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Studies on well water and possible health risks in Katsina, Nigeria

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SUMMARY

Well water was sampled from all four major wards in Katsina town. All 20 samples taken showed high coliform counts. Sixty-five per cent contained $\geqslant$ 2400 coliforms per 100 ml while the remainder had counts ranging from 79 to 920. Faecal coliforms and non-cholera vibrios were detected in all samples. There was no significant relationship between the coliform counts and the distances of latrines to wells, water table to ground level, slope relationship between wells and latrines, the pH of water and whether the wells were left permanently open or not. *Salmonella* sp., *Enterobacter* sp. and *Pseudomonas* sp. were each isolated from about 10 % of the samples, while *Proteus* sp. was isolated from 40 %, *Citrobacter* sp. 15 %, *Alcaligenes* sp. 5 % and an unidentified Gram-negative rod from 5 %.

Only 2 (10 %) of the sampled households, representing 23 (9·6 %) of the 239 people exposed to well-water had pipeborne water in addition. It was concluded that well water in Katsina town could be a human health hazard.

INTRODUCTION

Over the years, water has served as a vehicle for various pathogens with resulting outbreaks of epidemic disease in different countries (Skirrow, 1977; De Mol & Bosmans, 1978; Wright & Vernon, 1976; Blake, Allegra & Snyder, 1980; Morris, Wilson & Davis, 1981; Kim & Stone, 1980; CDC, 1976). With the ever-increasing human population, safe potable water has become vital for survival of populations, making it imperative that water from pathogen-free sources must be ensured.

Underground water supplies from wells and springs have usually been considered safe, provided they are properly located, constructed and operated (Diehl, 1960). However, defects such as improper construction of well casings and covers, lack of adequate drainage from the well at surface and connexion between wells and sewer and drainage systems have led to pollution (Diehl, 1960).

In developing countries like Nigeria where a majority of the people live in rural areas and wells represent a significant source of water supply, little is known about the role these wells play in disease outbreaks. Unfortunately, reporting of food or waterborne outbreaks is not done and furthermore, there are no standards for location of wells and operation and quality of water considered potable. In view of these facts, and the occurrence of a recent large waterborne outbreak with many fatalities in Katsina (unpublished data), an attempt was made to study well water in Katsina and possible associated health risks.

MATERIALS AND METHODS

Sampling areas

The investigation was conducted in Katsina, a town in the north-western part of Nigeria with a population of about 126000, an annual rainfall of about 0.25 m with most rain occurring in June, July and August. Acute water shortage coupled with relatively high temperature for most of the year is a common finding. The town is divided traditionally into four wards, locally called 'Wakilins', each directly under a ward head who is in turn responsible to the Emir. The four wards, namely Arewa (north), Yamma (south), Kudu (east) and Gabas (west) were made sampling areas. Five randomly selected compounds from each ward served as sampling units.

Sample collection

Due to the traditional 'purdah' system practised in the town where married women live under seclusion and movements of male visitors are not allowed, the assistance of trained female social workers, fluent in the Hausa language, was employed. For each selected household using a prepared questionnaire, the following information was obtained:

(i) Number of people in the household; (ii) number of people in the household with recent gastroenteritis; (iii) condition of the well in the household and the relationship to the latrine.

For the coliform count, 100 ml of freshly drawn well water was put into a sterile 200 ml bottle and ice-cooled until used. Approximately 5·0 ml of well water was added to 10·0 ml of Selenite F broth for salmonella–shigella detection while for vibrio detection, 10·0 ml of alkaline peptone water (APW) was used as a transport medium.

Bacterial isolation and identification

Coliform detection

To determine the most probable number (MPN) index for coliforms in well water samples, the presumptive, confirmed and completed tests were performed as described in standard methods (Rand, Greenberg & Taras, 1975). The confirmatory tests for faecal *Escherichia coli* were as described by Rand *et al.* (1975) with a slight modification. A loopful of inoculum from all positive brilliant green bile broth tubes was added to tubes containing *E. coli* (EC) medium and incubated at $44{\cdot}5 \pm 0{\cdot}2$ °C for 24 h. Growth and gas production was taken as positive. Additionally, streaks from positive EC tubes were made on Eosin Methylene Blue (EMB) agar and incubated overnight at 37 °C.

Table 1. *Character of water supply in Katsina town*

Wakilin	Well no.	Depth of water table (m)	Well normally covered	Latrine distance* (m)	People in household (no. with gastroenteritis)	Bacterial count† (MPN per 100 ml)
Arewa	1	6·3	Yes	5·7 (A)	10 (2)	⩾ 2400
	2	6·8	Yes	16·5 (S)	13 (1)	220
	3	5·1	No	6·9 (A)	12	⩾ 2400
	4	9·6	Yes	4·5 (A)	4	280
	5	6·0	No	2·6 (S)	2	⩾ 2400
Yamma	6	15·6	No	9·0 (A)	9	⩾ 2400
	7	13·5	No	3·3 (A)	12	920
	8	9·0	Yes	1·8 (A)	5	⩾ 2400
	9	9·0	Yes	2·3 (A)	8 (1)	540
	10	8·4	Yes	1·8 (B)	12	920
Kudu	11	11·3	Yes	3·0 (B)	12	920
	12	11·3	Yes	5·1 (A)	9	⩾ 2400
	13	12·6	No	5·4 (B)	10	79
	14	11·7	Yes	4·8 (A)	12 (1)	⩾ 2400
	15	11·4	Yes	4·8 (A)	1	⩾ 2400
Gabas	16	10·1	No	11·3 (A)	45 (1)	⩾ 2400
	17	9·0	No	12·0 (B)	13	⩾ 2400
	18	11·6	No	15·8 (B)	20	⩾ 2400
	19	10·8	Yes	5·3 (A)	21	⩾ 2400
	20	8·6	Yes	9·5 (A)	9	⩾ 2400

* On a sloping site the latrine is above (A), below (B) or on the same level as (S) the well mouth.

† Counts are most probable number estimates for coliform bacilli. All wells yielded faecal *Escherichia coli* and non-cholera vibrios. Wells 1 and 11 also yielded salmonellas.

Vibrio detection

Overnight growth at 37 °C of APW inoculated with water sample was streaked heavily on thiosulphate–citrate–bile–salt–sucrose agar (TCBS). Samples showing typical 2 mm diameter yellow colonies after overnight incubation were further identified as recommended by Furniss (1979). Slide agglutination tests using the polyvalent and *V. cholera* (Ogawa) antisera were performed on typical colonies on TCBS. All isolates that failed to agglutinate either sera were termed non-cholera vibrios (NCV).

Other enterobacteriaceae

Overnight growth of water-inoculated Selenite F broth at 42 °C was streaked on Brilliant Green Agar (BGA), Salmonella–Shigella agar (SS) and MacConkey agar. All identifications were carried out according to standard methods (Cowan & Steel, 1965).

Detection of calcium, cadmium, lead and arsenic

Atomic absorption readings were taken for calcium, cadmium, lead and arsenic using an atomic absorption spectrophotometer, Unicam SP 1900.

Table 2. *Variation in mean values of gastroenteritis attack rate; well to latrine, water table to surface distances, pH and MPN indices in Katsina wells*

Area (Wakilin)	No. of people in household	Attack rate for gastroenteritis (%)	Mean distance of water table to ground level (m)	Mean distance of latrine to well (m)	Mean pH of water	Per cent of well with MPN index ≥ 2400
Arewa	41	7·30	6·75 ± 1·7	7·23 ± 5·43	7·52 ± 0·35	60
Yamma	46	2·17	11·10 ± 3·24	3·63 ± 3·06	7·16 ± 0·055	40
Kudu	44	2·27	11·64 ± 0·57	4·62 ± 0·94	7·32 ± 0·44	60
Gabas	108	0·93	9·99 ± 1·24	10·14 ± 3·83	7·08 ± 0·84	100

RESULTS

Table 1 shows the relationship between the four wards as regards the number of people in sampled households, number of people involved in a recent gastroenteritis outbreak, source of water supply, relationship of well to latrine (pit toilet) and general condition of well water.

A total of 239 people were exposed to the 20 wells sampled. Only two households, both in Arewa, with 10 (4·2%) and 13 (5·4%) people respectively had pipeborne water supply. Each of the four wards recorded a case of on-going gastroenteritis; Arewa had three cases.

All the 20 wells had their openings elevated above ground level; however, none had cemented walls. Seven (35%) of 20 wells were permanently left open. The depth from well opening to water table ranged from 6·0 to 15·6 m with a mean of 9·9 m.

All 20 households have latrines and in Arewa, wells were situated at a higher level than latrines in three households and in the remaining two were on the same level; Yamma, four at a higher level and one lower; Kudu and Gabas both having three at a higher level and two at a lower. The closeness of wells to latrines varied from 1·8 to 16·5 m with a mean of 6·57 m. For well water from the four wards, 17 (85%) had a pH that was neutral or close (7·0–7·3) while water from two wells in Arewa had a pH of 7·9 and one from Kudu 8·1. Calcium content ranged from 0·50 to 0·74 p.p.m., lead from 0·01–0·04 p.p.m., arsenic from 0·00–0·001 p.p.m., while cadmium was not detected.

Bacteriologically, of the 20 samples, 13 (65%) had an MPN index for coliform equal to or over 2400, 3 (15%) with 920, 1 (5%) with 540, 1 (5%) with 280, 1 (5%) with 220 and 1 (5%) with 70.

All samples contained faecal *E. coli* and non-cholera vibrios. *Salmonella* sp. was isolated from 2 (10%) of the water samples, one in Kudu and the other in Arewa. *Proteus* sp. was most frequently isolated being found in 8 (40%) of the samples; *Citrobacter* sp. in 3 (15%); *Enterobacter* sp. in 2 (10%); *Pseudomonas* sp. in 2 (10%); *Alcaligenes* sp. in 1 (5%) and an unidentified gram negative in 1 (5%) well water sample. Four samples, 3 in Kudu and 1 in Gabas were negative for these enteric organisms.

The attack rate of a recent gastroenteritis outbreak in Katsina amongst households sampled varied from 0·93 % in Gabas to 7·30 in Arewa. Yamma and Kudu recorded 2·17 and 2·27 % respectively (Table 2).

The mean distance between the water table to ground level varied from $6{\cdot}75 \pm 1{\cdot}7$ to $11{\cdot}64 \pm 0{\cdot}57$ m showing that the water tables were relatively close to ground surface in all wards but there was no correlation between depth of water table and bacterial count. The mean distance between the latrines and wells was lowest in Yamma with a value of $3{\cdot}63 \pm 3{\cdot}06$ m and highest in Gabas with $10{\cdot}14 \pm 3{\cdot}83$ while Arewa and Kudu had means of $7{\cdot}23 \pm 5{\cdot}43$ and $4{\cdot}62 \pm 0{\cdot}94$ m respectively. Again there was no correlation with bacterial count. The pHs of water samples showed no significant difference between wards with Gabas having a mean of $7{\cdot}08 \pm 0{\cdot}084$ and Arewa, $7{\cdot}52 \pm 0{\cdot}35$. In Gabas, all the five wells sampled contained $\geqslant 2400$ coliforms per 100 ml, in both Arewa and Kudu, only 60 % contained such a degree of pollution while only 40 % of five wells in Yamma showed such counts.

DISCUSSION

Reporting systems for food- and water-borne infections and intoxications are virtually non-existent in Nigeria. The role played by water as a vehicle of illnesses is therefore unknown.

However, data presented in Tables 1 and 2 show that well water in Katsina town should be of public health concern as all 20 well-water samples taken randomly over the town were very highly polluted as evidenced by high MPN indices. All samples had counts well over the recommended standard of less than 2·2 coliforms per 100 ml for potable water by the United States Environmental Protection Agency (Rand *et al.* 1975; Freedman, 1977).

The isolation of faecal coliforms and non-cholera vibrios from all samples tested is of great importance as these organisms have been reported as causes of gastroenteritis in humans (Sack, 1975; Sack, *et al.* 1977; Furniss, 1979; Aldova *et al.* 1968; Dakin *et al.* 1974). The isolation of *Salmonella* sp. from two wells and other enteric organisms from 16 of these samples was further evidence that faecal contamination was responsible for the high MPN indices. The possibility of the presence of other unidentified water-borne pathogens like *Giardia intestinalis*, viruses, *Campylobacter* sp. and chemicals cannot be ruled out as the procedure employed selected essentially for enterobacteria.

It is interesting to note the absence of any correlation between the latrine–well distance and degree of pollution as reflected by MPN indices. Gabas recorded the highest mean latrine–well distance ($10{\cdot}14 \pm 3{\cdot}83$ m) yet had the greatest degree of coliform pollution (all wells with MPN indices $\geqslant 2400$) while Yamma, with the lowest mean distance of $3{\cdot}63 \pm 3{\cdot}06$ m surprisingly had the lowest degree of pollution with only 40 % of wells having $\geqslant 2400$ coliforms per 100 ml. (Table 2). It is, however, clear that in all the households sampled, the latrines were too close to the wells, ranging from only 1·8 to 16·5 m (mean of 6·57 m); much closer than the minimum of 30 m recommended by the WHO (Araoze & Subrahmanyan, 1970). Two factors could be responsible for the lack of correlation, namely, the various degrees of soil porosity in the areas sampled, since none of the wells had concrete sides, thereby allowing variable seepage of faecal materials and, secondly, the high degree of pollution, as shown by a wide count range of ⩾ 2400 coliforms per 100 ml for 13 samples, may have obscured any existing trend. Such reasoning could also explain the lack of any correlation between the MPN index and location of well and latrines relative to ground elevation, wells permanently left open or not and the distance from water table to ground level.

Chemical analysis showed that the well water samples did not present any health risks as to their lead, cadmium, and arsenic contents as they were within the limits recommended by the WHO (Freedman, 1977).

As long as the town has wells and latrines close together within relatively small enclosures, the potential health hazard posed by highly polluted well water cannot be over-emphasized. The majority of the population is dependent on well water for their daily needs, as reflected by the fact that only 2 of the 20 households having 23 (9·6 %) of 239 persons sampled have a pipeborne water supply, which upon investigation was dry most of the time. There is therefore a need for a public enlightenment on boiling of well water prior to use and for health agencies to ensure regular chlorination of such wells as a feasible solution. In addition, efforts need to be made to establish and enforce a safe well–to–latrine distance standard especially for new buildings.

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