ASSESSMENT OF WATER QUALITY PARAMETERS IN NYAMBAI, BRIKAMA, THE GAMBIA

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ABSTRACT

This study took place at Nyambai, Brikama, The Gambia. It was with a view to ascertaining the cause of problems with well water at the named location as complained by some inhabitants in an earlier study. Twenty well water samples were collected randomly, and nine water quality parameters were measured in each sample: nitrite, *E*-coli, conductivity, pH, hardness, manganese, cyanide, phosphate, and total dissolved solids. *E*-coli counts exceeded World Health Organization, WHO recommendation. This was attributed to violation of recommendations of distance between well water and toilet/dumpsite. All measured pH values were acidic; one sample site exceeded recommended conductivity values. All other parameters were within the National Environment Agency, The Gambia, guidelines. Nearly all wells in the study were open and had an average sanitary condition. Gambia Government needs to sensitize populace about the need to close wells and respect regulation of distance between well and dumpsite/toilet when constructing homes. Further to this, is the need to manage waste. *[African Journal of Chemical Education—AJCE 14(1), January 2024]*

INTRODUCTION

Nyambai is a part of Brikama Town in The Gambia. Its main source of water is through traditional wells, traditional/modern wells, also called hand dug wells, and government water or pipe-borne water.

The researchers in this study intended to measure water quality parameters in Nyambai with a view to ascertaining the problems by examining the measured values from collected water samples and comparing them with accepted values of water quality parameters *vis-à-vis* National Environment Agency, NEA. The Principal Investigator had earlier been involved in supervising a similar research project: Král *et al* [1]. The study done by Král *et al* mainly focused on Faraba, the permanent site of the University of The Gambia campus. Furthermore, there was the problem of inadequate materials needed to do a thorough sampling.

This study focused on water from the following sources: wells; traditional and modern. It is assumed that water from government poses no problems. This is easy to understand since well water is prone to contamination as a result of geology, for example, contamination of ground water by arsenic as detailed in several studies [2-4]. When water passes through the ground, (as in a well), it can be contaminated by what it encounters in the ground. Water from the government passes through pipes and not rocks before it reaches homes and other points of use. Further to this, some form of treatment of water is done by National Water and Electricity Company, NAWEC. Water from wells is not treated before use; this implies that its consumption is subject to risks.

Well water may be contaminated due to closeness to a latrine, dumpsite or graveyard. According to Rural Water Supply and Sanitation Program, "*Rules and Regulations indicate that distances between sanitary facilities and dug wells should not be less than 30 meters*." This was from a Gambia-specific project: Rural Water Supply and Sanitation Project for The Gambia [5]. Further to this, and according to National regulations on safe distance between latrines and waterpoints, the afore-stated distance is country specific, for example, in Ghana it is 50m, Burkina Faso 25m, Ethiopia 30m, Mali 15m and so on [6]. For each traditional well encountered in this research, the distance between it and a latrine/bathroom was measured. This would give an insight into one or more of the water parameters of interest, for example, *E*-coli.

Water quality is a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. The quality of drinking water is a powerful environmental determinant of health [7]. The drinking water quality management has been an important issue for over a long period of time. Water is essential for life, but it can and does transmit diseases.

The quality of water can be altered through contamination with a lot of materials. These materials may include different kinds of substances which may be unsafe for consumption. Water quality is based on certain parameters which are categorized according to whether it is physico-chemical, microbiological, or chemical parameter. Physico-chemical parameters include pH, temperature, turbidity, salinity, conductivity, total dissolved solids (TDS), color, odor and taste. Microbiological parameters are total coliform (TC) and fecal coliform (FC). The presence of *e*-coli is an indication of waste in one form or another. Chemical parameters include acidity, alkalinity, nitrate, nitrite, phosphate, potassium, ammonia, iron, chloride, and hardness.

Background

During a recent study by Král *et al [1]*, some inhabitants of Nyambai complained that the water they use was not good and that it gives them problems at times; problems of stomach pains. Water quality parameters were measured in the study and twenty-one samples were collected for this purpose. One of the samples collected at Nyambai had the second highest level of nitrate and the highest level of ammonia of all the samples looked at. The nitrate level violated the NEA water quality guidelines. Afore-mentioned nitrate and ammonia levels are indicative of pollution which may be that waste is nearby. Some parts of Nyambai are littered with a lot of dumpsites. Some of these were observed to be close to some of the wells sampled in this study.

Objectives

The study intends to

1. Find out the values of the water quality parameters pointed out earlier (with specific reference to Nyambia), and with a view to finding out the cause of the water problem in Nyambai.
2. Compare the values to that set by WHO and NEA.

METHODOLOGY/EXPERIMENTAL

The work was carried out in collaboration with the Water Resources Laboratory, Abuko. It is responsible for a lot of water related activities in The Gambia. Equipment used were manufactured by Hach, Company, America.

The following water quality parameters were investigated in this work: *E*-Coli (total and fecal), hardness, cyanide, manganese, phosphate, nitrite, pH, conductivity, total dissolved solids, (TDS), temperature, salinity, oxygen density, odor, and turbidity. In addition, sanitary survey of each well/sample site was carried out and the distance of each well to toilet, bathroom, and dumpsite, (if seen), was measured in meters using a tape rule.

A multimeter YSI 650MDS was used to measure: pH, TDS, salinity, temperature, time, date and oxygen density. These parameters were all measured on site. Samples of well water were taken on site and transported to the Water Resources Laboratory in Abuko. All other parameters were measured in the laboratory.

A Hach spectrophotometer model DR 1900 was used to measure, phosphate, nitrite, manganese, and cyanide.

Sampling

Only water from wells were sampled. Table 1 shows each sample site, coded, and its respective latitude and longitude. This information was used to construct a map; sampling map, figure 1. For each well, an attempt was made to search for the location of the nearest dumpsite that has a refuse or some other waste. For each of such site found, its distance from the well was measured. Sanitary condition of each well was noted, as well as distance from latrine and bathroom.

Table 1 Sampling sites and their respective latitudes and longitudes

SAMPLING POINT/CODE	LATITUDE	LONGITUDE
001-ShK	13.277680	-16.656324
002-GoK	13.281896	-16.659969
003-WeK	13.28238	-16.66005°W
004-CaK	13.28205	-16.661844
005-JaK	13.281097	-16.662245
006-JgK	13.277849	-16.658717
007-ByK	13.277566	-16.655855
008-JeK	13.27718	-16.659537
009-JhK	13.27700	-16.66017
010-MaK	13.27620	-16.66075
011-KhK	13.27528	-16.66025
012-MyK	13.27454	-16.66100
013-JuK	13.275923	-16.656186
014-DaK	13.277776	-16.656327
015-SeK	13.27504	-16.655543
016-ShK	13.275153	-16.656025
017-DeK	13.273412	-16.657421
018-DoK	13.272867	-16.656297
019-MyK2	13.274904	-16.658565
020-CyK	13.274126	-16.658915

RESULTS AND DISCUSSIONS

The research took place in two stages; stage one: on-site measurement of pH, TDS, conductivity, temperature, salinity, turbidity, sanitary survey, and microbial analysis in the laboratory (*E*-coli). One objective was to ascertain cause of the water problem at Nyambai; this was found to be the presence of *E-c*oli and it has been attributed, in part, to open wells, closeness to dumpsites and toilets/bathrooms. This was self-evident and expected, however, one of the sites, sample point 018-DoK had the lowest total coliform count. This was strange because it was open and had a lot of mango trees growing all around it with roots boring into the well. The phytochemicals in the roots are probably responsible for the low count. Phytochemicals affect bacterial growth [8]. 018-DoK was the only site that had such mango trees growing around a well. This finding is very interesting.

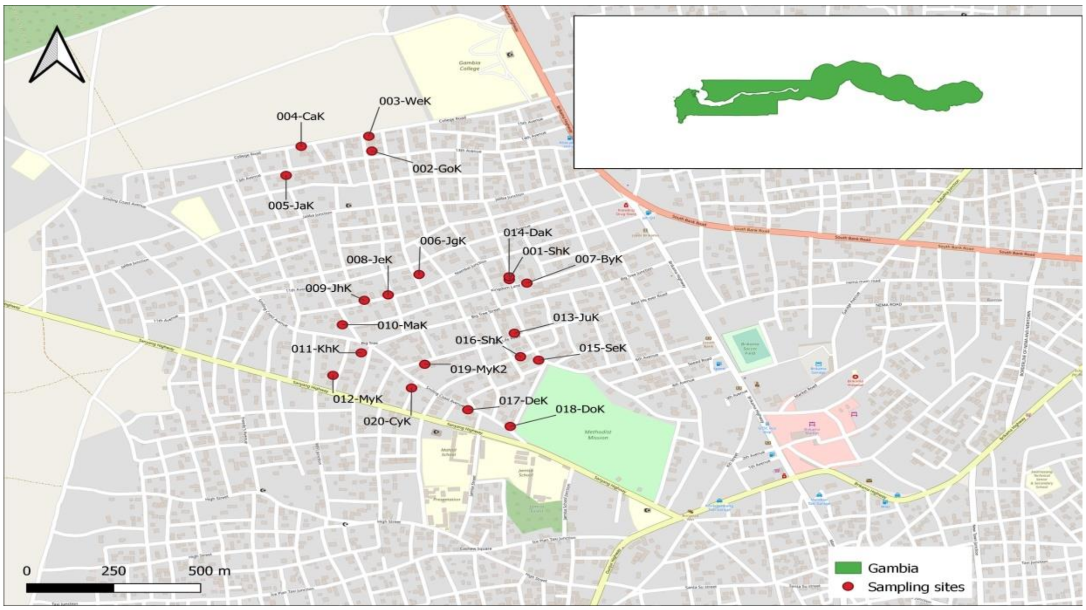

Figure 1. Sampling sites at Nyambai, Brikama

On another note, may be the inhabitants of Nyambai should be encouraged to plant more mango trees in their compounds; this would help with the pollution by *E*-coli and climate change.

The researchers initially expected the water problem at Nyambai to be due to some other reason apart from pollution by dumpsite; geological contamination due to rock composition.

Further to the above, filter papers used in the microbial analysis were sent to a specialized laboratory for specific identification of all microbes. This would help the researchers be able to know the possible ailments associated with consumption of the water samples that had a lot of *E-coli*. Table of results of the first stage of the study is shown in table 2 below.

Table 2 Results of the First Stage

SAMPLING POINT/CODE	**TYPE OF WELL**	**Fecal Coliform (count/sample vol.)**	**Total Coliform (count/100mL)**	**Remarks/Sanitary survey**	**Distance from**
001-ShK	Traditional	50	more than 100	Fairly clean	Latrine – 23m Bathroom - 7.1m
002-GoK	Traditional	50	more than 100	Clean	Latrine – 20.16m
003-WeK	Traditional	50	more than 100	Close to a dump Site */Clean	Latrine – 16.5m Dumpsite – 38m
004-CaK	Traditional	50	more than 100	Close to a dump Site/ Fairly clean	Latrine – 22m Dumpsite – 17m
005-JaK	Modern	50	more than 100	Fairly clean	Latrine – 19m Bathroom – 20m
006-JgK	Traditional	50	more than 100	Dirty surroundings	Latrine – 1m Poultry farm – 17.1m
007-ByK	Traditional	50	more than 100	Clean	-
008-JeK	Modern	50	more than 100	Fairly clean	Latrine – 36.8m
009-JhK	Traditional	50	more than 100	Fairly clean	Latrine – 23m
010-MaK	Traditional	50	more than 100	Fairly clean **.	Latrine – 9m
011-KhK	Traditional	50	more than 100	Clean	Latrine – 15m

					Bathroom – 12.2m
012-MyK	Traditional	50	more than 100	Fairly clean	Latrine – 35m
013-JuK	Traditional	50	more than 100	Clean	Latrine – 22.6m Bathroom – 17m
014-DaK	Traditional	50	more than 100	Fairly clean	Latrine – 18.7m
015-SeK	Open traditional	50	more than 100	Algae seen, in and around well; bathroom and soak away very close by. / Fairly clean	Dumpsite – 26.3m Septic Tank – 6.3m
016-ShK	Traditional	50	100	Abandoned well, next to borehole supplying water. Algae in dis-used well. /clean	Septic tank – 14.5m
017-DeK	Traditional	50	more than 100	Algae grows on inside of well. Fairly clean	Latrine – 21m
018-DoK	Traditional	16	32	Fairly clean	Latrine – 28m
019-MyK2	Traditional	50	more than 100	Clean	Septic tank – 18m
020-CyK	Traditional	50	more than 100	Dirty	Latrine – 16m

*Residents complained of sand seeping into water at times.
** Whole compound throws wastewater on ground around well; wash for a living.

Table 2 has displayed the distance of each sample site from latrine/dumpsite and in few cases soak away. These measurements should help provide an appreciation of the *e-coli* results as per closeness to waste. *E-coli* colonies too many to count were simply summarized as more than 100 or 50, depending on whether it was fecal coliform or total coliform.

As part of the results of the first stage of the study, table 3 shows other parameters measured with a multimeter on-site.

Table 3 Further results of the First Stage

SAMPLING POINT/CODE	pH	Conductivity (µS/cm)	TDS (mg/L)	Salinity (%)	Oxygen Density (mg/L)	Turbidity (NTU)
001-ShK	6.58	853	555	0.42	2.9	Less than 5
002-GoK	6.60	874	568	0.43	2.31	Less than 5
003-WeK	6.45	130	84	0.06	1.18	8
004-CaK	6.13	98	63	0.04	0.32	25
005-JaK	6.15	79	52	0.04	0.25	Less than 5
006-JgK	6.91	819	542	0.04	3.40	Less than 5
007-ByK	6.95	543	353	0.26	1.63	Less than 5
008-JeK	6.84	333	217	0.16	2.32	Less than 5
009-JhK	6.79	229	143	0.10	1.75	Less than 5
010-MaK	6.85	625	406	0.30	2.30	Less than 5
011-KhK	6.65	113	74	0.05	1.43	Less than 5
012-MyK	6.68	292	190	0.14	3.21	Less than 5
013-JuK	5.86	346.6	167	0.20	2.20	Less than 5
014-DaK	6.02	149.7	61.4	0.10	1.65	Less than 5
015-SeK	5.90	634	283	0.30	1.53	Less than 5
016-ShK	6.00	1390	642	0.60	1.71	Less than 5
017-DeK	5.80	217.3	94.4	0.10	1.69	Less than 5
018-DoK	5.77	123.8	49.3	0.10	2.31	8
019-MyK2	5.90	511	252	0.20	3.81	Less than 5
020-CyK	6.00	218.8	84.7	0.10	3.38	Less than 5

In addition to table 3, odor was also looked at and all samples showed a normal result; meaning no odor was detected in any of the samples.

The second stage of the research dealt with laboratory measurement of some chemical parameters. One of the research questions was: How do the values of water quality parameters in

Nyambai compare with accepted values of water quality parameters *vis-à-vis* NEA? The following chemical parameters were investigated: total hardness, cyanide, manganese, mercury, phosphate, and nitrite. As seen in table 4, total hardness values varied from 23.2mg/L to 274.1mg/L; cyanide, manganese and mercury were all zero mg/L; nitrite values ranged from 0.000mg/L to 0.131mg/L.

Table 4 Results of the Second Stage

SAMPLING POINT/CODE	Hardness (mg/L)	Phosphate (mg/L)	Nitrite (mg/L)
001-ShK	96.5	0.62	0.001
002-GoK	181.4	3.03	0.002
003-WeK	46.3	4.66	0.002
004-CaK	34.7	0.88	0.131
005-JaK	23.2	1.09	0.004
006-JgK	274.1	2.57	0.007
007-ByK	119.7	4.57	0.000
008-JeK	42.5	0.66	0.001
009-JhK	42.5	0.55	0.001
010-MaK	69.5	1.51	0.000
011-KhK	23.3	1.46	0.008
012-MyK	46.3	1.12	0.006
013-JuK	30.9	1.08	0.001
014-DaK	23.3	2.76	0.000
015-SeK	34.7	1.66	0.001
016-ShK	46.3	0.83	0.000
017-DeK	84.9	1.58	0.002
018-DoK	23.2	6.84	0.000
019-MyK2	42.5	7.14	0.000
020-CyK	38.6	0.85	0.000

Sample 004-CaK had a value of 0.131mg/L; the NEA standard for nitrite is 0.03mg/L, for WHO it is 3mg/L; 004-CaK exceeded the NEA standard but did not for WHO standard. Phosphate

0.55mg/L to 4.66mg/L. Sample 018-DoK had the lowest e-coli count, (first study); in this work, it was one of the sites with the lowest total hardness values. Similarly, it also has one of the highest values of phosphate ion.

NEA standard for phosphate is 0.4mg/L. All the sampling sites exceeded this standard. This is noteworthy. Sample 019-MyK2 had the highest level of phosphate in this regard. Sample 009-JhK had the lowest value.

NEA standard for hardness is 200mg/L. Sample 006-JgK was the only site that exceeded this standard. It was one of two sampling sites with the dirtiest surrounding. Sample 007-ByK had a value of 119.7mg/L, approximately 200mg/L. Some of the sampling sites were used for commercial purposes, washing clothes as a means of livelihood. From the values, one can conclude that the water is economically viable. Hard water is bad for the business of washing clothes for a living.

NEA standard for manganese is 0.05mg/L. All sampling sites complied with this standard. Thus, this heavy metal is not a problem.

NEA standard for cyanide is 0.05mg/L. None of the sites violated this standard.

Researchers did not know what to expect, in a general sense; they expected high levels of heavy metals for sites close to dump sites.

Regulation for guidelines stipulates a distance of 30m from a well to a toilet; only two sampled sites did not violate this guideline. 100m is the distance for a dumpsite; none of the sampled sites close to dumpsite was in agreement with this figure. This is noteworthy.

pH values of all the samples were within the guidelines of NEA and WHO. Conductivity value for sample 016-ShK was the only sample that was outside the NEA stipulated value of 1300µS/cm.

Table 5 shows a summary of some of the values for some water quality parameters obtained along with standards for WHO and NEA

Table 5 Summary of Values obtained for some water quality parameters and standards for WHO and NEA

Water Quality Parameter	**NEA standard**	**WHO standard**	**Range of Values obtained**
Nitrite	0.03 mg/L	3 mg/L	0.000 – 0.131 mg/L
E-coli	0 count/100mL	0 count/100mL	16 – 50 count/100mL(FC)* >>100counts/100mL (TC)**
Conductivity	1300 mg/L	50 - 500µS/cm	79 - 1390µS/cm
pH	5.5 to 8.5	6.5 – 8.5	5.77 – 6.95
Hardness	200 mg/L	1000mg/L	23.2 – 274.1mg/L
Manganese	0.05 mg/L	0.5mg/L	0.000mg/L
Cyanide	0.05 mg/L	0.1mg/L	0.000mg/L
Phosphate	0.4 mg/L	Less than 1mg/L	0.55 – 4.66mg/L
Total Dissolved Solids		300mg/L	52.0 – 642mg/L

CONCLUSION

Sample 018-DoK had the lowest count of *e*-coli and it was attributed to the presence of a lot of mango trees growing around the well. Nearly all the wells were open with and without covers. The researchers in this study advice that people should be sensitized about the importance of closing their wells, if they have covers and if not, making a cover for it. This is important because an open well means that microbes can easily enter the water from the air and pollute it. Further to this, some of the sample sites had dumpsites close by. People should be advised to stop dumping waste close to their wells as this eventually pollutes the water, especially during rainy season when runoff water percolates into the well.

Violations of the recommended distance from well to toilet is such that the inhabitants cannot go back and begin to rebuild their homes, however, Government of The Gambia can sensitize the populace about this and in addition, enforcing it as Law. The afore-mentioned violation as regards distance from a dumpsite is noteworthy; what is recommended is for a better waste collection policy and drive; this would do away with the indiscriminate dumping of waste which is the initial catalyst for a dumpsite.

Output

1. The following departments should work together to educate the public about the importance of closing their wells and also cleaning the area around it: The Department of Water Resources, Public Health officials, National Environment Agency and the Research Directorate, UTG. This study was carried out in a small community where some inhabitants use well water; other communities exist that also use well water and most likely have the same problems as regards open wells.
2. Further to 1 above, Village Heads, *Alkalos*, should be included in the exercise in order to make it more effective. This exercise should be Nation-wide.

Implications for Chemical Education in Africa

- There is a need for Africans who own and use well water for drinking to be educated about the negative implications of leaving their wells open. Opening wells makes it possible for microbes to enter and contaminate water inside.
- It would be good practice for people who own wells to plant trees around them.
- Latrines and bathrooms should be situated at respectable distances that do not violate the WHO standard of distance from latrines to source of potable water.

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ETHICAL ISSUE

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

COMPETING INTERESTS

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

AUTHORS' CONTRIBUTION

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

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