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Nemerow's Pollution Index: For Ground Water Quality Assessment

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ABSTRACT

The present study was intended to assess the ground water quality for drinking purpose and to determine principal pollutants of ground water through Nemerow's Pollution Index (NPI) in Bassi Tehsil of district Jaipur, Rajasthan, India. For this ground water samples from 71 sampling sites of 50 villages of study area were collected from tube wells and hand pumps of varying depths in pre and post monsoon seasons and analyzed for ten physico-chemical parameters namely pH, total alkalinity, total hardness, calcium, magnesium, chloride, nitrate, fluoride, total dissolved solid and electrical conductivity. Analysis of results showed that almost all parameters were exceeding the permissible limits prescribed by BIS, ICMR and WHO. According to NPI values the observed principal pollutants (pollution causing parameters) in the present study are total alkalinity, chloride, fluoride, nitrate, total dissolved solids and electrical conductivity in both pre and post monsoon seasons.

1. Introduction

"Water is life's matter and matrix, mother and medium. There is no life without water". Potable safe water is absolutely essential and is the basic need of all human beings on the earth. Due to rapid industrialization and subsequent contamination of surface and ground water sources, water conservation and water quality management has now a day's assumed a very complex shape. Attention on contamination and its management has become a need of the hour, because of its far reaching impact on human health.

In Rajasthan water is not only saline but it also contain many dissolved substances, due to which water is not suitable for drinking. These substances have either the toxic effects on the consumer or have long terms indirect effects [1-3]. Other than salinity, presence of many metal ions, chloride, sulphate, nitrate and fluoride are the major factors of the water quality, which influence badly the human health [4].

All the 33 districts of Rajasthan have been declared as fluorososis prone areas. The worst are- Nagaur, Jaipur, Sikar, Jodhpur, Barmer, Ajmer, Sirohi, Jhunjhunu, Churu, Bikaner, Ganganagar etc. [5, 6]. Nitrate is also one of the most common groundwater contaminants in Rajasthan. Ajmer, Alwar, Banaswara, Baran, Barmer, Bundi, Bharatpur, Bhilwara, Bikaner, Chittaurgarh, Churu, Dausa, Dhaulpur, Dungarpur, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jalor, Jhalawar, Jhunjhunun, Jodhpur, Karauli, Kota, Nagaur, Pali, Partapgarh, Rajsamand, Sirohi, Sikar, Sawai Madhopur, Tonk, Udaipur districts have been reported nitrate concentration more than 45 mg/L [7].

In Amer, Bassi, Chomu, Jamwa Ramgarh, Kotputali, Shahpura and Virat Nagar tehsils of Jaipur district there is the problem of high fluoride and nitrate concentrations in groundwater [8].

For the assessment of water quality several indices have been developed and are in usage from time to time. In the present study Nemerow's Pollution Index has been adopted to assess the status of existing water quality and to identify the physico-chemical parameters causing pollution. Nemerow's pollution index (NPI) is a simplified pollution index introduced by Neme [9] which is also known as Raw's pollution index. NPI provides information about extent of pollution for a particular water quality parameter with reference to its standard value. By calculating and analyzing the NPI values of water quality parameters for a region, principal pollutants of that region can be identified; which is a vital information regarding deteriorating water quality of the area and also for the improvement of water quality in the area..

2. Experimental Methods

2.1 Study Area

Rajasthan is known as "the land of king" and it is the largest state of the republic of India in terms of geographical spread. It is situated in the North- Western part of India having total area is around 3, 42, 239 sq.km. which represents 10.41% of total area of the country and population of 6.86 crores spread over in 44,672 villages, which is 5.67% of nations population but being just available 1% of the total water resources of the country. The state has extreme climatic and geographical condition and it suffers both the problems of quantity and quality of water [10, 11].

Jaipur, the capital of Rajasthan, has a total area of 11,117 sq. Km covering the 3.23% of the total area of the state, administered by 13 tehsils or sub-divisions. Our focused area of study is Bassi tehsil, out of the 13 tehsils of Jaipur district. The area of tehsil is 654.69 sq.km, located at 26^{0}96' N latitude and 75^{0}62'E longitude. In Bassi Tehsil there are 210 villages (famous for their leather footwear and Embroidery beading). In the study area there are no major surface water sources however; main sources of drinking water are open wells, hand pumps and bore wells [12-14].

In Bassi Tehsil 84 villages are reported having fluoride concentration more than 1.5 ppm, 78 villages are exhibiting nitrate concentration more than 45 ppm and 30 villages are having Electrical conductivity more than 3000 micromhos/cm [13, 15].

Review of literature reveals that very few studies have been made to scientifically investigate the ground water contamination of the study area. The present study aims to calculate the Nemerow's Pollution Index (NPI) in most rural habitations of Bassi Tehsil of Jaipur, Rajasthan, India in order to assess the suitability of ground water for human uses and to identify the principal pollutants of ground water in the study area; it also deals with the necessity of restoring the water quality.

2.2 Sample Collection

Ground water samples from a total of 71 sampling sites of 50 villages of Bassi Tehsil were collected in pre-cleaned and rinsed polyethene bottles of two litre capacity with necessary precautions [16]. The total water collection in the year of 2013 is divided in to two seasons, one is pre monsoon and another one is post monsoon. The sampling is carried out, during April 2013 for pre monsoon season and in September-October 2013 for post monsoon season from manually operated tube wells and hand pumps of varying depth.

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2.3 Physico-Chemical Analysis

All the samples were analyzed for the following Physico-chemical parameters; pH, Total Alkalinity (TA), Total Hardness (TH), Calcium hardness (CaH), Magnesium hardness (MgH), Chloride, Nitrate, Fluoride, Total Dissolved Solid (TDS) and Electrical Conductivity (EC). The analysis of water samples were out carried in accordance to standard analytical methods [17]. All the chemicals used were of AR grade and double distilled water used for preparation of solutions. Details of the analysis methods are summarized in Table 1.

2.4 Nemerow's Pollution Index (NPI) Calculation

NPI is calculated with the help of following equation,

$$\text{NPI} = \frac{Ci}{Li}$$

Where, Ci - Observed concentration of i^{th} parameter; Li - Permissible limit of i^{th} parameter.

Each value of NPI shows the relative pollution contributed by single parameter, It should be less than or equal to one. NPI values exceeding 1.0 indicate the presence of impurity in water [9, 18, 19].

Table 1 Parameters and methods employed in the physicochemical examination of water samples

S.No.	Parameters	Unit	Method Employed
1.	pH	-	Digital pH-meter
2.	Total Alkalinity	mg/L	Titrimetric method (with H_2SO_4)
3.	Total Hardness (as $CaCO_3$)	mg/L	Titrimetric method (with EDTA)
4.	Ca Hardness (as $CaCO_3$)	mg/L	Titrimetric method
5.	Mg Hardness (as $CaCO_3$)	mg/L	Titrimetric method
6.	Chloride (as Cl^-)	mg/L	Titrimetric method (with $AgNO_3$)
7.	Nitrate (as NO_3^-)	mg/L	Spectrophotometric method
8.	Fluoride (as F^-)	mg/L	Ion Selective Electrode
9.	Total Dissolved Solids	mg/L	Digital TDS-meter
10.	Electrical Conductivity	µs/cm	Digital Conductivity-meter

3. Results and Discussion

3.1 Physico-Chemical Parameters

The respective values of all observed water quality parameters of groundwater samples in pre and post monsoon seasons are illustrated in Tables 2 and 4 respectively. Statistical Parameters of groundwater samples of study area in both seasons are summarized in Tables 3 and 5.

3.2 Quality Assessment using NPI

Water quality parameters mentioned in Tables 2 and 4 are considered for calculating the NPI values using the above mentioned method. Li values for different water quality parameters are indicated in Table 6. NPI value exceeding 1.0 indicate the presence of impurity in water and hence require some treatment prior to use.

As per Nemerow's Pollution Index (NPI), the pollution creating parameters at each station is calculated and presented in Tables 7 and 8. These tables show the results of NPI. The predominant pollutants in the study area at each station are identified and presented in Tables 9 and 10. The detailed explanation of each parameter in the study is given below.

3.2.1 pH

In pre-monsoon season all seventy one sampling sites are found to have NPI values less than one while in post- monsoon season out of the seventy one samples two sampling sites *Akhepura (TW)* and *Jhajhwar (TW)* are having the NPI values greater than one. Alkaline state of pH might be due to the chemical buffering and release of bicarbonate and carbonate ions or salts [20].

3.2.2 Total Alkalinity

Alkalinity is the sum total of components in the water that tend to elevate the pH to the alkaline side of neutrality. Commonly occurring materials in water that increase alkalinity are carbonate, phosphates and hydroxides. Limestone bedrock and thick deposits of glacial till are good sources of carbonate buffering [21]. In our study, the NPI values are very much higher for alkalinity in both pre and post monsoon seasons. In pre monsoon there is only one sample having NPI value less than one – *Tunga* and in post monsoon all samples are found to have NPI value greater than one.

3.2.3 Total Hardness

The total hardness is an important parameter of water quality whether it is to be used for domestic, industrial or agricultural purposes. It is mainly due to the presence of excess of Ca, Mg salts. The carbonate and bicarbonate concentrations are useful to determine the temporary hardness and alkalinity. It is an indicator for hydrogeology and aesthetic quality of groundwater [22]. Out of the seventy one samples 23 samples are showing the NPI values greater than one in pre and post monsoon seasons both and indicate pollution.

3.2.4 Calcium

The samples 14 and 10 have NPI values exceeding one in pre and post monsoon seasons respectively. Calcium is also essential for healthy growth of bones and plays important role in biological systems. Calcium is most abundant ions in fresh water and is important in shell construction, bone building and plant precipitation of lime [23].

3.2.5 Magnesium

Magnesium is a beneficial metal but is toxic at higher concentration. Magnesium hardness associated with sulphate ion has laxative effect on persons not accustomed to it [24]. Out of the seventy one samples 32 and 38 samples are calculated having NPI values greater than one in pre and post monsoon seasons respectively.

3.2.6 Chloride

In pre monsoon 20 and in post monsoon 15 samples have NPI values more than one and represent pollution with reference to this parameter. All type of natural and raw water contains chlorides. It comes from activities carried out in agricultural area, industrial activities and from chloride stones. Its concentration is also high because of human activities.

3.2.7 Nitrate

In pre 12 samples and in post monsoon seasons 11 samples are representing NPI values greater than one. The high nitrogen content is an indicator of organic pollution. It may results from the added nitrogenous fertilizers, decay of dead plants and animals, animal urine, or feces. They are all oxidized to nitrate by natural process and hence nitrogen is present in the form of nitrate. The increase in one or all the above factors is responsible for the increase of nitrate content. The ground water contamination is due to the leaching of nitrate present on the surface with percolating water [25, 26].

3.2.8 Fluoride

The presence of fluoride in ground water can be attributed to geological reasons [27]. Fluoride exists naturally in water sources. Generally most groundwater sources have higher fluoride concentrations than surface water. The main source of fluoride in groundwater is basically from the rocks minerals. The concentration of fluoride in water sources depends upon various factors like source of water, solvent action of water on the rocks and soil of earth's crust, porosity of the rocks or soil through which water passes, the speed with which water flows, the temperature of the interaction of the rock and water, the hydrogen and calcium ion concentration, amount of annual rainfall etc. [5, 6, 27, 28]. In our study, out of the seventy one samples 24 samples have NPI values exceeding one indicating the higher contamination level of fluoride in the study area.

3.2.9 Total Dissolved Solids

Total dissolved solids denote mainly the various kinds of minerals present in the water. TDS are compounds of inorganic salts (principally Ca^{+2}, Mg^{+2}, K^+, Na^+, HCO_3^-, Cl^- and SO_4^{2-}) and of small amounts of organic matter that are dissolved in water. Presence of high levels of TDS in water may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers and household appliances. Water with extremely low concentrations of TDS may also be unacceptable to consumers because of its flat, insipid taste. It is also often corrosive to water supply system [29]. In the present study only for 2 and 4 sampling sites the value of NPI is less than one in pre and post monsoon season, respectively, indicating the fresh water quality.

3.2.10 Electrical Conductivity

The importance of EC is its measure of salinity; which greatly affects the taste. Thus EC has a significant impact on determining the potability of water. EC is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water [30]. Conductivity of water depends upon the concentration of ions, its nutrient status and variation in dissolve solid content. In our entire study only one sample in pre monsoon season namely *Tunga* has NPI value less than one rest all are found to have very large NPI values in comparison to one indicating the presence of higher amounts of total dissolved solids.

Table 2 Physico-chemical characteristics of groundwater samples – premonsoon season

S.No.	Village	Source	Sample No.	pH	TA	TH	CaH	Ca^{+2} ions	MgH	Mg^{+2} ions	Cl^-	NO_3^-	F^-	TDS	EC
1	Akhepura	HP	S1	7.9	411	529	237	94.8	292	70.95	400	56	0.71	2216	3165
		TW	S2	8.4	305	115	43	17.2	72	17.49	31	15	1.44	778	1111
2	Anantpura	HP	S3	7.9	748	360	151	60.4	209	50.78	278	22	0.37	2100	3000
		TW	S4	8.3	462	161	67	26.8	94	22.84	176	18	1.8	1470	2100
3	Banskho	HP	S5	7.5	651	516	172	68.8	344	83.59	137	28	2.12	1696	2422
		TW	S6	8.4	396	105	40	16	65	15.79	123	12	1.99	1298	1855
4	Barala	HP	S7	7.5	586	192	78	31.2	114	27.7	333	78	2.05	2146	3065
5	Bassi	HP	S8	8.4	258	158	64	25.6	94	22.84	202	86	1.14	1590	2271
		TW	S9	7.8	333	156	67	26.8	89	21.62	163	44	0.79	1191	1701
6	Benada	HP	S10	7.6	435	732	336	134.4	396	96.22	315	131	0.93	1740	2486
7	Bharampur	HP	S11	7.7	368	188	78	31.2	110	26.73	176	20	0.42	920	1314
8	Chainpuriya	HP	S12	7.7	562	115	46	18.4	69	16.76	80	12	1.3	1034	1477
9	Chapariya	HP	S13	7.7	426	163	70	28	93	22.59	60	70	1.13	760	1085
10	Charangarh	HP	S14	7.4	243	264	121	48.4	143	34.74	33	29	0.71	792	1131
11	Chatarpura	HP	S15	7.6	707	112	45	18	67	16.28	65	19	4.67	1200	1714
12	Danau Kalan	HP	S16	8.2	582	46	22	8.8	24	5.83	20	22	1.4	1055	1507
13	Danau Khurd	HP	S17	7.7	409	568	206	82.4	362	87.96	484	8	0.9	2644	3777
		TW	S18	8.2	458	284	121	48.4	163	39.6	140	22	2.9	1680	2400
14	Garh	HP	S19	8.1	651	108	44	17.6	64	15.55	361	118	1	1962	2803
15	Ghasipura	HP	S20	8.4	344	88	32	12.8	56	13.6	20	38	0.03	847	1210
		TW	S21	8.3	766	74	33	13.2	41	9.96	51	26	11.4	1613	2304
16	Ghata	HP	S22	7.1	402	437	198	79.2	239	58.07	601	11	0.86	2593	3704
		TW	S23	7.3	467	632	297	118.8	335	81.4	468	14	0.7	2171	3101
17	Gudha Meena	HP	S24	7.8	423	160	66	26.4	94	22.84	23	18	0.27	980	1400
18	Gumanpura	HP	S25	7.8	460	317	128	51.2	189	45.92	380	16	0.88	2310	3300
		TW	S26	7.9	595	528	238	95.2	290	70.47	259	72	1.4	1764	2520
19	Gwalini	HP	S27	7.9	520	374	171	68.4	203	49.32	22	8	1.8	1333	1904
20	Hans Mahal	HP	S28	7.6	157	424	187	74.8	237	57.59	220	7	0.32	1182	1688
21	Hanumanpura	HP	S29	7.7	552	123	51	20.4	72	17.49	83	27	0.8	967	1381
		TW	S30	8.2	784	67	23	9.2	44	10.69	95	24	12.5	1473	2104
22	Jhajhwar	HP	S31	7.4	523	668	283	113.2	385	93.55	1430	58	0.41	4235	6050
		TW	S32	8.4	254	109	45	18	64	15.55	107	45	0.8	980	1400
23	Jhar	HP	S33	7.9	412	233	102	40.8	131	31.83	44	37	0.65	960	1371
24	Kalyanpura	HP	S34	8.5	527	89	36	14.4	53	12.87	28	34	1.3	1122	1603
		TW	S35	8.2	530	65	22	8.8	43	10.44	41	16	1.8	1190	1700
25	Kaneta	HP	S36	7.8	286	364	144	57.6	220	53.46	1424	6	0.11	4762	6802
		TW	S37	8.4	564	77	34	13.6	43	10.44	40	14	0.7	1050	1500
26	Kaneti	HP	S38	7.5	586	867	322	128.8	545	132.43	1075	236	1.06	4890	6985
27	Kanota	HP	S39	8.3	409	203	90	36	113	27.45	296	33	0.62	1835	2621
		TW	S40	8.4	741	91	36	14.4	55	13.36	225	8	1.7	1983	2833
28	Kashipura	HP	S41	7.5	695	105	40	16	65	15.79	90	21	3.2	1305	1864
29	Keshopura	HP	S42	7.6	555	350	140	56	210	51.03	644	5	0.75	2520	3600
30	Kuthada Kalan	HP	S43	7.1	233	66	25	10	41	9.96	20	22	0.77	709	1013
31	Lalgarh	HP	S44	7.6	510	284	122	48.8	162	39.36	230	15	1.42	1240	1771
32	Mundali	HP	S45	7.7	482	117	46	18.4	71	17.25	55	12	4.2	1321	1887
		TW	S46	8.2	734	90	34	13.6	56	13.6	152	26	3.38	1682	2404
33	Nagal Karna	HP	S47	7.4	371	154	57	22.8	97	23.57	60	11	4.35	1295	1850
		TW	S48	8.1	795	73	32	12.8	41	9.96	80	26	5.9	1610	2300
34	Parasoli	HP	S49	7.7	412	774	397	158.8	377	150.8	320	2	1.17	2146	3065
		TW	S50	8.4	464	78	35	14	43	10.44	60	23	2.2	1050	1500
35	Parempura	HP	S51	7.8	431	641	283	113.2	358	86.99	444	18	1.15	3474	4963
36	Patan	HP	S52	7.1	655	622	264	105.6	358	86.99	885	10	0.52	3535	5050
37	Peepalabai	HP	S53	7.2	160	374	209	83.6	165	40.09	266	82	1.84	1680	2400
		TW	S54	8.2	435	400	185	74	215	52.24	65	26	8.95	1505	2150
38	Peipura	HP	S55	7.8	532	267	118	47.2	149	36.2	250	11	1.35	1750	2500
		TW	S56	8.4	435	110	40	16	70	17.01	35	28	1.5	875	1250
39	Rajwas	HP	S57	7.6	648	463	205	82	258	62.69	551	52	1.33	2306	3295
40	Ramser	HP	S58	7.3	520	254	103	41.2	151	36.69	60	18	3.8	1050	1500
		TW	S59	8.4	464	118	44	17.6	74	17.98	50	25	2	1053	1504
41	Ratanpura	HP	S60	7.9	532	299	135	54	164	39.85	80	32	1.02	1435	2050
		TW	S61	8.4	552	88	35	14	53	12.87	60	19	1.07	1129	1613
42	Roopura	HP	S62	7.5	263	107	42	16.8	65	15.79	130	24	1.44	1113	1590
		TW	S63	8.1	415	430	200	80	230	55.89	81	25	8.75	1610	2300
43	Sambhariya	HP	S64	7.4	314	232	96	38.4	136	33.04	58	14	0.07	356	508
44	Shankarpura	HP	S65	7.6	588	134	53	21.2	81	19.68	58	6	4.2	1028	1469
45	Siya Ka Bas	HP	S66	7.7	235	234	98	39.2	136	33.04	62	91	0.85	1225	1750

46	Tehda	HP	S67	8.2	276	145	62	24.8	83	20.16	221	20	1.4	1478	2111
47	Tekchandpura	HP	S68	7.8	328	306	133	53.2	173	42.03	40	14	0.2	563	804
48	Tilpatti	HP	S69	7.8	642	194	81	32.4	113	27.45	80	14	0.9	1280	1828
49	Todabhata	HP	S70	8.5	328	65	22	8.8	43	10.44	52	24	2	984	1405
50	Tunga	HP	S71	7.6	290	427	195	78	232	56.37	389	309	0.6	2245	3207

**Where- TA = Total Alkalinity, TH = Total Hardness, CaH = Calcium Hardness, MgH = Magnesium Hardness, Cl^- = Chloride, NO_3^- = Nitrate, F^- = Fluoride, TDS = Total Dissolved Solids, EC = Electrical Conductivity. All parameters are expressed in mg/L except pH and EC. EC is expressed in µmhos/cm.Ca^{+2} = Ca mg/L (as $CaCO_3$), Mg^{+2} = Mg mg/L (as $CaCO_3$)*

Table 3 Minimum, maximum and average characteristics of groundwater sampling stations – pre monsoon season

S.No.	Parameter	Minimum	Maximum	Average	Standard Deviation
1.	pH	7.1	8.5	7.86	0.39
2.	Total Alkalinity (mg/L)	36	795	469.47	162.55
3.	Total Harness (mg/L)	38	867	260.19	201.90
4.	Calcium Hardness (mg/L)	16	397	111.23	90.30
5.	Ca^{+2} Ions (mg/L)	6.4	158.8	44.49	36.12
6.	MagnesiumHardness (mg/L)	22	545	148.95	113.86
7.	Mg^{+2} Ions (mg/L)	5.34	150.8	37.02	30.14
8.	Chloride (mg/L)	15	1430	222.01	290.48
9.	Nitrate (mg/L)	2	236	32.16	35.64
10.	Fluoride (mg/L)	0.03	12.5	1.96	2.41
11.	TDS (mg/L)	63	4890	1589.88	899.48
12.	EC (µS/cm)	86	6985	2271.05	1285.04

Table 4 Physico-chemical characteristics of groundwater samples – post monsoon season

S.No.	Village	Source	Sample	pH	TA	TH	CaH	Ca^{+2} ions	MgH	Mg^{+2} ions	Cl^-	NO_3^-	F^-	TDS	EC
1	Akhepura	HP	S1	8.1	410	406	180	72	226	54.91	306	102	1.36	1581	2259
		TW	S2	8.6	294	82	32	12.8	50	12.15	22	21	1.94	616	880
2	Anantpura	HP	S3	7.7	607	284	122	48.8	162	39.36	194	15	0.85	1493	2132
		TW	S4	7.7	517	540	245	98	295	71.68	417	29	0.73	2074	2962
3	Banskho	HP	S5	7.8	580	478	173	69.2	305	74.11	193	31	0.92	1630	2328
		TW	S6	8.5	363	98	41	16.4	57	13.85	98	14	1.54	1207	1724
4	Barala	HP	S7	7.7	484	110	45	18	65	15.79	118	7	1.8	668	954
5	Bassi	HP	S8	7.6	459	161	68	27.2	93	22.59	171	94	0.81	1274	1820
		TW	S9	7.4	255	187	80	32	107	26	113	56	0.51	1356	1937
6	Benada	HP	S10	8.5	838	254	111	44.4	143	34.74	107	59	0.98	1612	2303
7	Bharampur	HP	S11	7.8	482	364	163	65.2	201	48.84	146	21	0.6	1044	1491
8	Chainpuriya	HP	S12	7.7	703	261	113	45.2	148	35.96	118	11	1	1206	1723
9	Chapariya	HP	S13	7.7	282	211	88	35.2	123	29.88	28	27	0.9	424	605
10	Charangarh	HP	S14	7.7	168	220	92	36.8	128	31.1	40	27	0.32	432	617
11	Chatarpura	HP	S15	7.6	698	147	63	25.2	84	20.41	60	18	2.6	956	1365
12	Danau Kalan	HP	S16	7.6	454	159	66	26.4	93	22.59	34	24	1.17	712	1018
13	Danau Khurd	HP	S17	7.2	312	660	237	94.8	423	102.8	103	106	0.45	910	1300
		TW	S18	7.8	382	337	151	60.4	186	45.19	84	29	2.6	1478	2111
14	Garh	HP	S19	7.8	422	777	392	156.8	385	93.55	355	94	1.02	1685	2407
15	Ghasipura	HP	S20	7.7	365	127	51	20.4	76	18.46	21	13	0.55	640	914
		TW	S21	7.9	817	92	37	14.8	55	13.36	54	19	11.9	1271	1816
16	Ghata	HP	S22	7.9	443	313	140	56	173	42.03	246	14	1.43	1414	2020
		TW	S23	7.7	514	501	217	86.8	284	69.01	367	17	0.96	1669	2384
17	Gudha Meena	HP	S24	7.6	403	199	88	35.2	111	26.97	20	19	0.4	642	917
18	Gumanpura	HP	S25	7.7	384	208	89	35.6	119	28.91	103	8	2	808	1154
		TW	S26	7.8	509	404	181	72.4	223	54.18	183	53	2.5	1205	1721
19	Gwalini	HP	S27	7.7	510	270	125	50	145	35.23	80	6	1.4	891	1273
20	Hans Mahal	HP	S28	7.6	476	1100	423	169.2	677	164.5	1455	20	2.08	5434	7763
21	Hanumanpura	HP	S29	7.1	560	316	144	57.6	172	41.79	507	95	1.6	2196	3137
		TW	S30	7.5	812	92	33	13.2	59	14.33	148	37	12.2	1837	2624
22	Jhajhwar	HP	S31	7.9	575	440	190	76	250	60.75	436	41	1.1	2204	3149
		TW	S32	8.6	278	76	31	12.4	45	10.93	154	38	1.08	647	924
23	Jhar	HP	S33	7.8	488	271	118	47.2	153	37.17	63	32	0.41	926	1322
24	Kalyanpura	HP	S34	7.8	256	307	134	53.6	173	42.03	30	18	0.8	487	696
		TW	S35	7.8	318	83	29	11.6	54	13.12	52	13	1.2	607	867
25	Kaneta	HP	S36	7.7	223	268	105	42	163	39.6	57	14	0.5	804	1148
		TW	S37	8.2	459	56	26	10.4	30	7.29	34	21	0.39	651	930
26	Kaneti	HP	S38	7.4	674	347	129	51.6	218	52.97	80	2	0.14	918	1312
27	Kanota	HP	S39	7.5	415	361	148	59.2	213	51.75	342	40	1.3	1436	2051
		TW	S40	7.8	689	134	61	24.4	73	17.73	266	11	2.3	1606	2294
28	Kashipura	HP	S41	7.6	411	161	64	25.6	97	23.57	86	19	1.35	910	1301
29	Keshopura	HP	S42	7.6	330	227	92	36.8	135	32.8	80	26	0.49	1333	1904
30	Kuthada Kalan	HP	S43	7.6	785	262	110	44	152	36.93	42	21	0.5	800	1142

31	Lalgarh	HP	S44	7.7	505	185	80	32	105	25.51	105	49	0.9	1042	1488
32	Mundali	HP	S45	7.8	600	106	42	16.8	64	15.55	92	21	5.6	1131	1616
		TW	S46	8.3	822	77	31	12.4	46	11.17	206	32	4.02	1951	2787
33	Nagal Karna	HP	S47	7.7	389	119	43	17.2	76	18.46	148	2	1.9	608	869
		TW	S48	8.5	859	53	21	8.4	32	7.77	112	19	3.25	822	1174
34	Parasoli	HP	S49	7.8	440	553	280	112	273	66.33	326	15	1.43	1322	1889
		TW	S50	8.5	516	48	22	8.8	26	6.31	56	34	1.8	693	990
35	Parempura	HP	S51	7.8	403	520	200	80	320	77.76	475	13	0.8	2880	4114
36	Patan	HP	S52	7.7	535	479	199	79.6	280	68.04	652	18	1.22	2468	3526
37	Peepalabai	HP	S53	7.8	206	228	123	49.2	105	25.51	58	25	0.5	408	583
		TW	S54	7.7	513	248	99	39.6	149	36.2	38	16	5.3	723	1033
38	Peipura	HP	S55	7.7	700	242	106	42.4	136	33.04	446	24	1.23	1946	2780
		TW	S56	8.2	504	97	34	13.6	63	15.3	47	41	1.3	1016	1451
39	Rajwas	HP	S57	7.6	704	428	183	73.2	245	59.53	320	27	1.3	2883	4118
40	Ramser	HP	S58	7.3	540	210	85	34	125	30.37	100	13	1.3	1040	1485
		TW	S59	8.3	483	89	27	10.8	62	15.06	66	21	1.06	924	1320
41	Ratanpura	HP	S60	7.8	860	260	113	45.2	147	35.72	193	8	1.13	1600	2286
		TW	S61	7.9	871	190	75	30	115	27.94	130	19	2.65	1440	2057
42	Roopura	HP	S62	7.8	353	243	110	44	133	32.31	60	30	1.4	722	1031
		TW	S63	8.4	511	627	283	113.2	344	83.59	58	28	8.49	1159	1656
43	Sambhariya	HP	S64	7.6	425	145	60	24	85	20.65	30	30	2.25	920	1314
44	Shankarpura	HP	S65	7.8	540	197	85	34	112	27.21	80	2	3.6	1125	1607
45	Siya Ka Bas	HP	S66	7.6	313	179	73	29.2	106	25.75	56	71	1.13	773	1104
46	Tehda	HP	S67	7.7	425	174	72	28.8	102	24.78	172	24	1.55	1140	1629
47	Tekchandpura	HP	S68	7.8	254	292	130	52	162	39.36	40	12	0.25	529	756
48	Tilpatti	HP	S69	7.8	633	366	153	61.2	213	51.75	114	22	0.76	1306	1867
49	Todabhata	HP	S70	7.8	550	129	54	21.6	75	18.22	63	20	1.8	1043	1490
50	Tunga	HP	S71	7.8	290	780	395	158	385	93.55	288	309	0.65	1604	2291

Table 5 Minimum, maximum and average characteristics of groundwater sampling stations – post monsoon season

S.No.	Parameter	Minimum	Maximum	Average	Standard Deviation
1.	pH	7.1	8.6	7.80	0.31
2.	Total Alkalinity (mg/L)	168	871	495.04	174.15
3.	Total Harness (mg/L)	48	1100	276.26	195.79
4.	Calcium Hardness (mg/L)	21	423	118.38	87.05
5.	Ca^{+2} Ions (mg/L)	8.4	169.2	47.35	34.82
6.	MagnesiumHardness (mg/L)	26	677	157.88	111.31
7.	Mg^{+2} Ions (mg/L)	6.31	164.51	38.36	27.05
8.	Chloride (mg/L)	20	1455	171.04	206.72
9.	Nitrate (mg/L)	2	309	32.77	40.60
10.	Fluoride (mg/L)	0.14	12.2	1.82	2.20
11.	TDS (mg/L)	408	5434	1252.28	746.36
12.	EC (µS/cm)	583	7763	1788.87	1066.23

Table 6 List of permissible value (Li) for water quality parameters in NPI

S. No.	Parameter	Permissible Value	Recommending Agency
1.	pH	8.5	BIS/ICMR/WHO
2.	Total Alkalinity	120 (mg/L)	ICMR/WHO
3.	Total Hardness	300 (mg/L)	BIS/ICMR
4.	Ca^{+2} Ions	75 (mg/L)	BIS/ICMR/WHO
5.	Mg^{+2} Ions	30 (mg/L)	BIS/ICMR/WHO
6.	Chloride	250 (mg/L)	BIS/ICMR
7.	Nitrate	45 (mg/L)	BIS/ICMR/WHO
8.	Fluoride	1.5 (mg/L)	BIS/ICMR/WHO
9.	Total Dissolved Solids	500 (mg/L)	BIS/ICMR/WHO
10.	Electrical Conductivity	300 (µS/cm)	ICMR/WHO

Table 7 Pollution causing parameters evaluated through Nemerow's pollution index (NPI) in pre monsoon season

S. No.	Village	Source	Sample	pH	TA	TH	Ca ions	Mg ions	Cl^-	NO_3^-	F^-	TDS	EC
				C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI
1	Akhepura	HP	S1	7.9 , (0.9)	411, (3.4)	529, (1.76)	94.8, (1.26)	70.95, (2.36)	400, (1.6)	56, (1.24)	0.71, (0.47)	2216, (4.4)	3165, (10.5)
		TW	S2	8.4, (0.9)	305, (2.5)	115, (0.38)	17.2, (0.23)	17.49, (0.58)	31, (0.12)	15, (0.33)	1.44, (0.96)	778, (1.55)	1111, (3.70)
2	Anantpura	HP	S3	7.9, (0.9)	748, (6.2)	360, (1.2)	60.4, (0.81)	50.78, (1.69)	278, (1.11)	22, (0.48)	0.37, (0.25)	2100, (4.2)	3000, (10.0)
		TW	S4	8.3, (0.9)	462, (3.85)	161, (0.53)	26.8, (0.35)	22.84, (0.76)	176, (0.70)	18, (0.4)	1.8, (1.2)	1470, (2.94)	2100, (7.0)
3	Banskho	HP	S5	7.5, (0.88)	651, (5.42)	516, (1.72)	68.8, (0.92)	83.59, (2.78)	137, (0.55)	28, (0.62)	2.12, (1.41)	1696, (3.39)	2422, (8.07)
		TW	S6	8.4, (0.98)	396, (3.3)	105, (0.35)	16, (0.21)	15.79, (0.52)	123, (0.49)	12, (0.26)	1.99, (1.33)	1298, (2.59)	1855, (6.18)
4	Barala	HP	S7	7.5, (0.88)	586, (4.88)	192, (0.64)	31.2, (0.42)	27.7, (0.92)	333, (1.33)	78, (1.73)	2.05, (1.36)	2146, (4.29)	3065, (10.21)
5	Bassi	HP	S8	8.4, (0.98)	258, (2.15)	158, (0.52)	25.6, (0.34)	22.84, (0.76)	202, (0.81)	86, (1.91)	1.14, (0.76)	1590, (3.18)	2271, (7.57)
		TW	S9	7.8, (0.91)	333, (2.77)	156, (0.52)	26.8, (0.36)	21.62, (0.72)	163, (0.65)	44, (0.97)	0.79, (0.53)	1191, (2.38)	1701, (5.69)
6	Benada	HP	S10	7.6, (0.89)	435, (3.63)	732, (2.44)	134.4, (1.79)	96.22, (3.21)	315, (1.26)	131, (0.52)	0.93, (0.62)	1740, (3.48)	2486, (8.28)
7	Bharampur	HP	S11	7.7, (0.90)	368, (3.06)	188, (0.63)	31.2, (0.42)	26.73, (0.89)	176, (0.70)	20, (0.44)	0.42, (0.28)	920, (1.84)	1314, (4.38)
8	Chainpuriya	HP	S12	7.7, (0.90)	562, (4.68)	115, (0.38)	18.4, (0.24)	16.76, (0.56)	80, (0.32)	12, (0.27)	1.3, (0.86)	1034, (2.06)	1477, (4.92)
9	Chapariya	HP	S13	7.7, (0.90)	426, (3.55)	163, (0.54)	28, (0.37)	22.59, (0.75)	60, (0.24)	70, (1.55)	1.13, (0.75)	760, (1.52)	1085, (3.61)
10	Charangarh	HP	S14	7.4, (0.87)	243, (2.02)	264, (0.88)	48.4, (0.65)	34.74, (1.15)	33, (0.13)	29, (0.64)	0.71, (0.47)	792, (1.58)	1131, (3.77)
11	Chatarpura	HP	S15	7.6, (0.89)	707, (5.89)	112, (0.37)	18, (0.24)	16.28, (0.22)	65, (0.26)	19, (0.42)	4.67, (3.11)	1200, (2.4)	1714, (5.71)
12	Danau Kalan	HP	S16	8.2, (0.96)	582, (4.85)	46, (0.15)	8.8, (0.18)	5.83, (0.19)	20, (0.08)	22, (0.48)	1.4, (0.93)	1055, (2.11)	1507, (5.02)
13	Danau Khurd	HP	S17	7.7, (0.90)	409, (3.41)	568, (1.89)	82.4, (1.09)	87.96, (2.93)	484, (1.94)	8, (0.17)	0.9, (0.6)	2644, (2.28)	3777, (12.59)
		TW	S18	8.2, (0.96)	458, (3.81)	284, (0.95)	48.4, (0.65)	39.6, (1.32)	140, (0.56)	22, (0.48)	2.9, (1.93)	1680, (3.36)	2400, (8.0)
14	Garh	HP	S19	8.1, (0.95)	651, (5.43)	108, (0.36)	17.6, (0.23)	15.55, (0.51)	361, (1.44)	118, (2.62)	1, (0.66)	1962, (3.92)	2803, (9.34)
15	Ghasipura	HP	S20	8.4, (0.98)	344, (2.87)	88, (0.29)	12.8, (0.17)	13.6, (0.45)	20, (0.08)	38, (0.84)	0.03, (0.02)	847, (1.69)	1210, (4.03)
		TW	S21	8.3, (0.97)	766, (6.38)	74, (0.25)	13.2, (0.17)	9.96, (0.33)	51, (0.20)	26, (0.58)	11.4, (7.6)	1613, (3.22)	2304, (7.68)
16	Ghata	HP	S22	7.1, (0.83)	402, (3.35)	437, (1.46)	79.2, (1.05)	58.07, (1.93)	601, (2.40)	11, (0.24)	0.86, (0.57)	2593, (5.18)	3704, (12.35)
		TW	S23	7.3, (0.85)	467, (3.89)	632, (2.11)	118.8, (1.58)	81.4, (2.71)	468, (1.87)	14, (0.31)	0.7, (0.46)	2171, (4.34)	3101, (10.34)
17	Gudha Meena	HP	S24	7.8, (0.91)	423, (3.52)	160, (0.53)	26.4, (0.35)	22.84, (0.76)	23, (0.09)	18, (0.4)	0.27, (0.18)	980, (1.96)	1400, (4.67)
18	Gumanpura	HP	S25	7.8, (0.91)	460, (3.83)	317, (1.06)	51.2, (0.68)	45.92, (1.53)	380, (1.52)	16, (0.35)	0.88, (0.59)	2310, (4.62)	3300, (11.0)
		TW	S26	7.9, (0.92)	595, (4.96)	528, (1.76)	95.2, (1.27)	70.47, (2.34)	259, (1.03)	72, (1.6)	1.4, (0.93)	1764, (3.52)	2520, (8.4)
19	Gwalini	HP	S27	7.9, (0.92)	520, (4.33)	374, (1.24)	68.4, (0.91)	49.32, (1.64)	22, (0.08)	8, (0.17)	1.8, (1.2)	1333, (2.66)	1904, (6.35)
20	Hans Mahal	HP	S28	7.6, (0.89)	157, (1.31)	424, (1.41)	74.8, (0.99)	57.59, (1.92)	220, (0.88)	7, (0.15)	0.32, (0.21)	1182, (2.36)	1688, (5.63)
21	Hanumanpura	HP	S29	7.7, (0.90)	552, (4.6)	123, (0.41)	20.4, (0.27)	17.49, (0.58)	83, (0.33)	27, (0.6)	0.8, (0.53)	967, (1.93)	1381, (4.60)
		TW	S30	8.2, (0.96)	784, (6.53)	67, (0.22)	9.2, (0.12)	10.69, (0.36)	95, (0.38)	24, (0.53)	12.5, (8.3)	1473, (2.94)	2104, (7.01)
22	Jhajhwar	HP	S31	7.4, (0.87)	523, (4.36)	668, (2.23)	113.2, (1.51)	93.55, (3.19)	1430, (5.72)	58, (1.29)	0.41, (0.27)	4235, (8.4)	6050, (20.17)
		TW	S32	8.4, (0.98)	254, (2.12)	109, (0.36)	18, (0.24)	15.55, (0.52)	107, (0.43)	45, (1.0)	0.8, (0.53)	980, (1.96)	1400, (4.67)
23	Jhar	HP	S33	7.9, (0.92)	412, (3.43)	233, (0.77)	40.8, (0.54)	31.83, (1.06)	44, (0.17)	37, (0.82)	0.65, (0.43)	960, (1.92)	1371, (4.57)
24	Kalyanpura	HP	S34	8.5, (1.0)	527, (4.39)	89, (0.29)	14.4, (0.19)	12.87, (0.42)	28, (0.11)	34, (0.75)	1.3, (0.86)	1122, (2.24)	1603, (5.34)
		TW	S35	8.2, (0.96)	530, (4.41)	65, (0.22)	8.8, (0.18)	10.44, (0.35)	41, (0.16)	16, (0.35)	1.8, (1.2)	1190, (2.38)	1700, (5.67)
25	Kaneta	HP	S36	7.8, (0.91)	286, (2.38)	364, (1.21)	57.6, (0.77)	53.46, (1.78)	1424, (5.69)	6, (0.13)	0.11, (0.07)	4762, (9.52)	6802, (22.67)
		TW	S37	8.4, (0.98)	564, (4.7)	77, (0.26)	13.6, (0.18)	10.44, (0.35)	40, (0.16)	14, (0.31)	0.7, (0.46)	1050, (2.1)	1500, (5.0)
26	Kaneti	HP	S38	7.5, (0.88)	586, (4.88)	867, (2.89)	128.8, (1.72)	132.43, (4.41)	1075, (4.3)	236, (5.24)	1.06, (0.70)	4890, (9.78)	6985, (23.28)
27	Kanota	HP	S39	8.3, (0.97)	409, (3.41)	203, (0.67)	36, (0.48)	27.45, (0.91)	296, (1.18)	33, (0.73)	0.62, (0.41)	1835, (3.67)	2621, (8.74)
		TW	S40	8.4, (0.98)	741, (6.17)	91, (0.30)	14.4, (0.19)	13.36, (0.45)	225, (0.9)	8, (0.17)	1.7, (1.13)	1983, (3.96)	2833, (9.44)
28	Kashipura	HP	S41	7.5, (0.88)	695, (5.79)	105, (0.35)	16, (0.21)	15.79, (0.53)	90, (0.36)	21, (0.46)	3.2, (2.13)	1305, (2.61)	1864, (6.21)
29	Keshopura	HP	S42	7.6, (0.89)	555, (4.62)	350, (1.17)	56, (0.75)	51.03, (1.70)	644, (2.57)	5, (0.11)	0.75, (0.5)	2520, (5.04)	3600, (12.0)
30	Kuthada Kalan	HP	S43	7.1, (0.83)	233, (1.94)	66, (0.22)	10, (0.13)	9.96, (0.33)	20, (0.08)	22, (0.49)	0.77, (0.51)	709, (1.41)	1013, (3.38)
31	Lalgarh	HP	S44	7.6, (0.89)	510, (4.25)	284, (0.95)	48.8, (0.65)	39.36, (1.31)	230, (0.92)	15, (0.33)	1.42, (0.94)	1240, (2.48)	1771, (5.90)
32	Mundali	HP	S45	7.7, (0.90)	482, (4.02)	117, (0.39)	18.4, (0.25)	17.25, (0.57)	55, (0.22)	12, (0.26)	4.2, (2.8)	1321, (2.64)	1887, (6.29)
		TW	S46	8.2, (0.96)	734, (6.12)	90, (0.3)	13.6, (0.18)	13.6, (0.45)	152, (0.61)	26, (0.58)	3.38, (2.25)	1682, (3.36)	2404, (8.01)
33	Nagal Karna	HP	S47	7.4, (0.87)	371, (3.09)	154, (0.51)	22.8, (0.30)	23.57, (0.78)	60, (0.24)	11, (0.24)	4.35, (2.9)	1295, (2.59)	1850, (6.17)
		TW	S48	8.1, (0.95)	795, (6.62)	73, (0.24)	12.8, (0.17)	9.96, (0.33)	80, (0.32)	26, (0.58)	5.9, (3.93)	1610, (3.22)	2300, (7.67)
34	Parasoli	HP	S49	7.7, (0.90)	412, (3.43)	774, (2.58)	158.8, (2.18)	150.8, (5.02)	320, (1.28)	2, (0.04)	1.17, (0.78)	2146, (4.29)	3065, (10.21)
		TW	S50	8.4, (0.98)	464, (3.87)	78, (0.26)	14, (0.19)	10.44, (0.34)	60, (0.24)	23, (0.51)	2.2, (1.46)	1050, (2.1)	1500, (5.0)
35	Parempura	HP	S51	7.8, (0.91)	431, (3.59)	641, (2.14)	113.2, (1.51)	86.99, (2.89)	444, (1.77)	18, (0.4)	1.15, (0.76)	3474, (6.94)	4963, (16.54)
36	Patan	HP	S52	7.1, (0.83)	655, (5.46)	622, (2.07)	105.6, (1.41)	86.99, (2.89)	885, (3.54)	10, (0.22)	0.52, (0.34)	3535, (7.07)	5050, (16.83)
37	Peepalabai	HP	S53	7.2, (0.84)	160, (1.33)	374, (1.24)	83.6, (1.11)	40.09, (1.33)	266, (1.06)	82, (1.82)	1.84, (1.22)	1680, (3.36)	2400, (8.0)
		TW	S54	8.2, (0.96)	435, (3.62)	400, (1.33)	74, (0.98)	52.24, (1.74)	65, (0.26)	26, (0.58)	8.95, (5.96)	1505, (3.01)	2150, (7.17)
38	Peipura	HP	S55	7.8, (0.91)	532, (4.43)	267, (0.89)	47.2, (0.63)	36.2, (1.20)	250, (1.0)	11, (0.24)	1.35, (0.9)	1750, (3.5)	2500, (8.33)
		TW	S56	8.4, (0.98)	435, (3.63)	110, (0.36)	16, (0.21)	17.01, (0.56)	35, (0.14)	28, (0.62)	1.5, (1.0)	875, (1.75)	1250, (4.17)
39	Rajwas	HP	S57	7.6, (0.89)	648, (5.4)	463, (1.54)	82, (1.09)	62.69, (2.08)	551, (2.20)	52, (1.15)	1.33, (0.88)	2306, (4.61)	3295, (10.98)
40	Ramser	HP	S58	7.3, (0.85)	520, (4.33)	254, (0.85)	41.2, (0.55)	36.69, (1.22)	60, (0.24)	18, (0.4)	3.8, (2.53)	1050, (2.1)	1500, (5.0)
		TW	S59	8.4, (0.98)	464, (3.87)	118, (0.39)	17.6, (0.23)	17.98, (0.59)	50, (0.2)	25, (0.55)	2, (1.33)	1053, (2.11)	1504, (5.01)
41	Ratanpura	HP	S60	7.9, (0.92)	532, (4.43)	299, (0.99)	54, (0.72)	39.85, (1.33)	80, (0.32)	32, (0.71)	1.02, (0.68)	1435, (2.87)	2050, (6.83)
		TW	S61	8.4, (0.98)	552, (4.6)	88, (0.29)	14, (0.19)	12.87, (0.43)	60, (0.24)	19, (0.42)	1.07, (0.69)	1129, (2.25)	1613, (5.38)
42	Roopura	HP	S62	7.5, (0.88)	263, (2.19)	107, (0.36)	16.8, (0.22)	15.79, (0.53)	130, (0.52)	24, (0.53)	1.44, (0.96)	1113, (2.23)	1590, (5.3)
		TW	S63	8.1, (0.95)	415, (3.46)	430, (1.43)	80, (1.06)	55.89, (1.86)	81, (0.32)	25, (0.55)	8.75, (5.83)	1610, (3.22)	2300, (7.67)
43	Sambhariya	HP	S64	7.4, (0.87)	314, (2.62)	232, (0.77)	38.4, (0.51)	33.04, (1.10)	58, (0.23)	14, (0.31)	0.07, (0.046)	356, (0.71)	508, (1.69)
44	Shankarpura	HP	S65	7.6, (0.89)	588, (4.9)	134, (0.45)	21.2, (0.28)	19.68, (0.65)	58, (0.23)	6, (0.13)	4.2, (2.8)	1028, (2.06)	1469, (4.89)
45	Siya Ka Bas	HP	S66	7.7, (0.90)	235, (1.96)	234, (0.78)	39.2, (0.52)	33.04, (1.10)	62, (0.25)	91, (2.02)	0.85, (0.57)	1225, (2.45)	1750, (5.83)
46	Tehda	HP	S67	8.2, (0.96)	276, (2.3)	145, (0.48)	24.8, (0.33)	20.16, (0.67)	221, (0.88)	20, (0.44)	1.4, (0.93)	1478, (2.95)	2111, (7.03)
47	Tekchandpura	HP	S68	7.8, (0.91)	328, (2.73)	306, (1.02)	53.2, (0.71)	42.03, (1.40)	40, (0.16)	14, (0.31)	0.2, (0.13)	563, (1.12)	804, (2.68)
48	Tilpatti	HP	S69	7.8, (0.91)	642, (5.35)	194, (0.65)	32.4, (0.43)	27.45, (0.91)	80, (0.32)	14, (0.31)	0.9, (0.6)	1280, (2.56)	1828, (6.09)
49	Todabhata	HP	S70	8.5, (1.0)	328, (2.73)	65, (0.22)	8.8, (0.18)	10.44, (0.35)	52, (0.21)	24, (0.53)	2, (1.33)	984, (1.97)	1405, (4.95)
50	Tunga	HP	S71	7.6, (0.89)	36, (0.3)	38, (0.13)	6.4, (0.08)	5.34, (0.18)	15, (0.06)	10, (0.22)	0.1, (0.06)	63, (0.12)	86, (0.29)

Table 8 Pollution causing parameters evaluated through Nemerow's pollution index (NPI) in pre monsoon season

S. No.	Village	Source	Sample	pH	TA	TH	Ca ions	Mg ions	Cl^-	NO_3^-	F^-	TDS	EC
				C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI	C_i &NPI
1	Akhepura	HP	S1	8.1, (0.95)	410, (3.41)	406, (1.35)	72, (0.96)	54.91, (1.83)	306, (1.22)	102, (2.27)	1.36, (0.9)	1581, (3.16)	2259, (7.53)
		TW	S2	8.6, (1.01)	294, (2.45)	82, (0.27)	12.8, (0.17)	12.15, (0.40)	22, (0.08)	21, (0.47)	1.94, (1.2)	616, (1.23)	880, (2.93)
2	Anantpura	HP	S3	7.7, (0.90)	607, (5.06)	284, (0.95)	48.8, (0.65)	39.36, (1.31)	194, (0.78)	15, (0.33)	0.85, (0.57)	1493, (2.99)	2132, (7.11)
		TW	S4	7.7, (0.90)	517, (4.31)	540, (1.8)	98, (1.31)	71.68, (2.39)	417, (1.67)	29, (0.64)	0.73, (0.49)	2074, (4.15)	2962, (9.87)
3	Banskho	HP	S5	7.8, (0.92)	580, (4.83)	478, (1.59)	69.2, (0.92)	74.11, (2.47)	193, (0.77)	31, (0.69)	0.92, (0.62)	1630, (3.26)	2328, (7.76)
		TW	S6	8.5, (1.0)	363, (3.02)	98, (0.33)	16.4, (0.22)	13.85, (0.46)	98, (0.39)	14, (0.31)	1.54, (1.03)	1207, (2.41)	1724, (5.75)
4	Barala	HP	S7	7.7, (0.90)	484, (4.03)	110, (0.37)	18, (0.24)	15.79, (0.53)	118, (0.47)	7, (0.16)	1.8, (1.2)	668, (1.34)	954, (3.18)
5	Bassi	HP	S8	7.6, (0.89)	459, (3.82)	161, (0.54)	27.2, (0.36)	22.59, (0.75)	171, (0.68)	94, (2.09)	0.81, (0.54)	1274, (2.55)	1820, (6.07)
		TW	S9	7.4, (0.87)	255, (2.12)	187, (0.63)	32, (0.43)	26, (0.87)	113, (0.45)	56, (1.24)	0.51, (0.34)	1356, (2.71)	1937, (6.46)
6	Benada	HP	S10	8.5, (1.0)	838, (6.98)	254, (0.85)	44.4, (0.59)	34.74, (1.16)	107, (0.43)	59, (1.31)	0.98, (0.65)	1612, (3.22)	2303, (7.68)
7	Bharampur	HP	S11	7.8, (0.92)	482, (4.02)	364, (1.21)	65.2, (0.87)	48.84, (1.63)	146, (0.58)	21, (0.47)	0.6, (0.4)	1044, (2.09)	1491, (4.97)
8	Chainpuriya	HP	S12	7.7, (0.90)	703, (5.86)	261, (0.87)	45.2, (0.61)	35.96, (1.19)	118, (0.47)	11, (0.24)	1, (0.67)	1206, (2.41)	1723, (5.74)
9	Chapariya	HP	S13	7.7, (0.90)	282, (2.35)	211, (0.70)	35.2, (0.47)	29.88, (0.99)	28, (0.11)	27, (0.6)	0.9, (0.6)	424, (0.85)	605, (2.02)
10	Charangarh	HP	S14	7.7, (0.90)	168, (1.4)	220, (0.73)	36.8, (0.49)	31.1, (1.04)	40, (0.16)	27, (0.6)	0.32, (0.21)	432, (0.86)	617, (2.06)
11	Chatarpura	HP	S15	7.6, (0.89)	698, (5.82)	147, (0.49)	25.2, (0.34)	20.41, (0.68)	60, (0.24)	18, (0.4)	2.6, (1.73)	956, (1.91)	1365, (4.55)
12	Danau Kalan	HP	S16	7.6, (0.89)	454, (3.78)	159, (0.53)	26.4, (0.35)	22.59, (0.75)	34, (0.14)	24, (0.53)	1.17, (0.78)	712, (1.42)	1018, (3.39)
13	Danau Khurd	HP	S17	7.2, (0.85)	312, (2.6)	660, (2.2)	94.8, (1.26)	102.78, (3.43)	103, (0.41)	106, (2.36)	0.45, (0.3)	910, (1.82)	1300, (4.33)
		TW	S18	7.8, (0.92)	382, (3.18)	337, (1.12)	60.4, (0.50)	45.19, (1.51)	84, (0.34)	29, (0.64)	2.6, (1.73)	1478, (2.96)	2111, (7.04)
14	Garh	HP	S19	7.8, (0.92)	422, (3.52)	777, (2.59)	156.8, (2.09)	93.55, (3.12)	355, (1.42)	94, (2.09)	1.02, (0.68)	1685, (3.37)	2407, (8.02)
15	Ghasipura	HP	S20	7.7, (0.90)	365, (3.04)	127, (0.42)	20.4, (0.27)	18.46, (0.61)	21, (0.08)	13, (0.29)	0.55, (0.37)	640, (1.28)	914, (3.05)
		TW	S21	7.9, (0.93)	817, (6.81)	92, (0.31)	14.8, (0.19)	13.36, (0.44)	54, (0.22)	19, (0.42)	11.9, (7.93)	1271, (2.54)	1816, (6.05)
16	Ghata	HP	S22	7.9, (0.93)	443, (3.69)	313, (1.04)	56, (0.75)	42.03, (1.40)	246, (0.98)	14, (0.31)	1.43, (0.95)	1414, (2.83)	2020, (6.73)
		TW	S23	7.7, (0.90)	514, (4.28)	501, (1.67)	86.8, (1.16)	69.01, (2.30)	367, (1.47)	17, (0.38)	0.96, (0.64)	1669, (3.34)	2384, (7.95)
17	Gudha Meena	HP	S24	7.6, (0.89)	403, (3.36)	199, (0.66)	35.2, (0.47)	26.97, (0.89)	20, (0.08)	19, (0.42)	0.4, (0.27)	642, (1.28)	917, (3.06)
18	Gumanpura	HP	S25	7.7, (0.90)	384, (3.2)	208, (0.69)	35.6, (0.47)	28.91, (0.96)	103, (0.41)	8, (0.18)	2, (1.33)	808, (1.62)	1154, (3.85)
		TW	S26	7.8, (0.92)	509, (4.24)	404, (1.35)	72.4, (0.96)	54.18, (1.80)	183, (0.73)	53, (1.18)	2.5, (1.67)	1205, (2.41)	1721, (5.74)
19	Gwalini	HP	S27	7.7, (0.90)	510, (4.25)	270, (0.9)	50, (0.67)	35.23, (1.17)	80, (0.32)	6, (0.13)	1.4, (0.93)	891, (1.78)	1273, (4.24)
20	Hans Mahal	HP	S28	7.6, (0.89)	476, (3.97)	1100, (3.67)	169.2, (2.25)	164.51, (5.48)	1455, (5.82)	20, (0.44)	2.08, (1.39)	5434, (10.87)	7763, (25.87)
21	Hanumanpura	HP	S29	7.1, (0.83)	560, (4.67)	316, (1.05)	57.6, (0.77)	41.79, (1.39)	507, (2.03)	95, (2.11)	1.6, (1.07)	2196, (4.39)	3137, (10.46)
		TW	S30	7.5, (0.88)	812, (6.77)	92, (0.31)	13.2, (0.18)	14.33, (0.48)	148, (0.59)	37, (0.82)	12.2, (8.13)	1837, (3.67)	2624, (8.75)
22	Jhajhwar	HP	S31	7.9, (0.93)	575, (4.79)	440, (1.47)	76, (0.63)	60.75, (2.02)	436, (1.74)	41, (0.91)	1.1, (0.73)	2204, (4.41)	3149, (10.49)
		TW	S32	8.6, (1.01)	278, (2.32)	76, (0.25)	12.4, (0.16)	10.93, (0.36)	154, (0.62)	38, (0.84)	1.08, (0.72)	647, (1.29)	924, (3.08)
23	Jhar	HP	S33	7.8, (0.92)	488, (4.07)	271, (0.90)	47.2, (0.63)	37.17, (1.24)	63, (0.25)	32, (0.38)	0.41, (0.27)	926, (1.85)	1322, (4.41)
24	Kalyanpura	HP	S34	7.8, (0.92)	256, (2.13)	307, (1.02)	53.6, (0.71)	42.03, (1.40)	30, (0.12)	18, (0.4)	0.8, (0.53)	487, (0.97)	696, (2.32)
		TW	S35	7.8, (0.92)	318, (2.65)	83, (0.28)	11.6, (0.15)	13.12, (0.44)	52, (0.21)	13, (0.29)	1.2, (0.8)	607, (1.21)	867, (2.89)
25	Kaneta	HP	S36	7.7, (0.90)	223, (4.86)	268, (0.89)	42, (0.56)	39.6, (1.32)	57, (0.23)	14, (0.31)	0.5, (0.33)	804, (1.61)	1148, (3.83)
		TW	S37	8.2, (0.96)	459, (3.82)	56, (0.19)	10.4, (0.14)	7.29, (0.24)	34, (0.14)	21, (0.47)	0.39, (0.26)	651, (1.30)	930, (3.1)
26	Kaneti	HP	S38	7.4, (0.87)	674, (5.62)	347, (1.16)	51.6, (0.69)	52.97, (1.76)	80, (0.32)	2, (0.04)	0.14, (0.09)	918, (1.84)	1312, (4.37)
27	Kanota	HP	S39	7.5, (0.88)	415, (3.46)	361, (1.20)	59.2, (0.79)	51.75, (1.72)	342, (1.37)	40, (0.89)	1.3, (0.87)	1436, (2.87)	2051, (6.84)
		TW	S40	7.8, (0.92)	689, (5.74)	134, (0.45)	24.4, (0.32)	17.73, (0.59)	266, (1.06)	11, (0.24)	2.3, (1.53)	1606, (3.21)	2294, (7.65)
28	Kashipura	HP	S41	7.6, (0.89)	411, (3.42)	161, (0.54)	25.6, (0.34)	23.57, (0.78)	86, (0.34)	19, (0.42)	1.35, (0.9)	910, (1.82)	1301, (4.34)
29	Keshopura	HP	S42	7.6, (0.89)	330, (2.75)	227, (0.76)	36.8, (0.49)	32.8, (1.09)	80, (0.32)	26, (0.58)	0.49, (0.33)	1333, (2.66)	1904, (6.35)
30	Kuthada Kalan	HP	S43	7.6, (0.89)	785, (6.54)	262, (0.87)	44, (0.59)	36.93, (1.23)	42, (0.17)	21, (0.47)	0.5, (0.33)	800, (1.6)	1142, (3.81)
31	Lalgarh	HP	S44	7.7, (0.90)	505, (4.21)	185, (0.62)	32, (0.43)	25.51, (0.85)	105, (0.42)	49, (1.09)	0.9, (0.6)	1042, (2.08)	1488, (4.96)
32	Mundali	HP	S45	7.8, (0.92)	600, (5.0)	106, (0.35)	16.8, (0.22)	15.55, (0.52)	92, (0.37)	21, (0.47)	5.6, (3.73)	1131, (2.26)	1616, (5.39)
		TW	S46	8.3, (0.98)	822, (6.85)	77, (0.26)	12.4, (0.16)	11.17, (0.37)	206, (0.82)	32, (0.71)	4.02, (2.68)	1951, (3.90)	2787, (9.29)
33	Nagal Karna	HP	S47	7.7, (0.90)	389, (3.24)	119, (0.39)	17.2, (0.23)	18.46, (0.61)	148, (0.59)	2, (0.04)	1.9, (1.27)	608, (1.22)	869, (2.89)
		TW	S48	8.5, (1.0)	859, (7.16)	53, (0.18)	8.4, (0.11)	7.77, (0.26)	112, (0.45)	19, (0.42)	3.25, (2.16)	822, (1.64)	1174, (3.91)
34	Parasoli	HP	S49	7.8, (0.92)	440, (3.67)	553, (1.84)	112, (1.49)	66.33, (2.21)	326, (1.30)	15, (0.33)	1.43, (0.95)	1322, (2.64)	1889, (6.29)
		TW	S50	8.5, (1.0)	516, (4.3)	48, (0.16)	8.8, (0.12)	6.31, (0.21)	56, (0.22)	34, (0.76)	1.8, (1.2)	693, (1.39)	990, (3.3)
35	Parempura	HP	S51	7.8, (0.92)	403, (3.36)	520, (1.73)	80, (1.06)	77.76, (2.59)	475, (1.9)	13, (0.29)	0.8, (0.53)	2880, (5.76)	4114, (13.71)
36	Patan	HP	S52	7.7, (0.90)	535, (4.46)	479, (1.59)	79.6, (1.06)	68.04, (2.27)	652, (2.61)	18, (0.4)	1.22, (0.81)	2468, (4.94)	3526, (11.75)
37	Peepalabai	HP	S53	7.8, (0.92)	206, (1.72)	228, (0.76)	49.2, (0.66)	25.51, (0.85)	58, (0.23)	25, (0.56)	0.5, (0.33)	408, (0.82)	583, (1.94)
		TW	S54	7.7, (0.90)	513, (4.27)	248, (0.83)	39.6, (0.53)	36.2, (1.21)	38, (0.15)	16, (0. 36)	5.3, (3.53)	723, (1.45)	1033, (3.44)
38	Peipura	HP	S55	7.7, (0.90)	700, (5.83)	242, (0.81)	42.4, (0.56)	33.04, (1.10)	446, (1.78)	24, (0.53)	1.23, (0.82)	1946, (3.89)	2780, (9.26)
		TW	S56	8.2, (0.96)	504, (4.2)	97, (0.32)	13.6, (0.18)	15.3, (0.51)	47, (0.19)	41, (0.91)	1.3, (0.87)	1016, (2.03)	1451, (4.84)
39	Rajwas	HP	S57	7.6, (0.89)	704, (5.86)	428, (1.43)	73.2, (0.98)	59.53, (1.98)	320, (1.28)	27, (0.6)	1.3, (0.87)	2883, (5.77)	4118, (13.73)
40	Ramser	HP	S58	7.3, (0.86)	540, (4.5)	210, (0.7)	34, (0.45)	30.37, (1.01)	100, (0.4)	13, (0.29)	1.3, (0.87)	1040, (2.08)	1485, (4.95)
		TW	S59	8.3, (0.98)	483, (4.02)	89, (0.29)	10.8, (0.14)	15.06, (0.50)	66, (0.26)	21, (0.47)	1.06, (0.71)	924, (1.85)	1320, (4.4)
41	Ratanpura	HP	S60	7.8, (0.92)	860, (7.16)	260, (0.87)	45.2, (0.60)	35.72, (1.19)	193, (0.77)	8, (0.18)	1.13, (0.75)	1600, (3.2)	2286, (7.62)
		TW	S61	7.9, (0.93)	871, (7.26)	190, (0.63)	30, (0.4)	27.94, (0.93)	130, (0.52)	19, (0.42)	2.65, (1.77)	1440, (2.88)	2057, (6.86)
42	Roopura	HP	S62	7.8, (0.92)	353, (2.94)	243, (0.81)	44, (0.59)	32.31, (1.08)	60, (0.24)	30, (0.67)	1.4, (0.93)	722, (1.44)	1031, (3.44)
		TW	S63	8.4, (0.99)	511, (4.26)	627, (2.09)	113.2, (1.51)	83.59, (2.79)	58, (0.23)	28, (0.62)	8.49, (5.66)	1159, (2.32)	1656, (5.52)
43	Sambhariya	HP	S64	7.6, (0.89)	425, (3.54)	145, (0.48)	24, (0.32)	20.65, (0.69)	30, (0.12)	30, (0.67)	2.25, (1.5)	920, (1.84)	1314, (4.38)
44	Shankarpura	HP	S65	7.8, (0.92)	540, (4.5)	197, (0.66)	34, (0.45)	27.21, (0.91)	80, (0.32)	2, (0.04)	3.6, (2.4)	1125, (2.25)	1607, (5.36)
45	Siya Ka Bas	HP	S66	7.6, (0.89)	313, (2.61)	179, (0.59)	29.2, (0.39)	25.75, (0.86)	56, (0.22)	71, (1.58)	1.13, (0.75)	773, (1.55)	1104, (3.68)
46	Tehda	HP	S67	7.7, (0.90)	425, (3.54)	174, (0.58)	28.8, (0.38)	24.78, (0.83)	172, (0.69)	24, (0.53)	1.55, (1.03)	1140, (2.28)	1629, (5.43)
47	Tekchandpura	HP	S68	7.8, (0.92)	254, (2.12)	292, (0.97)	52, (0.69)	39.36, (1.31)	40, (0.16)	12, (0.27)	0.25, (0.17)	529, (1.06)	756, (2.52)
48	Tilpatti	HP	S69	7.8, (0.92)	633, (5.27)	366, (1.22)	61.2, (0.82)	51.75, (1.72)	114, (0.46)	22, (0.49)	0.76, (0.51)	1306, (2.61)	1867, (6.22)
49	Todabhata	HP	S70	7.8, (0.92)	550, (4.58)	129, (0.43)	21.6, (0.29)	18.22, (0.61)	63, (0.25)	20, (0.44)	1.8, (1.2)	1043, (2.09)	1490, (4.97)
50	Tunga	HP	S71	7.8, (0.92)	290, (2.42)	780, (2.6)	158, (2.11)	93.55, (3.19)	288, (1.15)	309, (6.87)	0.65, (0.43)	1604, (3.21)	2291, (7.64)

Table 9 Pollutants present at each selected sampling sites as per NPI in pre monsoon

S.No.	Village	Source	Sample	Pollutants
1	Akhepura	HP	S1	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC
		TW	S2	TA, TDS and EC
2	Anantpura	HP	S3	TA, TH, Mg, Chloride, TDS and EC
		TW	S4	TA, Fluoride, TDS and EC
3	Banskho	HP	S5	TA, TH, Mg, Fluoride, TDS and EC
		TW	S6	TA, Fluoride, TDS and EC
4	Barala	HP	S7	TA, Chloride, Nitrate, Fluoride, TDS and EC
5	Bassi	HP	S8	TA, Nitrate, TDS and EC
		TW	S9	TA, TDS and EC
6	Benada	HP	S10	TA, TH, Ca, Mg, Chloride, TDS and EC
7	Bharampur	HP	S11	TA, TDS and EC
8	Chainpuriya	HP	S12	TA, TDS and EC
9	Chapariya	HP	S13	TA, Nitrate, TDS and EC
10	Charangarh	HP	S14	TA, Mg, TDS and EC
11	Chatarpura	HP	S15	TA, Fluoride, TDS and EC
12	Danau Kalan	HP	S16	TA, TDS and EC
13	Danau Khurd	HP	S17	TA, TH, Ca, Mg, Chloride, TDS and EC
		TW	S18	TA, Mg, Fluoride, TDS and EC
14	Garh	HP	S19	TA, Chloride, Nitrate, TDS and EC
15	Ghasipura	HP	S20	TA, TDS and EC
		TW	S21	TA, Fluoride, TDS and EC
16	Ghata	HP	S22	TA, TH, Ca, Mg, Chloride, TDS and EC
		TW	S23	TA, TH, Ca, Mg, Chloride, TDS and EC
17	Gudha Meena	HP	S24	TA, TDS and EC
18	Gumanpura	HP	S25	TA, TH, Mg, Chloride, TDS and EC
		TW	S26	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC
19	Gwalini	HP	S27	TA, TH, Mg, Fluoride, TDS and EC
20	Hans Mahal	HP	S28	TA, TH, Mg, TDS and EC
21	Hanumanpura	HP	S29	TA, TDS and EC
		TW	S30	TA, Fluoride, TDS and EC
22	Jhajhwar	HP	S31	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC
		TW	S32	TA, TDS and EC
23	Jhar	HP	S33	TA, Mg, TDS and EC
24	Kalyanpura	HP	S34	TA, TDS and EC
		TW	S35	TA, Fluoride, TDS and EC
25	Kaneta	HP	S36	TA, TH, Mg, Chloride, TDS and EC
		TW	S37	TA, TDS and EC
26	Kaneti	HP	S38	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC
27	Kanota	HP	S39	TA, Chloride, TDS and EC
		TW	S40	TA, Fluoride, TDS and EC
28	Kashipura	HP	S41	TA, Fluoride, TDS and EC
29	Keshopura	HP	S42	TA, TH, Mg, Chloride, TDS and EC
30	Kuthada Kalan	HP	S43	TA, TDS and EC
31	Lalgarh	HP	S44	TA, Mg, TDS and EC
32	Mundali	HP	S45	TA, Fluoride, TDS and EC
		TW	S46	TA, Fluoride, TDS and EC
33	Nagal Karna	HP	S47	TA, Fluoride, TDS and EC
		TW	S48	TA, Fluoride, TDS and EC
34	Parasoli	HP	S49	TA, TH, Ca, Mg, Chloride, TDS and EC
		TW	S50	TA, Fluoride, TDS and EC
35	Parempura	HP	S51	TA, TH, Ca, Mg, Chloride, TDS and EC
36	Patan	HP	S52	TA, TH, Ca, Mg, Chloride, TDS and EC
37	Peepalabai	HP	S53	TA, TH, Ca, Mg, Chloride, Nitrate, Fluoride, TDS and EC
		TW	S54	TA, TH, Mg, Fluoride, TDS and EC
38	Peipura	HP	S55	TA, Mg, TDS and EC
		TW	S56	TA, TDS and EC
39	Rajwas	HP	S57	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC
40	Ramser	HP	S58	TA, Mg, Fluoride, TDS and EC
		TW	S59	TA, Fluoride, TDS and EC
41	Ratanpura	HP	S60	TA, Mg, TDS and EC
		TW	S61	TA, TDS and EC
42	Roopura	HP	S62	TA, TDS and EC
		TW	S63	TA, TH, Ca, Mg, Fluoride, TDS and EC
43	Sambhariya	HP	S64	TA, Mg and EC
44	Shankarpura	HP	S65	TA, Fluoride, TDS and EC
45	Siya Ka Bas	HP	S66	TA, Mg, Nitrate, TDS and EC
46	Tehda	HP	S67	TA, TDS and EC
47	Tekchandpura	HP	S68	TA, TH, Mg, TDS and EC
48	Tilpatti	HP	S69	TA, TDS and EC
49	Todabhata	HP	S70	TA, Fluoride, TDS and EC
50	Tunga	HP	S71	Nil

Table 10 Pollutants present at each selected stations as per NPI in post monsoon season

S.No.	Village	Source	Sample	Pollutants
1	Akhepura	HP	S1	TA, TH, Mg, Chloride, Nitrate, TDS and EC
		TW	S2	pH, TA, Fluoride, TDS and EC
2	Anantpura	HP	S3	TA, Mg, TDS and EC
		TW	S4	TA, TH, Ca, Mg, Chloride, TDS and EC
3	Banskho	HP	S5	TA, TH, Mg, TDS and EC
		TW	S6	TA, Fluoride, TDS and EC
4	Barala	HP	S7	TA, Fluoride, TDS and EC
5	Bassi	HP	S8	TA, Nitrate, TDS and EC
		TW	S9	TA, Nitrate, TDS and EC
6	Benada	HP	S10	TA, Mg, Nitrate, TDS and EC
7	Bharampur	HP	S11	TA, TH, Mg, TDS and EC
8	Chainpuriya	HP	S12	TA, Mg, TDS and EC
9	Chapariya	HP	S13	TA and EC
10	Charangarh	HP	S14	TA, Mg and EC
11	Chatarpura	HP	S15	TA, Fluoride, TDS and EC
12	Danau Kalan	HP	S16	TA, TDS and EC
13	Danau Khurd	HP	S17	TA, TH, Ca, Mg, Nitrate, TDS and EC
		TW	S18	TA, TH, Mg, Fluoride, TDS and EC
14	Garh	HP	S19	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC
15	Ghasipura	HP	S20	TA, TDS and EC
		TW	S21	TA, Fluoride, TDS and EC
16	Ghata	HP	S22	TA, TH, Mg, TDS and EC
		TW	S23	TA, TH, Ca, Mg, Chloride, TDS and EC
17	Gudha Meena	HP	S24	TA, TDS and EC
18	Gumanpura	HP	S25	TA, Fluoride, TDS and EC
		TW	S26	TA, TH, Mg, Nitrate, Fluoride, TDS and EC
19	Gwalini	HP	S27	TA, Mg, TDS and EC
20	Hans Mahal	HP	S28	TA, TH, Ca, Mg, Chloride, Fluoride, TDS and EC
21	Hanumanpura	HP	S29	TA, TH, Mg, Chloride, Nitrate, Fluoride, TDS and EC
		TW	S30	TA, Fluoride, TDS and EC
22	Jhajhwar	HP	S31	TA, TH, Mg, Chloride, TDS and EC
		TW	S32	pH, TA, TDS and EC
23	Jhar	HP	S33	TA, Mg, TDS and EC
24	Kalyanpura	HP	S34	TA, TH, Mg and EC
		TW	S35	TA,TDS and EC
25	Kaneta	HP	S36	TA, Mg, TDS and EC
		TW	S37	TA,TDS and EC
26	Kaneti	HP	S38	TA, TH, Mg, TDS and EC
27	Kanota	HP	S39	TA, TH, Mg, Chloride, TDS and EC
		TW	S40	TA, Chloride, Fluoride, TDS and EC
28	Kashipura	HP	S41	TA, TDS and EC
29	Keshopura	HP	S42	TA, Mg, TDS and EC
30	Kuthada Kalan	HP	S43	TA, Mg, TDS and EC
31	Lalgarh	HP	S44	TA, Nitrate, TDS and EC
32	Mundali	HP	S45	TA, Fluoride, TDS and EC
		TW	S46	TA, Fluoride, TDS and EC
33	Nagal Karna	HP	S47	TA, Fluoride, TDS and EC
		TW	S48	TA, Fluoride, TDS and EC
34	Parasoli	HP	S49	TA, TH, Ca, Mg, Chloride, TDS and EC
		TW	S50	TA, Fluoride, TDS and EC

S.No.	Village	Source	Sample	Pollutants
35	Parempura	HP	S51	TA, TH, Ca, Mg, Chloride, TDS and EC
36	Patan	HP	S52	TA, TH, Ca, Mg, Chloride, TDS and EC
37	Peepalabai	HP	S53	TA and EC
		TW	S54	TA, Mg, Fluoride, TDS and EC
38	Peipura	HP	S55	TA, Mg, Chloride, TDS and EC
		TW	S56	TA,TDS and EC
39	Rajwas	HP	S57	TA, TH, Mg, Chloride, TDS and EC
40	Ramser	HP	S58	TA, Mg, TDS and EC
		TW	S59	TA, TDS and EC
41	Ratanpura	HP	S60	TA, Mg, TDS and EC
		TW	S61	TA, Fluoride, TDS and EC
42	Roopura	HP	S62	TA, Mg, TDS and EC
		TW	S63	TA, TH, Ca, Mg, Fluoride, TDS and EC
43	Sambhariya	HP	S64	TA, Fluoride, TDS and EC
44	Shankarpura	HP	S65	TA, Fluoride, TDS and EC
45	Siya Ka Bas	HP	S66	TA, Nitrate, TDS and EC
46	Tehda	HP	S67	TA, Fluoride, TDS and EC
47	Tekchandpura	HP	S68	TA, Mg, TDS and EC
48	Tilpatti	HP	S69	TA, TH, Mg, TDS and EC
49	Todabhata	HP	S70	TA, Fluoride, TDS and EC
50	Tunga	HP	S71	TA, TH, Ca, Mg, Chloride, Nitrate, TDS and EC

4. Conclusion

The principal pollutants (pollution causing parameters) observed in the present study are total alkalinity, chloride, fluoride, nitrate, total dissolved solids and electrical conductivity in both pre and post monsoon seasons. Though, some sampling sites also exhibits total hardness, calcium and magnesium as principal pollutants with other parameters whilst by analyzing the NPI values in both seasons it can also be concluded that in some samples all parameters except pH behaves like pollution causing parameters. In pre monsoon season all groundwater samples have pH value under the permissible limit whereas in post monsoon season two samples have higher pH value.

The results of current study revealed that ground water, used by the people residing in villages of Bassi Tehsil, is not suitable for drinking purpose. So, there is a need of continuous monitoring of water quality and proper environment management plan must be adopted to control drinking water pollution immediately. Based on these results and analysis of water samples, it is also recommended to use water only after boiling and filtering or by Reverse osmosis treatment for drinking purpose by the individuals to prevent adverse health effects.

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