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# Nitrate-nitrite conversion mechanism and its impact in the groundwater of Siruvachur village, Perambalur district

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**ABSTRACT**

*Nitrate contamination in the groundwater is one of the major problems. In the last few decades, nitrate concentrations in groundwater have increased dramatically. Groundwater contamination by nitrate ($NO_3^-$) is a global problem and is most often associated with leachates derived from fertilizers and animal or human wastes. The primary concern over nitrate in groundwater is the occurrence of a disease called methemoglobinemia in human infants who drink water containing the nitrate ion. Nitrate concentrations more than 50 mg/l are very harmful to infant, foetuses and people with health problems. Potential $NO_3^-$ source materials in the study area are animal manure N, synthetic $NH_4$ based fertilizers. The study presented here was carried out at Siruvachur village and its surrounding villages in Perambalur district. In this area, eight groundwater samples were collected from four different villages between the month of December 2011 and March 2012. The various Physico-chemical parameters were analyzed and compared with the standard values given by WHO. Analysis of these samples revealed that they have nitrate concentrations more than the maximum permissible limit recommended by WHO, which is due to the use of nitrogeneous fertilizers and animal or human waste.*

**Keywords:** Groundwater, Physico-Chemical parameters, Siruvachur village, Methemoglobinemia.

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## INTRODUCTION

In recent years, it has been recognized that the quality of groundwater is of nearly equal importance to the quantity [10]. Nitrate ($NO_3^-$) is one of the integral part in the growth of life. It is essential for the growth of many plants species, including most of those which are edible, but it becomes a problem if it gets into water in which it is not required. This leads to major environmental problem and also as a health hazard [13].

Human activities (like Agricultural practice, fertilizers application, wastewater discharge) have had a great influence on the quality of groundwater in different regions of the world [2]. Nitrate in contaminated water is known to cause methaemoglobinaemia in infants [1]. Nitrates could combine with amines in the body to form N- nitroso compounds that are known cancer causing agents. However this association is controversial [12]. Concentration of nitrate in the groundwater can occur if input of $NO_3^-$ into soil exceeds the consumption of plants and denitrification [7]. Moreover the increased nitrate level in drinking water may adversely affect the central nervous system [4].

Nitrate ($NO_3^-$) and nitrite ($NO_2^-$) are naturally occurring inorganic ions, which are part of the nitrogen (N) cycle. Microbial action in soil or water decomposes wastes containing organic nitrogen first into ammonia, which is then

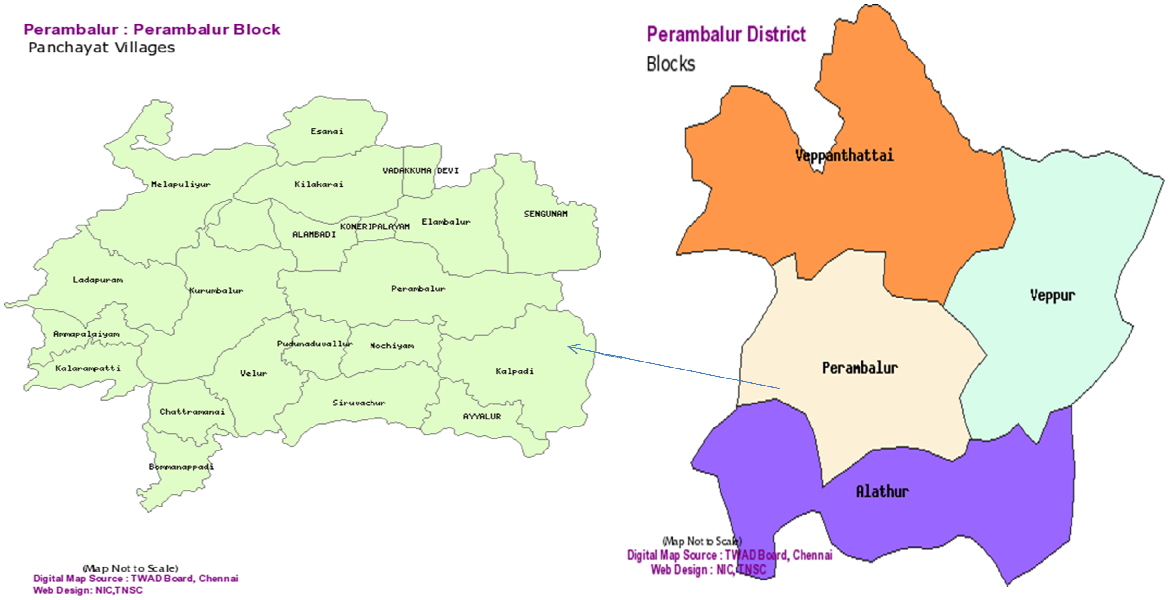
oxidized to $NO_2^-$ and $NO_3^-$ [7]. Because $NO_2^-$ is easily oxidized to $NO_3^-$, $NO_3^-$ is the compound predominantly found in groundwater and surface waters under oxidizing conditions. Contamination with N-containing fertilizers, including anhydrous ammonia, as well as animal or human natural organic wastes, can raise the concentration of $NO_3^-$ in groundwater [9]. $NO_3^-$ containing compounds in the soil are generally soluble and readily migrate into groundwater [8].

From the above details of excess nitrate and its alarming impact on the health of human beings, this project work was undertaken in the Siruvachur village.

**STUDY AREA**

The study area lies between the longitudes 78 ◌ 40'- 79 ◌ 30' E and the latitudes 10 ◌ 54'- 11 ◌ 30' N. It is fairly rich in mineral deposits. Celeste, lime stone, shale, sand stone, canker and phosphate nodules occur at various places. The study area is fairly rich in mineral deposits.

**Figure 1.Study Area Map**




**MATERIALS AND METHODS**

Eight groundwater samples were collected from four different villages in and around Siruvachur village, Perambalur district, Tamilnadu during December 2011 and March 2012. The location map of the study area is shown in figure. The samples were collected from bore wells and public water services which are extensively used for drinking and other domestic purposes. The collected groundwater samples were analyzed by using the procedures of APHA 2004, for various Physico-chemical parameters like pH, EC, Total Dissolved Solids, Total Hardness, Total Alkalinity, Calcium, Magnesium, Phosphate, Nitrate, Chloride, Dissolved Oxygen, COD, BOD and Fluoride. The concentrations of all the parameters are mg/l except pH (units) and EC in microsiemens/cm.

**Table 1: Physico-Chemical Parameters of the Groundwater in Siruvachur Village, Perambalur District**
*The units of all the parameters in mg/l except Temperature, pH, and EC in µs/cm*

| S.NO | PARAMETERS | PERMISSIBLE LIMIT | UNIT | S1(A) | S1(B) | S2(A) | S2(B) | S3(A) | S3(B) | S4(A) | S4(B) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | pH | 6.6 to 8.5 | | 7.2 | 7.1 | 7.3 | 7.4 | 7.6 | 7.5 | 7.4 | 7.1 |
| 2 | Temperature | - | ◌C | 30 | 29.5 | 31 | 31 | 30 | 31 | 30 | 30 |
| 3 | Electrical Conductivity | | µ s/cm | 1003 | 2007 | 1393 | 823.4 | 440.6 | 501.7 | 617.1 | 1333 |
| 4 | Colour | - | | Colorless | - | - | - | - | - | - | - |
| 5 | Odour | - | | Odourless | - | - | - | - | - | - | - |
| 6 | Total Hardness | 300 | mg/l | 484 | 546 | 350 | 476 | 274 | 450 | 390 | 402 |
| 7 | Alkalinity | 200 | " | 370 | 280 | 335 | 310 | 325 | 290 | 205 | 260 |
| 8 | Calcium | 75 | " | 68.13 | 168.13 | 68.93 | 66.53 | 40.08 | 54.50 | 84.16 | 156.31 |
| 9 | Magnesium | 30 | " | 101.47 | 92.15 | 68.58 | 99.91 | 51.07 | 96.5 | 74.62 | 59.94 |
| 10 | Phosphate | 5.0 | " | 0.30 | 0.47 | 0.58 | 0.60 | 0.35 | 0.42 | 0.71 | 0.81 |
| 11 | Nitrate | 45 | " | 62 | 108 | 149 | 105 | 85 | 124 | 135 | 127 |
| 12 | Chloride | 250 | " | 225.78 | 248.5 | 291.1 | 255.6 | 63.9 | 85.2 | 404.7 | 191.7 |
| 13 | DO | 5 | " | 12.13 | 9.10 | 9.10 | 8.09 | 8.09 | 6.06 | 7.08 | 5.05 |
| 14 | COD | 10 | " | 12.3 | 9.10 | 9.10 | 8.09 | 8.09 | 6.06 | 7.08 | 5.05 |
| 15 | BOD | 4 | " | 0.6 | 0.1 | 0.2 | 0.2 | 0.3 | 0.2 | 0.1 | 0.1 |
| 16 | TDS(Total Dissolved Solid) | 500 | mg/l | 123 | 31 | 27 | 34 | 250 | 39 | 59 | 34 |
| 17 | Fluoride | 1.5 | mg/l | 1.7 | 4.6 | 0.55 | 0.88 | 0.24 | 2.6 | 0.74 | 0.32 |

**STATIONS**
S1 → SIRUVACHUR
S2 → VILLAMUTHUR
S3 → VELLANUR
S4 → ARANARAI

A → PUBLIC WATER
B → BOREWELL WATER

## RESULTS AND DISCUSSION

The results of the chemical analysis of different constituents of the groundwater of the Siruvachur village, Perambalur district is shown in the table 1. The nitrate ion concentration was determined for eight groundwater sample during the study period are also tabulated. The values were compared with the standard values given by WHO, which shows that the nitrate ion concentration in all the groundwater samples were found to be more than the permissible limit, which is unsuitable for drinking purpose. Higher concentration of nitrate in groundwater is an anthropogenic pollutant contributed by the use of nitrogeneous fertilizers, human and animal waste. Nitrate has been linked to agricultural activities due to excessive use of nitrate fertilizers, which is reflected in this present study [15].

### Mechanism of nitrate contamination in the groundwater

Occurrence of nitrate in groundwater is normally of anthropogenic nature due to the contact of soil cover with contaminations like nitrate fertilizers. Factors which contribute to the aquifer contamination comprise the secondary porosity of aquifer and the porous and permeable soil cover. Aquifer could contaminate by leaching source, Point source and Biochemical source [14].

### Leaching mechanism

The use of nitrogen (N) fertilizer in agriculture has significantly increased over the past 30 years to meet the food and living requirements of the speedily growing population. Therefore, the use of nitrate in fertilizers causes a foremost predicament in groundwater contamination. Some of the fertilizers infiltrate with the irrigation and/or rainwater to recharge the aquifer. The increased uses of nitrate fertilizers in the villages enhance the contamination of groundwater. The local farmers of the study area admitted the use of excessive nitrate fertilizers and believe that it is necessary to have better agricultural productivity.

### Point source mechanism

Wastewater in the upper soil layer either from the cesspools or the disposal ponds could infiltrate to the groundwater aquifer. The absence of a sewage system encourages such types of contamination by nitrate. Thus, the level of nitrate in groundwater will continue to increase as the source of contamination. These sources are more dangerous than the leaching ones, because of the daily use of water, which then recharges the aquifer.

**Biochemical mechanism**

The interaction of nitrogen compounds with the surrounding media leads to oxidation of nitrogen compounds, which finally contaminate the aquifer. Generally organic matter-nitrate bearing-is distributed on the surface or near surface of the ground produces nitrate. Oxidation of ammonia (from waste water, eg., cesspools, sewage water and disposal ponds) into nitrite by bacteria (Nitrosomonas) follows the reaction below.

$2NH_4+4O_2 = 2NO_2^-+4H_2O$

Nitrite is then oxidized to nitrate by another type of bacteria (Nitrobacteria)

$2NO_2^-+O_2 = 2NO_3^-$

This conversion of ammonia in to nitrates is called nitrification. The nitrification rate increases in the presence of oxidation conditions and in the case of a high population of nitrifying bacteria.

## CONCLUSION

Nitrate ion assessment studies in and around the Siruvachur village, Perambalur district, Tamilnadu indicates that the concentration of nitrate is higher than the permissible limit (50 mg/l) in all the groundwater samples collected from the study area. The sources of nitrate pollution in the study area are agricultural activities and human and animal wastes. Fertilizer is a potential source of nitrate pollution. The appropriate remedial measures should be implemented in order to restore the aquatic ecology of the contaminated area.

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