CHRONIC FLUORINE POISONING CAUSED BY THE DRINKING OF SUB-TERRANEAN WATERS CONTAINING EXCESSIVE QUANTITIES OF FLUORINE*

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In my publications,[1-14] I have summarized the results of my field and laboratory investigations into chronic fluorine intoxication in man and animal conducted in the course of the past 25 years. In them I have also made an attempt to refer to and discuss the most relevant points in some hundreds of publications made by the foremost investigators and writers on chronic fluorine poisoning.

As early as 1938,[1] I reported the devastating effects that excessive concentrations of minerals, especially fluorides, in underground drinking-waters in the North-Western Cape Province had on the health of man and animal. At that time, I gave warning that, if steps were not taken to prevent the drinking of water containing excessive quantities of fluorides, in years to come many of the inhabitants of that area would not only show severe damage to their teeth, as they already were showing in 1938, but many would suffer from serious bony disturbances (legs, arms, back). This prediction was proved true when in 1959 we investigated 'a mysterious bone-disease' in about 200 children in the Kenhardt District, North-Western Cape.[10] At the time of writing, more cases of bone disease (suspected chronic fluorine poisoning) among children in the North-Western Cape Province are being investigated.

An outbreak of bone disease that I investigated in 1960 in children and adults in the Roedtan area, Potgietersrust District, Transvaal, proved to be fluorosis caused by the drinking of underground water containing excessive quantities of fluorine.[13] At the moment, further cases of fluorine poisoning are being investigated not very far from the Roedtan area.

SYMPTOMS OF CHRONIC FLUORINE POISONING

These can be multitudinous, for fluorine is a very active enzyme poison and is very prone to accumulate in the body. It disturbs the normal physiological action of many enzymes,[15] with possible serious repercussions on our health. However, I want to limit myself here to two very important aspects of chronic fluorine intoxication, viz. those concerned with the thyroid gland and with the bone system.

Thyroid

The high incidence of endemic goitre in an area (North-Western Cape Province) where the underground drinking-water supplies contained *many times more iodine than is necessary for normal human requirements and at the same time also contained toxic quantities of fluorine,* suggested to me a possible iodine-fluorine antagonism; in other words that fluorine has a thyrostatic effect.[11,12] In experiments upon rats I confirmed the truth of this hypothesis, although I realized that in some parts of the affected area excessive concentrations of calcium and iron in the drinking water might have synergistic effects with fluorine on the thyroid. I have fully discussed fluorine-iodine antagonism and, *inter alia,* referred to Gordonoff's work with radioactive iodine.[5,14]

The results of our investigations into the incidence of fluorine-induced endemic goitre in the North-Western Cape Province closely agree with a statement in an Editorial[16] in the *Journal of the American Dental Association*: 'We do know that the use of drinking water containing as little as 1·2 to 3·0 parts per million of fluorine will cause such developmental disturbances in bones as osteosclerosis, spondylosis and osteopetrosis, as well as goitre, and we cannot afford to run the risk of producing such serious systemic disturbances in applying what is at present a doubtful procedure intended to prevent development of dental disfigurements among children.'

The Bone System

Chronic fluorine poisoning occurs in large areas of South Africa where the subterranean waters contain harmful concentrations of fluorides. In the North-Western Cape Province the fluorine content of the drinking water of the affected children ranges from 3·6 to 13 parts per million parts of water.[10] We found that the affected children complained about pains in their legs within 8 - 12 years after having commenced drinking water containing 3·6 - 3·8 p.p.m. of fluorine, while the higher concentrations of fluorine induced bone symptoms within 3 years, especially in the youngest children. In the outbreak I subsequently investigated[13] in the Roedtan area, Transvaal, on one farm where the bore-hole water contained 5·5 p.p.m. of fluorine, the parents and their 4 children had for years complained of constant pains in their legs and back, especially on walking or running. Three of the children (brothers aged 5, 10 and 11), who had since birth drunk bore-hole water containing 10·0 p.p.m. of fluorine, showed serious bone abnormalities (short and markedly thickened feet and toes, thickened ankles, osteophytes). The typical radiological picture of fluorosis was confirmed in one case brought to the Pretoria General Hospital. The teeth of all the children were affected to varying degrees from pronounced mottling up to almost complete destruction.

The general picture seen in the affected children in the North-Western Cape Province and in the Roedtan area

* Based on a paper read at the Conference on Fluoride Research held at Berne, Switzerland, from 15 to 17 October 1962.

is the same, with the difference that the children in the latter area were not as seriously affected as those in the former. All the affected children in the Roedtan area live on cattle farms, with the result that they are much better fed (ample milk, meat, etc.) than the underprivileged children in the North-Western Cape Province.

The results of our investigations agree with the following statements:

1. 'M. C. Smith and H. V. Smith, in their studies at St. David, Ariz., found that, of the people using drinking water containing 1·6 to 4·0 parts per million of fluorine at the ages 12 to 14, 33% had caries; at ages 21 to 41, nearly 100% had caries; from 24 to 41, 50% had all teeth extracted and replaced by dentures. The authors concluded from these data that the teeth of the individuals of a community in which comparatively large amounts of fluorine are found, in this case say 1·6 to 4·0 parts per million, are structurally weak; in some cases the tooth structure being so impaired as to crumble on attempts to place fillings.... Because of our anxiety to find some therapeutic procedure that will promote mass prevention of caries, the seeming potentialities of fluorine appear speculatively attractive, but, in the light of our present knowledge or lack of knowledge of the chemistry of the subject, the potentialities for harm far outweigh those for good.'[16]

2. 'We do know that the use of drinking water containing as little as 1·2 to 3·0 p.p.m. of fluorine, can cause osteosclerosis, spondylosis and osteopetrosis.'[16]

3. 'Spondylitis (osteosclerosis of the spine) has occurred with 5·9 p.p.m. of fluorine in drinking water.'[17]

4. Ockerse[19] described severe osteosclerosis in Natives in the Pretoria District as a result of drinking water containing 11·78 parts per million of fluorine.

5. 'The dose of 2·55 p.p.m. of fluorine has in certain locations caused a condition known as "stiff back".'[21]

6. 'By means of balance experiments on human subjects, indirect evidence has been obtained that fluoride may be stored in human tissues over periods of months or years during which as little as 3 mg., as NaF, was ingested daily.'[22]

More publications which confirm the results of our investigations into fluorosis and support my conclusions could be quoted, but the above number suffices to support my view that there is a possibility that, under certain conditions (see below), concentrations of fluorine even below 1 p.p.m. in drinking water constitute a danger to the health of children.

The following statements express a contrary opinion:

'Epidemiological data and clinical and radiographic examinations of exposed industrial workers indicate that only when the fluoride content of a water supply exceeds 5 or 6 p.p.m. will its prolonged usage give rise to detectable osseous changes and then only in the most susceptible persons.'[20]

'A concentration of 14 serious illness after many years of water may lead to serious illness after many years of exposure in a hot arid climate.'[18] 'Studies in America have indicated that natural fluoride even in as high a concentration as 12 p.p.m. is comparatively innocuous.'[18] The least that can be said of the last statement is that it is contrary to observations made in the rest of the world.

DISCUSSION AND SUMMARY

I have given a brief summary of my investigations into fluorosis in man and animal in South Africa in the course of the last 25 years. Special attention is paid to the effects of fluorine on the thyroid gland and on the teeth and bone systems. The results of these investigations, especially those concerning the effects of fluorine on the teeth and bones, closely agree with those reported from other countries. From these it is clear that the drinking of water containing as little as 1 - 2 parts per million of fluorine may in certain circumstances cause serious disturbances of general health and especially of thyroid function and the processes of calcium-phosphorus metabolism. Under unfavourable conditions it is possible that concentrations of even less than 1 p.p.m. of fluorine in drinking water may be harmful, especially to children. Factors that govern the amount of harm that may ensue in an area where the drinking water contains fluorine include the following: (1) Length of period over which the water is drunk; (2) other minerals present in the water; (3) age; (4) sex; (5) state of health; (6) occupation; (7) diet; (8) use of beverages (tea, wine, etc.); (9) drugs taken; (10) the use of fluorine-containing insecticides on fruit and vegetables; and (11) in the case of artificial fluoridation of drinking water, the marked variation in fluorine-concentrations at the different points of the water reticulation systems. Undoubtedly, the two most important factors affecting the toxicity of fluorine are the diet and the great variations in the quantities of water drunk by different individuals under different conditions. It is known that certain individuals may drink more than 20 times as much water as others do.

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