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Simmons,B.D.; Menaker,Lew; Taylor,R.E.; Navia,J.M.

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# Concentration of Fluoride in Water Supplies from Areas around Lake Kivu, Rwanda: A Preliminary Study

B.D.
Barry Simmons, D.D.S.*‡, Lew Menaker, D.M.D., Sc.D. **
Robert E. Taylor **, and Juan M. Navia, Ph. D.**#

* Director, Dental Health International, Athens, Georgia DHI
** University of Alabama in Birmingham School of Dentistry, University Station, Birmingham, Alabama 35294

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**Abstract**

The high incidence of fluorosis among the people living in the area around Lake Kivu, Rwanda, and living on the islands in Lake Kivu led to this study of the water supplies for the villages. The individuals in these areas also showed evidence of malnutrition. A possible relationship between the severity of fluorosis and the degree of malnutrition was noted. Bone samples of domesticated animals were examined to determine the amount of incorporation of fluoride from the water supply into the bone. It was concluded that only one water site had a satisfactory level of fluoride and should be selectively used for drinking purposes.

## Introduction

Fluorosis, or mottled enamel, was first described in 1916 by McKay and Black (1) in the Colorado Springs area although they had been studying the condition since 1901. Mottled teeth had been observed by other dentists in other areas but was thought to be hereditary since the incidence appeared to be localized. Excess fluoride was not conclusively determined to be the cause of mottled enamel in patients with the condition until 1933, and then by two independent researchers within a few weeks of each other (2,3). These studies also showed an inverse correlation between fluorosis and the number of teeth with dental caries.

Since that time other studies have been done in the United States (4,5), Europe (6,7), and Africa (8). We wish to report on a preliminary study conducted in the Lake Kivu area of Rwanda, Africa. Rwanda was formerly Belgian East Africa and lies in East Central Africa. It covers and area of 10,166 square miles and has a population of 3,830,000. Lake Kivu is 60 miles long and 30 miles wide and lies in the Great Rift Valley north of Lake Tanganyika.

One of us (B.S.) had the opportunity to examine the teeth of individuals in this area as a volunteer dentist for Dental Health International(DHI), a non-profit organization dedicated to bringing better dental health to all parts of the world (9). It was quickly recognized that a high degree of fluorosis existed in this population and that

analysis of the water supply was essential to identify the cause and possibly lead to the designation of alternative drinking sources.

## Methods and Results

Samples of water in the Lake Kivu region were collected in carefully prepared polycarbonate vials. Specimens of bones from domesticated animals were also forwarded to the laboratory at the University of Alabama School of Dentistry.

Before measuring fluoride in the water samples, a standard curve was developed using known amounts and concentrations of fluoride in prepared solutions. The stock standard was 0.1 M NaF (2.0995 gm/50 ml NaF). The working standards used were 0.2 μM, 0.1 μM and 0.05 μM. Duplicate standard curves were prepared and the samples compared to these values.

In order to provide an unbiased study, the water samples sent to the laboratory were identified only by number with decoding accomplished after analysis. The results of the analyses are shown in Table I.

Samples from the bones of domensticated animals were also subjected to fluoride analysis. Three samples were taken from each of two bones. The bones were punch biopsied at three sites: the joint system, the shaft system and from the wall of the marrow cavity.

Each biopsy was 1 to 2 mm in depth and approximately 5 mm in diameter. The bone samples were air dried at 70-75° C for 12-24 hours and weighed[a] to the nearest 0.001 mg. Digestion with perchloric acid, adjusted so that 1.0 ml of 5N NaOH was needed for neutralization, took place at room temperature for 3 hours. The addition of 1.3 ml TISAB III[b] to the neutralized solution buffered it at pH 5.2. The final volume was adjusted to 3.0 ml with distilled, deionized water. Standards and samples were measured with a fluoride ion specific electrode[b] at 0,1,2 and 3 minute intervals to insure stability. The results of the fluoride analyses of the bone samples are shown in Table II.

## Conclusion

The water samples from Nambira, Ntumba and sites 2 and 3 had very high concentrations of fluoride (1.74-1.84 ppm). These levels are comparable to those reported by Bischoff et al (8) and associated with widespread severe fluorosis in poorly nourished populations. Recent studies in our laboratory, using a rat model, pointed to increased fluoride uptake in the protein malnourished rat combined with a decreased protection against dental decay when compared to adequately fed controls(10). Isaac et al (4) suggested that mottling is not caused by the actual amounts of fluoride deposited in the mature enamel but rather by an increase in the amount of fluoride ion present during enamel formation. This could account for the severity

[a]Cahn Electrobalance - Model RM-2

[b]Orion Research, Inc. - Cambridge, Mass.

of the fluorosis noted in the teeth of the subjects studied around Lake Kivu since these groups rarely move from their home sites and consume the high levels of fluoride throughout life. In addition, posteruptive uptake of fluoride has also been shown to take place (11).

The data from the bone analyses confirmed the ability of bones (and teeth) to concentrate ingested fluoride. This (2 to 7 fold) increase in fluoride concentration seen in the bone samples is not unusual. However, what may be a non-pathogenic condition in well-fed populations may be less than optimum when coupled with malnourished individuals. Murray (12) states that clinical deformation of bones has been associated with a lifelong daily fluoride intake of 20 mg or more.

Richards et al (5) have determined that the optimum fluoride level for community water supplies varies in relation to the temperature of the area which in turn has a direct bearing on the amount of liquid consumed. They have concluded that the optimum fluoride concentrations for three ranges of mean maximum termperatures are: 65° F or lower, 1.1 to 1.3 ppm; 66 to 79° F, 0.8 to 1.0 ppm; and 80° F or higher, 0.5 to 0.7 ppm. Considering this recommendation we have concluded from our studies that since site (1) has relatively low levels of fluoride (less than 20% of the other samples) it is this source that should be used for drinking by the residents of Lake Kivu, assuming it is not in other ways contaminated.

These findings have been forwarded to the Health Ministry of Rwanda. More recently an analysis of water samples from the Cameroons revealed a single site containing extremely high (6.7 ppm) fluoride. This information, too, has been made available to the local health ministries.

It is hoped that this cooperative effort between a private practioner and the resources of an academic health center will help bring an improved level of oral health to the residents of developing countries.

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Table I

Fluoride Content of Water Samples from Lake Kivu Area

| Samples | ppm Fluoride* |
|---|---|
| Ntumba | 1.74 |
| Rambira | 1.81 |
| site (1) | 0.35 |
| site (2) | 1.84 |
| site (3) | 1.84 |

*mean of two experiments

Table II

Fluoride Concentration in Bone from Domesticated Animals in Lake Kivu Area

| Sample | wt.(mg) | ppm Fluoride* |
|---|---|---|
| 1-A | 1.264 | 1179 |
| 1-B | 1.646 | 808 |
| 1-C | 1.605 | 1083 |
| 2-A | 1-584 | 827 |
| 2-B | 1.216 | 1421 |
| 2-C | 1.427 | 464 |

* Mean of two experiments

A - Samples taken from joint area

B - Samples taken from shaft area

C - Samples taken from marrow cavity wall