Original Research Article **Allied science**

International Journal of Pharma and Bio Sciences **ISSN 0975-6299**

GROUND WATER QUALITY ASSESSMENT OF RURAL HABITATION AT MEHAM BLOCK, ROHTAK, HARYANA (INDIA): FOCUSED ON FLUORIDE AND NITRATE

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ABSTRACT

The present study was carried out to find the ground water quality of Meham Block Rohtak, Haryana (India) with special focus on fluoride and nitrate. Fifty seven samples of ground water (well, tube well and hand pump) from nineteen villages were collected during January 2014. The samples were analysed for physico-chemical characteristics, viz., electric conductivity (EC), total dissolved solids (TDS), pH, nitrate (NO_3^-), fluoride (F^-), total hardness (TH), total alkalinity (TA), cations (sodium, potassium, calcium and magnesium) and anions (chloride, sulphate, bicarbonate and carbonate). The pH and EC varied from 7.11-8.63 and 210 – 4578 µmho cm^{-1}, respectively. Seventeen samples showed EC above highest permissible limit given by WHO. TDS was fluctuated from 134-2930 mg l^{-1}. In the present study pH, sulphate ions (SO_4^{2-}), chloride (Cl^-), calcium (Ca^{+2}), potassium (K^+) and magnesium (Mg^{+2}) of the analysed samples were below the WHO highest permissible limits, whereas sodium in 9%, bicarbonate in 30% and total hardness in 43% samples were above the highest permissible limit. The nitrate in 32% samples showed the excess concentration than prescribed limit. Fluorides in 86% samples were above the highest permissible limit given by WHO (1.5 mg l^{-1}). On the bases of fluoride concentration it is concluded that ground water of the area is not suitable for drinking purpose.

KEYWORDS: **Ground water quality, Fluoride, Nitrate and Drinking water.**

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INTRODUCTION

The ground water chemistry is controlled by the interaction with the aquifer minerals through which it flows. The chemical composition of ground water with respect to time and space depends upon the hydrogeochemical processes, which are responsible for alteration of water chemistry. Ground water in any area has unique chemistry due to soil/rock-water interaction during recharge and ground water flow[1,2]. The chemical characteristics of ground water play an important role in classifying and assessing water quality. Geochemical studies of groundwater provide a better understanding of possible changes in water quality[3]. Ground water can be contaminated through leaks and spills at factories, improper hazardous waste disposal, leachate from landfills, salts and chemicals used to deice roads, fertilizers, animal wastes, radioactive elements and by mining[4]. The major chemical related problems of ground water in India are high fluoride, salinity, and arsenic content[5]. Excess nitrate in drinking water may cause harmful biological effects. Agriculture farming alone pollutes more of our groundwater resources than anything else, because too many farmers are caught up in an escalating cycle of pollution[6]. Nitrate problem is world widely present, many studies have been carried out on nitrate concentration in ground water from different part of the world, California, Iowa (USA), UK, Senegal and Dar-es-Salaam, Tanzania[7-10].Fluoride is another contaminant in ground water, which cause determinant health effect on human being and other living organisms. Fluoride is essential for normal maintenance of teeth and bones. However, prolonged exposure to high concentration of fluoride is found to be deleterious to teeth, bones and other organs[11]. Groundwater is the major drinking water source in the villages of Meham block. Some researcher analysed the ground water quality from the Haryana state. But no one assessed the ground water of Meham block, Rohtak. Main objective of present study was to explore the ground water quality of Meham block, district Rohtak, Haryana (India) with special focus on fluoride and nitrate.

MATERIALS AND METHODS

Description of study area

Rohtak district of Haryana lies between 28º40': 29º 05' N latitudes and 76º13': 76º 51'E longitudes and 220 meters above mean sea level. District geographical area is 1745 sq.km. There are five blocks in Rohtak, Meham is one of them. Location and map of study area shows in Fig. 1 and Fig. 2. The study area extends over the Meham block which is situated on the north- west of the district Rohtak. This block has a rural area of 36977 hectares. Due to good network of canals, the region has shown great progress in the field of agriculture. The climate is ideal for agricultural development, particularly for wheat, rice, sugarcane and cotton crops. Normal annual rainfall is 592 mm and normal monsoon rainfall is 499 mm. Temperature varies from 3◦C (January) to 45◦C (May and June).The sediments consist of sand, slit, clay, gravel and kankar. The soil texture varies from sandy to clay having heterogenous composition with frequent calcium carbonate layers at shallower depths. The soil is coarse to fine loam in texture in most of the area[12].

Water sampling and Analysis

Fifty seven samples of ground water were collected during the month of January 2014 from 19 villages of Meham Block of District Rohtak, Haryana. From each village, three samples were collected by selecting one from each viz. tube well, well and hand pump. Electrical conductivity and pH were measured using Systonic soil and water testing kit at the sites. For the analysis of other parameters, samples were collected in clean Jerry canes and kept in an ice box and transported immediately to the laboratory. The water samples were filtered using a Millipore filtering system and analyzed according with Standard Methods of Examination of Water and Waste as prescribed by American Public Health Association[13]. The nitrate was measured colorimetric (mg l^{-1}) by using phenol disulfonic acid. Fluoride was determined by Sodium -2- (parasulfophenylazo)-dihydroxy-3,6 napthalene disulfonate (SPADNS) method.

RESULTS AND DISCUSSION

Geomorphology of an area largely influences the parameters of the groundwater. Soil of Meham block is loamy with coarse loam and alluvian. The present study involves the analysis of ground water of Meham block (Rohtak) with a view to evaluate the suitability for drinking purpose. The ground water depth was not very deep. Therefore, manually operated hand-pumps can be easily used for water extraction.

The pH, EC and TDS

The physico-chemical characteristics of ground water of Meham have been described in Table 1. The pH, EC and TDS values during present investigation varied from 7.1 (Kheri Meham) to 8.6 (Bharan), 210 µmho cm^{-1} (Ajaib) to 4578 µmho cm^{-1} (Bhaini Bharon) and 134 (Ajaib) to 2930 (Gurawar) mg l^{-1} for individual samples, where mean values (n=3 from each village) with standard deviation (SD) ranged from 7.5 ± 0.11 to 8.3 ± 0.24, 634 ± 367 to 4706 ±1165 µmho cm^{-1} and 405 ±235 to 2272 ± 565 mg l^{-1}, respectively. The groundwater in study area was found alkaline in nature. Two samples of ground water from study area showed the higher pH values than highest permissible limit (8.5) of WHO[14]. The drinking water quality is affected by the presence of different soluble salts[15]. More ionized matter increased conductance and vice –versa[16]. Sanchez-Perez and Tremolieres[17] concluded that the higher EC of the water is result of ion exchange and solubilisation in the aquifer. In 56% of studied samples, the electrical conductivity (EC) was above the prescribed limits of WHO[14]. The maximum permissible limits of TDS as prescribed by WHO is 1500 mg l^{-1}. On the consideration of TDS, 45% samples showed TDS above the permissible limit and rest samples 55% were well within the range. According to classification by Rabinove et al.[18] groundwater was non-saline in 28 groundwater samples, slightly saline in 28 samples, moderately saline in one sample (Table 2). The higher value of TDS is attributed due to application of agricultural fertilizers[19]. The higher concentration of TDS causes gastro-intestinal irritation to the human

beings, while the long time intake of water with the higher total dissolved solids can cause kidney stones and heart diseases[20].

Cations and Total Hardness

In present investigation Na^+ and K^+ varied from 15 (Bharan) to 314 mg l^{-1} (Sisar Khas) and 1 (Ajaib) to 137 mg l^{-1} (Madina Gindhran), respectively. Where range of mean values with SD were found from 49±26 to 284±59 mg l^{-1} and 1.67±1.15 to 69±52 mg l^{-1}, respectively (Table 1). Ca^{2+} and Mg^{2+} ions are important ions for total hardness of water. Ca^{2+} and Mg^{2+} values varied from 12.22 (Ajaib) to 191 mg l^{-1} (Bharan) and 0.24 (Madina Korsan) to 117 mg l^{-1} (Seman), while mean values with SD varied from 37±22 to 197±35 mg l^{-1} and 30±9 to 87±31 mg l^{-1}, respectively (Table 1). The sodium content in 9% of the evaluated samples is found to be more than its highest permissible quantity (200 mg l^{-1}) of WHO, while potassium, calcium, magnesium ions were within highest permissible limit. Water hardness has no known adverse effects. However, it causes more consumption of detergents at the time of cleaning and some evidence indicates its role in heart disease[21]. The total hardness (TH) varied from 140 (Ajaib) to 788 mg l^{-1} (Mokhara Khas) for individual samples, while mean values of TH of villages with SD ranged from 241±125 to 514±193 mg l^{-1}. Water having total hardness upto 500 mg/l is considered to be soft and it is highest permissible limit of WHO. Ground water samples of the present study found that 43% of the samples were crossing the maximum allowable content of total hardness.

Anions and Total Alkalinity

The sulphate (SO_4^{2-}) ion is one of the important anion present in natural water which produces catharsis, dehydration and gastrointestinal irritation effect upon human beings when it is present in excess of 150 mg/l. It is mainly derived from gypsum on oxidation of pyrites. The sulphide minerals add the soluble sulphate into the groundwater through oxidation process. In present investigation sulphate, chloride and bicarbonate values were found from 30 (Bharan) to 377 mg l^{-1} (Meham Rural), 14.2 (Bharan) to 247 mg l^{-1} (Bhaini Bharon) and 171 (Ajaib) to 957 mg l^{-1} (Kharkhara), respectively. While village mean with SD varied from 35±4.6 to 361±2.57 mg l^{-1}, 19±2.8 to 329±116 mg l^{-1} and 284±20 to 688±44 mg l^{-1}, respectively (Table 1). All the ground water samples shown the sulphate concentration within highest permissible limit (600 mg l^{-1}). Chloride concentration in present investigation was within highest permissible limit. Acceptable level of bicarbonate is 200 mg l^{-1}, which is extendable to 600 mg l^{-1} as a highest permissible limit given by WHO. Present study revealed that 30% samples exceed the highest permissible limit prescribed for bicarbonate. Carbonate ions were present only in 8 water samples with maximum concentration of 108 mg l^{-1}, rest of the samples showed its absence. Total alkalinity (TA) is sum of carbonate and bicarbonate alkalinity[22]. High concentrations of alkalinity causes unpleasant taste of water. The TA varied from 140 (Ajaib) to 784 mg l^{-1} (Khar Khara), where total alkalinity means of villages with SD varied from 232±17 to 564±36 mg l^{-1}. During the investigation it was observed that 4% showed the excess concentration of TA than highest prescribed limit (600 mg l^{-1}) of WHO.

Nitrate

Nitrates (NO_3^-) generally occur in trace quantities in surface water because nitrogenous materials are rare in geological system[23].The agricultural activities including nitrate fertilizer and nitrate derived from increased mineralization of soil through cultivation are also seemed to be the major source of nitrate in the groundwater and attain high levels[24,25]. Nitrate in low concentration is considered relatively non-toxic, but when taken in high nitrate concentration in drinking water, it can reduce the ability of blood to transport oxygen in infants. In babies, especially those under six months old its cause methaemoglobinaemia, commonly called blue-baby syndrome, can result from oxygen deprivation caused by drinking water high in nitrate. Death can occur in extreme cases. Other health problems associated with excessive nitrate are gastrointestinal cancers, alzheimer's disease, vasculardementia and multiple sclerosis in human beings. NO_3^- in present investigation varied from 1.2 (Kharkhara) to 95 mg l^{-1}(Madina Korsan) for individual samples. Nitrate mean values (n=3 from each village) of villages were; Ajaib (5.02 mg l^{-1}), Bahelbhan (3.61 mg l^{-1}), Bedwa (23.39 mg l^{-1}), Bhaini Bharon (19.69 mg l^{-1}), Bhaini Chanderpal (7.12 mg l^{-1}), Bharan (12.99 mg l^{-1}), Farmana Khas (72.28 mg l^{-1}), Farmana Maharajpur (86.19 mg l^{-1}), Gurawar (53.01 mg l^{-1}), Kharkhara (1.79 mg l^{-1}), Keri Meham (10.43 mg l^{-1}), Madina Korsan (92.14 mg l^{-1}), Madina Gindhran (35.81 mg l^{-1}), Mokhra Khas (14.72 mg l^{-1}), Mokhra Kheri (46.96 mg l^{-1}), Seman (22.74 mg l^{-1}), Sisar Khas (91.61 mg l^{-1}), Meham rural (2.77 mg l^{-1})and Nindana (61.21 mg l^{-1}), respectively. Mean values of villages with SD ranged from 1.79±0.79 to 92.14±3.28 mg l^{-1} (Table 3). Maximum mean nitrate concentration was observed in Madina Korsan followed by Sisar Khas and Farmana Maharajpur villages, it could be due to extensive agriculture of wheat and rice in which chemical fertilizer is used and water sampling sources were situated near agriculture fields. Point and non-point sources of NO_3^- in groundwater of study area could be N-fertilizer, geology of sub-surface soil layers, animal waste, organic manure, pit latrines etc. Results thus indicated that groundwater of this part of the Rohtak district is severely polluted due to anthropogenic activities. Nitrate in 32% ground water samples shown the excessive concentration than highest prescribed limit i.e., 50 mg l^{-1} of WHO. It is observed that 65% samples of groundwater contain nitrate upto 45mg l^{-1}, 30% samples showed nitrate range of 45 to 90 mg l^{-1} and 5% samples showed nitrate above 90 mg l^{-1} (Fig. 3). Nitrate results of present study were accordance with finding of Suthar et al. [26] evaluated the level of nitrate in some agro-economy based rural habitations of northern Rajasthan, India. They observed the NO_3^- level in groundwater from 7.10–82.0 mg l^{-1} for individual samples. Chaudhary et al.[27] also assessed the nitrate concentration of in ground water samples of different villages in Indira Gandhi, Bhakra, and Gang canal catchment area of northwest Rajasthan. They observed the range of nitrate in ground water samples from 0.0 to 278.68 mg l^{-1}.

Fluoride

Fluoride is important for the development of teeth and the bones. Phipps[28] suggested that small doses of fluoride have beneficial effects on the teeth by hardening the enamel and reducing the increase of caries. However, excessive intake of fluoride (more than 1.5 mg l^{-1}) results in dental and skeletal fluorosis[29-31].The maximum tolerance limit of fluoride in drinking water specified by the World Health Organization is 1.5 mg l^{-1}. The principal fluorine bearing minerals such as fluorite and fluorapatite are responsible for a high concentration of fluoride under normal pressure and temperature conditions. The factors that govern the distribution of fluoride in natural waters are dependent on amount of fluorine in the source rocks and soils, and the duration of contact of water with the rocks and soils[32,33]. As groundwater percolates through weathered rock into aquifers, it dissolves fluoride-bearing minerals, releasing fluoride into solution[34]. Study area consists of alluvial plains with sand, silt and clay. The fluoride varied in ground water samples from 0.5 (Mokhara Kheri) to 5.4 mg l^{-1} (Ajaib) for individual samples. Fluoride mean values of villages were; Ajaib (3.65 mg l^{-1}), Bahelbhan (3.35 mg l^{-1}), Bedwa (4.38 mg l^{-1}), Bhaini Bharon (3.66 mg l^{-1}), Bhaini Chanderpal (3.32 mg l^{-1}), Bharan (2.34 mg l^{-1}), Farmana (3.94 mg l^{-1}), Farmana Maharajpur (2.60 mg l^{-1}), Gurawar (1.54 mg l^{-1}), Kharkhara (2.97 mg l^{-1}), Keri Meham (3.26 mg l^{-1}), Madina Korsun (4.45 mg l^{-1}), Madina Gindhran (3.22 mg l^{-1}), Mokhra Khas (3.92 mg l^{-1}) Mokhra Kheri (2.34 mg l^{-1}), Seman (3.87 mg l^{-1}), Sisar Khas (3.77 mg l^{-1}), Meham rural (2.50 mg l^{-1}) and Nindana (2.67 mg l^{-1}), respectively (Table 3). Ranged of means (n=3 from each village) with SD between 1.54±0.94 to 4.45±1.7 mg l^{-1}. Acceptable level of fluoride is 1.0 mg l^{-1}, which is extendable to 1.5 mg l^{-1} in absence of alternative water resources as a highest permissible limit of WHO. The present study revealed that 86% groundwater samples exceed the highest permissible limit. Figure 4 shows that 14% samples upto 1.5 mg l^{-1}, while 26% samples were in the range of 1.5 to 3.0 mg l^{-1} and 60% samples were above the 3.0 mg l^{-1}, respectively. Main sources of natural fluorides in the study area are geological fluoride bearing minerals and excessive use of chemical fertilizers. Sequences of cations and anions in present investigation were Na> Ca> Mg> K and $HCO3^-$> SO_4^{2-}> Cl^-> NO_3^-> F^- , respectively. This indicated that sodium bicarbonate type of water present in study area. Range of pH in study area was from 7.1 to 8.6 for individual samples. Sodium biocarbonate water type with alkaline pH was the main contribute of high fluoride level in study area. Role of sodium bicarbonate with alkaline pH was further conformed by Saxena and Ahmed[35], they suggested that alkaline conditions with pH ranging between 7.6 and 8.6 are favourable for dissolution of fluorite mineral from the host rocks. The dietary fluoride allowances given by National Research Council are in the range of 0.1 to 1.0 mg/person/day for children under the age of one year; 0.5 to 1.5 mg/person/day for children between one and three; up to 2.5 mg/person/day for children under 12 and 1.5–4.0 mg/person/day for adults[36]. Water consumption in study area is approximately 2.5 liters per individual per day during the months of April to August. Fluoride intake through the drinking water in study area ranged from 1.25 to 13.5 mg/person/day. This indicating that most of individuals of study area taken excessive fluoride through the drinking groundwater than the recommended dietary fluoride limit for adults.

Table 1

Physico-chemical parameter (Averages of different villages) of ground water quality of Meham block, Rohtak

S.NO	Villages	pH	EC	TDS	Na^+	Ca^{2+}	Mg^{2+}	K^+	SO_4^{2-}	Cl^-	HCO_3^-	TA	TH
1	Ajaib	7.79[a]±0.59[b]	634±367	405±235	49.6±26.65	37.34±22.13	49.42±31.25	11.5±7.51	109±7.223	19.88±2.84	294±152	241±125	295±161
2	Bahelbhah	7.69±0.04	2558±1229	1637±786	121±69.94	109±45.91	46.99±35.10	17.00±13.75	153±9.591	62.48±12.37	451±73	387±31	465±159
3	Bedwa	7.64±0.26	1441±447	922±286.68	115±59.57	87.58±10.78	87.09±31.72	15.33±10.12	128±10.43	59.64±20.47	670±46	549±38	576±156
4	Bhaini Bharon	7.50±0.07	4706±1165	2007±1817	120±22.62	63.39±72.92	67.02±22.59	30.00±8.48	99.4±19.94	329±116	373±216	306±177	341±89.66
5	Bhaini Chanderpal	7.87±0.211	1146±309	733±198	53.33±24.78	57.37±24.99	60.40±18.84	14.67±17.79	84.9±17.64	27.45±8.19	404±149	331±122	391±97
6	Bharan	8.3±0.24	796±394	509±252	57±45.90	82.49±94.43	30.38±9.95	5.5±3.51	35.4±4.68	27.45±11.47	421±213	345±174	330±197
7	Farmana Khas	7.95±0.47	1581±1073	1012±686	151±131	60.42±26.89	66.84±36.23	14.00±6.00	131±1.823	61.53±28.72	556±178	479±162	425±215
8	Farmana Maharajpur	7.79±0.32	2064±1576	1321±1009	174±113	84.19±57.54	47.48±34.91	1.67±1.15	147±27.40	78.57±77.58	564±214	462±176	405±146
9	Gurawar	7.71±0.45	2923±1664	1871±1065	62.33±32.31	100±38.60	77.41±45.04	43.67±20.65	136±26.13	121±72.97	478±159	392±130	568±153
10	Khar Khara	7.81±0.71	2529±1533	1618±981	130±64.04	65.51±25.30	74.18±32.81	13.33±5.69	78.63±12.23	85.2±48.52	627±286	564±234	467±172
11	Kheri Meham	7.34±0.35	2997±995	1918±637	94±19.6	197±35.59	59.23±42.72	61.33±46.23	133±23.46	141±59.66	484±142	410±102	572±91
12	Madina Korsan	7.92±0.10	3550±882	2272±565	74±29.59	125±12.51	50.71±43.75	69.67±52.92	107±32.91	117±87.31	493±115	434±146	521±193
13	Madina Gindhran	7.75±0.33	1677±962	1073±615	284±59.43	60.76±37.17	50.63±44.75	52.00±73.70	85.63±24.95	87.09±77.58	688±44	564±36	359±270
14	Mokhra Khas	7.81±0.31	1618±860	1035±550	122±48.4	95.39±62.16	58.33±29.19	4.67±4.04	116±33.26	91.82±60.73	454±95	382±61	477±275
15	Mokhra Kheri	7.54±0.32	2108±1277	1349±817	83.66±51.86	91.99±17.94	68.30±24.60	41.00±45.64	128±21.86	96.56±108.25	515±54	422±44	510±145
16	Seman	7.64±0.59	1216±347	778.±222	142±67	72.98±19.49	69.27±53.26	34.00±38.97	154±26.92	44.49±42.72	507±148	472±91	466±247
17	Sisar Khas	7.34±0.11	2116±1110	1354±710	167±127	93.35±31.56	51.00±27.80	21.33±19.22	133±12.08	118±47.21	510±217	432±158	442±35
18	Meham rural	8.07±0.04	1967±1690	1249±1055	178±31.11	85.175±63.63	44.785±27.79	39.5±34.64	352±34.29	39.76±32.13	400±78.51	328±64.36	264±39.65
19	Nindana	7.88±0.21	1400±193	896±524	75.5±33.23	87.09±5.03	69.265±28.97	17±22.62	361±2.75	42.6±8.03	284±20.81	232±17.08	333±5.55
Overall Range		7.11-8.6	210-4578	134-2930	15-314	12.22-191	0.24-117	1-137	30.1-377	14.2-247	171-957	140-784	140-788

a represents mean value of village, b represent the standard deviation. All the parameters are in mg l^{-1} except pH and EC (µmho cm^{-1}) .Here EC- Electrical Conductivity, TDS- Total Dissolved Solids, TA- Total Alkalinity, TH- Total Hardness

Table 2
Classification of water samples on the basis of total dissolved salts.

Serial No.	Classification of ground water	Total dissolved salts Mg l^{-1}	No. of Samples
1	Non-saline	< 1000	28
2	Slightly Saline	1000-3000	28
3	Moderately Saline	3000-10000	1
4	Very Saline	> 10,000	Nil

Table 3
Fluoride and nitrate concentrations in ground water of Meham block, Rohtak.

	Fluoride		Nitrate	
Villages	Range (mg l^{-1})	Mean±SD (mg l^{-1})	Range (mg l^{-1})	Mean±SD (mg l^{-1})
Ajaib	0.98-5.49	3.65±2.36	2.23-6.87	5.02±2.46
Bahelbhah	3.08-3.69	3.35±0.30	3.32-4.12	3.61±0.45
Bedwa	3.45-4.91	4.38±0.80	17.58-27.84	23.39±5.26
Bhaini Bharc	3.04-4.29	3.66±0.88	14.49-23.89	19.69±4.78
Bhaini Chan	2.93-4.00	3.32±0.58	6.41-7.79	7.12±0.69
Bharan	1.48-3.03	2.34±0.79	12.37-13.40	12.99±0.54
Farmana Kh	2.97-5.39	3.94±1.27	70.52-74.07	72.28±1.78
Farmana Ma	1.43-3.31	2.6±1.02	82.72-88.68	86.19±3.09
Gurawar	0.78-2.60	1.54±0.94	47.72-57.34	53.01±4.88
Khar Khara	1.33-4.40	2.97±1.54	1.20-2.69	1.79±0.79
Kheri Mehar	2.31-4.20	3.26±0.94	9.85-10.71	10.43±0.50
Madina Kors	2.48-5.49	4.45±1.70	89.89-95.90	92.14±3.28
Madina Ginc	1.05-5.08	3.22±2.03	33.91-38.5	35.81±2.39
Mokhra Kha:	2.31-5.19	3.92±1.46	11.63-18.73	14.72±3.64
Mokhra Khei	0.57-3.73	2.34±1.61	41.42-52.76	46.96±5.68
Seman	2.18-6.21	3.87±2.09	18.90-28.01	22.74±4.72
Sisar Khas	2.55-5.28	3.77±1.38	87.14-91.79	91.61±5.53
Meham rura	2.28-2.72	2.50±0.31	2.69-2.86	2.77±0.12
Nindana	1.22-4.12	2.67±2.05	60.32-62.10	61.21±35.3

Figure 1
Study area location

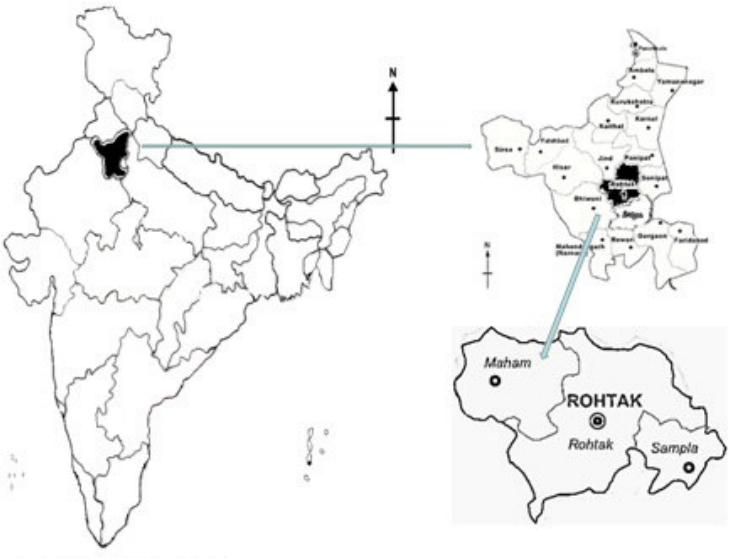


Figure 2
Map of Meham Block with sampling villages

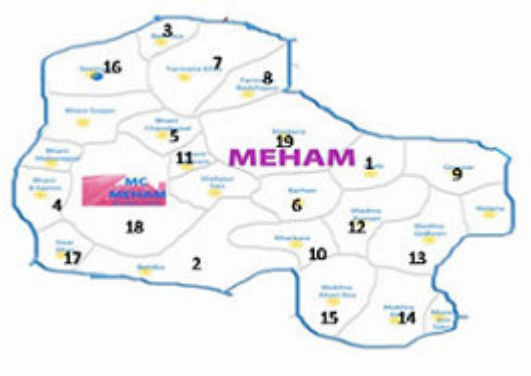


Figure 3
Nitrate ions (mg l^{-1})

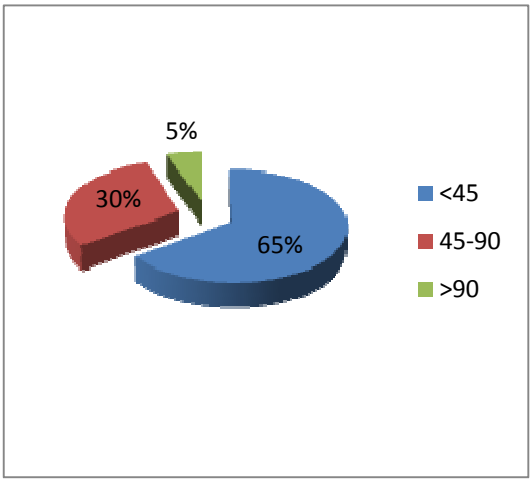
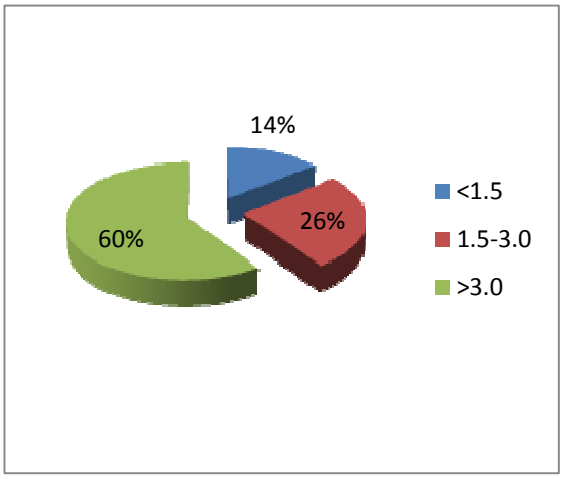


Figure 4
Fluoride ions (mg l^{-1})



CONCLUSION

In present study, a total of 57 samples were collected and analysed for various physico-chemical parameters governing the quality of groundwater. This study revealed that ground water is the only source for drinking water for the people residing in these areas. The physico-chemical parameters viz., pH, sulphate ions (SO_4^{2-}), chloride ions (Cl^-), calcium (Ca^{+2}), potassium (k^+) and magnesium (Mg^{+2}) in all the samples were below the WHO highest permissible limits. While sodium in 9%, bicarbonate in 30%, TDS in 45% and total hardness in 43% samples were above the highest permissible limit given by WHO. Nitrate in 32% samples shown the excess concentration of nitrate than prescribed. Fluoride level in 86% samples was above the highest permissible limit given by WHO. The study revealed that higher fluoride level could be due to higher concentration of sodium biocarbonate with alkaline pH. It can be concluded that the quality of ground water in Meham block was contaminated with high content of fluoride and nitrate and groundwater is severely affected by anthropogenic activities. Proper preventive measures are suggested to be taken in these villages to ensure the good quality of the water.

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