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# Blue Baby Syndrome: Nitrate Contamination in Water

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## ABSTRACT

Blue Baby Syndrome, medically termed *methemoglobinemia*, is a clinical condition characterized by a *bluish discoloration* of an infant's skin due to reduced oxygen-carrying capacity of blood. The disorder may be congenital or acquired. The acquired form is primarily associated with nitrate contamination in drinking water and food. Infants below one year of age are particularly vulnerable. The present study focuses on nitrateinduced methemoglobinemia in Pakur district, specifically in the Amrapara and Maheshpur blocks. Water samples collected from selected mining areas were analyzed to determine nitrate concentration and assess associated health risks. The findings indicate seasonal variations in nitrate levels, though values remain within permissible limits. Continuous monitoring and public awareness are nevertheless essential to prevent health hazards.

**Keywords**: Blue Baby Syndrome, Methemoglobinemia, Nitrate Contamination, Cyanosis, Groundwater, Pakur District

## INTRODUCTION

Blue Baby Syndrome refers to a pathological condition in which infants develop a bluish coloration of the skin, lips, and extremities, especially noticeable during crying. The condition occurs due to decreased oxygen supply in the bloodstream. Medically known as methemoglobinemia, it results from the oxidation of hemoglobin into methemoglobin, which is incapable of effectively transporting oxygen.

The disorder may be congenital, present at birth due to genetic abnormalities, or acquired, mainly through ingestion of nitrate-contaminated water or food. Infants under 12 months are particularly susceptible because their digestive systems facilitate the conversion of nitrate ($NO_3^-$) to nitrite ($NO_2^-$), which interferes with oxygen transport. Additional risk factors include anemia, metabolic acidosis, milk protein intolerance, and urinary tract infections.

This study primarily investigates nitrate contamination in groundwater sources of **Pakur district, Jharkhand**, with emphasis on mining-influenced regions.

### Causes of Blue Baby Syndrome:

Nitrate and nitrite concentrations in drinking water are regularly monitored due to their potential health hazards. The maximum admissible concentration (MAC) for nitrate in drinking water is generally **50 mg/L**, while lower limits are recommended for infant safety.

Nitrate occurs naturally in small quantities in surface water but may accumulate in higher concentrations in groundwater due to agricultural runoff, sewage disposal, and industrial activities. In infants below six months of age, excessive nitrate intake can lead to methemoglobinemia.

### Clinical symptoms of nitrate-induced methemoglobinemia include:

- Bluish discoloration of skin (cyanosis)
- Rapid heartbeat

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- Shortness of breath
- Nausea and diarrhea
- Lethargy
- Loss of consciousness
- Seizures

In severe cases, oxygen deprivation may lead to fatal outcomes.

## MATERIALS AND METHODS

### Study Area

Water samples were collected from selected sites in **Pakur** district, including:

- **Panem Coal Mines**
- **Udalbani Stone Chips Mines**
- **Dumkadanga Stone Chips Mines**

These locations fall within the Amrapara and Maheshpur blocks and are influenced by mining activities.

### Sample Collection

Samples were collected during pre-monsoon, monsoon, and post-monsoon seasons for the years 2017 and 2018. Standard procedures recommended by APHA were followed. Doubly washed plastic bottles were used to prevent contamination.

### Analytical Procedure:

Nitrate was estimated using the Devarda's alloy reduction method under strongly alkaline conditions. In this method, nitrate and nitrite are reduced to ammonia ($NH_3$), which is distilled and quantified either spectrophotometrically or titrimetrically.

**Reaction involved:**

$$3NO_3^- + 8Al + 5OH^- + 2H_2O \rightarrow 8AlO_2^- + 3NH_3$$

The liberated ammonia was absorbed in standard sulfuric acid and analyzed:

Spectrophotometric measurement at 424 nm using Nessler's reagent (valid for concentrations >0.5 ppm).

Titrimetric back-titration with 0.2N NaOH for higher concentrations (>5 ppm).

Conversion factor:

$$1 \text{ mL N } H_2SO_4 = 0.06201 \text{ g } NO_3^-$$

## RESULTS AND DISCUSSION

**Seasonal analysis of nitrate concentration revealed the following trends**:

### Pre-Monsoon Season

- Panem Coal Mines: 2.2 – 2.3 mg/L

- Udalbani Stone Chips Mines: 1.2 – 2.7 mg/L
- Dumkadanga Stone Chips Mines: 2.1 – 2.3 mg/L

**Monsoon Season**

- Panem Coal Mines: 1.3 – 2.1 mg/L
- Udalbani Stone Chips Mines: 1.1 – 1.4 mg/L
- Dumkadanga Stone Chips Mines: 1.1 – 1.9 mg/L

**Post-Monsoon Season**

- Panem Coal Mines: 2.1 – 3.36 mg/L
- Udalbani Stone Chips Mines: 1.2 – 1.4 mg/L
- Dumkadanga Stone Chips Mines: 1.6 – 3.3 mg/L

Groundwater samples generally showed higher nitrate concentrations compared to surface water. The highest values were observed during the post-monsoon season, possibly due to leaching and runoff effects.

Among the three sites, Panem Coal Mines recorded comparatively higher nitrate levels.

Although the observed concentrations remained within desirable limits, continuous exposure and seasonal fluctuations warrant regular monitoring.

## CONCLUSION

The nitrate concentration in groundwater sources of Pakur district is presently within *permissible limits*. However, sustained vigilance is necessary due to the vulnerability of infants and pregnant women.

Mild cases of methemoglobinemia may resolve without intensive treatment, but severe cases require immediate medical attention, including oxygen therapy or blood transfusion.

**Preventive measures include:**

- Regular testing of private wells and tube wells
- Avoiding nitrate-rich water for infants and pregnant women
- Monitoring groundwater quality in mining areas
- Public awareness programs regarding health risks

While congenital methemoglobinemia cannot be prevented, acquired forms can be minimized through safe drinking water practices and informed dietary choices.

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## REFERENCES

1. Ritu R., Ruby R., Arup G. A systematic review of potential health risk assessments for nitrate contamination in different water resources in India — Water, Air, and Soil Pollution (2025). Comprehensive meta-analysis of nitrate in Indian water and health risk assessment.

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**ResearchGate**

2. Al Mamun A., Alazmi A.S., Alruwaili M. Groundwater nitrate contamination and age-specific health risks in semi-urban northeastern Saudi Arabia — Cities (2025). Assesses nitrate levels, hazard quotients for infants/children. MDPI
3. Bencheikh A., et al. Nitrate contamination in deep aquifers: Health risks and trends — Science of the Total Environment (2025). Groundwater nitrate trends and non-carcinogenic risk evaluation in Algeria.

**ScienceDirect**

4. Abdipour H., Azari A., et al. Human health risk assessment for fluoride and nitrate contamination in drinking water of Zahedan, Iran — Applied Water Science (2025). Monte Carlo risk assessment including nitrate hazard for different age groups. Springer
5. Yazıcı Karabulut B., et al. A probabilistic approach to nitrate risk assessment of groundwater in the Harran Plain — Applied Sciences (2025). Spatial nitrate distribution and non-carcinogenic health risk assessment.

**MDPI**

6. Arezu Valizadeh, et al. A decadal analysis of drinking water quality and nitrate-related health risk assessment — Scientific Reports (2026). Ten-year groundwater quality and health risk evaluation including infants and children. Nature
7. “Disparities in potential nitrate exposures within Iowa public water systems” — Environmental Science: Water Research & Technology (2025). Highlights long-term nitrate exposure trends and public health concerns. RSC Publishing
8. “Assessment of fluoride and nitrate contamination in groundwater and their health implications in Kishangarh, Rajasthan, India” — Journal of Umm Al-Qura University for Applied Sciences (2025). Recent Indian groundwater nitrate study.

**Springer**

9. “Human health risk assessment of nitrate in repeatedly boiled water using Univariate regression and Monte Carlo simulation” — Scientific Reports (2025). Investigates nitrate concentration changes and health risks after boiling. Nature
10. “Nitrate contamination in groundwater and associated health risk assessment for Indo-Gangetic Plain, India” — Groundwater for Sustainable Development (2023). Regional study of nitrate levels and risk to children.
11. ScienceDirect