FLUORIDE

OFFICIAL QUARTERLY JOURNAL

OF

INTERNATIONAL

SOCIETY for

FLUORIDE

RESEARCH

FLUORIDE

Quarterly Reports

Issued by

THE INTERNATIONAL SOCIETY FOR FLUORIDE RESEARCH

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ABSTRACTS

The Fourteenth Conference of the International Society for Fluoride Research will be held in Morioka, Japan, June 12-15, 1985, at the Iwate Medical Association Hall. The Program Committee is now soliciting abstracts (up to 300 words) of papers dealing with any aspect of fluoride research for presentation at the conference. Abstracts should be written in English in the format shown below and sent by the end of February, 1985 to: Professor Humio Tsunoda, Dept. of Hygiene and Public Health, School of Medicine, Iwate Medical University, Morioka 020 Japan.

Note: Morioka, a city of 250,000 and the historical capital of Iwate Prefecture, is located about 500 km (300 mi) north of Tokyo on Honshu, the main island of Japan. Bullet Train service from Tokyo to Morioka is scheduled to begin March, 1985. Domestic airline service from Tokyo is also available.

ABSTRACT — Please be brief — 300 words maximum if possible. Title of paper should be ALL CAPS; author(s) listed by first name, middle initial, last name; indicate full address w/zip code. Single space, black carbon ribbon.

FLUORIDE MAXIMUM IN DRINKING WATER

The task of setting safe maximum levels for fluoride in drinking water is particularly challenging because, as generally agreed, the concentrations at which harmful dental effects are clearly evident in humans are only slightly higher - and sometimes even lower - than those commonly considered optimal for reduction of tooth decay (1). Moreover, numerous unrefuted cases of objective, symptomatic medical illness have been documented even at the recommended fluoride level of about 1 mg/L (1ppm) (2).

For the most part, investigations of the dental effects of fluoride in public water systems have made no provision to assess any differential dental or general health effects within the population under study. Thus, despite the known greater susceptibility to toxic effects of fluoride ion by persons with impaired kidney function and other ailments, comparatively little effort seems to have been made to identify and examine those segments of the population at increased risk. For example, in a follow-up study in Newburgh, N.Y. after ten years of fluoridation of the drinking water at 1.0-1.2 mg F/L, children were found to have a statistically significant greater incidence of cortical bone defects and hemoglobin anemia than children in the nearby unfluoridated control city of Kingston (3). These findings have never been explained satisfactorily or explored for further delineation.

Recently, a dental officer in New Zealand noted that statistical data regularly collected by that country's Health Department showed no significant difference in dental health of children living in fluoridated (1 mg/L) and nonfluoridated areas as measured by permanent tooth filling rates and by the mean number of decayed, missing, and filled teeth (DMFT). At the same time, the incidence of disfiguring dental fluorosis in the form of symmetrical, developmental diffuse enamel opacities was alarmingly high in the fluoridated areas of his district (Auckland) but virtually absent in the neighboring nonfluoridated ones (4). These observations, together with previous research (5), prompted him to re-examine the relationship between child dental treatment requirements and socio-economic (mainly income) level. When the data were tabulated in relation to both income level and freedom from dental caries, the caries-free percentage was consistently higher (statistically significant) in the areas to which no fluoride was being added to the water (6).

Thus, the analysis of dental health according to family income level succeeded in identifying an inverse relationship between water fluoride level and dental health that was obscured by gross comparison with water fluoride only. Nevertheless, gross comparisons did identify a significant deleterious effect in the form of dental fluorosis.

Evidence of this nature argues strongly for reassessment of currently recommended fluoride levels in drinking water with specific attention to general health levels in the population. Those who are aged, ill, malnourished, or otherwise less able to withstand a continual physiological in-

sult must be the major consideration in setting a maximum contaminant level for fluoride. This would be true irrespective of any demonstrable benefits of fluoride at any level in drinking water. Today, when dental fluorosis is increasing worldwide and comparable declines in tooth decay are occurring in areas with nominal fluoride levels of zero and 1 mg/L, (7), it is urgent that those less competent segments of the population be the major consideration in setting a maximum level.

The assessment of drinking waters naturally containing fluoride adds further considerations. Alkaline earth metals such as calcium, magnesium, and strontium normally present in such waters exert a buffering action and influence the effect of fluoride ion on humans (8). Careful study of drinking water supplies containing naturally significant levels of fluoride and alkaline earths should provide valuable guidance in setting economically attainable safe levels of fluoride in such waters.

The setting of a maximum contaminant level for fluoride in drinking water is based on the assumption that a known or maximum quantity of water will be ingested by individuals. This view is obviously not true but presents a particularly difficult judgment in setting a level because kidney-impaired and other ill or malnourished persons may consume more tap water and have less access to alternative water sources than others. Furthermore, the now-recognized exceptionally strong hydrogen bond between fluoride ion and amides (9) and its ability to interfere with DNA synthesis and other cell functions (10) clearly argue for setting the fluoride level in drinking water as low as possible.

As a chemical engineer, businessman, editor of a technical journal, and concerned citizen who has made an extensive study of the scientific literature on fluoride, I urge that the maximum contaminant level for this ion be set as far below 1 mg/L as economically feasible (11).

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CORRELATION BETWEEN OCCURRENCE OF FLUORIDE IN
GROUND AND SURFACE WATER RESOURCES AND
DENTAL FLUOROSIS IN KENYA

by

K.R. Nair, and J.N. Gitonga
Nairobi, Kenya

SUMMARY: In Kenya endemic fluorosis has been chronic for
over 30 years. A long-term study conducted by the authors
showed that the fluoride content of ground water in Kenya
ranged from 0.1 ppm to over 1 ppm in the majority of sam-
ples. Surface water contained a maximum of 34 ppm. Over
30% of Kenya's population suffers from dental fluorosis
and, in isolated regions where the people depend on
ground water for domestic use, nearly 100% of the popula-
tion manifests varying degrees of dental fluorosis. This
paper gives a general picture of the endemicity of den-
tal fluorosis in Kenya and discusses the possible reasons
that contribute to variations in incidence and severity
of dental fluorosis.

Introduction

Dental fluorosis, which has been endemic in Kenya for over 30 years
(1-10), constitutes one of its major public health problems. Drinking wa-
ter is Kenya's major source of fluoride ion, especially in those regions
of the country associated with volcanic rocks and hot springs (10,11,20).
Other important sources include food and drink (4,13) as well as dust in
some lake basins: for example, around Lake Nakuru, the dust has been
shown to have concentrations of fluoride which range between 2800 and
5600 ppm (10).

Ground and surface water form a major source of domestic supply for
the majority of Kenya's population (4) since only about 20% of the popula-
tion has access to piped water (4,14,15). Although the country has numer-
ous rivers and streams, because the majority of them contain water only
during rainy seasons (4,11) ground water is in demand. Water from these
sources, obtained by digging holes in river beds or by drilling boreholes,
is generally consumed raw with little or no treatment.

The major threat to water quality in Kenya is its high fluoride con-
tent (16,17), particularly in the Rift Valley region (with vast volcanic
soil) which bisects the country from north to south. The majority of Ken-
ya's population is concentrated in and around the province. Besides, in

this thickly populated region, isolated pockets of fluoride-laden soil are found all over the country. Water from many boreholes has been rejected by health officials due to its fluoride content which is, occasionally, above 100 ppm. Boreholes are expensive to build; when rejected, considerable money is wasted. Even worse, no reliable method is available at present to foresee, in advance, the level of fluoride in water from a borehole prior to extraction and analysis. In some areas, therefore, people have been obliged to consume water with fluoride levels well over 5 ppm. Because the income of the majority of the rural population is low, it is difficult for them to afford proper water treatment. However, when the health of the population is threatened, it becomes necessary to take measures to safeguard it (17). Although urban centers have improved water supply systems in many cases, including the capital city of Nairobi, they are inadequate for all inhabitants. Hence the peripheral populations of urban areas face a situation similar to that in rural areas.

Correlation between fluoride intake and dental as well as skeletal fluorosis is well documented (18-25). However, in Kenya, until the present study was initiated by the authors in 1977, research in this field was minimal largely due to inadequate professional manpower and technology. Probably the first attempt to study the occurrence and distribution of fluoride in ground waters in Kenya was made by Williamson (10) who examined the available results from analyses of some 200 samples, by the government chemist, of water fluoride levels from boreholes. The highest levels of fluoride reported in this study were 43.5 ppm in borehole water, 1640 ppm in Lake Elementaita and 2800 ppm in Lake Nakuru. Ogweny (26), who plotted the spacial distribution of the fluoride ion concentration of some 500 samples of water from boreholes, arrived at a similar conclusion. Whereas both studies indicated the location of high fluoride areas in the country, the samples did not adequately represent the entire nation (4). No exact figures are available on the number of people who depend upon ground water for domestic use. In a survey of some 19,000 individuals carried out by a WHO/FAO/UNICEF assisted team, 44.1% had dental fluorosis with a community index of 1.01 (3).

Over the last 5 years, in a study sponsored by the International Development Research Centre (Canada), the University of Nairobi and the Ministry of Water Development (Kenya) (4,6) carried out by researchers in the departments of Dental Surgery and Civil Engineering of the University of Nairobi, 1286 samples of borehole ground water and 149 samples of surface water were analyzed for their fluoride content and over 34,000 people, from all over the country, were examined dentally for evidence of dental fluorosis. The current paper, based on results obtained in that survey, attempts to correlate the level of fluoride with dental fluorosis in Kenya.

Material and Methods

With the help of Kenya's Ministry of Water Development, water samples were collected from boreholes currently being utilized and river beds throughout the country. Water samples were analyzed for fluoride content* using "Orion" fluoride meter having a fluoride ion activity electrode and a reference electrode (4).

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*Public Health Engineering Laboratory of Univ. of Nairobi and the Laboratory of the Government Chemist.

Table 1

Ground Water Samples in Each District Containing Various
Levels of Fluoride (in ppm) in Kenya

	0.0-0.4	0.5-1.0	1.1-3.0	3.1-5.0	5.1-8.0	8.1+	Total
Nairobi	18	18	36	24	29	58	183
Central Province							
Kiambu	88	69	100	28	21	32	338
Kirinyaga	3	-	-	-	-	-	3
Murang's	5	4	6	3	-	1	19
Nyandarus	5	7	11	4	-	-	27
Nyeri	1	4	3	1	-	-	9
Total	102	84	120	36	21	33	396
Coast Province							
Kilifi	20	9	14	3	-	2	48
Kwale	8	6	6	2	-	-	22
Mombasa	4	2	1	-	1	-	8
Taita Taveta	5	4	4	-	-	1	14
Tana River	1	-	-	-	-	-	1
(Lamu)	-	-	No information			-	-
Total	38	21	25	5	1	3	93
Eastern Province							
Embu	-	2	2	-	-	1	5
Isiolo	2	5	9	1	2	1	20
Kitui	6	5	8	-	1	-	20
Machakos	8	20	40	9	14	21	112
Marsabit	4	7	6	-	-	-	17
Meru	1	3	2	1	-	-	7
Total	21	42	67	11	17	23	181
Northeastern Province							
Garissa	3	8	10	2	2	1	26
Mandera	1	5	7	-	-	-	13
Wanjir	3	9	17	5	1	2	37
Total	7	22	34	7	3	3	76
Nyanza Province							
Kisii	3	-	-	-	-	-	3
Kisumu	-	5	6	3	2	1	17
Siaya	1	1	-	-	-	-	2
South Nyanza	4	3	2	-	-	-	9
Total	8	9	8	3	2	1	31
Rift Valley Province							
Baringo	1	1	1	-	-	1	4
Elgeyo Marakwet	1	1	-	-	-	-	2
Kajiado	10	12	32	9	1	2	66
Kericho	-	5	1	4	-	1	11
Laikipia	1	6	14	4	2	1	28
Nakuru	11	10	50	26	18	24	139
Narok	1	1	3	-	-	1	6
Samburu	-	2	8	-	1	-	11
Trans Nzoia	2	2	1	-	-	-	5
Turkana	9	5	6	-	1	-	21
Uasin Gizhu	8	4	5	-	2	1	20
Nandi	-	-	No information		25	31	
Total	44	49	121	43	25	31	313
Western Province							
Bungoma	4	-	-	-	1	-	5
Busia	5	1	-	-	-	-	6
Kakamega	1	1	-	-	-	-	2
Total	10	2	-	-	1	-	13
National Totals	248	247	411	129	99	152	1286
%	19.3	19.2	31.9	10.0	7.7	11.8	100.0

Figure 1

Geographical Provinces of Kenya

Legend:

1. Rift Valley

2. North Eastern

3. Nairobi

4. Central

5. Eastern

6. Coast

7. Nyanza

8. Western
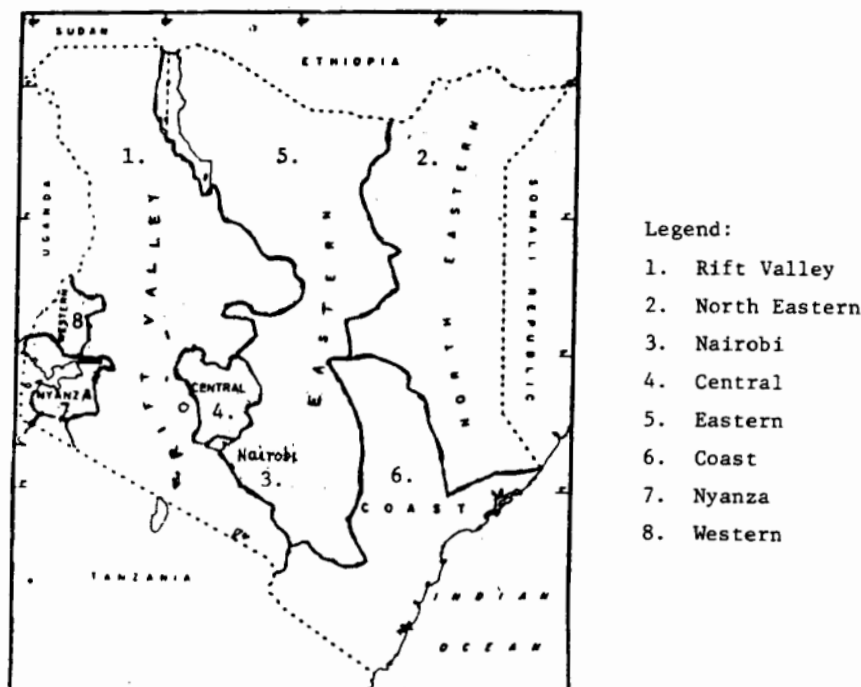
Dental examinations were conducted at schools, provincial hospitals and the Department of Dental Surgery of the University of Nairobi, assisted by dental interns and undergraduate dental students from the Dental Surgery Department. When conducted at centers other than the department of dental surgery, dental examinations were done in natural daylight for illumination, using mouth-mirrors and probes. The findings were recorded on standard forms prepared by the authors to indicate varying degrees of dental fluorosis for an individual tooth. Only people, born and brought up in each region, were included in the study. The number of people examined from each district varied depending on the total population.

Dental fluorosis was recorded as follows: 0 = no mottling; degree 1 = whitish or light brown patches on the coronal surface of the teeth; degree 2 = dark brown patches on parts of the coronal tooth surfaces; degree 3 = brownish/dark discoloration of the entire crown; degree 4 = brownish/whitish/dark discoloration associated with fracture of the enamel and/or presence of pitting or cracks on enamel. This method of clas-

sification was developed by the first author (K.R.N.) as a practical eas-
y to use, and reproducible method, for large samples appropriate for the
type and severity of dental fluorosis in Kenya (4,6).

Results

1. Occurrence of fluoride: Out of 1286 samples of ground water,
which were analyzed, 248 (19.3%) contained from 0.0 and 0.4 ppm fluoride
ion; 247 (19.2%) between 0.5 and 1.0 ppm; 411 (31.9%) between 1.1 and
3.0 ppm; 129 (10.0%) between 3.1 and 5 ppm; 99 (7.7%) between 5.1 and 8
ppm; and 152 (11.8%) 8.1 ppm and over (Table 1). The ranking, according
to maximum fluoride values, recorded provincially was 1) Rift Valley; 2)
North Eastern; 3) Nairobi; 4) Central; 5) Eastern; 6) Coast; 7) Nyanza;
and 8) Western (Table 2). Figure 1 shows the geographical location of
the provinces and districts.

Of 150 river water samples, 19 (12.6%) had more than 1.0 ppm; in on-
ly one sample, which was collected at the point where the river enters
Lake Nakuru, was the level as high as 34 ppm. At this point, fluoride
levels are extremely high compared to other river water samples which
rarely exceeded 3 ppm (Tables 2 and 3).

Unlike the rivers, however, in most of the Kenya lakes, fluoride lev-
els are alarmingly high, the result of continued evaporation of water over
a prolonged period (4). In some of the lakes, fluoride levels are the
highest in the world (Table 3).

2. Prevalence of dental fluorosis: In all, 34,268 persons were ex-
amined from across the country, 7410 from central province, 4887 from

Table 2
F⁻ Concentration of 150 River Water Samples in Kenya

F⁻ (ppm)	Samples	Percentage
0.1-1.0	131	87.3
1.1-2.0	11	7.3
2.1-3.0	4	2.6
3.1 and above	4	2.6

Table 3
F⁻ Content of Some of the Important Lakes in Kenya

Lake	Fresh/Saline	F⁻ (ppm)
Victoria	Fresh	0.6-3
Naivasha	Fresh	8.0-15
Baringo	Fresh	18
Turkana	Saline	100
Bogoria	Saline	1000-2800
Nakuru	Saline	1800-2800

Coast province, 4864 from Eastern province, 1959 from Northeastern pro-
vince, 4446 from Nyanza province, 5820 from Rift Valley province, 2346
from Western province and 2536 from the Nairobi area. Table 4 shows the
prevalence of dental fluorosis by province. The incidence of dental flu-

Table 4

Prevalence of Dental Fluorosis in Different
Provinces in Kenya

Province	No. Examined	No. with Fluorosis	% of Fluorosis
Central	7,410	4,108	55.4
Coast	4,887	703	14.4
Eastern	4,864	2,292	47.1
Northeastern	1,959	329	16.8
Nyanza	4,446	899	20.2
Rift Valley	5,820	1,979	34.0
Western	2,346	273	11.7
Nairobi	2,536	448	17.6
Total Kenya	34,268	11,031	32.2

Table 5

Comparison of Severity of Dental Fluorosis
in Different Provinces in Kenya

Province	Total No.	1st No.	1st %	2nd No.	2nd %	3rd No.	3rd %	4th No.	4th %
Nairobi	448	57	12.7	136	30.4	181	40.4	74	16.5
Central	4108	308	7.5	909	22.1	1624	39.5	1267	30.8
Coast	703	210	29.9	214	30.4	187	26.6	92	13.1
North-eastern	329	112	34.0	98	29.8	99	30.1	20	6.1
Eastern	2292	357	15.6	760	33.2	540	23.6	635	27.7
Nyanza	899	382	42.5	430	47.8	77	8.6	10	1.1
Rift Valley	1979	203	10.3	504	25.5	564	28.5	708	35.8
Western	273	219	80.2	49	18.0	2	0.7	3	1.1

orosis was highest in Central, Eastern and Rift Valley (above 34%) where-
as it was lowest (11.7%) in the Western province. Overall, 2% of Kenyans
had dental fluorosis. Table 5 presents the percentage and degree of den-
tal fluorosis in the different provinces. Rift Valley, Eastern and Cen-
tral provinces had the highest scores namely, 4th degree dental fluorosis
in 35.8%, 30.8% and 27.7% respectively. The lowest percentage (1.1%) was
found in Nyanza and Western provinces. In most of the provinces, third
degree dental fluorosis varied from 23.6% to 40.4%, with the lowest per-
centage of 8.6 and 0.7 in Nyanza and Western provinces respectively. The
percentages with 2nd degree dental fluorosis ranged from 18.0 to 47.8,
the highest being in Nyanza province. The mildest degree dental fluoro-
sis was highest (80.2%) in Western provinces followed by province Nyanza
(42.5%) and Northeastern (34.0%).

Based on data on distribution of fluoride in ground and surface wa-
ters, the proportion of people with dental fluorosis and the severity of
the condition was directly related to the proportion of water samples
containing fluoride in excess of 1 ppm. The probability that such an as-
sociation could have occurred by chance was less than one in a hundred
times (p > 0.01).

Discussion

Williamson (10), who examined about 4,500 people in 1953, found
39.6% overall prevalence of dental fluorosis in Kenya. Sample cases from
all districts were not included, although he felt the necessity to do so.
Investigations that followed in this field were sporadic with limited sam-
ple cases from selected regions (14,27,5,28).   On a comparative basis,
they showed variations in the findings which could be due largely to such
factors as: 1) the increase in population (Kenya is known to have the
highest population growth rate in world) which in turn necessitates in-
creased water resources and eventual dependence on more ground water; 2)
fluctuations in fluoride content, especially of ground water, from time

to time: for example, the greater the quantity of water retrieved from a
borehole within a short time, the lower the fluoride content in the wa-
ter; 3) migration of rural population to urban areas; 4) availability of
surface water which,generally, is low in fluoride; 5) the individual's nu-
tritional status in relation to food and beverages that contain varying
amounts of fluoride; e.g. Kenya's lake fish contain over 500 ppm fluoride
compared to sea fish which is relatively low in fluoride (13); 6) the pre-
sence of other substances in soil (e.g. sodium salts increase and lime-
stone decreases availability of ionic fluoride; 7) use of fluoride-con-
taining dentrifices; and 8) mode of domestic storage of water; e.g. in
this country plastic containers are commonly used for transportation and
storage of water which, unlike earthen pots, retain most, if not all, of
the fluoride in water.

Although, at the national level, the prevalence of dental fluorosis
is 32.2%, in certain sub-locations, for the above-discussed reasons, den-
tal fluorosis prevalence is over 95% (4). Little is known in Kenya of
how fluoride affects bone and soft tissues, mainly because professional
manpower and technology are inadequate. The need for extensive research
in the field of fluorosis is an absolute necessity since millions of
people in Kenya suffer, in most cases ignorantly, from chronic endemic
fluorosis.

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FLUORIDE IN GODAVARI RIVER AT PAITHAN,
MARATHWADA, MAHARASHTRA STATE

by

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SUMMARY: In view of the impact of dam construction and
reservoir formation at the Godavari River in Paithan
near the city of Aurangabad, India, the level of fluo-
ride in river water and in three species of bivalve
mollusks, which form an important link in the food
chain of the ecosystem, was estimated. Fluoride levels
in river water, collected at various distances from the
dam, were significantly lower, namely 0.47 ± 0.1 ppm 1
km distant compared to 0.74 ± 0.03 ppm 2.5 km distant.
Among bivalve species, fluoride levels in L. marginalis
(0.031 + 0.004 µg/g) obtained 1.5 km from the left bank
of the river were significantly higher than in L. cor-
rianus (0.026 ± 0.001µg/g) and in I. caeruleus (0.013
± 0.001 µg/g) both of which were obtained 1 km from the
right bank.

KEY WORDS: Godavari River, India; Bivalve mollusks; L. marginalis; L.cor-
rianus; I. caeruleus

Introduction

The exposure of living organisms to abnormal levels of fluoride,
which induces fluoride accumulation by the organisms, may result in an al-
teration of the organisms' biochemistry and morphology (1). The slightest
increase in fluoride in fresh water often becomes toxic to the organisms
(2). According to Groth (3), the habitat of fresh water organisms is al-
most fluoride free; thus they are not equipped to tolerate increased flu-
oride levels. The majority of studies, conducted on the effects of fluo-
ride, are confined to cattle (4,5) and man (6,7). In addition to the ha-
zards of fluoride to man, one must consider its possible noxious effect
on other living organisms which, in dynamic equilibrium with themselves
and their environment, constitute the different ecosystem, either aquatic
or terrestrial (8).

The present study aimed to determine the fluoride content in the
whole body of three species of the commercially important bivalves, name-
ly, Indonaia caeruleus (Prashad), Lamellidens corrianus (Lea) and L. mar-
ginalis (Lamarck) which inhabit the Godavari river at Paithan in Marath-
wada, the water of which is impeded by Nath Sagar Dam (Jayakwadi Project
at Paithan, Dist. Aurangabad). The fluoride content was also estimated
in water samples from the river.

Materials and Methods

The bivalves were collected from two different regions of the Godavari river where they occur abundantly. L. marginalis are found in large numbers on sandy bottom about 1.5 km distant from the dam, whereas L. corrianus and I. caeruleus occur on muddy bottom about 1.0 km distant from the dam, both in the direction of water flow. In addition to water samples collected from the above regions of the river, two additional water samples were collected at a distance of 2.0 and 2.5 km from the dam. Water samples were collected in polythylene bottles. Shell length of five samples of each species was measured (L. marginalis - 70-80 mm, L. corrianus - 75-80 mm and I. caeruleus - 60 mm), the flesh was carefully removed from the shell valves and blotted,and the wet weight of pooled samples of each species was determined. The animals were kept in air higher than 60° C. until a constant weight was obtained. Afterwards the dried body was powdered and analyzed for fluoride, in triplicate, separately. Fluoride in animals was estimated according to Wright and Davison (9); fluoride in water with an Orion fluoride electrode, Orion reference electrode and Elico pH meter. The calibration curve was prepared with sodium fluoride,and the potentials (mv) read on the pH meter were plotted on the linear axis of a semilog graph paper against the concentration on the log axis. Fluoride in the unknown was directly read from the calibration curve. The pH of the samples was adjusted with TISAB(total ionic strength adjust buffer) to 5.5 prior to analysis.

Results

Significantly, the fluoride was lower (0.47 ppm) in water samples 1 km distant from the dam than in samples 1.5 to 2.0 kms from the dam (0.58 and 0.60 ppm respectively) (P < 0.05); the difference between the latter two, however, is not significant (P > 0.1) (Table 1). Water collected 2.5 km from the dam was significantly higher in fluoride than water collected 1.0 km (P < 0.05), 1.5 km (P < 0.05), and 2.0 km (P < 0.1) from the dam.

The fluoride content in bivalves, L. corrianus and L. marginalis did not vary significantly (P > 0.1); it was highest in L.marginalis compared to I. caeruleus (P < 0.1) and L. corrianus (P < 0.05) (Table 2).

Table 1

F⁻ Content in Godavari River at Paithan

Distance from Dam (downward) in km	F⁻ (ppm)
1.0	0.47±0.01*
1.5	0.58±0.01
2.0	0.60±0.02
2.5	0.74±0.03

* mean ± standard deviation (n=3)

Table 2

F⁻ Content in Body of Bivalves

Bivalve Species	F⁻ (μg/g) (wet weight basis)
I caeruleus	0.013±0.001*
L. corrianus	0.026±0.001
L. marginalis	0.031±0.004

* mean ± standard deviation (n = 3)

Discussion

The level of fluoride in the Godavari river water gradually increases in direct relation to the distance from the dam.   The following reasons may account for the uneven distribution of fluoride in Godavari river water: the geographical features of the area as described by Fleischer (10) and stagnation of water at places in the Godavari river.   No correlation was observed between the fluoride content in the bivalves and the fluoride level in their habitat; it was higher in the body of L. marginalis and L. corrianus (0.031 and 0.026 µg/g, respectively) than in I.caeruleus (0.013 µg/g).   Bivalves, gills and mantle, which are continually being bathed with water, accumulate more fluoride compared to other organs (9). Since the bodies of L. marginalis and L. corrianus are longer than the body of I. caeruleus, they process larger quantities of water, which might have caused greater diffusion of fluoride ions from the water into the body of these two species.

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EFFECT OF HYDROGEN FLUORIDE FUMIGATION IN TRITICUM AESTIVUM, BRASSICA JUNCEA AND PHASEOLUS AUREUS PLANTS

by

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Thirty-five day old Triticum aestivum (Var. K-68) and Brassica juncea (Varuna, T-59) and 25 day old Phaseolus aureus (Pusa-Vaishakhi) plants were exposed to 20 ppb HF-air mixture for 2 hours daily in a 1.5 m^3 dynamic polythene chamber. Length of roots, shoot, number of leaves and phytomass generally decreased. Seeds produced were of poor quality.

KEY WORDS: Fluoride; Fumigation; Effects, wheat, mustard, moong

Introduction

Pollution by fluoride has caused more serious concern to us than that by any other pollutant. Airborne fluoride, toxic even at concentrations as low as 0.6 µg HF/m^3, is a cumulative poison and its effects are irreversible. All chemical compounds of fluoride such as HF, F_2, SiF_4, are phytotoxic and produce more or less similar symptoms in plants. Factors that affect F^- accumulation in plants are poorly understood. Fluoride enters the plant leaf through stomata; it passes into cellular spaces where it is absorbed into the mesophyll tissue (1).

Thus assimilated by plant leaves, fluoride does not move towards the stem, root and soil. Therefore, fluoride injury depends upon its accumulation at the active sites where it remains in toxic amounts.

In view of the occurrence of hydrogen fluoride in the air-shed of urban industrial areas, it is relevant to study its effects on some important crop plants, including a legume, a cereal and an oil yielding plant. Selected plant species were exposed to HF-polluted air in a dynamic system to identify and quantify the responses of these plants, and to assess their relative sensitivity at a particular HF concentration.

Material and Methods

Plants were grown in 1 m^2 plots and exposed to 20 ppb HF in 1.5 m^3 polythene chambers. HF-air mixture was generated by bubbling dry-filtered air into an aqueous solution of hydrofluoric acid (Fig. 1).

The concentration of HF-air mixture inside of the chamber was monitored throughout the duration of fumigation. Daily for 2 hours in the morning for 30 days, Phaseolus aureus (moong) was exposed from the 26th to

Figure 1

Schematic Diagram for
Gas Generation and
Sampling Assembly

Orifice manometer

Hopper

Manifold

Empty   Absorbing
bubler media

Manifold

Cham-
ber(m^3)

Sampling probe | Gas Distri-
Empty bubler   bution frame
Gas generator
Empty bubler

55th day of plant age, wheat
and mustard plants from 35th–
65th day. Pollutant-dose ex-
posure and sampling schedule
of each of the plants is
shown in Table 1. Samples of
control and treated plants
were collected and analyzed
with respect to changes in
protein, sugar, fluoride,
energy and oil content ac-
cording to the following
methods.
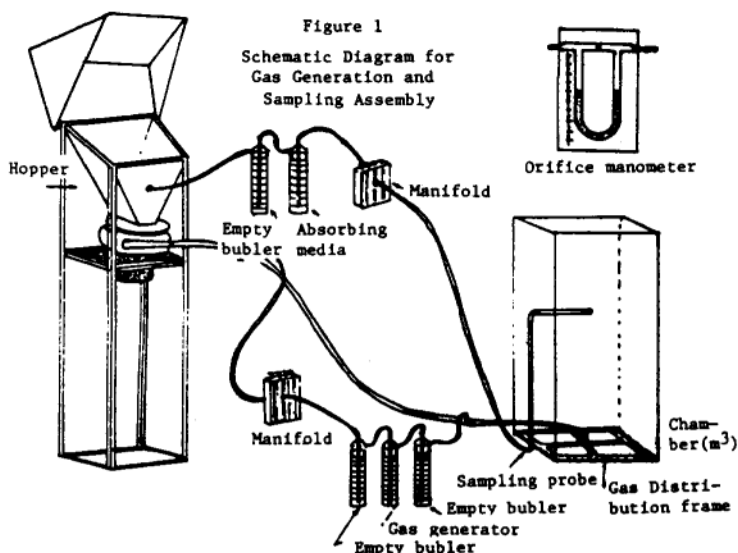
Table 1

Pollutant Exposure and Sampling Schedule for
Moong, Wheat and Mustard Plants

Plant Age (Days)	Wheat & Mustard	Cumulative Dose(HF)	Moong	Cumulative Dose(HF)	Sampling (Days)
1–25	---		⌐	--	25
26–35	⌐		⌐	400 ppb	35
36–45	⌐	400 ppb	⌐	800 ppb	45
46–55	⌐	800 ppb	⌐	1200 ppb	55
56–65	⌐	1200 ppb	-	--	65

Protein: Protein content of
freshly cut leaves was deter-
mined using Folin's method(2).

Sugar: By adopting the phenol method (3) for determing sugar content,
samples of fresh leaf (100 mg) were homogenized in 20 ml of 80% alcohol
and centrifuged at 3000 rpm for 30 minutes. The supernatant was evaporated
on waterbath and the residue dissolved in 50 ml distilled water. To 1 ml
aliquot was added 1 ml of 5% phenol and 5 ml concentrated H_2SO_4. Color in-
tensity was measured at 480 nm. The concentration was calculated from the
standard graph using glucose as standard source.

Fluoride: The plants were dried, powdered (200 mesh) and homogenized.
2 g of homogenized powder was fused with calcium formate and sodium hydrox-
ide pellets. Fused samples were diluted to 250 ml and acid distilled (4).
The fluoride content of the distillate was determined using SPADNS dye.

Energy: Energy content (Kcal/g) of whole plant samples was determined by using bomb calorimeter (5).

Oil Content: Oil content of seeds harvested from control as well as treated plants was determined by the Soxhlet extraction method (6).

Results

Foliar Injury: Typical fluoride injury symptoms in the form of lesions, browning of leaf margins and tip burn were visible after 7-10 days of HF fumigation on moong and wheat plants, whereas mustard plants showed no visible sign of fluoride injury. The extent of injury was 23.7 and 20.8% in moong and wheat plants at days 55 and 65 of the plant ages respectively.

Table 2

Variation in Root Length (RL), Shoot Length (SL), Number of Leaves (LN) in Control (C) and Pollutant Exposed (T) Plants

RL(cm)

Age (Days)	Moong C	Moong T	Wheat C	Wheat T	Mustard C	Mustard T
25	6.7	6.70	--	--	--	--
35	8.14	13.30	8.00	8.20	8.00	8.00
45	13.86	15.00	9.40	8.50	11.20	10.30
55	14.00	15.80	10.00	9.50	11.60	9.60
65	14.86	15.00	11.60	9.60	13.60	12.40
85	--	--	11.30	9.70	14.30	14.60
100	12.00	13.70	--	--	--	--
130	--	--	11.30	9.70	21.30	14.00

SL(cm)

Age (Days)	Moong C	Moong T	Wheat C	Wheat T	Mustard C	Mustard T
25	18.0	18.00	--	--	--	--
35	29.30	21.60	40.0	40.00	12.20	12.50
45	45.00	28.40	48.50	58.30	19.2	20.00
55	55.90	32.60	64.50	62.00	37.6	25.60
65	75.70	32.60	83.50	65.30	97.1	58.70
85	--	--	87.00	72.00	132.0	126.00
100	75.70	39.70	--	--	--	--
130	--	--	87.00	72.00	166.00	160.00

LN

Age (Days)	Moong C	Moong T	Wheat C	Wheat T	Mustard C	Mustard T
25	17.60	17.60	--	--	--	--
35	20.30	17.60	8.00	8.00	8.00	8.00
45	20.00	23.40	9.00	9.60	9.00	9.00
55	23.80	20.00	14.60	11.60	19.60	18.00
65	23.75	19.00	13.00	11.60	22.00	18.00
85	--	--	9.00	7.80	26.40	18.00
100	14.50	16.60	--	--	--	--
130	--	--	9.00	7.80	5.40	5.40

Morphological Characters: Average length of root and shoot and number of leaves per plant in HF-exposed plants varied considerably. Roots were longer in treated plants than in controls in moong but were shorter in wheat and mustard plants (except at the 45th and 85th day of plant age of wheat and mustard respectively), whereas shoot length of treated plants was less than control plants at all ages except at the 45th day of age in wheat and mustard plants (Table 2).

Phytomass Accumulation (dry wt.g/plant): Table 3 shows that phytomass values for HF exposed plants were higher than for control moong plants at days 35 and 45. In wheat and mustard plants, however, the phytomass of the exposed plants was less than control values at all ages.

Fluoride Accumulation (μg/g): Fluoride content in HF-exposed plants increased steadily until day 55 in moong, to day 65 in wheat and mustard plants; the values were 460, 240 and 404 μg/g for moong, wheat and mustard plants respectively. Thereafter the fluoride content in these plants decreased (Fig. 2).

Protein and Sugar Content: HF-exposure decreased the protein and sugar content of leaves in moong, wheat and mustard plants with one excep-

Table 3

Variation in Phytomass, Fluoride, Protein and Sugar Content
in Control (C) and Pollutant Exposed (T) Plants

Age (Days)	Moong C	Moong T	Wheat C	Wheat T	Mustard C	Mustard T
Phytomass (Wt.g/plant)						
25	0.406	0.409	--	--	--	--
35	2.242	2.510	1.36	1.26	0.799	0.799
45	4.238	5.836	2.46	2.43	1.394	0.926
55	11.11	6.80	4.88	4.60	2.459	2.259
65	12.135	8.30	15.30	13.81	4.160	2.830
85	--	--	17.84	16.34	13.53	12.90
100	7.435	6.61	--	--	--	--
130	--	--	21.2	16.45	35.48	19.66
Fluoride (µg/g)						
25	130	130	--	--	--	--
35	220	315	156	156	176.0	176.0
45	264	370	163	182	196.0	239.0
55	264	460	187	196	252.0	372.0
65	158	386	196	240	300.0	404.0
85	--	--	178	230	276.0	370.0
100	140	195	--	--	--	--
130	--	--	167	186	206	298
Protein						
25	0.30	0.30	--	--	--	--
35	0.56	0.48	0.20	0.20	0.40	0.40
45	0.72	0.64	0.66	0.66	0.50	0.33
55	0.88	0.79	0.68	0.64	0.75	0.63
65	0.85	0.76	0.87	0.62	0.78	0.65
85	--	--	0.74	0.60	0.40	0.44
Sugar						
25	1.40	1.40	--	--	--	--
35	1.90	2.10	1.250	1.25	1.10	1.20
45	2.60	2.40	2.50	2.5	2.10	1.70
55	2.75	2.48	2.50	1.70	3.00	1.80
65	2.25	1.86	2.25	2.70	3.70	2.20
85	--	--	1.85	1.90	2.60	2.60

tion – on days 65 and 85 of plant age in wheat plants, sugar content was slightly more in HF exposed plants than in controls (Figs. 2 and 3).

Yield/Seed Characteristics:

Seeds produced by HF-exposed plants were generally weak, shriveled and poor in quality; they weighed less than seeds obtained from control plants (Table 4). Also the energy content of seeds obtained from treated plants was higher by 2.4% in moong but lower by 10.59 and 4.88% for wheat and mustard seeds. The oil content of HF-exposed mustard plant seeds was 4.99% less than in control plant seeds. The fluoride content of pollutant-exposed plant seeds increased by 156.09, 68.36 and 62.4% in moong, wheat and mustard plants respectively (Table 4).

Figure 2

F^- Accumulation in Control (C) and HF Treated
(T) Plants at Different Ages
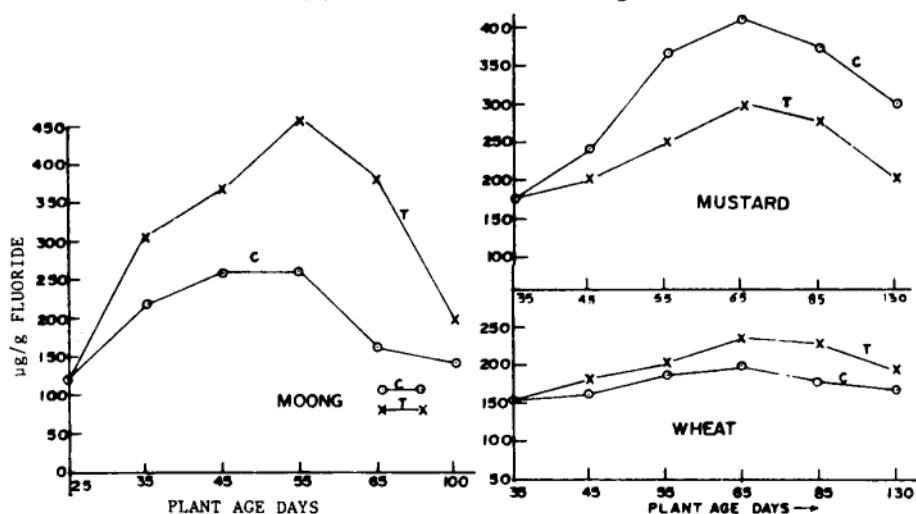
Figure 3

Variations in Leaf Sugar (%) in Control (C) and HF Treated (T) Plants at Different Ages
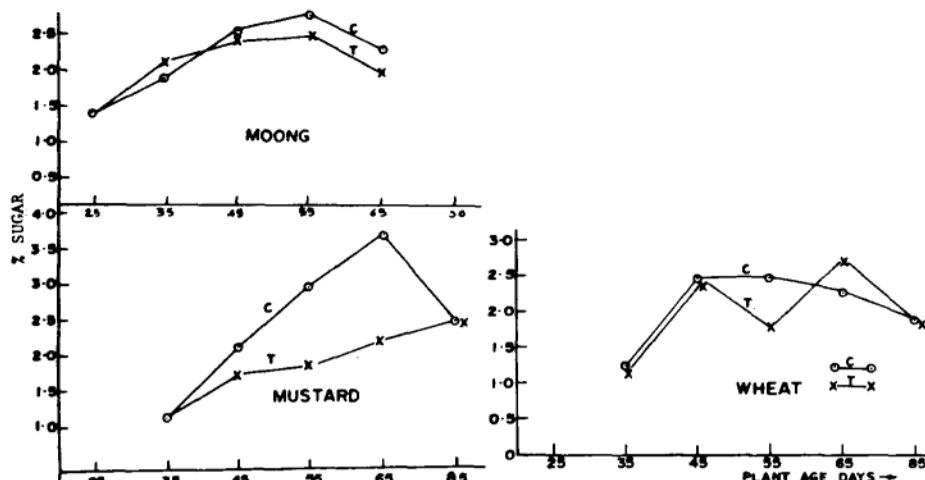
Discussion

Fluoride is a cumulative poison causing several irreversible metabolic changes in plants culminating in marginal necrosis and tip burn of leaves. A high F^- content in cell-sap may deactivate K^+, Ca^{2+}, and Mg^{2+} ions in the leaves (7).

Earlier studies revealed that moong and wheat plants exposed to 20 ppb HF showed leaf injury and reduction in leaf area (8). However, mustard plants failed to exhibit any sign of visible injury, possibly because those plants were relatively resistant to HF for the given doses.

Table 4

Characteristics of Seeds Obtained from Control (C) and Pollutant Exposed (T) Plants

No.	Moong C	T	Wheat C	T	Mustard C	T
No. grains/ plant	9.62	7.92	28.0	22.6	11.8	7.8
Seed yield (wt.g./plant)	2.96	2.03	11.0	5.6	13.95	5.7
wt.g/1000 seeds	33.49	35.19	43.54	32.06	4.56	3.27
F^- content (µg/g)	147.6	378	196	330	330	538
Oil (%)	-	~	-	-	34.35	32.65
Energy (Cal/g)	3845	3940	4438	3908	6770	6422

The reduction in length of root and shoots may be attributed to lower metabolic activity of plants exposed to HF pollution. It has been reported that prolonged HF-exposure induces loss of older leaves and reduction in yield (9,10). Chang and Thompson (11) suggested that growth reduction in fluoride-affected plants is due to the slowed rate of cellular division and expansion. The most frequent fruiting response to fumigation was reduced seed production due primarily to poor fertilization, resulting from inhibition of pollen germination or pollen tube growth (12). HF may also influence fruiting by affecting flower development.

The fluoride accumulation of the plant samples was related to the concentration and duration of HF treatments (Table 3). Moong plants showed a high degree of F^- accumulation because of their large number of leaves and greater leaf area, whereas comparatively less fluoride accumulated in wheat plants which are monocot with vertical upright and fewer leaves. F^- accumulation in seeds of these plants was maximum for moong, followed by mustard and least in wheat (according to Table 3). A lower F^- content in mustard seeds may be due to their resistance to fluoride, their affinity for sulphur as well as their rich oil content. Similar findings of differences in fluoride accumulation in various parts of plants and fruits have been reported by Pack & Sulzbach (13).

The observed reduction in sugar content (Fig. 2) conforms with findings of Yang & Miller (14) on inhibition of synthesis of sucrose in soybean exposed to HF pollution. As seen in Fig. 4, the protein content of leaves of HF-exposed plants is lower than in controls possibly because fluoride inhibits ribosomes which control protein synthesis (15).

Figure 4

Variations in Leaf Protein (%) in Control (C) and HF Treated (T) Plants at Different Ages
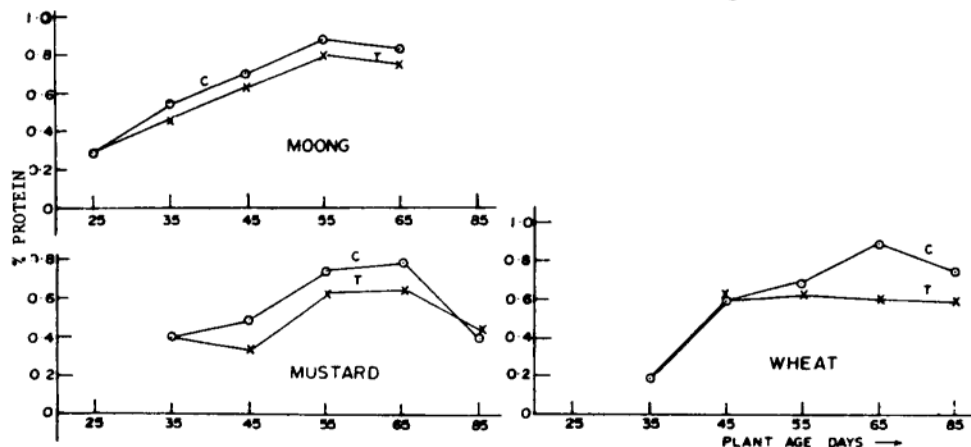
The overall performance of a plant is best indicated by the phytomass accumulation over a period of time. Phytomass reflects the net productivity which is dependent upon photosynthetic activity and yield.

Fluoride complexes with mg^{2+} in the chlorophyll molecule, rendering it unfit for photosynthesis (16). Further, it is reported that fluoride inhibits the Hill reaction (17). A second category of effects of fluoride consists in physiological changes leading to growth reduction and abnormalities in flowering and fruiting processes, reduction in number and quality of fruits.

Energy, Kcal/g of seeds obtained from HF-exposed plants, was lower than in seeds obtained from control plants. The decrease in energy content was due to low values of carbohydrate, proteins and fats in corresponding seed samples, since these parameters are a direct measure of energy in plants/seeds.

Conclusion

The effects of 20 ppb HF fumigation on moong, wheat and   mustard plants were quite apparent and their leaves of phytotoxicity could be arranged in the following decreasing order: moong > wheat > mustard.   There was a general decrease in morphological characteristics, such as length of root and shoot, number of leaves, phytomass and in sugar and protein levels of leaves, whereas the fluoride content was higher.

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A FIELD STUDY OF FLUORIDE POLLUTION OVER A PERIOD OF ONE YEAR
IN THE VICINITY OF ENAMELLING PLANTS

by

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Toulouse, France

SUMMARY: Atmospheric fluoride concentration was meas-
ured over a period of one year by two different methods:
one using static collectors sensitive to gaseous fluo-
ride derivatives and the other using dynamic collectors
which measure the total fluoride content of the air.

Several correlations were found: a) correlation be-
tween the mean annual values of the static method and
the fluoride content of the plants, b) correlation be-
tween the static and dynamic sampling methods. The tech-
nique using static samplers is considered the best
adapted to the study of fluoride pollution.

KEY WORDS: F^- in air; Enameling plant; Emissions; Air sampling

Introduction

The determination of fluoride levels in the atmosphere is of great
interest for public health, ecology and the study of diffusion phenomena.
Fluorine is present in the form of gas (HF) and aerosol particles (fluor-
spar, H_2SiF and NaF) and its levels are determined by dynamic sampling
methods (1) giving a value for total fluorine and by static methods (2 to
7) which preferentially measure gaseous fluorine.

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Any given fluoride pollution can be characterized by correlations between levels of total fluoride, gaseous fluoride and fluoride fixed by plant material over a whole year. This has already been reported by several authors for aluminum smelting plants with constant fluoride emission (1). The case under study is that of an enamelling factory where the pollution is emitted intermittently and is of various types.

The factory is situated in a valley used for agriculture, market gardening and grazing - its topography is presented in Figure 1.

Figure 1

Measurement Network-Topography

8 km

7 km

6 km

5 km

4 km

3 km

2 km

1 km

* static collectors
▲ dynamic collectors
10
*
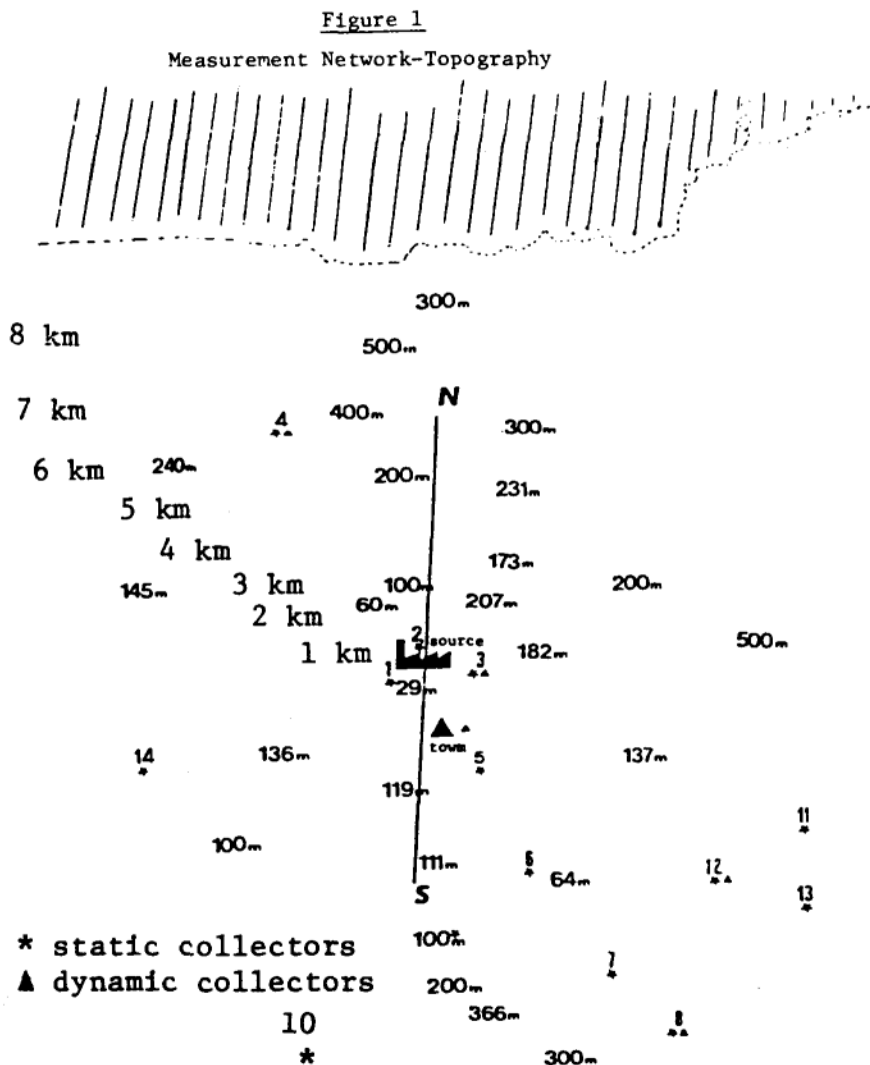
The waste emitted into the atmosphere is composed of spent furnace gases (10,000 m^3/h), which have passed through dry purifiers at an average temperature of 150°C, with a relative humidity under 10%. The level of total fluoride in the stacks varies markedly during the different phases of production (from a fraction of a mg to several hundred mg/m^3) but the percentage gaseous fluorine (mainly HF) is always between 50 and 80%.

The particulate emission is composed of fluorosilicate and fluorspar according to information given by the manufacturers. The furnaces are fired with heavy fuel oil; thus SO_2 emission accompanies that of the fluorine derivatives. Wind direction and speed were recorded three times per day.

Measurements in the Environment: Figure 1 shows the positions of 15 static samplers and 5 dynamic samplers which made up the measurement network. Samples of plant material in the form of pasture grass were taken in the immediate surroundings of the static collectors.

Materials and Methods

Dynamic Samplers: Total fluoride content of the atmosphere (1 m^3/h) was trapped directly on passing air through a paper filter impregnated with a 1 M solution of NaOH containing 5% glycerol (8). This process avoids the use of tubing which, whatever the type, involves fluoride losses. Trapping efficiency is 100% up to a concentration of 100 μg HF/m^3 (the filter contains about 40 mg NaOH).

After exposure for 24 hours, the filter was treated with 10 ml 0.125M H_2SO_4 for an hour and assayed with a fluoride specific electrode in 0.5 M sodium citrate medium.

Static Samplers: Each collector was composed of a 9 dm^2 sheet of Whatman paper impregnated with a solution of 40 g/l NaOH, dried at room temperature and rolled into a cylinder which was placed inside a screen two meters above ground. Thus sheltering it from direct effects of the weather while allowing free circulation of air around the sides and lower surface. After exposure for 1 month, the papers were placed in 200 ml distilled water for at least 12 hours. Assaying was carried out, using a specific electrode, on 20 ml of the solution after addition of a further 20 ml of 1 M sodium citrate.

Plant Material: Each month, as the static samplers were changed, surrounding plant material was collected. The vegetation was dried at 110°C and 10 g of the resulting powder heated for 12 h at 400°C followed by 30 minutes of alkaline fusion at 550°C in the presence of 5 g of NaOH pellets. The residue was taken up in 200 ml dilute HCl, 20 ml of which was used for the assay with 20 ml 1 M sodium citrate.

Results

The results obtained are presented in Tables 1 to 4. Table 4 indicates the relative frequencies of four types of wind direction . Maxi-

mum wind speed never exceeded 1.6 m/s.   The prevailing wind was from the N-W.

Table 1
Static Sampler Values

Sampler	Mar. 82	Apr. 82	May 82	June 82	July 82	Aug. 82	Sept. 82	Oct. 82	Nov. 82	Dec. 82	Jan. 83	Feb. 83	Mar. 83	Apr. 83	May 83
2	9.62	4.31	3.71	6.18	3.72	3.61	5.18	2.02	-	1.44	0.87	1.65	3.07	0.84	-
3	4.42	2.96	4.53	5.62	17	6.5	-	4.33	4.07	14.4	1.84	3.63	-	1.73	0.86
4	5.68	1.87	1.81	3.15	2.67	-	1.81	1.59	1.33	2.21	1.28	1.56	1.88	1.12	1.53
5	9.2	4.92	-	7.15	4.62	3.23	2.59	1.67	1.66	1.86	0.81	1.23	0.95	0.79	0.56
6	2.42	3.58	1.56	1.69	1.23	1.05	0.70	0.78	0.79	1.33	0.30	0.51	0.61	-	0.33
7	10.7	4.88	4.32	7.47	2.36	2.75	1.96	0.96	0.84	0.81	0.65	0.50	0.65	0.36	0.37
8	6.6	3.3	2.56	3.49	2.53	-	2.51	1.22	1.35	1.73	0.8	0.79	0.77	0.45	-
9	8.0	2.85	3.42	3.98	-	2.89	1.65	1.23	1.37	1.07	0.66	0.54	0.51	0.54	0.33
10	8.83	2.84	2.34	3.76	1.58	2.51	-	1.65	-	-	0.43	0.64	0.56	0.49	0.78
11	5.86	2.17	2.41	4.83	-	-	2.45	2.64	1.41	3.74	1.0	1.23	1.05	0.68	0.85
12	12.1	6.22	5.96	9.1	5.5	-	3.67	3.0	2.80	3.0	0.92	1.22	0.99	0.72	0.70
13	7.35	3.55	4.89	6.87	-	3.99	4.10	2.2	1.79	1.70	1.2	1.42	1.06	0.62	0.47
14	6.61	2.35	4.24	6.83	5.1	5.27	-	1.57	1.18	2.0	0.62	0.80	0.61	0.64	0.51
15	12.1	-	4.71	3.36	-	2.62	1.88	1.48	-	-	3.94	3.71	2.22	1.62	2.7

Expressed in $\mu g.dm^{-2}.day^{-1}$; -: paper damaged (assay not carried out)

Table 2
Dynamic Sampler Values

Sampler	Mar. 82	Apr. 82	May 82	June 82	July 82	Aug. 82	Sept. 82	Oct. 82	Nov. 82	Dec. 82	Jan. 83	Feb. 83	Mar. 83	Apr. 83	May 83
2	0.22	1.47	0.69	0.40	1.28	0.51	5.9	0.37	0.88	0.59	0.86	1.64	2.87	1.14	2.30
3	0.12	0.25	0.24	0.28	1.02	0.48	0.40	0.12	0.19	0.55	0.36	0.28	0.82	0.15	0.59
4	0.03	0.09	0.10	0.10	0.20	0.15	0.32	0.09	0.18	0.12	0.11	0.14	0.17	0.11	0.28
5	0.02	0.06	0.07	0.09	0.08	0.09	0.08	0.06	0.05	0.07	0.12	0.05	0.05	0.09	0.09
6	0.07	0.05	0.07	0.07	0.11	0.10	0.07	0.05	0.06	0.15	0.07	0.06	0.09	0.07	0.17
8	0.13	0.16	0.15	0.24	0.22	0.11	0.16	0.15	0.19	0.13	0.26	0.13	0.17	0.06	0.10
12	0.12	0.22	0.34	0.68	0.25	0.63	6.65	5.2	1.59	-	1.28	1.0	0.55	0.24	0.24

Expressed in $\mu g\ F^{-}.m^{-3}.day^{-1}$; 6: sampler situated in town center; 7: sampler situated in large industrial zone

Discussion

- Static collector, plant content correlation:

A correlation was found between the average annual pollution values, indicated by the static collectors, and the corresponding level of fluoride in the plant material (Fig. 2). The variance of the residues ($\pm \frac{1}{n}\sum d^2y$) with respect to the estimated slope of y indicates that 68% of the values

FLUORIDE

Table 3
Plant Values

Samp-ler	Mar. 82	Apr. 82	May 82	June 82	July 82	Aug. 82	Sept. 82	Oct. 82	Nov. 82	Dec. 82	Jan. 83	Feb. 83	Mar. 83	Apr. 83	May 83
2	72	120	20	18.2	79	12.6	21.6	17	21.2	16.8	15.5	35	10.7	12.6	11.5
3	66	61	35.2	24.8	160	23	33	15.8	36	49.8	25	45	27.2	15	26
4	64	17	20.6	17.4	32	10	15.5	13.5	23.5	15	21.7	20.6	10.4	10.4	8.2
5	60	11	6.0	12.8	13	6.2	9	9.1	15.8	7.7	10.4	6.4	7.2	4	8.6
6	32	14	11	15.2	15	9.5	11.5	17	20.5	18	13	28	7.6	-	9.3
7	31	15	8	10.3	12	6	36.7	23.6	42.5	28	30	14	17	9	18
8	24	14	7.5	11.4	10	8.3	13.2	110	59	20	30	36	40.6	9	6
9	21	5	12	12.6	9.2	9.2	11.5	10.4	11.5	14.4	10.8	19.5	7.6	6	9.4
10	70	20	8	9.4	9.6	12	11	11	12.6	7.6	11	15.5	13.7	9.8	8
11	70	16	9.5	11	14.4	9	8.1	9.9	30	23	7.7	11.5	14.3	11	6.9
12	42	19	8	12.6	16.4	12	11.5	28.3	36	20	15.4	13	9.6	9.5	6.8
13	53	14	22.3	11	17.5	6	8.3	8.2	13.5	8.3	12.7	10	9.1	4.5	6.2
14	120	36	16	10.2	10.5	13	32.4	21.3	47	26	28	60	21.2	7.3	7
15	68	20	8.5	10.6	11	16.5	8.4	10.4	12.3	-	9.3	11	11.7	5	5.8

F^- in ppm dry plant material

Table 4
Wind Direction Frequency

Month	Calm	N - W	S - E	S - W
Mar. 82	0.130	0.619	0.166	0.085
Apr. 82	0.200	0.561	0.161	0.078
May 82	0.161	0.425	0.328	0.086
June 82 24 days	0.167	0.479	0.187	0.167
July 82	0.161	0.607	0.189	0.043
Aug. 82	0.032	0.549	0.371	0.048
Sept. 82	0.100	0.367	0.450	0.083
Oct. 82	0.129	0.317	0.398	0.156
Nov. 82	0.200	0.323	0.405	0.072
Dec. 82 28 days	0.321	0.321	0.233	0.125
Jan. 83	0.129	0.269	0.526	0.076
Feb. 83	0.214	0.286	0.446	0.054
Mar. 83	0.258	0.543	0.172	0.027
Apr. 83	0.200	0.400	0.200	0.200
Mean 14 Months (417 days)	0.170	0.434	0.305	0.091

Figure 2

Linear Regression Static Collectors/Plants
(annual mean)

STATIC COLLECTORS VALUES (annual mean)
$\mu g\ F^-.dm^{-2}.day^{-1}$

PLANT F⁻ CONTENT (annual mean)
ppm

Y=1.428 + .069 X   R=.588 Significant p < 0.05

remain grouped. This correlation is only valid for mean annual values, as shown by the analysis of the results for the periods March to September and October to February (Figs. 3 and 4). Comparing Figures 3 and 4 reveals correlation is almost nonexistent for the period October to February which demonstrates the confounding effect of growth on the fluoride content.

The study of the variations occurring over a year in the ratio "ppm plant F⁻/ μg F⁻dm⁻² day⁻¹" shows that, during the growing season, the ratio decreases as a result of dilution of the fluorine in the plant. The opposite is observed from September to October - a period of attenuated plant growth. However, in the area enclosed by points 11, 12 and 13, the variation is not as marked which suggests the presence of an additional source of pollution of a different origin.

- Correlation between static and dynamic samplers:

The ratio "μg F⁻ static.dm⁻².day⁻¹/μg total F⁻.m⁻³" can be considered to represent the rate of fluoride uptake by the static paper (v = 1 x t⁻¹). Four static samplers were placed in the vicinity of four dynamic samplers and comparison of their mean annual values gives a regression line (Fig. 5 slope A). The correlation is not significant owing to station 12. However, the regression line obtained from stations 3, 4 and 5 (Fig. 5 slope B) is significant to p < 0.1, even considering the low number of points of comparison. This fact indicates the presence of a different type of pollution at station 12 confirming the interpretation of the plant F⁻/static F⁻ ratios.

Figure 3

Linear Regression Static Collectors/Plants
(mean values from March to September)

PLANT F⁻ CONTENT
ppm

Static Collectors Values
$\mu g.dm^{-2}.day^{-1}$

y - 5.561 + 3.352 x   R = 4.88

- Correlation between plant F⁻ and dynamic F⁻:

The ratio "ppm plant F⁻/μg total F⁻.m⁻³" shows that at station 12, very

Figure 4

Linear Regression Static Collectors/Plants
(mean values from October to February)

$y = 16.962$ EXP. $(.082\ X)$ $R = .212$
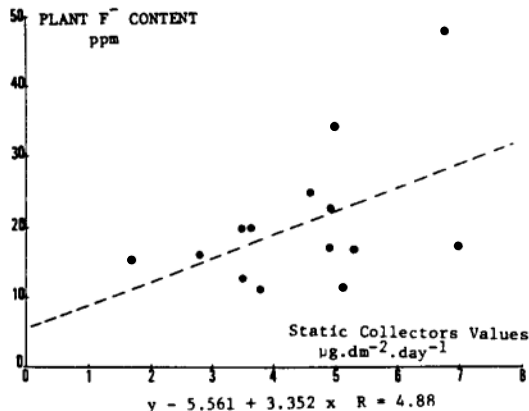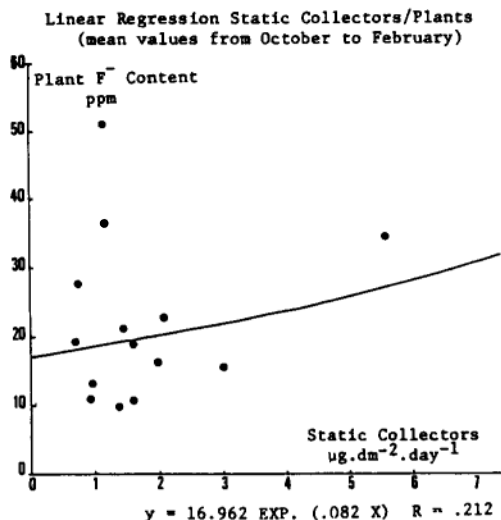
little fluoride is taken up by plants. This is unlike the situation at stations 2, 3 and 4 and thus provides further proof of the difference of this zone which is probably exposed to insoluble particulate fluoride.

- Correlation between static sampler values and the distance from the factory:

The linear regression of these values follows the equation $y + 3.442 - 125\ x$, in which $R = 0.394$; the correlation is significant. It is illustrated in Figure 6 where curve (a) represents the theoretical values calculated by multiple regression against the distance from the factory, and curve (b) represents the values actually measured. Two special cases become apparent: station 6 owing to its orographic position, and stations 11, 12 and 13 which are subjected to an additional source of pollution.

The rate of HF uptake by the static samplers was not affected by wind direction as confirmed by the fact that there was absence of correlation between the parameter "$\mu g\ F^-.dm^{-2}.day^{-1}$" and direction.

Figure 7 represents the correlations between the plant fluoride content and the disstance from the pollution.

- Pollution in the urban center:

The levels of pollution measured in the center of the town were very low; they were almost constant during the entire year and were not influenced by closure of the factory during the month of August

Figure 5

Linear Regression Static Collectors/Dynamic Collectors

$y = 0.558 + 12.412\ X$
$R = 0.98$
$p < 0.10$

$y = 2.671 + 0.916$
$R = 0.315\ X$

(station 12)

A: corresponds to sampling stations 3,4,5,12
B: corresponds to sampling stations 3,4,5
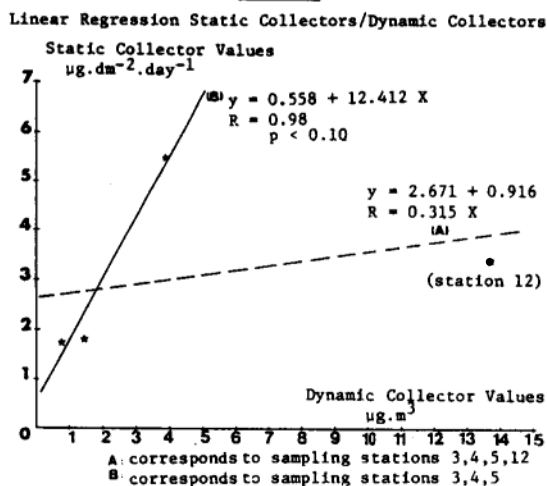
Figure 6

Correlation Between Static Collector Values
and Sampling Station Position

Static Collector Values
$\mu g.dm^{-2}.day^{-1}$

Sampling Station

a. theoretical curve
b. experimental curve   R. 0.60
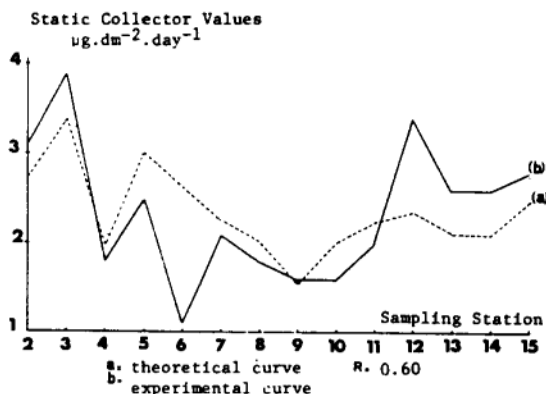
which can be explained by the screening effect of the buildings. The pollution measured corresponds to urban activity: it represents only half the mean average pollution of a large industrial zone near the area studied.

Conclusion

The correlations established between the levels of pollution measured by the static samplers, the dynamic samplers, and the plant fluoride content, indicate that the static samplers (which are financially advantageous, easy to set up ånd do not require an energy source) are best adapted to the study of long-term fluoride pollution. They mainly measure HF, the most harmful to human health when inhaled (9) and the most phytotoxic for the environment.

Figure 7

Correlation Between ppm Plant F⁻ and
Sampling Station Position
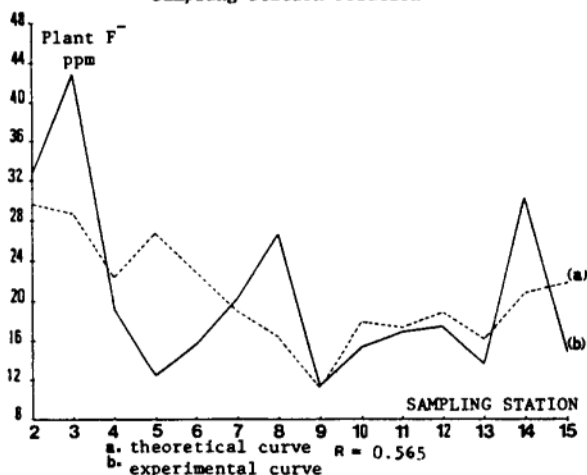
Plant F⁻
ppm

SAMPLING STATION

a. theoretical curve   R = 0.565
b. experimental curve

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LEVEL OF F⁻ IN ENAMEL SPOTS UNDER FLUORIDATION AND TRACE CONCENTRATIONS OF F⁻ IN DRINKING WATER

by

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SUMMARY: Epidemiological investigation of dentition of children made after eight years of water fluoridation in Szczecin revealed the occurrence of disturbances of enamel mineralization in about 8% of investigated children. In order to explain the cause of observed enamel spots, the level of fluoride in enamel, saliva and urine of children was estimated. The level of enamel and urine fluoride was higher in children with enamel spots than in children with sound enamel. The level of fluoride in saliva was almost equal in all children. Additionally,

the questionnaires taken from mothers of investigated
children revealed that the children with enamel spots
took more antibiotics and other drugs during the first
three years of their life than the children with sound
enamel.

Introduction

In 1977, we performed an epidemiological study of 7829 preschool and
school children in Szczecin to evaluate an 8-year program of fluoride pro-
phylaxis which consisted of water fluoridation (1 ppm) in one region of
the town and contact fluoride prophylaxis in all children regardless of
the region (1). Disturbances of enamel mineralization,which were found in
about 8% of investigated children, occurred more often in the fluoridated
(11%) than in nonfluoridated water region (6%).

Material and Methods

In order to explain the background of observed changes, 472 children
aged 7 to 10 were investigated, including 364 children with enamel miner-
alization disturbances and 108 with normal enamel as controls. The inves-
tigation consisted of: 1) clinical evaluation of enamel, taking into con-
sideration the presence of chalky white to light brown spots as well as
hypoplasias of enamel, 2) estimation of the level of fluoride in enamel
(both with spots and normal), saliva and urine in children.

The enamel biopsy was taken from the upper right central incisors.
The tooth to be biopsied was isolated with cotton rolls and soft debris
was removed. Next, the labial surface of the tooth was abraded by means
of sterile rubber cup and a slurry consisting of quartzite in glycerol.
Sampled enamel was collected and placed into a plastic tube.

The fluoride level in enamel, saliva and urine was determined by an
ion selective fluoride electrode – Orion Research Inc. Parents of inves-
tigated children were requested to fill out questionnaires to establish
the course of the mother's pregnancy and medicines taken by both mother
and child.

Results

Clinical evaluation of disturbances of enamel mineralization in in-
vestigated children is presented in Tables 1, 2, 3 and 4. Table 1 re-
veals that, among the children with disturbances of enamel mineralization
in both regions, the percentage of spots and hypoplasias was similar and
that the percentage of hypoplasia in both regions was higher in older
children (9-10 years) than in the younger ones (7-8 years).

From Table 2 it can be seen that in spite of similar mean age of
children of all groups, the average number of erupted teeth was higher in
children from the fluoridated area than in the nonfluoridated area.

Janczuk, Opalko, Lisiecka, Domzalska

Table 1

Enamel Spots and Hypoplasias in Children from Both Regions

Age	Enamel Spots	Hypoplasias	Total%	Enamel Spots	Hypoplasias	Total%
	Fluoridated Water			Nonfluoridated Water		
7 - 8	117 90.7%	12 9.3%	100	17 94.4%	1 5.6%	100
9 - 10	109 86.5%	17 13.5%	100	31 84.1%	5 13.9%	100
Total	226 88.6%	29 11.4%	100	48 88.9%	6 11.1%	100

Table 2

Mean Age of Children and Average Number of Permanent Teeth

Region	Group of Children	Number of In-vestigated Children	Mean Age	Average Num-ber of Perma-nent Teeth
Fluoridated water	Disturbances of enamel minerali-zation	255	8.5	14.2
	Normal enamel	109	8.3	13.0
Nonfluori-dated water	Disturbances of enamel minerali-zation	54	8.8	14.9
	Normal enamel	54	8.5	12.0

Table 3

Average Number of Teeth with Enamel Spots and Hypoplasias

Age	Enamel Spots	Hypoplasias	Enamel Spots	Hypoplasias
	Fluoridated Water Average Number of Teeth		Nonfluoridated Water Average Number of Teeth	
7 - 8	5.4	7.8	3.0	6.0
9 - 10	7.1	7.6	4.2	6.2
Total	6.2	7.7	3.8	6.1

Table 4

Prevalence of Disturbances of Enamel Mineralization in Separate Groups of Teeth

Region	Age	% of Teeth with Enamel Spots			% of Teeth with Hypoplasias		
		Incisors	Premolars	Molars	Incisors	Premolars	Molars
Fluoridated Water	7 - 8	38.1	0.5	12.0	38.1	2.1	27.3
	9 - 10	21.1	12.0	7.8	27.9	6.8	7.5
	Total	27.9	7.4	9.5	31.1	5.4	13.6
Nonfluori-dated Water	7 - 8	28.6	-	-	50.0	-	10.0
	9 - 10	18.0	5.0	1.7	18.1	3.2	11.7
	Total	20.8	3.7	1.3	21.1	2.9	11.5

Table 3 shows that the average number of teeth, both with spots and hypoplasias, was rather high in comparison with the average number of erupted permanent teeth shown in Table 2 and they were higher in children from the fluoridated area.

Table 4 illustrates the prevalence of disturbances of enamel mineral-
ization in the separate groups of teeth. The percentage of teeth with
enamel spots was higher in the fluoridated water region whereas the per-
centage of teeth with enamel hypoplasias was, in general, similar in
children from both regions. Table 4 also shows that enamel mineraliza-
tion disturbances occurred in both areas, most often on incisors, and that
the percentage of teeth both with spots and hypoplasias was higher in
children aged 7 to 8, than in older ones.

Figure 1 demonstrates the mean level of fluoride in enamel of child-
ren of all investigated groups. The highest level (5190.5 ppm) was found
in enamel spots of teeth in children from the fluoridated area. However,
the relatively high level of 4682.6 ppm fluoride was found in children
from the fluoridated area, without any mineralization disturbances. The
differences between the two groups were not statistically significant.
The differences, however, between the mean level of fluoride in enamel of
children residing in fluoridated and nonfluoridated areas were statistic-
ally significant.

The mean levels of fluoride in saliva are presented in Figure 2. In
both groups of children mean differences between levels of saliva fluo-
ride and urinary fluoride were not statistically significant as shown in
Figure 3.

Figure 1

Mean Level of Fluorine in Enamel

Figure 2

Mean Level of Fluorine in Saliva
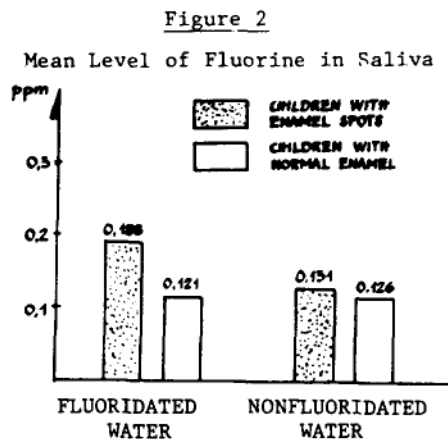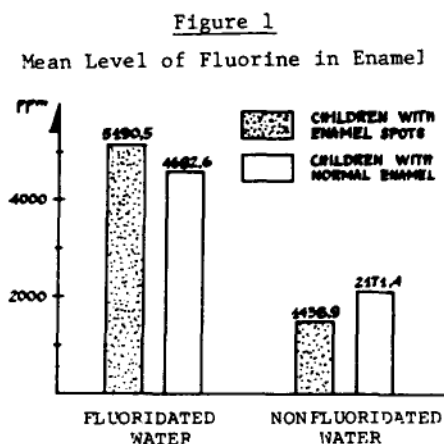
The percentage of mothers of investigated children who took medicines
during pregnancy, shown in Table 5, was low but slightly higher in mothers
of children from the fluoridated region with disturbances of enamel miner-
alization.

Table 6 presents the percentages of children who were taking fluoride
and iron during the first three years of life. The percentage of children
taking fluoride in tablets was low, except for the group with enamel miner-
alization disturbances from the nonfluoridated area. Iron was taken by

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Figure 3

Mean Level of Fluorine
in Urine
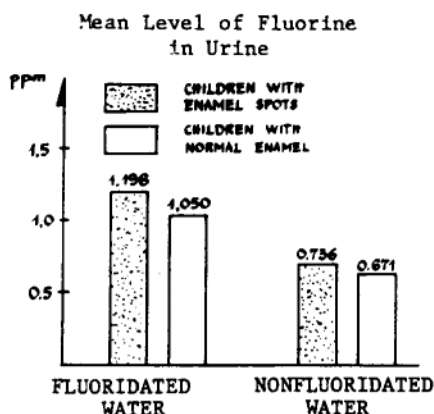
children of all groups more often than fluoride, especially by children from the nonfluoridated area.

According to Table 7, investigated children often used antibiotics, the frequency of which was higher among children with enamel mineralization disturbances with no regard to the region. However, antibiotics were taken more often by children aged 1 to 3.

Because the data obtained, in response to questionnaires, from parents regarding nutrition of mothers during pregnancy and of children from birth to 3 years were not exact, they were not utilized.

Table 5

% of Mothers Taking Medicines During Pregnancy

Region	Group of Children	
Fluoridated Water	Disturbances of enamel mineralization	15.2
	Normal enamel	1.8
Nonfluoridated Water	Disturbances of enamel mineralization	7.4
	Normal enamel	9.4

Table 6

Percentage of Children Taking Fluoride and Iron

Region	Groups of Children	Birth-1 yr. F	Fe	1-3 yrs. F	Fe
Fluoridated water	Enamel mineralization disturbances	4.3	19.5	7.8	21.1
	Normal enamel	6.4	13.8	6.4	17.4
Nonfluoridated water	Enamel mineralization disturbances	7.4	24.1	13.0	27.7
	Normal enamel	5.7	18.9	5.7	30.2

Discussion

Dental fluorosis has been recorded from fluoride naturally in drinking water (2-7,9) below the level which is being recommended for teeth, as well as from artificially fluoridated water (8,9). According to recent data, 7.1 to 15.1% enamel spots were observed in Cuban children where drinking water contains 0.1 to 0.8 ppm F⁻(7). In two low fluoride (0.05 to 0.41 ppm) districts in Finland, 41% and 74% of the children respectively, had enamel mottling (including the "questionable" category) and, in a fluoridated (1.08 ppm) community, the incidence was 98% (9). Many additional instances could be cited.

Use of fluoridated water in commercial food processing is

Table 7

Percentage of Children Taking Antibiotics

Region	Groups of Children	Birth-1 yr.	1-3 yrs.
Fluoridated water	Enamel mineralization disturbances	61.3	82.0
	Normal enamel	39.5	68.8
Nonfluoridated water	Enamel mineralization disturbances	53.7	83.4
	Normal enamel	49.0	73.6

known to increase food F^- content.   Thus consumption of fluoride in food-
stuffs, in addition to fluoridated water, cannot help but cause fluoride
ingestion to rise as observed by Marier and Rose (10) who reported that
dietary F^-, excluding drinking water, averaged 1.0 to 2.0 mg per day and
that foods and water combined may provide a daily F^- intake of 2 to 3, or
even 5 mg F^- (10).

The results, obtained in this study, revealing the higher level of flu-
oride in enamel spots of teeth in children from the fluoridated area   sug-
gest the role which fluorides may play in the pathogenesis of observed al-
terations.

Another factor which may be connected with the enamel spots observed
in examined children is the high intake of antibiotics and iron by child-
ren up to age three.   The side effects of tetracyclines to hard dental
tissues have been observed by many authors.   Changes of enamel were ob-
served in 60.3% of teeth in children who had been given tetracycline anti-
biotics during the first two years of life (10).

Although the described spots are considered mild, enamel mineraliza-
tion disturbances cannot be disregarded, and indicate the necessity for
better control of the fluoride level in our environment and   the com-
prehensive limitation of drugs, especially tetracyclines administered to
children.

Conclusions

1. The observed enamel spots, disturbances of mineralization, are caused
    by many factors.
2. In the development of these spots, fluorides, antibiotics, and other
    drugs as well as nutrition may play an important role. Interaction
    between the above-mentioned factors cannot be excluded.

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FLUORIDE DISTRIBUTION IN TWO SALT-AFFECTED SOILS

by

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SUMMARY: In horizon samples of two salt-affected
soils from an area where soils are naturally high
in F^-, total F^- was related to clay content. The
proportion of F^- found in coarse fractions, how-
ever, was higher than in the literature. The F^-
origin and soil texture are the main cause of
these results. Only one soil could be considered
evolving towards a "normal" F^- distribution. Fac-
tors affecting these processes include the topo-
graphical position of the soils, height of phrea-
tic waters, and climate.

The resin-extractable F^- was low and was not
related to soil phosphorus, to other soil proper-
ties, or to other soil F^- components, thereby giv-
ing rise to doubts about the advantage of this
kind of soil determination. The $CaCl_2$-soluble F^-
values were high and showed a good correlation
with soil pH but were not related to other soil
F- forms. Data on F^- in organic matter are simi-
lar to those in other soils.

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Introduction

Some saline and alkaline soils from west Buenos Aires Province are high in soluble F⁻, as the result of the capillary rise of high F⁻ ground-water (1,2). The distribution of F⁻ compounds is almost unknown in these soils. The relationships between some soil characteristics and soluble or total F⁻ are the only ones which have been studied (2-4).

To fill this information gap, we have considered:

1). The F⁻ distribution in the three soil textural fractions (sand, silt and clay), about which little is known. The few data which are available show a close relationship between F⁻ and clay content (5).

2). The resin extractable F⁻, which is a measure of labile F⁻ and may be related to soil phosphorus (6). The relationship between fluoride and phosphates was shown early by Robinson and Edington (7) in soils both P-rich naturally and enriched through chemical fertilization (7,8).

3). The dilute-salt-solution extractable F⁻, which is a measure of solubility of soil F⁻ compounds, soluble F⁻ and weakly absorbed F⁻ (10).

4). The F⁻ bound to organic matter, which is usually low (5).

Material and Methods

Samples of horizons (surface and subsurface soil layers) from two soil profiles were taken near the town of C. Tejedor (province of Buenos Aires, Argentina). The soils (an Entisol and an Alfisol) represent the more important soil orders of salt-affected of the area (Hurtado and Gimenez, Personal communication). The soils were similar to those numbered 3 and 4 respectively in a previous paper where additional soil characteristics are recorded (2).

The soils are covered by halophytic vegetation (especially soil 1). The soils are not used for crops, nor have they been plowed or fertilized with phosphorus. They are used for grazing (mainly soil 2).

After removal of organic matter with hydrogen peroxide, the soils were fractionated into sand, silt, and clay. The sand fraction was separated by wet sieving (300 mesh). The silt and clay fractions were separated by repeatedly siphoning off the clay (5). The volume of clay suspension was reduced by water evaporation at low temperature. The F⁻ in each soil fraction was extracted by steam distillation with sulfuric acid at 165°C and perchloric acid at 135°C (9).

Resin extractable F⁻ was obtained by the following procedure: Soil F⁻ was retained using a Dowex 1-X8, 20-50 U.S. mesh resin and leached from it using a dilute aqueous Na_2SO_4 solution (6). Soluble F⁻ was extracted with $CaCl_2$ solution in a 3:1 ratio to soil (10). F⁻ bound to organic matter was obtained by removal of organic matter with sodium hypochlorite (5, 11). F⁻ determination in the different extracts was performed by titrimetry with thorium nitrate in the presence of alizarin red S (9).

Table 1

F^- Distribution in Two Salt-Affected Soils

Soil	Horizons	F^- in fraction (1 Sand	Silt	Clay	Proportion of total (2 Sand	Silt	Clay	Bound to org. matter (1 F	Extractable (1 F⁻	Soluble (1 F⁻
Entisol	A	31.5	65.0	144.0	42.6	35.3	22.1	5.4	8.04	1.05
	B	26.0	25.0	100.0	41.4	20.6	38.0	-	1.62	3.20
	BC	22.0	35.0	48.5	43.7	31.4	24.9	-	1.62	3.00
Alfisol	A	16.0	25.0	30.0	43.2	43.3	13.5	5.9	2.84	0.25
	AB	15.5	22.0	80.0	35.2	32.8	32.0	8.5	1.62	0.25
	B	10.0	25.0	87.0	6.7	24.3	69.0	-	1.62	1.50
	BC	98.5	117.0	550.0	18.3	21.0	60.7	-	16.23	3.95
	C	83.0	85.0	308.0	29.1	35.9	35.0	-	2.84	3.95

Table 2

Coefficient of Correlation, Significance and Regression Equation Between F⁻ Components and Some Soil Properties

X	Y	r	Significance	Slope a	Intercept b
% Clay	Proportion of Total F⁻ in Clay Fraction	0.92	**	5.07	2.06
Total F⁻	idem	0.85	**	17.92	0.13
Soil pH	idem	0.74	*	0.00	0.00

Also determined were: soil texture (pipette); available P (Bray Kurtz No. 1); and soil pH (paste).

Results and Discussion

Table 1 shows the F⁻ content in the three main soil size fractions and the proportion of F⁻ contributed by these fractions to total F⁻. The highest absolute values were found in the clay fraction (see Table 2).The results are in accordance with those published by Omueti and Jones (5), but with the following difference: they found, on an average, 1.3% of the total F⁻ in the sand, 37.3% in the silt, and 61.3% in the clay. We found on an average 32.5% of the total F⁻ in the sand, 30.6% in the silt, and 36.9% in the clay.

The results of Omueti and Jones as well as those of other authors (12), could be considered as the ideal F⁻ distribution in soils subjected to rainfall leaching, eluviation, and a component redistribution in the profile. In this process the clay fraction becomes enriched in F⁻. Omueti and Jones showed that soils with lower degrees of development had less F⁻ in the clay fraction.

Our results suggest that F⁻ enrichment was due to capillary rise of groundwater (2). A portion of the F⁻ in solution was adsorbed by the soil colloids but, because of the low clay content, a significant portion of the soluble F⁻ had to be adsorbed or precipitated on the mineral surface of other soil fractions.

In the Entisol, found in a low topographic position with a high phreatic water level (around 0.60 m depth) the above-mentioned process is still operative, which explains why, in these soils, the absolute and relative proportion of F⁻ in coarse particles was high and the total F⁻ profile was ascendant.

In the Alfisol, located in a medium position in the landscape, with a relatively low phreatic water level (around 2m depth), some kind of F⁻ redistribution is occurring, and the F⁻ is being adsorbed and concentrated in the clay enriched horizons (B and BC)(see F⁻ profile in Table 1). These horizons have a F⁻ distribution in the soil fraction similar to that found by Omueti and Jones (5) in soils with an "ideal" F⁻ distribution.

Resin-extractable F⁻ values shown in Table 1 were lower than those found in the literature (6,10). The resin-extractable F⁻ was not related to other soil properties such as available P, pH, total F⁻, and F⁻ in clay fraction (r:0.47; 0.30; 0.21 and 0.32 respectively).

The $CaCl_2$ solution-soluble F⁻ was higher than the values given in the literature (6,10). The ratio of resin-extractable F⁻ to $CaCl_2$-soluble F⁻ which, according to Omueti and Jones (5), is around 50 was only 2 here. This finding could explain the apparent uselessness of the resin-extractable F⁻ values in these soils, and the cause could lie in the low P content (13) and the origin of F⁻ in these soils.

The $CaCl_2$-soluble F^- was not related to several soil properties such as total F^-, F^- in clay fraction, and resin-extractable F^- ($r:0.33$; 0.36 and 0.38 respectively) but it was related to soil pH as found by others [10] and as expected from our own previous data [2] (see Table 2).

F^- values in organic matter of surface horizons (Table 1) are similar to those in other soils [5].

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EFFECTS OF FLUORIDE ON RABBITS FED LOW CALCIUM DIET

by

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SUMMARY: Rabbits were fed a low Ca diet (Ca:0.4%)
or a normal Ca diet (Ca:1.6%) for 8 weeks starting
5 weeks after birth. Subsequently they were given
0, 5 and 15 mg F/kg intraperitoneally. Decrease
in serum total Ca and Ca^{++} and delay in recovery
as well as increase in the serum glucose level were
more marked in the low Ca group than in the normal
Ca counterpart. F^- was retained in serum for a
long time and urinary excretion was markedly de-
creased in the low Ca group. That changes in the
toxicity and metabolism of F^- occur when the diet
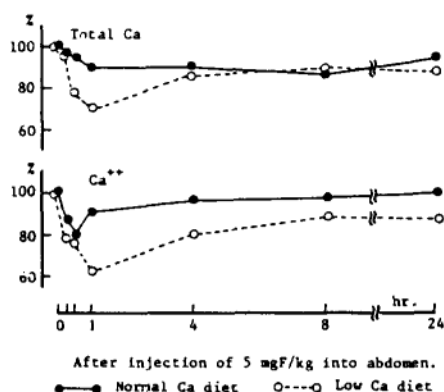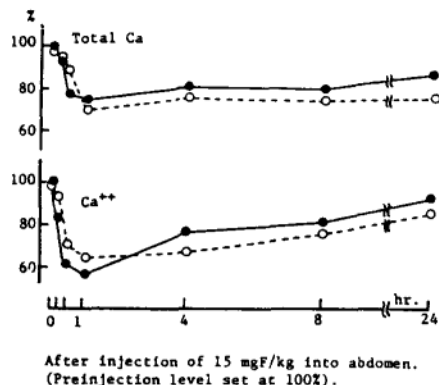is low in Ca was confirmed.

Introduction

In discussing the safety and toxic effect of fluoride (F) on the
living body, it is important to give due consideration to nutritional
conditions, particularly in calcium (Ca) intake. In Japan, where Ca in-
take is low (Japanese average daily Ca intake was 546 mg in 1981), about
one half to one third that of Western countries (1), the incidence of
mottled teeth is high despite a low fluoride level in drinking water (2,
3). The incidence of fluorosis was particularly high in parts of South
India where Ca intake is low (4,5). These reports suggest a close rela-
tionship between Ca intake and fluorosis and that the F toxicity is in-
creased by low Ca intake.

Based on these considerations, experiments were conducted to study
the effect of F on rabbits given a low Ca diet with special reference to
the serum Ca and glucose levels.

Material and Methods

Rabbits were fed for 8 weeks, beginning at 5 weeks of age, different
diets in terms of Ca content, namely low Ca diet (Ca: 0.4g/100g) and nor-
mal Ca diet (Ca: 1.6g/100g). Rabbits, weighing about 2.5 kg,were divided
into three groups of five rabbits according to Ca intake. After sodium
fluoride was injected into the abdomen, fluctuations in components of se-
rum and urine were observed. Sodium fluoride was given in doses of 0
(control), 5 and 15 mg F/kg of body weight.

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Figure 1   Figure 2

Fluctuations in Serum Total Ca and Ca^{++} Indices

After injection of 5 mgF/kg into abdomen.
●——● Normal Ca diet   o---o Low Ca diet

After injection of 15 mgF/kg into abdomen.
(Preinjection level set at 100%).

Concentrations of F in serum and urine were measured by the fluoride
ion electrode method (6). Serum total Ca levels were determined by atom-
ic absorption spectrophotometry (7) and serum ionized Ca (Ca^{++})   levels
with Orion Model SS-20 ionized calcium analyzer (8). Serum values of glu-
cose were measured by the OTB method (9).

Results

Fluctuations in serum total Ca and Ca^{++}: Before injection of F, the
serum total Ca was 12.7 mg/dl for the group which had received a   normal
Ca diet, and 10.4 mg/dl for the group on a low Ca diet. The Ca^{++} levels
were half of the total serum Ca. Ca^{++}, which is not linked to proteins
in the blood, plays an important physiological role in living things.

To compare degrees of fluctuation between groups fed low Ca and those
fed normal Ca, fluctuations in the levels of serum total Ca and Ca^{++} are
shown in Figures 1 and 2 with the preinjection level set at 100%. After
each injection, the total Ca and Ca^{++} levels dropped sharply; the lowest
level was reached after about 1 hour, after which levels gradually return-
ed to those observed prior to injection. As is discernible from Figures
1 and 2, the drop in total Ca and Ca^{++} serum levels was more conspicu-
ous for groups fed low Ca than for those fed normal Ca, and recovery was
far slower. When 15 mg F/kg was injected, differences were noticed after
4 hours; no signs of recovery were observed in groups fed low Ca even af-
ter a lapse of 24 hours. There were no changes in the total Ca and Ca^{++}
serum levels in the control groups fed low and normal Ca diets.

It is apparent that the metabolism of serum Ca is markedly influenced by F especially when diets are low in Ca.

Fluctuations in the serum glucose level: Fluctuations in the serum glucose level after injection of 5 and 15 mg F/kg, are shown in Figs. 3 and 4 with the preinjection level set at 100%. In contrast to fluctuations in serum Ca levels, serum glucose levels rose sharply after an injection. The level was highest after 1 hour and returned to the preinjection level about 4 hours later. The serum glucose level is more apt to rise in the low Ca groups than in those fed normal Ca; the former returned to normal at a slower rate than the latter. Particularly in the low Ca groups, the serum glucose level rose considerably after 15 mg F/kg was injected. Even after a lapse of 24 hours, it had not returned to the preinjection level. No changes occurred in either of the control groups.

Figure 3
Fluctuations in Serum Glucose Indices

O----O Low Ca diet group
●——● Normal Ca diet group

(Preinjection level set at 100%) after injection of 5 mgF/kg into abdomen

Figure 4
Fluctuations in Serum Glucose Indices

After injection of 15 mg F/kg into abdomen.
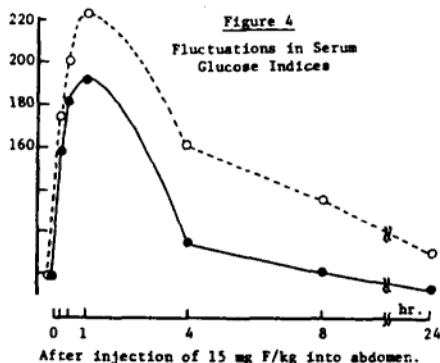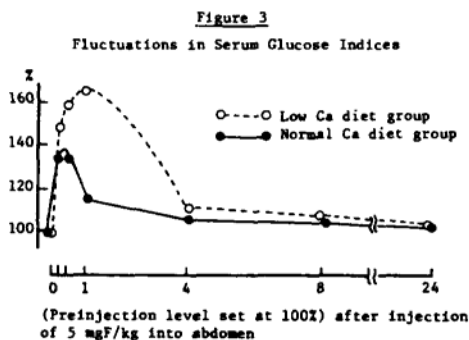
Based on these results, the serum glucose level of the low Ca group rose promptly and returned to normal levels only after considerable delay.

Fluctuations in serum F levels in low Ca and normal Ca group: Fluctuations in F serum level are indicated in Tables 1 and 2. Whereas the low Ca groups and those fed normal Ca did not differ in the amount of time required to reach the highest serum F level, subsequent elimination of F from the serum differed significantly. In the low Ca groups, a considerable amount of injected F remained in the serum and was not completely eliminated. Twenty-four hours after injection of 15 mg F/kg, 0.41 ppm F remained in the serum of the low Ca group, 4 times as much as in the normal Ca group, namely 0.11 ppm, a significant difference. The quantity of F⁻ discharged through the urine for a period up to 24 hours after injection of F is shown in Fig. 5. After injecting two different quantities of F, discharge was significantly lower for the low Ca groups than for those fed normal Ca ($p < 0.01$ in both cases). In the low Ca group, only 1% of F⁻ was discharged, far less than in the normal Ca group namely 10%.

Tsuchida and Yanagisawa

Table 1

Fluctuations in Mean Value and Standard
Deviation of Serum F Level

Diets	Hr. 0	15'	30'	1 hr.	4 hr.	8 hr.	24 hr.
Low Ca diet group	0.036 ±0.005	13.2 ± 1.83	7.28 ±0.74	3.35 ±0.87	0.45 ±0.41	0.19 ±0.11	0.06 0.01
Normal Ca diet group	0.032 ±0.001	12.0 ± 2.05	6.79 ±1.44	0.86**0.39 ±0.38 ±0.21	0.16 ±0.10	0.04* 0.005*	

After injection of 5 mg F/kg in low Ca, and normal Ca groups

* $P < 0.05$; ** $P < 0.01$; Unit: ppm

From such dynamics of F^- in serum and urine (Tables 1, 2 and Fig. 5), it was found that injected F was long retained in the serum and urinary excretion markedly decreased in the low Ca groups.

Table 2

Fluctuations in Mean Value and Standard
Deviation of Serum F Level

Diets	Hr.						
Low Ca diet group	0.035 ±0.003	39.8 ±4.51	32.7 ±1.90	24.2 ±3.25	2.20 ±0.64	1.51 ±0.46	0.41 ±0.20
Normal Ca diet group	0.034 ±0.002	39.2 ±3.11	30.4 ±4.92	17.4° ±2.68	1.37° ±0.40	0.38** ±0.15	0.11* ±0.02

After injection of 15 mg F/kg in low Ca, and normal Ca groups

° $P < 0.1$; * $P < 0.05$; ** $P < 0.01$; Unit: ppm

Discussion

With respect to the drop in serum Ca level caused by F, Fujimoto et al. (10) proposed the following model equation to explain serum total Ca and Ca^{++} levels resulting from the mechanism shown above:

$$[Ca\text{–}Protein] \rightleftharpoons Ca^{++} + Protein,$$
$$Ca^{++} + F \rightleftharpoons [CaF^-] + F \rightleftharpoons CaF_2$$
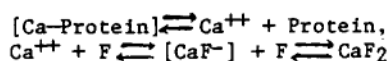
Based on this formula and the behavior of serum Ca after F adminis-

Figure 5

Urinary F⁻, 24 Hours After F⁻ Injection

* P < 0.01

Discharge of F (mg)

control   5mg F/kg   15mg F/kg
           injected   injected

☐ Low Ca diet   ■ Normal Ca diet

tration in rabbits fed a low Ca diet both total Ca and Ca^{++} in serum is usually lower than in the group fed normal Ca. This i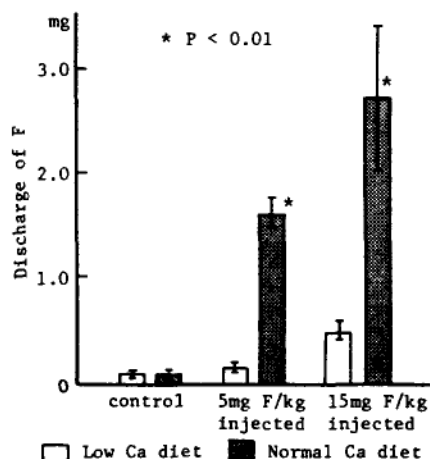ndicates that the capacity to inactivate the toxicity of F⁻ through reaction with the F⁻ which entered the blood stream and free protein-bound Ca^{++} in blood, (i.e., the capacity to compensate for drop in Ca concentration in a short period of time including absorption from bone) is small. The difference is considered to have caused a marked drop in serum total Ca and Ca^{++}, a delay in recovery and a marked elevation in the serum glucose level in the low Ca diet group compared to the normal Ca diet group. The elevation of serum glucose resulting from F⁻ administration, caused by inhibition of glycolytic enzyme activity such as enolase and phosphoglucomutase (11), is marked in the low Ca diet group, the level of active F⁻ in serum is high and retention prolonged.

Furthermore, phenomena specifically related to inhibition of F⁻ excretion, such as prolonged retention of F⁻ in serum and drastic reduction in urinary F⁻, were also observed in the low Ca diet group after F administration. This phenomena may be attributed to the fact that reaction products of F⁻, CaF or CaF_2 are readily excreted into urine. Therefore, in the low Ca diet group, with little Ca^{++} to mobilize for reaction with F⁻, a change in the somatic metabolism of F⁻ could be observed. In other words, Ca in serum plays the dual role of lessening the toxicity of F⁻ by binding with F⁻ which has already entered the body, as well as contributing to F⁻ excretion from the body. The differences observed between rabbits given a low Ca diet and those given a normal Ca diet are considered to result from a difference in serum Ca levels.

Conclusion

These phenomena have not been observed previously, It has been confirmed that changes take place in F⁻ metabolism and toxicity when Ca consumption is low. Thus, in countries where dietary intake of Ca is low, such as Japan and India, fluoride may have more serious toxic effects than elsewhere. Studies of the effects which might arise from oral administration of NaF are underway.

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A PRELIMINARY INVESTIGATION OF INDUSTRIAL FLUOROSIS
IN A HIGH FLUORIDE AREA OF CHINA

by

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SUMMARY: This paper reports an investigation of industrial
fluorosis in an area of Guizhou province, China, with fluo-
ride in drinking water up to 12.5 ppm. In view of the epi-
demiological analysis, the native workers have suffered du-
al effects from fluoride. The clinical manifestations, x-ray
skeletal changes and laboratory findings differed not only
from the original endemic fluorosis but, also, from simple
industrial fluorosis. The authors consider the results sig-
nificant and recommend further studies.

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Introduction

In 1932 industrial fluorosis was described for the first time in Danish cryolite workers (1). Roholm thoroughly described this disease in his classical book (2).   Subsequently, additional cases have been reported from numerous countries around the world (3). However, rarely has the hazard of industrial fluoride in a high fluoride area been noted. On the other hand bony lesions whether industrial, or endemic, or both, must also be identified. In this study the native workers came from a high fluoride area and had either been exposed to drinking water or foods high in fluoride prior to employment. Thus, the target organs, teeth or bones had very likely been adversely affected and were continually being damaged by industrial pollution during employment. On this account a preliminary investigation was carried out to evaluate the problem.

Material and Methods

From 700 workers, 146 male workers were selected by mass screening in an aluminum plant. They were suffering from higher than 0-1 industrial fluorosis according to Diagnostic Criteria described in a previous publication (4), and were divided into the following two groups:

1. 95 Natives whose ages ranged from 27-52 years (average 40.4) and the duration of whose employment averaged 15.41 years (4-26) had been residing in Xian Xi or Bi Jie districts, Guizhou province - where endemic fluorosis has been previously reported (5,6) - from 13 to 31 years prior to employment.

2. 51 workers from another province, where fluorosis was not endemic, ranged in age from 29-61 years (average 44.6); their employment period averaged 18.2 years (6-30).

Clinical examination was supplemented by skeletal x-rays. Orthopedic and dental examination in addition to electrocardiograms were carried out. The fluoride content in urine and enamel of the teeth was measured (7).

Regarding symptomatology, post-employment complaints of workers were genuine:

Workers were examined with reference to various large joint movements of the forearms, shoulders, knee and hip joints respectively. Examination of enamel mottling was performed according to Dean's index and enamel samples were collected simultaneously by dentists. Lastly, routine ECG check-up was recorded using 9 leads.

92 workers in an opencut alumina mine, situated 50 km distant from this factory, without industrial pollution by fluoride, were selected at random as controls. The fluoride content in urine of 72 workers and the

enamel of the teeth in 20 workers was analyzed for fluoride. Samples col-
lected from the environs of the alumina mine, including drinking water,
soil and vegetables were also analyzed for fluoride as well as the air
of the workshop and its surroundings.

Results

1. The potroom of this plant uses "vertical stud Soderberg cells"
in the electrolysis process. The plaster of carbon anode is roasted in
an open electrolyzer, HF and fumes with coal tar pitch were emitted from
pots.

F^- levels monitored in the workshop ranged from 0.87 - 3.18 mg/m^3.
In recent years 23 samples averaged 2.98 mg/m^3, two times the permissible
level in China namely, 1 mg HF/m^3. Outside, the atmosphere was seriously
polluted by fluoride emission. 100 meters (westward), it had increased
40.6 - 62.9 times (0.007 mg HF/day, mean value), which was above the per-
missible level in China.

Fluoride in drinking water, soil, rice, Chinese cabbage and celery
were determined by using F- electrode; each sample was analyzed 6 times.
Results are summarized in Table 1.

Table 1
Fluoride Content of Drinking Water, Soil and Foods

Place of sampling	Drinking Water (ppm)	Soil m/g/kg	Rice	Chinese cabbage	Celery
Mine area for control	0.2(Tap Water)	583.3 (280.0-760.0)	2.7 (2.6-2.8)	2.9 (2.5-3.0)	
Leeward position of workshop (50-300 meters)	11.7 (Well) (10.9-12.5)		1.64* (1.3-2.0)	3.1 (2.8-3.6)	8.5 (8.2-9.2)
Windward position of workshop (100-2000 meters)	———	1098.33 (1000.0-1580.0)	6.5** (6.3-7.0)	2.6 (2.2-3.3)	———

*Sample from canteen and nonlocal rice.   **Sample from local market.

The results indicated that fluoride in drinking water, from the tap,
was low in accordance with previous studies (5,6). The soil and local
staple foods (including the mine area) contained F$^-$ at high levels com-
pared with the low fluoride area of Guizhou province (6). Moreover, ow-
ing to industrial pollution, the fluoride level in well water near the
workshop contained fluoride at a seriously high level. Thus, the area
under study suffered dual effects from fluoride.

2. Complete clinical data were obtained on 115 nonendemic cases; the

analyses were as follows:

(1) in 76 natives, the mean age and period of employment were shorter than those of the 39 nonendemic workers. The native group averaged 40.4 years of age and 15.4 years of employment, compared to 44.6 and 18.2 respectively of the nonendemic group. Among native cases who suffered from fluorosis the degree of severity was as follows: 27 cases in stage 0-1, 34 in stage 1, 12 in stage 2, and 3 in stage 3.

The degree of fluorosis was usually related to the duration of residence in the endemic area. In other words, duration of residence of the cases above stage 1 who had been residing in the high fluoride area ·for 13-31 years (average 20.1) was longer than in those of stage 0-1, namely 14-28 years (average 18.8). Respecting the degrees of skeletal fluorosis in the nonendemic group with the exception of 28 cases in stage 0-1, all were in stage 1. In spite of the fact that their average age was older and they had been employed longer, neither stage 2 nor stage 3 was identified among them.

(2) The clinical manifestations of the two groups are presented in Table 2.

A common finding among the natives, poor nutrition and below average growth, was associated with markedly increased symptoms. Physical examination revealed that, in 90% of patients classified in stage 2 or stage 3, restriction of joint movement coincided with abnormal ossification around bones or articular degeneration.

(3) Concerning chronic nasopharyngitis, the frequency in the natives was higher than among the nonendemic group, possibly attributable to their lack of personal hygiene and incorrect use of labor protection devices.

Table 2

Comparison of Clinical Manifestations of Two Groups
(Positive Percentage %)

Clinical Manifestations	Native (76 cases)	Nonendemic (39 cases)
Neurasthenia syndrome	21.05	23.08
Abdominal pain	18.42	10.26
Backache	76.32*	51.28
Restricted joint movement	69.74**	28.21
Chronic nasopharyngitis	52.62*	33.33
Enamel mottling	66.22**	0
Lesions on surface of teeth	13.51*	38.46
Dental caries	10.81*	30.77
Periodontia	8.11	2.56

*$p < 0.05$; **$p < 0.01$

(4) Dental examination revealed that 66.2% of the native group had
dental fluorosis, 90.6 % of which were categorized higher than third de-
gree according to Dean's index. In the nonendemic group, the corroded
appearance on the surface of the teeth appeared to be caused by hydroflu-
oric acid erosion.

In general, enamel mottling can only occur when fluoride is absorbed
prior to eruption of permanent teeth. Therefore, in the present study,
it is recognized that dental fluorosis would not occur in adults from ex-
posure to fluoride and that, in native workers, enamel mottling was the
result of exposure to fluoride endemically prior to employment.

Routine ECG checkup was carried out on 108 cases, 72 of whom were na-
tives and 36 were nonendemic. The frequency of abnormalities was higher
in natives than in the nonendemic (41.7 versus 30.5%). Analysis of the
abnormal ECG features revealed that sinus arrhythmias were more frequent;
sinus arrhythmia and/or bradycardia were found in 40%; the remainder had
various conduction blocks, T wave changes (V_3, V_5), premature beats and a
few myocardial ischemias. The myocardium and arteries may have been dam-
aged by fluoride (8,9). According to this investigation, ECG changes
were more evident in native workers.

3. Analysis of radiograms of the pelvis, forearms and lower legs
are presented in Table 3.

According to x-ray skeletal films, the main change in both native
and nonendemic workers was osteosclerosis. The degree of skeletal lesions
was more severe in the natives than in the nonendemic group. In the na-
tives, pelvic trabeculae became linen-like, bone structure marble-like
but not in the nonendemic workers (Table 3). Regarding ossification
around bone or articular degeneration, some frequencies of occurrence in
both groups were approximately the same. With respect to pelvic deform-
ity the natives,particularly, seem to have suffered from osteomalacia due
to malnutrition or calcium deficiency during early development.

4. The urinary fluoride in both groups (102 cases; interval 24 hrs.
in the majority) averaged 3.3 mg/1 (0.4-19.8) compared with the average
of 0.9 mg/1 (0.2-8.1) in mine workers not exposed to industrial fluoride
pollution (p < 0.01). Moreover, the native group averaged 4.0 mg/1 (0.4-
19.8) and the nonendemic group 2.3 mg/1 (0.6-15.5) respectively. The dif-
ference between the groups was significant (p < 0.01). Urinary fluoride
levels showed that the body burden of fluoride was higher in natives than
in nonendemic workers.

Fluoride in enamel of teeth was determined according to procedures
described by Brudevold et al. (7). The enamel sample was taken from the
right maxillary central incisor by biopsy and performed as consistently
as possible. Samples for analysis were selected from 82 cases, 32 na-
tives, 30 nonendemic, and 20 controls. Significant differences (p<0.05)
in enamel F^- levels were found between the two industrial fluoride groups
average in the natives was 2888.2 ppm (399.2 — 20,267.3) in the nonendem-
ic 940.5 ppm (119.1 - 14,597.1). Between the 3 groups, the average enam-

Table 3

Comparison of Two Groups on Radiological Findings in Skeleton
(Positive Percentage %)

Radiological Findings	Native (95 cases)	Nonendemic (51 cases)
Pelvis:		
Various degrees of density increases	79.0	45.1
Trabeculae gauze-like*	22.1	17.4
Trabeculae linen-like**	18.9	0
Bone structure marble-like***	3.7	0
Deformity	20.0	5.9
Increase of density in extremity bones:		
Forearms	5.26	0
Lower legs	7.37	0
Ossification of ligaments and interosseous membranes:		
Sacrospinosum	16.8	3.9
Iliolumbale	37.9	51.0
Obturatoria	66.3	51.0
Forearms	66.3	45.1
Lower legs	81.1	82.4
Articular degeneration (calcifications in the capsule, chondrocalcinosis and osteophytes):		
Elbow	23.2	9.8
Knee	35.8	33.3

*Trabeculae - slightly coarse; **Trabeculae - obviously coarse;
***Trabeculae - no longer discernible, bone structure white
and marble-like.

el F⁻ level was lowest in controls, namely 818.5 ppm (129.0-7525.8). In
the control group, which consisted mainly of local mine workers, 75% had
dental fluorosis. It is suggested that the fluoride had only accumulated
on the surface of the enamel, which led to elevation of enamel F⁻; it did
not cause enamel mottling which is associated with industrial fluoride
pollution.

Discussion

An attempt was made to determine the degree of hazard due to industrial fluorosis in a high fluoride area of China. Our first locality of
investigation was an endemic fluoride area. In previous studies (5, 6)
the chief cause of fluorosis had been attributed to foodborne fluoride
which concurred with our investigation since the F⁻ level in drinking water was only 0.2 mg/l.

Actually, the native workers were suffering "double-effect" from dual sources of fluoride, in view of the fact that some of them had probably
been affected by endemic fluorosis, with dental or skeletal manifestations
or both, prior to employment.

Nonendemic workers, who were only exposed to industrial pollution,
suffered as did natives. However, in cases of industrial fluorosis, the

manifestations were the same (10).   In workers exposed to fluoride dur-
ing childhood, chronic fluorosis seemed more severe than in those first
exposed to fluoride as industrial workers. On the whole, we conclude with
the following thoughts:

In native workers (endemic plus industrial fluoride), the disease
was distinct from simple industrial fluorosis. The average employment pe-
riod for developing skeletal fluorosis was 15.4 years. This period was
shorter than that of previous studies (3,10) in which 12 cases (15.9 %)
had advanced to stage 2,and 3 cases (4.0 %) to stage 3. Clinically, the
level of nutrition and status of the body were inferior and some symptoms
were more frequent. Abnormal ECGs were common. Radiologically, the de-
gree of skeletal lesions was more severe. Enamel mottling became a pre-
dominant sign with elevated enamel F^- levels. As long as industrial pol-
lution remained at the same level, urinary fluoride content was high.

In China, the nutritional level of workers is superior to that of a
peasant. Therefore, in spite of the fact that bone lesions were found ex-
tensively at stage 3, rarely were scoliosis, kyphosis, and serious malfor-
mation on extremities observed. Thus the degree of skeletal lesions was
likely to be moderate. Due to inhalation of materials from industrial
pollution, the frequency of chronic nasopharyngitis was obviously elevat-
ed. In addition to enamel mottling, fluoride deposited on the surface of
the enamel caused F^- levels to be markedly high.

Conclusion

We believe that the dual sources of fluoride are significant and
should not be disregarded. As the result of our investigation, we sug-
gest the following:

1. Factories emitting fluoride should not be located in high fluo-
ride areas.
2. For the sake of safety, persons with endemic fluorosis should
not be employed where they are exposed to additional fluoride.

Acknowledgement

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EFFECT OF FLUORIDE ON SOFT
TISSUES IN VERTEBRATES
(A REVIEW)

by

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Detectable traces of fluoride occur in almost every substance, and animals everywhere consume measurable amounts of fluoride. At sub-lethal doses, the concentration of fluoride in blood will approach a steady state, proportional to the rate of fluoride infusion (1). However the total amount of fluoride in sera of different species given the same dose of fluoride varies considerably, and the peak concentration of fluoride in sera of these different species occurs at different times and varies in duration (2).

Signs of acute high dose fluoride poisoning in mammals are nausea, vomiting and diarrhea, followed by cramping, collapse, coma, and death. In humans, death from an oral dose usually occurs within 4 hours. The signs of chronic (low dose) fluoride poisoning are, however, less well defined.

The purpose of this paper is to summarize data concerning the effects of fluoride on various soft tissue systems in vertebrates after oral, subcutaneous, or intraperitoneal administration.

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Endocrine System

Adrenals: Several authors have reported an increase in weight of ad-
renals after fluoride intoxication, allegedly due to an increased content
of protein (3,4). McGown and Suttie (5) reported a four-to five-fold in-
crease in plasma epinephrine and suggested that the hyperglycemia induced
by the fluoride was mediated by epinephrine, secreted by the adrenal medul-
la. It is possible that these phenomena represent a general stress re-
sponse, secondary to metabolic poisoning by fluoride, and mediated through
the sympathetic nervous system.

Thyroid: In high enough concentrations , fluoride will interfere with
the functions of the thyroid directly or indirectly (6-8), but this effect
will be minimized when the supply of iodine is adequate (6). Fluoride may
interfere with the normal functioning of follicular cells, for example,
by inhibiting the proteinases responsible for splitting thyroglobulin mole-
cules into thyroxine and triiodothyronine (9, 10).   There could possibly
be an effect of fluoride on the feedback mechanism mediated through the
hypothalamus and adenohypophysis which regulate thyroid secretions through
thyrotropin (TSH).

Parathyroid: Studies on humans and animals indicate that, in high
enough concentrations, fluoride affects the function of the parathyroids
indirectly by altering serum calcium and phosphate (11-17). Evidence for
secondary hyperparathyroidism in fluoride-treated animals and man is
structural and ultrastructural appearance (12, 14,15, 17-19). It is also
based on changes in bone resorption (20) and direct measurements of para-
thormone concentrations in blood by radioimmunological assay methods (12,
21). In sheep, treated with 100 mg of fluoride ion per day for four weeks,
circulating parathormone increased five-fold (12). In humans, four out
of nine patients suffering from skeletal fluorosis had elevated levels of
immunoreactive parathormone (21).   However, in studies with rats, no
changes were found in the parathyroid glands, bone resorption and circu-
lating levels of parathormone (22-25).

Fluoride has caused a drop in the circulating calcium in man and in
several experimental animals (26-28). It has been suggested that the re-
duction in circulating calcium is due to fluorapatite formation and, be-
cause of its decreased crystal solubility, inhibition of osteoclastic
bone resorption. Any situation which causes decreased levels of circulat-
ing calcium would induce parathormone release and, if prolonged, would
lead to secondary hyperparathyroidism. Due to species variability (29-31)
and the dose-dependent effect of fluoride, it is reasonable to assume that
rats, which are known to be more resistant to fluoride than sheep and rab-
bits, would exhibit fewer toxic changes, particularly if the fluoride dose
is not excessive, as in the recent studies of Rosenquist et al. (25).

Urinary System

Nephropathy is a major manifestation of fluoride toxicity in its ear-
ly stages. Large doses of fluoride induce necrosis of the convoluted tu-
bules and inflammation of glomeruli, changes which result in impaired kid-

ney function such as polyuria, polydipsia, and increased non-protein ni-
trogen (33). In rats, at low levels (for example 1 to 10 ppm NaF), alter-
ations to kidney structure and function are reported to be minimal(34-37).

Renal function studies on rats exposed to constant IV infusion of flu-
oride have produced, in dose-dependent responses, an increase in urine
flow rate, urinary osmolality, inner medullary sodium and chloride concen-
trations, and glomerular filtration rate, and a decrease in the excretion
of sodium, chloride, and potassium (38).

All published data reflect the dose-dependent effect of fluoride on
kidney tissues. Tissue destruction increasing with the dose, and the tox-
ic effects are seemingly related to altered activity of enzyme systems,
some stimulated (37,39-40) and some inhibited (39, 41-42). As' kidney
damage increases, clearance of fluoride is reduced (43). The toxic effects
of fluoride are also exacerbated by the altered renal clearance of other
electrolytes, metabolites, and waste.

Digestive System

Gastrointestinal tract: Waldbott et al. (44) have designated stomach
and bowel disorders as cardinal features of fluoride intolerance in humans.
Formation of hydrofluoric acid in the gut appears to account for the symp-
toms of nausea, vomiting, abdominal pain, and diarrhea associated with
fluoride poisoning (44,45). Data on the effect of fluoride on absorption
of calcium from the gastrointestinal tract are equivocal (46-48). On
theoretical grounds, it might be expected that simultaneous administra-
tion of fluoride and calcium would result in reduced calcium absorption
due to precipitation of the relatively insoluble fluoride salts of calci-
um. It is not known whether fluoride interferes with the absorption of
calcium by the epithelial cells of the duodenum and jejunum. The possi-
bility that fluoride interferes with the active transport mechanism or
with calcium-binding proteins has not been explored.

Oral Mucosa: Branemark (49) cautioned dentists about the potential
toxicity of topical fluoride to gingiva, particularly when the tissue is
inflamed. Gabler (50) showed that fluoride ions can be absorbed through
the oral mucosa of rats, even if at a relatively slow rate.

The gingival crevice is a natural sink for the retention of fluoride
long after topical application has been completed. Patients with exten-
sive supra and/or infra-bony gingival pockets would be predisposed to
prolonged retention of fluoride against tissues.

In rabbits, Hume et al. (51) found that exposure to gingival ex-
plants to levels of fluoride up to 10,000 ppm reduced incorporation of H³
proline and H³ thymidine, and that the degree of depression varied direct-
ly with the concentration and exposure time. Comparison of their data
with that of previously reported studies showed that gingival tissue me-
tabolism was profoundly depressed by fluoride applications at or near the
in vitro threshold for preventing growth of suspected periodontal patho-
gens. However, if gingival epithelium were intact, fluoride toxicity

from topical application was considered to be negligible. Different cellular responses to NaF in vitro, namely genotoxic transformations, have been reported with other cells (52).

Liver: Fluoride interferes with the normal functioning of the liver and causes disruption of hepatocytes (53,54). The route of fluoride administration is important. Pathological changes in the liver of rats ensued following use of a gastric tube to administer chronic doses of the sodium fluoride and to ensure that each animal received a constant daily dose (55). On the other hand, deCamargo and Merzel (37) who simply added the fluoride to the water supply, found no changes in the liver. In the latter experiments, if the animals ate first and then drank, the fluoride would have entered a full stomach which might have resulted in decreased absorption of fluoride.

Cardiovascular System

Branemark (49) applied 0.05, 0.2, 1.0 and 2.0 per cent solutions of sodium fluoride to the cheek pouch of hamsters. The resulting disturbances varied in degree and severity according to the concentration of fluoride and the state of the tissue. Vascular changes, characterized by microvascular injury, perivascular disintegration of tissue cells, and vascular proliferation, predominated. Another indication of the vulnerability of vessels to fluoride is the microscopic appearance of the bruise-like skin lesions, Chizzola maculae which have been emphasized by Waldbott (44). (See "Skin" for additional details).

Large doses of NaF (12 mg/kg) fed to rats (56) have induced chronic myocarditis and dystrophic changes in heart muscle fibres. Massive doses of fluoride can cause severe heart damage resulting in cardiac irregularities and low blood pressure in experimental animals (57). Changes in ECGs of humans and dogs due to massive doses of fluoride have been cited by Baltazar et al. (58). It is not clear whether these cardiac changes are secondary to fluoride poisoning or a direct effect of fluoride on cardiovascular tissue. Most authors agree that calcification of arteries is an integral feature of skeletal fluorosis.

Central Nervous System

In humans, the partial and complete paralysis of arms and legs in advanced fluorosis is usually considered to be related to pressure upon the spinal cord by newly formed bone protruding into the spinal canal, and upon nerves at the point of their exit from the spine. However, it has been suggested that the spinal cord lesions and muscular damage in patients suffering occupational fluorosis are also the result of a direct action of the fluoride ion on the ganglion and muscle cells (59).

Due to a lack of precise experimental data, it is difficult to draw conclusions concerning the effects of fluoride on the central nervous system. It seems likely that chronic ingestion of low doses of fluoride stimulates enzymes systems (60), and that this effect may be mediated through fluoride activated adenylate cyclase (61,62).

Eyes: Large doses of NaF are toxic to the retina in varying degrees. Waldbott (44) observed in his patients, that fluoride could cause a widening of retinal vessels leading to retinitis and involvement in cataract formation.

Rabbits and mice show dystrophy of retinal pigment cells with subsequent damage to the photoreceptors by fluoride doses exceeding 25 mg/kg body weight (55). In the ganglion cells of the retina, the content   of rRNA was reduced in mice when the dose of fluoride was 12 mg NaF/kg body weight. This inhibition of RNA synthesis was more pronounced in the ganglion cells, and a decrease in protein synthesis was detected in the perikaryons of the photoreceptors. It has been proposed that this retinopathy is correlated with a disturbance of ascorbic acid metabolism, namely in the transport of its oxidized form (4). The retina is basically composed of modified neurons (rods, cones). As such, it is susceptible to fluoride toxicity. Furthermore, the production of rhodopsin (visual purple) is dependent upon several enzyme-catalyzed reactions, which may be inhibited by fluoride.

Respiratory System

Gaseous fluoride above 3 ppm for more than 10 minutes (63) is toxic to respiratory tissues. Whitford et al. (64) however, found no evidence of fluoride binding in the lung of rats following a single intravenous injection of ^{18}F, 9.1 μCi/rat. Detailed histological investigations as well as studies on the effects of ingested fluoride on respiratory tissues seem to be lacking.

Some Selective Tissues

Muscle: The signs and symptoms of muscle involvement in acute fluoride toxicity, namely hyperactive reflexes, painful muscle spasms, weakness and tetanic contractions have been related to fluoride-induced hypocalcemia. Studies are lacking on the direct effect of an acute dose of fluoride on muscle. In chronic fluoride intoxication, fluoride seems to alter muscle function and to damage muscle cells (44, 65,66) but,if the dose is not excessive (4), muscle is able to adapt to the insult.

Skin: From clinical observations, Steinegger (67) and Waldbott (68) described a characteristic sign of chronic fluoride poisoning which occurs mainly in children and women, namely, pinkish to bluish-brown skin lesions called Chizzola maculae (inflammation around capillary blood vessels). These lesions can be distinguished from traumatic bruises, mainly because they are always round or oval, about 1 to 2.5 cm in diameter, and are usually asymptomatic. They fade after 5 to 7 days but do not turn yellow as do bruishes, which can be any size or shape. There is little doubt that fluoride is involved in the production of these lesions. However the lesions were not reproduced experimentally; their high prevalence among children and women suggest that other factors as well as fluoride may be involved (68,69).

Collagen: Fluoride influences the metabolism of bones and teeth. It

has been proposed, but not proven, that it is essential for normal calcification (70,71). Excessive fluoride intake can interfere with bone metabolism, particularly through its effect on collagen formation: 2 mg F/kg body weight given to young rabbits (72) interfered with the normal hydroxylation of proline, producing inadequately hydroxylated collagen; fluoride reduced the synthesis of tropocollagen molecules with reduced numbers of aldehydes resulting in inadequate cross-linked collagen fibres; reduced lysine residues which caused inadequate cross links in collagen; and the collagen laid down during excessive exposure to fluoride was more rapidly catabolized. Fluoride has also been shown to decrease the amount of soluble and insoluble collagen in skin and lungs (73). Joseph and Tydd (74), however, found that 10 and 150 ppm sodium fluoride in the drinking water of rabbits accelerated tissue regeneration during the first three or four weeks following removal of the whole thickness of 1 cm^2 of the rabbit's ear.

The mechanism of the effect of fluoride on collagen metabolism is still unknown. At high concentrations, fluoride may inhibit proline uptake into collagen and its conversion into hydroxyproline but at the same time stimulate enzyme systems involved in collagen formation. It is difficult to compare the work of Susheela and Sharma (71) and that of Drozdz et al. (73), with that of Joseph and Tydd (74) because their research protocols differed; tissues and animals studied were different; the fluoride was administered differently and the fluoride doses differed. Nevertheless, fluoride administration seems to lead to production of abnormal collagen (75).

Retention of fluoride in soft tissues: Under normal conditions soft tissue organs contain little or no fluoride (68,76). However, with impaired kidney function or prolonged fluoride exposure, relatively large amounts of fluoride can accumulate in soft tissues (44). Based on data from a survey by Call et al. (77) on humans, the order of magnitude of storage is as follows: aorta, thyroid, lung, kidney, heart, pancreas, brain, spleen and liver. Levels as high as 8400 (78) ppm in the aorta have been recorded in a fluoridated area; 290 ppm in skin (79), 186 in nails (79), 185 in bladder (79), and 181 (79) in kidneys in an area with little or no fluoride in water.

Accumulation of fluoride may be involved in many disease processes and it may induce a wide variety of signs and symptoms. Fluoride is one of the most reactive ions in nature. To what extent it affects the function of vital organs remains an enigma. Further work on this and on certain idiopathic clinical phenomena are warranted.

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CYTOTOXICITY, CHROMOSOME ABERRATIONS AND UNSCHEDULED DNA SYNTHESIS IN
CULTURED HUMAN DIPLOID FIBROBLASTS INDUCED BY SODIUM FLUORIDE

by

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The effects of exposure of cultured human diploid fibroblasts (JHU-1
cells) to sodium fluoride were studied with respect to cytotoxicity as
well as induction of chromosome aberrations and unscheduled DNA synthesis
(UDS). Cytotoxicity of NaF on JHU-1 cells, as determined by a decrease
in colony-forming ability, increased linearly with increasing dose of NaF
(50-150 µg/ml) or exposure time (1-24h). Treatment of the cells with 50µg
NaF/ml for 24 hours resulted in a lethality ($\approx$70%) similar to that ob-
tained with 100 µg/ml for 12 h. When JHU-1 cells were treated with 20 -
50 µg NaF/ml for 12 or 24 h, and analyzed for chromosome aberrations, a
significant increase in the frequency at the chromatid level was observed
in a dose-dependent manner. The minimum significant level of chromosome
aberrations or UDS was induced by treatment with 20 µg NaF/ml for 24 h or
100 µg/ml for 8 h (Table 1).

Table 1

Chromosome Aberrations of Human Diploid Fibroblasts Induced by NaF

Dose of NaF (µg/ml)	Treatment period(h)	Number of meta-phases scored	Type of aberrations[a] (%)						Aberrant meta-phases (%)
			G	B	E	D	O	F	
0	12	400	1.8	0	0	0	0	0	0.8
25	12	500	2.8	0	0	0	0	0	2.8
50	12	112	16.1	3.6	0	0	0	0	17.9
75	12		few metaphases						
0	24	100	1.0	0	0	0	0	0	1.0
20	24	100	6.0	2.0	0	0	0	0	7.0
40	24	100	39.0	21.0	0	0	0	0	47.0

[a]G, gap; B, break; E, exchange; D, dicentric; O, ring; F, frag-
mentations

The number of times the population of JHU-1 cells used in this study
doubled was between 15 and 20. In control cultures, few metaphases con-
tained chromosome aberrations.

For detection of UDS, confluent JHU-1 cells were cultured with medium
containing low serum. Subsequently they were exposed to NaF in the pre-
sence of 10 mM hydroxyurea. Treatment with 100-400 µg NaF/ml for 4 - 24 h

reproducibly elicited UDS in a dose-related fashion as determined by direct scintillation counting of [^{3}H] thymidine incorporated into DNA during repair synthesis. Induction of UDS in JHU-1 cells was observed in a dose-dependent fashion by all the chemicals except benz(a)pyrene which requires oxidative metabolic conversion not found in human diploid fibroblasts.

In other recent studies, DNA single-strand breaks, detected by the alkaline elution method, were elicited in JHU-1 cells treated with NaF (100-200 μg/ml) for 16 h.

Regarding the delay in response of DNA repair in NaF treated cells, two possible explanations may be considered. First, the possibility that DNA damaging activity of fluoride may be weak or insufficient to induce detectable DNA damage during a short treatment time under our conditions. Secondly, inhibition of protein synthesis by fluoride may retard the process of DNA repair following DNA damage. It has been known for some time that fluoride inhibits a number of metalloproteins including DNA polymerase of E. coli. Further experiments are necessary to elucidate these possibilities.

In conclusion, the present studies provide the first evidence that NaF induces chromosome aberrations and UDS in human diploid fibroblasts in vitro. In recent experiments, when Syrian hamster embryo cells were exposed to between 75 and 125 μg NaF/ml for 24 h, cell survival was approximately 90-40% and the frequency of morphological transformation of the cells was dose-dependent. Mass cultures of cells treated with 75 or 100μg NaF/ml for 24 h, followed by continuous cultivation, were transformed to the tumorigenic state. Furthermore, a significant increase in chromosome aberrations at the chromatid level, sister-chromatid exchanges and UDS was induced by treatment of the same cells with 40-100 μg NaF/ml for 24 h. These results suggest that NaF is potentially dangerous to humans.

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Abstract

INDUCTION OF UNSCHEDULED DNA SYNTHESIS IN CULTURED
HUMAN ORAL KERATINOCYTES BY SODIUM FLUORIDE

by

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The effect of treatment of cultured human oral keratinocytes with so-
dium fluoride (NaF) was investigated with respect to induction of unsched-
uled DNA synthesis (UDS). Oral keratinocytes were isolated from excised
buccal mucosa of normal individuals by trypsinization at 4° C. overnight
following which the mucosal epithelium was separated from lamina propria
mucosae with forceps. Isolated cells were cultured in vitro and all ex-
periments were performed with secondary cultures.

For detection of UDS, the keratinocytes were cultivated with medium
containing 1% fetal calf serum (FCS) for 2 days. Subsequently they were
treated with 100-300 μg NaF/ml for 4 h in medium containing 1% FCS and 10
mM hydroxyurea (1% FCS-HU medium). Following NaF treatment, UDS was mea-
sured by direct scintillation counting of [^{3}H] thymidine incorporated in-
to DNA of the cells in 1% FCS-HU medium.

UDS at significant levels was induced in a dose-related fashion by
NaF treatment. The results suggest that NaF causes DNA damage in cultured
human oral keratinocytes.

Other recent findings show that treatment of cultured human diploid
fibroblasts with NaF result in induction of chromosome aberrations and UDS
and that NaF causes morphological and neoplastic transformation of Syrian
hamster embryo cells, as well as chromosome aberrations, SCEs and UDS in
the same cells. These results, including the present data, suggest that
NaF treatment leads to DNA damage in cultured mammalian cells. Further
studies with living cells are needed to resolve the mechanisms whereby NaF
causes DNA damage and neoplastic transformation, and its carcinogenic risk
to man.

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DENTAL CARIES AND STRONTIUM CONCENTRATION
IN DRINKING WATER AND SURFACE ENAMEL

by

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Among trace elements, other than fluoride, strontium has been referred to as a possible cariostatic agent, evidence for which has been derived from a number of experimental and epidemiological studies.

The present study was designed to investigate the effect of strontium on the development of dental caries in the absence of significant fluoride concentrations by relating the DMFT index to the strontium concentration of drinking water and in surface enamel. An epidemiological survey of dental caries was conducted in two selected neighboring districts in the northwestern part of Greece - Ioannina and Arta - where the drinking water contains almost the same low amounts of fluoride and selenium but different amounts of strontium. Also, strontium and fluoride determinations in enamel surfaces were carried out on samples obtained from the population examined in both districts. Male and female children(582), ranging in age from 11 to 14, lifelong residents of two neighboring districts, Ioannina (282) and Arta (300), who represented approximately 10% of the population of this age group in each district, were surveyed.

Strontium concentration was low (0.2-1.3 ppm) in Ioannina, and high (2.9-7.0 ppm) in Arta. In both districts, fluoride (0.05-0.06 ppm), calcium and selenium (<0.003) were low; calcium was 32.5 in Ioannina and 40.0 in Arta. For all age groups, the DMFT index is higher in the low-strontium area than in the high-strontium area. These differences were statistically highly significant ($p < 0.05-0.01$), using Student's t test. The average value of fluoride concentration in the examined samples of surface enamel from both districts was about the same.

Table 1

Dental Caries Prevalence in Low-and High-Strontium Areas
in Persons 11-14-Years Old

	Ioannina		Arta			
Age	No. of Children	DMFT Mean±SD	No. of Children	DMFT Mean±SD	t^a	Significance
11	47	5.21±2.68	68	3.62±2.02	3.593	$p < 0.01$
12	71	5.77±2.75	51	4.57±2.84	2.326	$p < 0.05$
13	84	7.61±3.82	91	5.93±3.61	2.973	$p < 0.01$
14	80	9.25±4.94	90	6.94±4.04	3.372	$p < 0.01$

Total 282 Ave. 6.96   Total 300 Ave. 5.26

[a]Comparison of two means with degrees of freedom ($n_1 + n_2 - 2$).

FLUORIDE

The socio-economic factors, as well as nutrition and dietary habits, the dental care received, including application of preventive measures, were similar. In both districts, the low fluoride concentration eliminates the possibility that the fluoride could be a factor in explanation of the observed differences.

The strontium concentration was not only significantly higher in the drinking water of the Arta district, with lower DMFT values, but the strontium concentration in the surface layer of enamel was also higher in the Arta high-strontium district. Therefore, the observed differences in the DMFT values between the two districts appears to be due to the differences in the strontium concentrations in drinking water. The cariostatic effect of strontium is exerted regardless of whether the element is incorporated into enamel during or after tooth development. Whether strontium causes heteroionic exchange of calcium in the apatite lattice rendering the apatite crystal less susceptible to demineralization by acids remains to be established.

These findings support the concept that the strontium incorporation in dental enamel renders it more resistant to caries.

KEY WORDS: Caries; Strontium; Enamel; Greece, caries and drinking water in

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ENDEMIC FLUOROSIS IN ANDHRA PRADESH

by

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About a decade ago, an ominous new dimension was added to the problem of skeletal fluorosis. The National Institute of Nutrition at Hyderabad discovered that, in parts of Andhra Pradesh, long known to be endemic to fluorosis, large numbers of adolescents and young adults have developed genu valgum (knock-knees), the deformity characterized by outward bowing of the legs from the knees down. Occurring mainly between ages 10 and 20, genu valgum not only has added to existing economic problems but has also created new psychosociological ones. In 28 selected villages in three of the endemic districts, more than 600 (2.8%) of about 21,000 subjects examined had the deformity. The prevalence rates among villages ranged between 0.2% and 17%.

Construction of dams leads to an elevation in the level of subsoil water in the dam vicinity; soil alkalinity rises and influences the concentration of trace elements in food grains grown in that area. A consequence of the increase in the content of the trace element molybdenum is the rise in consumption of molybdenum-rich foods which leads to copper deficiency in the body. In turn, copper deficiency can lead to osteoporosis, a possible contributing cause of genu valgum.

The relationship between development of genu valgum and dam construction, together with elevated fluoride intake, appears to be one of cause and effect, not merely coincidence: where dams have not been built, genu valgum has not made an appearance except in the Punjab. The further role of dietary and nutritional factors is not clear. According to Lakshimjah and Srikantia, when fluoride intake is similar, fluoride retention and therefore toxicity is higher on jowar-based diets than on wheat or rice-based diets. Prevalence was four times higher among those whose staple food is jowar than in nonjowar eaters.

In adults, fluoride toxicity affects the bony skeleton, ligaments, and tendons thereby leading to irreversible and incurable crippling. The central pathological process, excessive formation of bone and inappropriate calcification of soft tissues, leads to limitation of movement of the spine and joints as well as neurological manifestation due to pressure on peripheral nerves.

In view of epidemiological surveys in parts of India where crippling fluorosis has been recorded in subjects habitually consuming only 1 ppm fluoride in water, 0.5 ppm should be the upper limit for fluoride in drinking water for protection of the entire population from fluoride toxicity. Prevention is imperative because, once the disease sets in, there is no known treatment for it.

KEY WORDS: Fluoride; molybdenum, nutrition; Genu valgum; Dam construction; Osteoporosis; Copper deficiency.

Reprints: T.K. Parathasarthy, Editor, Nutrition Foundation of India, B-37, Guimohar Park, New Delhi

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CARDIOPULMONARY RESPONSE TO SODIUM
FLUORIDE INFUSION IN THE DOG

by

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Ft. Worth, Texas

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(Abstracted from J. of Toxicol. and Environ Health, 11:765-782, 1983)

Because humans are occasionally acutely exposed to high levels of fluoride (F⁻), and cardiac and especially pulmonary tissue accumulate

higher concentrations of F⁻ than do the other soft tissues, the present
study was undertaken to investigate the effects of acute exposure to tox-
ic plasma levels of F⁻ on cardiopulmonary hemodynamics.

Anesthesized dogs were instrumented with right and left cardiac cath-
eters to measure pulmonary arterial and wedge pressures, left ventricular
and aortic pressures, left ventricular dP/dt, and cardiac output. An in-
travenous loading dose of NaF followed by a 3-h infusion produced a plas-
ma F⁻ level of 800 μM in the "low" group of 6 animals, and 1300 μM in the
"high" group. The mean pulmonary arterial pressure peaked at 1 h, 83%
above preinfusion values in the high group, while that of the low group
attained the same level by the end of the infusion period. Impaired pul-
monary gas exchange, as indicated by an increased alveolar-arterial P_{O_2}
gradient occurred in half the animals, and an obvious hyperventilation
was reflected in a decreased P_{CO_2} value; there was no change in arterial
pH. ECG T-wave peaking was common. The central venous pressure declined
steadily, while there were no significant changes from controls in system-
ic arterial pressure, heart rate, cardiac output, or myocardial contrac-
tility (dP/dt). Thus, pulmonary hemodynamics and the systemic capaci-
tance vessels are more affected by acute exposure to F⁻ than is cardiac
function.

                                Authors' Abstract

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                    INORGANIC FLUORIDE CONCENTRATION AND RENAL
                     FUNCTION AFTER ENFLURANE ANESTHESIA

                                    by

                               Shoko Aso
                             Fukushima, Japan

Methoxyflurane is metabolized, in part, to inorganic fluoride. Cases
of fluoride ion-induced renal failure have been reported following its
use. Enflurane undergoes similar metabolism.

In the present study, serum and urinary inorganic fluoride concentra-
tions during and following anesthesia were measured, and the influence of
enflurane on renal function was monitored in 15 surgical patients.   For
comparison, six control patients were anesthetized with halothane.

Moreover, inorganic fluoride levels in 5 elderly patients between
63-76 years of age and in 10 younger subjects 18-52 years old were com-

pared during the following enflurane anesthesia. Inorganic fluoride lev-
els were measured by an Orion Specific Ion Meter Model 407 with the fol-
lowing results:

1. Peak serum fluoride levels were higher (34±10.0 vs. 15.0±4.1 µM/
L) in elderly patients than in younger subjects.   These levels were
reached 2 hours after termination of enflurane anesthesia.

2. Peak urinary fluoride levels were also higher (1409±492.9) vs.
827.6±353.6 µM/L) in elderly than in younger patients.

3. Patients anesthetized with halothane showed insignificant changes
in serum and urinary inorganic fluoride concentrations.

4. BUN, serum creatinine, Ccr, Cosm and TcH_2O did not change from
preoperative values.

Metabolism of enflurane to inorganic fluoride was insufficient to
cause clinically significant renal dysfunction. However, it should be
noted that enflurane anesthesia in elderly patients may induce renal dys-
function.

KEY WORDS: Enflurane, halothane, methoxyflurane anesthesia; Serum and
            urinary F levels

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           Japan.

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<center>Ostéose fluorée d'origine hydro-tellurique
chez une insuffisante rénale</center>

<center>FLUOROSIS DUE TO FLUORIDE IN WATER AND SOIL IN A
CASE OF RENAL INSUFFICIENCY</center>

<center>by</center>

<center>B. Hurault De Ligny, B. Gilson, A. Mariot, M. Keszler,
A. Arlot, P.J. Meunier, and C. Huriet
Paris, France</center>

<center>(Abstracted from Sem. Hop. Paris, 60:119-123, 1984)</center>

Chronic renal insufficiency due to a congenital renal malrormation
was aggravated in a 23-year-old Algerian woman by fluoride in her drink-
ing water (2.70 mg/l). Roentgenograms indicated osteosis with bone densi-
ty suggestive of fluorosis rather than renal osteodystrophy. Fluoride as-
says of bone specimens confirmed this diagnosis.

Histomorphometric analysis of bone biopsy specimens showed mixed le-

sions; major osteocondensation due to bone fluorosis and morphologic and dynamic osteomalacia were related to the chronic renal failure.

In addition to fluoride obtained from water (2.70 mg/1), estimated to be 2 to 3 liters per day or up to 8 mg per day, a considerable amount of fluoride was ingested through tea high in fluoride and from dates.

Hydrofluorosis is rare among patients less than 35 years old.

Key words: Renal insufficiency; Skeletal fluorosis.

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Action du F⁻ sur le métabolisme hépatique de la diméthylnitrosamine et du benzo(a)pyrène chez le rat

ACTION OF F⁻ ON DIMETHYLNITROSAMINE AND BENZO(A)PYRENE LIVER METABOLISM IN RATS

by

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(Abstracted from Toxicological Eur. Res., 5:31-35, 1983)

The action of fluoride on liver metabolism of dimethylnitrosamine and benzo(a)pyrene was investigated with respect to three following parameters: (a) dose level, (b) age of rats, and (c) method of administration. The results showed that, parallel with increasing the dose to certain concontrations either by intraperitoneal injections, ingestion, or inhalation, there occurred generally an induction of dimethylnitrosaminedemethylase and a reduction in the amount of cytochrome P_{450}. On the other hand, fluoride failed to affect benzo(a)pyrene metabolism.

For this study, inhalation seems to be the most suitable method of F⁻ administration. It permits the level in blood to remain relatively constant, and it brings about the greatest changes in the metabolism of dimethylnitrosamine (30 to 70% induction) and 10 to 40% decrease in cytochrome P_{450} compared to controls. Under the conditions of the experiment, fluoride augments the carcinogenic effect of dimethylnitrosamine without affecting benzo(a)pyrene.

KEY WORDS: Dimethylnitrosamine, Benzo(a)pyrene; Cytochrome P_{450}; Fluorine.

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