HIGH FLUORIDE WATER IN THE GILGIL AREA OF NAKURU COUNTY, KENYA

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SUMMARY: Fluoride (F) levels were determined in 37 randomly sampled water sources in the Gilgil-Elementaita area and part of the Nakuru municipality in Nakuru County, Kenya using a F ion selective electrode. Lake water had F levels close to 200 ppm. Of the other sources, the highest mean F levels were in piped water (7.69 ppm) and borehole water (6.57 ppm). The level of water F appeared to increase with proximity of the source to the lakes in the region. There was also an apparent increase in the level of F in piped water compared to the original borehole water, which is ascribed to extensive evaporation during treatment and storage of piped water. With one exception, the river water had the lowest mean F concentrations (<0.1 ppm). These results indicate that most of the rivers in this region are relatively low in F and therefore are the safest sources of water for domestic and industrial use.

Keywords: Borehole water; Fluoride in water; Gilgil area; Kenya water sources; Lake Elementaita; Nakuru County, Kenya.

INTRODUCTION

Endemic fluorosis in Kenya has been a public health problem for many years,[1] and now there is a heightened public health concern about the fate of fluoride (F) in soil and groundwater sources, particularly in areas associated with the Great Rift Valley and the Central Highlands.[2] In addition, rapid population growth[3] and changes in rainfall patterns in many parts of Kenya have exacerbated the problem of water scarcity, forcing communities to turn to poor quality water sources for their needs.[4]

Primary sources of water for rural populations in Kenya are rivers, streams, springs, and wells in well-watered areas and boreholes in arid and semi-arid regions. Piped water is limited to urban areas.[5] Communities in rural areas use water from natural sources without treatment, and water monitoring is not possible because many rural areas are relatively inaccessible. Thus, especially in recent studies, it has been proposed that more F surveys should be conducted to establish the risk posed by increasing F exposure in certain communities.[6] The present investigation was therefore undertaken to determine F levels in domestic water sources of the rural populations in the Gilgil area and in the peri-urban region of the Nakuru municipality in Nakuru county, Kenya, to evaluate the potential risk of fluorosis to people using these waters.

MATERIALS AND METHODS

A total of 37 water samples were collected from different water sources selected randomly in the study region. Table 1 summarizes these sample selections by type of water source. The samples were collected in clean 60-mL plastic bottles and stored frozen at –10ºC before analysis. F was determined using TISAB II (total ionic strength adjustment buffer) and Tx EDT Model 3221 direct-ion electrodes.[6]

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For calibration, standard solutions containing 0.01, 0.1, 1.0, 10.0, and 100.0 ppm F prepared by serial dilution of a 1000-ppm F stock solution with de-ionized water were employed.

Table 1. Water samples collected from the study area for F analysis

Sampling region	Tap	Stream or river	Borehole (wells)	Storage Tank	Lake	Total samples
Mbaruk	2	2	5	0	0	8
Lanet-Elementaita	6	2	10	0	2	19
Gilgil-Kariandusi	0	3	3	1	0	10
Total	8	7	19	1	2	37

RESULTS AND DISCUSSION

Figure 1 shows the study area in the Gilgil area of Nakuru County, Kenya, Africa.

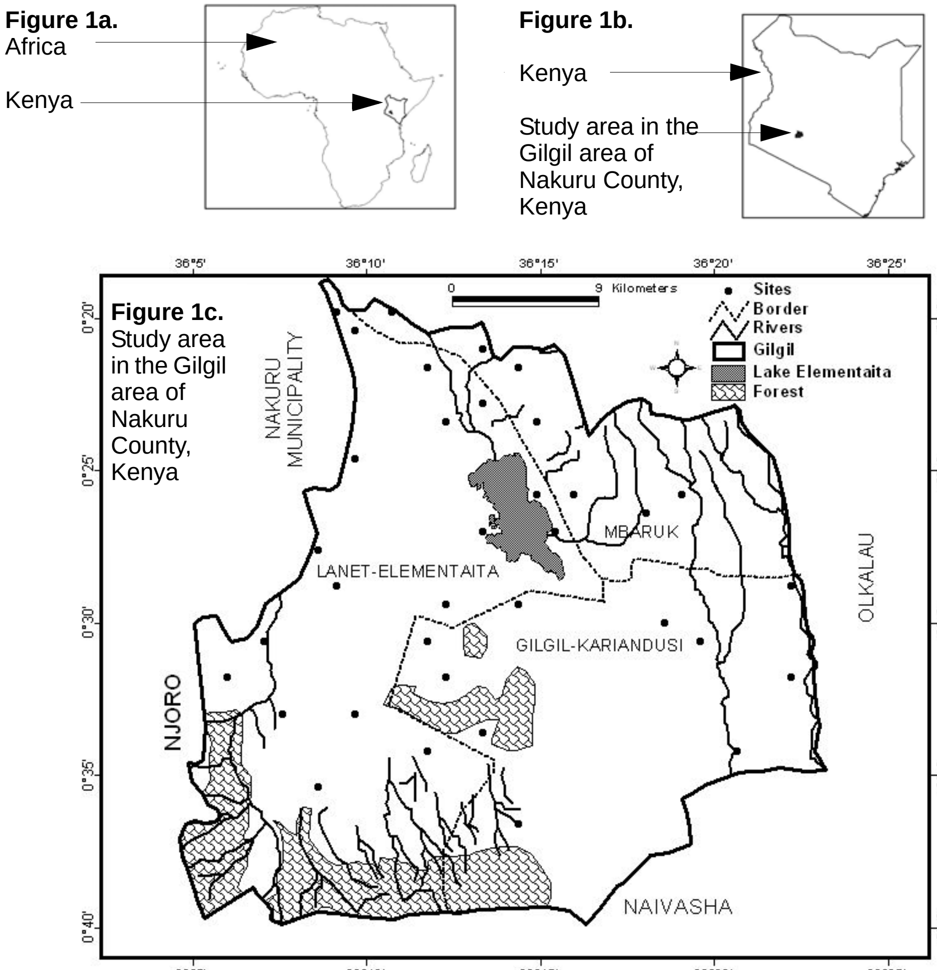

Figure 1. Map of the study area showing sampling sites in the Gilgil area of Nakuru County, Kenya.

The study area of about 1100 km^2 has a population of approximately 130,000 people[7] distributed by the age brackets shown in Figure 2, which shows that children under age 5, who are most vulnerable to the toxic effects of F, comprise 14% of the population.

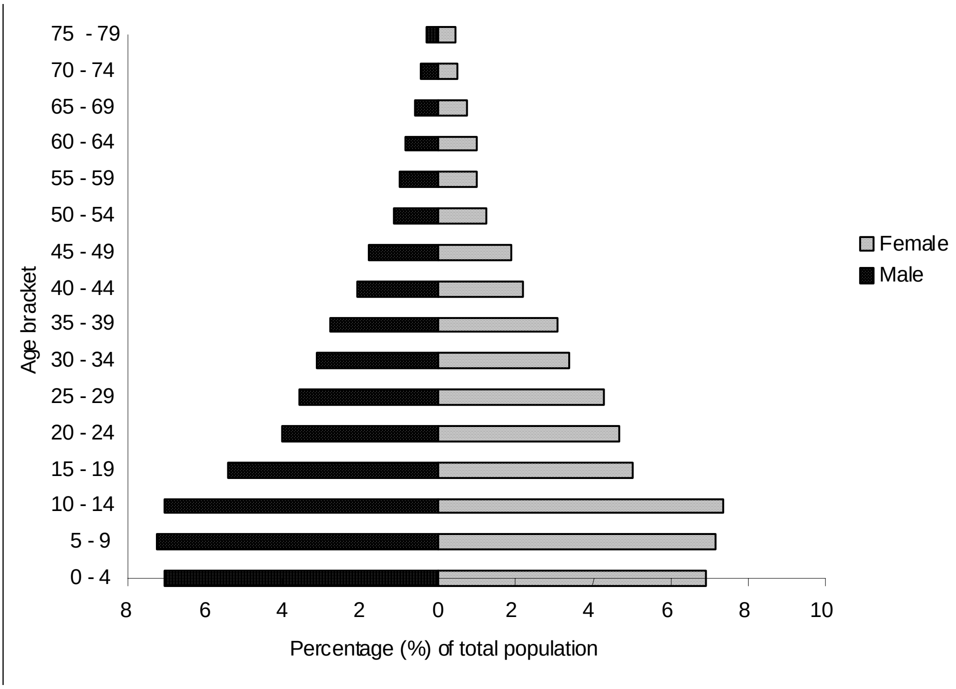

Figure 2. Population distribution in the Gilgil study area by age and gender.

As seen in Table 2, slightly over half the samples came from borehole water, and a nearly equal number came from piped or stream and river water. The primary sources of piped water, however, were either boreholes or streams and rivers. At the household level, most of the inhabitants who use piped water collect and store it in plastic tanks to ensure continuous availability. Results of F analyses are presented in Tables 2 and 3.

Table 2. F levels in the water samples

Source	Number of samples (%)	Range of F content (ppm)	Mean F concentration (ppm)	Standard Deviation
Tap (piped)	8 (21.6)	0.001–32.80	7.69	11.9
Streams/rivers	7 (18.9)	0.002–5.79	2.32	2.54
Boreholes	19 (51.4)	0.026–21.50	6.57	6.07
Lake	2 (5.4)	159.0–166.0	162.5	4.95
Storage tank	1 (2.7)	–	5.13	–
Overall	37 (100)	–	14.3	36.6

Table 3. Proportion of water samples with F levels exceeding the recommended maximum of 1.5 ppm

Type of Source	Number of samples with F>1.5 ppm (%)	Mean F concentration (ppm)	Standard deviation
Stream	1 (14.3%)	5.79	–
Borehole	16 (84.2%)	7.34	5.96
Lake	2 (100%)	162.5	4.95
Storage tank	1 (100%)	5.79	–
Tap (piped)	4 (50%)	12.3	13.3
Overall	26 (70.2%)	5.85 (excluding high F lake water)	7.34

From Table 3 it is clear that a high percentage of the water samples have excessively high F levels, even excluding the two lake water samples. Among the seven stream/river samples, only one sample contained F above the recommended maximum of 1.5 ppm F.[8] In fact, with one exception, the stream/river water samples in our study were remarkably low in F (mean <0.1 ppm) compared to somewhat higher levels in rivers in other high F parts of Kenya.[6] Thus these waters may be used for domestic and industrial applications with much less risk of causing fluorosis.

Among the 19 borehole water samples, 16 (84.2%) had F contamination above the permissible 1.5-ppm level. We noted that the severity of F contamination of borehole water increased with proximity to the lakes and the depth of the borehole. This is in agreement with earlier surveys by Williamson,[9] who found that water sources that were high in F were usually near high F lakes. It can be assumed that deep boreholes close to Lake Elementaita cut through F-rich underground feeder streams to the lake, resulting in these boreholes having high F water levels. Further studies, however, will be required to determine the safe distance from this and other lakes for the location and depth of domestic and industrial water boreholes.

Half the eight samples of piped (tap) water whose primary sources were borehole water showed high F levels with a mean concentration of 12.3 ppm F, which is well above the 7.34 ppm mean F level of the borehole water. Apparently the long storage hours used for traditional water handling techniques in open tanks result in extensive evaporation, and perhaps solubilization of F from earthen filtration media causes elevated levels of F in the water, regardless of its initial sources. This can also explain the high F levels recorded in water sample drawn from a storage tank. The high mean F level of 162.5 ppm in the Lake Elementaita water is attributed to leaching of F from the F-rich volcanic rock systems around the lake that enrich underground drainage into the lake with F.[10] The high tropical temperature in the region causes extensive evaporation from the lake, thereby increasing the concentration of F. Moreover, since the lake does not have overland outlets, it has turned into a natural reservoir for dissolved salts leading to high accumulation of F in its waters.

Unfortunately, most of the inhabitants in the area use borehole water, which contains high levels of F, thereby posing a serious risk of fluorosis. Although a significant proportion of the population uses stream and river water that is relatively low in F and safe, the streams and rivers are few, with long walking distances for access to them. An alternative would be harvesting rainwater, which, unfortunately, is often sparse and sporadic. Defluoridation of existing waters will be appropriate, provided the treated water is handled and stored in such a way as to minimize evaporation to avoid increasing the F concentration.

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