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The Statistical Assesment of Fluoride and Nitrate Contamination Status of Ground Water in Various Tehsils of District Jaipur, Rajasthan, India

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Abstract: *Water is an essential natural resource for sustaining life and environment but over the last few decades the water quality is deteriorating due to its over exploitation. Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at focal point. Groundwater is the major source of drinking water in rural as well as in urban areas and in India over 94% of the drinking water demand is met by groundwater. Fluoride and nitrate are the critical chemical parameters, which influence the quality of ground water. Excess intake of fluoride and nitrate through drinking water cause fluorosis and methaemoglobinaemia (blue baby disease) on human beings in many states of India, including Rajasthan.*

This paper provides the actual status of fluoride and nitrate contamination in Bassi, Amer, Chomu, Jamwa Ramgarh, Kotputali, Shahpura and Virat Nagar Tehsils of Jaipur District, Rajasthan, India. Paper also gives a brief idea about sources of fluoride and nitrate in ground water and extent of fluorosis and methaemoglobinaemia in these areas. As per the desirable and maximum permissible limit for fluoride and nitrate in drinking water, determined by WHO, BIS and ICMR standards, a lot of groundwater sources are unfit for drinking purposes. The maximum limit of fluoride and nitrate is found to be 12.5 and 368 mg/L in Bassi and Virat Nagar Tehsils respectively. Fluoride contamination is highest in bassi tehsil as 64% villages are having fluoride concentration more than permissible limit. Due to the higher fluoride and nitrate levels in drinking water several cases of dental, skeletal fluorosis and methaemoglobinaemia have appeared at alarming rate in these regions. After evaluating the data of this study it is concluded that there is an instant need to take ameliorative steps in these regions to prevent the population from adverse health effects.

Keywords: *Statistical assessment, Ground water, fluoride, nitrate, fluorosis, methaemoglobinaemia, Tehsils of Jaipur, Rajasthan.*

1. INTRODUCTION

"Water is life's matter and matrix, mother and medium. There is no life without water." In now days, the expanded population with resulting industrial operation has intensified the old problem of polluting our life, mother and medium. At present our life, mother and medium is being polluted and even worse situation is that we encounter with scarcity of this degraded quality of water too. It has raised certain basic challenges in our environment and we are suffering both the problems of quality and quantity of water. Groundwater is the major source of drinking water and over 94% of the drinking water demand is met by groundwater. Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at focal point since it is directly linked with human welfare.

Major problems are being faced by the country due to the presence of excess fluoride, arsenic and nitrate in groundwater in certain parts of country. Fluorine is the most electronegative of all chemical elements and is therefore never found in nature in elemental form. Combined chemically in the form of fluorides, it ranks 17th in abundance of elements in the earth's crust representing about 0.06–0.09% of the earth's crust (WHO, 1994). Fluoride is one of important life elements to human health. It is essential for normal mineralization of bones and formation of dental enamel with presence in small quantity (Chouhan and Flora, 2010). But Excess fluoride concentration in

drinking water has deleterious effects on human health. It causes a dreadful disease known as fluorosis. Fluoride more than permissible limit, become toxic and causes clinical and metabolic disturbance in animals and human being such as dental, skeletal and non-skeletal Fluorosis (Hussain et al., 2002, 2004a, 2010, 2011, 2012; Singh et al., 2007).

The permissible limit of fluoride in drinking water is 1.5mg/L by WHO, 1.0 mg/L by ICMR and 0.6 to 1.2 mg/L by BIS. (BIS1991; WHO 1994) The problem of fluorosis is worldwide and almost 25 nations of the world are under its dreadful fate. In Asia, India and China, the most populous countries are worst affected. In India problem is most pronounced in Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh (Godfrey et al. 2006; Ayoob and Gupta 2006; Sharma et al. 2007; Khaiwal and Garg 2007; SIHFW 2008; Hussain et al. 2012).

Rajasthan is the largest state in the country in terms of geographic spread. It has an area of 342,239 lakh Sq kms being largest state of the country having 10.41 % of the country's area and 5.5% of nation's population but has low water resources i.e. 1% of the country's resources. The state has extreme climatic and geographical condition and it suffers both the problems of quantity and quality of water. All the 32 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. (SIHFW,2008; Singh P et al 2011; Hussain et al, 2012).

Nitrate (NO_3^-) contamination of the groundwater, due to the intensive use of fertilizers has also become a serious ecological problem in many rural areas of India and in many developing nations worldwide. The level of nitrate in groundwater has been increasing over the past three decades (Mueller et al., 1995,1996). Producing an adequate quantity of healthy food without polluting the environment is a formidable challenge for future agriculture in the world. The global mean nitrogen use efficiency is estimated to be about 50% (Mosier.,2002) .The remaining quantity of nitrogen is lost into the environment. A large population of this nitrogen gets converted into nitrate which, being soluble in water and not retained by soils, gets leached into water bodies. Leaching of nitrate from agricultural land and from other sources to groundwater is a global phenomenon. The nitrate concentration in groundwater is influenced by rainfall. Where the amounts of rainfall are low, the concentration tends to be high because the diluting effect is reduced. A number of workers from India and abroad have reported the presence of high concentration (3800 ppm) of nitrate in groundwater (Malik et al., 1981; Hamilton et al., 1992) and identified their probable sources. In India, as high 530 mg/l of nitrate has been reported in Churu district of Rajasthan (Sunitha and Rajeswara Reddy, 2006). Consumption of drinking water with nitrate, at concentrations greater than 45 mg/l can be detrimental to human health (Canter, 1987).

The permissible limit of nitrate in drinking water is 45mg/L by WHO, 50 mg/L by ICMR and 100 mg/L by BIS. (BIS1999; WHO 2006) Infants under one year old are particularly at risk from excessive amounts as it cause methaemoglobinaemia, commonly called blue baby syndrome, by blocking the oxygen-carrying capacity of haemoglobin, when approximately 70% of the total haemoglobin have been converted to methaemoglobin (WHO, 1983). Infants are most prone to nitrate contamination because they have under developed metallic enzyme, relatively small blood volume and greater reactivity of fetal haemoglobin. A further concern is that nitrate can be converted by bacteria in the digestive tract into nitrosamines which are potentially carcinogenic. However, whereas low levels of nitrate are harmful is often contested (Sunitha and Rajeswara Reddy, 2006).

Review on the literature showed that no studies have been undertaken in these study areas with regard to fluoride and nitrate problems yet. So the objective of this study was to investigate the quality of drinking water (underground water) with special reference to the concentration of fluoride and nitrate in most rural habitations of Bassi, Amer, Chomu, Jamwa Ramgarh, Kotputali, Shahpura and Virat Nagar Tehsils of Jaipur, Rajasthan, India.

2. MATERIALS AND METHODS

2.1. Study Area

Jaipur district with geographical area of 11,151 sq. km forms East-central part of the Rajasthan which is administered by 13 tehsils and 13 blocks. The district covers about 3.3% of total area of

the State. Jaipur, the capital city is also popularly known as Pink city and is situated towards central part of the district. The semi-arid district receives normal annual rainfall of 527mm (1901-71) while average annual rainfall for the last 30 years (1977-2006) is 565mm. Over 90% of total annual rainfall is received during monsoon. (CGWB, 2007; JDA,2012).

Bassi, Amer, Chomu, Jamwa Ramgarh, Kotputali, Shahpura and Virat Nagar tehsils are out of 13 tehsils of district Jaipur. There are no major surface water sources in the study area however, main sources of drinking water are open wells, hand pumps and bore wells.

2.2. Water Sampling

Ground water samples of a total of 50 villages in Bassi Tehsil, 50 villages in Amer Tehsil, 50 villages in Chomu Tehsil, 18 villages in J. Ramgarh Tehsil, 27 villages in Kotputali Tehsil, 35 villages in Shahpura Tehsil and 43 villages in Virat Nagar Tehsil of Jaipur district were collected in pre-cleaned and rinsed polythene bottles with necessary precautions. (Brown et al. 1974) The samples were collected, during April 2012 to March 2013 from manually operated hand pumps, open wells and bore wells.

2.3. Methodology

All the samples were analyzed for fluoride and nitrate concentration electrochemically, using fluoride ion selective electrode and Spectrophotometric method, respectively (APHA, 2005). All the chemicals used were of AR grade and double distilled water used for preparation of solutions.

3. RESULT AND DISCUSSION

3.1. Fluoride Distribution

All the ground water samples collected were clear without any visible color, odor and turbidity. The fluoride concentration in ground water varied greatly in different sampling sites of study areas. All the villages were categorized according to following concentration range (Table-1). The abstract of fluoride distribution of all tehsils is shown in Table- 2.

- Category I: Fluoride concentration below 1.0 mg/l
- Category II: Fluoride concentration between 1.0 - 1.5 mg/l
- Category III: Fluoride concentration between 1.6 - 3.0 mg/l
- Category IV: Fluoride concentration between 3.1 - 5.0 mg/l
- Category V: Fluoride concentration above 5.0 mg/l

Table1. *Fluoride Categorisation of villages in Tehsils*

Fluoride Concentration (mg/L)	Representing No. Of Samples						
	Bassi	**Amer**	**Chomu**	**J.Ramgarh**	**Kotputali**	**Shahpura**	**Virat Nagar**
Category I (<1.0)	13	43	35	14	18	24	41
Category II (1.0-1.5)	05	01	06	02	05	06	-
Category III (1.6-3.0)	14	05	08	02	04	05	1
Category IV(3.1-5.0)	06	01	01	-	-	-	1
Category V (>5.0)	12	-	-	-	-	-	-
Total Villages	50	50	50	18	27	35	43

Table2. *Abstract of fluoride distribution in Tehsils*

Tehsil	No. Of Villages	**Fluoride Concentration in mg/L**						
		Min.	**Max.**	**<1.0**	**1.0-1.5**	**1.6-3.0**	**3.1-5.0**	**>5.0**
Bassi	50	0.1	12.5	13(26%)	05(10%)	14(28%)	06(12%)	12(24%)
Amer	50	0.01	3.98	43(86%)	01(2%)	05(10%)	01(2%)	-
Chomu	50	0.01	3.3	35(70%)	06(12%)	08(16%)	01(2%)	-
J. Ram.	18	0.1	2.5	14(77.7%)	02(11.1%)	02(11.1%)	-	-
Kotputali	27	0.2	2.7	18(66.6%)	05(18.5%)	04(14.8%)	-	-
Shahpura	35	0.2	2.4	24(68.5%)	06(17.3%)	05(14.2%)	-	-
V.Nagar	43	0.1	4.0	41(95.3%)	-	01(2.32%)	01(2.32%)	-

3.2. Nitrate Distribution

The nitrate concentration in ground water varied greatly in different sampling sites of study areas. All the villages were categorized according to following concentration range (Table-3). The abstract of nitrate distribution of all tehsils is shown in Table- 4.

- Category I: Nitrate concentration below 45 mg/l
- Category II: Nitrate concentration between 45-50 mg/l
- Category III: Nitrate concentration between 51-100 mg/l
- Category IV: Nitrate concentration between 101-150 mg/l
- Category V: Nitrate concentration above 150 mg/l

Table3. *Nitrate Categorisation of villages in Tehsils*

Fluoride Concentration (mg/L)	Representing No. Of Samples						
	Bassi	**Amer**	**Chomu**	**J.Ramgarh**	**Kotputali**	**Shahpura**	**Virat Nagar**
Category I (<45)	42	36	37	15	18	20	28
Category II (46-50)	-	01	01	-	-	01	01
Category III (51-100)	06	12	10	02	02	09	08
Category IV(101-150)	01	01	-	01	05	02	03
Category V (>150)	01	-	02	-	02	03	03
Total Villages	50	50	50	18	27	35	43

Table4. *Abstract of nitrate distribution in Tehsils*

Tehsil	No. Of Villages	**Nitrate Concentration in mg/L**						
		Min.	**Max.**	**< 45**	**46-50**	**51-100**	**101-150**	**> 150**
Bassi	50	01	206	42 (84%)	- (0.0%)	6 (12%)	1 (2%)	1 (2%)
Amer	50	02	178	36 (72%)	1 (2%)	12 (24%)	1 (2%)	-
Chomu	50	01	186	37 (74%)	1 (2%)	10 (20%)	-	2 (4%)
J. Ram.	18	06	142	15(83.3%)	-	2 (11.1%)	1 (5.5%)	-
Kotputali	27	01	310	18(66.6%)	-	2 (7.4%)	5(18.5%)	2 (7.4%)
Shahpura	35	01	285	20(57.1%)	1(2.8%)	9 (25.7%)	2(5.7%)	3(8.5%)
V.Nagar	43	01	368	28(65.1%)	1 (2.3%)	8(18.6%)	3(6.9%)	3(6.9%)

1. **Bassi Tehsil:** The results of fluoride and nitrate concentrations in ground water samples of bassi tehsil is presented in Table -5.

Fluoride- The variation of fluoride concentration in ground water samples of study area is depicted in Figure -1. Figure- 2 depicts the percentage of villages with respect to above categories.

Table5. *Fluoride and Nitrate Concentration in Villages of Bassi Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate(mg/L)
1.	Akhepura	S1	0.76	26
2.	Biharipura	S2	1.4	24
3.	Anatpura	S3	0.37	22
4.	Ratanpura	S4	1.5	42
5.	Kaneta	S5	0.11	06
6.	Gurhameena	S6	2.7	12
7.	Banskhoh	S7	7.6	10
8.	Kashipura	S8	4.6	12
9.	Ram Rakhapura	S9	4.1	06
10.	Moondali	S10	7.9	06
11.	Gumanpura	S11	0.88	16
12.	Chak Madhogarh	S12	0.83	16
13.	Nagal Karana	S13	7.2	02
14.	Jhajhawar	S14	0.48	68
15.	Gwalini	S15	1.8	08
16.	Madhogarh	S16	1.7	08
17.	Padasoli	S17	2.3	02
18.	Peipura	S18	1.7	12
19.	Ramsar	S19	3.8	18
20.	Kanota	S20	1.2	22
21.	Siyaka Bas	S21	1.3	20

22.	Kishanpura	S22	1.9	20
23.	Mandurupura	S23	2.2	36
24.	Tungi	S24	0.59	12
25.	Sankh	S25	1.1	142
26.	Ralawata	S26	5.5	90
27.	Ramsar Palawala	S27	0.58	68
28.	Hans Mahal	S28	0.85	02
29.	Patan	S29	0.24	18
30.	Barala	S30	4.3	206
31.	Hanumanpura	S31	12.5	24
32.	Peepalabai	S32	12.3	24
33.	Virajpura	S33	0.95	22
34.	Basedi	S34	1.8	06
35.	Bishansinghpura	S35	2.8	22
36.	Bassi	S36	1.9	74
37.	Ghasipura	S37	11.4	26
38.	Ramsinghpura	S38	10.9	26
39.	Roopura	S39	11.7	25
40.	Ramratanpura	S40	4.1	10
41.	Kalayanpura	S41	1.8	16
42.	Doodhali	S42	2.0	25
43.	Kuthara Khurd	S43	3.7	11
44.	Madhogarh	S44	2.2	23
45.	Tunga	S45	0.1	01
46.	Hardi	S46	2.5	89
47.	Gangarampura	S47	11.4	29
48.	Handi	S48	10.0	75
49.	Jagdishpura	S49	6.2	33
50.	Todabhata	S50	0.4	03

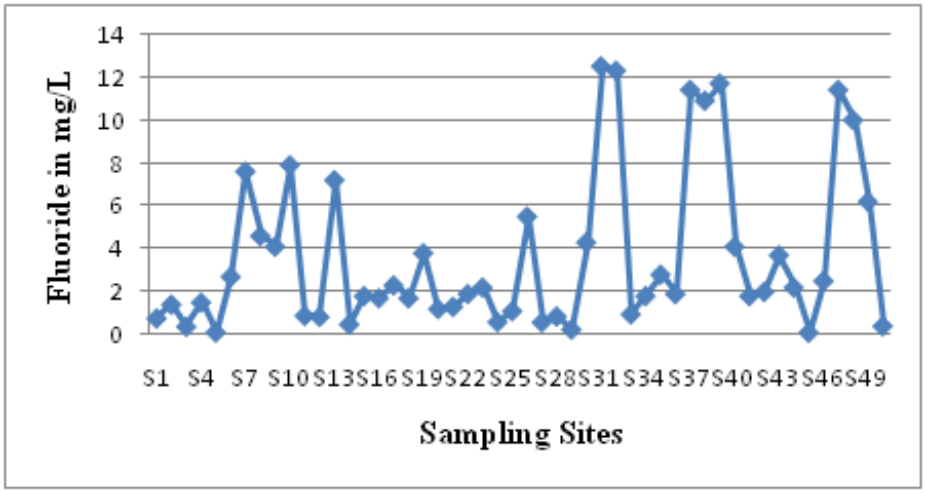

Fig1. *Variation in Fluoride (mg/L) with sampling sites of Bassi Tehsil*

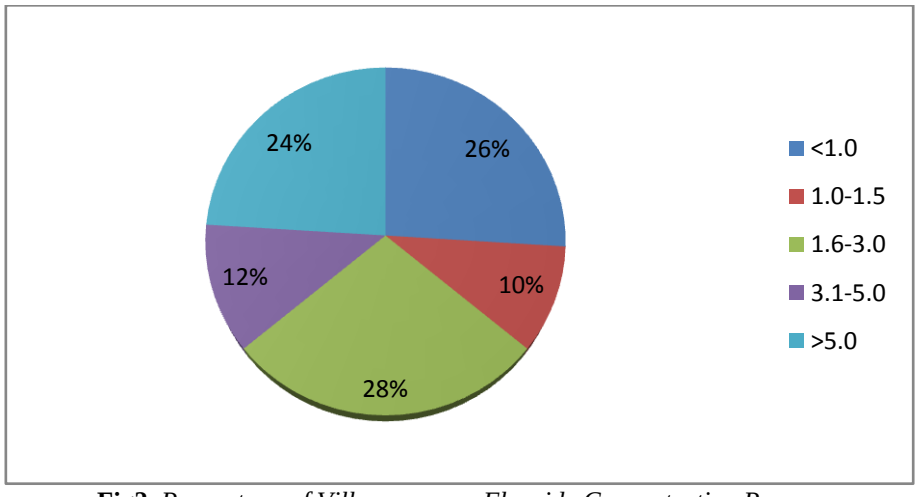

Fig2. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.1 to 12.5 mg/L in ground water samples, with lowest value 0.1 mg/L (S45) in village Tunga and highest value 12.5mg/L (S31) in village Hanumanpura. The study reveals that out of 50 villages of Bassi Tehsil 13 villages (26%) have fluoride concentration below 1.0 mg/L. 5 villages (10%) have fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L. Population of these habitations, fluoride intake through drinking water is more than 4 mg/day in an individual. Therefore, an incidence of dental fluorosis is possible in local residents of these habitations.

14 villages (28%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. At this concentration, teeth lose their shiny appearance and chalky black, gray, or white patches develop known as mottled enamel. In 6 villages (12%) fluoride concentration in ground water is equal to 3.1mg/L and below or equal to 5.0 mg/L. The intake of fluoride per day by population in these habitations is very high and cause dental as well as skeletal fluorosis. In the entire study 12 villages (24%) falls in category V, in these villages fluoride concentration is above 5.0 mg/L, which may result in all types of fluorosis among inhabitants.

Nitrate- The variation of nitrate concentration in ground water samples of study area is depicted in Figure -3 and Figure- 4 depicts the percentage of villages with respect to above categories.

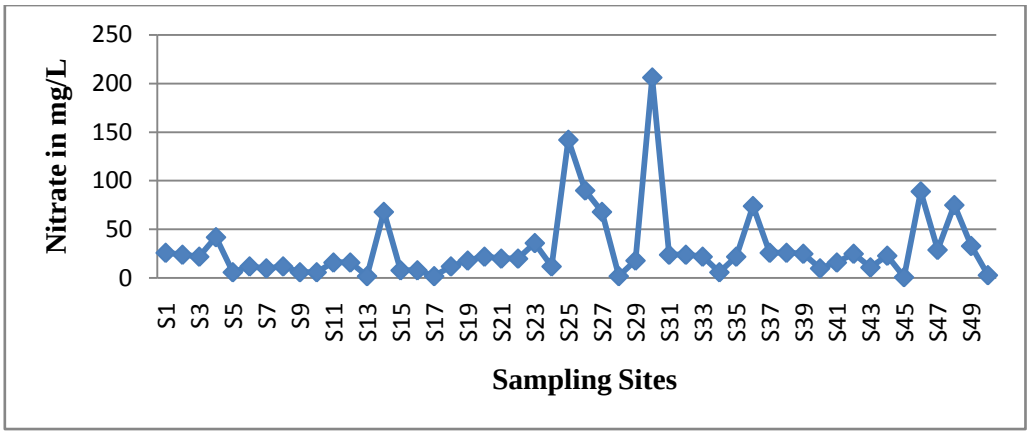

Fig3. *Variation in Nitrate (mg/L) with sampling sites of Bassi Tehsil*

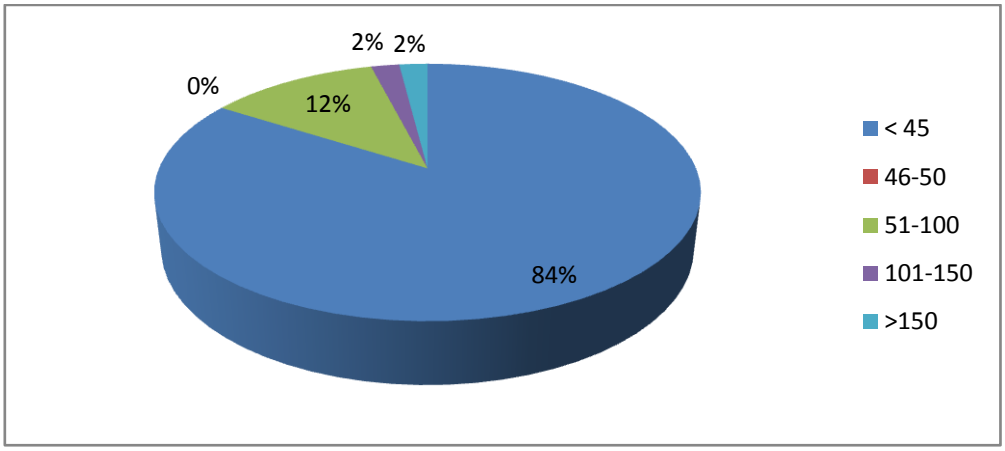

Fig4. *Percentage of Villages as per Nitrate Concentration Ranges*

Nitrate concentration in sampling sites ranges from 1 to 206 mg/L in ground water samples, with lowest value 1 mg/L (S45) in village *Tunga* and highest value 206 mg/L (S30) in village *Barala.* The study reveals that out of 50 villages of Bassi Tehsil 42 villages (84%) have nitrate concentration below 45 mg/L. There is no village having nitrate concentration above 45 mg/L and below or equal to 50 mg/L which is above the maximum permissible limit prescribed by WHO.

6 villages (12%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L .In 1 village (2%) nitrate concentration in ground water is equal to 101mg/L and below or equal to 150 mg/L. In the entire study 1 village (2%) falls in category V, in these village nitrate concentration is above 150 mg/L.

2. Amer Tehsil: The results of fluoride and nitrate concentrations in ground water samples of amer tehsil is presented in Table -6.

Fluoride- The variation of fluoride concentration in ground water samples of study area is depicted in Figure -5. Figure- 6 depicts the percentage of villages with respect to above categories.

Table6. *Fluoride and Nitrate Concentration in Villages of Amer Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate (mg/L)
1.	Bheempura	S1	1.1	02
2.	Kali Ghati	S2	0.41	70
3.	Peelawa	S3	1.6	22
4.	Naitapuri Kichi	S4	0.49	68
5.	Harvar	S5	0.75	56
6.	Harchandpura	S6	0.81	80
7.	Kukas	S7	2.0	56
8.	Bhuranpura Nestibas	S8	0.3	32
9.	Lalbas	S9	3.98	178
10.	Chandabas	S10	1.9	28
11.	Sevapura	S11	0.26	52
12.	Deeppura	S12	0.01	36
13.	Dola ka bas	S13	1.6	52
14.	Deesa	S14	2.1	20
15.	Hanumanpura	S15	0.04	30
16.	Bishangarh	S16	0.01	50
17.	Laxmi Narainpura	S17	0.04	26
18.	Luniyabas	S18	0.01	30
19.	Aakeda Doongar	S19	0.01	24
20.	Jaisalya	S20	0.01	20
21.	Bada Goan Jarkhya	S21	0.03	34
22.	Rampura (Sevapura)	S22	0.08	12
23.	Chirada	S23	0.03	18
24.	Dhubarnya bas	S24	0.15	32
25.	Motu ka bas	S25	0.18	34
26.	Rajabas	S26	0.01	16
27.	Machada	S27	0.27	54
28.	Jagannathpura	S28	0.01	24
29.	Udayapuriya	S29	0.01	22
30.	Sherawatpura	S30	0.28	44
31.	Maheshbas Kalan	S31	0.47	10
32.	Chak Bhejada	S32	0.13	52
33.	Jaitpura	S33	0.09	16
34.	Savdarpura	S34	0.01	04
35.	Sindolai	S35	0.01	02
36.	Harchandpura	S36	0.12	16
37.	Chatarpura	S37	0.27	22
38.	Govindpura	S38	0.2	67
39.	Hardattapura	S39	0.34	51
40.	Kishanpura	S40	0.22	53
41.	Dalpura	S41	0.32	22
42.	Risani	S42	0.12	30
43.	Maheshpura Ravan	S43	0.61	08
44.	Nangal Siras	S44	0.55	20
45.	Chak Degada bas	S45	0.38	38
46.	Nangal Bagadi	S46	0.44	17
47.	Jairampura	S47	0.35	02
48.	Bugaliya	S48	0.35	15
49.	Bichandi	S49	0.33	23
50.	Nada	S50	0.98	18

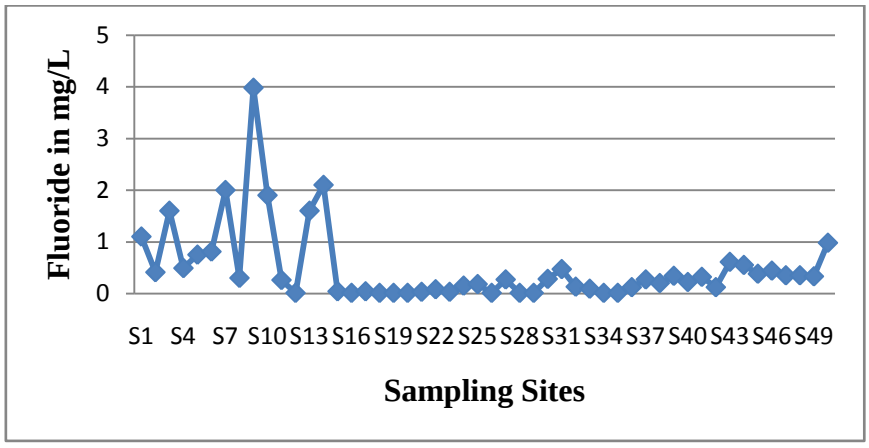

Fig5. *Variation in Fluoride (mg/L) with sampling sites of Amer Tehsil*

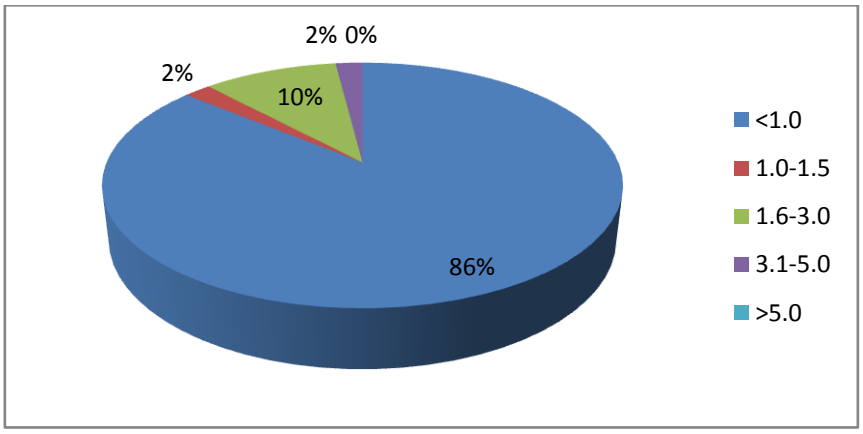

Fig6. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.01 to 3.98 mg/L in ground water samples, with lowest value 0.01 mg/L and highest value 3.98 mg/L (S9) in village Lalbas. The study reveals that out of 50 villages of Amer Tehsil 43 villages (86%) have fluoride concentration below 1.0 mg/L. 1 village (2%) is having fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L.

5 villages (10%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. In 1 village (2%) fluoride concentration in ground water is equal to 3.1mg/L and below or equal to 5.0 mg/L. In the entire study of amer tehsil there is no village falling in category V.

Nitrate- The variation of nitrate concentration in ground water samples of study area is depicted in Figure -7 and Figure- 8 depicts the percentage of villages with respect to above categories.

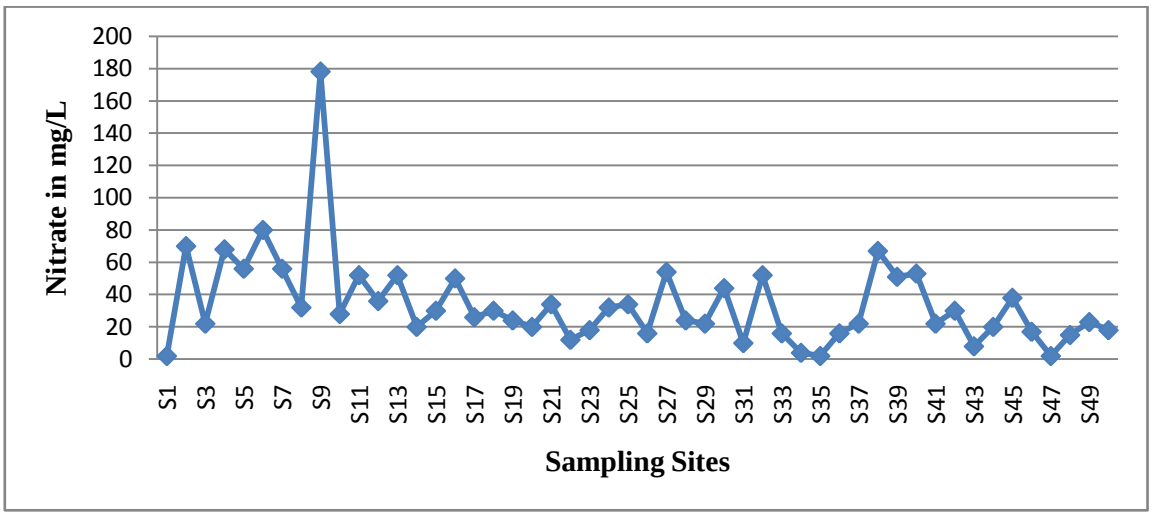

Fig7. *Variation in Nitrate (mg/L) with sampling sites of Amer Tehsil*

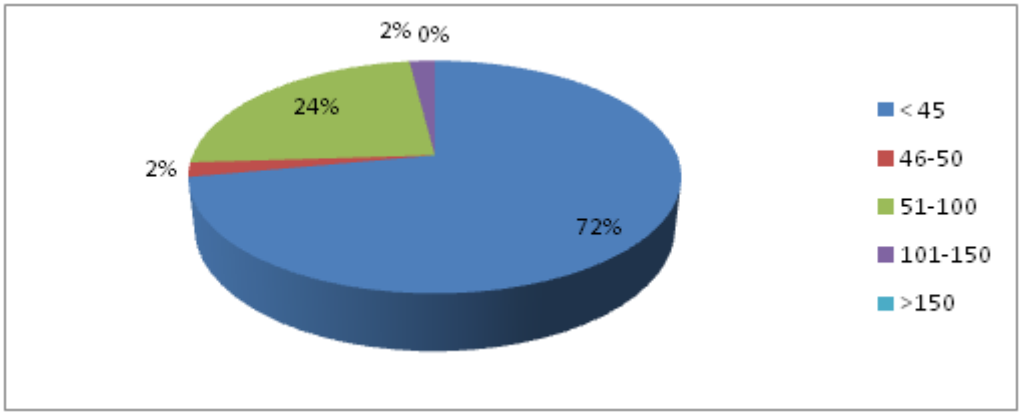

Fig8. *Percentage of Villages as per Nitrate Concentration Ranges*

Nitrate concentration in sampling sites ranges from 2 to 178 mg/L in ground water samples, with lowest value 2 mg/L (S1,S35,S47) in village *Bheempura*, *Sindolai and Jairampura* and highest value 178 mg/L (S9) in village *Lalbas.* The study reveals that out of 50 villages of Amer Tehsil 36 villages (72%) have nitrate concentration below 45 mg/L. 1 village (2%) have nitrate concentration above 45 mg/L and below or equal to 50 mg/L which is above the maximum permissible limit prescribed by WHO.

12 villages (24%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L .In 1 villages (2%) nitrate concentration in ground water is equal to 101mg/L and below or equal to 150 mg/L. In the entire study no village falls in category V.

3. **Chomu Tehsil:** The results of fluoride and nitrate concentrations in ground water samples of Chomu tehsil is presented in Table -7.

Fluoride- The variation of fluoride concentration in ground water samples of study area is depicted in Figure -9. Figure- 10 depicts the percentage of villages with respect to above categories.

Table7. *Fluoride and Nitrate Concentration in Villages of Chomu Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate (mg/L)
1.	Bagadi	S1	0.42	26
2.	Kishanpura	S2	0.86	04
3.	Aashti Kalan	S3	0.6	30
4.	Aashti Khaurd	S4	1.6	22
5.	Khejaroli	S5	0.69	20
6.	Nangal Koju	S6	1.5	34
7.	Chak Laddu	S7	0.01	20
8.	Niwana	S8	1.7	06
9.	Dhola ka bas	S9	1.6	76
10.	Bawadi	S10	1.6	19
11.	Syau	S11	0.49	02
12.	Govindgarh	S12	0.63	20
13.	Malikpur	S13	0.83	14
14.	Charanwas	S14	1.5	62
15.	Sandarsar	S15	0.81	38
16.	Aalisar	S16	0.16	34
17.	Hasteda	S17	1.0	66
18.	Bawadi Gopinath	S18	1.5	18
19.	Thothasar	S19	3.3	02
20.	Nadya	S20	0.73	02
21.	Singod Khurd	S21	1.9	88
22.	Sabalpura	S22	1.1	08
23.	Jahota	S23	0.44	08
24.	Kaladera	S24	0.8	26
25.	Malikpur	S25	0.77	18
26.	Govindgarh	S26	0.98	22
27.	Aaiti Kalan	S27	1.7	60
28.	Mahor Kalan	S28	2.3	32
29.	Kaspura	S29	0.95	14

30.	Guwadi	S30	1.65	01
31.	Rampura	S31	0.5	76
32.	Nagal Purohitan	S32	0.2	77
33.	Khota Shyamdas	S33	0.2	70
34.	Ramalawala	S34	0.3	40
35.	Govindgarh	S35	0.7	01
36.	Rampura Dabari	S36	1.4	29
37.	Kanarpura	S37	0.9	78
38.	Guwardi	S38	0.81	06
39.	Dhahar Tankarda	S39	0.01	22
40.	Tankarda	S40	0.68	02
41.	Loharwada	S41	0.16	36
42.	Tigariya	S42	0.01	10
43.	Barwada	S43	0.29	186
44.	Kishanpura	S44	0.01	22
45.	Nangal Kalan	S45	0.27	154
46.	Shimbhupura	S46	0.57	16
47.	Dhoblai	S47	0.2	75
48.	Sigod Khurd	S48	0.1	24
49.	Malikpur	S49	0.25	50
50.	Ashti	S50	0.4	42

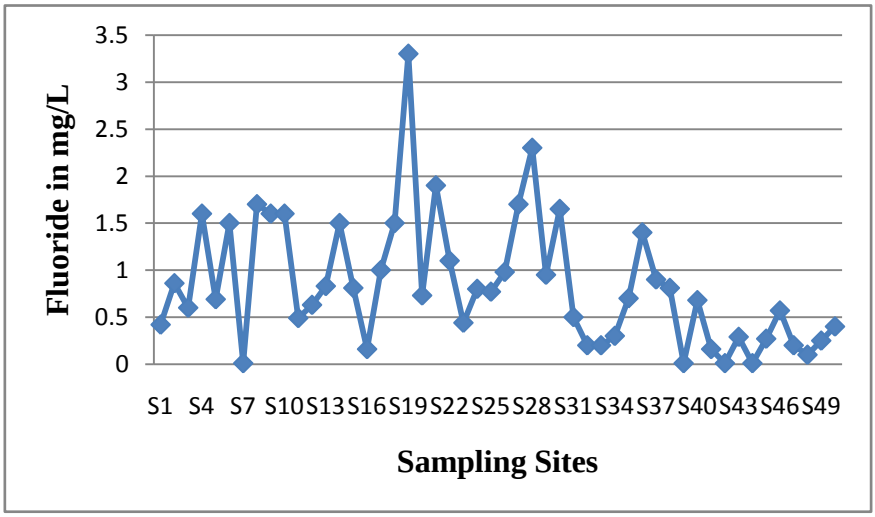

Fig9. *Variation in Fluoride (mg/L) with sampling sites of Chomu Tehsil*

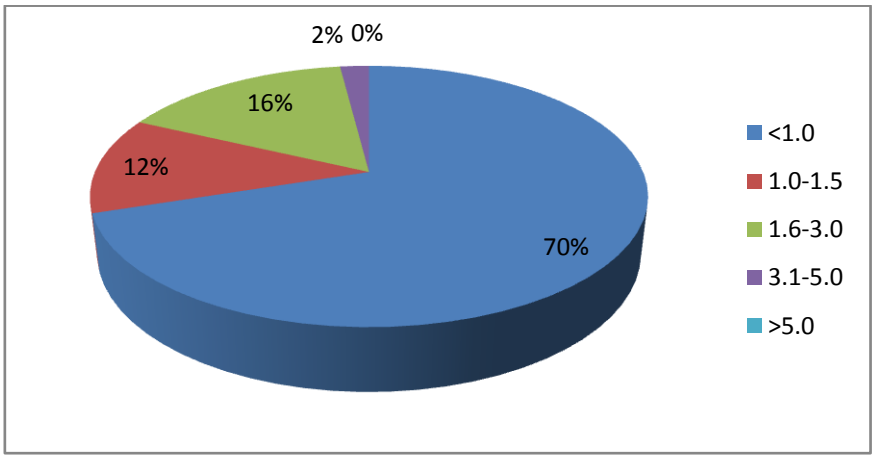

Fig10. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.01 to 3.3 mg/L in ground water samples, with lowest value 0.01 mg/L and highest value 3.3 mg/L (S19) in village Thothasar. The study reveals that out of 50 villages of Chomu Tehsil 35 villages (70%) have fluoride concentration below 1.0 mg/L. 6 villages (12%) are having fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L.

8 villages (16%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. In 1 village (2%) fluoride concentration in ground water is equal to 3.1mg/L and below or equal to 5.0 mg/L. In the entire study of Chomu tehsil there is no village falling in category V.

Nitrate- The variation of nitrate concentration in ground water samples of study area is shown in Figure -11 and Figure- 12 represents the percentage of villages with respect to above categories.

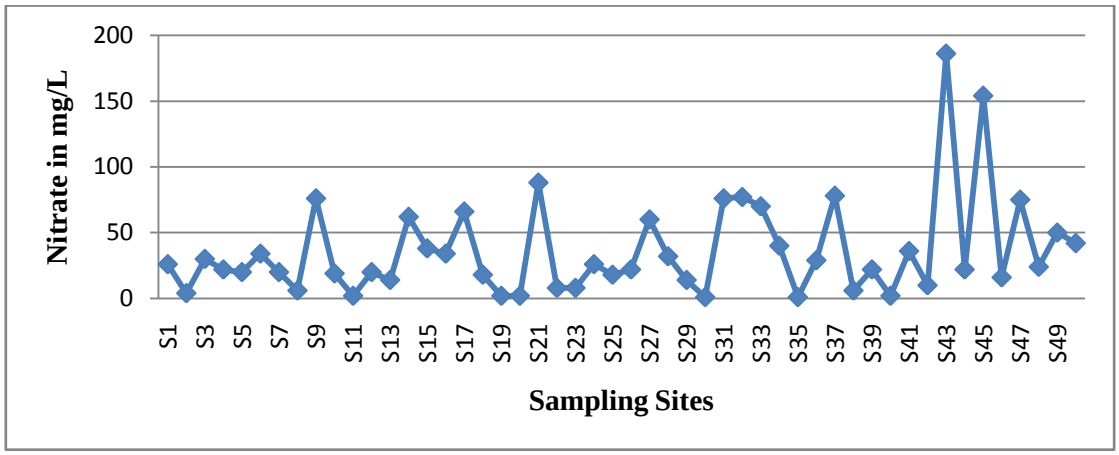

Fig11. *Variation in Nitrate (mg/L) with sampling sites of Chomu Tehsil*

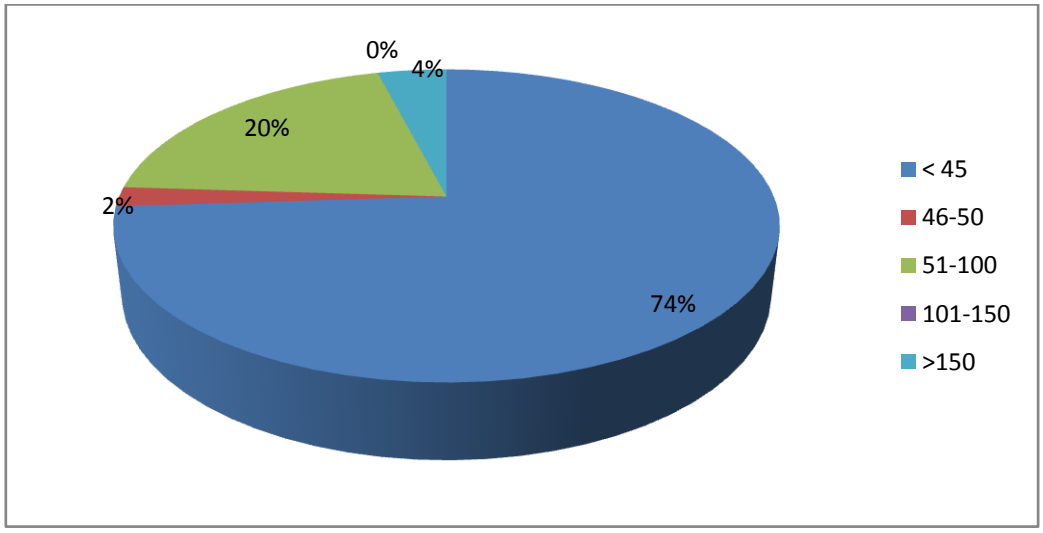

Fig12. *Percentage of Villages as per Nitrate Concentration Ranges*

Nitrate concentration in sampling sites ranges from 1 to 186 mg/L in ground water samples, with lowest value 1 mg/L (S30, S35) in village *Guwadi and Govindgarh* and highest value 186 mg/L (S43) in village *Barwada.* The study reveals that out of 50 villages of Chomu Tehsil 37 villages (74%) have nitrate concentration below 45 mg/L. 1 village (2%) is having nitrate concentration above 45 mg/L and below or equal to 50 mg/L which is above the maximum permissible limit prescribed by WHO.

10 villages (20%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L .There is no village exhibiting nitrate concentration equal to 101mg/L and below or equal to 150 mg/L. In the entire study 2 villages (4%) falls in category V, in these villages nitrate concentration is above 150 mg/L.

4. **Jamwa Ramgarh Tehsil:** The results of fluoride and nitrate concentrations in ground water samples of Jamwa Ramgarh tehsil is presented in Table -8.

Fluoride- The variation of fluoride concentration in ground water samples of study area is depicted in Figure -13. Figure- 14 shows the percentage of villages with respect to above categories.

Table8. *Fluoride and Nitrate Concentration in Villages of J. Ramgarh Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate (mg/L)
1.	Saipura	S1	0.4	32
2.	Jamwa Ramgarh	S2	1.48	19
3.	Sarpura	S3	0.73	64
4.	Phutala	S4	0.82	34
5.	Andhi	S5	0.65	26
6.	Jarund	S6	0.95	20
7.	Nakachi Ghati	S7	0.09	19
8.	Nai ki Thadi	S8	0.36	142
9.	Chainpura	S9	0.52	29
10.	Heerawala	S10	2.11	58
11.	Nayabas	S11	2.5	31
12.	Chavand ka Mand	S12	1.2	44
13.	Lali	S13	0.47	36
14.	Kharad Dam	S14	0.1	14
15.	Raiwala Dam	S15	0.1	06
16.	Mansagar Dam	S16	0.2	20
17.	Mansagar Nahar-I	S17	0.2	20
18.	Mansagar Nahar-II	S18	0.2	15

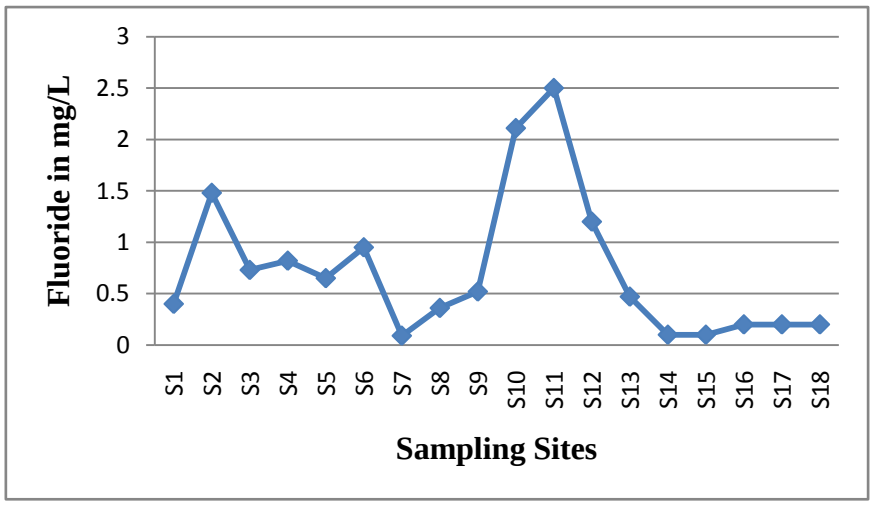

Fig13. *Variation in Fluoride (mg/L) with sampling sites of Jamwa Ramgarh Tehsil*

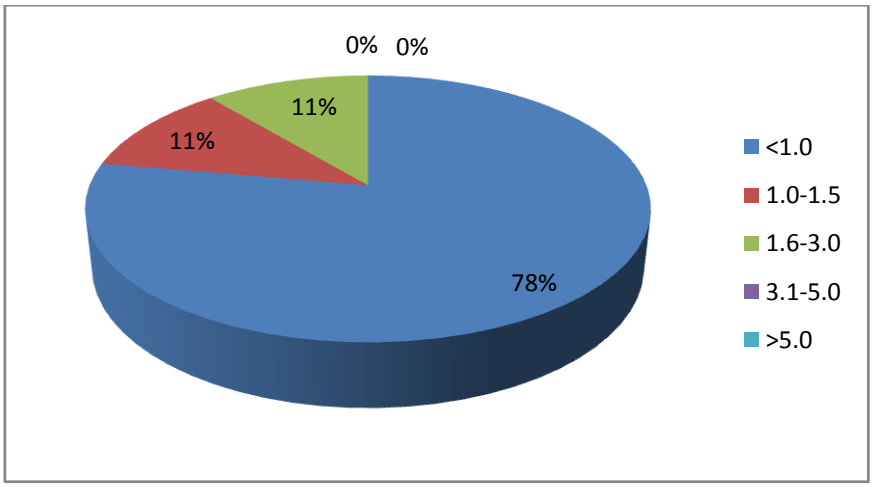

Fig14. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.1 to 2.5 mg/L in ground water samples, with lowest value 0.1 mg/L (S14, S15) and highest value 2.5mg/L (S11) in village Nayabas. The study reveals that out of 18 villages of Bassi Tehsil 14 villages (77.7%) have fluoride concentration below 1.0 mg/L. 2 villages (11.1%) have fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L.

2 villages (11.1%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. While there is not any water sample exhibiting the fluoride concentration range of category IV and V.

Nitrate- The variation of nitrate concentration in ground water samples of study area is depicted in Figure -15 and Figure-16 represents the percentage of villages with respect to above categories.

Nitrate concentration in sampling sites ranges from 6 to 142 mg/L in ground water samples, with lowest value 6 mg/L (S15) in *Raiwala Dam* and highest value 142 mg/L (S8) in *Nai ki Thadi*. The study reveals that out of 18 villages of *Jamwa Ramgarh* Tehsil 15 villages (83.3%) have nitrate concentration below 45 mg/L. 2 villages (11.1%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L. In 1 village (5.5%) nitrate concentration in ground water is equal to 101mg/L and below or equal to 150 mg/L. In the entire study there is not any water sample falling in Category II and V.

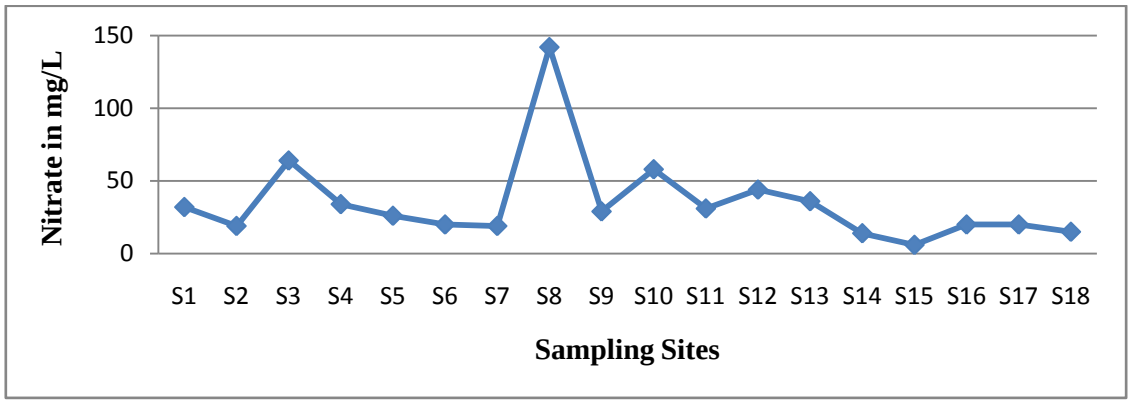

Fig15. *Variation in Nitrate (mg/L) with sampling sites of Jamwa Ramgarh Tehsil*

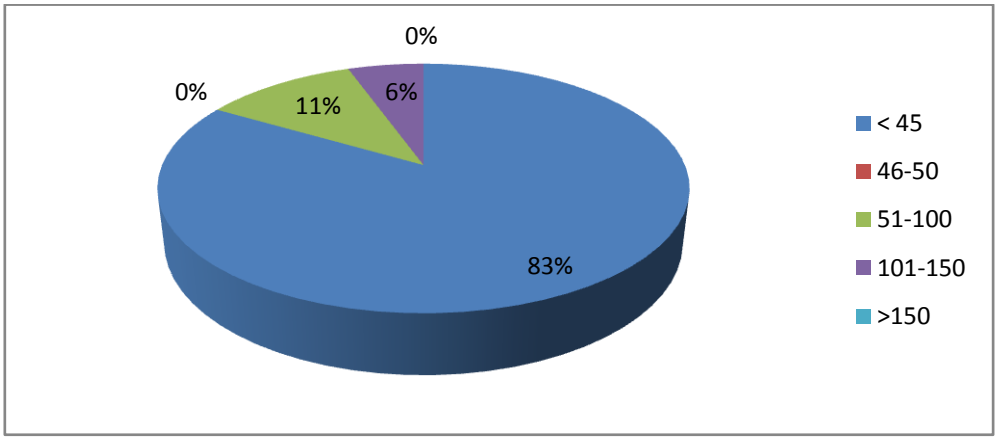

Fig16. *Percentage of Villages as per Nitrate Concentration Ranges*

5. **Kotputali Tehsil:** The results of fluoride and nitrate concentrations in ground water samples of Kotputali tehsil is presented in Table -9.

Fluoride- The variation of fluoride concentration in ground water samples of study area is represented in Figure - 17. Figure- 18 depicts the percentage of villages with respect to above categories.

Table9. *Fluoride and Nitrate Concentration in Villages of Kotputali Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate (mg/L)
1.	Banethi	S1	1.6	02
2.	Kayampura Bas	S2	2.6	148
3.	Kheda Nihalpura	S3	1.2	08
4.	Kansali	S4	0.5	45
5.	Malpura	S5	0.29	02
6.	Khadab	S6	0.83	02

7.	Naval Kushalpura	S7	1.3	22
8.	Beri	S8	0.82	20
9.	Naurangpura	S9	2.2	134
10.	Bhojabas	S10	2.7	284
11.	Basai	S11	0.58	310
12.	Sadabas Rural	S12	0.75	140
13.	Bachhadi Rural	S13	0.59	28
14.	Shekhupur	S14	0.69	12
15.	Khedaki Makkad	S15	0.48	64
16.	Chaturbhuj	S16	0.46	54
17.	Gopipura	S17	0.73	22
18.	Khadab	S18	0.89	132
19.	Kotputali	S19	0.95	14
20.	Pawata	S20	0.95	125
21.	Habaru	S21	0.8	04
22.	Bhuri Doongari	S22	0.86	09
23.	Bhawas	S23	1.76	36
24.	Aantela	S24	1.44	34
25.	Pragpura	S25	0.47	25
26.	Sundarpura	S26	0.2	03
27.	Bakharana	S27	1.1	01

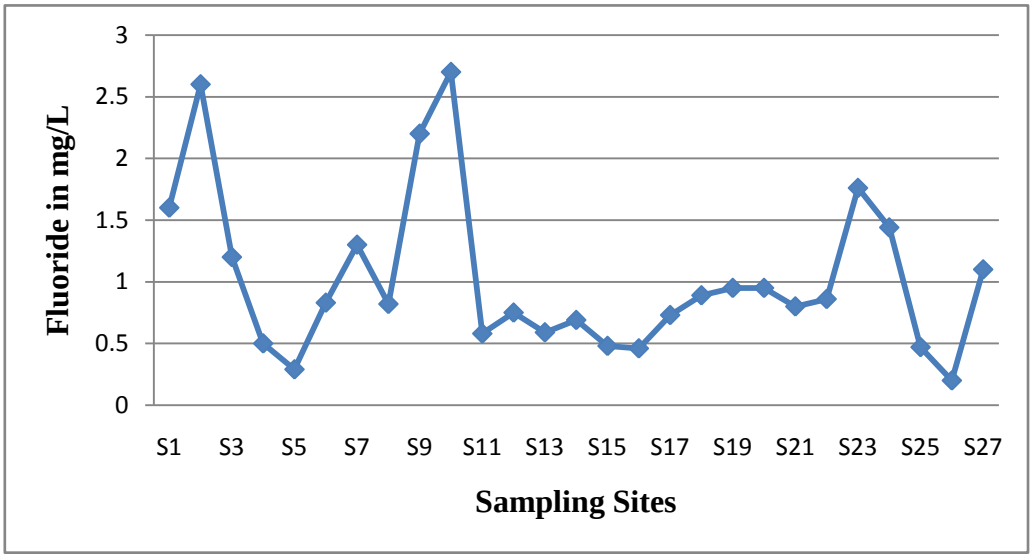

Fig17. *Variation in Fluoride (mg/L) with sampling sites of Kotputali Tehsil*

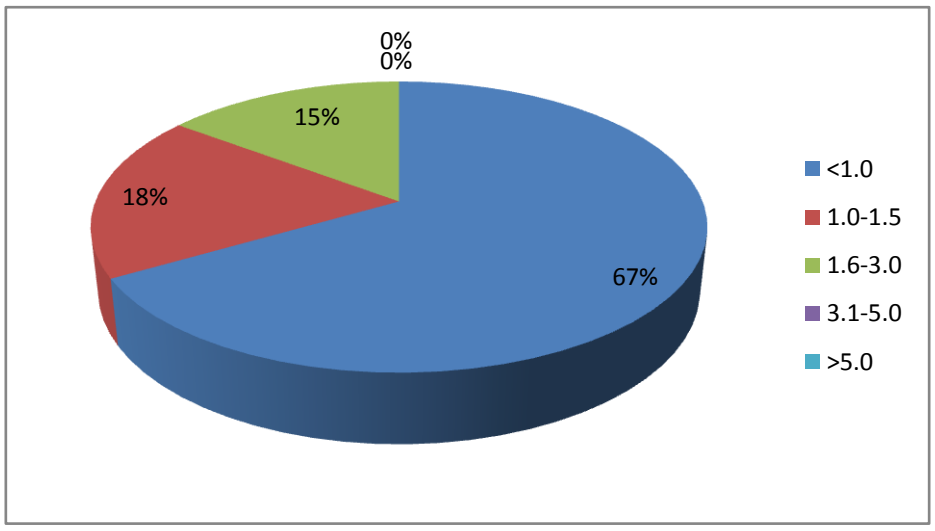

Fig18. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.2 to 2.7 mg/L in ground water samples, with lowest value 0.1 mg/L (S14, S15) and highest value 2.5mg/L (S10) in village Bhojabas. The study reveals that out of 27 villages of Bassi Tehsil 18 villages (66.6%) have fluoride concentration

below 1.0 mg/L. 5 villages (18.5%) have fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L.

4 villages (14.8%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. In the entire study of Kotputali tehsil there is no village falling in category IV and V.

Nitrate- The variation of nitrate concentration in ground water samples of study area is exhibited in Figure -19 and Figure-20 shows the percentage of villages with respect to above categories.

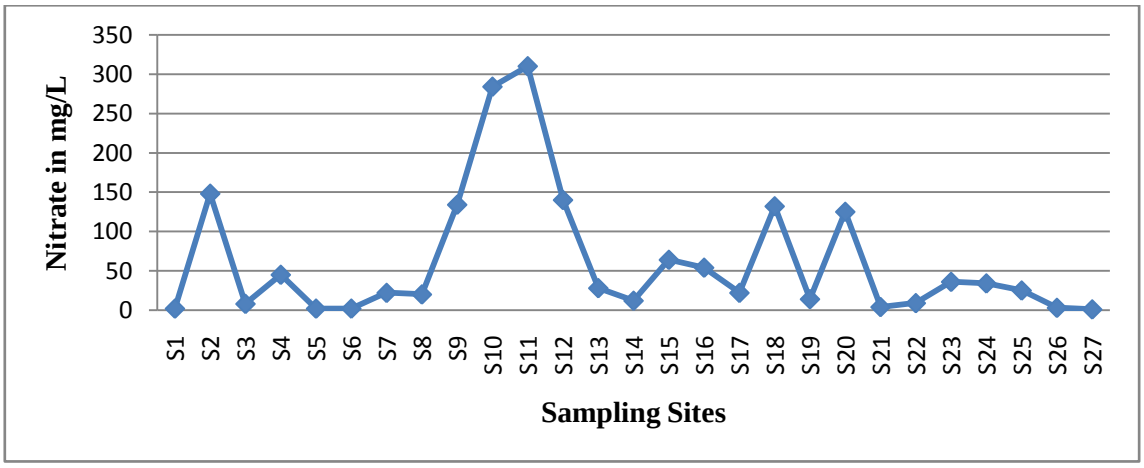

Fig19. *Variation in Nitrate (mg/L) with sampling sites of Kotputali Tehsil*

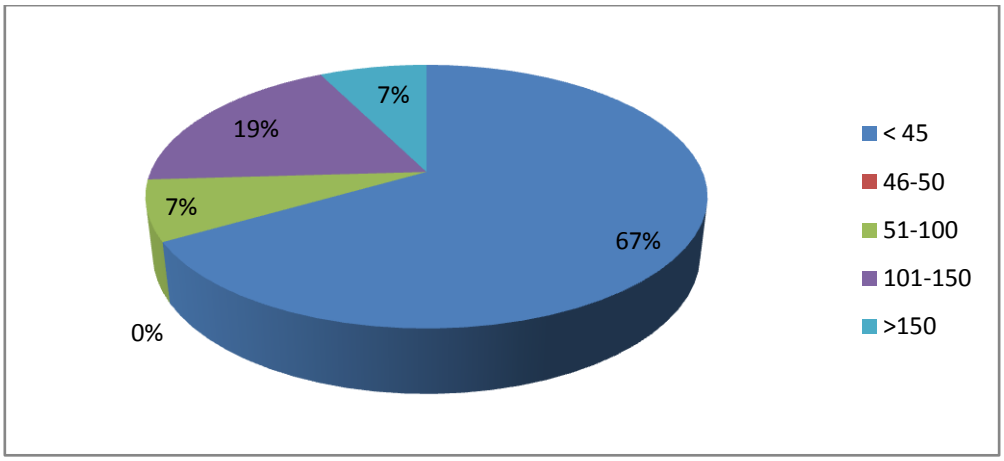

Fig20. *Percentage of Villages as per Nitrate Concentration Ranges*

Nitrate concentration in sampling sites ranges from 1 to 310 mg/L in ground water samples, with lowest value 1 mg/L (S27) in village *Bakharana* and highest value 310 mg/L (S11) in village *Basai*. The study reveals that out of 27 villages of Kotputali Tehsil 18 villages (66.6%) have nitrate concentration below 45 mg/L. No village is having nitrate concentration above 45 mg/L and below or equal to 50 mg/L which is above the maximum permissible limit prescribed by WHO.

2 villages (7.4%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L .In 5 villages (18.5%) nitrate concentration in ground water is equal to 101mg/L and below or equal to 150 mg/L. In the entire study 2 villages (7.4%) falls in category V, in these villages nitrate concentration is above 150 mg/L.

6. **Shahpura Tehsil:** The results of fluoride and nitrate concentrations in ground water samples of Shahpura tehsil is presented in Table -10.

Fluoride- The variation of fluoride concentration in ground water samples of study area is depicted in Figure -21. Figure- 22 depicts the percentage of villages with respect to above categories.

Table10. *Fluoride and Nitrate Concentration in Villages of Shahpura Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate (mg/L)
1.	Manoharpur	S1	0.73	126
2.	Shahpura	S2	2.1	59
3.	Gunawata	S3	0.58	80
4.	Bedhawadi	S4	0.91	79
5.	Lawana	S5	0.55	143
6.	Bhuri ki Doongari	S6	1.69	19
7.	Manoharpura	S7	1.09	285
8.	Amarsar (Dhavali)	S8	1.1	50
9.	Amarsar (Nayan)	S9	1.0	26
10.	Amarsar (Hanutpura)	S10	1.7	74
11.	Nithala	S11	1.4	02
12.	Ghasipura	S12	1.8	01
13.	Mahar Khurd	S13	2.4	30
14.	Buchara Dam	S14	0.2	09
15.	Lobdabas	S15	0.3	74
16.	Lakhani	S16	0.2	16
17.	Bhanipura	S17	0.3	71
18.	Amarpura	S18	0.5	45
19.	Devipura	S19	0.4	280
20.	Saiwad	S20	0.5	188
21.	Radhunathpura	S21	0.4	45
22.	Badijodi	S22	0.8	58
23.	Ramchandrapura	S23	1.2	04
24.	Jasvantpura	S24	0.9	24
25.	Nathawala	S25	0.5	39
26.	Chimanpura	S26	0.6	33
27.	Shiv Singhpura	S27	1.0	23
28.	Majipura	S28	0.8	24
29.	Gulab Badi	S29	0.95	07
30.	Jagatpura	S30	0.7	19
31.	Aamloda	S31	0.7	23
32.	Devipura	S32	0.4	58
33.	Saibad	S33	0.68	60
34.	Raghunathpura	S34	0.85	22
35.	Lobadabas	S35	0.8	33

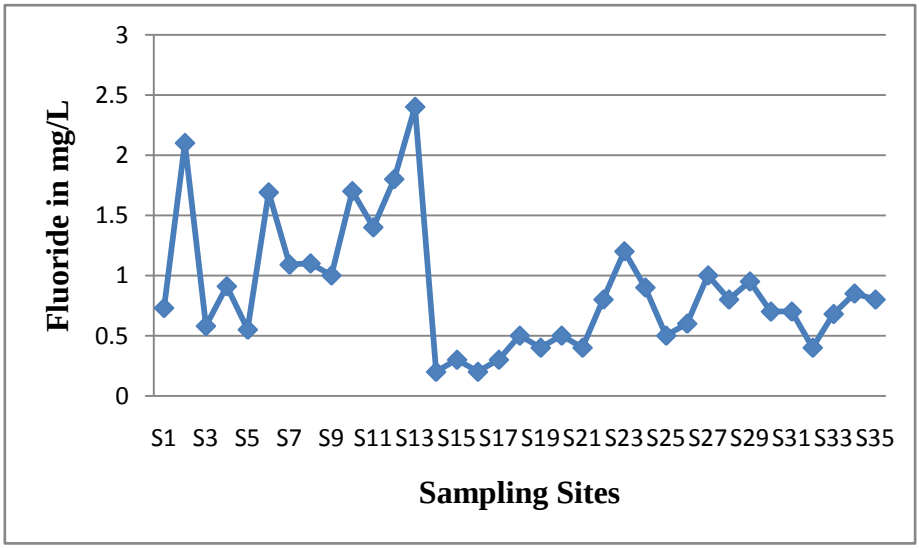

Fig21. *Variation in Fluoride (mg/L) with sampling sites of Shahpura Tehsil*

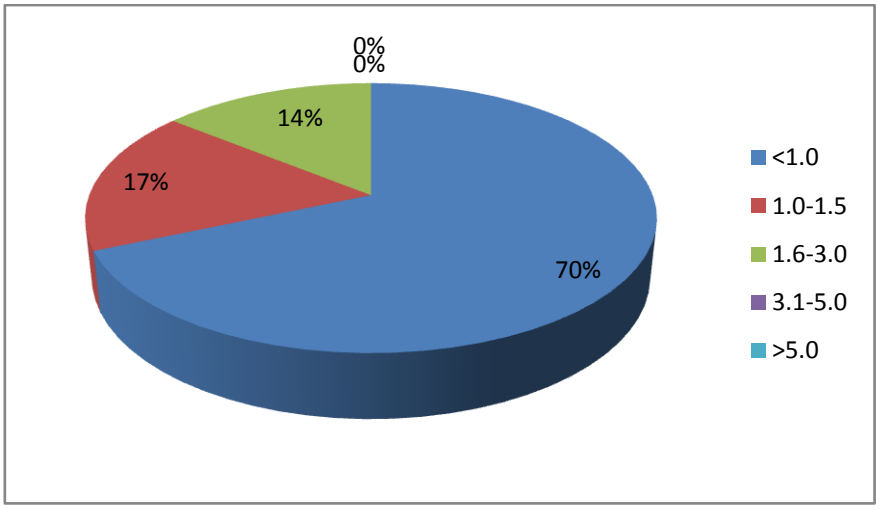

Fig22. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.2 to 2.4 mg/L in ground water samples, with lowest value 0.1 mg/L (S14, S16) and highest value 2.4mg/L (S13) in village Mahar Khurd. The study reveals that out of 35 villages of Shahpura Tehsil 24 villages (68.5%) have fluoride concentration below 1.0 mg/L. 6 villages (17.3%) have fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L.

5 villages (14.2%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. In the entire study of Shahpura tehsil there is no village falling in category IV and V.

Nitrate- The variation of nitrate concentration in ground water samples of study area is represented in Figure -23 and Figure-24 exhibits the percentage of villages with respect to above categories.

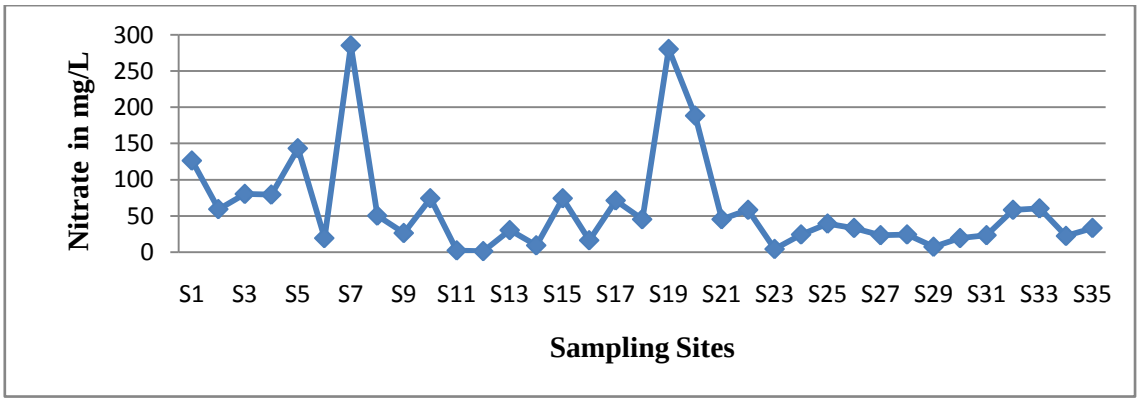

Fig23. *Variation in Fluoride (mg/L) with sampling sites of Shahpura Tehsil*

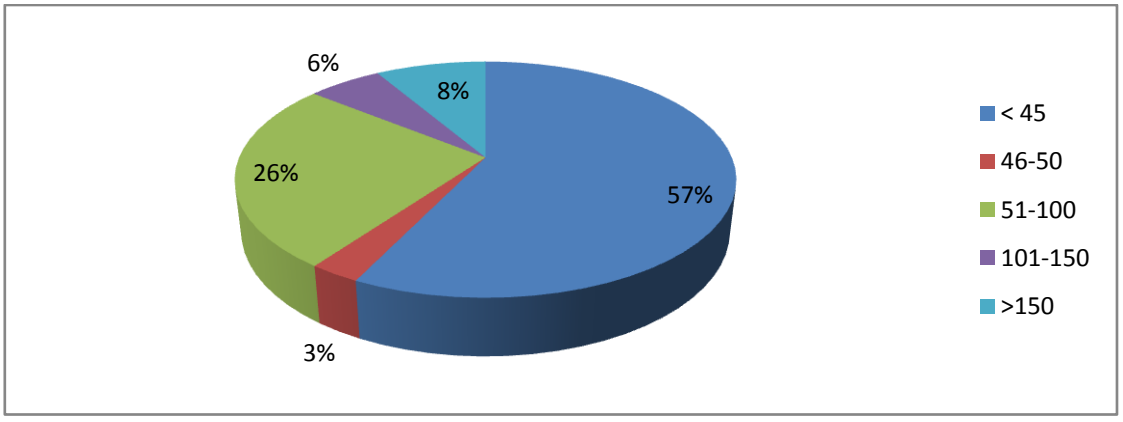

Fig24. *Percentage of Villages as per Fluoride Concentration Ranges*

Nitrate concentration in sampling sites ranges from 1 to 285 mg/L in ground water samples, with lowest value 1 mg/L (S12) in village *Ghasipura* and highest value 285 mg/L (S7) in village *Manoharpura.* The study reveals that out of 35 villages of Shahpura Tehsil 20 villages (57.1%) have nitrate concentration below 45 mg/L. 1 village (2.8%) is having nitrate concentration above 45 mg/L and below or equal to 50 mg/L which is above the maximum permissible limit prescribed by WHO.

9 villages (25.7%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L .In 2 villages (5.7%) nitrate concentration in ground water is equal to 101mg/L and below or equal to 150 mg/L. In the entire study 3 villages (8.5%) falls in category V, in these villages nitrate concentration is above 150 mg/L.

7. Virat Nagar Tehsil: The results of fluoride and nitrate concentrations in ground water samples of Virat Nagar tehsil is presented in Table -11.

***Fluoride*-** The variation of fluoride concentration in ground water samples of study area is depicted in Figure -25. Figure- 26 depicts the percentage of villages with respect to above categories.

Table11. *Fluoride and Nitrate Concentration in Villages of Virat Nagar Tehsil (Jaipur, Rajasthan, India)*

S.No.	Sampling Site	Code of Sampling Site	Fluoride (mg/L)	Nitrate (mg/L)
1.	Bilwadri	S1	0.2	132
2.	Aamaloda	S2	0.6	06
3.	Jogipura	S3	0.24	53
4.	Beelwadi	S4	0.24	21
5.	Tevadi	S5	0.46	87
6.	Dhani Sevaran	S6	0.4	03
7.	Bhairupura	S7	0.5	02
8.	Naurangpura	S8	0.6	08
9.	Kukadela	S9	0.54	12
10.	Bhamod	S10	0.46	11
11.	Paladi	S11	0.6	368
12.	Shyampura	S12	0.9	136
13.	Maid	S13	0.66	16
14.	Mahasingh ka bas	S14	4.0	06
15.	Badshahpur	S15	1.8	01
16.	Sodhana	S16	0.6	02
17.	Badshahpur	S17	0.46	42
18.	Jaisinghpura	S18	0.65	96
19.	Luhakana Khurd	S19	0.22	20
20.	Surajpura	S20	0.34	198
21.	Luhakana Kalan	S21	0.28	30
22.	Chhitoli	S22	0.4	66
23.	Chhid	S23	0.65	37
24.	Malibada	S24	0.3	65
25.	Purawala	S25	0.26	69
26.	Kheda	S26	0.6	10
27.	Bilbadi	S27	0.3	22
28.	Chatarpura	S28	0.2	37
29.	Jawanpura	S29	0.2	44
30.	Bhabru	S30	0.6	39
31.	Dhani Geskan	S31	0.8	55
32.	Antela	S32	0.3	49
33.	Neelka	S33	0.7	16
34.	Rampura	S34	0.1	06
35.	Hanuman Nagar	S35	0.1	45
36.	Bharampur	S36	0.3	10
37.	Lakhawala	S37	0.2	04
38.	Jadu ka bas	S38	0.2	133
39.	Raghunathpura	S39	0.2	167
40.	Jaisinghpura	S40	0.2	64
41.	Bhagatpura	S41	0.4	27
42.	Bagabas Ahiran	S42	0.2	17
43.	Taliyara	S43	0.2	21

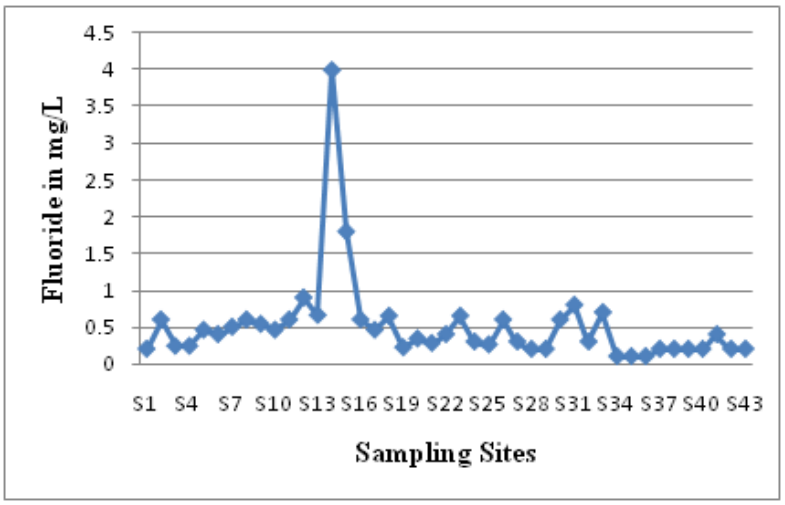

Fig25. *Variation in Fluoride (mg/L) with sampling sites of Virat Nagar Tehsil*

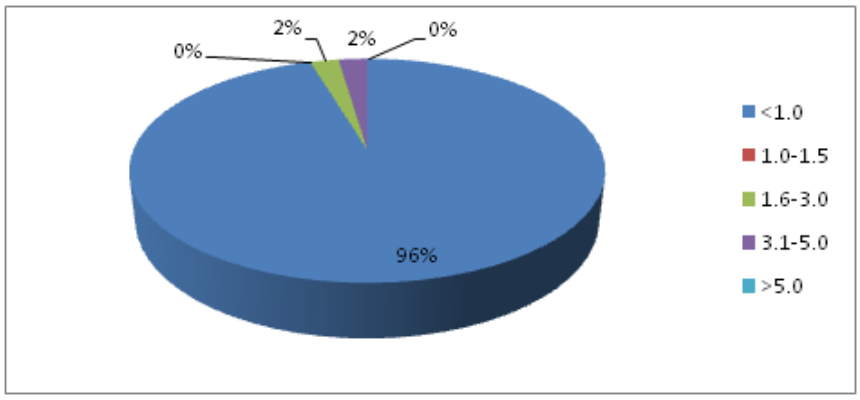

Fig26. *Percentage of Villages as per Fluoride Concentration Ranges*

Fluoride concentration in tehsil ranges from 0.1 to 4.0 mg/L in ground water samples, with lowest value 0.1 mg/L (S34, S35, S36) and highest value 4.0 mg/L (S14) in village Mahasingh ka bas. The study reveals that out of 43 villages of Virat Nagar Tehsil 41 villages (95.3%) have fluoride concentration below 1.0 mg/L. While there is not any water sample having fluoride concentration above 1.0 mg/L and below or equal to 1.5 mg/L.

1 village (2.32%) have ground water with fluoride concentration equal to 1.6 mg/L and below or equal to 3.0 mg/L which is above the maximum permissible limit prescribed by BIS and WHO. In 1 village (2.32%) fluoride concentration in ground water is equal to 3.1mg/L and below or equal to 5.0 mg/L In the entire study of Virat Nagar tehsil there is no village falling in category V.

Nitrate- The variation of nitrate concentration in ground water samples of study area is depicted in Figure -27 and Figure-28 shows the percentage of villages with respect to above categories.

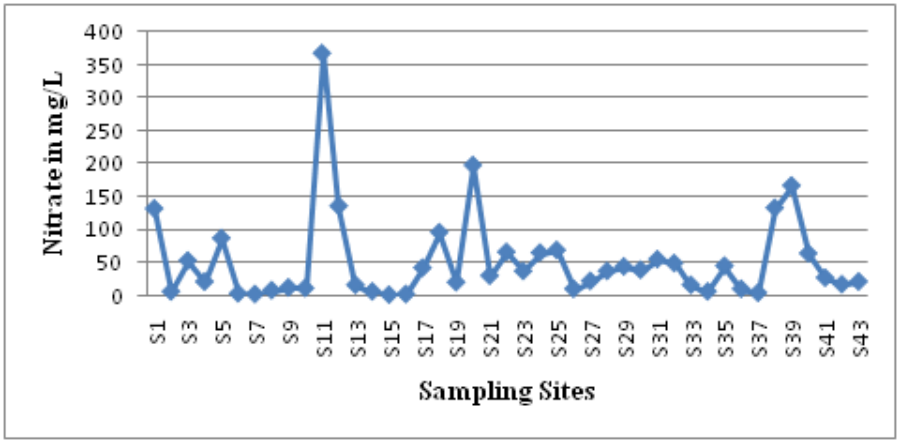

Fig27. *Variation in Nitrate (mg/L) with sampling sites of Virat Nagar Tehsil*

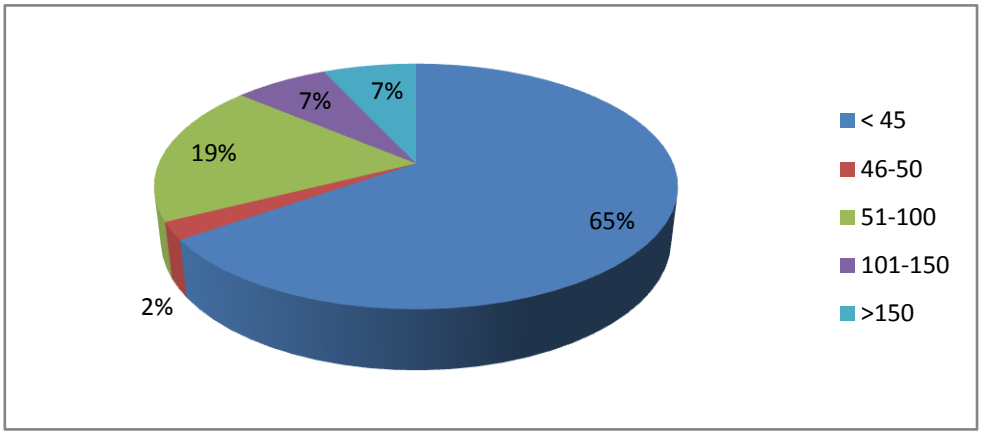

Fig28. *Percentage of Villages as per Nitrate Concentration Ranges*

Nitrate concentration in sampling sites ranges from 1 to 368 mg/L in ground water samples, with lowest value 1 mg/L (S15) in village *Badshahpur* and highest value 368 mg/L (S11) in village *Paladi.* The study reveals that out of 43 villages of Virat Nagar Tehsil 28 villages (65.1%) have nitrate concentration below 45 mg/L. 1 village (2.3%) is showing nitrate concentration above 45 mg/L and below or equal to 50 mg/L which is above the maximum permissible limit prescribed by WHO.

8 villages (18.6%) have ground water with nitrate concentration equal to 51 mg/L and below or equal to 100 mg/L .In 3 villages (6.9%) nitrate concentration in ground water is equal to 101mg/L and below or equal to 150 mg/L. In the entire study 3 villages (6.9%) falls in category V, in these villages nitrate concentration is above 150 mg/L.

3.3. Sources of Fluoride

The presence of fluoride in ground water can be attributed to geological reasons. (Ashok Kumar Yadav et al. 2009) 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 shown in Table-12. These minerals are commonly associated with the country rocks through which the ground water percolates under variable temperature conditions. Besides these minerals, alkali rocks, hydrothermal solutions, phosphate fertilizers, burning of coal, manufacturing process of aluminium, steel and bricks may also contribute to higher concentration of fluoride in groundwater.

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. (Ashok Kumar Yadav et al. 2009; Tailor & Chandel 2010; Singh P et al. 2011; Hussian et al. 2012;)

Table12. *Source of Fluoride in Ground Water*

Minerals	Chemical Composition
1. Fluorite (Fluorspar)	CaF_2
2. Fluorapatite	$Ca_5(F,Cl)PO_4$
3. Micas	
Biotite	$K(Mg\ Fe^{+2})_3(AlSi_3)O_{10}(OHF)_2$
Muscovite	$KAl_2(AlSi_3O_{10})(OHF)_2$
Lepidolite	$K_2(Li,Al)_5(Si_6Al_2)O_{20}(OHF)_4$
4. Amphiboles	
Hornblende	$NaCa_2(Mg\ Fe^{+2})_4(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$
Tremolite Actinolite	$Ca_2(Mg\ Fe^{+2})_5(Si_8O_{22})\ (OHF)_2$
5. Topaz	$Al_2SiO_4(OHF)_2$
6. Rock Phosphate	$NaCa_2(MgFe^{+2})_4(AlFe^{+3})(SiAl)_8O_{22}(OHF)_2$

3.4. Effects of Fluoride on Human Health

Fluoride in drinking water has both positive and negative effects on human health. Low levels of fluoride in drinking water results in incorporation of fluoride in to teeth during the formative years of children, which makes the teeth resistant to decay and development of dental caries.(Tailor and Chandel, 2010) But, high intake of fluoride causes both short term and long term effects. Acute high level exposure to fluoride causes immediate abdominal pain, excessive salivation, nausea and vomiting. Seizures muscle spasms, muscle fibrillation and numbness of mouth may also occur.(Singh P et al. 2011) Long term effect of excess fluoride through water, appear to create fluorosis which manifests itself as dental, skeletal and non- skeletal fluorosis.

In dental fluorosis, excessive fluoride usually causes yellowing of teeth, white spots, and pitting or mottling of enamel. The natural shine or lustre of the teeth disappears. In the early stage, the teeth appear chalky white and then gradually become yellow, brown or black. The discoloration will be horizontally aligned on the tooth surface as "lines" away from the gums. Dental fluorosis affects both the inner and outer surface of the teeth. The disease has mostly cosmetic implications and has no treatment.

Excessive fluoride intake may also result in slow, progressive crippling scourge known as skeletal fluorosis. It causes pain and damage to bones and joints. Skeletal fluorosis affects the bones/skeleton of the body. Skeletal fluorosis can affect both young and old alike. One can have aches and pain in the joints. The joints which are normally affected by skeletal fluorosis are neck, hip, shoulder and knee, fluoride mainly gets deposited in these joints and makes it difficult to walk and movements are painful. Rigidity or stiffness of joints also sets in. (Beg, 2009) At advanced stage vertebrae may fuse together and a victim may be crippled. (Meenakshi and Maheshwari, 2006)

Apart from bones and teeth an excess intake of fluoride can damage or impart ill effects on other soft tissues, organs and systems also, categorised as non-skeletal fluorosis. A review by earlier workers reveals that almost all systems of body including muscle, liver, kidney, blood, cardiovascular and even reproductive, are affected. The symptoms include gastro-intestinal complaints, loss of appetite, pain in stomach, constipation followed by intermittent diarrhoea. Muscular weakness and neurological manifestations leading to excessive thirst tendency to urinate more frequently are common among the afflicted individuals. Cardiac problems may arise due to cholesterol production. Repeated abortions or still birth, male infertility due to sperm abnormalities are also some of the complications. (Tailor and Chandel, 2010; Singh P et al, 2011)

3.5. Nitrate and Human Health

Nitrate (NO_3^-) contamination of the groundwater is mainly due to the intensive use of fertilizers. Leaching of nitrate to groundwater is due to excessive application of N- fertilizer, the absence of proper soil and water management practices, septic tanks, improper disposal of domestic wastes.

Nitrate content in groundwater serves as a basis for detecting pollution. High nitrate levels found in drinking water have been proven to be the cause for numerous health conditions across the world such as gastrointestinal cancers, methaemoglobinaemia, alzheimer's disease, vascular dementia, multiple sclerosis in human beings. Nitrate contamination leads to Eutrophication of water bodies (Sunitha et al.,2012).

Ingested nitrites and nitrates also have a potential role in developing cancers of the digestive tract through their contribution to the formation of nitrosamines. In addition, some scientific evidences suggest that ingested nitrites and nitrates might result in mutagenicity, teratogenicity and birth defects, contribute to the risks of non-Hodgkin's lymphoma and bladder and ovarian concerts, play a role in the etiology of insulin dependent diabetes mellitus and in the development of thyroid hypertrophy, or cause spontaneous abortions and respiratory tract infections. Indirect health hazards can occur as a consequence of algal toxins causing nausea, vomiting, diarrhea, pneumonia, gastroenteritis, hepatoenteritis, muscular cramps and several poisoning syndromes. Other indirect health hazards can also come from the potential relationship between inorganic nitrogen pollution and human infectious diseases (Malaria, cholera Camargo and Alonso, 2006). Nitrate contamination is a long-term problem and remedial action is necessary.(Susiladevi et al, 2010)

4. CONCLUSION

This study provides an overview of the fluoride and nitrate contamination status of ground water of Bassi, Amer, Chomu, Jamwa Ramgarh, Kotputali, Shahpura and Virat Nagar Tehsils of Jaipur and show that almost in every tehsil, there is the problem of high fluoride and nitrate concentrations to some extent but there is an acute fluoride problem in Bassi Tehsil as only 36% of ground water samples have fluoride content with in the permissible limit (> 1.5 mg/L, WHO) and remaining 64% of villages are having very high fluoride concentrations. Out of these 7 tehsils the lowest fluoride contamination level is in Virat Nagar Tehsil as 95.3% water samples have fluoride concentration within the permissible limit. The favourable factor which contributes to rise of fluoride in ground water is presence of fluoride rich rock salt system.

The nitrate contamination is highest in *Shahpura* Tehsil as 42.7% villages are exhibiting the nitrate concentration beyond the permissible limit and contamination is least in *Bassi* Tehsil as 84% water samples are having nitrate concentration within the permissible limit. The highest nitrate value is found in Virat Nagar Tehsil and it is up to 368 mg/L, which is far beyond the permissible limit. The prime sources of nitrate enrichment are leaching from the sewage effluents being utilized extensively for irrigation, leakage from sewerage systems, septic tanks and natural drains carrying municipal wastes, and application of fertilizers.

The results of current study indicate that the drinking water, used by the people residing in villages of these Tehsils, is not potable. So, the 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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REFERENCES

[1] APHA (1991). Standard methods for the examination of water and wastewater (17thed.), Washington, DC: American Public Health Association.

[2] APHA (2005). Standard Methods for the Examination of Water and Waste Water (21th ed.). Washington DC: American Public Health Association.

[3] Arif, M. Hussain, I. Hussain, J. Sharma, S. And Kumar, S. 2012. Potential Fluoride Contamination in the Drinking Water of Nagaur Tehsil of Nagaur District, Rajasthan, India, Bulletin of Environmental Contamination & Toxicology (BECT)" (DOI 10.1007/s00128-012-0572-4 Online Published on 14 March, 2012)

[4] Arif, M. Hussain, I. Hussain, J. Kumar, S. 2012. Fluoride Distribution in Ground Water and Survey of Dental Fluorosis in Villages of Didwana Tehsil of Nagaur District of Central Rajasthan, India. India Water Week2012- Water, Energy and Food Security.

[5] Ayoob, S., & Gupta, A. K. (2006). Fluoride in drinking water: A review on the status and stress effects. Critical Reviews in Environmental Science and Technology, 36, 433–487. doi:10.1080/10643380600678112.

[6] Beg, M.K.,(2009). Geospatial Analysis of Fluoride Contamination in Ground Water of Tamnar Area, Raigarh District, Chhattisgarh State. Thesis submitted in ITC and IIRS.

[7] Brown, E., Skougstad, M. W., & Fishman, M. J. (1974). Method for collection and analysis of water sample for dissolved minerals for dissolved minerals and gases (Book No. 5). Washington, DC: US Department of Interior.

[8] Bureau of Indian Standard (BIS) (1991). Indian standard specification for drinking water (pp. 2–4). Delhi: BIS, IS 10500.

[9] Bureau of Indian Standards, 1999. Indian Standards Drinking Water Specifiation: New Delhi. IS: 10500.

[10] Camargo, J.A. and A. Alonso, 2006. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. *Env. Int.*,32: 831-849.

[11] Canter, L.W., (1987): Nitrates in groundwater from agricultural practices-causes, prevention and clean up. July 1987, Report to United Nations Development Program, University of Oklahoma, Norman, Oklahoma.

[12] Central Ground Water Board, Ministry of Water Resources, Government of India, (2007). Ground Water Scenario, Jaipur District, Rajasthan, CGWB, Jaipur.

[13] Chouhan, S. & Flora, S. J. S. (2010). Arsenic and Fluoride: Two Major Groundwater Pollutants, Indian J Experimental Biology, 48:666-678.

[14] Gautam, R., Bhardwaj, N., Saini, Y. (2011). Study of Fluoride Content in Ground Water of Nawa Tehsil in Nagaur, Rajasthan. Journal of Environmental Biology, 32(1): 85-89.

[15] Godfrey, S., Wate, S., Kumar, P., Swami, A., Rayalu, S., & Rooney, R. (2006). Health-based risk targets for fluorosis in tribal children of rural Madhya Pradesh. In India 32ndWEDC international conference. Colombo, Sri Lanka, 2006.

[16] Hamilton A.P. and Shedlock J.R., Are fertilizers and pesticides in the groundwater. A case study of the Delmarve Peninsula, Delaware, Maryland, Virginia, VSGS circular, 1080, p.1-16 (1992).

[17] Hussain, I., Hussain, J., Sharma, K. C., & Ojha, K. G. (2002). Fluoride in drinking water and health hazardous: Some observations on fluoride distribution Rajasthan. In Environmental Scenario of 21st Century (pp. 355–374). New Delhi: APH.

[18] Hussain, J., Sharma, K. C., & Hussain, I. (2004a). Fluoride in drinking water and its ill affect on Human Health: A review. Journal of Tissue Research, 4(2), 263–273.

[19] Hussain J, Hussain J. And Sharma K.C. 2010 Fluoride and Health hazards: Community Perception in a fluorotic area of Central Rajasthan(India) An arid environment, Environmental Monitoring and Assessment, 162:1-14 (2010).

[20] Hussain I, Arif M, Hussain J. 2011. Fluoride Contamination in Drinking water in Rural Habitations of Central Rajasthan, India, Environmental Monitoring and Assessment (DOI: 10.1007/s10661-011-2329-7) Online Published on 20 September, 2011).

[21] Jaipur Development Authority, (2012). Master Development Plan-2025, Jaipur Region (Vol. 1), JDA, Jaipur.

[22] Khaiwal, R., & Garg, V. K. (2007). Hydro-chemical survey of groundwater of Hisar City and assessment of defluoridation methods used in India. Environmental Monitoring and Assessment, 132(1–3), 33–43. doi:10.1007/s10661-006-9500-6.

[23] M. Susiladevi, K. Pugazhendy, K. Jayachandran and C. Jayanthi. (2010). Nitrate contamination in ground water of Cuddalore Town, Tamil Nadu, India. International Journal of Recent Scientific Research. 4: 97-101.

[24] Malik S., and Banerji S., Nitrate pollution of ground water as a result of agriculture developmentin Indo-Gango Plain, India, In: proc; Int.symp.on Quality of Groundwater the Nether lands, (1981).

[25] Meenakshi and Maheshwari, R.C., 2006. Fluoride in Drinking Water and its Removal. Journal of Hazardous Materials, 137(1):456-463.

[26] Mosier A.R., Nutr.Cycl. Agroecosyst, 63: p.101-106 (2002).

[27] Mueller D.N., Hamilton P.A., Helsel D.R., Hitt K.J., Reddy B.C., (1995). Nutrients in ground water and surface water of the united states – an analysis or data through 1992, water- resources investigations report 95-4031, United State Geological Survey, Denver.

[28] Mueller D.K. and Helser D.R., Nudrienty in the nation's water- too much of a good thing? U.S.Geological Survey circular 1136, United States Geological Survey, Denver, (1996).

[29] Sabal, D., Khan, T.I. (2008). Fluoride Contamination Status of Ground Water in Phulera Tehsil of Jaipur District, Rajasthan. J. Environ. Biol., 29(6): 871-876.

[30] Saxena, U., Saxena, S., (2013). Study of Fluoride Contamination Status of Ground Water in Bassi Tehsil Of District Jaipur, Rajasthan, India. International Journal of Environmental Sciences, 3(6):2251-2260.

[31] Saxena, U., Saxena, S., (2014). Ground water quality evaluation with special reference to Fluoride and Nitrate contamination in Bassi Tehsil of district Jaipur, Rajasthan, India. International Journal of Environmental Sciences, 5(1):144-163.

[32] Sharma, K. C., Arif, M., Hussain, I., & Hussain, J. (2007). Observation on fluoride contamination in groundwater of district Bhilwara, Rajasthan and a proposal for a low cost defluoridation technique. In The XXVIITH conference of the international society for fluoride research (ISFR XXVII), 9–12 October, 2007. Beijing, China.

[33] Singh, B., Gaur, S. And Garg, V.K. (2007): Fluoride in Drinking Water and Human Urine in Southern Haryana, India, J. Hazard. Mater. 144:147–151.

[34] Singh, P., Rani, B., Singh, U. And Maheshwari, R.(2011): Fluoride Contamination in Ground Water of Rajasthan and its Mitigation Strategies. Journal of Pharmaceutical and Bio-medical Sciences. 6(6):1-12.

[35] State Institute of Health and Family Welfare, (2008). Report on Fluorosis, SIHFW, Jaipur.

[36] Sunitha, V. and B. Rajeswara Reddy, (2006): Nitrate contamination in groundwater of Urvakonda, and surrounding areas, Anantapur district, Andhra Pradesh, *J. Appl. Hydrol.*, XIX(1&2): 111-120.

[37] SunithaV., Reddy B. Rajeswara, Reddy M. Ramakrishna. 2012. Ground Water Quality Evaluation with special reference to Fluoride and Nitrate Pollution in Uravakonda, Anantapur District, Andhra Pradesh– a case Study. International Journal of Research in Chemistry and Environment. 2(1): 88-96.

[38] Tailor, G.S., Chandel Singh, C.P. (2010). To Assess the Quality of Ground Water in Malpura Tehsil (Tonk, Rajasthan, India) with emphasis to Fluoride Concentration. Nature and Science. 8(11): 20-26.

[39] WHO, 1983. Guidelines to drinking water quality, World Health Organization, Geneva.

[40] World Health Organisation, (1994). Fluorides and Oral Health, (Technical Report Series No. 846), World Health Organisation, Geneva.

[41] World Health Organization, Fluorides and human health., Monogr. Ser. 59, 1970, World Health Organization Publ., WHO, Geneva.

[42] WHO, 2006. WHO Guidelines for drinking-water quality First addendum to third edition, World Health Organisation, Vol. 1.

[43] Yadav, A.K., Khan. P., Saxena.U. Geo-chemical observation of fluoride in ground water of Tonk (Rajasthan).Rasayan J.Chem .2009; 2 (4):994-1000.

[44] Yadav, R.K., Gautam, R., Saini, Y., Singh, A. (2012). Determination of fluoride content in Drinking Water in Vicinity Areas of Dausa District, Rajasthan, India. IJSN. 3(1): 176-179.

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