

NITRATE POLLUTION OF GROUND WATER IN SOUTHERN AND SOUTH-WESTERN HARYANA, INDIA

Y.P. KAKAR

Central Ground Water Board, Chandigarh, India

ABSTRACT

With the establishment of direct relationships between concentration of nitrate in drinking water with incidence of methemoglobinemia, which may prove fatal for infants, study of distribution of nitrate in domestic supply has become vitally essential. In southern and south-western Haryana, nitrate levels exceeding 500 mg/l at shallow depths have been observed at several places.

In absence of any known geological source of nitrate in the area and non-uniform pattern of distribution of nitrate along the direction of groundwater movement, nitrate pollution is likely to be caused by sewage and agricultural wastes. While some nitrate in water may originate from fertilisers, major nitrate pollution is likely to be from sewage. Confinement of large number of cattle near wells particularly in hot seasons and uncontrolled discharge of animal wastes is a common practice in the area under study. Concentration of cattle in small areas, coupled with the fact that ruminant animals produce considerable amounts of nitrogenous organic waste in the area, is damaging manifestation of nitrogen pollution from farm animals. Since coarse textured soils prevalent in the area, have low retention capacity, relatively small amount of rainfall or irrigation water readily moves the leachate from sewage below the root zone.

Statistical analysis reveals that there are strong positive correlations between nitrate and chloride at several places where nitrate concentrations are high in ground water. Similarity in the geo-chemical characteristics of nitrate and chloride ions and strong positive correlations between these ions indicate the possibility of nitrate from sewage which is also evidenced by other factors. High concentrations of nitrate in groundwater are health hazard and pollution abatement measures are necessitated to prevent further degradation of groundwater quality.

---

INTRODUCTION

Man in his endeavour to increase agricultural production and to improve his living conditions has affected the natural environment which has far reaching consequences. Disposal of agricultural wastes and sewage becomes source of groundwater pollution. Extensive use of fertilisers and confinement of farm animals often adversely affects

groundwater quality in rural areas. The presence of high nitrates in natural waters at several places indicates the impairment of groundwater quality as a result such activities of man.

Nitrate in drinking water is associated with methemoglobinemia which can prove fatal for infants. In the present study, nitrate distribution and its sources in shallow groundwaters have been studied in southern and south-western parts of Haryana comprising districts of Furgaon, Mahendragarh and Bhiwani.

#### GEOLOGY OF THE AREA

In Haryana, Quaternary formations comprising fluvial and aeolian deposits of considerable thickness occur in most of the area. Older rocks such as Siwalik group and those belong to Delhi system are exposed in some areas and underline the Quaternary deposits. The area in Gurgaon district comprises extensive, almost flat plains uninterrupted by a long rocky ridge, isolated buttes and clusters of sand dunes. Strike ridges of rocks belonging to Delhi system overlain by Quaternary deposits comprising alluvium, blown sands and talus are found in area under Mahendragarh district. The area in Bhiwani district is underlain by alluvium comprising silt, sands, sandy clays and clays in association with varying amount of kankar. Arid brown and desert soils are extensively found in the area.

#### EXPERIMENTAL

Water samples were collected and analysed by methods detailed in literature (Brown et al. 1972, APHA 1971, Handa 1976). Nitrate was determined by Phenol-disulphonic acid method and high concentrations of nitrate were checked by reduction method. Samples were collected in 1978 and 1979 for this study.

#### DISCUSSION

In the chart attached, nitrogen cycle, agricultural cycle, different valency states of nitrogen, some of locations with high nitrate levels in groundwater, changes in nitrate concentrations in 1978 - 1979 and values of correlation coefficients are shown.

High concentrations of nitrate in groundwater have been observed at several places. At Firozpur Zirka in Gurgaon district, nitrate concentration of 1038 mg/l has been recorded. At Faruk Nagar, Jatauli and Gurgaon, nitrate levels of 856, 200 and 127 mg/l respectively have been observed. At Narnaul in Mahendragarh district, nitrate concentration of 1920 mg/l in groundwater has been found. At several other places levels as high as 641, 544, 330 mg/l have been recorded. In Bhiwani district also, high nitrate concentrations of 700 and 626 mg/l have been recorded.

No discernable pattern about distribution of nitrate in groundwater in the area under study could be established. At Faruk Nagar, nitrate level is 856 mg/l whereas

at Gurgaon which is near Faruk Nagar, nitrate concentration is 127 mg/l. In district Mahendragarh, nitrate concentration in groundwater at Budhwal is 320 mg/l which shows decrease to a level of 51 mg/l at Lujata and sharp increase to 1920 mg/l at Narnaul which is situated along the direction of groundwater movement. At Khudana in Bhiwani district nitrate level is 700 mg/l which decreases to 188 mg/l at Hanswas Khurd and decreases further to 43 mg/l at Singhani along direction of groundwater movement.

Sudden steep changes during traversing of groundwater both on positive and negative sides in nitrate levels and also during lapse of one year (as shown in chart) indicate that there is no regular pattern of nitrate distribution and pollution appears to be localised.

#### SOURCES OF NITRATE IN GROUNDWATER

Some of important sources which may contribute nitrate in groundwater through direct or indirect processes are:

##### i) Atmosphere and precipitation

Abundance of ammonium bearing particles in atmospheric aerosols have been reported by Junge & Manson (1961) and for nitrate and ammonia by Junge (1958). In India, Handa (1968, 1969) has carried out extensive studies about chemical composition of rainfall over different parts of country and has reported concentration of ammonium and nitrate ions in rainwater less than 1 mg/l which indicates that contribution by rainwater for high nitrate concentrations in groundwater is very less.

##### ii) Geological deposits

In absence of any major reported occurrence of nitrate deposits in the area under study, chances of nitrate in groundwater being leached from geological deposits are not significant.

##### iii) Industrial sources

In the effluents of industries like fertiliser, distillery, butchery, meat packing etc. high concentrations of nitrogenous compounds are often present which may enter into groundwater body as a result of infiltration. In absence of any of these industries on large scale in the area, chances of nitrate pollution from industrial effluents are very little.

##### iv) Sewage and animal sources

Raw or inadequately treated sewage discharged on land surface is often the cause of groundwater pollution. In the rural areas, farm animals produce large amounts of nitrogenous waste. The nitrate content as Nitrogen (N) of animal manure slurries has been indicated to range from 0.13 to 0.42% for cattle, 0.3 to 0.9% for hogs, 0.41 to 1.7% for poultry (Morris 1966). The total nitrogen content for farm waste has been shown to contain from 100 to 4200 mg/l for cowsheds and milking parlors and 1175 mg/l for farrowing house (Loehr 1970). During bacterial degradation, nitrogen is converted into ammonia or ammonium ions which on oxidation yield nitrite and eventually nitrate.

Ammonium ions ( $\text{NH}_4^+$ ) being positively charged get attached with clay particles and clay humus which are negatively charged. Nitrate ions are free to move and are leached and enter into groundwater body.

In the area under study, in rural areas cattle are confined in relatively small places. In summer months, large number of cattle sit near village pond or wells as these places are comparatively cool. Excreta gets accumulated near wells and is leached by rainfall. In some of dug wells, pigeons make holes in the sides of wells and often large number of pigeons live in wells. Handa (1974) has reported high nitrates due to excreta of pigeons in certain areas in Rajasthan.

Schmidt (1972) has reported high concentrations of chloride where high nitrate has been found in groundwater as a result of pollution from excreta. Computation of correlations between nitrate and chloride ions in groundwaters shows that values of coefficient of correlation ( $r$ ) in districts Gurgaon and Mahendragarh are +0.53 and 0.72 respectively. These values indicate the possibility of nitrate being derived from excreta to an appreciable extent. Corresponding value of correlation coefficient in groundwater in Bhiwani district was found to be +0.05. Poor correlation in this area indicates the possibility of nitrate sources other than excreta.

#### v) Agricultural sources

Some of sources of nitrate connected with agriculture include fertilisers, barn yards, silo waste, disposal of crop residue and application of herbicides and insecticides. Though fertilisers play a vital role in increasing agricultural production, indiscriminate use of fertilisers is not only harmful but also unutilised nitrogen causes high concentration of nitrate in groundwater.

In the area under study, the fertilisers like N.P.K. (Nitrogen, Phosphate and Potassium) and are extensively used. High concentration of potassium to the level of 496, 230, 194 mg/l have been observed in groundwater at some places. Correlation coefficient value between nitrate and potassium in groundwater in district Mahendragarh has been found to be +0.85. As high concentrations of potassium have been detected only at a few places, correlations between potassium and nitrate will not represent true conditions about origin of these ions. While farm excreta is likely to be major source of nitrate in ground water, high concentrations of potassium at some places suggest the possibility of fertilisers also contributing nitrate to some extent.

#### ACKNOWLEDGEMENTS

The author is indebted to Dr. B.D. Pathak, Chief Hydrogeologist & Member, Mr. N.C. Bhatnagar, Director and Dr. B.K. Handa, Chemist (Sr.), Central Ground Water Board for their keen interest and help during the present study.

#### CONCLUSION

In parts of southern and south-western Haryana, high concentrations of nitrate in

groundwater have been observed which can be deleterious to the health of infants. Occurrence of high nitrates in natural waters at shallow levels is likely to be caused by local pollution as no conspicuous pattern regarding areal distribution of nitrate has been observed along direction of groundwater movement. Ameliorative measures are necessitated to prevent high concentrations of nitrate in groundwater to safe guard public health.

#### REFERENCES

- 1 A.P.H.A., Standard methods of analysis of water and waste water. 1976, 14th edition.
2. Bhatnagar, N.C., Hydrogeological conditions in the state of Haryana with possibilities of groundwater development. 1977, C.G.W.B. mimeographed report.
3. Brown et al, Methods of collection & analysis of water samples for dissolved minerals & gasses. USGS 1972, Book V, Chapter A1.
4. Handa B.K., Chemical Composition of Premonsoon showers over Calcutta in 1968, Science and Culture.
5. Handa B.K., Chemical Composition of monsoon rains over Calcutta, Tellus 21, '69, pp 95 - 106.
6. Handa B.K., Occurrence of high nitrate ion concentration in groundwater from some parts of India, Assoc. Internat. De Hydrogeologues Congress de Montpellier, France '74
7. Handa B.K., Groundwater pollution in India, Nat Symp on Hydrology, Univ. of Roorkee Nov. 13 - 15, 1975.
8. Handa B.K., Technical manual on modern methods of analysis. Technical Manual no 3, Ministry of Agriculture & Irrigation 1976.
- 9 Junge C.E., The distribution of ammonia and nitrate in rainwater over USA, Trans. Amer. Geophys. Union, 39 (2), 1958, pp 241 - 248.
- 10 Junge C.E. & Monson J.E., Stratospheric aerosols studies, Journ. Geophys. Research 66 (7), 1961, pp 2163 - 2182.
- 11 Loehr R.C., Control of nitrogen from animal waste waters. Proceedings 12th Sanitary Engg. Conference Feb. 11 - 12, 1970, Urbana Illinois, pp 153-169.
- 12 Morris W.H.M., Economics of Liquid manure disposal from confined livestock. Proc. of Nat Symp on Animal Waste Management, A.S.A.E. publication SP-0366, 1966, 126-131.
- 13 Schmidt, K.D. Aquifer protection and rehabilitation, Bull Session No 4, Ground Water Jan-Febr 1972.
- 14 Sidhu G.S., Sharma A.C., Dhingra D.R., Soils of Haryana, Capter 6 of soils of India, Fertiliser Ass. of India, New Delhi, 1972, pp 102 - 111.
- 15 Steward B.A., Volatalisation and nitrification of nitrogen from urine under simulated cattle feed lot conditions. Environmental Science & Techn, 4, 1970, pp 579-582.