

SPECTROPHOTOMETRIC DETERMINATION OF SULPHATE AND NITRATE IN DRINKING WATER AT ASIA-PACIFIC INTERNATIONAL UNIVERSITY CAMPUS, MUAKEK, THAILAND

Anthony Swamy Thangiah

Senior Lecturer in Chemistry, Asia-Pacific International University, P.O. Box 4, Muak Lek, Saraburi 18180, Thailand.

E-mail: drtanthony2011@yahoo.com

ABSTRACT

The quality of water we drink is imperative and it forms a large percent of our bodies, allowing essential cellular chemical reactions to occur. It is, therefore, necessary to monitor for any physiochemical contaminants in the water. The aim of this research was focused to determine the level of sulphate and nitrate ions in drinking water at different locations from Asia-Pacific International University campus by using UV-Spectrophotometer. The drinking water has undergone by reverse-osmosis. Sulphate levels were measured using the turbidity method at 420 nm and nitrate levels by phenoldisulphonic acid methods at 410 nm. The research revealed the sulphate level to be 3.65 to 5.72 mg/L and nitrate level of 1.15 to 4.62 mg/L and these values are significantly lower than the WHO recommended guideline values for drinking water. The continued use of reverse osmosis as a mechanism to purify water is recommended.

Keywords: Sulphate, Nitrate, Spectrophotometric, UV-Visible Spectrophotometric, Water.

© RASĀYAN. All rights reserved

INTRODUCTION

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve drinking-water that is as safe as possible. Those at greatest risk of waterborne disease are infants and young children, people who are debilitated and the elderly, especially when living under unsanitary conditions. Those who are generally at risk of waterborne illness may need to take additional steps to protect themselves against exposure to waterborne pathogens, such as boiling their drinking-water. Safe drinking-water is required for all usual domestic purposes, including drinking, food preparation and personal hygiene. However, the water of higher quality may be required for some special purposes, such as renal dialysis and cleaning of contact lenses, or for certain purposes in food production and pharmaceutical use¹.

Universally the concern of contaminant levels in drinking water has been a long and contentious problem². Pollution of water has been reported to cause 80% of human diseases and 30% of infant mortality. It is, therefore, very necessary to monitor the quality of ground water pollution of various parts of our country³. Sulphate ions usually occur in natural waters and many sulphate compounds are readily soluble in water. Ingestion of water containing a high concentration of sulphate can have a laxative effect, which is enhanced when sulphate is consumed in combination with magnesium⁴.

High doses of sulphate particularly magnesium sulphates, cause catharsis or purging of the bowels, and magnesium sulphate or Epsom salts have been used as a purgative⁵. Children, transients and the elderly are such populations because of the potentially high risk of dehydration from diarrhea that may be caused by high levels of sulfate in drinking-water⁶. Humans are under serious threat owing to irregular change in

the physical, chemical and biological properties of water⁷. Dehydration has also been reported as a common side-effect following the ingestion of large amounts of magnesium or sodium sulfate⁸.

The soil surface contains many contaminations and they modify water quality. The urbanization has a direct influence on water resources through the settlement around the vicinity of bodies by enhancement and the uptake of NO_3^- by plants are responsible for most of the removal of nitrate from surface water⁹⁻¹². Naturally, nitrate is the product of the oxidation of nitrogen (which comprises approximately 78% of Earth's atmosphere) by microorganisms in plants, soil and water. The WHO recommended maximum limit for nitrate concentration in drinking water is 50 mg per liter NO_3^- . The harmfulness of excess nitrate in the human being is mainly attributable due to the reduction of nitrate to nitrite¹³.

Physiological amounts of nitrite inhibit stage 1-3 colon cancer proliferation and metastatic potential and emerging epidemiological data suggest that dietary nitrate exposure may be associated with thyroid cancer^{14, 15}. The aim of this research was to determine the level of both sulphate and nitrate ions in drinking water at different locations from the Asia-Pacific International University campus by using UV-Spectrophotometer.

EXPERIMENTAL

Sample Collection

The drinking water samples were collected from the University campus at different locations using brown bottles and they were tightly capped and placed in a cool box. The samples were filtered using Whatman filter papers to avoid interference due to turbidity and coloring matter and kept in a refrigerator at a temperature below 4°C.

Analysis of Sulphate (Turbidity Method)¹⁶

Preparation of Reagent and Standards

Conditioning Reagent

Fifty milliliters of glycerol mixed with a solution containing 30 ml con. HCl, 300 ml distilled water, 100 ml 95% iso-propyl alcohol and 75 gm NaCl.

Stock Sulphate Solution

The standard sulphate solution (100 ppm) was prepared by weighing exactly 0.1479 g of analytical grade anhydrous sodium sulphate in a minimum quantity of distilled water and then diluted to 1000 ml in a standard measuring flask (1 ml = 0.1mg SO_4^{2-} or 1 ml = 100 μg SO_4^{2-}).

Standard Sulphate Solution

A series of standard sulphate solution (10 to 50 ppm) was prepared by diluting 10 ml, 20 ml, 30 ml, 40 ml and 50 ml of the stock sulphate solution in five separate 100 ml standard measuring flask (SMF) by using distilled water.

Hydrochloric Acid (1+9)

The HCl (1+9) solution was prepared by dissolving one volume of the con. HCl with 9 volumes of distilled water.

Calibration

To 20 mL of a clear aliquot of the water sample, 1 mL of HCl (1+9) solution and 1 mL of conditioning reagent were added and mixed well for 30 seconds. After 10 minutes, the analysis was done at a wavelength of 420 nm by using UV-5100 Spectrophotometer. The calibration curve was prepared by using standard sulphate (10 ppm to 50 ppm) solution and a blank solution.

Analysis of Nitrate (Phenoldisulphonic Acid Method)¹⁶

Preparation of Reagent and Standards

Phenoldisulphonic Acid (PDA)

PDA was prepared by dissolving 25 g of white phenol in 235 ml of conc. H_2SO_4 by constant stirring and heated for 2 hrs on a water bath.

Stock Nitrate Solution (10 ppm)

The stock solution was prepared by dissolving 721.8 mg of anhydrous potassium nitrate in distilled water and then diluted to 100 ml (1ml = 10 µg N or 1L = 10 mg N).

Standard Nitrate Solution

Fifty ml of the stock nitrate (10 ppm) solution was evaporated to dryness on water-bath and the residue was dissolved in 2 ml of PDA reagent and then diluted to 500 ml by using distilled water to get 100 ppm (1ml = 100 µg N or 1L = 100 mg N). From which a series of standard nitrate solution (10 to 50 ppm) was prepared by diluting 10 ml, 20 ml, 30 ml, 40 ml and 50 ml of the stock sulphate (100 ppm) solution in five separate 100 ml SMF by using distilled water.

Calibration

In a 100 ml beaker, 10 ml of an aliquot of the sample was taken and evaporated to dryness. To the dry residue, 2 ml of phenoldisulphonic acid (PDA) reagent was added. Then 10 ml of concentrated NH_4OH was added carefully in a fume hood. Finally, the content was made up to 100 ml by using distilled water. The absorbance of the sample was read by using a UV spectrometer at 410 nm. In the similar way the calibration curve was prepared by using standard nitrate (10 ppm to 50 ppm) solution and blank solution (for the blank, distilled water was used in place of the sample).

RESULTS AND DISCUSSION

The absorbance values of sulphate in drinking water samples from various locations were analyzed using UV-5100 Spectrophotometer at 420 nm and presented in Table-1. From which, the concentration of sulphate was calculated by using the standard sulphate graph (Fig.-1). The results indicated that the maximum value of 5.72 mg/L of sulphate was observed in SA Building and M3 faculty house and the lower value of 3.65 mg/L at Solomon hall.

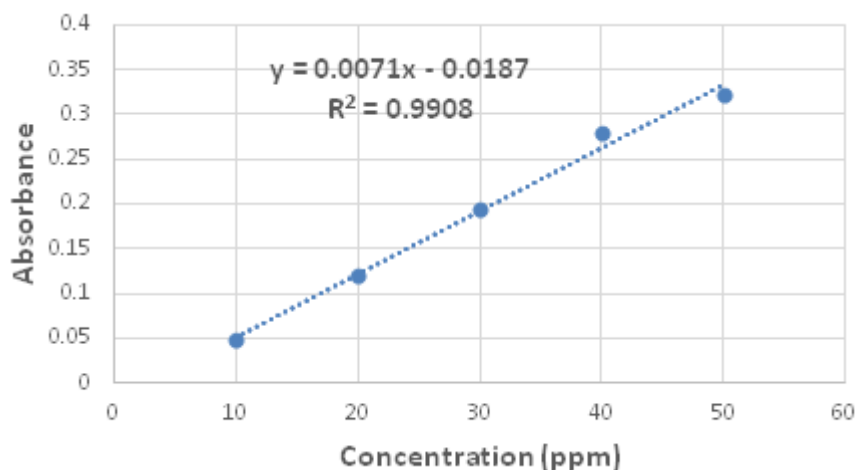


Fig.-1: Sulphate Standard Graph(420nm)

Table-1: Absorbance and Concentration of Sulphate at Different Locations

Sample locations	Absorbance (420 nm)	Concentration $[\text{SO}_4^{2-}]$ mg/L
Dr. T Anthony's House	0.0087	3.89
Cafeteria	0.0100	4.07
Solomon Hall Dorm	0.0070	3.65
Ruth Hall Dorm	0.0100	4.07
Esther Hall Dorm	0.0100	4.07
Sarah Hall Dorm	0.0080	3.79

Dr. Maxine's House	0.0090	3.93
Science Building	0.0080	3.79
Eve Hall Dorm	0.0080	3.79
Dr. Tatenda's House	0.0110	4.21
Library Fountain	0.0120	4.35
195/24 G Faculty House	0.0130	4.50
Church Fountain	0.0130	4.50
K4 Faculty House	0.0160	4.92
195/9 B8L Faculty House	0.0130	4.50
House #2 Water Pump	0.0130	4.50
SA Building	0.0130	5.72
M3 Faculty House	0.0130	5.72

No health-based guideline was proposed for sulfate in water. However, because of the gastrointestinal effects resulting from the ingestion of drinking-water containing high sulfate levels, WHO (world health organization) is recommended that the maximum permitted level of sulphate in water is 500 mg/L. Babies are more sensitive to sulphate than adults. As a safety measure, water with a sulphate level exceeding 400 ppm should not be used in the preparation of baby food. Sulphate gives a bitter or medicinal taste to water if it exceeds a concentration of 250 mg/L. This may make it unpleasant to drink the water^{17, 18}.

USEPA advisory recommends the reduced form of sulphate concentrations in drinking water should be either equal to or below 250 mg/L. However, the concentration of sulphate in all the tested samples are agreeing with below the permissible limit as per IS 10500, WHO and USEPA^{12,19}.

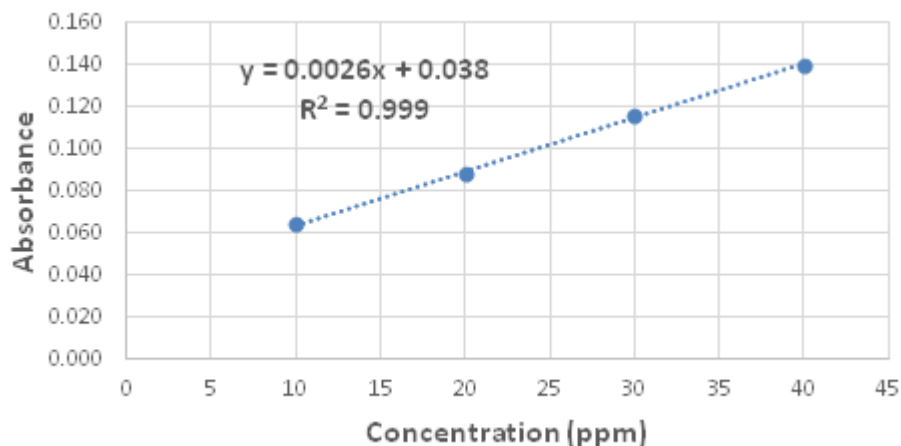


Fig.-2: Nitrate Standard Graph(410nm)

Table-2 shows the absorbance values of nitrate from different samples measured using UV-5100 spectrophotometer at 410 nm and its concentration were calculated by using nitrate standard graph (Fig.-2). The results revealed that the amount of nitrate in the tested samples ranged from 1.15 to 4.62 mg/L. The highest concentration of 4.62 mg/L was obtained from the Solomon hall and K4 faculty house and the lowest value of 1.15 mg/L at the science building and B7/L faculty house.

According to the world health organization, the guideline value for nitrate in drinking water is 50 mg/liter²⁰. No convincing evidence was found of an association between gastric cancer and the consumption of drinking-water in which nitrate concentrations of up to 45 mg/L were present. It is recommended that water should not be used for bottle-fed infants when nitrate levels are above 100 mg/L²¹.

The mutagenicity and genotoxicity of nitrate and nitrite have been extensively reviewed by IARC. For nitrate in food and nitrate or nitrite in drinking-water, the studies provide inadequate evidence of carcinogenicity⁹. There are no incidences of methaemoglobinaemia at nitrate concentrations below 45 mg/L in drinking-water for bottle-fed infants aged under 6 months.²²

The link between nitrate concentration in drinking water and infantile methaemoglobinaemia (IM) is complex and there are several other causes of IM including genetic causes and exposure to other oxidizing agents besides nitrates.²³ While pregnant women are more susceptible to methaemoglobinaemia, epidemiological evidence does not support a causal relationship between nitrates in drinking water and adverse reproductive effects²⁴. Moreover, the nitrate levels in all the tested samples are within the quality standard as per IS 10500.¹²

Table-2: Absorbance and Concentration of Nitrate at Different Locations

Sample locations	Absorbance (410 nm)	Concentration [NO ₃ ⁻] mg/L
Science Building	0.041	1.15
195/21 G5 Faculty House	0.047	3.46
Eve Hall Dorm	0.045	2.69
Esther Hall Dorm	0.045	2.69
Café Fountain	0.043	1.92
B7/L Faculty House	0.041	1.15
Church Building	0.043	1.92
Ruth Hall Dorm	0.044	2.31
Dr. Tatenda House	0.048	3.85
Library Fountain	0.049	4.23
K4 Faculty house	0.050	4.62
Solomon Hall Dorm	0.050	4.62

CONCLUSION

In this paper were able to determine the levels of sulphate and nitrates from different drinking water sources at Asia-Pacific International University. In all the tested cases, the levels of sulphate and nitrates were significantly below the permitted WHO levels. This could be due to the reverse osmosis process the drinking water goes through ensuring safe drinking water for the campus population.

ACKNOWLEDGMENT

I am very grateful to the Asia-Pacific International University, Thailand for providing financial support for this research work. Also, I would like to thank my students Ms. Phearom Ly and Ms. Y Soun Phann for their tireless assistance during the research work.

REFERENCES

1. WHO, Guidelines for Drinking Water Quality, World Health Organization, Geneva, Switzerland, 4th Edn., (2011).
2. M.T. Bashir, *Pak. J. Med. and Health Sci.*, **6(3)**, 648(2012).
3. A.K. Srivastava, Mishra, D.K. Sarika and P. Singh, *Nat. Envir. Poll. Tech.*, **2**, 315(2007).
4. R. Kantor and J.I. Silverberg, *Expert Rev Clin Immunol.*, **13(1)**, 15(2017), DOI: [10.1080/1744666X.2016.1212660](https://doi.org/10.1080/1744666X.2016.1212660).
5. D. M. Cocchetto and G. J. Levy, *Pharm. Sci.*, **70**, 331(1981), DOI: [10.1002/jps.2600700330](https://doi.org/10.1002/jps.2600700330)
6. W.J. Dechent and M. Ketteler, *Clin Kidney J.*, **5(1)**, i3(2012), DOI: [10.1093/ndtplus/sfr163](https://doi.org/10.1093/ndtplus/sfr163).
7. R. K. Yadav and M. R. Augur, *Rasayan J. Chem.*, **11(2)**, 537(2018), DOI: [10.31788/RJC.2018.1122089](https://doi.org/10.31788/RJC.2018.1122089)
8. P. Sengupta, *Int. J. Prev. Med.*, **4(8)**, 866(2013).

9. IARC. Ingested Nitrate and Nitrite and Cyanobacterial Peptide Toxins. Lyon: International Agency for Research on Cancer. Vol. 94. (2010), <https://www.ncbi.nlm.nih.gov/books/NBK326544/>
10. R. Arora, H. C. Joshi, I. P. Pandey and V. K. Tewari, *Rasayan J. Chem.*, **10(4)**, 1167(2017), DOI:10.7324/RJC.2017.1041753
11. P. S. Bytyci, H. S. Cadraku, F. N. Z. Etemi, M. A. Ismaili, O. B. Fetoshi and A. M. S. Abazi, *Rasayan J. Chem.*, **11(2)**, 653(2018), DOI: 10.31788/RJC.2018.1123015
12. D. Kumar, V. Kumar and S. Kumari, *Rasayan J. Chem.*, **11(4)**, 1477(2018), DOI: 10.31788/RJC.2018.1143075
13. WHO, Nitrate and Nitrite in Drinking-Water Background Document for Development of WHO Guidelines for Drinking-Water Quality, Geneva, World Health Organization, (2011).
14. H. Jiang, Y. Tang, H.K. Garg, D.K. Parthasarathy, A.C. Torregrossa, N.G. Hord, and N.S. Bryan, *Nitric Oxide.*, **26 (4)**, 267(2012), DOI: 10.1016/j.niox.2012.03.010
15. B.A. Kilfoy and Y. Zhang, *Int. J. Cancer*, **129(1)**, 160(2011), DOI: 10.1002/ijc.25650
16. APHA. Standard Methods for Examination of Water and Wastewater, 22nd edn. American Public Health Association, Washington (2012).
17. WHO, Sulphate in Drinking-Water, Background Document for Preparation of WHO Guidelines for Drinking-Water Quality. 4th Ed. Geneva, World Health Organization, 2011, p.419.
18. WHO, Guidelines for Drinking-Water Quality. Vol. 1, 3rd Edn. Geneva, (2004).
19. USEPA, Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sulfate. Office of Water, Washington, DC. EPA 822-R-03-007 (2003).
20. WHO, Guidelines for Drinking Water Quality, 3rd Edition, incorporating the 1st and 2nd addenda, Vol.1, Recommendations, Geneva, 2008.
21. WHO, Nitrate and Nitrite in Drinking-Water, Background Document for Development of WHO Guidelines for Drinking-Water Quality, Geneva, 2011, WHO/SDE/WSH/ 07.01/16/
22. A. M. Fan and V. E. Steinberg, *Reg. Tox. Pharmacol.*, **23(1)**, 3(1996),
23. L. Fewtrell, *Environ Health Perspect.*, **112(14)**, 1371(2004), DOI: 10.1289/ehp.7216.
24. D.M. Manassaram, L.C. Backer, and D. M. Moll, *Envir. Health Perspectives*, **114(3)**, 320(2006), DOI: 10.1289/ehp.8407

[RJC-5201/2019]