A case study on a ground water nitrogen pollution in a town Achhnera, Agra

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Abstract

N_2 is close to the environment as nitrogen in large amount and it is fixed either by the substantial development by some bacteria or by cyanobacteria (blue green algae). Six ground water samples were collected from different places from December, 2017 to December, 2018 in a town of Achhnera, Agra. Water samples were analyzed for pH, TDS, total hardness, Cl^- ions, total nitrogen, nitrate, nitrite and ammonia nitrogen. The total nitrogen and NO_3-nitrogen revealed regular small changes and huge variations in NH_4-nitrogen in inhabited areas other than remarkable regular patterns.

NO_2-nitrogen in irrigated sites may be unbalanced although it was nearby at far above the ground extents. Whole Nitrogen and NO_3-nitrogen were considerably less in housing sites than in undeveloped sites. The land water inside the majority of the areas is larger than the upper limit stipulated by World Health Organization.

Keywords: Groundwater, Nitrate, Cancer, Methemoglobinemia, Thyroid disease.

Introduction

Nitrogen contamination happens to be of Achhena, Agra. It is the most important area for rising urban farming which is able to provide the major basis of vegetables and fruits for a lot of inhabitants.[10] It is significant to study the nitrogen contamination crisis in rural-urban area close to Achhnera to decide the collision on foodstuff protection and physical condition of the inhabitants.[3]

Nitrates are the end harvest of the aerobic stabilization of natural nitrogen and take place generally in trace quantity in surface water materials other than ground levels.[14] Limit of nitrate content of potable waters (45-50 mg/L) is fixed by WHO standards while in some countries, only 25 mg/L nitrate is permissible in potable waters.[2] Nitrate is also the form of nitrogen in which absorption of nitrogen by plant species occurs more readily; nitrate ions can also be acted upon by bacteria under suitable conditions.

Consequently, excess nitrate ions are not taken up by the plants subjected to mainly three processes denitrification, immobilization and leaching.[12] Some microorganisms like Pseudomonas change nitrates into molecular nitrogen by denitrification.[15] The denitrification process may be represented schematically as follows:

$$\begin{array}{ccccc} 2HNO_3 \rightarrow & HNO_2 & \rightarrow & H_2N_2O_2 \rightarrow 2H_2O + N_2 \\ & \downarrow & & \downarrow \qquad\qquad \uparrow \\ & 2NO+H_2O & & N_2O + H_2O \quad \rightarrow \uparrow \end{array}$$

In many cases, maximum nitrates (levels > 50 mg/L) are at present approaching or are greater than the suggested (14.50 mg/L) NO_3-nitrogen consumption water standard. Maximum nitrates (levels > 50 mg/L) in the drinking water cause health risks such as alteration of hemoglobin to methemoglobin which depletes oxygen levels in the blood. Nitrate in the stomach of adult humans in part converts into nitrite. The existence of nitrite in water indicates complete pollution. Biodecomposition of nitrogenous natural matter such as dirt and creature wastes contributes nitrites.[18] Nitrite interacts with amines to produce N-nitrosamine which in investigational animals has been exposed to cause stomach cancer.[11,17] Likewise, waterborne nitrogen contamination could be rehabilitated into gases.

The following chemical equations 1, 2 and 3 explain the oxidation and reduction reaction of the environment:

$$4NH_4 + 7O_2 \rightarrow 4NO_2^- + 4H^+ + 6H_2O \qquad (1)$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^- \qquad (2)$$

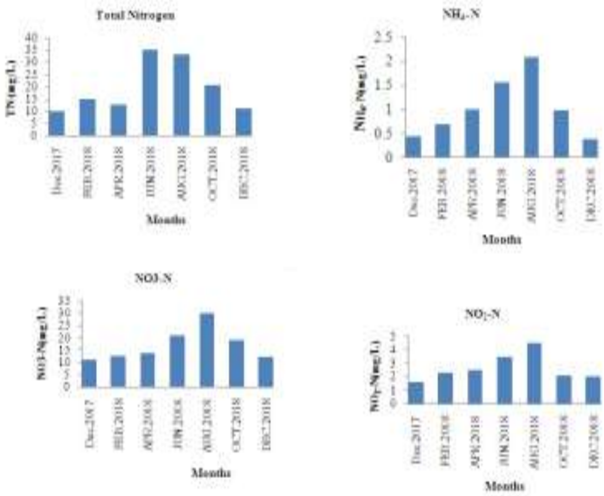
$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2 \qquad (3)$$

Material and Methods

The study area Achhnera (27° 11' 00" N 77° 53' 00" E) in Agra District of Utter Pradesh has an average elevation of 547 feet. The weather in Achhnera is characteristic of Northern India with frozen night in winter and high temperature waves in summer. Achhnera had a population of 22,780 of which males were 12,117 and female were 10,667.

Sampling and Preparation of Material: For determining different parameters, standard methods of collection of water sample were adopted. We sampled water from 12 wells enclosed by undeveloped sites and 12 wells and hand pumps in inhabited sites (Fig. 1). Ground water was collected from different areas namely site – 1- Station Bazar, site-II-Railway loco Colony, site-III- Rathiya Mohalla, site-IV-Jatwan Mohalla ,site- V- Shekhan Mohalla, site-VI-Bajahera Mohalla, site-VII- Railway Crossing area from the depth of 35' and 75' ft. Irrigated samples were collected from December 2017 to December 2018 at one month intervals time.

Graphical Abstract:



Undeveloped Sites

Inhabitated Sites

For collecting samples, reagent bottles of two liter capacity were used.

Temperature: Temperature was measured by mercury thermometer calibrated from 0° C to 100 °C. Water sample was collected in a plastic container and its temperature was recorded immediately by dipping the thermometer for about one minute.

pH: Unfiltered and settled irrigated sample was used for the determination of pH which was determined by the digital pH meter (Systronic Make) electrode calibrated as per instruction manual. Readings were recorded directly.

Conductivity: Conductivity is determined by the digital conductivity meter (Systronic Make) electrode which was calibrated according to the instruction manual; and readings were directly recorded.

Total hardness: It was determined by "EDTA titrimetric method".

Chlorides: For the determination of chlorides, "Argentometric method" was used.

Nitrate: 0.5 mL of sample was taken by dilution in the glass tube and then 2 ml of 30% NaCl and 10 mL of 75% H_2SO_4 were added and heated at 80°C for 10 minutes on a water bath, then cooled and absorbance on spectrophotometer was recorded at 410 nm. Distilled water was used as blank. Standard nitrate solution was processed in a similar manner and their absorbance and concentration were plotted and nitrate contents of samples were determined by comparing their absorbance with the standard curve.

Nitrite: 0.5 mL of sample was taken by dilution into a 50 mL volumetric container and 10 ml of sulphanilamide was added. After 5 minutes, 1.4 mL of N-EDTA was further added and the volume made up to 50 ml with the distilled water and absorbance on spectrophotometer was recorded at 540 nm and NH_4^+-Nitrogen was measured calorimetrically using the indophenols blue method. Distilled water was used as blank. Standard nitrite solution was processed in a similar manner and their absorbance and concentration were plotted and nitrite contents of samples were determined by comparing their absorbance with the standard curve.

Results and Discussion

The different parameters of water quality of collected samples from various agricultural location were analyzed by standard method reported in literature as shown in table 1. All samples were collected during December 2017 to December 2018.

Figure 1 outlines the consequences of the groundwater observed for the four types of nitrogen for wells in undeveloped sites namely site-III- Rathiya Mohalla and site-VII- Railway Crossing area from December 2017 to December 2018. Both sites are situated near the open ground which is suitable for agriculture.

Its highest value was due to the influx of nitrogenous fertilizers through agricultural lands and also due to the unnecessary nitrogen fertilizer applied, the region with cropland covering will have high potential nitrogen contamination effects. It was measured through the certain local or regional case study. Temperature is an important factor to influence the biological reaction in water. Higher values of temperature augment the chemical reaction and reduce solubility of gases and dissolved oxygen. In the month of April, June and August, temperature was found 30.30-45.59 °C at both sites. At the both sites, pH ranged between 7.60-7.78.

Hand pumps are installed by the side of gutters where animal and vegetable waste are scattered all along the sides of these gutters. Peels of vegetable, fruits and morsels of edibles make the soil alkaline resulting in increase of pH value. Conductivity is measurement of the dissolved solids in ms/cm. No permissible limit has been decided for this.

In these sites, conductivity varied from 650.00-663.00 ms/cm. Chloride varied from 356.00 392.00 mg/l. Chloride content was found higher than the desirable limit (250 mg/l,ISI,1991) but under the permissible limit for drinking water (1000 mg/l,ISI,1991) at both sites. The total nitrogen attentiveness was upper from June 2018 to August 2018 than for the period of other months.

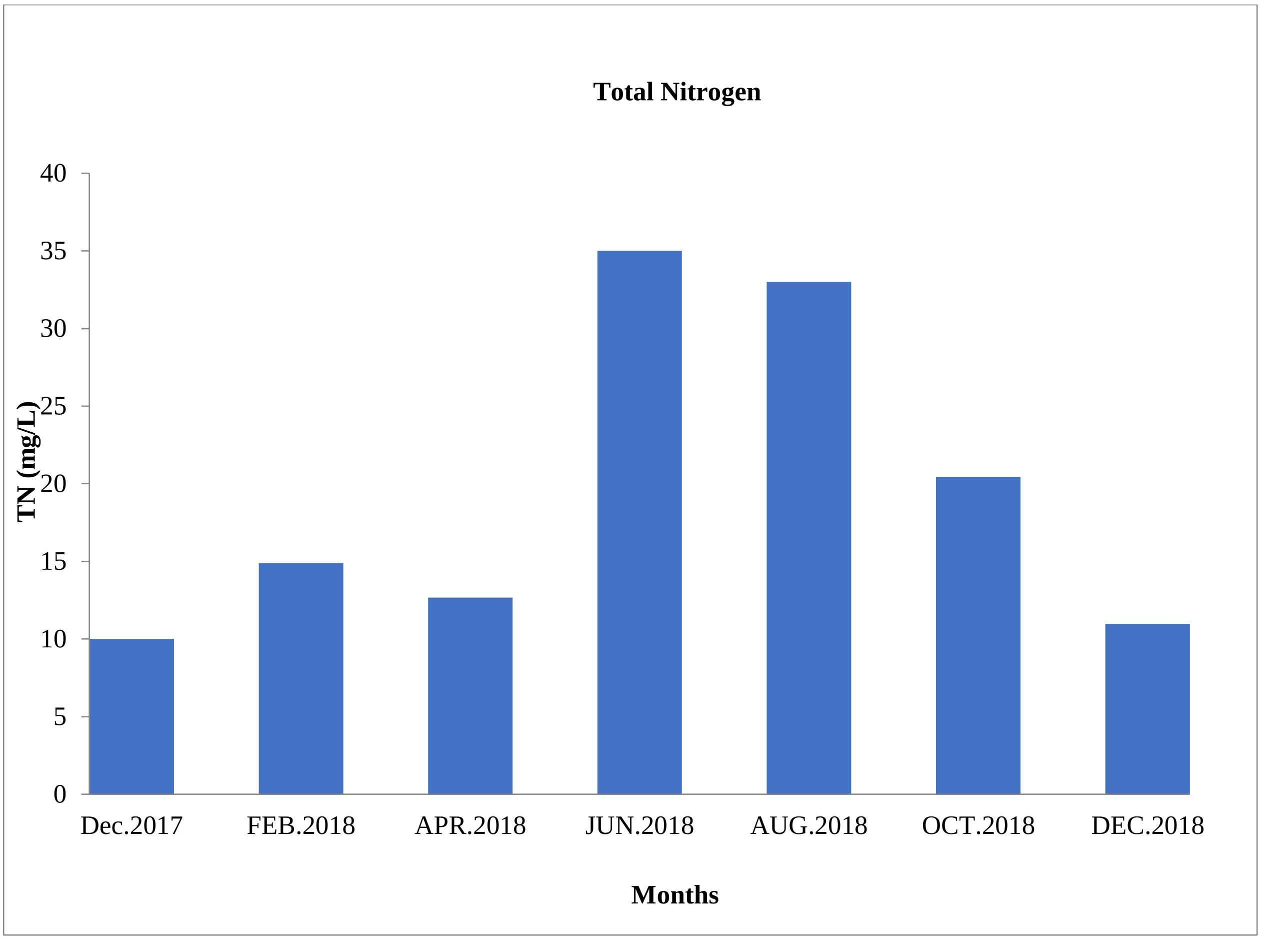
The whole Nitrogen absorption break is 30 mg/L in the months of June 2018 to August 2018 (Figure1a). In the months of December 2017 to February 2018, the total N absorption in groundwater extended to its very low value, since NO_3^-N was considered for 68 to 89 % of all N, Monthly changes in NO_3-Nitrogen were like individuals for total Nitrogen (Figure1b).

The groundwater value for most sites in the months of June 2018 to August 2018 ranged between 20 to 30 mg/L, even though some sites were above 30 mg/L: in other months, the groundwater value range decreases to 20 mg/L. The NH_4-Nitrogen contamination was lower in range than the NO_3-Nitrogen pollution.

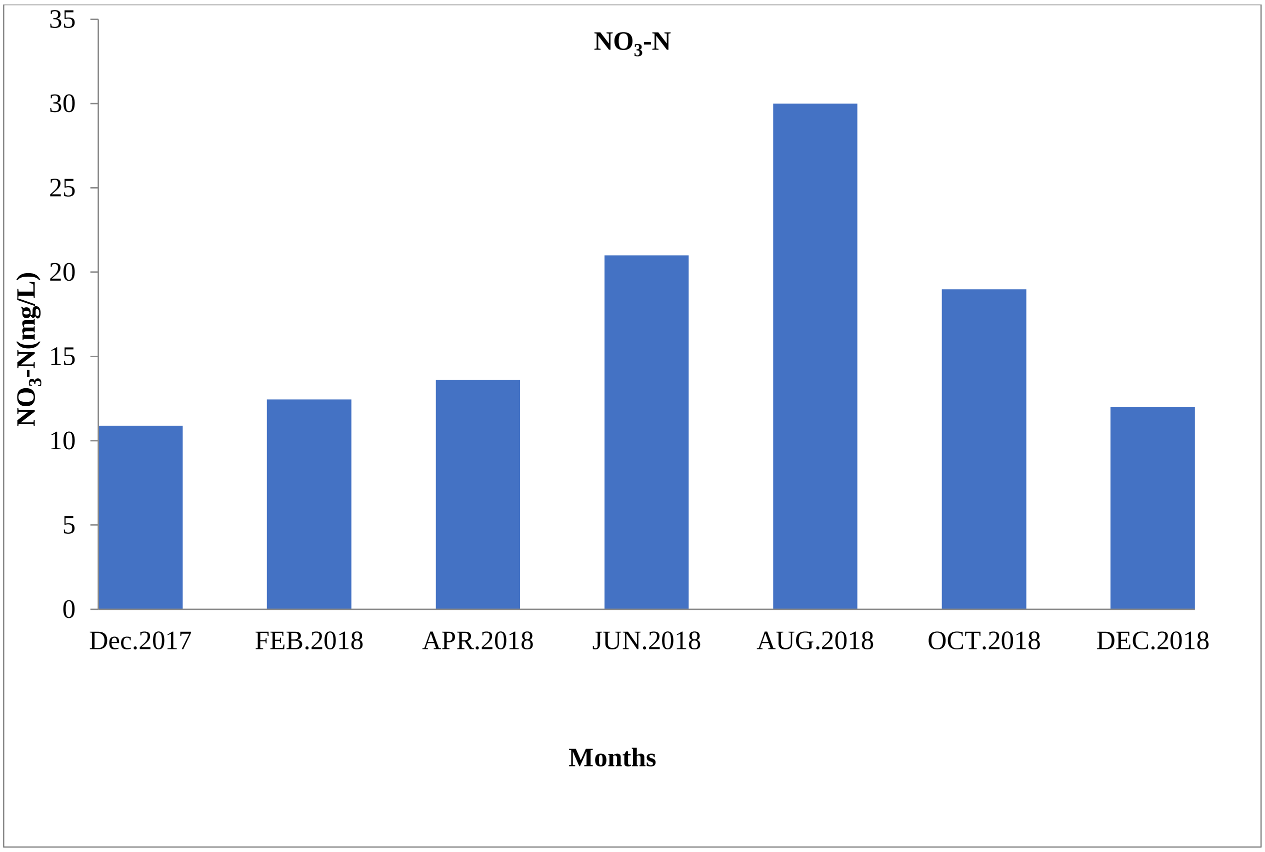
NH_4 -Nitrogen level was ranging between 0.19 mg/l to 01.00 mg/L in all months except in the months of June 2018 to July 2018 as the range between 1.89 mg/L to 2.08 mg/L (Figure1c). In the months of September 2018 to May 2018, the NH_4-Nitrogen absorption was comparatively stable. The NO_2-Nitrogen absorption range is minimum from December 2017 to February 2018 in undeveloped sites (Figure1d).

The results of the groundwater observed for the four types of nitrogen for sites namely site-I-Station Bazar, site-II-Railway Loco Colony, site-IV-Jatwan Mohalla, site-V-Shekgan Mohalla and site VI-Bajahera Mohalla are marked with qualities of effectively clean water as in figure 2. Whole nitrogen absorption was lower in inhabited sites compare to undeveloped sites (Figure 2a).

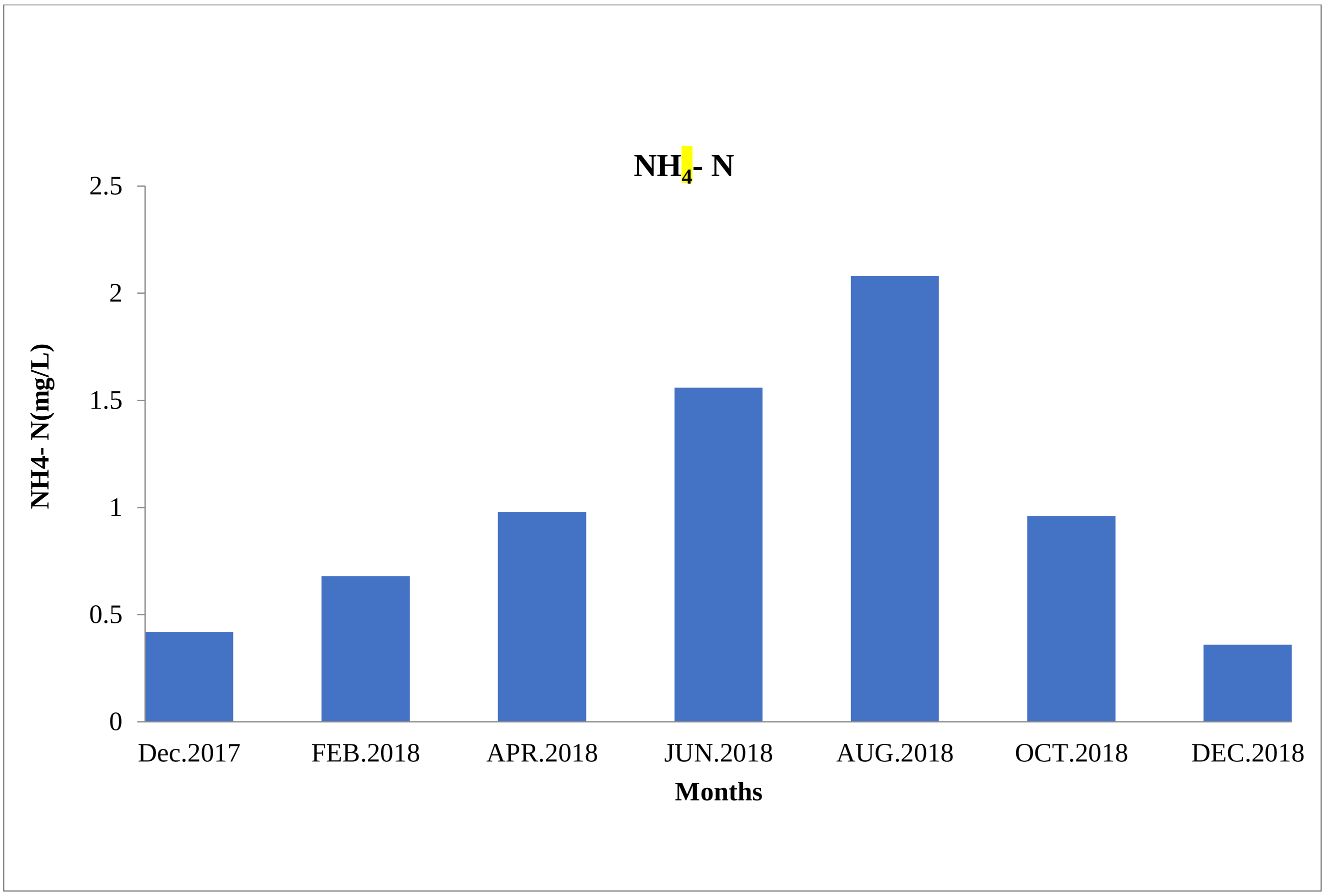
Even though the NO_3-Nitrogen levels were small in inhabited than undeveloped sites. The residential NO_3-nitrogen concentration ranged from 11mg/L to 25mg/L (Figure 2b). They showed the same outline of change to that in the undeveloped sites. The variation in NH_4-nitrogen absorption in inhabited sites was big (Figure 2c). The groundwater value based on NH_4-Nitrogen extents ranged which was similar to the range in undeveloped areas. The NO_2-nitrogen absorptions were lesser than those in undeveloped sites (Figure 2d).


Total Nitrogen
40
35
30
25
20
15
10
5
0
TN (mg/L)
Dec.2017
FEB.2018
APR.2018
JUN.2018
AUG.2018
OCT.2018
DEC.2018
Months

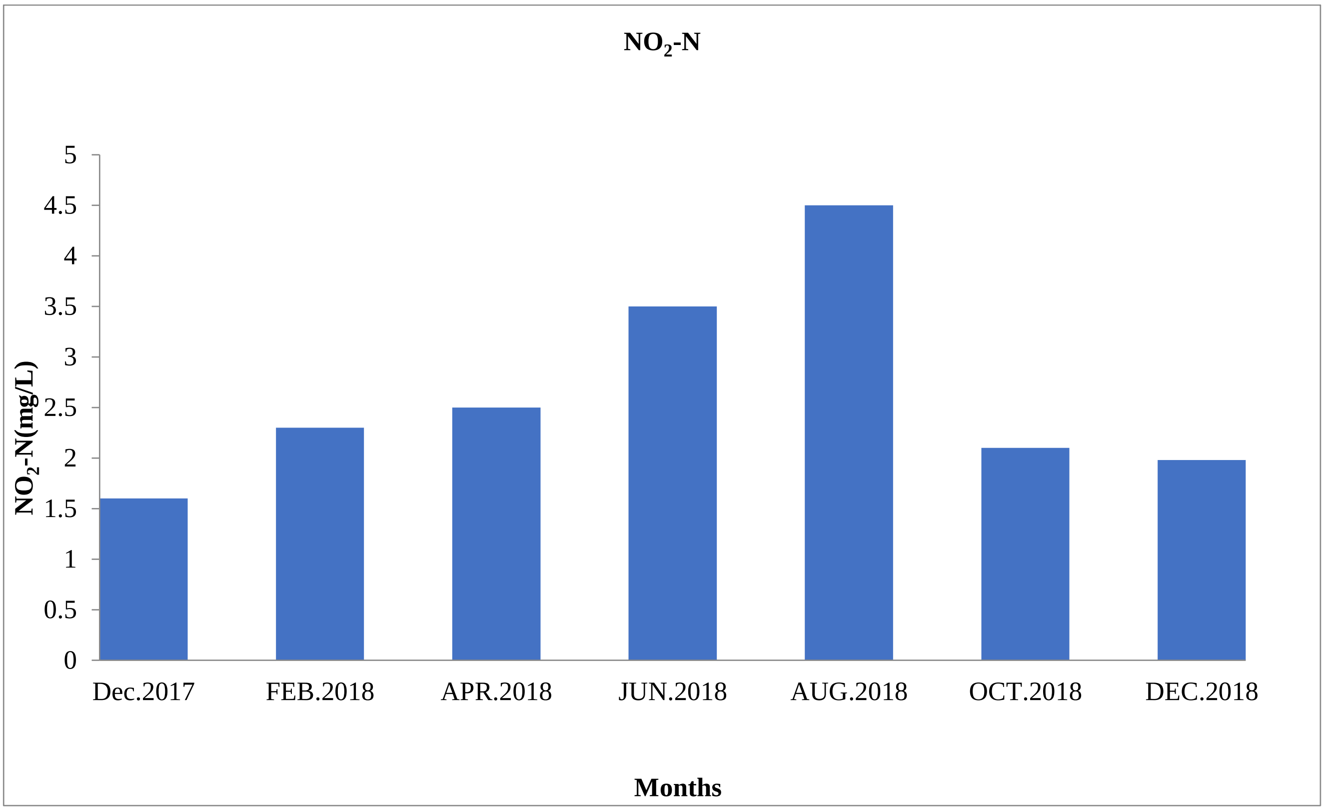
(a)


NO3-N
35
30
25
20
15
10
5
0
NO3-N(mg/L)
Dec.2017
FEB.2018
APR.2018
JUN.2018
AUG.2018
OCT.2018
DEC.2018
Months

(b)

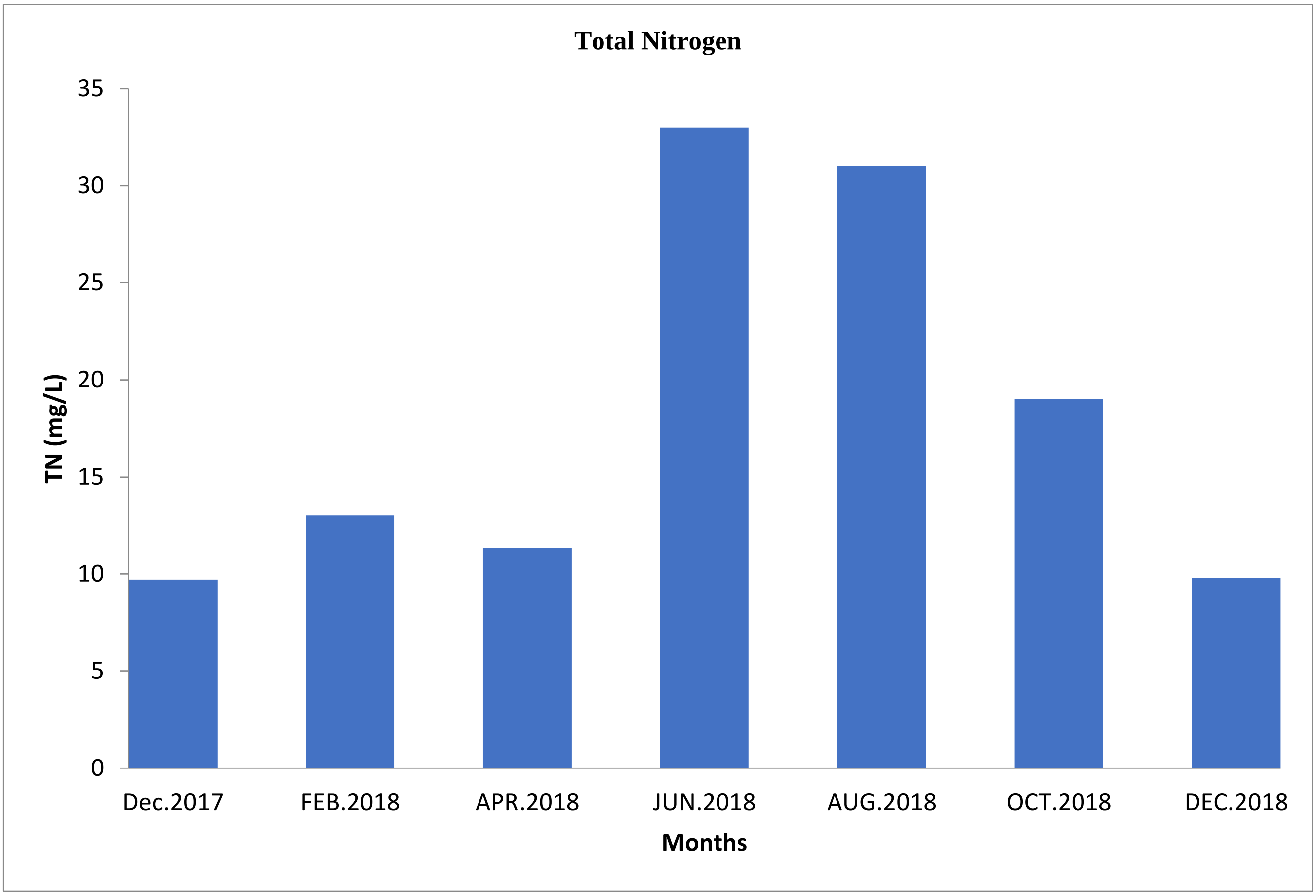


(c)

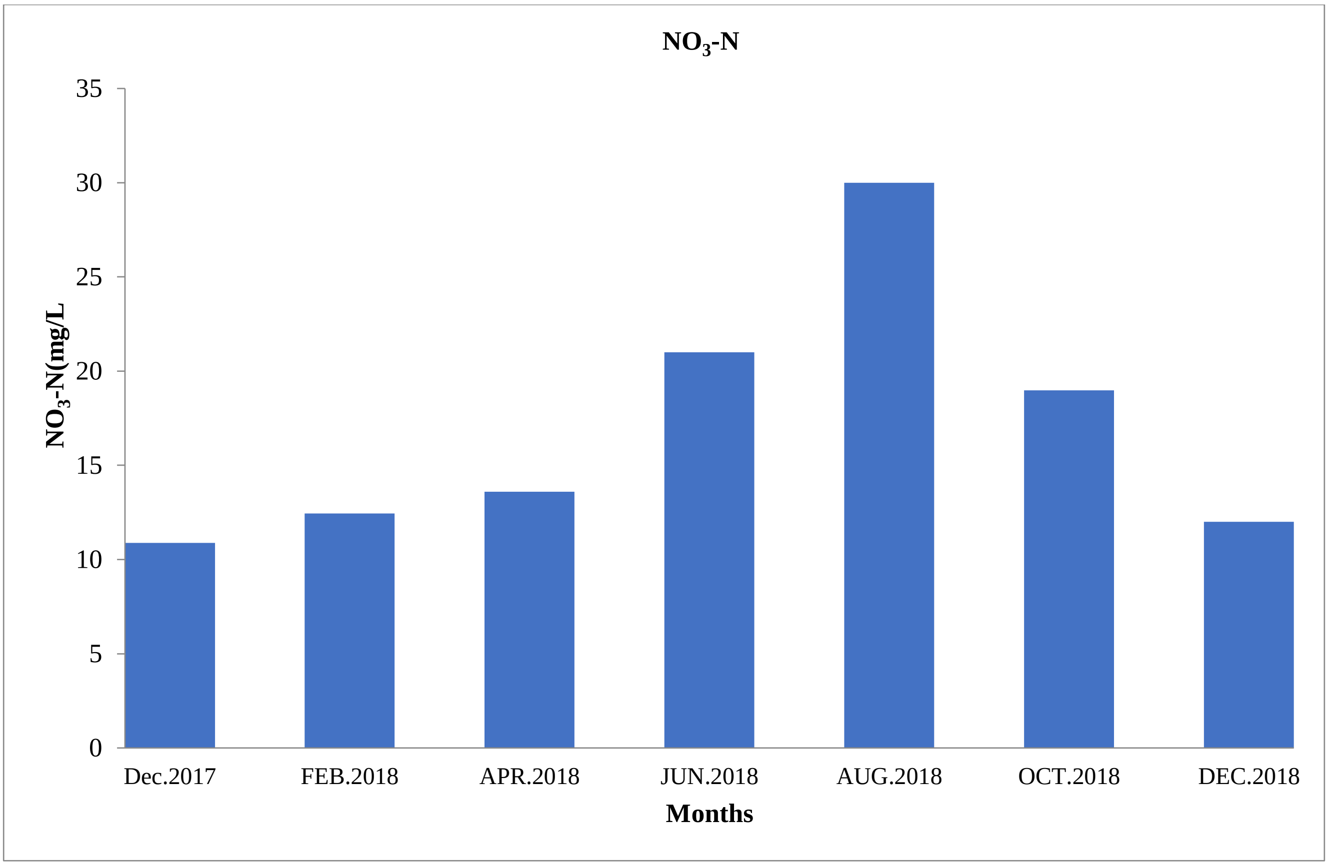


(d)

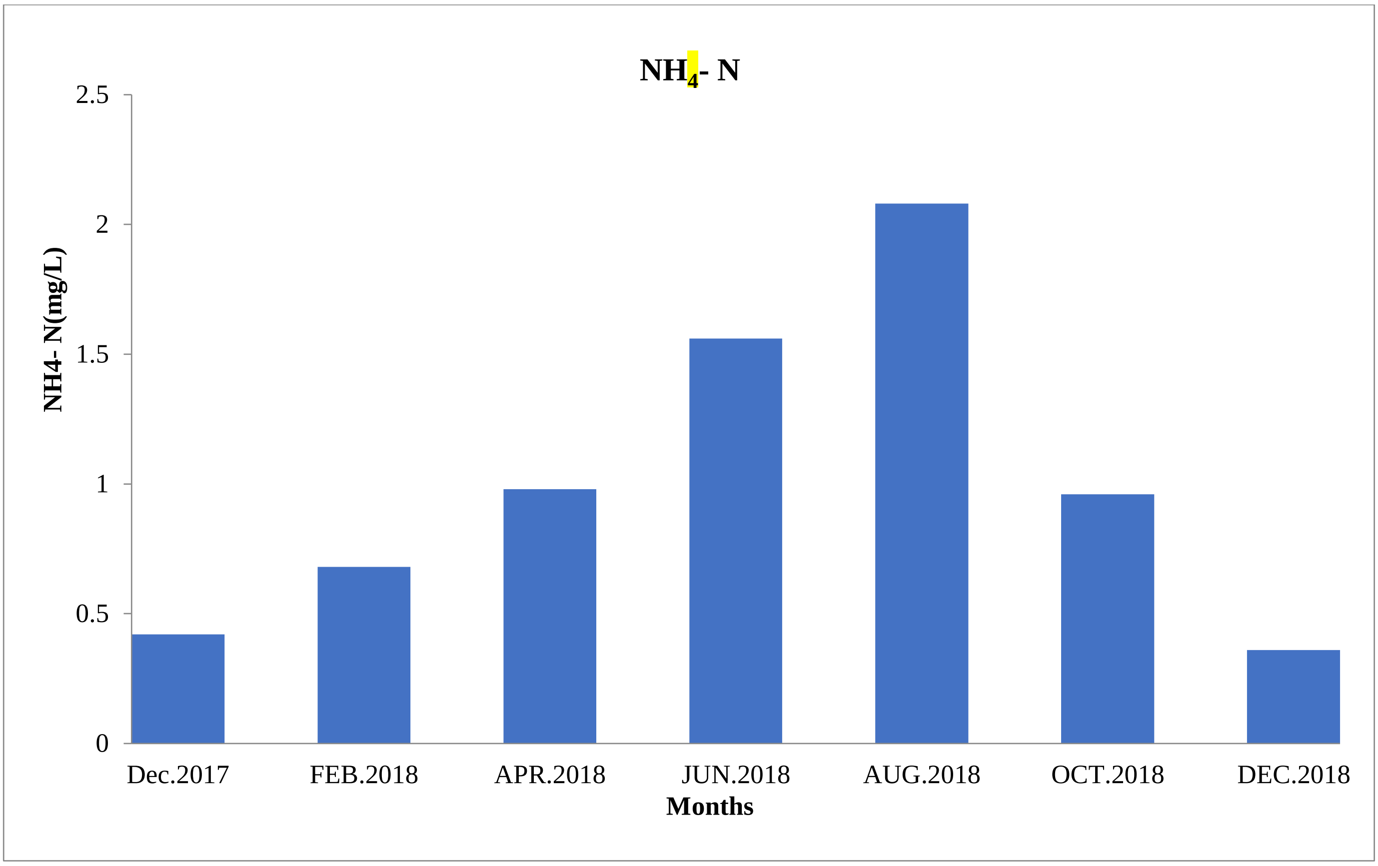
Figure 1: Groundwater of agricultural areas of Achhenra Town Water quality grades defined in table 1. (a) Total Nitrogen (b) Nitrate Nitrogen (c) Ammonia Nitrogen (d) Nitrite Nitrogen


Total Nitrogen
35
30
25
20
15
10
5
0
TN (mg/L)
Dec.2017
FEB.2018
APR.2018
JUN.2018
AUG.2018
OCT.2018
DEC.2018
Months

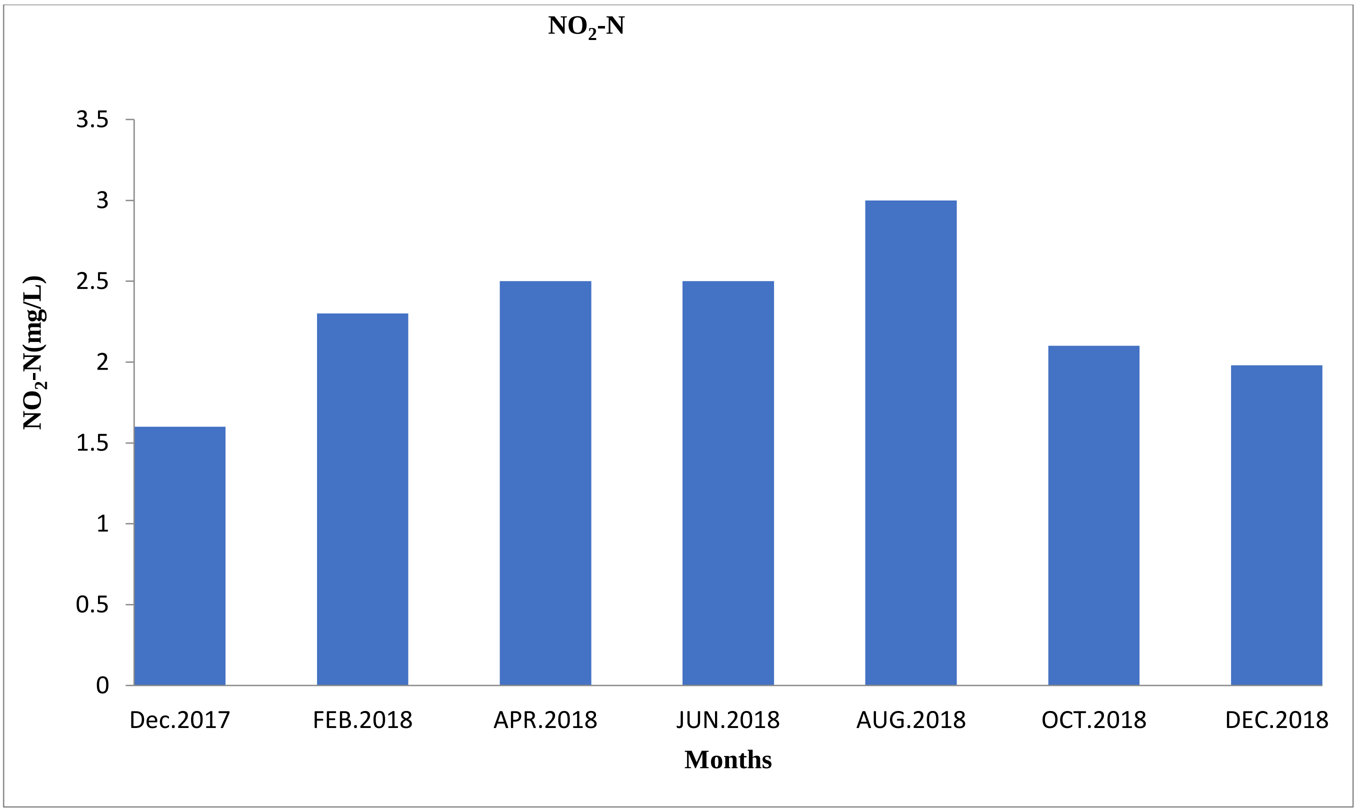
(a)


NO3-N
35
30
25
20
15
10
5
0
NO3-N(mg/L
Dec.2017
FEB.2018
APR.2018
JUN.2018
AUG.2018
OCT.2018
DEC.2018
Months

(b)



(c)



(d)

Figure 2: Groundwater of residential areas of Achhenra Town Water quality grades defined in table 1. (a) Total Nitrogen (b) Nitrate Nitrogen (c) Ammonia Nitrogen (d) Nitrite Nitrogen

Table 1
Ground Water of Agricultural Areas of Achhnera Town, Agra Based on Nitrogen Levels (Geographical Coordinates: 27° 11' 00" N 77° 53' 00" E and Population 22,780)

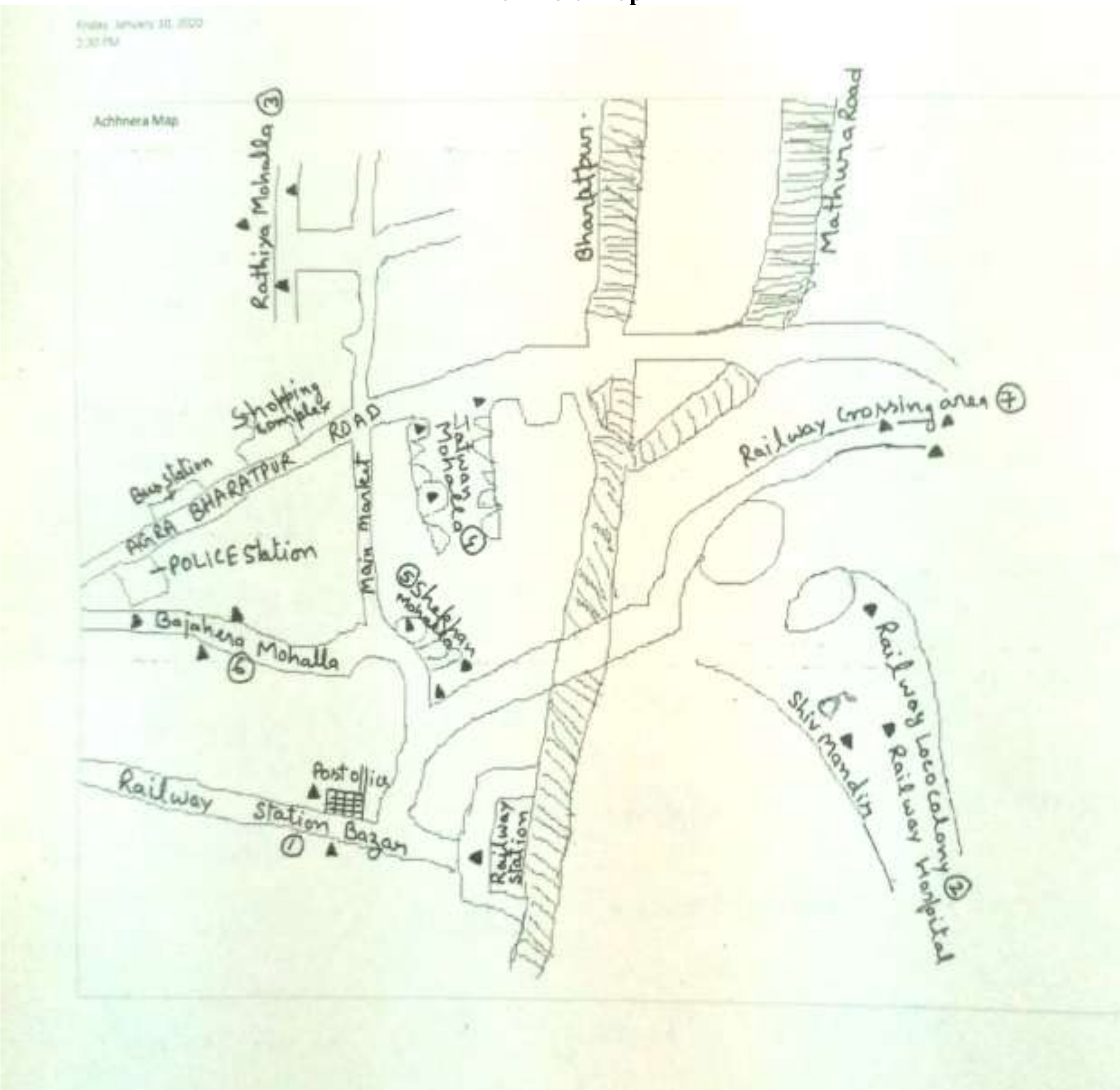
Sample collection months	Unit	December 2017	February 2018	April 2018	June 2018	August 2018	October 2018	December 2018
Temperature	ºC	15.30 (± 0.01)	19.30 (± 0.05)	30.20 (± 0.04)	45.45 (± 0.51)	35.67 (± 0.08)	30.67 (± 0.05)	16.00 (± 0.04)
Conductivity	µs/cm	650.00 (± 0.65)	662.00 (± 0.56)	665.00 (± 0.44)	668.00 (± 0.34)	678.00 (± 0.33)	669.00 (± 0.01)	640.00 (± 0.53)
pH	-	7.58 (± 0.01)	7.45 (± 0.11)	7.63 (± 0.12)	7.46 (± 0.14)	7.56 (± 0.10)	7.67 (± 0.11)	7.89 (± 0.01)
Chloride	mg/L	356 (± 0.44)	360 (± 0.61)	386 (± 0.54)	391 (± 0.28)	392 (± 0.71)	367 (± 0.32)	360 (± 0.53)
Total Nitrogen	mg/L	10.00 (± 0.01)	14.89 (± 0.09)	12.67 (± 0.21)	35 (± 0.45)	33 (± 0.01)	20.45 (± 0.80)	10.98 (± 0.11)
NH_4- Nitrogen	mg/L	0.29 (± 0.03)	0.08 (± 0.50)	0.98 (± 0.30)	1.89 (± 0.32)	2.08 (± 0.23)	0.98 (± 0.01)	0.06 (± 0.60)
NO_3-Nitrogen	mg/L	10.89 (± 0.11)	12.45 (± 0.09)	13.6 (± 0.06)	21.00 (± 0.05)	30.00 (± 0.03)	18.98 (± 0.07)	12.00 (± 0.04)
NO_2-Nitrogen	mg/L	1.6 (± 0.05)	2.3 (± 0.41)	2.5 (± 0.03)	3.5 (± 0.02)	4.5 (± 0.04)	2.1 (± 0.01)	1.98 (± 0.09)

Table 2
Ground Water of Residential areas of Achhnera Town, Agra Based on Nitrogen Levels (Geographical Coordinates: 27° 11' 00" N 77° 53' 00" E and Population 22,780)

Sample collection months	Unit	December 2017	February 2018	April 2018	June 2018	August 2018	October 2018	December 2018
Temperature	ºC	15 (± 0.01)	18 (± 0.05)	29 (± 0.04)	42 (± 0.51)	36 (± 0.08)	29 (± 0.05)	15 (± 0.04)
Conductivity	µs/cm	655.00 (± 0.65)	665.00 (± 0.56)	668.00 (± 0.44)	688.00 (± 0.34)	670.00 (± 0.33)	667.00 (± 0.01)	664.00 (± 0.53)
pH	-	7.55 (± 0.01)	7.44 (± 0.11)	7.62 (± 0.12)	7.46 (± 0.14)	7.56 (± 0.10)	7.56 (± 0.11)	7.65 (± 0.01)
Chloride	mg/L	356 (± 0.44)	360 (± 0.61)	386 (± 0.54)	391 (± 0.28)	392 (± 0.71)	367 (± 0.32)	360 (± 0.53)
Total Nitrogen	mg/L	9.7 (± 0.01)	13 (± 0.09)	11.34 (± 0.21)	33 (± 0.45)	31 (± 0.01)	19 (± 0.80)	10.98 (± 0.11)
NH_4- Nitrogen	mg/L	0.42 (± 0.02)	0.68 (± 0.50)	0.98 (± 0.30)	1.56 (± 0.32)	2.08 (± 0.23)	0.98 (± 0.01)	0.36 (± 0.60)
NO_3-Nitrogen	mg/L	10.67 (± 0.11)	13.45 (± 0.09)	14.6 (± 0.06)	23.00 (± 0.05)	32.00 (± 0.03)	19.98 (± 0.07)	13.00 (± 0.04)
NO_2-Nitrogen	mg/L	1.56 (± 0.05)	2.33 (± 0.41)	2.7 (± 0.03)	3.5 (± 0.02)	.3.5 (± 0.04)	3.1 (± 0.01)	2.38 (± 0.09)

•Sampling Station of Achhnera

Achhnera Map



A comparative analysis of entire results of the study ultimately led to the inference that the groundwater has slight high degree of pollution. This work was compared with others. However the pollution of groundwater may be combated with minimization of its hazards with the materialization and implementation of the following recommendations:

1. Sewage and industrial wastes should be treated daily before being discharged.
2. Low cost sanitation schemes should be raised in the town.
3. ‘Sulabh Sauchalayas’ and ‘Urinals’ should be provided at public places. There should be provided adequate arrangement for proper disposal of wastewater.
4. The groundwater should be continuously monitored for physico-chemical parameters.
5. Scientifically planned groundwater recharge projects are to be formulated and implemented for augmenting the resource availability. Identification of areas through remote sensing technique is amenable to artificial recharge including induced recharge forming a regular part of groundwater survey and investigation programs.
6. Modern techniques of groundwater water management through system approach need to be adopted. It is therefore imperative that all operational models are documented and kept ready to be used for the prospective uses.

Conclusion

Ground water from the month of December 2017 to December 2018 showing most unfavorable health effect associated to drinking water as nitrate are owing to a combination of high nitrate ingestion and factors that increase endogenous nitrosation. The anxiety is due to occurrence of methamoglobinemia. The nitrate dipping bacteria in the oral microbiome and characterizing genetic variation in NOC metabolism hold promise for identifying high risk groups in epidemiologic studies.

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