Scholastic Case Reports (ISSN: 3108-1827)
Research Article
Volume 2 Issue 3 March 2026

A simple method for purifying nitrite-contaminated drinking water

Takahashi Masaaki[1], Takemoto Yukimasa[1], Go Takahashi[2]

[1] *Yokkaichi University Environmental Research Laboratory: Kayo-cho 1200, Yokkaichi, Mie, Japan*

[2] *Mie Automobile Service Ltd: Omiyanishi-machi 16-3, Yokkaichi-Shi, Mie , Japan*

Corresponding Author: Takahashi Masaaki, Yokkaichi University, Research Laboratory of Environmental Technology.

Received: March 20, 2026; **Published:** March 28, 2026

Abstract

High levels of nitrite nitrogen contamination have been reported in well water in developing countries. A simple treatment method using sodium hypochlorite was investigated to remove nitrite nitrogen from groundwater and make it drinkable. Nitrite nitrogen could be converted to the less toxic nitrate nitrogen by adding sodium hypochlorite at a rate comparable to that used in conventional sterilization. The addition rate could be controlled by monitoring the residual chlorine level, making this a useful simple treatment method for drinking water in developing countries.

Keywords: nitrite pollution, treatment method, drinking water, sodium hypochlorite

Introduction

In developing countries such as the Philippines and Mongolia, groundwater contamination by nitrite and nitrate nitrogen had been reported [1]. Nitrite nitrogen, in particular, is highly toxic and poses a serious problem for drinking water.

As the Nitrite removal methods, membrane filtration [2], electrodialysis [3], and adsorption [4], have already been put to practical use. However, these methods require expensive equipment and difficult maintenance, making them unsuitable for developing countries.

Nitrite ions are easily oxidized to nitrate ions under aerobic conditions. While nitrate ions are also harmful, they are less toxic than nitrite, and environmental standards for nitrite nitrogen are set at more than an order of magnitude lower than those for nitrite nitrogen (nitrite nitrogen: 0.4 mg/L, nitrate nitrogen: 10 mg/L) [5]. Therefore, for relatively low levels of contamination, converting nitrite nitrogen to nitrate nitrogen may reduce the levels below the drinking water standards.

Nitrite can be easily oxidized by an oxidizing agent and converted to nitrate nitrogen. Therefore, we investigated a simple treatment method to oxidize nitrite nitrogen and convert it to nitrate nitrogen.

2. Introduction of the groundwater pollution case

As an example, we will introduce the contamination situation on Negros Island in the Philippines. The analytical method and results are shown below.

In this study, the amount of test water collected was small, and the collection containers were not dedicated. Furthermore, due to the time that had passed since collection, the analysis items were limited.

The nitrite nitrogen concentration was far exceeded the standard. However, even if all the nitrite nitrogen was converted to nitrate nitrogen, the nitrate nitrogen concentration remained well below the standard, suggesting that removing nitrite through oxidation is effective. Other findings included high calcium levels, salt content, and somewhat high levels of nitrate nitrogen, but no significant contamination was observed.

Table 1: Outline of the analytical results

Item	Data	Unit	Analytical method
pH	6.4		pH meter (Horiba)
EC	583	μS/cm	EC meter (Horiba)
COD	0.6	mg/L	Acidic Manganese method
Na	36	mg/L	Ion electrode (Horiba [6])
K	7	mg/L	Ion electrode (Horiba)
Ca	230	mg/L	Ion electrode (Horiba)
Cl	>50	mg/L	Pack test (Kyoritsu chemical test lab. Cor.[7])

Zn	<0.2	mg/L	Pack test (Kyoritsu chemical test lab. Cor.)
Cr^{6+}	ND	mg/L	Pack test (Kyoritsu chemical test lab. Cor.)
NH4-N	0.2	mg/L	Pack test (Kyoritsu chemical test lab. Cor.)
NO2-N	0.5	mg/L	Pack test (Kyoritsu chemical test lab. Cor.)
NO3-n	3.6	mg/L	Ultraviolet light method
D-Fe	ND	mg/L	Pack test (Kyoritsu chemical test lab. Cor.)
D-Mn	ND	mg/L	Pack test (Kyoritsu chemical test lab. Cor.)
As	<0.001	mg/L	Official method [8]
Hg	<0.00005	mg/L	Official method
Pb	<0.001	mg/L	Official method
Se	<0.001	mg/L	Official method
Cd	<0.0003	mg/L	Official method

3. Water Purification Methods

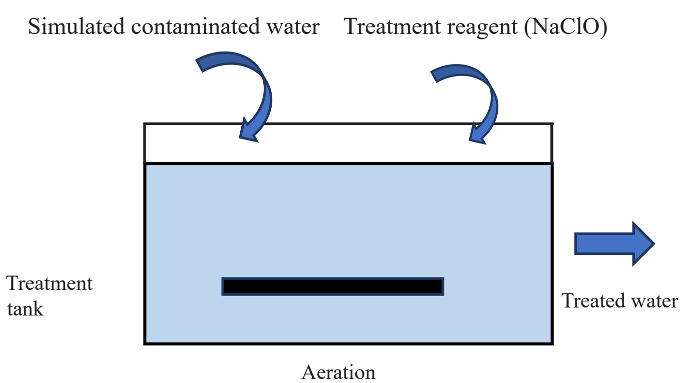
3.1. Treatment reagent

Possible methods for oxidizing nitrite nitrogen include aeration and the addition of oxidizing chemicals. In order to oxidized nitrite ion, possible oxidizing agents include water peroxide or sodium hypochlorite. Hydrogen peroxide is not appropriate because it is harmful if added in excess. Sodium hypochlorite is widely used as a disinfectant for tap water and is therefore easy to handle. It is also considered easy to monitor.

In this study, we examined aeration (air oxidation) and the addition of sodium hypochlorite (effective chlorine amount 5%)

3.2 Experimental Apparatus

63 L of well water (on-site well water) was placed in a 100 L tank (Fig. 5), and an appropriate amount of sodium nitrite reagent (adjusted to a nitrite nitrogen concentration 0.15 mg/L to 0.5 mg/L) to make simulated contaminated water was added. Aeration was performed from the bottom with air supply 40L per minutes (Fig.1).



Treatment tank size: Length 63 cm, Width 44 cm, Water depth 25 cm, Total volume 63L

Figure 1: Treatment apparatus.

Treatment tank size: Length 63 cm, Width 44 cm, Water depth 25 cm, Total volume 63L

Figure 2: Picture of the Apparatus.

3.3 Water measurement method

pH was measured using a pH meter (Horiba Co.)

Nitrite nitrogen and residual chlorine were determined using pack test method as mentioned.

4. Experimental Results

4.1 Aeration without treatment reagent

Aeration without addition of any treatment agent for four hours was performed, but no significant reduction in nitrite nitrogen was observed, indicating minimal effect (Fig. 3).

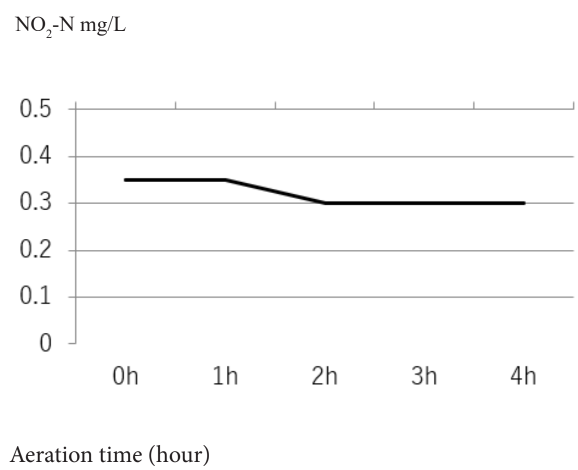


Figure 3: Transition of the nitrite nitrogen with aeration

4.2 Treatment with addition of sodium hypochlorite

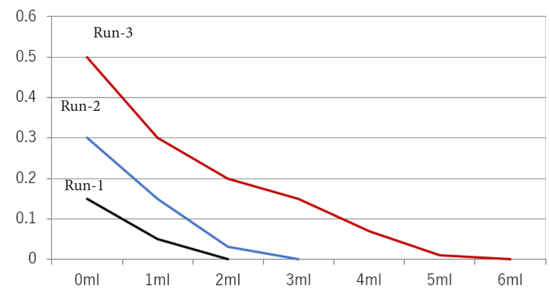
Nitrite-contaminated water of 0.15 mg/L to 0.5 mg/L was prepared, and 1 ml of hypochlorite reagent as mentioned was added to the water. A 50 mL of the treated water was taken out for the analysis.

The nitrite nitrogen concentration instantly decreased upon addition of the agent, reaching a stable value. Further addition was continued until the nitrite nitrogen concentration reached ND.

Fig. 4 shows the relationship between nitrite nitrogen concentration and the amount of sodium hypochlorite added. Although this varies depending on the initial nitrite nitrogen concentration, adding a few mL of nitrite nitrogen reduces it to ND, and it was determined that it could easily be reduced to below the environmental standard value (0.4 mg/L).

When the residual chlorine (hypochlorous acid concentration) in the treated water was examined, it was undetectable at the stage when nitrite nitrogen was detected, but residual chlorine was detected (0.2 mg/L) once nitrite nitrogen became undetectable (0.005 mg/L or less).

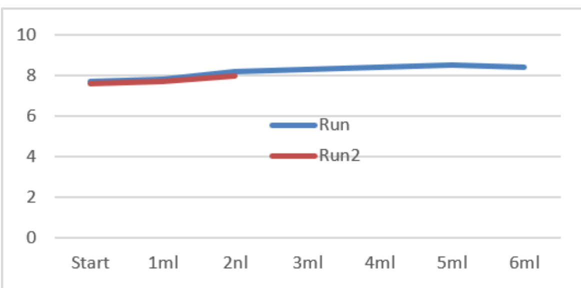
NO2-N mg/L



NaClO addition rate

Figure 4: Relation with concentration of nitrite nitrogen and sodium hypochlorite addition rate.

pH



Hypochlorite addition rate (mL)

Figure 5: Relation of the pH and sodium hypochlorite addition rate.

Discussion

Aeration without any reagent was difficult to convert nitrite nitrogen to nitrate nitrogen in a short time.

The addition of sodium hypochlorite was shown to be effective in removing nitrite nitrogen, and it remains in the treated water once nitrate nitrogen treatment is complete. Therefore, the amount of sodium hypochlorite added can be controlled by monitoring the available chlorine content of the treated water. Although the addition of sodium hypochlorite slightly increased the pH, this is not considered to pose a major problem.

The addition of sodium hypochlorite is an essential step in sterilization for the drinking water, and nitrite components are likely to be easily removed.

Summary

We investigated a method to improve drinking water quality by converting highly toxic nitrite ions to slightly less toxic nitrate ions.

Although aeration without addition of any treatment agent did not have a significant effect, the addition of sodium hypochlorite easily converted nitrogen to nitrate, meeting drinking water standards.

Sodium hypochlorite is commonly used for sterilization, so its use and management are considered easy.

As a simple water treatment method, it is considered suitable as a technology for developing countries.

Acknowledgement

The authors wish to express their appreciation to Kassui Plant Co Ltd who offered us the test water and the site of the experiment.

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