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Full Length Research Paper

Nitrate anion levels in water from selected wells and points along Kimondi River, Nandi

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This paper focuses on the comparative determination of nitrate anion concentration from selected wells and points along the Kimondi River using UV-Visible spectrophotometric method. The areas monitored were Tulon, Sitatunga swamp, Sironoi, Kimondi Bridge, kipchabo tea factory and Samoo. This research was to determine whether nitrate anions in water are beyond the threshold limit which is harmful to both plant and animal life. Relatively high concentrations of NO_3 usually have their origin in processes of organic pollution and excessive use of inorganic fertilizers. In the case of agricultural areas for example, Nandi County where our analysis was based, these activities may generate great quantities of nitrates. The water was sampled from both the river point and one selected borehole in the respective areas. Three samples were obtained from each of the sampling points and were analyzed for nitrate using the UV-Visible spectrophotometer set at 420 nm. The average of the three-absorbance values was computed and converted to concentration in mg/L. The research showed that levels of nitrate ion in both river and well waters were below the threshold limits.

Key words: Nitrate anion, threshold limit, UV-Visible spectrophotometric method.

INTRODUCTION

The determination of nitrate (NO_3^-) is a difficult task because of the relatively complex procedures involved, the high probability that interfering constituents will be present and the limited concentration ranges of the various techniques. An analytical technique that measures the absorbance is suitable for screening uncontaminated water (low in organic matter). This method is applicable to the analysis of drinking river water, borehole water and surface water.

According to Villa et al. (2010), the modern civilization, industrialization, urbanization and increase in population have led to fast degradation of our groundwater quality. As water is the most important component of eco-system, any imbalance created either in terms of amount, which is presence of impurities added to it can harm the whole eco-system (Hem, 1961).

According to World Health Organization (WHO), the permissible limit of nitrate value is in the range of 40 to 50 mg/L. The Indian Council of Medical Research has recommended desirable limit of 20 mg/L of nitrate for drinking water Nitrate is a problem as a contaminant in drinking water (primarily from groundwater and wells) due to its harmful biological effects (Hallberg and Keeney, 1993).

Research shows that 97% of the world water is saline and is thus, non-drinkable, while 2% is locked in glaciers and polar ice caps. This leaves 1% to meet humanity needs (Elliot et al., 2008).

Nitrates exist largely due to the presence of animal manure in the water bodies. The excess of nitrates has contributed to the high levels of eutrophication along River Kimondi and the entire water bodies in Nandi County. There is great evidence from the fact that, there is an intensive growth of papyrus and other plant species which if not monitored, may in future clog the whole Kimondi River.

Increasing population size, climate change and pollution will exacerbate the nitrate pollution situation (Jagessar, 2011). The results showed that the concentrations of nitrates were not as high and are below

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the internationally accepted threshold values. The applicable range of concentrations using the stated method is in the range of 0.1 to 2 mg/L NO_3^-. A maximum level of 45 mg/L is established as worldwide guidance for nitrate concentration in water.

In Europe, the maximum permitted levels of nitrate in potable water is 50.0 mg/L, while in the US-Environmental Potential Agency (EPA) has established a guideline for the maximum level of nitrate-nitrogen of 10 mg/L.

MATERIALS AND METHODS

Apparatus, materials and reagents

The apparatus, materials and reagents used in this study are UV spectrophotometer, hot plate, volumetric pipettes (2.5 and 10 ml), calibrated pipette, fume hood, analytical balance, volumetric flask (25 to 1000 ml), weighing dish, funnel, 100 ml beaker, distilled water, ammonium molybdate, sodium sulphide, sodium hydrogen phosphate, measuring cylinder, sulfuric acid, phenol, hot water bath, centrifuge, conical flask, silver sulphate, phenoldisulphonic acid, potassium hydroxide, ammonia, anhydrous potassium nitrate and filter paper.

Procedure for water sample collection and determination of nitrates

Sampling plan was specific for each sampling site (APHA, 1999). Water samples were collected in brown, resistant borosilicate winchester bottles, which had previously been washed thoroughly with detergent, rinsed with HCl, followed with distilled water for a prolonged period. They were filled to the brim and then sealed with Teflon lined caps. The choice of the brown bottles was to prevent decomposition through light. Sampling bottles were kept closed and much caution was taken not to contaminate the inner surfaces of stoppers, caps and necks of bottles. They were transferred to the laboratory in big plastic cooler. The samples were then acidified using 1 M HCl acid in order to prevent interference from hydroxide or carbonate concentrations up to 1000 mg $CaCO_3$/L. 1 M sodium arsenite and 1 M hydrogen peroxide were added to all the samples to stop potential interference with oxidizing and reducing agents, respectively. The samples were stored in the refrigerator at 4°C. They were then analyzed immediately for nitrates, using UV-Vis method by a DR 5000 Spectrophotometer following the method developed by Eaton et al. (1995). The same sampling procedure was used in sampling water from the boreholes corresponding to the points of river points.

The preparation of reagents

The nitrate standard (1000 ppm) was prepared using potassium nitrate that had been dried in oven for 1 h at 105°C and stored in desiccators until cool. 3.6107 g of potassium nitrate (KNO_3 was weighed and washed over into a 500 ml flask with distilled water, 1000 ppm std). 10 ml of distilled chloroform was added to the prepared standard solution to stop the effect of interfering agents. It was stopped, shaken and then labeled. 50 ml was pipette into a 500 ml volumetric flask. The sample was then diluted to 500 ml with distilled water (100 ppm stock std.) and again stopped, shaken and labeled. 10 ml was then pipette from the 100 ppm stock solution into 100 ml volumetric flask and was made up to mark (10 ppm std), stopped, shaken and then labeled.

Table 1. Nitrate standards concentration (ppm) and absorbance reading at 420 nm.

Nitrate concentration (ppm)	Absorbance
0.1	0.031
0.2	0.047
0.3	0.076
0.4	0.105
0.5	0.143

Preparation of samples

5 ml of distilled water was pipette into a 150 ml beaker (blank). 5 ml of sample was then filtered and added into the 150 ml beaker (sample volume), and placed on a hot plate and taken just to dryness. 2 ml of phenoldisulphonic acid was added and the sides were washed down lightly, warmed on hot plate, removed and allowed to cool. 10 ml of concentrated ammonium hydroxide (NH_4OH) was then added carefully. The reaction was violent. The absorbance of the samples was measured with the aid of a UV/Visible spectrophotometer set at 420 nm (Clessicens et al., 1995). The same procedure was followed for standards. The following are the quantities of standards that were placed in a beaker: 1 ml of 10 ppm was pipette into 150 ml beaker = 10 ppm, 2 ml of 10 ppm was pipette into a 150 ml beaker = 20 ppm, 3 ml of 10 ppm was pipette into 150 ml beaker = 30 ppm and 4 ml of 10 ppm was pipette into 150 ml beaker = 40 ppm. A standard calibration graph was then prepared for nitrate (Table 1 and Figure 1).

RESULTS AND DISCUSION

Table 2 and Figure 2 show the average concentration of nitrate in water from the randomly selected points in the river Kimondi and the wells adjacent to the river sampling point. The wells were almost of same depth averaging 50 feet. From the results, generally the river water contained less amounts of nitrates than the well. The flow of well water is slow and hence contaminants are not diluted and washed away as they are in a swiftly moving river (Girard, 2005). The eight river points had a mean concentration of 0.40, 0.66, 0.34, 0.18, 0.35, 0.33, 0.30 and 0.41 mg/L, respectively, while the eight selected wells had an average of 0.34, 0.66, 0.78, 0.27, 0.45, 0.17, 0.64 and 0.68 mg/L, respectively. Well water flow is slow. Hazardous chemicals from dump sites and other sources seep through the ground; some pollutants are filtered by soil and travel only short distances. Nitrates are soluble ions which percolate downward into groundwater from septic tanks, fertilized farms and feedlots.

From the data analysis of Kipchabo Tea factory area, the well sample had the highest concentrations of nitrates. According to Hill et al. (1991), Nolan (1996) and Speiran et al. (1996), raw waste effluents from factories and sewage treatment usually have high levels of ammonia and nitrogenous wastes. Additionally, prevailing temperatures within factories and their effluent encourage

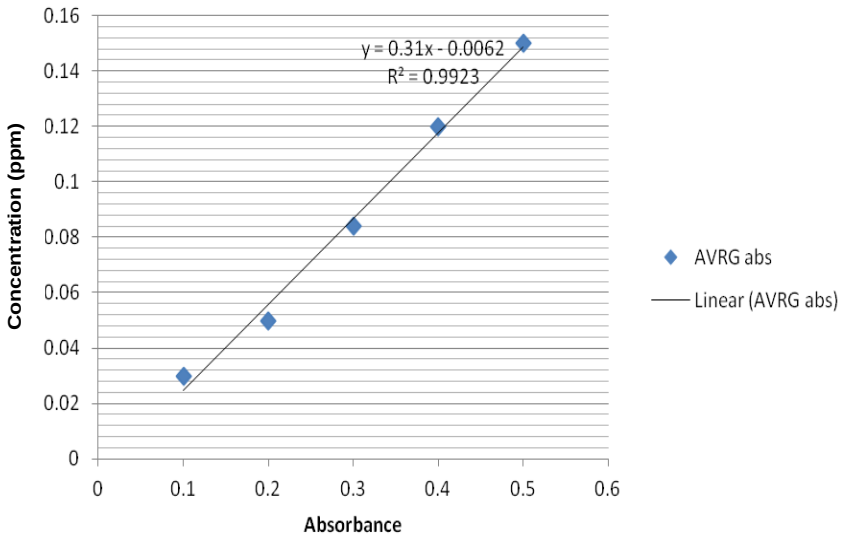

Figure 1. Graphical representation of nitrate standards for concentration (ppm) against absorbance taken at 420 nm.

rapid multiplication of bacterial population. These two factors can elevate the levels of nitrates in the adjacent water bodies through aerobic and anaerobic bacteria activities.

The nitrate level for both river and well samples from Kingwal-Sitatunga area was quite high with 0.41 and 0.68 mg/L, respectively. This area is inhabited by the largest population of a rare antelope species called Sitatunga in the country. The animals graze in the swamp and live there, their wastes go directly to the river; this could explain the higher level of nitrate concentration in this area. Gray (1994), Roeve et al. (1994), Calley et al. (1997) and Chapman et al. (1992) qualified the usual claim that excessive use of nitrate fertilizers and animal manure constitute most of the elevated levels of nitrates in water bodies.

Tulon source, Kimondi Cataracts and Samoo Bridge showed relatively low levels of nitrate anion concentrations. Tulon source had the lowest levels of nitrate concentration both for the river and well samples which according to the research is attributed to the fact that it is the source of the river under study and according to European Environmental Agency (1999), the natural nitrate level in water source and groundwater are generally low, but their concentration grow due to human activities, such as agriculture, industry, domestic effluent and emission from combustion engines.

From the readings, it was evident that there is slightly higher concentration at Kimondi Bridge (0.66), Kingwal Bridge (0.36), which according to our study could be attributed to the chemical present in run-off water from the surrounding agricultural farm and vehicle depositions of the exhaust fumes. The sampling area is a rich agricultural place, where there is large scale farming of tea, maize and horticulture where famers use inorganic fertilizers in planting and in top dressing. The presence of nitrates in groundwater could be anthropogenic or as a result of irrational use of nitrogenous fertilizers.

The increasing use of artificial fertilizers, the disposal of wastes (particularly from animal farming), and changes in land use are the main factors responsible for the progressive increase in nitrate levels in river water and supplies over the last 20 years (Akinsola, 2005). Generally, the nitrate concentration in the water samples for both the river points and the wells was far below the International Nitrate Standard Threshold; however, there is evidence that water is getting enriched with nutrients due to the intense growth of papyrus plants along the river Kimondi. The WHO has guideline values for nitrate from agricultural activities that are of health significance in drinking water at 50 mg/L (WHO, 2006). The low levels of nitrate in the river waters, that is, along the river points is not surprising because plants use it up and bacteria catalysts decomposes it too.

Well waters contained appreciable nitrate level because the soil contains nitrate-rich rock minerals, which can dissolve gradually. Leaching from the soil surface can also contribute to its presence. However, the results indicate that the NO_3 levels of all the samples were below the limits. Natural nitrate levels in groundwater are generally very low (typically less than 10 mg/L NO_3), but nitrate concentrations grow due to human activities, such as agriculture, industry, domestic effluents and emissions from combustion engines.

Nitrates generally moves relatively slow in soil and groundwater, there is a lag time of approximately 20 years between the pollution activity and the detection of the pollutant in groundwater. For this reason, it is

Table 2. The mean concentration of nitrates (mg/L), the standard deviation and the variance for the sample analysis.

Sample location	River point sample concentration (mg/L)				Well adjacent to river point sample concentration (mg/L)			
	Nitrate conc. for three readings (mg/L)	Mean conc. (mg/L)	Standard deviation	Variance	Nitrate conc. for three readings (mg/L)	Mean conc. (mg/L)	Standard deviation	Variance
Kimondi cataracts	0.13, 0.16, 0.14	0.14	0.01528	0.00023	0.33, 0.33, 0.35	0.34	0.01155	0.00013
Kimondi Bridge	0.66, 0.66, 0.67	0.66	0.00577	0.00003	0.66, 0.65, 0.68	0.66	0.01528	0.00023
Kipchabo tea factory	0.32, 0.34, 0.36	0.34	0.02	0.0004	0.79, 0.79, 0.77	0.78	0.01155	0.00013
Tulon source	0.17, 0.19, 0.19	0.18	0.01155	0.00013	0.27, 0.26, 0.29	0.27	0.01528	0.00023
Kingwal Bridge	0.36, 0.35, 0.35	0.35	0.00577	0.00003	0.43, 0.47, 0.45	0.45	0.02	0.0004
Samoo Bridge	0.33, 0.35, 0.33	0.33	0.01155	0.00013	0.17, 0.18, 0.16	0.17	0.01	0.0001
Sironoi Bridge	0.30, 0.30, 0.31	0.30	0.00577	0.00003	0.62, 0.64, 0.65	0.64	0.01528	0.00023
Kingwal Sitatunga area	0.40, 0.41, 0.42	0.41	0.01	0.0001	0.67, 0.68, 0.70	0.68	0.01528	0.00023

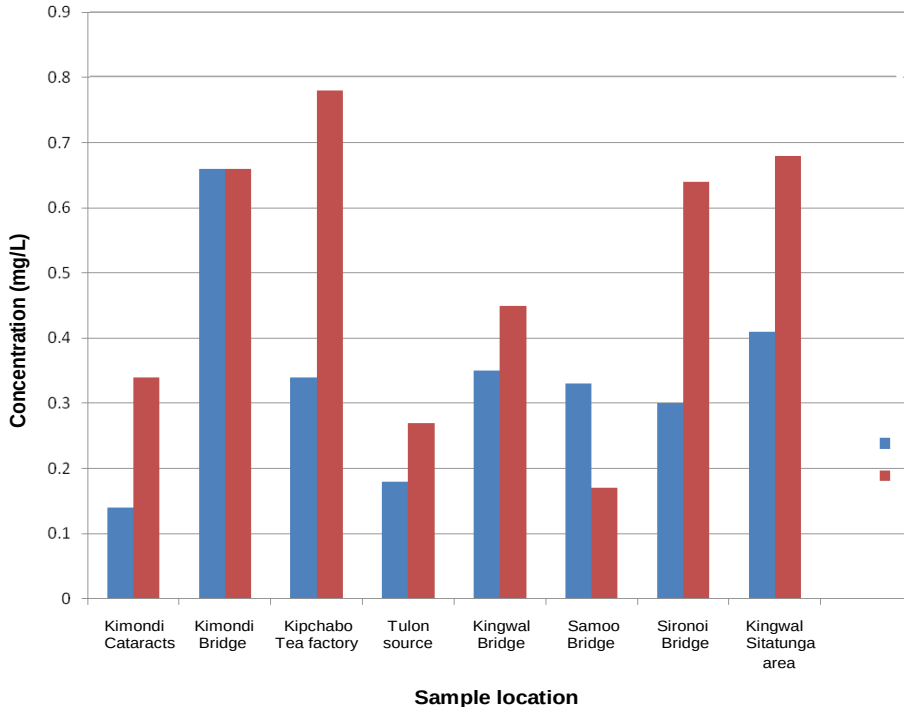

Figure 2. Bar graph showing a comparison between the nitrate anion concentration for both the River points and wells. Key: Red is Well point; Blue is River point.

predicted that current polluting activities will continue to affect nitrate concentrations for several decades (Eaton et al., 1995). Groundwater contains various types of pollutants and several other substances are dissolved in it. Concentration of these pollutants is useful for human body but in a specific limit (Ranjana, 2012).

According to Pulido-Bosch et al. (2000), shallow wells which draw water from intensively cultivated superficial formations, yield waters with a high NO_3 content. When the boreholes are deeper and penetrate low-permeability formations in the superficial layers, the waters contain little NO_3; similar to what happens in areas of recharge where agricultural activities are absent. Due to the detrimental biological effects, treatment and prevention methods must be considered to protect groundwater aquifers from nitrate leaching and high concentrations.

Conclusion

Further water analysis should be carried out periodically to obtain enough data for thorough assessment. Such analysis should include further chemical and microbial investigations. The health authorities and water board should monitor the safety of drinking waters in the communities to avoid all the potential dangers associated with nitrate pollution. Proper agricultural management practices need to be introduced avoiding overuse of nitrogen-based fertilizers. Nutrient pollution coupled with climate change might render clean drinking water scarce and hence bring about more strive.

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REFERENCES

Akinsola RO, Godowoli IA (2005). Determination of nitrate content in drinking Water: Asurvey of Bama Local Government Area, Borno State, Nigeria. Chem. Class J. 2:5-9.

APHA (1999). Standard methods for the examination of water and wastewater, American public health association: Washington D.C USA.

Calley AGF, Starfford CF, Stafford DA (1997). Treatment of Industrial Effluent, Holder and Stroughton: London. p. 328.

Chapman D (Ed.) (1992). Water Quality assessment. A guide to the use of biota, Sediments and Water, Chapman and Hall: London. pp. 71-76; 281-282, 412-416.

Clessicens SL, Greenberg EA, 19th ed. American Public Health Association, 1015 Fifteenth Street, NW, Washington, DC, pp. 49-51.

Eaton AD (1995). “Standard methods for the Examination of Water and Waste Water.

Elliot S (2008). “Testing the water”, Royal Society of Chemistry, RSC, News Mag. 12(5):12-13.

European Environmental Agency (1999). Ground Water Quality and Quantity in Europe. Fatoki, O.S.S. Afr. J. Sci. 95:237.

Girard J (2005). Principles of Environmental Chemistry. Jones and Bartlett Publishers, Michigan. pp. 243-244.

Gray NF (1994). Drinking water Quality Problem and solution, John Wiley: New York.

Hallberg GR, Keeney DR (1993). Nitrate, Alley, William A., ed., Regional Groundwater Quality, Van Nostrand Reinhold, New York. Pp. 297-322.

Hill MJ (1991). Nitrates and Nitrites in Food and Water, Ellis Horwood: New York. pp. 14-92; 131-187.

Hem JD (1961). Some aspects of Chemical Equilibrium in ground water contamination, Public Health Service Symposium, A. Report Taft Sanitary Engr. Centre, Report WEI-5.

Jagessar RC, Sooknundun L (2011). Determination of nitrate anion in waste water from nine selected areas of coastal Guyana via a spectrophotometric method. Int. J. Res. Rev. Appl. Sci. 7(2):203-212.

Nolan BT, Hitt KJ (2006). Vulnerability of Shallow Groundwater and Drinking-Water Wells to. Nitrate in the United State. J. Environ. Sci. Technol. 40:7834-7840.

Pulido-Bosch AS, Bensi LM, Vallejos JMAC, Pulido-Leboeuf P (2000). Nitrates as indicators of aquifer interconnection. Application to the Campo de Dalia (SE-Spain). Environ. Geol. 39(7).

Ranjana A (2012). Nitrate contamination in ground water samples of Gangapurcity town (SawaiMadhopur District) Rajasthan. J. Chem. Biol. Phys. Sci. 2:511-513.

Roeve RN (1994). Enviromental Analysis (analytical chemistry by open learning), John Wiley: New York. pp. 17-19.

Speiran GK (1996). Geohydrology and Geochemistry near coastal ground-water-discharge areas of the Eastern Shore, Virginia: U.S. Geol. Surv. Water Supply pap. 2479, USGS, Richmond, Virginia.

World Health Organization (2006). Guidelines for Drinking water quality incorporating First addendum. Vol. 1, Recommendations. – 3rd Ed. WHO Publication Centre, Albany, 191 New York.