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Spatial and temporal distribution of Nitrate (NO_3^-) In groundwater of Rohtak municipality area.

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Abstract:- The contamination of ground water has increased with rapid urbanization, agricultural inputs and industrialization. In the last few decades the nitrate (NO_3^-) pollution is on the increase in the urban areas. Contamination of ground water with nitrate is mainly by the process of leaching due to high mobility of nitrate ions through soil. By mapping water quality using the decision support system like geographical information system (GIS), the data can be represented graphically in map and is useful for taking quick decision. The objective of present study was to monitor the spatial and temporal nitrate ion concentration in ground water of Rohtak city in pre monsoon, monsoon and post monsoon season of private ground water drinking sources, and graphical representation of data using GIS. The samples from the various colonies of Rohtak city showed nitrate range from 1.8 mg/l to 45mg/l. Most areas showed a ground water nitrate level within permissible limits of 45 mg/L (CPCB) how ever Village Samargopalpur had the highest nitrate concentration (79mg/L). Higher nitrate concentration was observed in area having history of agriculture use and open sewage, septic tanks, municipal solid waste and dairy waste dumps. In all the sampling sites the nitrate concentration was highest during the pre monsoon season.

Keywords:- Nitrate toxicity; methaemoglobinaemia; ground water; ERDAS,GIS
Abbreviations: CPCB – Central Pollution Control Board; GIS – Geographical Information System; AOI – Area of Interest; FCC- False color composite; GPS- Geographical positioning system.

I. INTRODUCTION

While nitrate is a common nitrogenous compound due to natural processes of the nitrogen cycle, anthropogenic sources have greatly increased the nitrate concentration, particularly in groundwater. Water from beneath the ground has been exploited for domestic use, livestock and irrigation since the earliest times. Groundwater is almost globally important for human consumption, and changes in quality can have serious consequences (Reddy *et al*., 2012). Water pollution not only affects water quality but also cause threats to human health, economic development, and social prosperity of a country (Milovanovi., 2007). Contamination of ground water has become a major challenge to environmentalist in the rapid developing countries. The quality of ground water has been distorted by rapid urbanization, agriculture and industrialization. In the last few decades the nitrate (NO_3^-) concentration in ground water is on the increase in the urban areas due to inadequate system to handle the huge amount of domestic sewage and organic waste generated. Nitrate is often considered to be a major threat to ground water quality because nitrate dissolves freely in water and is not held on the soil particles (Addiscott *et al*., 1991) due to its negative charge (Staufer, 1998). Contamination of ground water with nitrate mainly occurs by the process of leaching. Open sewage, septic tanks, solid waste, commercial fertilizers, domestic wastes and cow dung from dairies are the main sources of nitrate leaching. When nitrate concentration increase beyond standard level, it becomes harmful for living organisms. The protective enzyme systems present in red blood cells maintain methemoglobin levels less than 1% of total hemoglobin in healthy people. But exposure to excessive nitrate level (oxidizing agent) may accelerate the rate of formation of methemoglobin up to 1000 fold, overwhelming the protective enzyme systems and acutely increasing the methemoglobin level thus causing acquired methemoglobinemia or blue baby syndrome. Partial reduction of nitrates to nitrites in humans takes place in saliva for all ages and in the gastrointestinal tract in infants (6 months). Therefore babies up to 6 months of age are more susceptible since they transform 100% of ingested nitrates into nitrites, while only 10% is expected in adults and children. Nitrite act in the blood to oxidize the hemoglobin to methemoglobin, which is not an oxygen carrier to the tissues, with consequent anoxia (methemoglobinemia). In adults large concentration of nitrate in water may result the potential formation of the carcinogenic nitrosamines (Dezune., 1997). The physiological studies provide strong support indicating the association between nitrate contamination of drinking water and increased cancer rates. N-nitroso compounds has been associated with many types of cancers including tumors in bladder, stomach, brain, esophagus, bone, skin, kidney, liver, lungs oral and nasal cavities, pancreas, peripheral nerve system, thyroid, trachea, acute myeloid leukemia and lymphomas (Mirvish., 1995). High nitrate concentrations also have been linked to hypertension (Malburge, 1978), central nerve system birth defects (Dorch., 1984), non-Hodgkin's lymphoma (Ward *et al*., 1996; Weisenburger, 1991) and diabetes (Parslaw *et al*., 1997).

The use of GIS technology covers a wide range of applications (AhnHong and ChonHyo, 1999; Burrough, 1986). By mapping water quality using the decision support system like geographical information system (GIS), it is useful to take quick decisions based on geographical representation of the data. Given the health risks associated with nitrate contamination of groundwater, government agencies are concerned with the nitrate levels in public drinking water supplies.

The CPCB has set the health advisory level at 10ppm NO_3 -N or 45 ppm NO_3 for drinking water supplies. While the CPCB regulations safeguard public water supplies, private groundwater supplies are unregulated. Ground water is used as municipal water supply is erratic and in summer inadequate in quantity and hence public uses ground water as well. The objective of present study is to monitor the spatial and temporal nitrate ion concentration in ground water of Rohtak city in pre monsoon, monsoon and post monsoon season of private ground water drinking sources, and the possible cause of high concentration of nitrate.

II. MATERIALS AND METHODS

Study Area

Rohtak lies in south-east part of Haryana. Rohtak city is located between the $76^0$531'E to$76^0$690'E (Longitude) and $28^0$848'N to $28^0$941'N (Latitude) (Fig 1). The average elevation of Rohtak is 214 meter. Total Geographical area of Rohtak District is 1745 sq km and area under Municipal Corporation of Rohtak City is 104.10 sq km area (2011). The District area falls in Yamuna sub basin of Ganga basin and is mainly drained by artificial drain No-8 which flows from north to south (Khan, 2007). Population of city is 4,84,382 (MC Rohtak 2013).

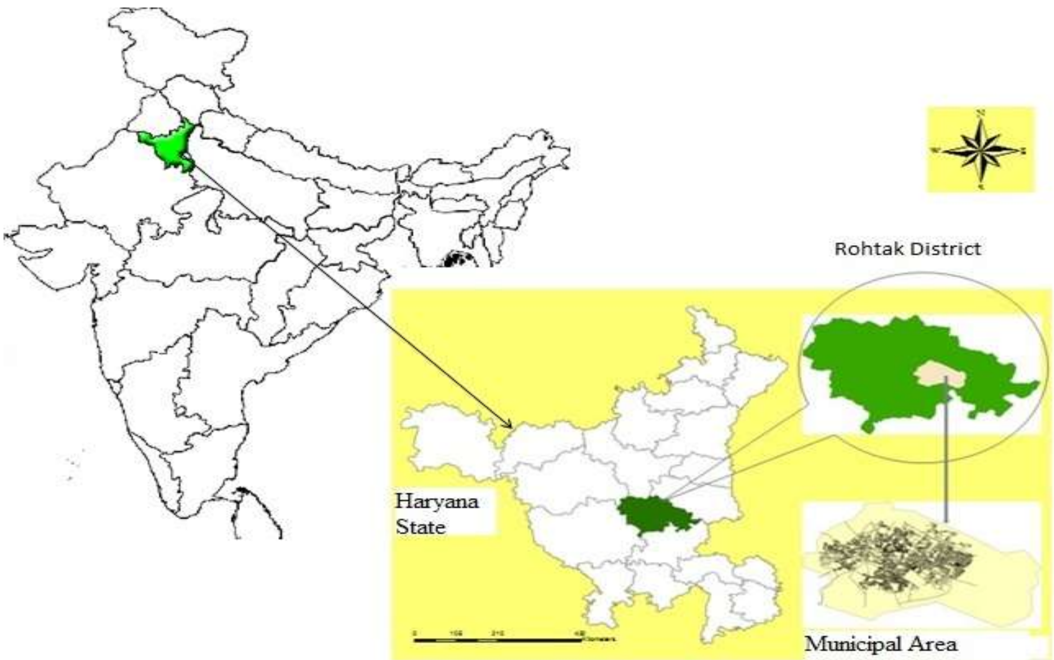

Fig.1 The study area

III. METHODOLOGY

Survey of India topographic sheet No. H43W9 at scale of 1:50,000 was used as a base map for the geo-referencing of guide map of municipal boundary, Google earth image and LISS-IV FCC image acquired in 2010. ERDAS 9.0 software was used for geo-referencing of spatial data. After geo-referencing area of interest (AOI) was generated. The sampling sites were selected by dividing the study area into grids of 1x1 Km size. Sampling was done from within the grids using GPS to register the locations. Number of samples taken from within each grid was dependent on the number of the different drinking water sources, sewerage network, solid waste dumps, dairies and habitation. At least one sample was taken from each grid. Samples were taken from hand-pumps used by in the people of the locality. Nitrate (NO_3^-) concentration in groundwater was determined by ultraviolet (UV) spectrophotometric method at 220 nm and 275 nm. Concentration of nitrate was calculated using a calibration graph prepared using KNO_3 (Maiti, 2001). Field survey on septic tanks, dairies, solid waste dumps and open drainage of the study area was done. Arc-Map GIS 9.3 software was used for digitization, integration, overlay and presentation of spatial and non spatial data. The flow chart of methodology is given Fig. 2.

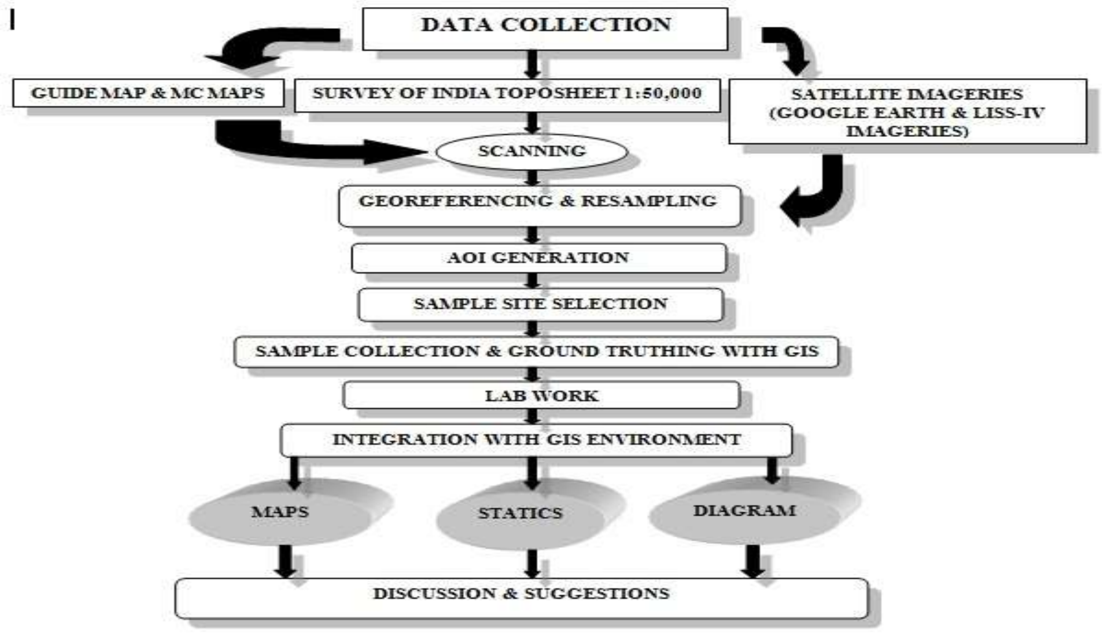

Fig. 2 Flow chart of the methodology used in the study.

IV. WATER SAMPLING

A total of 49 ground water samples from bore wells and hand pumps were collected. 32 from the selected residential colonies from the city and 17 from the nearby villages. The sampling was done for Pre Monsoon (March to June), Monsoon (July to September) and Post Monsoon (October to January). For the collection of water samples from bore well and hand pumps, water was pumped out for 5 minutes. Water samples were taken in polyethylene bottles after rinsing with the sample water. Coordinates of sampling sites were taken using Garmin etrex GPS.

V. RESULT AND DISCUSSION

The nitrate (NO_3^-) concentration was determined for 49 samples during the Pre Monsoon (March to June), Monsoon (July to September) and Post Monsoon (October to January) period is presented in Table 1 and 2. Nitrate level of different sampling locations was compared with standard permissible limit of 45 mg/L recommended by CPCB. Nitrate concentration was found to vary from 1.8 mgL^{-1} to 79 mgL^{-1} in Pre Monsoon season, 0.1 mgL^{-1} to 40 mgL^{-1} in monsoon season and 0.4 mgL^{-1} to 41 mgL^{-1} in Post Monsoon season. On the basis of nitrate ion concentration in pre monsoon the study area has been classified into three categories i.e. low (1.8-30 mg/L), moderate (32-38 mg/L) and high (40-79 mg/L) as shown in Table 1. The mean ground water nitrate ion concentration in pre monsoon was 18.6 mgL^{-1} followed by monsoon (14.86 mg/L) and post monsoon (16.4 mg/L) as shown in Fig.3. The mean concentration of nitrate is highest in pre monsoon season and lowest in monsoon season which may be due to dilution through percolation of rain water through soil in monsoon season as soil is sandy loam.

Table 1: Groundwater Nitrate concentration in different colonies of Rohtak municipal area.

Sr.no	Name	Sampling			Division Based on pre monsoon
		Pre Monsoon	Monsoon	Post Monsoon	
1	Khokhrakot	20.20±0.06	15.00±0.04	17.00±0.04	Low
2	Nehru Colony	14.00±0.01	9.00±0.04	11.00±0.02	Low
3	J.P colony	19.80±0.02	15.20±0.02	17.00±0.02	Low
4	Near Sainik Colony	20.00±0.02	13.00±0.06	16.30±0.04	Low
5	Sainik Colony	20.00±0.03	14.80±0.04	17.00±0.01	Low
6	Ranekpura	2.00±0.06	0.40±0.01	1.00±0.04	Low

7	Near Milk Plant	5.00±0.01	1.90±0.04	3.00±0.02	Low
8	Vijay Colony	4.00±0.02	1.40±0.05	2.00±0.05	Low
9	Rajnara Colony	20.00±0.03	14.90±0.04	16.00±0.06	Low
10	Shivaji Colony	13.00±0.06	7.00±0.03	9.00±0.02	Low
11	Sector 6	17.00±0.01	10.90±0.02	13.30±0.01	Low
12	Azadgharh	16.00±0.02	11.00±0.01	12.30±0.02	Low
13	Shyam Colony	3.00±0.06	0.98±0.02	1.30±0.04	Low
14	Quillamohalla	16.00±0.02	11.00±0.01	13.30±0.06	Low
15	Indervihar	3.20±0.01	0.40±0.06	1.00±0.01	Low
16	Sector 2	18.00±0.06	16.00±0.04	18.00±0.02	Low
17	Sector 3	16.00±0.04	14.00±0.02	16.00±0.01	Low
18	Ramgopal Colony	45.00±0.01	20.00±0.02	28.00±0.02	High
19	Sector 14	18.00±0.06	16.00±0.02	18.00±0.03	Low
20	Dev Colony	24.00±0.01	22.00±0.02	23.00±0.02	Low
21	Model Town	40.00±0.02	37.00±0.01	39.00±0.01	High
22	Dariyao Nagar	38.00±0.01	32.00±0.02	36.00±0.02	Moderate
23	Gandhi Nagar	35.00±0.01	33.00±0.06	34.00±0.01	Moderate
24	Vikas Nagar	20.00±0.02	18.00±0.02	19.00±0.02	Low
25	DLF Colony	25.00±0.01	24.00±0.04	25.00±0.06	Low
26	Old Powerhouse Colony	31.00±0.03	28.00±0.01	30.00±0.02	Moderate
27	Janta Colony	30.00±0.02	28.00±0.02	29.00±0.04	Low
28	Huda Complex	29.00±0.06	27.00±0.04	28.00±0.05	Low
29	Sukhpurachowk	15.00±0.02	13.00±0.04	14.00±0.02	Low
30	Shrinagar Colony	36.00±0.02	35.00±0.06	34.00±0.04	Moderate
31	Durga Colony	24.00±0.02	25.00±0.02	27.00±0.02	Low
32	Tilak Nagar	42.00±0.04	40.00±0.04	41.00±0.06	High

Values ±S.E.

Table-2: Groundwater Nitrate concentration in rural villages of Rohtak municipal area.

Sr.no	**Name**	**Sampling**			**Division Based on pre monsoon**
		Pre Monsoon	**Monsoon**	**Post Monsoon**	
1	Samargopalpur	79±0.04	28±0.05	29±0.01	High
2	Makdoli khurd	10±0.06	6.00±0.02	9.00±0.03	Low
3	Makdoli Kala	11±0.02	6.8±0.01	9.00±0.05	Low
4	Ladoth	11±0.03	6.8±0.03	9±0.01	Low
5	Bhalot	28±0.06	10±0.01	12±0.05	Low
6	Sundurpur	18±0.01	10±0.03	14±0.02	Low
7	Bhaiyapur	22±0.03	9±0.01	18±0.05	Low
8	Kharawad	28±0.02	8±0.03	15±0.04	Low
9	Kanehli	1.80±0.04	0.10±0.06	0.40±0.03	Low
10	Bohr	20.90±0.02	13.00±0.01	16.00±0.06	Low
11	Majra Village	5.00±0.02	0.40±0.06	1.0±0.01	Low
12	Astal Bohr Village	2.00±0.06	0.30±0.02	0.50±0.01	Low
13	Intermediate (Bohr –Baliyana)	17.80±0.01	10.30±0.01	12.00±0.02	Low
14	Sunaria Village	4.00±0.01	0.90±0.02	1.30±0.01	Low
15	Kherisadh Village	20.00±0.02	12.30±0.01	16.00±0.06	Low
16	Baliyana Village	7.90±0.02	2.40±0.02	0.40±0.04	Low
17	Bhau	18±0.01	10±0.02	14±0.02	Low

Values ±S.E.

In city residential area the highest value of nitrate in ground water was found in Ramgopal colony (45 mgL^{-1}) followed by Tilak Nagar (42 mgL^{-1}), Model Town (40 mgL^{-1}), Dariyao Nagar (38 mgL^{-1}), Gandhi Nagar (35 mgL^{-1}), Shrinagar Colony (36 mgL^{-1}), old power house Colony (31 mgL^{-1}) and all other 33 colonies lies between 1.8 mgL^{-1} to 30 mgL^{-1} which comes under low concentration zone. And in rural village area categorythe highest concentration was found in Samargopalpur which is 79 mgL^{-1} . About 7.3% of the study area comes under high concentration zone while medium and low concentration zones is comprise of 12.2% and 80.5% respectively (Fig.4).

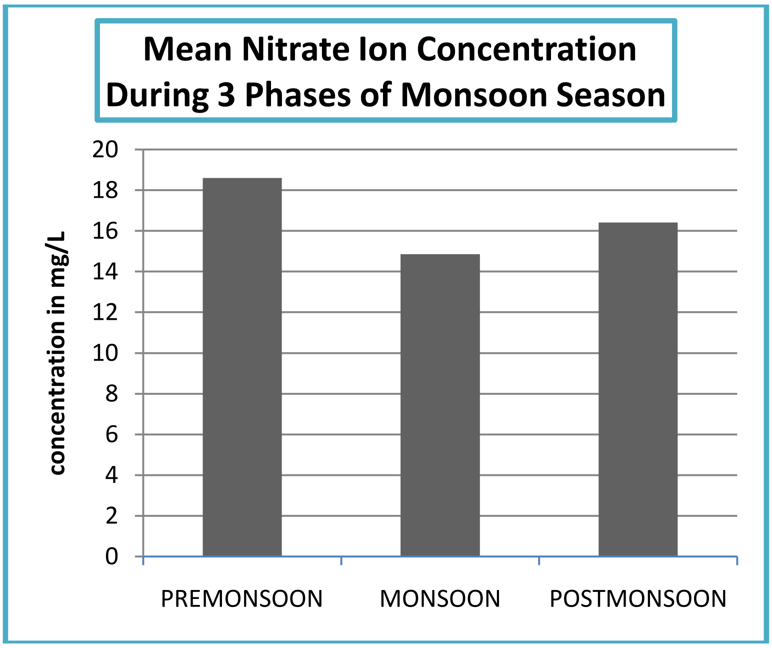

Fig. 3 Mean Nitrate concentration at different stages of monsoon.

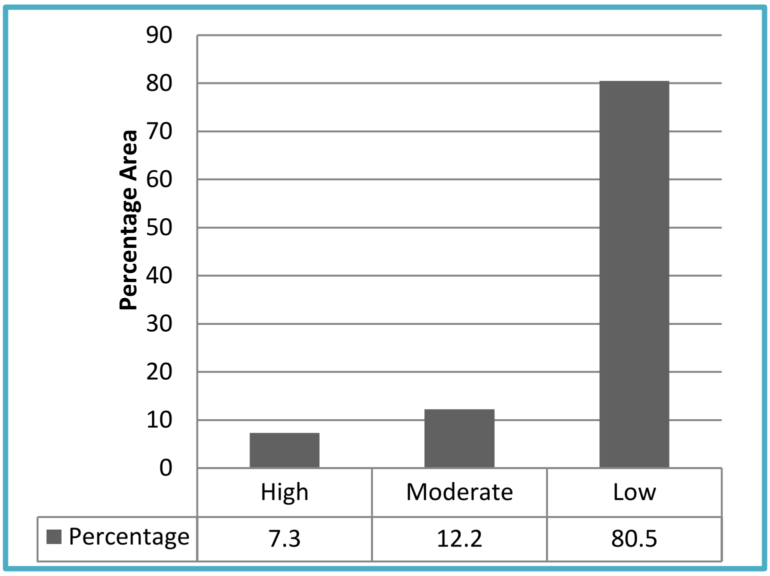

Fig. 4 Percentage of area with different concentrations of nitrate.

Spatial distribution of groundwater nitrate concentration with sampling point is presented in Fig.5 and nitrate concentration zones in Fig.6. The high and moderate nitrate ion concentration area in Rohtak Municipality boundary is located in the central part of city area having old and recently developed colonies. This area of city is highly congested with population and this zone is commercial cum residential type. In these areas municipal sewerage system has been layed in last few years and still there are large number of houses which are not connected to the sewage system. The old septic tanks of most houses still exist even though they are not in use and are a source of nitrate leaching during rainy season. The outer colonies which earlier were agricultural land the nitrate high level may be due to remains of nitrogen rich fertilizer use. In Ramgopal Colony nitrate is highest as compared to other Colonies which is due to presence of large number of dairies, septic tanks, drainage of domestic and dairy waste water to low lying vacant plots, open dumping of domestic solid waste in vacant plots and dumping of cattle waste/manure on open and unlined ground surface. In Tilak Nagar and Model town same situation is present as described above but number of dairies as compared to Ramgopal colony is less. The soil of study area is sandy loam type which has high seepage and low water holding capacity due to which rate of leaching is high. Water percolation also high hence dilution in monsoon.

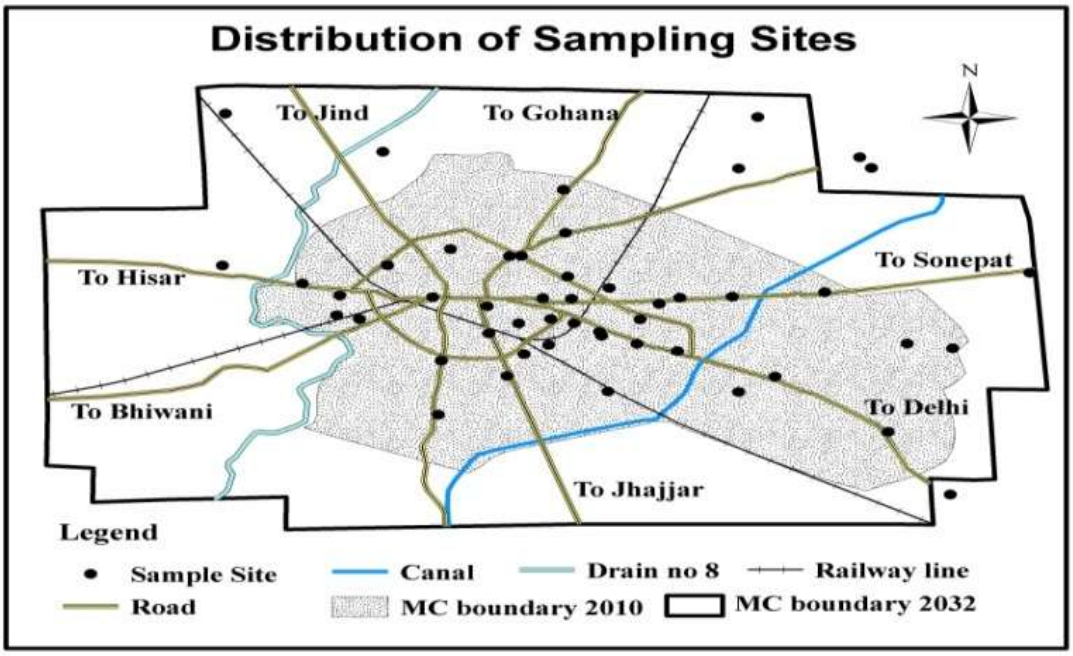

Fig. 5 Study area with sampling sites.

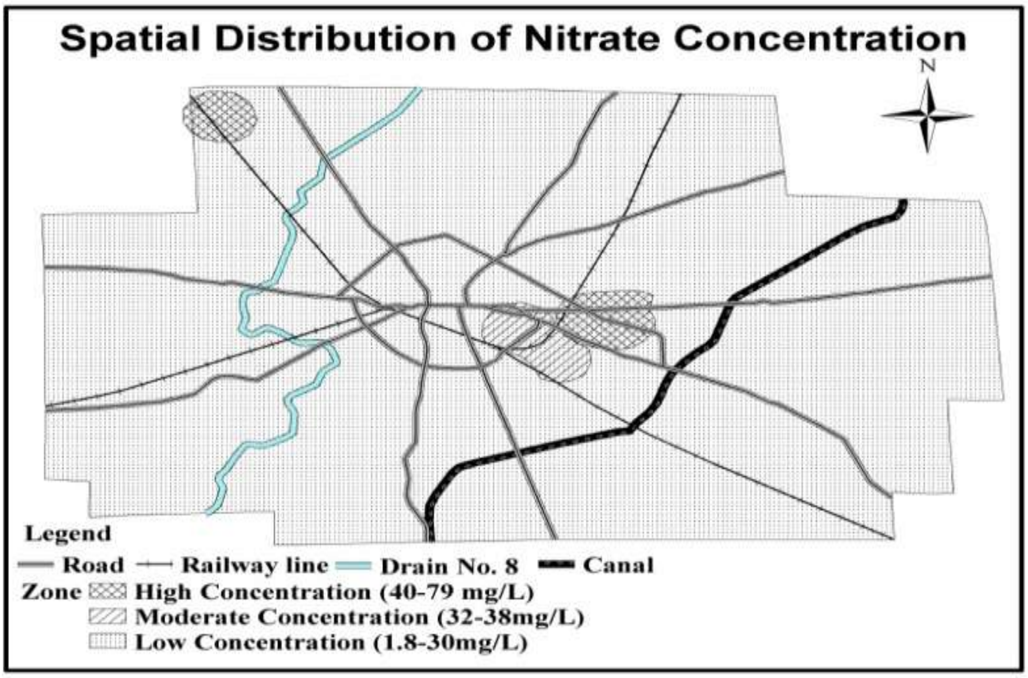

Fig. 6 The nitrate concentrations zone of study area.

VI. CONCLUSIONS

The study revealed that many private groundwater sources suffer from nitrate contamination**.** The present investigation concludes that the groundwater nitrate level in study area is within the permissible limit of 45 mg/L recommended by CPCB a number of area comprising 7.3% of the area. In pre monsoon period, the scarcity of water is at its peak due to fewer water supplies by the municipality and also high consumption hence more ground water will be used. Also during summer season when dietary intake of water is more hence danger of high nitrate intake from areas having moderate concentration is possible so in summer 19.5% of area should be considered as high concentration zone and precautions taken. High concentration of nitrate in central part of the study area was found due to large number of dairies and septic tanks as compared to less nitrate concentration sites. The main sources of nitrate (NO_3^-) were found to be septic tanks, open disposal of domestic and dairy waste water, solid waste, and history of agricultural use. While nitrate cannot be completely removed from groundwater, the use of treatment methods such as ion exchange, reverse osmosis and the adoption of preventative measures to lower leaching, the proper dumping of municipal solid wastes and dairy will help to reduce nitrates to safe levels.

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