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Determination of nitrate content in drinking water: A survey of Bama Local Government Area, Borno State, Nigeria

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ABSTRACT

The level of nitrate in drinking water of Bama Local Government Area of Borno State, Nigeria has been investigated. None of the water sources studied had nitrate level above acceptable limits. The study includes samples from deep borehole, shallow wells and running streams. The nitrate level of the stored water samples was found to decrease with time.

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INTRODUCTION

Nitrate is an anion and occurs as radical with valency of negative one. Nitrogen has a valency of five in Nitric acid hence the name trioxonitrate (V) acid. Nitrate enters into the natural waters through various sources such as rock minerals, fertilizer run offs and leguminious plants. The threshold limits of nitrate is high because of its high solubility in water. [1]. The presence of nitrate in excess of few milligrams per liter in a drinking water constitute sufficient ground for the rejection of the supply because the toxic qualities has been recognised as early as the eleventh century [1]. Nitrate is relatively toxic at high milligrams level and its consumption can have damaging effects to both plants and animals including human beings. [2-4]. Nitrate is present in natural water but in recent years its concentration in both ground and surface waters have increased in some areas in industrial towns [5]. Sizeable proportion of the landmass in the Local Government Area and environs is essentially used for agricultural activities. The areas have high density of animal confinement, rocks, farms and plain sands. Hence the high rate of penetration thereby making it possible for nitrate being carried in flood from highly chemically fertilized soils to percolate the tables in the area [4].

A nitrate concentration of more than 100 ppm impact bitter taste to water and may cause physiological distress. Drinking water containing more than 50ppm nitrate can cause methamoglobinemia in infants. Nitrate causes the overgrowth of algae, other organisms and fouls the water system [6]. Epidemiological studies have predicted association between exposure to nitrate and gastric cancer, because of the reaction of nitrate with amine in diet forming carcinogenic nitrosamines [6].

Numerous methods have been developed for the determination of Nitrate by many workers. Only a few have been investigated thoroughly and found suitable for the estimation of the compound. Spectrophotometric procedures has been widely adapted as a standard method for the determination of macro, micro, and semi-micro amounts of nitrate levels in drinking waters [7]. The choice is due to sensitivity, the economy, its accuracy, precision and other factors of the method.

Only the few big towns in Bama Local Government Area get their drinking waters from running tap, which is from deep boreholes. Residents of smaller towns, villages and settlements drink water from shallow wells and running streams.

This study was therefore aimed at determining the nitrate content of underground and running drinking waters of Bama Local Government Area. The findings of the study hopefully, will be an additional information to the three tiers of government and health workers.

MATERIALS AND METHODS

In the preparation of reagents, chemicals of analytical grade purity and distilled water were used. All glasswares were washed with detergent before rinsing with water and drying in the oven. All weighing were carried out on a Gallenkamp Mettler balance Model H30. Water samples were taken from the towns, villages and many settlements. Samples from 17 sites were analysed and were of three categories, viz the deep boreholes, the shallow wells and the running streams. Deep boreholes are those that are dug up to the depth of about 580m below the surface, whereas the

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Table 1: Data for Underground Waters for the Months of January – March; Dry Season (NO_3mg/l)

Locality	Source	January			February			March		
		Range	**Mean**	**Standard deviation**	**Range**	**Mean**	**Standard deviation**	**Range**	**Mean**	**Standard deviation**
Bama	Deep borehole D1	12.00 – 12.80	12.45	0.6	13.00 – 13.40	13.25	0.7	12.00 – 12.20	12.10	0.5
	Shallow Well A	8.00 – 8.40	8.24	0.2	7.00 – 7.30	7.12	0.3	8.00 – 8.20	8.10	0.2
	Shallow Well B	8.00 – 8.20	8.09	0.2	7.70 – 7.90	7.79	0.3	7.30 – 7.50	7.39	0.2
Banki	Deep borehole D2	17.00 – 17.50	17.20	1.2	17.00 – 17.20	17.10	0.6	17.00 – 17.20	17.13	0.6
	Shallow Well C	10.00 – 10.40	10.15	1.1	11.00 – 11.30	11.19	0.5	10.70 – 10.80	10.77	0.4
Ngurosoye	Shallow Well E	11.90 – 12.30	12.13	0.5	12.00 – 12.30	12.13	0.4	11.70 – 11.90	11.81	0.3
	Shallow Well F	11.20 – 11.70	11.47	0.4	12.00 – 12.10	12.07	0.4	11.00 – 11.40	11.30	0.3
Gulumba	Shallow Well G	4.00 – 4.30	4.14	0.2	4.70 – 5.00	4.80	0.2	4.50 – 4.70	4.56	0.1
	Shallow Well H	3.20 – 3.60	3.40	0.3	3.20 – 3.60	3.40	0.1	3.00 – 3.40	3.12	0.1
Darjamai	Shallow Well J	0.30 – 0.70	0.48	0.1	0.30 – 0.40	0.35	0.1	0.30 – 0.60	0.38	0.1
	Shallow Well K	0.10 – 0.30	0.20	0.1	0.30 – 0.40	0.35	0.1	0.30 – 0.40	0.35	0.1
Jere	Shallow Well M	1.10 – 1.50	1.33	0.2	1.40 – 1..60	1.47	0.4	1.40 – 1.70	1.55	0.4
	Shallow Well N	0.98 – 1.30	1.07	0.2	1.10 – 1.30	1.16	0.4	1.10 – 1.30	1.18	0.1
Abram	Shallow Well P	11.00 – 11.30	11.13	0.5	10.10 – 10.30	10.25	0.3	10.60 – 10.80	10.72	0.2
	Shallow Well R	9.60 – 9.90	9.78	0.2	9.40 – 9.60	9.53	0.2	9.30 – 9.50	9.38	0.3
Sabsowa'a	Shallow Well T	15.30 – 15.50	15.35	0.1	14.70 – 15.00	14.82	0.5	15.00 – 15.30	15.14	0.2
	Shallow Well V	15.00 – 15.30	15.10	0.2	15.00 – 15.30	15.14	0.4	14.00 – 14.30	14.15	0.1

Table 2: Data for Underground Waters for the Months of June – August; Wet Season (NO_3mg/l)

Locality	Source	JUNE			JULY			AUGUST		
Bama		Range	Mean	Standard deviation	Range	Mean	Standard deviation	Range	Mean	Standard deviation
	Deep borehole D1	7.20 – 7.40	7.29	1.1	6.90 – 7.20	7.01	0.3	6.80 – 7.00	6.83	0.4
	Shallow Well A	4.50 – 4.70	7.64	0.2	4.00 – 4.40	4.20	0.3	4.00 – 4.30	4.10	0.2
	Shallow Well B	3.80 – 4.00	3.89	0.6	3.10 – 3.40	3.20	0.2	3.00 – 3.60	3.34	0.3
Banki	Deep borehole D2	9.00 – 9.30	9.17	0.3	9.00 – 9.30	9.13	0.3	8.70 – 9.20	8.94	0.3
	Shallow Well C	6.00 – 6.20	6.14	0.2	5.40 – 5.70	5.58	0.3	4.90 – 5.30	5.13	0.2
Ngurosoye	Shallow Well E	5.30 – 5.50	5.40	0.3	5.00 – 5.30	5.15	0.2	4.50 – 4.80	4.62	0.1
	Shallow Well F	4.00 – 4.20	4.12	0.2	4.00 – 4.30	4.10	0.2	3.60 – 4.00	3.95	0.1
Gulumba	Shallow Well G	1.50 – 1.70	1.56	0.1	1.30 – 1.50	1.41	0.3	1.10 – 1.40	1.24	0.2
Darjamai	Shallow Well J	0.30 – 0.40	0.37	0.1	0.10 – 0.40	0.22	0.4	0.00 – 0.10	0.10	0.1
	Shallow Well K	0.10 – 0.20	0.14	0.1	0.00 – 0.20	0.09	0.1	0.00 – 0.10	0.01	0.4
Jere	Shallow Well M	0.50 – 0.60	0.55	0.1	0.30 – 0.60	0.44	0.1	0.01 – 0.30	0.20	0.1
	Shallow Well N	0.30 – 0.50	0.42	0.1	0.20 – 0.40	0.32	0.4	0.00 – 0.20	0.11	0.1
Abram	Shallow Well P	4.20 – 4.40	4.31	0.2	4.00 – 4.20	4.14	0.2	3.70 – 4.10	3.95	0.3
	Shallow Well R	5.00 – 5.20	5.12	0.3	4.60 – 5.00	4.78	0.3	4.10 – 4.50	4.27	0.3
Sabsowa'a	Shallow Well T	7.00- 7.70	7.14	0.4	6.70 – 6.80	6.75	0.4	5.10 – 5.40	5.21	0.2
	Shallow Well V	7.90 – 8.80	8.79	0.2	7.60 – 8.10	7.89	0.2	5.90 – 6.30	6.07	0.3

shallow wells are somewhere between 2 - 8m deep from the earth's surface. The water samples were collected with previously cleaned 1000cm^3 polythene bottles and were preserved with trioxonitrate (V) acid. However, part of the samples were kept for some days (5–7) days longer before they were analysed. Standard methods [9] were

used for the determinations. Sampling and analysis of each source were done six times in the year 2004, that is, in January, February and March, which fall within the dry season and in June, July and August, which lie within the raining period. A standard curve was prepared using sodium salicylate colorimetrically by spectronic 20 (Gallenkamp, UK). The sodium salicylate reacts with nitrate ions in tetraoxosulphate (vi) acid medium to produce sodium nitrosalicylate, which has yellow colour under alkaline condition. The intensity of the yellow colour is proportional to the nitrate concentration in the sample and bears a linear relationship. Maximum absorbance is obtained at wavelength of 420nm. The minimum detectable concentration by this method is 0.01mg per litre.

RESULTS AND DISCUSSION

Table 3: Mean values for dry and wet seasons when sample and analysis were done

S/N	Locality	Source	$[NO_3]$(mg/l) Dry Season	Wet Season
1	BAMA	Deep Water Borehole D1	12.59	7.04
		Shallow Well A	7.81	4.36
		Shallow Well B	7.76	3.60
2	BANKI	Deep Borehole D2	17.15	9.08
		Shallow Well C	10.70	5.62
3	NGUROSOYE	Shallow Well E	12.02	5.06
		Shallow Well F	11.61	3.06
4	GULUMBA	Shallow Well G	4.50	1.40
		Shallow Well H	3.28	1.20
5	DARJA-MAI	Shallow Well J	0.40	0.23
		Shallow Well K	0.32	0.12
6	JERE	Shallow Well M	1.44	0.40
		Shallow Well N	1.14	0.28
7	ABRAM	Shallow Well P	10.70	4.13
		Shallow Well R	9.56	4.72
8	SABSOWA 'A	Shallow Well T	15.40	6.37
		Shallow Well V	14.30	7.58

Means at each are not significantly difference at P = 0.05

Only underground waters (Deep and shallow wells) contained appreciable nitrate levels. The results obtained are as presented in Tables 1 and 2 for the samples from different localities. Table 3 shows the mean values for the dry and wet seasons.

Table 4: Nitrate concentration in selected stream and river

S/No	Source	$[NO_3]$ (mg/l) Dry Season	Wet Season
1.	Bararam Stream	0.03	0.02
2.	Duu-Ma River	0.03	N.D
3.	Dombiya Stream	0.04	0.01
4.	Fulongu River	0.01	N.D
5.	Gwannge Stream	0.02	0.08

ND = Not detected by this method

■ Mean results of several replicate analysis are recorded.

$$1/5NO + 6/5H^{+} \xrightarrow{\text{bacteria}} 1/10N_2 + 3/5H_2O$$

Means at each season are not significantly different at P = 0.05.

Nitrate concentrations in selected streams and rivers are presented shown in Table 4. The absence of nitrate in the surface waters, that is, running streams and rivers is not surprising because plants use it up and bacteria catalysts decomposes it too. [10]

Conversely, underground waters contained appreciable nitrate level because the soil contains nitrate-rich rock minerals which can dissolve gradually. Leaching from the soil surface can also

$$NO_3^- + 1/4CH_2O + 6/5H^{+} \xrightarrow{\text{bacteria}} 1/10N_2 + 1/4CO_2 + 7/2H_2O$$

contribute to its presence. It could be observed that the wet season values were lower than those of the dry season, it was attributed to the dilution effect of the rains. However, the results indicate that the NO_3 levels of all the samples were below the limits. [8].

Table 5 shows the effect of storage on nitrate concentration. The rate at which the nitrate concentration falls may be attributed directly to the amount of organic substances present in the water samples.

A possible equation of reaction has been suggested. [11].

Implication for health workers

Further analysis of these drinking waters 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 so as to avoid all the potential dangers associated with poisoning.

CONCLUSION

Table 5: Effect of Storage (5-7days) on Nitrate Concentration

S/N	Locality	Source	Date Collected	Date Analysed	NO_3mg/l
1.	Bama	Deep borehole D1	16/1/04	16/1/04	12.14
		Shallow Well A	2/3/04	22/1/04	8.36
		Shallow Well B	11/7/04	3/3/04	7.74
				10/3/04	4.80
				11/7/04	2.90
				17/7/04	0.31
2.	Banki	Deep borehole D2	21/2/04	23/2/04	16.83
		Shallow Well C	18/8/04	28/02/04	10.68
				18/8/04	5.00
				24/8/04	2.90
3.	Ngurosoye	Shallow Well E	10/3/04	10/3/04	10.15
		Shallow Well F	16/6/04	15/3/04	8.10
				16/6/04	4.00
				22/6/04	2.03
4.	Gulumba	Shallow Well G	11/1/04	12/1/04	3.40
		Shallow Well H	20/8/04	19/1/04	1.06
				22/8/04	1.16
				28/8/04	0.67
5.	Darjamai	Shallow Well J	2/3/04	3/3/04	0.26
		Shallow Well K	21/7/04	10/3/04	0.09
				23/7/04	0.09
				30/7/04	0.03
6.	Jere	Shallow Well M	2/2/04	3/3/04	1.60
		Shallow Well N	6/6/04	9/2/04	0.94
				8/6/04	0.38
				14/6/04	0.16
7.	Abram	Shallow Well P	17/3/04	19/3/04	8.76
		Shallow Well R	9/6/04	24/3/04	3.98
				11/6/04	4.43
				16/6/04	1.77
8.	Sabsowa'a	Shallow Well T	14/1/04	14/1/04	15.17
		Shallow Well V	11/8/04	20/1/04	10.68
				11/8/04	6.00
				16/8/04	4.20

Mean results of several replicate analysis are recorded.
Means at each season are not significantly different at P = 0.05

The result in Table 5 shows that water that is rich in nitrate may become safe for drinking after storing it for several hours or days. The intensive and extensive sampling and analysis which have been done on the drinking water of Bama Local Government Area of Borno State, Nigeria, reveal no source with excessively high nitrate concentration. The highest concentration obtained was about 17.15mg per litre from Banki Deep Borehole which is far below the safe limit of 45mg per litre. [8]. Wells should be deep, at least 30m from pit latrines, internally ringed with concrete and raised at least two metres above the ground level. Both ground surface waters should be treated before use at least by boiling [12].

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