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ASSESSMENT OF THE DISTRIBUTION OF NITRATES AND OTHER POLLUTANTS IN GROUNDWATER

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https://doi.org/10.5281/zenodo.23672508

Abstract. This article reviews groundwater contamination by nitrates, pesticides, heavy metals, arsenic, fluoride, and per- and polyfluoroalkyl substances (PFAS), with emphasis on migration mechanisms and monitoring approaches. It is a narrative review of identified scientific sources; no new field sampling or laboratory measurements were performed. The World Health Organization (WHO) guideline value of 50 mg/L for nitrate (as NO_3^-) was used for preliminary screening. The reviewed evidence indicates the vulnerability of shallow aquifers to anthropogenic pressures, the persistence of legacy nitrate pollution, and the need for multiparameter monitoring. A source-oriented prevention and monitoring framework is proposed.

Keywords: groundwater, nitrate, contamination, hydrogeochemistry, monitoring, GIS, pesticides, arsenic, PFAS, risk assessment.

INTRODUCTION

Groundwater is an essential resource for drinking-water supply, irrigation, and industry. Excessive application of nitrogen fertilizers, livestock waste, wastewater infiltration, and defective sewage systems can increase nitrate loads. Organic compounds, pesticides, and PFAS originating from industrial and domestic activities, as well as naturally released arsenic and fluoride, may further impair groundwater quality [1, 5].

Nitrate is highly soluble and relatively stable under oxidizing conditions, enabling its movement through the unsaturated soil zone into aquifers. Its transport rate depends on groundwater flow, infiltration, aquifer porosity, and dispersion. Under reducing conditions, denitrification may decrease nitrate concentrations, but this process is spatially variable. Consequently, the concentration measured in a single well cannot characterize an entire area [3, 4].

WHO sets drinking-water guideline values of 50 mg/L for nitrate (as NO_3^-) and 3 mg/L for nitrite (as NO_2^-). These values are informed particularly by health concerns related to methemoglobinemia in infants [1]. Importantly, 50 mg/L NO_3^- is equivalent to approximately 11.3 mg/L nitrate-nitrogen (NO_3–N); confusing these units can lead to erroneous assessments.

The aim of this study is to synthesize recent scientific evidence on the distribution of nitrate and other major groundwater contaminants, compare assessment indicators, and propose a practical monitoring approach. Its objectives are to (1) identify contamination sources and migration pathways; (2) compare findings from recent studies; and (3) propose a set of indicators for monitoring and risk mapping.

MATERIALS AND METHODS

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Study design. This study was conducted as a narrative scientific review based on secondary information. Priority was given to studies published during 2024–2026, complemented by WHO, UNEP, USGS, and European Environment Agency documents as regulatory and methodological references [1–9]. This is not a full PRISMA-compliant systematic review or meta-analysis; reported figures are interpreted within their original study contexts.

Assessment framework. Contamination was evaluated along the sequence "source → unsaturated zone → aquifer → well → consumer." Risk factors included land use, fertilizer application intensity, groundwater depth, lithology, infiltration, redox conditions, well construction, and seasonal variation. Core water-quality indicators were NO_3^-, NO_2^-, NH_4^+, pH, electrical conductivity, dissolved oxygen, and major ions; depending on local conditions, As, F^-, Pb, Cd, pesticides, and PFAS were also considered [1, 3, 5, 6].

A screening quotient may be calculated as K = C / Cguideline, where C is the measured laboratory concentration and Cguideline is the applicable value for the same substance and unit. K > 1 indicates an exceedance of that value, but does not independently establish clinical risk or identify a pollution source. Where nitrate and nitrite coexist, the WHO approach based on the sum of their respective concentration-to-guideline ratios should be applied [1].

For spatial assessment, well coordinates are entered into a GIS database and overlaid with aquifer-depth and land-use maps. Interpolation (e.g., IDW or kriging) is appropriate only with adequate sampling density, spatial correlation, and cross-validation; otherwise, point maps are preferable. Source attribution may be supported by $\delta^{15}N–NO_3^-$ and $\delta^{18}O–NO_3^-$ isotope indicators and, when needed, $\delta^{11}B$, alongside hydrochemical evidence [4].

RESULTS

Spatial and temporal nitrate distribution. A global modelling study published in 2026 estimated that by 2020, shallow aquifers had accumulated 162 ± 6 Tg of nitrogen in the form of nitrate, and modelled exceedance of the WHO guideline across approximately 10% of the land area [7]. These figures are model outputs, not the percentage of sampled wells exceeding the guideline. The study suggests that historical nitrogen stores in the unsaturated zone may sustain pollution long after fertilizer inputs decline.

The European Environment Agency's 2025 monitoring review drew on time series from 2,104 groundwater bodies in 22 countries over 2007–2023. This illustrates how long-term observations help distinguish trends more reliably than one-off sampling [8].

Other contaminants. A 2024 scientific review indicated that the occurrence of geogenic arsenic, fluoride, selenium, and uranium is shaped by geological setting, water–rock interactions, and redox processes [5]. The USGS description of its 2024 national monitoring network covers 2,089 wells and measurements of nutrients, trace elements, and PFAS, with pesticides and volatile organic compounds assessed in selected wells [6]. These examples support monitoring beyond nitrate alone.

Table 1. Priority groundwater contaminants and assessment approaches

Contaminant / group	Main sources	Factors affecting transport	Monitoring method

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Nitrate (NO_3^-)	Fertilizers, manure, wastewater	Infiltration, oxidation, groundwater flow	Ion chromatography or validated laboratory method
Pesticides	Agriculture	Sorption, degradation, soil type	LC-MS/MS or GC-MS
Arsenic, fluoride	Geogenic sources	Rock composition, pH, redox	ICP-MS / suitable ion analysis
Pb, Cd and other metals	Industry, waste, some geogenic sources	pH, complexation, sorption	ICP-MS / AAS
PFAS	Industry, firefighting foams, waste	Compound chain length, transport, sorption	Targeted LC-MS/MS

The presented tables indicate that the distribution of nitrates and other pollutants in groundwater depends on agricultural activities, geological conditions, and groundwater flow characteristics. Nitrates are primarily associated with fertilizer application and wastewater infiltration, while heavy metals and other contaminants may originate from both natural and human activities. The findings highlight the importance of regular groundwater monitoring, integrated pollution assessment, and effective management strategies to reduce contamination risks and protect drinking water quality.

Source differentiation. A 2025 review of isotope methods reported that nitrogen and oxygen isotopes of nitrate, supplemented where necessary by boron isotopes, can help differentiate fertilizer, manure, and wastewater sources. However, isotope ranges can overlap, and denitrification may alter isotopic signatures; isotope evidence should therefore be interpreted together with hydrochemical and local contextual data [4].

DISCUSSION

Comparison of the reviewed sources suggests that shallow and poorly protected aquifers are particularly vulnerable to contamination from agriculture and settlements [3, 7]. Nevertheless, site-specific conditions matter: clay layers can retard migration, while poorly sealed wells may create preferential pathways to deeper aquifers. Broad conclusions based solely on well depth or land use are therefore limited.

The relatively high mobility of nitrate and the persistence of legacy nitrogen require long-term management. Optimizing fertilizer use, safely storing manure, repairing leaking sewage systems, and protecting sanitary zones around wells are key prevention measures [1, 3, 7]. Boiling nitrate-contaminated water does not remove nitrate; where elevated concentrations are confirmed, validated treatment or a safe alternative water source is needed.

Controlling anthropogenic inputs alone is insufficient for arsenic and fluoride because geological formations can be major sources [5]. PFAS and pesticides require substance-specific laboratory methods and evaluation against applicable national

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standards. Regulatory limits vary among jurisdictions; the WHO nitrate guideline must not be treated as a universal threshold for other contaminants.

The following practical monitoring sequence is recommended: (1) inventory potential sources and wells; (2) perform seasonal sampling with quality controls (blanks, duplicates, calibration); (3) measure nitrate, major ions, and redox indicators; (4) add metals, pesticides, and PFAS based on local risk; (5) conduct GIS analysis and isotope testing when warranted; and (6) repeat sampling at high-risk sites and develop source-specific interventions [3, 4, 6].

Limitations. This review does not present newly collected samples, and the geographical coverage, periods, and methods of the cited studies differ. Therefore, global estimates cannot be directly applied to any particular region or well in Uzbekistan. Local conclusions require well records, laboratory analyses, hydrogeological profiles, and seasonal observations.

CONCLUSION

The reviewed evidence indicates that groundwater quality is influenced jointly by anthropogenic nitrate loading and other natural-geochemical and human-derived contaminants. Assessment of nitrate must account for concentration units, aquifer properties, and long-term transport. Integrating multiparameter monitoring, GIS, hydrochemical analysis, and isotope techniques where appropriate can improve source identification and the prioritization of prevention measures. For Uzbekistan, a logical next step is seasonal monitoring of regional wells and the development of validated risk maps.

REFERENCES

1. World Health Organization. Nitrate and nitrite in drinking-water: Chemical fact sheet. — Geneva: WHO, 2022. — URL: https://cdn.who.int/media/docs/default-source/wash-documents/water-safety-and-quality/chemical-fact-sheets-2022/nitrate-and-nitrite-fact-sheet-2022.pdf
2. World Health Organization. Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. — Geneva: WHO, 2022. — URL: https://www.ncbi.nlm.nih.gov/books/NBK579460/table/ch12.tab106/
3. United Nations Environment Programme. Water Quality Monitoring and Assessment of Groundwater: Technical Guidance. — Nairobi: UNEP, 2022. — URL: https://wedocs.unep.org/handle/20.500.11822/40414
4. Global applications of stable isotopes for identifying nitrate pollution sources in groundwater: a comprehensive review // Frontiers in Water. — 2025. — DOI: 10.3389/frwa.2025.1666498.
5. U.S. Geological Survey. The U.S. Geological Survey National Water Quality Network—Groundwater, 2024. — URL: https://usgs.science/record/usgs%3Agip256/the-u-s-geological-survey-national-water-quality-network-groundwater-2024
6. The long tail of nitrate pollution in groundwater challenges governance of global water quality // Nature Communications. — 2026. — DOI: 10.1038/s41467-026-75014-8.
7. European Environment Agency. Groundwater nitrate 2007–2023 // Monitoring report on progress towards the 8th EAP objectives 2025. — 2025. — URL: https://www.eea.europa.eu/en/analysis/publications/monitoring-report-on-progress-towards-the-8th-eap-objectives-2025/groundwater-nitrate-2007-2023