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A study of the risk of ground water pollution by shallow septic tank system in Aligarh, India

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ABSTRACT

Ground water being major source of drinking water and to study the risk of contamination through septic tank leachates; sixteen ground water samples were identified from eight sampling slum locations in Aligarh during May 2017 to August 2017 in pre and post monsoon stages. Samples were collected from hand pumps nearer to septic tanks in range of 10-30 m distance. All samples were analyzed for TDS, chloride, nitrate and coliforms using standard methods from CPCB (Central Pollution Control Board) manual. High concentration of NO_3 and fecal coliforms were found. Almost all of the samples were having maximum values of TDS exceeding the desirable limit of B.I.S Guideline. One of the major conclusion from this study is about the effect of on-site sanitation on ground water is very much significant in all slum areas. This is due to leachate from septic tanks contaminating sampling water sources like hand pumps in its vicinity. Proper check for sanitation, ground water quality monitoring and health awareness is needed in these slums.

Key words : *On-site sanitation, Sampling, Nitrate, Chloride, Coliforms, BIS standard limit.*

Introduction

The major source of drinking water in India is the ground water of which quality is a serious concern. This study presents the ground water quality status with due effect of on-site sanitation in slums surrounding A.M.U campus, Aligarh city, Uttar Pradesh, India.

Objective of Study

To assess the effect of on-site sanitation on groundwater quality in the chosen sampling regions through estimation of bacteriological, physical and chemical parameters. To suggest restorative and protective measures for counteractive action of water contamination if there should arise an occurrence of positive proof of contamination of ground water sources to develop rules for counteractive action and mitigation of ground water contamination in and around project regions.

Study Area

The study zone in Aligarh area is situated between latitude 27° 88' 0'' to 27° 93' 0'' N longitude 78° 06' 0'' to 78° 10' 0''E. It has a normal height of 178 meters above mean sea level (Wasim *et al*., 2012). The city is situated in the interfluves of the Ganges and the Yamuna waterways and having yearly precipitation of 781.6 mm and the normal evapotranspiration of 1900 mm (CGWB 2012-13). The soil pattern in the city is controlled by sedimentation and land evolution during quaternary period. The major type of soils found in the city are loamy and coarse silty. Net annual Ground water availability is 789.80 MCM. The depth of water level in the city generally ranges between 1.75 m and 26.63 m below ground level with an average of 11.85 m. While in post monsoon the water level ranges between 0.35m and 27.57m below GL on an average 10.93 m.

The dominant part of individuals living in these areas still needs acceptable sanitation systems. Pit and Septic tank latrines systems are popular in Aligarh. Aligarh city has all around 78 notified ,49 un-notified and19 non-notified slums distributed over the region(NUHM 2013-14) (Fig. 1). The majority of the slums were having population in range of 1500-3500. They were fundamentally reliant on drinking water sources on open/lakes/well/hand pumps. A large portion of the inhabitants uses open/drain/outside place like fields for toilets. Few were using community toilets and few were having their individual house latrine and septic tanks. The wastewater from their homes is carried through open drains and solid garbage are scattered in the locality. Few houses have their effluent from latrines connected to open drains. Reciprocating and submersible pumps are installed near toilets due to lack of space. So there is tremendous danger of water borne diseases.

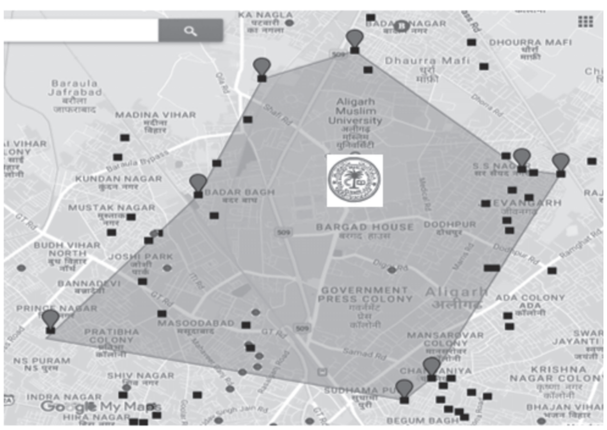

Fig. 1. Map of India, Aligarh District and location map of study area

Sample collection

After reconnaissance survey by visiting residents of locality and gathering information about the sanitation, water sources and health related issues prevailing through questionnaire sites were marked nearby septic tanks in range of 10 to 30 m; incorporating the most negative sources of conceivable contamination through septic tank leachates SMWW. 1989. Sampling was done in 8 different slum areas named listed in table from hand pumps in vicinity of septic tanks in two phase pre and post monsoon from May 2017 to August 2017 as in Table 1 to study the monsoon effect on contamination. Samples were collected in new clean 500 mL plastic bottles for physio- chemical parameters following WHO and CPCB guidelines for water quality monitoring (CPCB., 2007). 300 mL glass bottles were used for collecting samples for bacteriological parameters. The sample volume should be ideally sufficient that it can be transported with ease and sufficiently large for analytical purposes. After collection, all necessary details were labeled over the bottles like date and time of sampling, location name and conveyed to laboratory within 2 hours for test.

Method of Analysis

Total Dissolve Solids (TDS) Samples were filtered through membrane filter, evaporated and dried at 180 °C.

Nitrate Nitrate is the most exceptionally oxidized type of nitrogen commonly present in natural waters. Using UV spectrophotometer method nitrate was calculated in sample MOEF. Reading obtained was in mg/L of NO_3–N; further converted into mg/l of NO_3.

Chloride determined by titration with silver nitrate solution MOEF. The end point by red silver chromate due to excess silver nitrate. The results in mg/L of chlorine.

Coliform test A small portion of sample was added to a sterile, agar-based growth medium in a shallow petri dish, the sample was covered, the agar sets and incubated at 37 °C for 24 hrs or 48 hrs during which colonies were formed enough to be counted. The results of eight sampling areas were statistically compared using graphs for pre and post monsoon.

Results

Bacteriological and physico-chemical parameters were studied in all the samples. As on the basis of previous studies on impact of on-site sanitation on ground water quality these three parameters nitrate, chloride and coliforms were likely to be affected. Per capita 4 kg a year, nitrogen is released and huge part of it goes converted into nitrate Lawrence, 2001. Around 4 g chloride per capita per day is released through urine and feces Lawrence, 2001. The focus was on nitrate and coliforms mainly not the TDS which was just for the quality of ground water.

Table 1. Slum study areas with population and rubble stone masonry tank

Sampling site	Population	Quality ofSanitation	No. of sample	Distance from drinking water source (m)	
				min	max
Alambagh	4376	Open/drain/house latrine	8	5	30
Beghambagh	4566	Individual house latrine	8	8	30
Chandaniya	7182	Individual house latrine	8	12	25
Firdaus Nagar	2856	Open/drains/Individual house latrine	8	10	30
Jamalpur	8178	Individual house latrine	8	3	30
Jagjeevan colony	2130	Open/drains/Individual house latrine	8	14	26
Lakshmipur	2188	Open/drains/Individual house latrine	8	10	30
Zakir Nagar	4328	Individual house latrine	8	13	30

Alambagh, the TDS ranging 515- 872 mg/L and 487-624 mg/L in pre and post monsoon seasons respectively with an average TDS 669.5 mg/L in pre and 560 mg/L in post monsoon [Fig. 2(a)]. This trend can be attributed to the dilution during monsoon. Nitrate and Chloride in this area was within permissible range of Guideline by WHO and BIS. Average chloride concentration lies in between 148-214 mg/L in pre and post monsoon respectively [Fig. 2(b)]. Nitrate values range from 18.6 to 32.4 mg/L during pre-monsoon season and 8.9 to 17.1 mg/L in post monsoon. The average nitrate concentration is 26.14mg/L and 12.18 mg/L in pre and post monsoon respectively [Fig. 2 (c)]. Almost every sample showed the presence of coliform colonies ranges between ND to TNC (too numerous to count) in pre monsoon and 20 to TNC CFU/100 mL in post monsoon.

Beghumbagh: TDS between 719-633 mg/L pre and post monsoon respectively Fig. 3 (a). Chloride varies from 250 to 566 mg/L pre and 418 to 621 mg/L post monsoon Fig. 3 (b). Nitrate varies between 36.6-82 mg/L pre and 38.8-81.4 mg/L post monsoon season Fig. 3(c). The coliform count from 36 to TNC CFU/100 mL pre and 160 to TNC CFU/100 mL post monsoon Fig. 3(d).

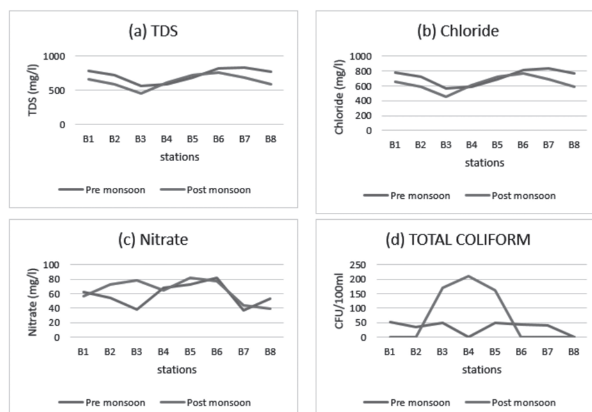

Fig. 3. Beghambagh (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

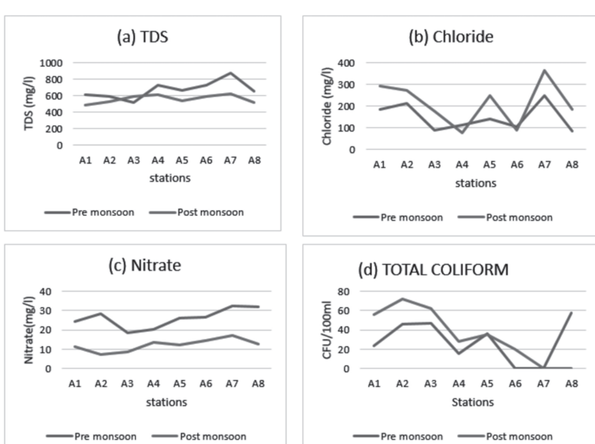

Fig. 2. Alambagh (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

Chandaniya: TDS with similar pattern varying from 616 to 782 mg/L pre and 545 to 732 mg/L post monsoon Fig. 4 (a). Chloride ranges between 86-220 mg/L pre and 72-162 mg/L post monsoon Fig.4 (b). Nitrate very high between 65.5-131.1 mg/L in pre and 56.9-121.3 mg/L in post monsoon Fig. 4 (c). The coliform count 33- TNC CFU/100ml pre and ND to TNC post monsoon Fig. 4 (d).

Firdaus Nagar, TDS similar varying from 588-912 mg/L and 528 to 842 mg/L in pre and post monsoon respectively Fig. 5(a). Chloride between 123-202 mg/L pre monsoon and 142-252 mg/L post monsoon Fig. 5 (b). Nitrate very high between 23.6-103.2 mg/L in pre and 44.2-111.8 mg/L post monsoon Fig. 5 (c). The coliform count from 48 to TNC

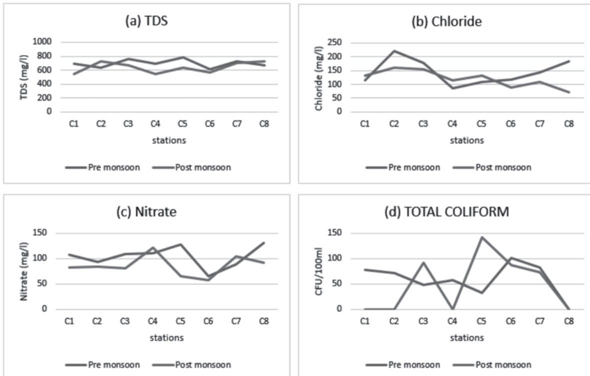

Fig. 4. Chandanya (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

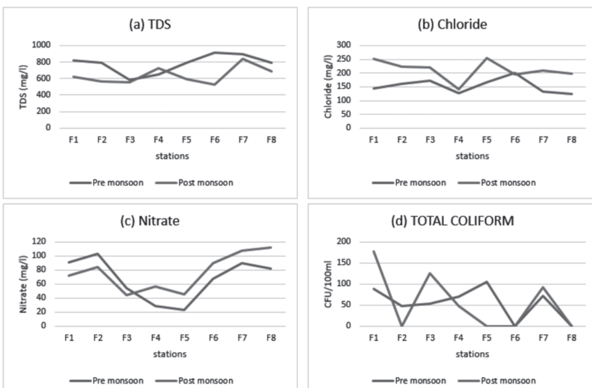

Fig. 5. Firdaus Nagar (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

CFU/100 mL pre and 42 to TNC CFU/100 mL post monsoon Fig 5 (d).

Jamalpur: TDS varies from 495 to 598 mg/L and 353-545 mg/L pre and post monsoon respectively Fig. 6 (a). Chloride from 218 to 312 mg/L pre and 156 to 412 mg/L post monsoon Fig. 6 (b). Nitrate between 38.4 to 78.2 mg/L pre and 26.6 to 59.2 mg/L post monsoon Fig. 6 (c). The coliform count from 44 to TNC pre and 210 to TNC CFU/100 mL post monsoon Fig. 6 (d).

Jagjeevan colony, TDS from 512 to 592 mg/L and 428 to 563 mg/L in pre and post monsoon respectively Fig. 7 (a). Chloride between 266-452 mg/L pre and 376-513 mg/L post monsoon Fig 7 (b). Nitrate between 10.2-38.5 mg/L pre and 3.8-21.6 mg/L post monsoon Fig. 7 (c). The coliform count found in between 28-TNC pre and 42 to TNC CFU/100 mL post monsoon Fig. 7 (d).

Lakshmipur, TDS between 360-526 mg/L and 284-522 mg/L pre and post monsoon respectively Fig. 8

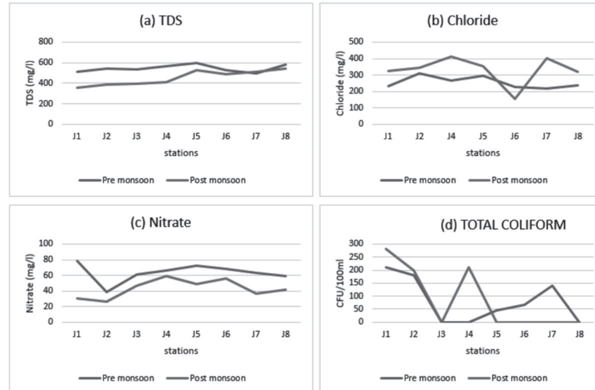

Fig. 6. Jamalpur (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

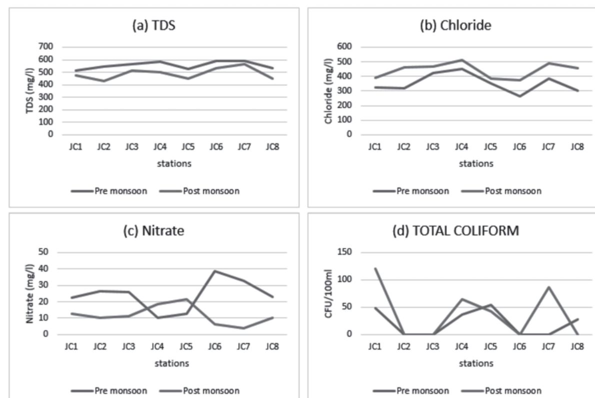

Fig. 7. Jagjeevan (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

(a). Chloride between 167-414 pre and 287-518 mg/L post monsoon Fig. 8 (b). Nitrate 3.5 to 11.6 mg/L pre and 1.8 to 4.2 mg/L post monsoon Fig 8 (c). The coliform count from 5 to TNC pre and 28 to TNC CFU/100ml post monsoon Fig. 8 (d).

Zakir Nagar, TDS from 529 to 676 mg/L and 472 to 592 mg/L pre and post monsoon respectively Fig. 9 (a). Chloride between 116-312 mg/L pre and 201-387 mg/L post monsoon Fig. 9 (b). Nitrate between 10.9- 31.8 mg/L pre and 14.1-48.8 mg/L post monsoon Fig. 9 (c). The coliform count numerous in number as TNC CFU/100 mL in both season.

Discussion

High values of Nitrate and Chloride in samples shows the contamination due to leachate of septic tank. Though Chloride is not a concern of health but impacts acceptability.

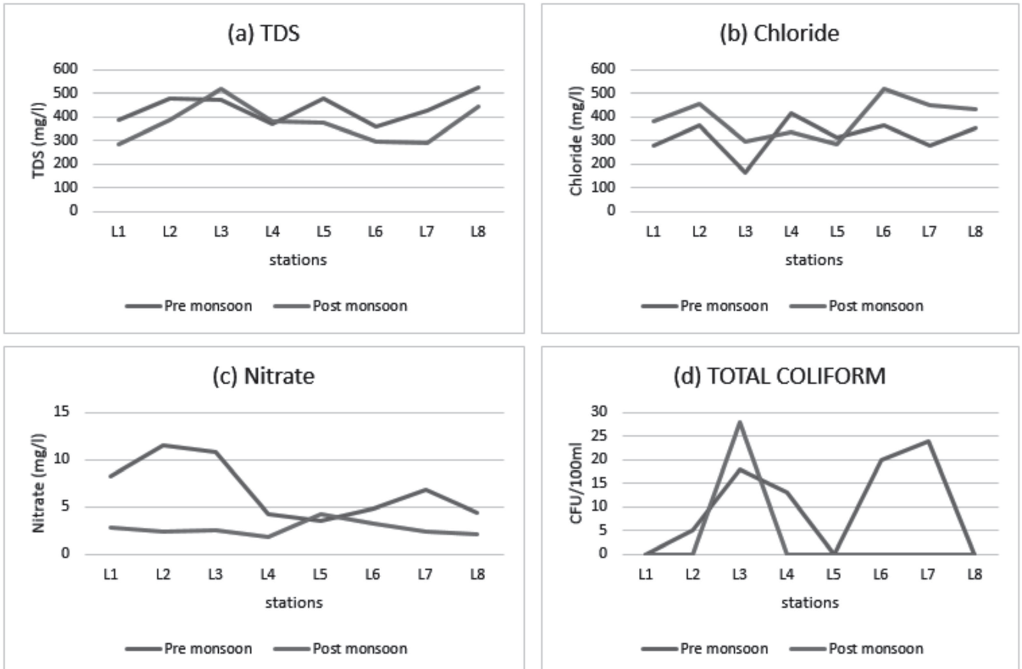

Fig. 8. Laxmipur (a) TDS, (b) Chloride, (c) Nitrate, (d) Coliform

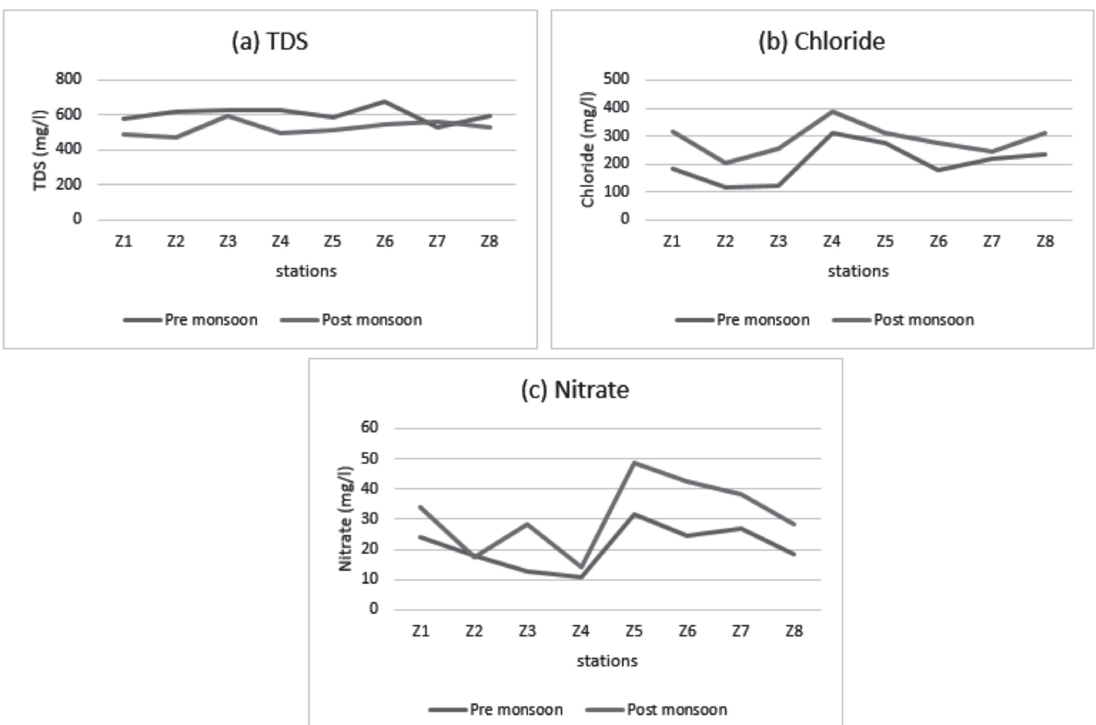

Fig. 9. Zakir Nagar (a) TDS, (b) Chloride, (c) Nitrate

High TDS but less than permissible range of 2000 mg/L. Post monsoon TDS is lesser than pre monsoon; may be due to dilution during ground water recharge after monsoon. Chloride in excess cause's bad taste and corrosion related issues. Slums like Begham Bagh, Jamalpur, Jagjeevan colony and

Laxmipur showed high value of chloride in both season beyond the BIS desirable limit of 250 mg/L Fig. 3 (b), Fig. 6 (b), Fig. 7 (b), Fig. 8 (b).

Ground water quality of Begham Bagh, Chandaniya, Firdaus Nagar, Jamalpur found very alarming for the health perspective of residents. Samples from Chandaniya showed maximum value of nitrate above 100 mg/L in pre monsoon which is quite harmful for the health Fig. 4 (c). In post monsoon sampling Nitrate reduced in most of the samples from Begham Bagh, Chandaniya and Firdaus Nagar above 45 mg/L Fig 3 (c) Fig. 4 (c), Fig. 5 (c). The post monsoon reduced Nitrate may be due to infiltration of precipitation which recharges the ground water table and dilutes nitrate concentration.

Few places like Begham Bagh, Zakir Nagar and Firdaus Nagarcontrast this trend as Nitrate value increases in post monsoon sampling; may be due to availability of aerobic condition Fig. 3 (c), Fig. 5 (c), Fig. 9 (c). During post monsoon ground water level is shallow as compared to pre monsoon and this shallow water table provides an aerobic condition that cause conversion of free Nitrogen into Nitrate and vice versa (Lawrence, 2001). Hence Nitrate concentration shows contrasting response in some of the locations in comparison among pre and post monsoon sample.

Total Coli form observed in all samples. Infiltration and ground water recharge post monsoon causes faster movement of pathogens to reach ground water faster that is why post monsoon coliform counts observed higher than pre monsoon sampling. Another factor may be soil type, its porosity, permeability and presence of rock fractures, faults etc. that may help in interaction of source contaminants to receptor. The open drains carrying domestic wastewater may contaminate ground water. There may also be some other source of pathogens like solid waste dump, live stocks, open drains etc. around sampling site. Presence of even a single colony of pathogens is not desired for drinking purpose and almost all samples showing their presence were not tolerable.

Conclusion

In any case, while it is the severe types of pollution, so there is an urgent need of different controls in the region of the source to diminish contamination. Protective measures are not usually considered in key sanitary during maintenance developing pollutant pathways. Sanitary conditions ought to be enhanced and public awareness should be made in regards to impacts of inappropriate sanitation and their health concerns. Ascent of a level of government funded training concerning sanitary conditions and cleanliness is the imperative component of procedure of change of parameters of health in slum areas.

There is still lot of scope for the study; effect of on-site sanitation on ground water in details and also the regular monitoring of ground water quality and sanitation systems in these areas mostly slums and rural areas.

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