 75	14160 00	112 00	9062 40	10 00	127 50	1310 00	3638 75	20 00	107 50	489.60	128 26	241 35	2090 00	50 00
Pre-monsoom 1995																
Segras	J-193	7 61	24072.00	67 00	15406 08	0 00	222 50	1680 00	2989 10	0 00	222 50	480.00	254 51	254 74	.780 00	37 00
Bobdi Nadi	J-187	7 35	60888 00	1687 00	38968 32	5 00	260 00	14500 00	7029 00	10 00	250 00	576 00	1941 88	2353 65	5766 00	185 00
Garej Pond #	J-186	8 40	1699 20	13 20	1087 49	10 00	195 00	225 00	252 05	20 00	175 00	52 80	50 10	24 37	11 00	9 50
Navibandar	J-185	7 85	49560 00	405 60	31718 40	10 00	180 00	3825 00	10579 00	20 00	160 00	907 20	356 71	715 54	2145 00	136 00
Post-monsoon 1993																
Segras	J-62	7 75	1062.00	16 00	679 68	7 50	200 00	155 00	131 35	15 00	185 00	0.00	32 06	18 28	104 00	6 00
Bobdi Nadi	J-73	7 60	9204 00	12 00	5890 56	10 00	332 50	1060 00	1657 85	20 00	312 50	763 20	172 34	153 57	682 00	88 00
Garej	J-63	8.10	1401 84	16 00	897 18	10 00	172 50	190 00	252 05	20 00	152 50	0 00	36 07	24 37	144 00	4 00
Garej Pond #	J-64	7 83	1189 44	20 00	761 24	7 50	160 00	120 00	195 25	15.00	145 00	0 00	20 04	17 07	128 00	5 00
Navibandar	J-65	7 58	1062 00	8 00	679 68	5 00	160 00	135 00	166 85	10 00	150 00	0 00	34 07	12 18	112 00	4 00
Post-monsoon 1994																
Paswali	J-141	8 45	1132 80	8 00	724 99	7 50	172 50	240 00	145 55	15 00	157 50	57 60	46 09	30 47	91 00	6 50
Segras	J-143	8 55	1104 48	0 00	706 87	10 00	180 00	240 00	142 00	20 00	160 00	0 00	50 10	28 03	95 00	6.50
Bobdi Nadi	J-144	7 73	637 20	412 80	407 81	0.00	132 50	7100 00	8001 70	0 00	132 50	772 80	ND	ND	2790 00	139 00
Garej	J-145	8.51	2548 80	36 00	1631 23	2 50	185 00	370 00	497 00	5 00	180.00	0 00	50 10	59.73	150 00	9 50
Garej Pond #	J-146	8 54	778 80	11 60	498 43	5 00	155.00	100 00	95 85	10.00	145 00	9.60	18 04	13 41	87 00	8 00
Navibandar	J-147	8 49	1203 60	5 20	770 30	7 50	182 50	230 00	159 75	15 00	167 50	14 40	48 10	26 81	99 00	7 50

PA . Phenolpthalein alkalinity ; TA : Total alkalinity ; EC in micromho/cm ; ND : Not detected
Surface control stations

Table 5. 8 : Sub-surface water quality in the coastal area (pre - monsoon)

Stations	Sample No	pH	EC	TSS	TDS	PA	TA	Hardness	Cl mg/l	CO_3 mg/l	CO_2 mg/l	SO_4 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Pre-monsoon 1993																
Limbadi	J-33	7 54	28320 00	33 50	18124 80	0 00	262 50	1390 00	3070 75	0 00	262 50	398 40	176 35	231 59	1568 00	39 50
Pre-monsoon 1994																
Katwana	J-82/83	7 97	4177.20	13.40	2673 41	37 50	360.00	507 50	857 33	75 00	285 00	189 60	47 10	95 08	649 00	2 00
Paswali #	J-84	8 17	3964.80	70 40	2537 47	27 50	432.50	440 00	713 55	55 00	377 50	216 00	28 06	90 21	638 00	14 00
JND - 11	J-88/89	7 51	13452.00	108 70	8609 28	3 75	148 75	2247 50	3299 73	7 50	141 25	307 20	398 80	305 30	1365 00	29 50
Gosa	J-90	7 98	7778.00	47 60	4984 32	2 50	95 00	1155 00	2059 00	5 00	90 00	192 00	170 34	177 95	1164 00	22 00
Limbadi	J-91	7 79	14160.00	91 40	9062 40	0 00	135 00	1400 00	3262 45	0 00	135 00	374 40	148 30	251 10	1792 00	46 00
Mokal	J-92	7 80	8496 00	68.80	5437 44	2 50	155 00	890 00	1988.00	5.00	150 00	268 80	138 28	132 85	1188 00	2 00
Mahira	J-93	7 93	7080 00	43 80	4531 20	5 00	175 00	830 00	1579 75	10 00	165.00	446 40	90 18	147 50	1020 00	6 00
Nedhana	J-94	8 26	807 12	1 20	516 56	10 00	245 00	150.00	81.65	20 00	225 00	0 00	32 06	17.07	73 00	7 00
Pharer	J-95	7 87	6513.60	39 20	4168 70	2 50	117 50	735 00	1292 20	5 00	112 50	456.00	116 23	108 47	900 00	3 00
Bantwa	J-96	8 97	1699 20	0 00	1087 49	35 00	267 50	30 00	120 70	70 00	197 50	326 40	8 02	2 44	420 00	2 50
Pre-monsoon 1995																
Katwana	J-190/191	8 02	6867 60	1220.00	4395 26	22 50	435 00	980.00	1185.70	45 00	390 00	199.20	60 12	202 36	524 00	9 25
Paswali #	J-192	8 39	3823.20	4 00	2446.85	50 00	412 50	320 00	507 65	100 00	312.50	163.20	44 09	51 20	181 00	18 00
JND - 11	J-184	7 71	26904 00	180 00	17218 56	12.50	160 00	2370 00	3816 25	25 00	135 00	288 00	464 93	294 91	1254 00	51 50
Gosa	J-183	8 09	25488 00	50 00	16312 32	10 00	180 00	1380 00	2474 35	20 00	160 00	201 60	220 44	202.32	1078 00	37 50
Pharer	J-188	8 00	9912 00	32.80	6343 68	12 50	302 50	1050.00	1679 15	25 00	277 50	542 40	198 40	135 27	979.00	7 00
Bantwa	J-189	8.50	2265 60	5 60	1449 98	45 00	487 50	70.00	131 35	90 00	397 50	508 80	12 02	9 76	160.00	4 50

PA : Phenolpthalein alkalinity ; TA : Total alalinity ; EC in micromho/cm
Sub-surface control stations

Table 5. 9 : Sub-surface water quality in the coastal area (post-monsoon)

Stations	Sample No.	pH	EC	TSS	TDS	PA	TA	Hardness	Cl mg/l	CO_3 mg/l	HCO_3 mg/l	SO_4 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l
Post -monsoon 1993																
Katwana	J-59/60	7 66	7646 40	10 00	4893 69	15 00	255 00	1345 00	1686 25	30.00	225 00	465 60	225 45	190 74	632 00	5 00
Paswali #	J-61	7 93	3256 80	8 00	2084 35	40 00	400 00	305 00	514 75	80 00	320 00	158 40	40 08	49 98	384 00	8 00
JND -11	J-66	7 30	49560 00	12 00	31718 40	7 50	187 50	2485 00	4057 65	15 00	172 50	628 80	507 01	297 35	1520 00	31 00
Gosa	J-67	7 42	12036 00	64 00	7703 04	7 50	180 00	1420 00	2360 75	15 00	165 00	384 00	254 51	191 34	935 00	21 00
Limbadi	J-68	7 62	12036 00	8 00	7703 04	27 50	320 00	1035 00	2204 55	55 00	265·00	307 20	146 29	163 33	1034 00	35 00
Mokal	J-69	7 63	9912 00	8 00	6343 68	5 00	297 50	875 00	1767 90	10 00	287 50	374 40	174 35	107 24	957 00	3 00
Jambu	J-70	7 43	14160 00	12 00	9062 40	7 50	195 00	1915 00	2829 35	15 00	180 00	523 20	348 70	254 71	1067 00	2 00
Mahira	J-71	7 60	10620 00	16 00	6796 80	12 50	372 50	1195 00	1870 85	25 00	347 50	734 40	178 36	182 83	968 00	3 00
Nedhna	J-72	7 80	849 60	12 00	543 74	12 50	315 00	155 00	63 90	25 00	290 00	0 00	36 07	15 84	77 00	3 00
Pharer	J-74	7 52	9912 00	8 00	6343 68	2 50	247 50	1250 00	1764 35	5 00	242 50	729 60	244 49	155 99	858 00	2 00
Bantwa	J-75	8 26	2194 80	8 00	1404 67	60 00	587 50	85 00	163 30	120 00	467 50	369 60	18 04	9 75	330 00	2 00
Post-monsoon 1994																
Paswali #	J-142	8 59	778 80	17 20	498 43	12 50	215 00	195 00	78 10	25 00	190 00	0.00	44 09	20 72	69 00	8 50
JND - 11	J-148	8 10	325 68	108 80	208 44	0 00	137 50	2130 00	2254 25	0 00	137 50	307 20	428 86	258 35	1080 00	45 00
Gosa	J-149	8 10	6796 80	41 60	4349 95	0 00	127 50	1040 00	1611 70	0 00	127 50	62 40	190 38	137 72	770 00	26 50

PA : Phenolpthalein alkalinity ; TA : Total alkalinity ; EC in micromho/cm
 # Sub-surface control stations

Concentration of parameters like oil and grease, phosphate and nitrate for the water of point source and Bhadar at Jetpur, were compared with raw dye collected during the first season, which are as follows:

	Raw dye	Point source	Bhadar at Jetpur
Oil & Grease	0.29mg/l	0.085mg/l	0.027mg/l
Phosphate	56.0mg/l	9.250mg/l	4.50mg/l
Nitrate	1283.60mg/l	21.600mg/l	21.38mg/l

Their results show very low value and have been considered insignificant for further consideration.

STATISTICAL ANALYSIS

A quantitative approach to the quality of the water requires various parameters and their respective standards before making any statement or conclusion. The conclusion reached in a quantitative study will be based at least in part of inference drawn from the measurements. Therefore, one must be aware of the nature of the parameters and their measurement as a system. Hence, the author has tried to minimize the variable by understanding the parameters which are dependent and/or changeable from one to another by conversion calculation. For eg. monovalent cation K^+ was converted into its equivalent Na^+; divalent cation ie Mg^{+2} was converted into its equivalent Ca^{+2}; hydroxyl and carbonate ions into its equivalent bicarbonate. EC was considered as it depends on the TDS value.

The results are of multivariant type in which location of the observations are repeated and also scattered within the blocks. The locations thus, can be grouped. This type is concerned with clustering, classification and the examination of the inter-relations among the date set, in which sample locations are not considered. For this 'Friedman test' (Lehmann and D' Abrera, 1975, p. 262) has been used to bring out a single population mean value.

It is more appropriate and practical to have the samples of control and non-control rather than the established standards. The advantage if local control samples will be of more practical application of the adverse industry does not exist. Therefore, firstly the control and the non-control quality of individual parameters have been compared by applying t-test. Also, the quality of water between pre-monsoon and post-monsoon on individual parameters were assessed. This exercise was done with the aim to understand the influence of seasonal change.

The t-test is one type of probability distribution in which the exact shape of the curve changes according to the number of observations in the samples being used to estimate the population.

t-distribution is similar to normal distribution but is dependent on the size of the samples taken. It is having an advantage over the normal distribution because of its wider 'spread'. When the number of observations in the sample is infinite the t-distribution and normal distribution are identical.

t-test is useful for establishing the likely hood that a given sample could be a member of population with specified characteristic for testing the equivalency of two samples. It is often employed in for quality control fields. Since the means are unequal in the above results the t-test (Lehmann, 1986) has been computed by the following formula

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{(S_1^2/n_1 + S_2^2/n_2)}}$$

where $\overline{X}_1$ = mean of first sample ; $\overline{X}_2$ = mean of second sample; S_1^2 and S_2^2 are sample variance; n_1 and n_2 are sample size.

The results of the statistical analyses worked out at 5% significance level using Micro Soft EXCEL (Version 5.0) on a personnel computer is furnished in table 5.10, 5.11 and 5.12. The analytical results allude that in majority of the cases, the mean (of individual variables) of the non-control and pre-monsoon are more than that of control and post-monsoon respectively. However, in few parameters it is reverse. Accordingly, the t-test value is positive or negative. Further, to know the level of significance, the P values (Probability of a wrong claim of significant difference one test) worked out at 5% significance level and divided into four, based on +ve / -ve t and P value, are as under.

Selected levels of significance based on P values

t-stat	P value	Significance	Class
+	< 0.01	Highly Significant	I
+	0.01-0.05	Significant	II
+	> 0.05	Moderately Significant	III
-		Not Significant	IV

Based on the selected level of significance, classes have been assigned for various parameters and are computed and furnished in table 5.10, 5.11, and 5.12.

TRACE ELEMENTS

In addition to the above parameters, the trace elements have been analysed to have a better understanding of the quality of water and its impact an human life. The following elements viz. Fe, Mn, Zn, Ni, Cr, Sr, Al, B, Cd, Cu, Pb, Co and F were analysed for selected stations. the analytical results are given in tables 5.13, 5.14 and 5.15.

Table 5.10 : Statistical analyses of pre-monsoon water samples

Variables	Mean		Observations		t-stat	P(T ≤ t) one tail	Significance
	Control	Non-control	Control	Non-control			
Surface water, Bhadar valley							
pH	7 92	8 17	2	26	-2 418	0 0472	II
EC	1182 36	1984.03	2	26	-5 349	6 7 E - 06	I
TSS	11 95	61 83	2	26	-1 989	0 033	II
Cl	129 57	222 28	2	26	-5 410	7 39 E - 06	I
SO_4	-	-	-	-	-	-	-
HCO_3	294 25	322 58	2	26	-0 821	0.2162	III
Ca	90 32	103 29	2	26	-1 702	0 0936	III
Na	88 32	224 65	2	26	-3 582	0 00072	I
Hardness	225 00	248 85	2	26	-1 129	0 1610	III
Sub-surface water, Bhadar valley							
pH	7 88	8 10	3	28	-1 578	0 1063	III
EC	774 08	1956 36	3	28	-5 544	3 14 E -06	I
TSS	8 93	12 64	3	28	-0 449	0 338	III
Cl	67 45	231 13	3	28	-5 258	6.2 E-06	I
SO_4	38 40	154 45	3	28	-2 197	0 032	II
HCO_3	191 97	304 53	3	28	-4 029	0 0002	I
Ca	68 90	120 64	3	28	-3 997	0 0002	I
Na	49 19	180 66	3	28	-3 608	0 0006	I
Hardness	171 67	300 53	3	28	-3 992	0 0002	I
Surface water , coastal area							
pH	8 72	7 69	3	7	2 405	0 9311	
EC	1274 40	23657 31	3	7	-2 584	0 0208	II
TSS	10 10	339 28	3	7	-1 429	0 1014	III
Cl	192 88	3450 01	3	6	-2 159	0 0416	II
SO_4	17 60	431 31	3	7	-3 792	0 0045	I
HCO_3	181 02	185 85	3	7	-0 156	0 4418	III
Ca	60 87	1337 37	3	7	-1 663	0 0736	III
Na	89 21	1878 27	3	7	-2 472	0 0241	II
Hardness	151 67	3330 00	3	7	-1 663	0 0736	III
Sub-surface water, coastal area							
pH	8 28	8 09	2	15	1 951	0 9269	
EC	3894 00	10928 02	2	15	-2 988	0 0049	I
TSS	37 20	48 55	2	15	-0 320	0 4014	III
Cl	610 60	1793 22	2	15	-3 574	0 0014	I
SO_4	189 60	313 28	2	15	-2 694	0 0154	II
HCO_3	423 80	235 53	2	15	5 868	1 54 E - 05	I
Ca	152 66	394 95	2	15	-3 087	0 0038	I
Na	418 90	952 82	2	15	-2 040	0 0891	III
Hardness	380 00	1012 33	2	15	-3 334	0 0023	I

Table 5.11 : Statistical analyses of post- monsoon water samples.

Variables	Mean		Observations		t-stat	P(T ≤ t) one tail	Significance
	Control	Non-control	Control	Non-control			
Surface water, Bhadar valley							
pH	8 18	8 27	2	24	-0 874	0.2371	III
EC	1040.76	1459.83	2	24	-1 311	0 1405	III
TSS	42.00	25.21	2	24	0 536	0 6566	-
Cl	133 12	153 91	2	24	-0 683	0 2719	III
SO_4	-	-	-	-	-	-	-
HCO_3	249 38	235 80	2	24	0 148	0 5467	-
Ca	93 34	92 73	2	24	0 048	-0 5158	-
Na	81 00	109 58	2	24	-1 668	0 0696	III
Hardness	232 50	231 04	2	24	0 043	0 5152	-
Sub-surface water, Bhadar valley							
pH	8.08	8 28	3	16	-1 095	0 1768	III
EC	1793.60	2369 15	3	16	-1.060	0 1648	III
TSS	46 80	197 91	3	16	-0 835	0 2084	III
Cl	233 11	365.87	3	16	-1 246	0 1264	III
SO_4	-	-	-	-	-	-	-
HCO_3	218.78	363 92	3	16	-2 215	0 0244	II
Ca	209 41	186 58	3	16	0.390	0 6449	-
Na	78 14	222.31	3	16	-2.574	0 0099	I
Hardness	521 67	477 66	3	16	0 305	0 6150	-
Surface water , coastal area							
pH	8 18	8 08	2	9	0 263	0 5820	-
EC	984 12	2150 75	2	9	-1 265	0 1187	III
TSS	15.80	57 11	2	9	-0.922	0 1916	III
Cl	145 55	394 05	2	8	-1 293	0 1160	III
SO_4	4 80	178 67	2	9	-1 557	0 0790	III
HCO_3	157 71	191 05	2	9	-1 757	0 0584	III
Ca	44 17	131.46	2	9	-2.011	0 0421	II
Na	111 32	491 81	2	9	-1 244	0 1243	III
Hardness	110 00	1080 00	2	9	-1.279	0.1184	III
Sub-surface water, coastal area							
pH	8 26	7 70	2	12	1.630	0.8249	-
EC	2017 80	11337 44	2	12	-2 379	0 0174	II
TSS	12.60	25 70	2	12	-1 292	0 1127	III
Cl	296 42	1852 78	2	11	-3 891	0 0029	I
SO_4	79 20	407 20	2	12	-3 170	0 0252	I
HCO_3	308 38	268 98	2	12	0 394	0 6196	-
Ca	100 37	499 42	2	12	-4 675	0 0003	I
Na	231 35	861 06	2	12	-3 287	0 0407	II
Hardness	250 00	1244 17	2	12	-4 675	0 0003	I

Table 5.12 : Statistical analyses of pre and post monsoon water samples

Surface water Bhadar valley							
Variables	Mean		Observation		t-stat	P(T≥t one tail)	Significance
	Pre	Post	Pre	Post			
pH	8 17	8.27	26	24	-1 0036	0 8397	IV
EC	1984 03	1459.83	26	24	1 9874	0.0268	II
TSS	61.83	25.21	26	24	1 5232	0 0686	III
Cl	222.28	153 91	26	24	2 6625	0, 054	III
SO_4	121.85	37 40	26	24	2 0749	0.0214	II
HCO_3	322 57	235.79	26	24	2 3550	0.0114	II
Hardness	248.85	231.04	26	24	0.7211	0.2373	III
Ca	103.29	92 73	26	24	1 1501	0.1286	III
Na	224 65	109 58	26	24	2 8487	0 0038	I

Sub-surface water Bhadar valley

Variables	Mean		Observation		t-stat	P(T≥t one tail)	Significance
	Pre	Post	Pre	Post			
pH	8.10	8 28	28	16	-1 9369	0 9701	IV
EC	1956 36	2369 15	28	16	-1 0154	0 8402	IV
TSS	12.64	197.91	28	16	-1 0277	0 8398	IV
Cl	231 13	365 87	28	16	-1 6978	0.9475	IV
SO_4	154 45	86 55	28	16	1 4521	0.0769	III
HCO_3	304 53	363 92	28	16	-1 0046	0 8370	IV
Hardness	300 53	477 65	28	16	-1 8085	0 9564	IV
Ca	120 64	186.58	28	16	-1.6276	0 9395	IV
Na	180.65	222 31	28	16	-0.6466	0 7386	IV

Surface water Coastal area

Variables	Mean		Observation		t-stat	P(T≥t one tail)	Significance
	Pre	Post	Pre	Post			
pH	7.69	8 08	7	9	-2.5423	0 9863	IV
EC	23657 10	2150 75	7	9	2.4707	0.0242	II
TSS	339.28	57 11	7	9	1 2030	0 1371	III
Cl	3450 01	394 05	7	9	2 0114	0 0502	III
SO_4	431 31	178 67	7	9	1 6297	0 0627	III
HCO_3	185.85	191.05	7	9	-0.2097	0.5815	IV
Hardness	3330 00	1080.00	7	9	1 0947	0 1528	III
Ca	1337.37	131 46	7	9	1 5694	0.0838	III
Na	1878 27	491 81	7	9	1.7677	0 0575	III

Sub-surface water Coastal area

Variables	Mean		Observation		t-stat	P(T≥t one tail)	Significance
	Pre	Post	Pre	Post			
pH	8.00	7.70	15	12	2.2616	0.0163	II
EC	10928 02	11337 44	15	12	-0 0931	0 5366	IV
TSS	48 55	25 70	15	12	1 4823	0 0756	III
Cl	1793 22	1852 78	15	11	-0 1296	0 5510	IV
SO_4	313 28	407 20	15	12	-1 2290	0.8826	IV
HCO_3	235 53	268.98	15	12	-0 7008	0 7548	IV
Hardness	1012 33	1244 17	15	12	-0 8490	0 7977	IV

Table 5.13 : Trace elements of control points and point source.

HIGH LANDS													
Stations	Fe	Mn	Zn	Ni	Cr	Sr	Al	B	Cd	Cu	Pb	Co	F
pre-monsoon surface water													
Sultanpur bridge	<0 001	<0 001	0 012	<0 001	<0 001	2 133	<0.001	<0 001	0 076	0 047	1 010	0 391	1 43
Post monsoon surface water													
Sultanpur bridge	0 067	<0.001	0 016	<0 001	<0 001		<0 001	<0 001	0 085	0 037	0 662	0 446	2.14
Pre-monsoon sub-surface water													
Khirasara	0 019	<0 001	0 012	<0 001	<0 001	0 948	<0 001	<0 001	0 079	0 072	0 964	0 390	0 33
Post monsoon sub-surface water													
Khirasara	<0 001	<0 001	0 027	<0 001	<0 001		<0 001	<0 001	0 081	0 034	0 661	0 512	1 82

COASTAL AREA													
Pre-monsoon sub-surface water													
Paswali	0 037	<0 001	0 004	<0 001	0 021	-	<0 001	<0 001	0 074	0 023	1 045	0 647	0 00
Post-monsoon sub-surface water													
Paswali	<0 001	<0 001	0 004	<0 001	<0 001	-	<0 001	<0 001	0 065	0 068	0.866	0 335	0 00

PONT SOURCE													
Pre-monsoon													
Derdi	0 553	<0 001	0 022	<0 001	0 090	0 611	<0 001	<0 001	0 092	0 164	1 092	0 724	1.11
Jeptur	0 123	0 024	0 048	<0 001	<0 001	0 840	<0 001	<0 001	0 085	0 179	1 159	0 652	1.04
Panchpipla	0 046	<0 001	0 021	<0 001	<0 001	-	<0 001	<0 001	0 120	0.248	1 160	1.114	0 00
Lunagiri	0 094	<0.001	0 064	<0 001	<0.001	-	<0 001	<0 001	0 102	0 095	1 141	1 141	0 00
Post- monsoon													
Derdi	0 077	<0 001	0 018	0 021	<0 001	-	<0 001	<0 001	0 099	0 113	0 818	0 782	0 00
Jeptur	0 409	0 052	0 095	0 030	<0 001	-	<0 001	<0 001	0 102	0 280	1 063	0 390	0.00
Panchpipla	0 022	0.021	0 170	0 043	<0 001	-	<0 001	<0 001	0 081	0.060	0 657	0 362	2 15
Lunagiri	0 896	0 066	0.051	0 076	<0 001	-	<0 001	<0 001	0 086	0 041	0 290	0 587	0.00

Table 5.14 : Trace elements in the pre-monsoon water samples

Station	Fe	Mn	Zn	Ni	Cr	Sr	Al	B	Cd	Cu	Pb	Co	F
Surface water Bhadar valleys													
Galoliya Nadi	0 041	0.002	0 037	<0 001	<0 001	1 795	<0 001	<0 001	0.085	0 089	0 986	0 659	0 47
Jetpur	<0 001	<0 001	0 001	<0 001	0 006	0 589	<0 01	<0 001	0 124	0 119	1 023	0 832	1 56
S of Keralı	0 050	<0.001	<0 001	<0 001	<0 001	3 226	<0 001	<0 001	0 075	0 067	0 936	0 748	0 93
Vegdı	<0 001	<0.001	0 008	<0 001	<0 001	3 290	<0 001	<0 001	0 098	0 053	0 823	0.793	0 54
Bhukı	<0 001	<0.001	0 005	<0 001	<0 001	2 634	<0 001	<0 001	0 081	0 031	0 838	0 541	0 70
Dhorajı	0 016	<0 001	<0 031	<0 001	<0 001	2 674	<0 001	<0 001	0 065	0 044	0 761	0 445	1 31
S of Dhumiyani	0 001	<0 001	0 002	<0 001	<0 001	2 642	<0 001	<0 001	0.083	0 037	0 753	0 471	4.50
Upleta	<0 001	<0 001	0 015	<0 001	<0 001	2 660	<0 001	<0 001	0 063	0 037	0 721	0 463	1 33
S of Isra	<0 001	<0 001	0 013	<0 001	<0 001	2 447	<0 001	<0 001	0 114	0 030	0 693	0 411	2 14
S of Chauta	<0 001	<0.001	0 014	<0 001	<0 001	2 623	<0 001	<0 001	0 076	0 031	0 474	0 296	-
Sub-surface Bhadar valley													
Jetpur	<0 001	<0 001	0 008	<0 001	<0 001	1 293	<0 001	<0 001	0 050	0 037	0.855	0 461	9 10
Panchpıpla	<0 001	<0 001	0 001	<0 001	<0 001	1 963	<0 001	<0 001	0 073	0 053	0 885	0 435	2 76
Lunagırı	<0 001	<0 001	0 005	<0 001	<0 001	-	<0 001	<0 001	0 098	0 053	1 010	0 579	0 00
Vegdı	0 039	<0 001	0 008	<0 001	<0 001	-	<0 001	<0 001	0 108	0 060	1 036	0 604	0 00
Bhukı	<0 001	<0.001	0 001	<0 001	<0 001	6 102	<0 001	<0 001	0 088	0 031	0 842	0 462	0 93
Dhorajı	0 031	<0 001	<0 001	<0 001	<0 001	2.042	<0.001	<0 001	0 038	0 025	0 444	0 310	0 07
Dhumiyanı	0 032	<0 001	0 009	<0 001	0 041	2 923	<0 001	<0 001	0 054	0 036	0 814	0 251	0 14
Upleta	0 039	<0 001	0 011	<0 001	0 029	-	<0 001	<0 001	0 111	0 024	1 077	0.453	0 00
Isara	0 053	<0.001	0 007	<0 001	0 027	-	<0 001	<0 001	0 125	0 044	1.082	0.356	0.00
Ganod	0 004	<0.001	0 007	<0 001	0 004	8 186	<0 001	<0 001	0 119	0 027	0 874	0 415	1.43
Surface Coastal area													
Segrs	0 048	<0 001	0 040	<0 001	<0 001	-	<0 001	<0 001	0.107	0 027	1 163	0 503	2 10
Garej	0 021	<0 001	0 011	<0 001	<0 001	1 528	<0 001	<0.001	0 083	0 034	0 466	0 235	1 65
Navıbandar	0 033	<0.001	0 013	<0 001	0 006	4 039	<0 001	<0 001	0.121	0 032	0 715	0 423	8 12
Subsurface coatal area													
Gosa	0 010	<0 001	0 026	<0 001	<0 001	-	<0 001	<0 001	0 062	0 025	0 806	0 499	0 00
Mahira	0 020	<0 001	0 009	<0 001	<0 001	-	<0 001	<0 001	0 048	0 033	1 102	0 323	0 00
Nedhna	0 048	<0 001	0 004	<0 001	<0.001	-	<0 001	<0 001	0 113	0 040	1 049	0 586	0 00

All values expressed in mg/l

Table 5.15 : Trace elements in the post-monsoon water samples.

Stations	Fe	Mn	Zn	Ni	Cr	Al	B	Cd	Cu	Pb	Co	F
Surface water Bhadar valley												
Galoliya Nadi	<0 001	<0 001	0 016	<0 001	<0 001	<0 001	<0 001	0 084	0 032	0.535	0 599	1 83
Jetpur	2 009	<0 001	0 019	0 045	<0 001	<0 001	<0 001	0.075	0 048	0 753	0 352	0 00
S of Kerali	<0.001	0 016	0 016	<0 001	<0 01	<0 001	<0 001	0 071	0.050	0 677	0 336	1 96
Vegdi	<0 001	0 008	0 026	<0 001	<0 001	<0 001	<0 00	0 080	0 055	0 668	0 341	0 00
Bhuki	<0.001	0 004	0 028	0 020	<0 001	<0 001	<0 001	0 070	0 054	0 648	0 300	0 00
Dhoraji	<0 001	0 004	0 030	<0.001	<0 001	<0 001	<0 001	0 068	0 050	0 680	0 064	2 06
S of Dhumiyani	<0 001	<0 001	0 030	0 023	<0 001	<0 001	<0 001	0 143	0 047	0 684	0 363	0 00
Upleta	<0 001	<0 001	0 026	0 002	<0 001	<0 001	<0 001	0 058	0.049	0 889	0 281	2 04
S of Isra	<0 001	<0 001	0 033	0.000	<0.001	<0 001	<0 001	0 057	0 048	0 849	0 238	2 28
S of Chauta	<0 001	0 006	0 029	0 042	<0 001	<0 001	<0 001	0 078	0 052	0 938	0 280	2 51
Sub-surface water Bhadar valley												
Panchpipla	0 309	0 015	0 010	0 023	<0 001	<0 001	<0.001	0 089	0 041	0 627	0 220	0 00
Lunagiri	<0 001	0 011	0 047	0 004	<0 001	<0 001	<0 001	0 086	0 051	0 694	0 255	0 00
Vegdi	<0 001	0 003	-	-	<0 001	<0 001	<0 001	0 088	0.057	0 622	0 267	0 00
Bhuki	<0 001	0 006	0 030	<0 001	<0 001	<0 001	<0 001	0 056	0 046	0.609	0 392	0 00
Upleta	<0 001	<0 001	0 012	0 048	<0 001	<0 001	<0 001	0 065	0 052	0 915	0 277	0 00
Ganod	<0 001	<0 001	0 015	0 028	<0 001	<0 001	<0 001	0 007	0 050	0 933	0 295	0 00
Surface water coastal area												
Segras	<0 001	<0 001	0 022	0 003	<0 001	<0 001	0 001	0 129	0 053	0 877	0 353	2 24
Bobdi nadi	<0 001	0 005	0 007	<0 001	<0.001	<0 001	<0 001	0 100	0.084	1.299	0 296	0 00
Garej	<0 001	<0 001	0 020	0 050	<0 001	<0 001	<0 001	0 095	0 048	0 965	0 337	0 00
Navibandar	<0 001	<0 001	0 031	0 046	<0 001	<0 001	<0 001	0 086	0.053	0 976	0 197	2 88
Sub-surface water coatal area												
Gosa	<0.001	<0.01	0 009	<0 001	<0 001	<0 001	<0.001	0 133	0.048	1 134	0.350	0 00
Mahira	<0 001	0.009	0 012	<0.001	<0 001	<0 001	<0 001	0 139	0 055	1 189	0 335	0 00
Nedhna	<0 001	<0.001	0 000	<0.001	<0.001	<0 001	<0 001	0 079	0 048	0 972	0.194	0 00

All values expressed in mg/l

DISCUSSION

The field observations followed by the analytical results of the surface and sub-surface water of the Bhadar basin clearly point to the effect of dye industrial effluents on the water quality. The dyes used (for details refer Compliment-A), among which Ramazol is the chief one, contain heavy metals in the dyeing and printing units. Afterwards use of various salts like sodium chloride, sodium sulphide, sodium hydrosulphite, sodium perborate, potassium dichromate and copper sulphate in the washing and processing units have led to the increase in concentration of some other elements. These salts and dyes are also responsible for the presence of major cations and anions, which are also reflected in the EC and TDS values.

The alkalinity of the water is mainly on account of hydroxyl, carbonate and bicarbonate ions (Sawyer et al., 1994). In the Bhadar water samples, the carbonates and bicarbonates dominate over the hydroxyl ions. Between the former two, bicarbonates are more dominant. The higher concentration of major cations and anions, very much reflected in the EC and TDS values, in the surface and sub-surface water in the coastal area, can be attributed to saline water ingression.

Data of trace element analyses reflects higher values when compared with the WHO, ICMR standards. However, the control and non-control have less variation except the samples which are nearer to point source, which have higher values. Apart from the dye industrial contamination, it is conspicuously noted that in the surface water there is a drastic increase in the flourides. This is very critical, and it is essentially on account of felsic rock sources which are seen occurring in the Alech hills and its neighborhood.

Statistical analyses reveal that the mean concentration of the variables is higher in the non-control than in the control for the surface and sub-surface water of the pre- and post monsoon seasons. This amply points to the effect of dye industrial effluents in Bhadar valley proper and saline water ingression in the coastal areas. The significance level of the pre and post monsoons non-control points with their respective control reveals that during the post-monsoon, the water quality improves, which may be on account of dilution factor

Pre and post monsoon samples of non-control stations reveal that pre-monsoon surface water have more chemical constituents than the post-monsoon. This may be on account of dilution with rain water. On the other hand, in the sub-surface water, the mean of individual parameters is less in the pre-monsoon than in the post-monsoon, which is also reflected from the negative t-test value. This is due to the recharge factor.