FLUORIDES

FLUORIDATION AND

ENVIRONMENTAL QUALITY

(Translation)

Report prepared for the

MINISTER OF THE ENVIRONMENT

by the

ADVISORY COMMITTEE

ON THE FLUORIDATION OF WATER SUPPLIES

Gouvernement du Québec

Ministère de l'Environnement du Québec

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Sainte-Foy

November 1979

Québec, November 30, 1979

Monsieur Marcel Léger
Ministre de l'Environnement
Edifice "A", bureau 56
Assemblée nationale du Québec
Cité parlementaire, Québec

SUBJECT: Report on Fluorides, Fluoridation and Environmental Quality

Dear Sir,

I am pleased to submit the report which the Advisory Committee on the fluoridation of water supplies has just prepared on the above subject.

Much more comprehensive than was originally planned, this study confirmed among other things that water which is artificially fluoridated to inhibit tooth decay contains mutagens.

Full-scale retrospective epidemiological studies whose scientific value has been demonstrated before the

courts have revealed that there is a marked correlation between increased cancer mortality rates and the artificial fluoridation of public water supplies.

In the light of these and other findings dealt with in the report, the committee recommends that application of Bill 88 be suspended indefinitely until such time as the studies required to scientifically evaluate the risks of artificial fluoridation to the population have been fully considered and acted upon.

In the last section of this report, you will find a summary of the committee's conclusions followed by the appropriate recommendations (see pages 189 to 207).

Yours truly,

J.-BENOIT BUNDOCK
Senior adviser to the minister
Ministère de l'Environnement du Québec

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INTRODUCTION

1. AIM OF THE REPORT

In June 1975, the Québec government enacted Bill 88 compelling municipalities which had their own water treatment plants to fluoridate their water supplies to a fluoride concentration of 1.2 ppm (parts per million). The purpose of this legislation was to reduce tooth decay (1).

Since that time, it has been difficult to enforce Bill 88. Major scientific and technical problems which had not been foreseen or had not been thoroughly investigated before the bill was adopted have now arisen and pressure has been continuously brought to bear on the government to reexamine the effects of fluoridation on the environment and on health before proceeding further (2).

As early as 1975, the Conseil consultatif de l'environnement had voiced concern over an increase in fluoride sources in the environment and the failure to recognize the problem. The Conseil recommended a general study of the matter to evaluate all the consequences (social, medical, environmental) before any new source of fluoride was introduced into the environment (3).

Large-scale retrospective epidemiological studies carried out recently show that there is a significant correlation between higher cancer mortality rates and artificial fluoridation of public water supplies. Even though these studies are a subject of scientific controversy, they must be given close attention if the risks to people using artificially fluoridated water are to be accurately determined (4) (5).

A multidisciplinary study carried out last year by the environment protection services revealed that the control system for standardizing artificial fluoridation of water supplies was ineffective (2).

To correct this, the minister responsible for the environment asked the advisory committee on fluoridation of the environment protection services to reevaluate the situation and report its findings to him as early as possible.

2. METHODOLOGY

In carrying out its mandate, the committee took a comprehensive and multidisciplinary approach. A first analysis of the situation revealed that the many questions raised on the subject of fluoridation are only part of a

wide range of much deeper problems linked to the increase of fluorides and their effects on public health and the environment. Artificial fluoridation of water supplies is in fact only one of the many sources of fluorides to which people, animals and plants are increasingly exposed; fluorides are also present in water, air and in various foods and there are other very specific sources such as toothpastes and teflon cooking pans which have a polyvinyl fluoride base, but all are environmental contaminants (6).

Given the resources available to it, the committee decided to begin with as comprehensive a study as possible of fluorides and their effects on health and the environment.

The committee then conducted a more detailed study on some of the technical, ecological, medical and administrative problems linked to fluoridation.

3. DIVISIONS OF THE REPORT

This report comprises eight chapters and ends with conclusions and recommendations.

1. Chapter one is devoted to a brief study of the various fluoride sources and their effect on the environment.

It goes on to deal with environmental fluoride sources, their toxicity and their increase, and assesses the amounts of fluorides ingested by human beings.

2. Chapter two deals with industrial fluoride emissions as a source of environmental pollution. A number of sections look at the different forms and sources of fluorides and the quality of the work environment; others deal with industrially-induced fluorosis and atmospheric pollution in the vicinity of industrial plants.

3. Chapter three studies the effects of fluorides on the environment and discusses protection measures for ecological milieu. The first section of this chapter deals with the effects on plants and wildlife of fluorides unrelated to water fluoridation. The next section studies the effects of water fluoridation on animal and plant life. The last section looks at the effect on living creatures of fluoride accumulation along fresh water food chains.

4. Chapter four deals with the medical evaluation of fluoridated water supplies. It examines first the effectiveness of fluoridation in preventing dental caries and then its side effects.

5. Chapter five deals with water quality and problems related to fluoridation. It first studies the quality standards necessary to maintain public health and protect the environment. It goes on to examine the technical problems involved in maintaining optimum fluoride concentration during the fluoridation process itself.

6. Chapter six looks at Canadian legislation on the artificial fluoridation of water supplies as a tooth decay inhibitor. The risks of a conflict between section 26 of the Public Health Protection Act and the regulations respecting water supplies (Environment Quality Act) are also evaluated.

7. Chapter seven comprises a brief description of Canadian, American and Quebec court decisions on the fluoridation of public water supplies.

8. The eighth and last chapter reviews the principal fluoridation experiments conducted in Canada and abroad.

4. ADVISORY COMMITTEE ON THE FLUORIDATION OF WATER SUPPLIES

Appendix I of this report lists the members of the advisory committee on the fluoridation of water supplies who participated in the preparation of this report.

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C H A P T E R I

PRESENCE AND EFFECTS OF FLUORIDES IN THE ENVIRONMENT

CHAPTER I

PRESENCE AND EFFECTS OF FLUORIDES IN THE ENVIRONMENT

This first chapter deals briefly with fluoride sources and their effects on the environment.

In the few years since fluorides began to be used to combat dental decay, and it was recognized that in the long term industrial fluoride emissions result in insidious chronic intoxication, fluorides have been ranked high among environmental problems.

Their toxicity is such that in 1947, the American Association for the Advancement of Science considered the fluoride ion the most dangerous atmospheric pollutant after sulphur dioxide and ozone, and placed it third among the urgent problems to be examined in this field (56).

People today are increasingly exposed to fluorides and it is important to determine the total amount they ingest little by little from water and beverages, air and food and from specific sources such as toothpastes and cooking utensils which have an internal coating of organic fluorine derivatives (teflon: polyvinyl fluoride) (57).

In this respect, it is necessary to prevent the cumulative effects of fluorides which may lead to long term intoxication through repeated absorption. While it would take a much greater dose than one gram of sodium fluoride to cause a severe intoxication in humans, a repeated daily dose of a few centigrams would be sufficient over a long period of time to cause an intoxication called "fluorosis" which is manifested by dental and bone lesions due to the retention of fluorides by calcified tissues.

1.1 Sources of fluorine and fluorides (59)

Fluorine is a constant constituent produced by the slow weathering of eruptive rocks both on the soil and in sea and surface waters. However, the marked insolubility of most natural fluorides severely restricts their diffusion by water. In certain regions (North Africa, Colorado), fluorine-containing rocks are found on the ground and once they have been weathered to dust, they are carried by the winds onto fodder crops and thus, indirectly, into the animal kingdom.

The principal minerals containing fluorine are fluorspar, CaF_2 and cryolite, sodium fluoaluminate $Na_3 AlF_6$; the world's largest deposits of cryolite are found at Ivitgut, in southeastern Greenland. These two minerals are much

used in the metallurgical industry as fluxes, especially in aluminum metallurgy. The steel industry also uses certain quantities.

Fluorine is also present in some mineral species as a secondary constituent or as an impurity. It is present in the apatites having the general formula $3Ca_3(PO_4)_2$, CaX_2 or X-F, Cl or OH. These phosphate minerals are the raw material used in the manufacture of superphosphates used as fertilizers and it will be shown that fluoride emissions into the atmosphere which result in severe intoxication may be traced to this product. When the apatite is attacked by concentrated sulfuric acid, calcium fluoride frees hydrofluoric acid which, in the presence of silica, yields silicofluoride:

$$Si\ O_2 + 4HF \longrightarrow Si\ F_4 + 2H_2O$$

In contact with water either in the atmosphere or in tower scrubbers, silicofluoride is transformed into hydrofluosilicic acid:

$$SiF_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HF$$

$$2SiF_4 + 4HF \longrightarrow 2Si\ F_6H_2$$

It is generally this acid or its salts which are found in polluted air; sodium and aluminum fluosilicates or silicofluorides are soluble in water and are found in the waste-water ponds of the superphosphate industry.

Silicofluorides are decomposed by heated alkalis; incineration in the presence of bases is the first step in any determination of fluorides no matter what the source of the sampling:

$$Na_2Si\,F_6 + 4NaOH \longrightarrow 6NaF + SiO_2 + 2H_2O$$

1.1.1 Fluorine in water (60)

Sea water contains from 1 to 1.4 ppm ionic fluorine. It is always present in fresh water for fluorine is a universal mineralizing element; its concentration varies by a few fractions from 1 to 5 or 6 ppm. Exceptionally, fresh water may contain up to 10 or 12 ppm fluorine generally in the form of alkaline fluorides.

In the United States, more than 1 500 municipalities are supplied with raw water containing more than the optimum 1.2 ppm fluorine concentration; they must then precipitate the excess fluorine by means

of lime or alum floc; if water contains more than 1.5 ppm fluorine, dental fluorosis appears in the form of unsightly black stains.

Since water fluoridation is becoming more and more prevalent on the North American continent, it must now be included with the other fluoride sources.

1.1.2 Fluorine in the air (61)

The fluoride ion concentration in the air in rural or urban residential areas is generally very low, ranging between 0.04 and 1.20 ppb (0.03 to 0.9 mg F/m^3) which makes an analytical determination difficult. But this concentration can be increased appreciably by industrial activity; in the vicinity of aluminum plants for instance, fluoride concentrations in the air have been found to range from 3 to 18 ppb and sometimes even as high as 80 ppb (70 mg F/m^3). Industry-induced fluoride air pollution can come from many sources and may be in the form of gaseous products such as hydrofluoric acid or solid substances reduced to very fine dust particles which may or may not be soluble in water.

- Coal may contain up to 550 ppm fluorides, part of which is vapourized with the ashes; it is estimated that in 1961, 25 000 tons of fluorides were dispersed into the atmosphere in England and Wales from coal alone.

- One ton of cryolite is needed to produce one ton of aluminum and 20 kg of the cryolite are lost by vapourization into the atmosphere (about a third of this in the gaseous state and two-thirds in the form of solid particles).

- The steel industry uses from 5 to 40 pounds of fluorspar for each ton of steel produced.

- The oil industry uses hydrofluoric acid to catalyze the alkylation reaction which results in high octane gasoline; one particular refinery loses 500 to 750 tons of hydrofluoric acid annually.

- The ceramic and brick-making industries are also sources of fluoride emissions.

- The major source is to be found in the manufacture of apatite-based superphosphates

in which tricalcium fluorophosphate is soaked for 30 to 60 days in concentrated sulfuric acid; the galleries in which this process takes place are probably a constant source of hydrofluoric acid, their atmosphere containing up to 86 mg of HF/m^3; in Florida in 1966, it was estimated that a superphosphate plant could emit up to 3 500 pounds of atmospherically-soluble fluorides daily.

It is recommended that fluoride emissions from these various sources be checked not only by means of the usual water sprays, electrostatic precipitators and chemical absorbers but also by sealing the plants hermetically to prevent fluorides escaping through doors, windows, air shafts, etc.

1.2 Increase in environmental fluorides

Fluoride emissions into the environment are constantly increasing. In the United States in 1970, annual fluoride emissions into the atmosphere were estimated at almost 120 000 tons. It is safe to say that this figure has doubled for the 1971-1980 period despite the fact that 90% of all emissions are intercepted at source by various devices (62).

As a result, human beings and the ecosystems they are part of are increasingly exposed to different, more or less toxic sources of fluoride, not all of which are identified. Surveys conducted recently in Québec have shown that the harmful gases emitted by aluminum plants are responsible for the fluorosis found in the vicinity of the plants - a potential hazard to people, and to the animal and plant life of the region.

According to a number of works consulted, the effects of this form of pollution may be felt within a radius of several kilometres of the plants despite the recovery systems in operation. The damage is even greater in the immediate vicinity (within a radius of four miles) and the prevailing winds can carry the gases distances of up to fifteen miles (2). This subject is dealt with in greater detail in chapter two of this report.

The environmental consequences of CFM (chlorofluoro-methane) emissions are a source of growing concern. Under Environment Canada's Atmospheric Environment Service, a consultative committee on stratospheric pollution which is studying the consequences of the continued use of this type of fluoride as a propellent in aerosol cans and as a refrigerant reports that this form of pollution

is a serious hazard to the earth's protective ozone layer. Its potential effects can be summed up as:

1. effects on climate (the extent of which is not known);

2. possible increase in the incidence of skin cancer;

3. effects on plants and animals unable to protect themselves from ultraviolet B rays (55).

If appropriate action is to be taken to protect the environment and the health of the population from these fluorides, most of them toxic, their sources must be identified and their medium of diffusion accurately defined without delay. The total sum of the fluorides absorbed must also be established and their effects on health and environmental quality fully understood.

1.3 Sources and effects of fluorides in Quebec

Just as in other highly industrialized nations, the new sources of fluorides and their number are increasing constantly in Quebec. However, little is yet known of their effects on public health and the environment (49).

It might also be said that the ecological consequences of artificially-fluoridated water supplies have not been studied (50).

We have already mentioned fluoride accumulations along the food chains and their possible synergetic interaction with other pollutants, a factor disregarded by current studies (51).

1.4 Inventory of fluorides ingested by humans

Although American health authorities consider a 1.2 ppm fluoride concentration a safe and effective dose for public water supplies, no scientific consensus has ever been reached on a safe maximum absorption dose in absolute terms (mg/day) (3).

The American Dental Association considers 6 mg per day to be the maximum safe dose for adults (3); it recommends that a daily dose of 0.5 mg for children under the age of two or three and 1 mg per day for children over three should not be exceeded.

The U.S. National Research Council suggests 2 mg/day of fluorides as the maximum safe dose for children (4).

Krepkogorsky (5) concludes that adults should not ingest more than 3 mg of fluorides per day.

Still others indicate that the safe maximum should be from 3.5 to 5.4 mg per day.

The World Health Organization (7) reports that in the United States, epidemiological studies show that no undesirable effects have been observed in people who have been consuming naturally fluoridated water containing 8 ppm of fluorides for thirty-seven years. But the Organization also reports that a daily fluoride dose of 20 mg exceeds the threshold at which undesirable manifestations, particularly skeletal, begin to appear (8). These examples clearly show that there is no precise or definitive information on the maximum safe daily fluoride dose.

Water, food and air are the three major sources of fluorides and the contribution of each varies from person to person depending on weather and climatic conditions. This last point is particularly important.

The fluoride concentration standards laid down by the U.S. Public Health Service on the basis of climate are shown in the following table.

TABLE 4

Fluoride concentration recommended for drinking water (9)

Average annual maximum temperature in degrees F	Fluoride concentration (ppm)		
	Minimum	optimum	maximum
50.0 to 53.7	0.9	1.2	1.7
53.8 to 58.3	0.8	1.1	1.5
58.4 to 63.8	0.8	1.0	1.3
63.9 to 70.6	0.7	0.9	1.2
70.7 to 79.2	0.7	0.8	1.0

In southern Québec, the average annual maximum temperature varies between 45.6 F^{O} and 52.4 F^{O} (45, 46). It should be remembered however that in Québec temperature changes are abrupt and this could certainly contribute to variations in individual daily water consumption.

1.4.1 Fluoride intake from water

The quantity of fluorides ingested from water supplies depends of course on the fluoride concentration of the water and the amount consumed. Fluoride concentration can easily be determined but water consumption is extremely difficult to assess.

McClure (10) estimated in 1943 that children from one to three years of age consumed between 390 and 560 ml of water daily while ten- to twelve-year olds consumed between 812 and 1166 ml. He concluded that if the quantity of water ingested contains 1 ppm of fluoride, the fluoride intake of the one- to three-year olds amounted to between 0.390 and 0.560 mg/day and reached between 0.810 and 1.165 mg/day for the ten- to twelve-year olds (11).

In a study conducted in Canada in 1964, Bonham et al. (12) noticed that children up to the age of six ingested quantities of water that varied from 0 to 824 ml per day. They also concluded that in a cold climate there are considerable variations in the amounts of liquids ingested by children in the course of a day.

In 1973, Groth noted that children drink between 200 and 500 ml of water per day (13).

In a study conducted on adults, Marier and Rose (14) showed that water containing 1 ppm of fluoride gives a daily fluoride intake of between 1 and 3 mg.

Following an exhaustive review of literature on the subject, Groth (15) noted that adults consume between one and five litres of water per day. He pointed out that heavy tea drinkers ingest between 2 and 3 mg/day of fluorides from this source alone. In beer drinkers, the fluoride quantities ingested vary greatly from one individual to another and may exceed 6 mg per day.

1.4.2 Fluoride intake from food

As a rule, all foods contain a certain amount of fluoride (Table 5).

TABLE 5

Fluoride content of various foods (16)

	Dry base (ppm)	Wet base (ppm)
Peanuts	1.36	
Beets	17.70	
Butter		1.50
Wheat		0.58
Beef	2.00	
Carrots	6.92	0.4
Celery, leaves		0.14
Spinach	1.11	
Cheese		1.62

Powdered gelatine	2.50	
Tomatoes	2.40	0.40
Milk		1.00
Corn	8.0	
Salmon	19.3	
Potatoes		0.20
Pears		0.19
Fish	12.10	
Apples	0.13 to 0.43	0.22 to 1.32
Tea	14.00 to 88.75	
Sugar		0.32

Fluoride pesticides, phosphate fertilizers and water used for irrigation and washing can all increase the above fluoride quantities.

A study carried out in Japan in 1967 revealed that the fluoride content of vegetables had increased considerably between 1958 and 1965 (Table 6). This rise was attributed to the use of phosphate fertilizers containing apatite-derived fluorides.

TABLE 6

PLANT SPECIES	FLUORIDE CONCENTRATION	1958	1965
Chinese cabbage		0.87 ppm	2.01 ppm
Cucumbers		0.34 ppm	5.04 ppm
Spinach		1.97 ppm	13.31 ppm
Green tea		88.75 ppm	599.50 ppm

The fluorides present in processed foods must also be mentioned. When fluoridation was first introduced, it was accepted without question that this would add little or nothing to fluoride intake. But today the facts are better known. The consumption of processed foods has outstripped that of fresh foods and most of the North American food-processing industry is supplied with fluoridated water. Martin (18) showed that when foods are cooked in water containing 1 ppm of fluoride, their fluoride content is increased three to five times. This demonstrates the multiplier effect of water fluoridation.

The study by Marier and Rose of the National Research Council of Canada (19) shows that commercial foods and beverages prepared with fluoridated water contain on the average about three and a half times more fluorides than the rate established by Hodge and Smith for non-fluoridated regions (Table 7).

TABLE 7

INDUSTRIAL PROCESS 1. CANNED FOOD	PREPARED WITH NON-FLUORIDATED WATER (ppm)		PREPARED WITH FLUORIDATED WATER		DIFFERENCE	
Fluoride quantities	(ppm)		(ppm)		(ppm)	
Pork and beans	0.27		0.77		+0.50	
Tomato soup	0.04		0.38		+0.34	
	Liquid	Solid	Liquid	Solid	Liquid	Soli
Mixed vegetable	0.30	0.37	1.30	1.05	+1.00	+0.68
Green beans	0.14	0.20	0.71	0.89	+0.57	+0.69
Whole potatoes	0.13	0.38	0.87	0.79	+0.74	+0.38
Diced carrots	0.30	0.19	0.55	0.61	+0.25	+0.42
Whole grain corn	0.10	0.20	0.48	0.56	+0.38	+0.36
2. BEVERAGES						
Beer	0.30		0.68		+0.38	
Soft Drinks	0.02		0.77		+0.75	

This table shows that the fluoride content is increased when fluoridated water is used in the industrial or domestic preparation of foods. In fact, cooking and drying techniques considerably reduce the quantity

of water previously used in the preparation stage, thereby increasing the fluoride concentration.

The results obtained by Marier and Rose (21) complement Table 8 as established by Hodge and Smith (22), which shows fluoride intakes from food and water. Marier and Rose (23) demonstrated that an adult exposed to water containing 1 ppm of fluoride consumes an average of between 2 and 5 mg of fluorides from food.

TABLE 8

Total fluoride intake from (food and water) based on the fluoride concentration in drinking water (24)

Fluoride content of water (ppm)	Age of subject (years)	Time observed (days)	Daily fluoride intake (mg)		
			water	food	TOTAL
0.1	33	140	0.3	0.2	0.5
2	35	96	2.4	1.2	3.6
5.5	55	60	3.8	1.3	5.1
6.1	57	133	6.7	1.0	7.7
8	57	140	11.3	2.5	13.8
20	30	45	20.8	1.5	22.3

Following an analysis of balanced diets over a period of six years, Osis et al. (25) found that the fluoride quantities ingested from food varied between 0.86 and 1.96 mg per day in non-fluoridated areas and 1.6 to 1.9 mg per day in fluoridated areas. Since the subjects studied consumed an average of from one to two litres of liquid per day containing a fluoride concentration of 1 ppm, their total fluoride intake ranged between 3.0 and 4.0 mg per day. Similar results were obtained by Kramer et al. (26).

1.4.3 Fluoride intake from the air

A sedentary person breathes between 12 and 15 cubic metres of air per day; a person whose work demands a relatively large amount of energy breathes an average of 20 cubic metres (27).

On this basis, it was established that the fluoride quantities absorbed by a worker in central London ranged from 0.003 mg per day normally to 0.03 mg on a day of thick fog and heavy pollution (28). It is quite certain that at such rare and highly

localized pollution rates, a person performing a physically arduous task absorbs a quantity of fluorides well beyond the safe maximum dose mentioned earlier. This intake must of course be added to that contained in his daily diet.

A recent study conducted in Utah by Call et al. (29) found that atmospheric fluorides posed no more than a minor health risk. The study also indicated that even in areas where industrial pollution was very high in fluoride concentrations, this type of atmospheric pollution would only add a few hundredths of a milligram of fluorides to a person's total intake.

This conclusion may not hold true for a person working in an industrial environment where the atmospheric fluoride content reaches the threshold limit value (TLV) of 2.5 mg/m^3 which was established by the American Conference of Governmental Industrial Hygienists (1969) (30). In this case, the worker inhales 25 mg of fluorides in ten hours. Hodge and Smith (31) estimated that in the case of a person working in an atmosphere containing 2.5 mg of fluorides per cubic metre (TLV), the body may

retain daily from 5 to 6 mg of the fluorides inhaled. The remaining fluorides absorbed would be excreted in the urine or perspiration.

1.4.4 Conclusions

The foregoing analysis points to two conclusions:

1. the first indicates that the total fluoride ingested daily by human beings varies greatly;

2. the second shows that these approximations do not constitute a basis for satisfactory scientific criteria to define the maximum safe dose of fluorides.

1.5 Increase in human fluoride intake

In 1949, McClure (32) estimated that humans ingested between 1.0 and 1.5 mg of fluorides per day.

Cholak (33) reported in 1960 that food provided a daily fluoride intake of between 0.34 and 0.80 mg.

In 1965, Hodge and Smith (34) estimated that food alone contributed a fluoride intake varying from 0.5 to 1.5 mg per day.

More recent studies have shown that food alone now contributes significantly to a person's fluoride intake; Marier and Rose (36) assessed the daily intake of fluorides from food at more than 2 mg.

In a study of hospital patients fed balanced diets, Spencer et al (36) confirmed these figures by showing that the quantity of fluorides ingested by the patients varied from 1.45 to 2.17 mg per day.

Osis et al (37) reported similar values.

In a 1978 Québec study, Bellemarre and Giroux reported that the present total fluoride intake from air, food and water ranged from 0.53 to 1.07 mg/day. Following fluoridation, this total rises to between 0.73 and 2.38 mg per day.

And so, apart from this latest Quebec study, the most recent works show the total quantity of fluorides ingested by normal adults (excluding those who drink abnormal quantities of liquids or those whose diets are rich in fish) to be between 2 and 5 mg per day or more, depending on whether or not the water supplies are fluoridated (24).

According to Groth (39), ingestion of fluorides from food has increased significantly since fluoridation became generalized on the North American continent. He adds that a comparison of the McClure estimates (40) and those arrived at during the last seven years reveal that fluoride quantities in the human diet have increased from 3 to 10 times since fluoridation.

The total quantity of fluorides ingested from different sources has presumably doubled or even tripled during the same period (41).

1.6 CONCLUSIONS

1. On the basis of authoritative evidence, it can be confirmed that the fluoride ion is second only to sulfur dioxide and ozone as the most dangerous atmospheric pollutant.

2. The number of industries using fluorides and fluorine compounds increases each year.

3. A similar development is in full swing in Québec.

4. The ever-growing and almost universal practice of water fluoridation in North America adds one more source to the many existing natural and artificial sources.

5. An increase in the fluoride content of processed foods and beverages has been noted in areas supplied with

fluoridated water.

6. The difference between harmless and dangerous amounts of fluoride is slight and there is no doubt that in fluoridated regions - and elsewhere - quantities higher than the amount considered safe are frequently ingested (43).

7. Given the various and often highly toxic fluoride sources to which humans and the ecosystems are exposed, it is of paramount importance to establish just how much fluoride is being gradually ingested in order to prevent cumulative effects and the onset of long-term toxicity from repeated absorption.

8. The synergetic effects of general fluoridation and the serious threat they pose to human health and the natural environment must be studied and fully understood.

9. There will have to be assurance that general fluoridation will have no harmful effects in the long term (44).

10. The pollution problem posed by the accumulation of fluorides in the environment and the increased risks to people exposed to them has been defined very

realistically by Paul Ehrlich who writes that fluoride pollution is serious and incontrovertible. He goes on to say that emissions into the atmosphere from steel mills, aluminum plants, phosphate industries, glass, ceramics and brick-making industries may increase the fluoride quantities ingested by people who drink fluoridated water and that there is an increased fluoride content in food and beverages prepared in regions where the water is fluoridated. He considers the difference between harmless and dangerous amounts to be slight and that in fluoridated regions and elsewhere quantities exceeding the safe limit are frequently absorbed (43).

1.7 RECOMMENDATIONS

The committee's recommendations are as follows:

1.7.1 Studies on fluoride sources and their effects on public health and the environment

The committee recommends that a long-term research program be launched to determine with accuracy:

1. the location of fluoride sources in the

environment in Quebec;

2. their means of diffusion;

3. their effects on public health and the environment.

The reader will find more specific recommendations on this subject in chapter three of this report which deals with the protection of ecosystems.

1.7.2 Studies on total fluoride intake

1. The committee recommends that a survey be conducted to compute the total fluoride intake of Quebecers from the various existing fluoride sources.

2. The committee recommends that the fluoride content of foods and beverages consumed be evaluated on a continuous basis.

1.7.3 Studies on the synergetic effects of fluorides

The committee recommends that studies be conducted on the additive effects or the synergetic interactions of fluorides and atmospheric contaminants such as ozone and sulfur dioxide which could aggravate the long-term effects of atmospheric concentration on human health and that of animals and plants.

1.7.4 Suspension of fluoridation of water supplies

The committee recommends that artificial fluoridation of water supplies be suspended until such time as the studies recommended in this chapter and elsewhere in the report have been carried out so that a complete and in-depth evaluation can be made of the impact of water fluoridation on public health and environmental quality.

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C H A P T E R 2

INDUSTRY AND THE EMISSION OF FLUORIDES INTO THE AIR

CHAPTER 2

INDUSTRY AND THE EMISSION OF FLUORIDES INTO THE AIR

The emission of fluorides by industry is an important source of environmental pollution, both in the atmosphere and in the work place for employees in certain types of plants (14).

2.1 Types of fluorides

In this context, it is important to know that fluorides may be found in the form of particles. In Québec, in 1972, the total emission of fluorides into the atmosphere was estimated to be around 7 750 tons, 50% of the Canadian total for the period (1).

2.2 Sources of fluorides

These emissions come from three main categories of plants in Québec. Plants producing primary aluminum, which are located in the regions of Arvida, Shawinigan, Beauharnois, Île Maligne and Baie Comeau, are responsible for more than 6 700 tons of emissions. The sector producing fertilizer ranks second, with emissions of 373

tons of fluorides in 1972. Steel production follows in third place with a total of 198 tons of fluorides.

In the electrolytic vat process for the production of aluminum cryolite, a compound of aluminum and sodium (NA_3 Al F_6) is used. The emissions of fluorides are caused by:

1. the high temperatures in the electrolytic vat process, thus diffusing into the atmosphere a considerable quantity of fluorides;

2. the production of hydrofluoric acid in the form of vapour;

3. the presence of silicon fluorides and fluoride particles which are then washed into the reactive gas.

Sixty-six percent of these emissions are discharged through ceiling ventilators in the vat areas. The other fluorides reach the atmosphere via chimneys which are part of the purification systems; these partially filter the gas sucked up by ventilation on the vats themselves.

In fertilizer plants, the thermal reaction process of the phosphate is the major cause of emissions of hydrogen fluorides. Unfortunately, this type of production has not been investigated very thoroughly in Québec. However, the following table gives a fairly good indication of the emission of fluorides throughout Canada in this area of fertilizer production.

TABLE I

Emission of fluorides by Canadian fertilizer plants in 1972

PROCESS	TOTAL EMISSION OF FLUORIDES (tons)
Phosphoric acid	1 608
Ammonium phosphate	235
Triple superphosphate	290
Superphosphate	255
Primary phosphorus	280

In the production of iron and steel, fluorspar is used to remove impurities during smelting and to facilitate the separation of the liquid metal from the slag by considerably increasing the fluidity of the slag. In steel works, the use of electric furnaces for the production of steel is widespread and eight to ten pounds of fluorspar are generally used for each ton of steel produced by this process. As a result, this manufacturing sector was responsible for discharging into the atmosphere about 198 tons of fluorides in Quebec in 1972.

2.3 Conditions in the work place

It is especially interesting to study the quality of employee working conditions in the three sectors mentioned above. In Quebec, it has been possible to measure the amount of fluorides in the work place of employees in the vat areas for the aluminum electrolytic process. The results were obtained from two aluminum plants.

2.3.1 Accumulation of fluorides in the bodies of workers exposed to them

As an employee spends a third of his life at work, it is logical to assume that he may accumulate

pollutants in his body if they are present at his work place. Those who are exposed regularly to fluoride gases and particles are likely to be additionaly affected by the fluoridation of water. The mechanics of absorption and excretion of fluorides by a person are part of medical knowledge, and it must be realized that a worker regularly exposed to fluorides may accumulate in his body a considerable quantity of these substances. A normal man breathes in about 20 cubic metres of air daily, a third of this at his work place, or about seven cubic metres. If the air which he breathes at work contains fluorides in the proportion of three to four milligrams per cubic metre of air, a rapid calculation indicates that the worker absorbs 21 to 28 milligrams on the job daily.

An American study (2) has shown that in the case of employees in the vat areas for the aluminum electrolytic process who are exposed to fluoride concentrations in the air exceeding the norm of 2.5 milligrams per cubic metre of air and whose urine contains fluoride in excess of 9 ppm (parts per million), the incidence of osteosclerosis is often high.

This same study indicated that in eight X-ray reports there were no signs of osteosclerosis in the case of workers exposed to fluorides not exceeding the norm of 2.5 mg/m^3 of air. In these cases, the rate of fluorides found in the urine did not exceed 5 ppm.

In comparing the exposure of workers in an aluminum plant to fluoride gases and particles with the rate of fluorides in the urine of workers in another aluminum plant in Québec, one can understand more precisely the problems which may arise for this category of workers, if the water is fluoridated.

Table II gives the amounts of fluoride gases (Fg) and particles (Fp) measured in an aluminum plant in Québec. The two measurements were added to produce the total amount.

TABLE III

Results of the measurement of fluoride gases and particles in the work place at an aluminum plant in Quebec

mg / m^3 F_g	mg / m^3 F_p	mg / m^3 F_t
0.63	0.55	1.18
1.7	3.4	5.1
0.38	1.09	1.47
0.76	1.86	2.62
1.16	1.64	2.80
0.84	0.72	1.56
1.01	0.61	1.62
0.59	0.61	1.20
0.61	0.67	1.28
1.59	1.58	3.17
1.08	0.76	1.84
0.43	1.06	1.49
1.3	1.05	2.38
1.08	0.97	2.05
0.68	0.98	1.66

mg / m^3 F_g	mg / m^3 F_p	mg / m^3 F_t
0.94	0.62	1.56
0.72	1.93	2.65
0.46	1.49	1.95
0.60	0.72	1.32
.91	.93	1.84
.87	1.36	2.23
1.76	0.33	2.09
.63	1.38	2.01
.62	0.89	1.51
.64	1.47	2.11
.85	2.17	3.02
1.03	0.34	1.37
2.82	7.47	10.29
1.54	4.81	6.35
1.71	1.96	3.67
.88	.89	1.77
1.66	1.99	3.65
1.93	4.28	6.21
2.95	1.08	4.03
6.54	4.01	10.55
5.64	2.85	8.49
3.14	3.84	6.98
4.79	5.74	10.53

mg / m^3 F_g	mg / m^3 F_p	mg / m^3 F_t
3.17	2.60	5.77
1.73	3.41	5.14
2.09	1.91	4.00
1.67	1.25	2.92
5.38	3.53	8.91
4.62	1.71	6.33
4.49	1.39	5.88
3.08	3.72	6.80
4.86	4.32	9.18
5.64	4.95	10.59
1.66	1.41	3.07
2.07	1.66	3.73
2.31	3.05	5.36
1.92	2.56	4.48
2.56	3.43	5.99
2.31	3.63	4.94
3.25	5.34	8.59
4.85	3.20	8.05
3.72	2.09	5.81

It will be noted that the norm for the total amount of fluorides in the air (2.5 mg/m^3) is very often exceeded in the work place of employees in an aluminum plant.

In Table III, we reproduce the level of fluorides in the urine of employees in an aluminum plant in Quebec. These rates were revealed during a medical checkup of these employees in 1977.

TABLE III

FLUORIDES ppm	NUMBER OF SAMPLES
0 - 10	165
1.1 - 2.0	250
2.1 - 3.0	176
3.1 - 4.0	107
4.1 - 5.0	62
5.1 - 6.0	37
6.1 - 7.0	19
7.1 - 8.0	15
8.1 - 9.0	5
9.0 - 10.0	9
10.1 - 11.0	3
11.1 - 12.0	1
12.1 - 13.0	2
13.1 - 14.0	0
14.1 - 15.0	0
15.1 - 16.0	0
16.1 - 17.0	1
17.1 - 18.0	0

2.3.3 Incidence of possible osteosclerosis

In the light of these figures (Tables II and III), even though they are limited to two aluminum plants in Québec, it can be assumed that an incidence of osteosclerosis is likely, although we do not have precise figures concerning the specific state of health of each of the workers in Québec.

2.3.4 Effects of fluorine on the health of workers

Bellemare and Giroux have made a study on the effects of emissions of fluorine in an aluminum plant on the health of workers and have confirmed that workers directly exposed to these may suffer a higher rate of fluoride intake (13). The symptoms described by Roholm are headaches, dizziness, stiffness, rheumatic pain, insomnia, fatigue, diarrhea, constipation, nausea, vomiting and difficulty in breathing (4).

2.4 Comments on fluorosis of industrial origin

According to Largent, much more information is now available on fluorosis of industrial origin pertaining to deposits of fluorides in the bones of animals and men.

The first reported case of fluorosis of the bones and ligaments goes back to 1933. Among the symptoms were a greater opacity of bony tissue to X-rays, the formation of bony growths on the rib cage and the calcification of the intervertebral ligaments. Fluorosis also causes changes in the structure of the teeth (spotted enamel) (3).

The fluoride level in the urine serves as a guide in devising preventive measures for exposed employees. It can be stated

(a) that as long as the proportion of fluorides in the urine is less than 4 ppm, there is little cause for alarm;

(b) that when the rate of fluorides in the urine reaches 6 pmm, examination of workers and technical prevention measures must be considered;

(c) that at 8 pmm and beyond one can anticipate radiological opacification through accumulation of fluorine in the bone structure if the rate of exposure remains the same over a period of several years (5).

In industry, dust particles laden with fluorides play a role in a high proportion of cases of exposure, real or presumed, to fluorides and the ingestion of these particles can be a determining factor. Industrial exposure to fluorides can be due in large part to fluoride gases, but even in these cases, only rarely can the risk of ingestion be eliminated entirely, either because of the ever present risk of contamination from food and drink in the work place or from the transfer to the digestive tract of phlegm carrying fluorides which have been inhaled. When workers are exposed to a mixture of fluoride gases and particles, absorption can be both respiratory and digestive (6).

2.5 Atmospheric pollution of the neighbourhood (12)

Pollution originating in industry and caused by emissions of fluorides into the air can also affect human beings as well as animal and plant life in the vicinity of these industries. This is made clear in the environmental studies carried out by SPEQ in the Arvida sector (formerly the town of Arvida) of the town of Jonquière exposed to emissions of fluorides by Alcan.

They deal with the effect of fluorides in the atmosphere on neighbouring waterways and the effect of particles, sulfur dioxide and fluorides on the animal and plant life of this region. The result of these studies is summarized in the following section.

2.5.1 The fluoride gases which are emitted by the plant chimneys fall on the ground and there is no doubt that they affect the waterways; however, this phenomenon has not been studied specifically up to now. The following map, illustrates the distribution of concentrations of fluorides on the ground in the Saguenay region. It was determined from an analysis of 350 samples of snow taken from this inhabited territory as a whole.

However, it was impossible to establish the relationship which exist between the fluoride concentrations found in the snow and those measured in the rivers system of the Saguenay region. Data available indicate that the water levels of fluorides are low. They vary between 0.02 and 0.19 mg/l as shown in the following table.

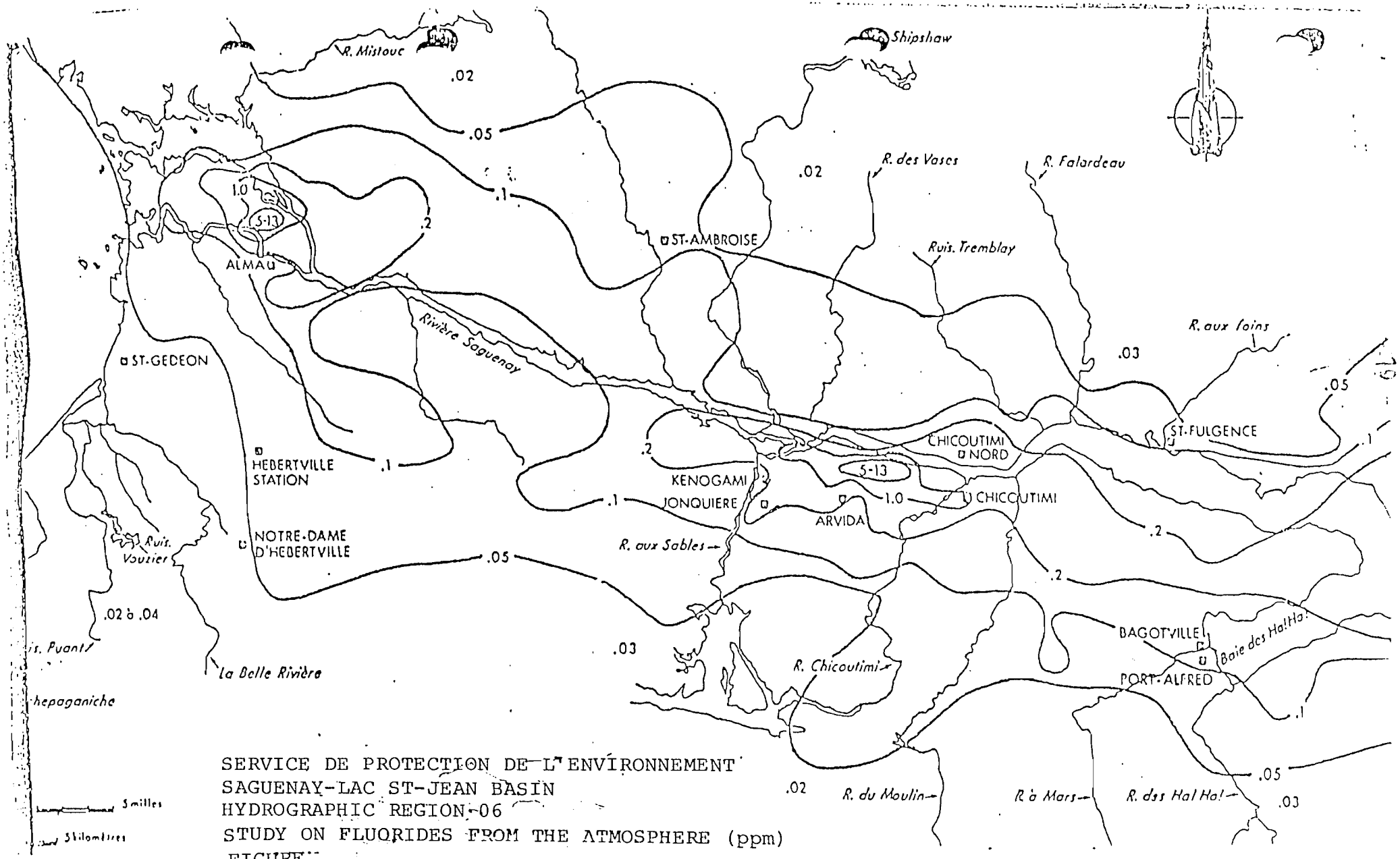
However, the quantity of data available is too limited and the period of observation during which this study was conducted is too short to evaluate with

precision the real significance of these atmospheric emissions. Therefore, it is believed that to reach more definite conclusions, a specific monitering programme extending over a period of time sufficiently long to give us a complete picture of the hydrological conditions of the region should be put into effect.

Finally, as mentioned later in this report, our knowledge concerning the effects of fluorides on the aquatic fauna is rather limited. We believe that a more intensive research program should be carried out in this area.

CONCENTRATION OF FLUORIDES IN THE WATERS OF THE PRINCIPAL RIVERS OF THE CHICOUTIMI AND ALMA REGION

River	Concentration mg/l F soluble		
	78-06-14	78-06-19	78-09-05
Du Moulin	0,05	-	0,14
Chicoutimi	0,02	0,02	0,06
Chicoutimi (at the water intake)	0,02	0,02	0,08
Aux Sables	0,02	0,02	0,08
Saguenay to Chicoutimi			0,07
Saguenay to Alma			0,04
Mistouc	0,04	0,02	0,05
Bédard	0,05		0,16
Ruisseau rouge		0,07	0,19



SERVICE DE PROTECTION DE L'ENVIRONNEMENT
SAGUENAY-LAC ST-JEAN BASIN
HYDROGRAPHIC REGION-06
STUDY ON FLUORIDES FROM THE ATMOSPHERE (ppm)
FIGURE

2.5.2 The norms for dust in the air and for fluoride gases often exceeded (12)

We have seen that the norms established for dust in the air are frequently exceeded and that the levels of fluoride gas exceed the amounts established as objectives for a residential or industrial zone.

The northern district of the Arvida sector has been particularly inconvenienced by these contaminants emitted by the Alcan plants because of the prevailing southeasterly winds.

2.5.3 Effects of fluorides on farm animals (12)

Studies dealing with the concentration of fluorides in fodder have shown levels exceeding the norms established to protect livestock against toxic effects.

As one of the principal effects is changes in dentition, dairy production could be adversely affected.

The reader will find a more detailed description of animal fluorosis and its economic repercussions in chapter 3 of this report.

2.5.4 Effects on plant life (12)

In the case of the vegetation, studies of the effects of the levels of fluoride gas recorded have shown that sensitive plant species may be affected by this pollutant. This is confirmed, moreover, by findings which indicate that damage to coniferous trees and certain flowers could impair their growth and lessen their ornamental value.

However, over the years, natural and sometimes deliberate selection of species resistant to fluorides, at the expense of sensitive species, has considerably tempered the harmful effects of fluorides and ensured the growth of a very resilient and important type of plant life in the Arvida sector (12).

2.5.5 Fluorosis in the neighbourhood (13)

In 1946, Murray and Wilson described a form of chronic fluorosis found among people who live in the vicinity of aluminum plants and are exposed to emissions of toxic fluoride from these plants.

The animals and plants of the exposed areas also suffer from the effects of this form of pollution.

Patients afflicted suffer from headaches, rheumatic pain, indigestion, muscular stiffness and blurred vision. In certain cases there are signs of fluorosis of the skeletal system.

Fluorosis is rarely diagnosed at the onset of the disease, as the symptoms observed are common to other disorders, making diagnosis difficult.

To prevent this disease, inhabitants of these regions are advised to have periodic medical examinations for early detection and to undergo effective treatment before the chronic stage is reached.

2.6 Conclusions

2.6.1 Industrial activity in its emission of fluorides is an important source of environmental pollution, both in the atmosphere and directly in the work place in certain categories of plants.

2.6.2 In 1972, about 7 750 tons of fluorides were discharged into the atmosphere in Québec, about 50% of the total emission of fluorides in Canada for the same period.

2.6.3 Recent surveys have shown that the acceptable norm for fluorides in the air (2.5 mg/m^3) is often exceeded at the work places of employees in aluminum plants.

Furthermore, in some cases, the presence of fluorides in the urine of employees exceeded established norms.

2.6.4 Faced with such a situation, the committee expressed considerable reserve concerning the real value of artificial fluoridation of water. The conclusion was reached that this would only increase the amounts of fluorides to which certain workers are

already exposed beyond safety levels.

2.6.5 Industrial pollution caused by the emissions of fluorides into the air can also affect human beings as well as animals and vegetation in the neighbourhood and exposed to this contamination.

2.6.6 Recent studies have shown that the norms established for dust particles are frequently exceeded and that the levels of fluoride gases exceed the amounts established for a residential or industrial zone.

2.6.7 Studies on the concentration of fluorides in fodder have also revealed that the norms established to protect livestock against the toxic effects of fluorides are exceeded. The health of cattle exposed in this way is seriously affected and milk production diminished.

2.6.8 Finally, in the case of vegetation, these studies also showed that certain species were damaged in such a way that their growth could be impaired and their ornamental value lessened.

2.6.9 "Neighbourhood fluorosis" is a form of chronic fluorosis encountered in people, animals and vegetation in the vicinity of aluminum plants and other industries contributing to pollution by fluorides. It is quite common but not always detected in time because of lack of experience on the part of professional and technical staff responsible for maintaining public health and for protecting the environment. Training is needed in order to single out persons likely to be affected by this type of fluorosis.

2.7 Recommendations

The following measures are recommended by the committee:

2.7.1 Protection of health in aluminum plants and other industrial sources of fluorides (7)

To prevent injury to the respiratory system, the concentration of fluorine or its compounds must not exceed the fixed maximum.

Industrial processes involving a risk of industrial exposure should be provided with a local ventilation

system which should be mechanized, if at all possible.

Workers handling dangerous material must be provided with chemical safety goggles and protective visors, respiratory devices, clothing, boots and leggings.

As a supplementary measure, employees could also be furnished with lanolin to be used as a protective cream.

Workers should be forbidden to eat or drink in the work place. They should be reminded of the importance of a hygienic routine before meals.

2.7.2 Medical supervision of workers (8)

The relationship between maximal admissible concentrations of fluorides in the air and early changes in the radiological opacification of bony tissue has not been clearly established. Medical supervision of workers is therefore called for as well as appropriate measures to make certain that admissible concentrations of fluorides in the air are not exceeded.

The presence of fluorides in the urine of all exposed workers should be checked periodically. In addition, they should undergo X-ray examinations of their bones, especially of the pelvic area.

2.7.3 Protection of public health

The committee recommends that the struggle against pollution caused by fluorides should be intensified by the systematic application of the following measures:

1. by eliminating, as much as possible, the formation of fluoride emissions at their source, through the use of better technical methods;

2. if this is not possible, to drain them off by treating the effluent;

3. by choosing future sites carefully to ensure effective dispersal;

4. and, in all cases, by informing and educating those responsible for the emissions.

2.7.4 Public medical supervision

The committee recommends that people living near aluminum plants and other industrial establishments which are sources of pollution from fluorides undergo periodic medical examinations for early diagnosis and prevention of chronic fluorosis.

2.7.5 Study program on the intake of fluorides and their effect on human health

The committee recommends that continuing studies be made to calculate the total amount of fluorides absorbed by the population so that the level to which it is exposed can be controlled scientifically.

2.7.6 Program of epidemiological and experimental studies

The committee recommends that epidemiological and experimental studies be made on the likely mutagenic, teratogenic and carcinogenic effects on people exposed, in many cases, to dangerously high levels of fluorides (10).

It is recommended that the epidemiological studies

be forward looking and make use of sensitive parameters for the early detection of anomalies to reveal the threshold limit value of fluoride toxicity to ensure that it is not exceeded.

2.7.7 Restrictions concerning the fluoridation of water supplies

Finally, the committee recommends that water supplies not be fluoridated to ensure that working people, many of whom are already subject to a higher level of fluorides than recommended, not be exposed even further.

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C H A P T E R 3

EFFECTS OF FLUORIDES ON THE ENVIRONMENT AND PROTECTION OF ECOSYSTEMS

CHAPTER 3

3. EFFECTS OF FLUORIDES ON THE ENVIRONMENT AND PROTECTION OF ECOSYSTEMS

There is an abundant variety of works available on the harm done to grazing animals by fluorides in the atmosphere, through terrestrial plants acting as agents. By atmospheric convection, the latter receive dust particles from the erosion of rocky outcrops. The same mechanism operates in the emission of fluorides from industrial sources. We will deal briefly with this aspect here. However, we will concentrate more on the ecological effects of the fluoridation of water supplies.

3.1 Effects of fluorides not linked to the fluoridation of water supplies (37)

Fluoride gases (FH, SiF_4, H_2SiF_6) or solids (F_6AlNa_3, F_3Al, F_2Ca, FNa, fluorapatite) not linked to the fluoridation of water enter plants through the stomata or by direct foliar translocation. However, radicular absorption is also involved, especially in soil heavily polluted by these substances.

As fluorine plays a marginal physiological role where plant life is concerned and as it is not subject to metabolism, it accumulates at a considerable rate, especially in the foliar system. When the concentration of fluorides reaches a certain level, which varies with each species, foliar damage can be noted. The characteristics are chlorotic streaks in some cases or, in others, a greenish gray colouring of the parenchyma before necrosis develops.

The foliar limb as a whole takes on a brownish colour with a darker line indicating the limit between the affected area and the rest of the leaf.

In conifers, the necrotic zones become brownish towards the base.

3.1.1 Effects on vegetation

There is a great variability in the toxic effects of fluorides on vegetation. The most sensitive plants can be affected by a week's exposure to a concentration of about 1 ppb (part per billion) of this element. The most

tolerant develop necroses only when exposed to concentrations twenty times greater.

Species particularily sensitive to fluorides are the liliaceae, the gentianaceae, the rosaceae (Prunus spp., Amygdalaceae in particular), conifers and vines.

While gladiola (Gladiolus sp.,) develop necroses when there are 20 or more ppm of fluorine in their leaves, certain black walnuts (Carya sp.) can contain up to 1 000 ppm in the foliar limb without apparent damage.

When subjected to microscopic examination, the parenchymatic cells affected reveal granulations, vacuolation and finally total plasmolysis. In addition, in conifers, the resin ducts are closed by hypertrophy of their parietal cells.

Fluorides seriously inhibit photosynthetic activity of the vegetation when they are present in concentrations well below those which cause foliar damage. In addition, they also inhibit enolase, an enzyme necessary for glycolysis in

plant life.

The damage wrought in forests by fluoride pollution can be very considerable. In France, several thousand hectares of conifers have already been destroyed in the Maurienne valley where, as early as 1960, some 1 200 hectares of Pinus sylvestris had disappeared in the vicinity of an electrochemical plant for processing aluminum.

3.1.2 Effects on animals (48)

Domestic animals fed on fodder containing fluorides ultimately show signs of the poisoning known as fluorosis. In addition to its own cytotoxic properties, fluorine, because of its affinities for calcium, disturbs the ossification process.

Taken in excessive quantities, it causes fluorosis, symptoms of which appear in various disorders of increasing severity. The effects of the fluorine vary according to the intensity of the poisoning. Where the emission of

fluorine is greatest, the animals' teeth decay and wear out completely; they are no longer white but yellow or brown. The animals become incapable of grinding food. The teeth work loose and finally fall out. As a result, chewing becomes difficult, if not impossible, causing digestive ailments, a rapid loss of weight, a drop in production and, finally, complete loss of life.

In addition to these dental disorders there are others: digestive difficulties, dystrophy of the bone in the young (rickets) and in adults (osteomalacia).

After a period of time, which varies according to the intensity of the poisoning, locomotor disorders appear in cattle and gradually the animal is unable to move. The limbs swell, lacteous secretion diminishes and pregnant females frequently abort. Finally there is a progressive cachexia (general debility) which is fatal to the affected animals.

The maximum concentration which cattle seem able to tolerate in their food is somewhere between 30 and 50 pmm of fluorine; it goes as high as 100 ppm for pigs and 300 ppm for domestic gallinaceae (domestic fowl).

Losses incurred as the result of the poisoning of domestic animals can be enormous for agricultural producers. As an example, we can mention the case of ALCAN in Arvida, where l'Union des Producteurs agricoles demanded and obtained from this aluminum plant, from 1951 to 1973, compensation amounting to $2 868 953 paid to 319 farmers (Anonymous, 1975) (1).

There have been some improvements but total compensation paid in 1977 and 1978 still came to more than $250 000. More than 3 000 head of cattle suffered from poisoning from fluorides during these two years.

Poisoning from semi-lethal amounts causes a falling off in milk production and a decrease in the amount of lipids in the milk.

Another ecological and toxicological result of fluorine pollution is the marked deterioration of the entomofauna. In fact, fluorine is highly poisonous for most insect life. Bees are especially sensitive to it and no apiary can survive in an area where this pollution exists.

3.2 Effects of fluoridation of water supplies on animal and plant life

Available statistics on the effects of fluoridation of water supplies on plant and animal life are too inadequate to provide a clear picture of the situation. It is generally recognized that exposure of living organisms to concentrations of fluorides results in an accumulation of these. It can also bring about biochemical and morphological alterations of these organisms. Directly or indirectly, such changes can limit their ability to maintain their positions in natural ecosystems.

3.2.1 Effects on animals

All aquatic animals ingest fluorides in water

directly; moreover, indirectly, herbiverous and carniverous animals can be affected by fluorides in their food.

The effects of fluorides on fresh water invertebrates are very inadequately known. However, some studies have been undertaken on certain species found in estuaries. Moore noticed that oysters contain fluorides reaching a level of 2 ppm and above (55).

In the vertebrates, it should be noted that frogs' eggs undergo a delay in their embryonic development when they are subjected to a concentration of 1 ppm of fluorides. This is also true for tadpoles (8).

Wiber (47) reports that water with a concentration of fluorides of 1.5 ppm has visible harmful effects on the embryogenesis of fish eggs. Following an extensive review of literature on the effects of fluorides, this writer considers that it is necessary to suggest a maximum concentration of 1.5 pmm of fluorides in water if the aquatic life is to be maintained and preserved.

Other studies on the toxicity of fluorides on fish have shown that trout eggs do not hatch normally if 1.5 ppm of fluorides are present; adult trouts are killed by concentrations of 2.7 to 4.7 ppm if they are exposed for several days (Newhold and Sigler) (34).

Angelovic et al. have shown that the toxic effects of fluorides on rainbow trout in water considered "soft"[1] are important and related to water temperature. At 12.5 C, the lethal concentration of fluorides, for 50% of fish, is between 2.6 and 6.0 ppm. As the temperature rises, the toxicity increases.

As to waters considered "hard",[1] they can reduce the toxic effects of fluorides on animals. This phenomenon may be due to the precipitation of fluorides in the form of calcium fluoride

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1 Hardness of the water: this is caused by the presence of calcium and magnesium bicarbonates dissolved in the water. It is expressed as an equivalent of $CaCo_3$. Water is considered soft when the hardness in $CaCo_3$ is less than 60 ppm; water is hard when it contains 200 ppm of $CaCO_3$.

and of magnesium fluoride. The toxicity of fluorides seems to be related to the inhibition of certain essential enzymatic reactions (Angelovic et al.) (4).

According to the authors consulted, a large number of species show abnormal reactions during exposure to fluorides. The reaction of fish could be strongly influenced by a large number of factors such as the species concerned, stress caused during the study, the hardness and temperature of the water, the size and age of the species being studied (40).

Fish and other aquatic species tend to accumulate fluorides in their organisms, mainly in the skeleton and the exoskeleton. These deposits can be very important depending on the different species involved. Furthermore, in certain species (the crab, for instance), this accumulation may be responsible for diminishing growth and result in a decrease in weight and size (40).

Practically nothing is known about the effects of fluorides on microorganisms, worms, insects or almost any other invertebrates of the aquatic environment (Groth) (16). As a result, the accumulation potential of fluorides in fresh water food chains is completely unknown.

On the other hand, water fluoridation can contribute to the addition of fluorides to the diet of land animals directly by the absorption of the fluoridated water or indirectly through plants. In the latter case, it is not always possible to distinguish between the amount of fluorides in the plants which is coming from soil watered and drained by fluoridated water from that caused by atmospheric pollution.

From studies conducted by H.L. Richardson, pathologist at the University of Oregon, it has been shown conclusively that fluorides in a concentration of 1 ppm can sterilize chinchillas on a farm. This concentration of fluorides may cause a weakening of the intestines, abortion, a high rate of still birth, weakness in the newborn and the death of the mother at the time

of expulsion. All breeders had the same problem: an extremely low rate of productivity and a high mortality rate in the newborn (72% in Kelowna) (National Health Federation) (33).

No figures are available as to the long-term impact of fluoridated irrigation water on the multitude of species living in the soil (Groth) (16). As all life on the earth depends on numerous biological processes which operate through species living in the soil (such as the fixation of nitrogen and the transformation of organic matter), the potential and cumulative toxic effects of fluorides on the soil biotope should be studied carefully (Groth) (16).

3.2.2 Effects on vegetation

Plants receive fluorides from various sources: land, air or water. For a plant, there is no real difference between land and water as a source of fluorides. While phytotoxicity from fluorides in the soil or water is at present considered relatively unimportant, the form and quantity of fluorides in plants

is very important for grazing animals (National Academy of Science) (32).

Fluorides are capable of affecting aquatic plant life as much as terrestrial plants. These two categories require the same mineral elements. In the case of terrestrial plants, atmospheric fluoride gases can be absorbed in relatively large amounts by the foliage. Fluorides originating in the soil are absorbed by the roots in very small quantities. As to emergent aquatic plants, the ions can be absorbed from the deposit on the bottom or from the water. In the case of submerged aquatic plants, mineral salts are absorbed mainly by the leaves. In this case, absorption of the ions is related to the permeability of the epidermis and not all epidermic cells are equally permeable to salts in solution.

For instance, the absorption of anions by the Canadian elodea seems to be independent of the external concentration of ions in the atmosphere as a whole, if this concentration is below 0.057 ppm. The decreasing series of principal

anions absorbed by plants are bicarbonates, sulphates, phosphates, chlorides and nitrates. Fluorides do not appear among the principal anions absorbed.

The absorption of anions depends on the pH factor, light, temperature and a concentration gradient of the different ions.

Although fluorides are widely distributed in nature either as a constituent of rocks and soil or present in plant and animal tissue, they are not ions essential to normal plant growth (MacIntire et al.) (26).

It has been shown by MacIntire et al. (26) (27), Prince et al. (35) and Hurd-Karren (21) that the amount of fluorides taken in by plants from soil is not usually related to the fluoride content in the soil. Bear (5) has calculated that the average amount of fluorides in terrestrial plants is from 2 to 20 ppm (dry base). Certain plants, like tea, can accumulate more, up to or above 400 ppm. As to the soil, its average fluoride content is from 100 to 300 ppm and this

amount increases with depth. The type of soil, its phosphorus content and the pH factor seem to be the predominant controlling factors. In fact, the toxicity of fluorides lessens if there is a high pH factor or in the presence of phosphates. There are more fluorides fixed if the soil is fine rather than coarse. These researchers have also shown that the addition of large quantities of water containing soluble fluorides to acid soil causes an increase of fluorides in the plants, which can be harmed in this way. In these cases, the symptoms are the same as those caused by atmospheric pollution.

Fluorides cannot be drawn from the soil in large quantities: only a few ppm if the soil is chalky (Aaron, D.I. et al.) (3). Acid soils are conducive to a higher concentration of fluorides in the roots and leaves of plants. This can be corrected by appropriate liming.

The New Jersey Experimental Farm Station has observed damage on the edge of leaves of peach trees, tomato plants and wheat after hydroponic

cultivation in fluoridated water (Leone) (25). Wheat and peach trees show symptoms after 10 to 13 days of cultivation in water containing 25 ppm of fluorides; the same phenomenon can be seen in tomatoes after 27 days in fluoridated water at a level of 50 ppm or 44 days in water with 25 ppm of fluorides.

Rand and Schmith (38) have reported an increase of fluorides in fodder in the cultivation of which irrigation water containing 6.2 ppm of fluorides has been used. This suggests that large amounts of fluoridated water can add small quantities of fluorides to a plant. However, the problem may be marginal and very localised (National Academy of Sciences) (32).

Smith et al. (44) have shown that the growth of a green unicellular alga Chlorella, which is an important element in several food chains, is inhibited at 1.9 ppm of fluorides.

Danilova (12) has shown that aquatic plants contain fluorides in amounts relatively high in relation to the host medium (with an increase

in concentration of about 40 ppm). However, little information exists on the concentration of these fluorides along aquatic food chains.

The accumulation of fluorides in aquatic plants and plankton is a very important phenomenon because of its potential impact on all animals which consume these organisms, including man. Some recent data suggest that the concentration of fluorides along a food chain is certainly not less than 10 to 1 (40).

3.2.3 Physiological effects of fluorides on plants

The fluoride ion causes certain physiological disorders in plants. This has been shown by the harmful effects which it has had on enzymatic reactions. Furthermore, fluorometabolites have been found in the plants.

The first to be identified was fluoroacetate, FCH_2COO^-, a toxic anion. In animals, fluoroacetate is transformed into fluorocitrate. This compound is not metabolized or very slightly and can block the citric acid cycle.

The result is a loss of energy. This synthesizing property of fluoroacetate was first identified in South African plants: the Dichapetalum cymosum and the D toxicarrum, then in an Australian plant: the Acacia georginae, in the soya bean (50) and in lettuce (51). About 15 vegetables are now known to be capable of producing organic fluorides (52).

As Miller has shown (53), it is well known that glycolysis is inhibited by fluorides in very low concentrations. This is especially important when phosphate ions and magnesium ions are present.

Rorison (54) has studied the role of fluorides in inhibiting phosphatase and in hindering the transfer of ions in a concentration of 2 ppm. The effectiveness or ineffectiveness of fluorides in the absorption of a phosphate ion and its translocation may be due to the fact that the plant absorption system does not have a great affinity for fluorides and that

these ions only penetrate slowly into the plant.

3.2.4 Sub-lethal effets of fluorides on the behaviour of aquatic organisms and food chains

Finally, we possess very little knowledge about the sub-lethal effects of fluorides on the behaviour and reproduction patterns of aquatic organisms or on the accumulation potentials of these substances in the food chains. Sub-lethal effects are characterized by the slowing down of growth, a greater susceptibility to disease, reduction of photosynthesis, morphological and biochemical alterations and limitations in the capacity of these organisms to maintain their ecological position in the natural ecosystems. According to some scientists, such effects are much more serious and could even have a much greater ecological significance than the mortality risks from massive fluoride pollution over short exposure periods.

3.3 CONCLUSIONS

1. There is an abundant variety of works available on the harm done to grazing animals by fluorides in the atmosphere, through terrestrial plants acting as agents. The latter are subject to atmospheric dust particles from the erosion of rocky outcrops.

2. There is a great variability in the toxic effects of fluorides on vegetation. The most sensitive plants can be affected by a week's exposure to about 1 ppb (part per billion) of this element. The most tolerant develop necroses only when exposed to concentrations twenty times as strong.

3. The damage wrought in forests by fluoride pollution can be very considerable.

4. Domestic animals fed on fodder containing fluorides ultimately give indications of the **intoxication.** known as fluorosis. In addition to its own cytotoxic properties, fluorine, because of its affinities for calcium, disturbs the ossification process.

5. Losses incurred as the result of the intoxication of domestic animals can be enormous for agricultural producers.

6. Available statistics on the effects of water fluoridation on plant and animal life are insufficient to provide a clear picture of the situation.

   It is generally recognized that the exposure of living organisms to concentrations of fluorides results in an accumulation of these. It can also bring about biochemical and morphological alterations of these organisms.

7. The accumulation of fluorides in aquatic plants and plankton is a very important phenomenon because of its potential impact on all animals which consume these organisms, including man. Some recent data suggest that the concentration of fluorides along a food chain is certainly not less than 10 to 1.

8. Finally, we possess very little knowledge about the sub-lethal effects of fluorides on the behaviour and reproduction patterns of aquatic organisms or

on the accumulation potentials of these substances in aquatic food chains. Some suggest that such effects are even more serious and could have a much greater ecological significance than the mortality risks which come from massive fluoride pollution over short periods of exposure.

3.4 Recommendations

3.4.1 Physicochemical studies

The committee recommends that studies be made on the hydrological behaviour of fluorides in an aquatic environment. Studies will be needed on:

1. the capacity and mechanisms of dispersal of the fluorides in this environment;

2. the currents of the principal waterways where the fluoride effluents will be discharged and the behaviour patterns of municipal effluents in the waterways to discover if dilution is effective and in what percentage;

3. the tendency of fluorides to form combinations with suspended particles and sediments.

4. the capacity of fluorides to react with other substances.

3.4.2 Studies on biological elements

The committee recommends that a long-term research program be undertaken on the effects of fluorides on certain biological elements in various aquatic conditions as follows:

1. the identification of different sources of fluorides, a description of how they are carried and a precise assessment of their effects on the environment at all levels of the food chains;

2. the accumulation potential of fluorides in aquatic food chains;

3. the effects of fluorides on fresh water vertebrates.

3.4.3 Finally, the committee recommends that the introduction of any form of artificial fluoridation of water supplies be postponed until a scientifically precise assessment has been made from these studies of the impact of such a measure on animal and plant life.

Naturally this decision should take into account other relevant factors concerning water fluoridation discussed elsewhere in this report.

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C H A P T E R 4

EFFECTIVENESS OF FLUORIDATION IN THE PREVENTION OF DENTAL CARIES AND ITS SECONDARY EFFECTS

CHAPTER 4

The following chapter deals with the medical evaluation of fluoridation of drinking water. It first discusses the effectiveness of this measure in preventing dental caries, and then considers the secondary effects of this measure.

4.1 Effectiveness against dental caries

Fluoridation of drinking water dates back a little more than thirty years. It was first tried out following epidemiological research by Dean (1) to isolate the causes of dental fluorosis observed in part of the population of about 25 American states.

The studies by Dean (1) and several others (2, 3, 4) which showed that fluorides can cause dental fluorosis were later confirmed by experiments under controlled laboratory conditions. Subsequent research, in fact, revealed that fluorides can cause poisoning of the ameloblasts, resulting in the formation of dental enamel with obvious signs of hypomineralization; this anomaly is commonly called dental fluorosis (5, 6).

On the other hand, it has not yet been established with any

certainty that water with the recommended level of fluoridation is effective in preventing tooth decay.

Dean, in his studies (7), noted that there seemed to be a correlation between the presence of dental fluorosis and a reduction in caries. His proposed dosage (1.2 ppm) seems to be a compromise between "an acceptable rate of dental fluorosis" and any reduction whatever in caries. Calculations made at the time estimated that an adult could absorb 1 to 2 mg per day (8). When the time came to confirm the effectiveness in preventing tooth decay by adding fluorides at this level, matters became quite complicated, and even today the only valid evidence is that obtained from studies made on human populations. We must recognize that in this respect we are witnessing the most extensive toxicological study ever made on the human race, and that this study is being carried out without the consent of the people involved.

The difficulties in carrying out the experiments stem from the very large number of factors that can influence the rate of dental caries in the population. Among them, mention may be made of dietary habits (9, 10), hardness of food (11), presence in drinking water of such elements as vanadium, strontium, calcium, magnesium, phosphorus,

fluorine, copper (12, 13, 14), the type of bacterial growth in the mouth (15, 16), the presence or absence of anti-bodies against "streptococcus mutans" in the saliva (17), dental hygiene (18), genetic factors (19, 20), the use of dentrifices with a fluoride base or those containing antiseptics, etc. (21, 21). The presence of such a large number of variables, all of which may have important effects on the results, creates serious problems in interpreting the collected epidemiological data. It is therefore not surprising that many scientists question the interpretation given to these studies by public health services. The differences in percentages of the reduction in dental caries found in the various studies appear to be further confirmation of the doubts expressed, and in general it can be said that it is impossible to predict the results from any given population.

In a situation like this, the data assembled in epidemiological studies are normally confirmed by laboratory tests under controlled conditions. But in this instance, while it would seem <u>a priori</u> that experiments with animals could easily be carried out, this is not the case. Fluorides are so prevalent in nature that it is almost impossible to prepare a diet for laboratory animals that does not have excessive amounts of these substances. The few experiments

that have been made with diets that are chemically pure are so far removed from normal experience that any extrapolation to the human situation seems irrelevant. This is a problem that modern technology has not yet solved.

In conclusion, it is not surprising that works published about the prevention of tooth decay have not yet established any consensus within the scientific community. For the present, it seems that research efforts should be directed to an understanding of the basic mechanisms of dental caries, since only more complete knowledge in the field will enable us to improve the present situation. We certainly have not reached the point where we would be justified in imposing anything on anyone.

4.2 Secondary effects of fluoridation

According to Rose and Marier (22), over the past decades there has been a considerable increase in the amount of fluorides in water, food and the atmosphere. These authors and several others (23, 24, 25, 26) state that, whether we like it or not, our systems absorb larger quantities than the 1 to 2 mg the WHO considers a safe daily dose (27). Under these circumstances, any

additional fluorides would seem to be both useless and dangerous. Furthermore, according to Rose and Marier (22) fluoridation of drinking water has extraordinary consequences when food is prepared in factories and when food concentrates are reconstituted. It therefore seems that at present we should be more concerned with possible intoxication than with shortages of fluorides.

Fluorine has a very toxic effect on the human organism, and there is a very fine line between the acceptable level and the toxic level. Dean (1, 7) has noted that with a fluoride level of 0.9 ppm in drinking water, close to 12% of children suffer from dental fluorosis; at the level of 1.2 ppm, this disease can affect 20 to 30% of the child population. Dean's work is partially confirmed by a recent publication in the Archives of Oral Biology (28). This publication states that nearly 70% of young children who take vitamin drops with a daily fluoride supplement of 0.5 mg suffer from dental fluorosis.

Dental fluorosis seems to be a first indication of fluorine intoxication of the population (29, 30, 31). The seriousness of disorders and diseases caused by fluorine seems to increase with the degree of intoxication.

This is true, for example, for persons who absorb a higher than normal amount of fluorides, such as those with kidney deficiencies, sufferers from polydipsia, diabetics and those on dialysis (32, 33, 34), and a number of cases of osteomalacia and osteosclerosis have also been reported. In regions where fluorosis is endemic, Singh (35) has noted calcification of the joints, tendons and spinal column, with fusion of vertebrae and major malformations of different parts of the skeleton. In these regions there are also a number of children with a form of fluorosis that can cause major malformation of the knee (Genu Valgum) (36)

The examples Singh documented can be considered advanced cases of intoxication; but they also provide evidence of certain processes of chronic fluorine intoxication. Some patients with fluorosis also suffer from hyperparathyroidism (37) and severe neurological disturbances (38, 39). Finally, it seems that fluorosis can cause a kidney disease called insipid diabetes (40, 31, 42, 32).

Two reports among the very extensive literature on fluorine deserve special attention. The first deals with a study published by Rapaport (43) who relates an increase

in the frequency of Down's syndrome (mongolism) which is proportional to the level of fluorides in drinking water in certain cities in the state of Minnesota. The genetic components of this disease and the incidence of its concentration in the population are well known. This study would not be particularly significant if it were not indirectly confirmed by recent studies showing that even a low level of fluorides can cause modifications in the genetic material of the cell (44, 45, 46). The ways in which fluorides act are still not completely understood and this subject is one of great concern, particularly in view of the present exposure of the public to this toxic agent.

The second point of concern is found in the publication by Yiamouyiannis (47) of an epidemiological study demonstrating that there is a higher rate of cancer in cities that fluoridate their drinking water at a rate of 1.2 ppm than in those that use non-fluoridated water. This study was severely criticized by the public health services. Quite recently it has been reaccredited before a Pennsylvania court (48). It is rather amusing to see that law courts now seem called upon to discharge a function that normally falls to public health services. But this report is not completely surprising since several other scientists have published studies showing

that fluorides seem to have carcinogenic effects (44, 45, 46, 49, 50, 51, 52, 53, 54). These studies also seem to raise the possibility of the formation of fluoridated substances with carcinogenic properties, either when water is treated or when it is subsequently used by industry. It is now known that a good many organic halogenic products are carcinogenic (55). Even if our knowledge of these fluoridated organic compounds is still rudimentary, the possibility of these substances resembling other organic halogenic products with respect to their carcinogenic properties is very disturbing.

A careful examination of the works of Yiamouyiannis and Burk (47) reveals that the carcinogenic effects of fluorides seem to be closely related to the quantity absorbed. It should be kept in mind that the target population of the study, those of cities considered free of water fluoridation, absorbs an average of 2.1 mg of fluorides per day (22). The average daily consumption in cities that fluoridate their drinking water is 4.5 mg, or a difference of 2.4 mg a day. If Yiamouyiannis' figures are interpreted in this light, it becomes apparent that a very small difference in the amount absorbed results in very significant increases in cancer rates. It must also be realized that the reference population already

consumes enough fluorides to show a higher cancer rate than it should; this could disguise an even greater increase than the one mentioned in the study.

4.3 Clinical entities due to consumption of artificially fluoridated water

Finally, it should be mentioned that the diseases described above are difficult to treat medically. We can thus speak of fatal diseases such as cancer or permanent diseases such as mongolism. But there is also a whole series of disorders which could be classified as intoxications ranging from light to severe, and which are caused by an intolerance to fluorides. Waldbott (55) reports no less than 400 cases of intolerance with symptoms that are either minor or major. The works of Waldbott (56) and others (57) deserve attention since very few doctors know how to recognize fluoride intoxication or how to treat it.

4.3.1 Symptomatology and clinical signs

According to this author, the characteristics of this intoxication are vomiting, gastro-intestinal pain, stomatitis (buccal inflamation with ulceration) polydipsia (need to drink frequently), pain in the

joints, migraine, eye troubles, buzzing in the ears, and mental depression.

Cases were hard to diagnose at first, since so little was known about the disease. But with experience it is now possible to identify the clinical picture and diagnosis can be scientifically carried out.

Many cases have been reported in medical journals. Diagnosis was established as follows:

1. first, identification of the symptoms described above;

2. disappearance of symptoms when patients stopped drinking fluoridated water;

3. among the patients who had been cured, reappearance of symptoms of intoxication when they again began to drink fluoridated water or when they were given artificially fluoridated water.

4. these medical experiments were subject to strict

scientific controls;

5. the results have been published in many medical journals.

4.4 CONCLUSIONS

4.4.1 The scientific value of studies on dental caries is now being questioned. Dental caries constitute a combination of very complex pathological phenomena subject to a great many variables, all of which can influence the results of studies in a significant way and which cannot be controlled. This creates extraordinary complications in interpreting data and distorts the results obtained. Under these circumstances, it is easy to understand why many scientists have serious doubts about the real value of these studies.

4.4.2 A number of studies, carried out under strict controls, have shown that there has been a substantial increase in fluorides in water, in food and in the atmosphere, and that those exposed perforce absorb a much higher amount daily than the 1 to 2 mg considered safe by the WHO.

In the circumstances, the committee is of the opinion that an additional amount of fluorides would be not only useless but dangerous (22, 23, 24, 25, 26, 27). In other words, we should be more concerned about possible intoxication than with deficiencies of fluorides.

4.4.3 Fluorine is very toxic for the human system, and there is only a thin line separating the acceptable level from the toxicity level. It has been determined that with a fluoride level of 0.9 ppm in drinking water, nearly 12% of children suffer from dental fluorosis; at 1.2 ppm, this disease can affect 20 to 30% of the child population.

4.4.4 Dental fluorosis seems to be the first indication of fluorine intoxication of the population (29, 30, 31). It has also been noted that the seriousness of disorders and diseases caused by fluorine increases with the degree of intoxication.

4.4.5 Recent studies have shown that fluorides may cause genetic changes, and that even small amounts of fluoride can cause modifications in the genetic material of the cell (44, 45, 46).

These data are very significant because genetic change is a phenomenon that precedes carcinogenesis at the somatic level. Nearly all carcinogens are agents of genetic change and, conversely, nearly 90% of mutagens are carcinogenic (59).

4.4.6 Recent large-scale, retrospective epidemiological studies involving large population segments under observation for many years point to a significant correlation between the high cancer mortality rate and artificial fluoridation of drinking water.

We should pay careful attention to these studies to ascertain as precisely as possible the extent of the risks for a population whose drinking water has been artificially fluoridated (44, 45, 46, 49, 50, 51, 52, 53, 54).

The results of these studies are extremely important because they are closely linked to the mutagenic properties of fluorides, a phenomenon that has been demonstrated by experiments carried out under the strictest scientific conditions (58).

4.4.7 Many cases of intoxication caused by drinking artificially fluoridated water have been diagnosed and cured after a return to drinking non-fluoridated water.

These medical experiments were rigorously controlled and have been published in medical journals.

Unfortunately, it is highly probable that a number of such cases have not been diagnosed because of a lack of professional experience with this relatively recent form of chronic intoxication by fluorides.

4.5 RECOMMENDATIONS

The committee recommends:

4.5.1 that a research program on the basic characteristics of dental caries be effected. The committee believes that more complete knowledge in this area would lead to an improvement in the present situation;

4.5.2 that a survey be made to determine the total amount of fluoride absorbed daily by the population from existing sources of fluoride;

4.5.3 that a monitoring system be established to evaluate and control, on a continuing basis, the fluoride content of food and drink, so that it can be kept within the maximum tolerable limit (see the committee's recommendation 1.7.2 on this point, at the end of the first chapter of the report);

4.5.4 that the results of these analyses be distributed to the public so that everyone can actively participate in preventing diseases related to chronic fluoride intoxication;

4.5.5 that the standards used to control fluorine with a view to protecting the quality of drinking water be made the subject of multi-disciplinary studies and that they be based on scientific criteria which take into account the ecological, medical, judicial and socioeconomic aspects of the standards to be applied;

4.5.6 that these standards be periodically evaluated and revised;

The subject of standards for the control of fluorides is taken up in detailed fashion in the next chapter

of this report;

4.5.7 that a long-term program of epidemiological studies and experimental research be set up to determine the mutagenic, teratogenic and carcinogenic effects that fluoridated water may have on public health (60, 61);

It is recommended that the epidemiological studies be focussed on future needs and use parameters that are sensitive for the early detection of anomalies in order to determine the toxicity limits of fluorides and hence to avoid exceeding them (62).

4.5.8 that persons who absorb more than a normal amount of fluorides, such as those with kidney deficiencies, those affected with polydipsia, diabetics and those on dialysis, be kept under constant medical supervision, and that the total amount of fluorides they take in be strictly controlled;

4.5.9 that a suitable program of professional and technical training be set up for health professionals and technicians on the subject of fluoridation of

drinking water and its medical implications, with emphasis on the prevention of this form of intoxication;

4.5.10 Finally, after careful consideration of all these findings, the committee recommends that the application of Bill 88 be suspended until there has been time to examine and to apply, with scientific precision, all the recommendations concerning the long and short-term risks incured by the population related to this program of water fluoridation.

Furthermore, in the context of a more general perspective, this reevaluation of the problem of artificial fluoridation of drinking water should take into account the effects that the application of this measure, when combined with the effects of all other fluorides, would have on public health and the quality of the environment.

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C H A P T E R 5

DRINKING WATER STANDARDS

AND

TECHNICAL PROBLEMS OF FLUORIDATION

CHAPTER 5

WATER QUALITY AND TECHNICAL PROBLEMS OF FLUORIDATING DRINKING WATER

The following chapter examines water quality and the problems of fluoridating drinking water. It considers, first, standards for drinking water in order to maintain public health and protect the environment, and then the technical problems of maintaining the optimum level of fluorides during fluoridation.

5.1 Quality standards for water supplies to maintain public health and protect the environment

Acceptable drinking water is a critical factor in maintaining public health and protecting the environment. It goes without saying that water for public consumption must be free of pathogenic organisms and pollutants that are dangerous to health and the environment.

To meet these objectives, it is essential to adhere to minimum standards set by the authorities responsible for the supply of drinking water.

5.1.1 Minimum WHO standards for drinking-water

At the international level, the World Health Organization (WHO) has adopted minimum standards, and recommends analytical procedures to determine the bacteriological, biological and chemical purity of water, while noting at the same time that drinking-water should not only be safe but also reasonably pleasant to drink (that is, fresh, clear, colourless, and free from odour or disagreeable taste). The WHO also insists on the importance of freedom from organisms originating from fecal pollution (Escherichia coli, Streptococcus, Clostridium perfringens), and on the control of pesticide levels. Limits have also been set for radioactivity, certain chemical products, organic matter and polycyclical hydrocarbons of the aromatic series, as well as for certain non-toxic substances that may be harmful to health if present in excessive amounts. Finally, upper and lower limits are recommended for hardness of water, with the indication that a $CaCO_2$ content of more than 500 mg/l may lead to excessive deposits in the distribution network, while water with less than 100 mg/l can be aggressive and attack heavy metals. (11)

5.1.2 Guidelines for Canadian Drinking Water Quality 1978

In 1978, the Department of National Health and Welfare published revised guidelines for Canadian Drinking water quality to replace the 1968 Canadian Drinking Water Standards and Objectives.

The maximum acceptable concentration recommended for fluorides in drinking water is 1.5 mg/L. Fluoride levels in excess of this limit produces dental fluorosis, a condition characterized by mottling of tooth enamel.

In most Canadian communities the optimum concentration of fluoride recommended to reduce dental caries is 1.0 mg/L; however, because the amount of water (and consequently the amount of fluoride) ingested by children is primarily influenced by air temperature, the optimum concentration is higher in communities with cooler climates. The objective concentration is therefore 1.0 mg/L, except where the annual mean daily maximum temperature is less than 10°C, in which case it is 1.2 mg/L.

Where fluoridation is practised to adjust the concentration of fluoride ion to the optimum level, at least 1 sample of treated water per day should be collected and analysed for its fluoride content.

fluoride ion concentration above 1.5 mg/l should be regarded as unfit for human consumption because of the possibility of the appearance of enamel fluorosis in a small number of children who use the water over a long period of time. If the concentration of fluoride ions is above 1.5 mg/l, dental supervision is recommended to study the possible incidence of enamel fluorosis and to determine whether the water should be treated to reduce the concentration of fluoride ions.

Sampling: When fluoridation is used to bring the concentration of fluoride ions up to the optimum level, at least one sample of the treated water should be taken every day, and the concentration of fluoride ions should be measured by the "Standard Method", or according to some other acceptable method, approved by the supervisory board.

If the concentration of fluoride ions naturally present is below 1.5 mg/l, in normal circumstances the sampling program recommended in section 6 for other chemicals could be followed.

5.2 Difficulty of maintaining optimum concentrations during fluoridation of drinking water

The S.P.E. are responsible for controlling the quality of drinking-water and for applying quality standards to protect public health and the environment. Strict adherence to standards during fluoridation is, however, difficult to achieve.

5.2.1 According to the provisions of Bill 88, the concentration of fluorides in drinking-water should be so adjusted that the water coming out of the taps of consumers in any city is at the level of 1.2 mg/l. On the other hand, the standards generally in force for fluoridation require a maximum concentration of 1.5 mg/l. This seems unrealistic for existing water distribution systems.

It has to be borne in mind that pipes of asbestos cement, as well as cast iron pipes with an inner lining of concrete have a tendency to collect and hold fluorides. This reduces the concentration coming out of the taps.

Thus, when fluorides are added at the filtration plant, the concentration must be above the 1.2 mg/l level prescribed by law so that persons farthest away will receive the prescribed amount at the taps. On the other hand, in such cases, those living closest to the filtration plant run the risk of receiving drinking water with a higher concentration than that prescribed by law, or even permitted by the standards.

5.2.2 Installation of stations to readjust the concentration of fluorides

The difficulty of keeping an optimum concentration of fluorides in water in a large distribution system could be solved by installing stations to adjust the concentration at various points along the system. However, this requires sophisticated machinery that will inject fluorides into the water at a rate controlled both by the fluoride content of the water coming from the filtration plant and by the flow of this water in the pipes.

This procedure requires constant surveillance in order to minimize the risks of malfunctioning of

the machinery and possible intoxications within the community served. The case of intoxication of children (2) in a school that fluoridated its water by this method, on a reduced scale, should make us very cautious about using this procedure.

5.2.3 The American experience

The major variations in distribution networks and their components pose some important problems in maintaining so-called "optimum" concentrations to prevent dental caries. As an example, mention might be made of an American study (3) on 623 localities that fluoridated their water supplies, in a dozen southern American states. The study shows that 290 of them, or 47.1%, supplied water with a concentration outside the desired limits, that is between 0.7 and 1.2 ppm; 113 communities had water with less than 0.4 ppm, 154 were between 0.4 and 0.7 ppm, 339 were between 0.7 and 1.2 ppm, 23 were above the upper limit, and three of the latter group had clearly excessive levels of 2.10, 2.96 and 3.28 ppm. In the group within the desired limits, 106 had a concentration below 0.8 ppm, and only 31 were close to the upper limit, or 1.10 ppm.

These results show that close to 60% of the systems sampled were considered "too low to be effective in preventing dental caries."

5.3 Conclusions

1. In the light of these studies, it is evident that strict adherence to the recommended standards in applying fluoridation is difficult to achieve.

2. Major variations in the systems and in their components add important difficulties to the maintenance of so-called optimum concentrations for prevention of dental caries.

3. Fluorides are very toxic substances. Unfortunatly, extensive and careful studies have shown that the system for controlling standards is not very effective, and it is very probable that a large number of people are using drinking water with a concentration of fluorides that is plainly above recommended standards. Considering the excessive levels to which the communities studied were exposed, that is, 2.10, 2.96 and 3.28 ppm, it may well be asked to what extent they suffered from fluoride intoxication.

4. The following recommendations are made to correct this state of affairs.

5.4 Recommendations (6)

In the event the decision is made to continue fluoridation of drinking water, the committee recommends:

5.4.1 that, in order to ensure better management, specific studies be made of technical problems connected with the administration of standards for controlling fluoridation of drinking water;

5.4.2 that these studies be multidisciplinary and be based on scientific criteria taking into account the ecological, medical, juridical and socioeconomic aspects of the standards to be applied (7);

5.4.3 that the objectives and proposed standards take into account the needs and characteristics of the various regions;

5.4.4 that the citizens concerned be invited to participate in the studies and be kept informed of the standards in force so that they will be in a position to intervene with the responsible authorities when

they see that these are not being properly applied (8);

5.4.5 that the standards be applied to public and private water supplies;

5.4.6 that the standards be included in executory directives, and made public;

5.4.7 that the standards be periodically revised in the light of available new scientific information;

5.4.8 that a surveillance system be set up to ensure effective application of the established standards (9);

5.4.9 that the fluoridation program be periodically evaluated to ensure that the quality standards applied are in conformity with the proposed objectives (10);

5.4.10 that a suitable body be designated, or set up if necessary, to ensure the definition of the overall objectives, the revision of the scientific criteria used, and the refinement of the standards to be applied in protecting the public health and the quality of the environment;

5.4.11 finally, the committee recommends that Bill 88 (Division IV of the Public Health Protection Act) be suspended until these recommendations and other relevant recommendations made in other parts of the report have been considered and applied.

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C H A P T E R 6

LEGISLATION

CHAPTER 6

LEGISLATION

This chapter looks at the various Canadian laws on the artificial fluoridation of public water supplies as a preventive measure against dental caries.

6.1 Canada

Standards and objectives for drinking water and fluorides in Canada were recommended in 1968 by the Department of National Health and Welfare and the Canadian Public Health Association and are described in Chapter 5 of this report (section 5.1.2).

6.2 Provincial laws

6.2.1 Manitoba

Municipalities which operate their own water treatment plants or are planning to build new plants can obtain subsidies to defray the total purchase and installation costs of the necessary

fluoridation equipment.

These subsidies are granted on condition that the municipalities concerned have passed an order in council approving the project and have obtained the necessary authorization from the Minister of Health and Social Development (3).

6.2.2 New Brunswick

General regulations - Public Health Act (RSNB 1973, C. H-2). Reg. 66-43 (as am. 76-2, 76-35, 76-53), sections 184 to 191.

If, in the opinion of the Minister, a public or other waterworks system which provides community water supplies does not contain sufficient fluorine compounds to inhibit tooth decay, the municipality or other agency supplying the water must add fluoride to make up the deficiency.

The type of fluoride and its concentration will be decided by the Minister but in no case will the concentration exceed 1.5 ppm. The regulation gives

very precise percentages for measuring the amount of fluoride to be used in the installations.

The Minister will ensure that water-treatment plant employees are versed in fluoridation procedures.

Plant operators must take all safety measures necessary to protect employees against the toxic effects of fluorine compounds.

6.2.3 British Columbia

Municipal Act, 1960, RSBC c. 255 s. 634.

Municipal waterworks systems may be fluoridated if more than three-fifths of the eligible voters have approved the measure by referendum and, if more than 60 per cent of these have participated in the referendum, a simple majority will suffice.

Other water systems may be fluoridated provided a notice to this effect is published and no more than 40 per cent of the citizens affected have notified the public official responsible of their disapproval within three months of publication

of the notice (4).

6.2.4 Alberta

Public Health Act (1970) RSA c. 294 s. 42.

This act stipulates that a municipal council may, by regulation, order that its water supply be fluoridated. However, a plebiscite must first be held and the regulation can only be applied if the proposal is approved by a majority of the voters. If the proposal is defeated, no new plebiscite can be held for two years.

Fluoridation regulations - Alberta regulations 3817 B (Clean Water Act, S.A. 1971. 17).

This regulation specifies the fluoridation standards for water supplies which apply to all non-industrial waterworks systems.

It states that fluoridation can only be implemented if the municipal authorities have adopted a regulation authorizing fluoridation and if a building permit and operating licence have been issued by the Director of Standards and Approvals

in accordance with the Clean Water Act and the Clean Water (Municipal Plants) Regulations (A.R., 37-73).

Authorization must also be sought from the Director of Standards and Approvals to amend the operating licence so that a waterworks may be altered to accommodate a fluoridation installation.

The content of the application is described in the regulation which also provides for the installation of a meter, permanent control equipment and the obligation of maintaining these in good order.

The maximum permissible fluoride concentration in treated water is 1.0 mg/l except for:

- an average monthly variation of 0.1 mg/l;
- an daily variation of 0.2 mg/l.

A monthly analysis report must be sent to the Director of Pollution Control and the local health authorities giving the daily reading of the water meter, the daily volume of fluoridated water,

the daily weight of the fluorine compounds and so on.

Another section of the regulation provides for the suspension of fluoridation when repairs or replacement of the equipment make this necessary. The operator of the fluoridation facilities must be equipped with the necessary safety devices and these must be inspected regularly and maintained in good order.

The following fluorine compounds may be used: hydrofluosilic acid, sodium fluoride, sodium silicofluoride and those approved by the Director of Standards and Approvals.

The fluorine must be stored separately from other chemicals.

The operators must keep a record of the daily analyses and fluoride concentrations and submit samplings to the Department of Health whenever requested to do so by the Minister.

6.2.5 Nova Scotia

The existing law authorizes city councils to install water treatment systems requiring chemical, electrical, mechanical or other processes authorized by the council.

The Department of Public Works grants subsidies for the purchase and installation of fluoridation equipment (5).

6.2.6 Ontario

Fluoridation Act (1970 RSO c. 178).

Under this law, a municipal council may, by regulation, set up fluoridation equipment in a municipal waterworks system following a plebiscite on the issue.

The question to be voted on is: are you in favour of fluoridation of the public water supply of this municipality?

The result of the plebiscite determines whether

or not the regulation is adopted.

In cases where the water is already fluoridated, the council may suspend fluoridation by regulation and with the consent of the voters.

6.2.7 Saskatchewan

Water Resources Management Act (1972 SS c. 146; as am. by 1976-77 c. 101).

Under this law, any person operating a water-works system may treat the water chemically, electrically, mechanically or by any other means, in accordance with the Minister's directives.

A directive to this effect entitled Water Quality Objectives was issued in February 1967.

Part (e) of this directive deals with quality standards for drinking water and stipulates that the maximum allowable fluoride concentration is 1.5 mg/l.

6.2.8 Newfoundland

An Act Relating to the Municipal Affairs of the City of St. John's (1970 RSNF c. 40).

This act deals with the fluoridation of the drinking water in St. John's, Newfoundland.

The municipal council may order fluoridation but only after a plebiscite has been held. If the proposal is turned down by a majority of the citizens, no new plebiscite can be held for three years.

However, if the proposal is approved, the council is not obliged to fluoridate the water.

6.2.9 Prince Edward Island

The holding of a plebiscite has been authorized by special legislation adopted for this purpose.

6.2.10 Quebec

Québec legislation is dealt with in Chapter 8 of this report (section 8.3.6).

6.3 Risk of conflict between section 26 of the Public Health Protection Act and the regulation respecting water supplies for human consumption (Environment Quality Act).

The committee studied the possible risk of conflict between section 26 of the Public Health Protection Act (RSQ 1977 c. P-35) and the regulation respecting water supplies for human consumption established under the Environment Quality Act (RSQ 1977 c. Q-2).

Section 26 of the Public Health Protection Act reads as follows:

> 26. If the natural fluorine concentration of the drinking water supplied by a filtration plant is below 1.2 ppm, the owner of the plant must install a fluorination device in it and have it in operation regularly to obtain a fluorine concentration of 1.2 ppm in the water supplied by such a plant.

But the first paragraph of section 45 of the Environment Quality Act, as replaced by Bill 76 (1977 c. 55),

states that:

> 45. The operator of a waterworks system, and the operator of a public, commercial or industrial establishment supplied with water by a supply source independent of a waterworks system, shall in making water available to the public or to his employees for human consumption, supply drinking water only, to the extent and in accordance with the standards provided by regulation of the Lieutenant-Governor in Council.

The draft regulation respecting water supplies for human consumption under the Environment Quality Act prohibits the distribution of water whose fluoride concentration exceeds 1.5 mg/l (section 4).

The experts consulted indicated that in order to provide water with a fluorine content of 1.2 ppm, it would in certain cases be necessary to introduce into the system and to maintain, particularly in the parts located near the treatment plant, fluoride concentrations which could exceed the maximum 1.5 mg/l prescribed in section 4 of the regulation.

There is therefore a definite risk of conflict between the two laws. From the legal point of view it will be difficult to reconcile the two standards which at first

sight do not seem to be irreconcilable since they allow a leeway of 0.3 mg/l. But the technical realities dictate otherwise.

The problem is real enough to warrant attention for it could result in difficulties for every municipality operating a waterworks system and treatment plant.

6.4 Study of section 19a ff. of the Environment Quality Act (RSQ 1977 c. Q-2) (1)

Section 19a of the Environment Quality Act, adopted under Chapter 64 of the 1978 Statutes, gives everyone the right to environmental quality, to its protection and to protection of the living creatures who share it, within the bounds of the act. Section 19b provides recourse to the injunction procedure to prevent any action which may interfere with the exercise of this right.

The injunction process as a means of preventing or halting water fluoridation is only possible if a waterworks system comes under the statutory definition of "environment". Water is part of the environment and is defined as surface and underground water wherever it is found. The underlined words make the definition

sufficiently broad to include the water in a waterworks system.

Although the heavy burden of proof would seem to preclude such a possibility, a citizen could conceivably cite the provisions under sections 19a ff. of the Environment Quality Act in order to halt fluoridation of water supplies.

6.5 CONCLUSIONS

6.5.1 Each province has its own legislation authorizing the fluoridation of water supplies.

6.5.2 The committee studied the risks of conflict between section 26 of the Public Health Protection Act (RSQ 1977 c. P-35) and the regulation respecting water supplies for human consumption under the Environment Quality Act (RSQ 1977 c. Q-2) and concluded that there is certainly a risk of conflict between the two laws.

6.6 RECOMMENDATIONS

The committee recommends that:

1. section 26 of the Public Health Protection Act and the regulation respecting water supplies for human consumption (Environment Quality Act) be revised in order to reconcile the two standards in accordance with the technical requirements.

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C H A P T E R 7

JURISPRUDENCE

CHAPTER 7

JURISPRUDENCE

This chapter gives a brief description of Canadian, American, and Quebec jurisprudence concerning the fluoridation of community water supplies as a preventive measure against tooth decay.

7.1 Canadian jurisprudence

On only two occasions has Canadian jurisprudence dealt with the question of fluoridation of drinking water: The Municipality of Metropolitan Toronto v. The Corporation of the Village of Forest Hill (1957, SCR, 569) and The Queen v. Fredericton (1956, 2 DLR (2d), 551).

The issue in these two cases was not to establish whether fluoridation ran counter to the individual's basic rights but rather to determine the extent of the powers conferred on municipalities by the provincial legislatures and whether the municipalities had indeed the authority to fluoridate drinking water.

In the Ontario case, it was ruled that the right of the government to adopt regulations respecting pure and wholesome water supplies did not include the right to fluoridate water since fluorine per se neither added nor detracted from the purity or wholesomeness of drinking water. In short, the powers conferred did not include the right to fluoridate.

The second case is similar in that it too questioned the unwarranted action of the municipality of Fredericton; the case also contains a lengthy argument on recourse to certiorari as an appropriate remedy in this situation.

These cases have no more than a relative effect in Quebec since fluoridation is decreed by a provincial law whose legality cannot be questioned on the grounds that it goes beyond the limits of its powers. Nor can it be inferred from these cases that fluoridation would be excluded in the quality standards for drinking water which the Lieutenant-Governor in Council has the power to define under section 45 of the Environment Quality Act (RSQ 1977 c. 49).

7.2 American jurisprudence

This section is drawn largely from studies by Groth on the scientific development and evolution of the administrative policies governing the application of fluoridation in the United States.

7.2.1 Since fluoridation was first introduced as a means of reducing dental decay, a number of actions have been brought before the courts by its opponents on the grounds that it interferes with their constitutional rights. Except in one very specific case explained in section 7.2.6, the courts have always decided in favour of fluoridation.

The actions were appealed before the supreme courts of several states but the U.S. Supreme Court has always refused to hear appeals from the state courts. The Supreme Court's stand must not however be interpreted as approval of the decisions of the state courts; this may signify that problems of this type should be resolved by legislation rather than by the government's judicial apparatus (3).

7.2.2 Court judgments were handed down on most of the arguments raised against fluoridation. The courts declared that it was legal for a state to use the powers conferred on it to prevent dental decay and that fluoridation was a reasonable means of achieving this objective; in some cases, they declared that fluoridation was the best option available (4).

7.2.3 The arguments, which were based on religious freedom and constitutional rights, were dismissed on the grounds that the rights of the individual are never absolute and must sometimes be subordinated to the common good.

In essence, the courts affirmed that the desire of the majority to prevent dental decay in children was more important that the wish of individuals and minorities to choose their own medical treatment (5).

7.2.4 All these decisions are highly subjective and are founded on individual philosophical values and beliefs. In each case, the judges agreed with those who favoured fluoridation and a number of their statements tend to indicate that they were

influenced by the "establishment", by the prestige and ex cathedra declarations of pro-fluoridation organizations which have always unanimously declared it as safe, effective and beyond dispute (6).

7.2.5 Setting a precedent

The many court decisions in favour of fluoridation have established an important precedent in medical jurisprudence. Indeed, they open the way for government to use public water supplies to administer medication to whole populations on the grounds that this would be for the common good and is a reasonable method of solving certain public health problems.

In theory, a great many substances could be added to public water supplies to improve the health of all citizens; a good example would be the addition of vitamin C to prevent influenza (or colds) and minerals recognized as essential to good nutrition.

These possibilities are mentioned not because they might violate individual rights but rather to

illustrate the magnitude and complexity of the biological controls needed to protect the health of the public if these new substances were added to drinking water (7).

7.2.6 A recent decision

A very recent case in the United States is worthy of mention: Paul W. Aitkenhead v. Borough of West View (Court of Common Plea, Allegheny County, Penn., #GD-4585-78, Nov. 16, 1978). This was an action similar to a writ of evocation against a final and unappealable decision of the Department of Environmental Resources to issue a fluoridation permit to the municipality of West View. The petitioner asked the court to order the municipality to halt fluoridation of its drinking water. He argued that the addition of 1.0 ppm of fluorine was a threat to his health and to that of the public and cited an epidemiological study which showed a correlation between the consumption of fluoridated water and cancer. This non-codified procedure was admitted on the grounds that equity alone was an adequate remedy to the defiance of justice which the plaintiff claimed to be a victim

of, justice which recognized his right to "life, liberty and the pursuit of happiness" but had not been able to intervene when the decision to fluoridate the community water supply was made by a government agency.

The judge pointed out, obiter dictum, that no government official, bureaucrat or learned judge, has the right to decide what is good for the people, particularly when the subject in question is a highly controversial one. Too often, government officials forget that their role is to serve, that it is the citizens, and not the government or some impersonal institution, who are supposed to be the masters. Civil servants would do well to understand the true significance of their designation.

The preponderance of the evidence led to the conclusion that water fluoridation may be carcinogenic (1) (2).

This case is now being appealed before the higher courts of the State of Pennsylvania. Only the

jurisdiction of the court is at issue and not the evidence presented on the effects of fluoridation.

7.3 Québec jurisprudence

In Québec, a case of this kind based on human rights could not have its origin in the Charter of Human Rights and Freedoms (RSQ 1977 c. C-12), since under its interpretive provisions, the Charter applies only to the extent provided by the legislator. As a general law which came into force one year after the act sanctioning fluoridation, the Charter, in accordance with its interpretive provisions, cannot override the earlier special statute. It should however be stressed that the Charter enshrines the right to physical integrity.

7.4 CONCLUSIONS

7.4.1 On only two occasions has Canadian jurisprudence dealt with the question of fluoridation and each of these cases was concerned with determining the extent of the powers conferred on the municipalities by the provincial government in order to decide whether the municipalities did indeed

have the power to fluoridate drinking water.

7.4.2 Except in the specific case outlined in the following paragraph, American courts of justice have always pronounced themselves in favour of fluoridation to prevent tooth decay and have declared it legal for states to use the powers conferred on them to achieve this objective. The Supreme Court has always turned down appeals by the state courts although this would seem to run contrary to their usual practice of granting priority to cases which are in the national interest.

7.4.3 A recent noteworthy case (Paul W. Aitkenhead v. Borough of West View, Court of Common Plea, Allegheny County, Penn.) presented weighty evidence that fluoridation of drinking water could be carcinogenic.

7.5 RECOMMENDATIONS

The committee recommends that a coherent government policy be adopted which would reconcile the recent law recognizing the fundamental right to physical integrity

and the earlier law which foists fluoridation on all citizens without dissenting voices being heard on an issue affecting the health of the public.

7.6 BIBLIOGRAPHY

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C H A P T E R 8

FLUORIDATION OF DRINKING WATER

CHAPTER 8

FLUORIDATION OF DRINKING WATER

The eighth and final chapter examines the experiences and results of fluoridation of drinking water in foreign countries and in Canada.

8.1 Foreign experiences (1)

In the thirty years the process has been in use, fluoridation of drinking water as a means of preventing dental decay still remains essentially a North American development. In 1977, there were 212.7 million people, or about 9% of the world's population, using the process.

Of this total, the combined populations of the United States, Canada and Mexico using the process came to more than 132.5 million.

On the other hand, in 30 European countries, only 15.5 million out of a total of 700 million, or only 2% (2), were using artificially fluoridated water. In Appendix 2 the reader will find more detailed information on the countries that use fluoridation to any great extent.

8.1.1 AUSTRIA

Fluoridation of drinking water is not mandatory in Austria. Fluorides in the form of tablets are distributed to pregnant women, infants, young children and children of school age.

Some citizens are opposed to the program. All charges made against it have been examined by the Ministry of Health and the Environment and found to be without foundation. Only one province has stopped distributing fluoride in the form of tablets. The Ministry endorses this process, which is used in eight other provinces (3).

8.1.2 WEST GERMANY

Since the first of January 1975, new legislation has authorized the addition of fluorides to drinking water as a means of combatting dental caries, subject to the application of certain operating conditions (4).

8.1.3 BELGIUM

Fluoridation is not compulsory (5).

8.1.4 DENMARK

The National Health Council is convinced that fluoridation is a valid health measure. It has been observed that people living in a region 50 miles south of Copenhagen where the water is naturally fluoridated have fewer cavities than the rest of the population. However, fluoridation is not obligatory. The sale of toothpaste with fluorine has been permitted since 1964 (6).

8.1.5 SPAIN

Fluoridation is not compulsory, but the government encourages this prophylactic measure. It has been used mainly in large cities with water supply systems (7).

8.1.6 FINLAND

The government of Finland strongly supports fluoridation. One city in Finland with a

population of over 70 000 fluoridates its drinking water (7).

8.1.7 FRANCE

In accordance with the opinion of the Superior Council of Public Health, the Ministry of Health is not in favour of adding fluorine compounds to public water supply systems.

A national campaign to analyse the fluorine content of water supplies is now in progress. The results to date (March 27, 1975) indicate that the water is not deficient in fluorine to the extent that it would be useful to add any. And in addition, in view of the situation in France where there is great variation in the amount of water consumed in drinks and used in the preparation of food, depending on the individual, the region and the age, it would seem impossible to control the amount of fluorine taken in by the individual in tap water.

Other methods (dentrifices, local external medication, fluoridated salt, etc.) seem to be preferred,

the more so since fluorine does not appear to have any effect on dental caries except at certain ages, particularly in later childhood. It is therefore useless and perhaps harmful to administer it to the population as a whole (9).

8.1.8 GREECE

In January 1974, Greece approved a law requiring communities of more than 10 000 to fluoridate their water supplies (10).

8.1.9 ISRAEL

Fluoridation is not obligatory, but the government is not opposed to it (11).

8.1.10 ITALY

Fluoridation is not compulsory. In November 1974, the Italian Senate passed a law designed to prevent dental caries through the administration of fluorides, by mouth, to children 5 to 14 years of age. Specialists also recommend the use of fluoridated toothpaste (12).

8.1.11 JAPAN

Fluoridation is not obligatory (18).

8.1.12 NORWAY

Norway has no legislation on fluoridation; consequently, the water is not fluoridated. However, a committee commissioned by the government in 1968 to study the question has come out unanimously in favour of fluoridation.

In 1974, a parliamentary committee on health and social services expressed the opinion that a more exhaustive review of the subject was required before a decision could be made.

In 1975, the Minister of Social Affairs stated before Parliament that the effects of fluoridation had been sufficiently demonstrated to justify authorizing fluoridation (19).

8.1.13 NETHERLANDS

Fluoridation of water is practised in the Netherlands under the law respecting water supplies, passed

in 1961. A group of opponents of the measure instituted court proceedings and, in a decision handed down in 1973, the Superior Court of the Netherlands ruled that the scope of the 1961 law was too restrictive to permit the fluoridation of drinking water.

In 1976, the Minister of Public Health prepared new national legislation to legalize fluoridation, which he submitted to Parliament, but it was not approved (20).

8.1.14 SWEDEN

In 1971, the Swedish Parliament repealed a law passed in 1962 that authorized fluoridation to improve dental hygiene (21).

8.1.15 SWITZERLAND

By law, the Swiss cantons have the authority to fluoridate the water. The city of Basel uses fluoridation at the rate of 1.0 ppm (22).

8.1.16 YUGOSLAVIA

Fluoridation is authorized by law in Serbia (23).

8.2 Canadian experience (1)

Thirty-four years ago, on June 20, 1945, Brandford became the first city in Canada, and one of the first three in the world, to add fluorine to its drinking water in an effort to reduce dental caries (24).

Today Canada ranks among the countries that are the highest users of the fluoridation process. In 1977, 8 557 554 people, or 37% of the Canadian population, were using fluoridated water.

In Appendix 3 the reader will find a table with detailed information on the use of fluoridation in Canada up to December 31, 1976.

8.2.1 Experience of the Department of Health and Welfare (25)

The Department of Health and Welfare is of the opinion that fluoridation of water is an effective means of reducing the incidence of dental caries, and therefore of lowering dental costs.

8.2.1.1 Evaluation of dental health (26)

For a continuing evaluation of the state of the dental and general health of Canadians using fluoridated water supplies, the Department is carrying out studies that will make it possible to keep up-to-date information on the state of fluoridation of water supplies in Canada.

8.2.1.2 Fluoridation and cancer (27)

The Department is also carrying out research on fluoridation and cancer. In 1977, the Environmental Health Directorate made a study of 79 groups of municipalities throughout Canada to determine whether fluoridation of water supplies increased

the risks of death from cancer among residents of the areas.

The study covered the period from 1954 to 1973 inclusive; mortality rates from cancer in groups of municipalities using fluoridated water were compared with the rates in other groups of municipalities that did not.

No appreciable difference was observed during this period in the mortality rates for all kinds of cancer or for any particular cancer between groups of municipalities that fluoridated their water and those that did not. Nor was any significant difference observed in the mortality rates of all types of cancer within the same group of municipalities before and after the introduction of fluoridation of the water supply.

The study was criticized first because of the choice of cities. The variations among them were such that it was difficult

to compare cancer death rates, since some of the cities were highly industrialized, others rural, some were port cities, and others dormitory cities.

The cancer death rates at the beginning of the study in 1953 varied widely from city to city.

Moreover, the study did not take into account the level of fluorides in food, a factor that is more important in big cities with fluoridated water since more food products are prepared with such water (39).

8.3 Québec experience

8.3.1 Fluoridation at Pointe Claire (28)

Controlled fluoridation began in Quebec at Pointe Claire in 1955, ten years after Brandford, Ontario.

8.3.2 Brief submitted by STOP (Society to Overcome Pollution) to the Department of the Environment, entitled "Water fluoridation... The human diet and the environment" (29)

In 1971, STOP submitted to the Minister of the Environment a brief in which it recognized the advantages of fluoridation in reducing dental caries among children. However, it had serious reservations about the environmental effects of adding still another chemical substance to Quebec's water system, which is already polluted.

It was concerned because neither the government nor any international body had succeeded in establishing a safe upper limit for the daily consumption of fluorides by adults and children. The unofficial safe levels varied between 1 mg and 5 mg per day.

Moreover, it emphasized that water fluoridation benefited only a small proportion of the population, that is, children from the time their teeth came through up to the age of 14.

In its statement, STOP declared that the fluorides consumed came from many environmental sources,

and that the total of these amounts was rarely made public or that the public simply was not aware of the problem. In any event, the levels of fluorides in the natural state in drinking water were rarely checked.

STOP then listed a number of food and environmental sources of fluorides which, working their way through the food chains, ended in the food consumed daily by Quebecers.

The organization made the following recommendations:

1. that the proposed fluoridation of drinking water be reconsidered in light of the facts mentioned above;

2. that a survey be made to determine the total amount of fluorides Quebecers absorb, from all existing sources of fluorides;

3. that the level of fluorides in food and drink be continously evaluated;

4. that there be constant surveillance of drinking water to control the presence of fluorides in

the environment (by means of a monitoring system).

Finally, STOP concluded by asking why the absorption of fluorides from food and drink (apart from water) was not sufficient for dental protection, since there was very little difference in fluorides obtained from food and from water.

8.3.3 Report of the Conseil consultatif de l'environnement on the ecological consequences of water fluoridation (30)

8.3.3.1 Purpose of the study

On August 14, 1975 the Conseil consultatif de l'environnement submitted to the Minister of the Environment a report it had prepared, at the request of the Society to Overcome Pollution, on the ecological consequences of water fluoridation.

The purpose of the study was to analyse the possible consequences of mandatory water fluoridation in Quebec, on animals (other than human beings) and on plant life.

The first part of the report sought to determine in a general way the quantities of fluoride in the environment. More specifically, it sought to establish what the level of fluoride concentration in wastewater in Québec would be if there were mandatory fluoridation of drinking water in the province. To this end, the following points were considered: the progress of fluorides in drinking water to waste water, the ingestion and elimination of fluorides by human beings.

The second part of the report discussed the immediate effects on the environment of water that has been fluoridated. After noting the amount of fluorides that people can absorb daily, the study turned to the effects of fluorides on animals and on plant life, both on land and in the water.

8.3.3.2 Conclusions of the Conseil

The study brings out the following points:

1. Sources and quantities of fluorides are constantly increasing. In Quebec, there is no reliable information on the sources or on the total amount of fluorides they add to the environment.

2. If drinking water is fluoridated, it can be assumed that virtually all of the added fluorides will be found in the wastewater. It is these fluorides that will actually affect the environment.

3. The ecological consequences of fluoridated water have been given little attention anywhere in the world, and none at all in Quebec.

4. The Conseil noted that, on the basis of the few data there are available, there does not seem to be any serious problem due to fluoridation of drinking water. This opinion is based on the fact that in large hydrographic basins, the dilution factor should keep the concentration of fluorides below the

level likely to affect the environment. However, it added that in basins with a weaker flow more caution is advisable.

5. Further, the Conseil pointed to the possibility of an accumulation of fluorides along the food chains and of synergisms with other pollutants which have not yet been specifically studied.

6. The Conseil also noted that it had had great difficulty in identifying the origin and quantity of fluorides absorbed by the population.

7. Finally, it noted there is no consensus among scientists on the maximum daily dose of fluoride the body can safely take in.

8.3.3.3 Recommendations of the Conseil

The Conseil made the following recommendations:

1. since existing scientific data is clearly inadequate for a precise evaluation of the ecological effects of fluoridation of drinking water, that a research program be established immediately to determine and evaluate precisely the effects of fluorides on the environment and particularly on aquatic flora and fauna;

2. further, that the research program include the studies required to evaluate, on a continuing basis, the effectiveness of fluoridation of drinking water;

3. finally, in view of the lack of scientific data on the effects of all fluorides on the environment in Québec, that a comprehensive research program

be set up to work out an effective surveillance and control policy for all the fluorides introduced into the environment.

8.3.4 Presentation of briefs to the parliamentary committee before the adoption of Bill 88 (31)

A number of professional associations, representing among others dentists, doctors and pharmacists, submitted briefs in support of artificial fluoridation of drinking water. They emphasized that this step would result in a noticeable reduction of the incidence of dental caries, without any attendant danger to public health.

8.3.5 Brief of the Common Front Against Fluoridation

The Common Front Against Fluoridation also submitted a brief to the parliamentary committee on Bill 88. Some extracts from it are summarized below.

1. Artificial fluoridation is not a scientific measure because it provides no way of controlling the total amount of fluorine absorbed by each person. The amount of liquids

taken into the body varies considerably from person to person. Some people drink a great deal, others very little. The first group will necessarily take in more than the required dosage of fluorine, while the second will fall short of it. And since children generally more often drink milk and fruit juices, it is possible that fluoridation of water offers them very little benefit. The measure thus becomes useless.

A more scientific measure would be a system of distributing fluorine tablets which could be added to the liquids children drink. In this way the amount of fluorine absorbed could be closely controlled, and the procedure would be more scientific.

2. Supporters of artificial fluoridation do not seem to take account of the fact that the food we eat already has significant amounts of fluorine. This provides all the fluorine the body needs, and in a much less toxic form than artificial fluorine compounds.

Studies of the National Research Council in Ottawa have shown that people living in cities whose water is artificially fluoridated at the level of one part per million absorb between 2 and 5 milligrams of fluoride per day. These findings have been confirmed by other responsible researchers. It is clear that the human body under these circumstances is already taking in too much fluorine.

3. The prevention of dental caries lies essentially in better food habits. The government should be working in this direction if it really wants to improve the health of Quebecers.

8.3.6 Approval of Bill 88 on fluoridation of drinking water

The Assemblée nationale du Québec has approved Bill 88 dealing primarily with the fluoridation of drinking water and has incorporated it in Division IV of the Public Health Protection Act of June 27, 1975.

This division of the act stipulates that if the

fluoride content of water supplied by a filtration plant is below 1.2 parts per million (mg/l), the owner of the plant must install fluoridation equipment and operate it in such way that the water will have a fluoride content of 1.2 parts per million (mg/l).

The number of people now being furnished with fluoridated water totals about 1 060 240.

8.4 American experience

In December 1975 there were 105 338 000 people in the United States using fluoridated water. Of this total, 10 711 000 consumed naturally fluoridated water; 94 627 000, on the other hand, were supplied with artificially fluoridated water. Fluoridation was used by 70% of the cities with a population of more than 100 000.

8.4.1 Development and evolution of fluoridation in the United States

The following section is devoted to a study of the scientific development of the administrative

policies governing fluoridation of public drinking water in the United States since it was first introduced at the beginning of the 1940s. It is based largely on the work of Groth and deals briefly with the following problems:

1. the controversial nature of fluoridation;

2. the lack of scientific proof of the advantages and safety of fluoridation;

3. the scarcity of genuinely independent studies on fluoridation;

4. the inadequacy of studies on alternatives to fluoridation to reduce dental caries;

5. the lack of real public participation in the decision-making process respecting fluoridation;

6. finally, the type of body which should be formed so that the public can take a more effective part in the debate and in decisions about fluoridation.

8.4.1.1 Fluoridation always has been and remains a controversial subject (32)

The fluoridation of drinking water recommended by public health services as a means of preventing dental caries in persons who drink fluoridated water during childhood is at the heart of a scientific controversy that has been the subject of extensive debate over the past three decades. Despite the unanimous support of government, it has had to deal with strong opposition since it was first introduced.

Many persons have raised questions, and still do, about the long-term effects of absorbing fluorides, whose toxicity even in small quantities is recognized; they have maintained that there had not been enough research on the synergic and long-term effects of fluoridation of drinking water before the procedure was adopted.

In view of the controversial nature of the problem, those supporting it as well as

the opponents of fluoridation have adopted and used political tactics and electoral propaganda to have the measure either adopted or rejected by communities across the country.

Over the past thirty years, fluoridation has been in use in about half the cities and towns with public water supplies in the United States.

From the beginning, the struggle has been between two opposing camps: those in favour of fluoridation and those against it. This polarization had an effect on subsequent events. Many of those supporting the process were scientists who at the same time were conducting research on the subject, and the campaigns organized by the United States Public Health Service undoubtedly influenced the course and interpretation of the research and the quality of the debate that ensued in the scientific community.

This polarization has caused a division of opinion among experts over the scientific aspects of the debate. Those in favour of fluoridation maintain there is unequivocal proof that fluoridation is an effective procedure for reducing dental caries and that it is absolutely safe. Opponents of fluoridation maintain, with equal conviction, that proof of these alleged benefits is not conclusive, and that in addition it has been shown beyond any doubt that the health of some persons has been affected by this procedure.

Faced with these contradictory views, citizens and elected representatives no longer know what to believe. It is true that most highly placed authorities are in favour of fluoridation, but scientific proof is not made by simple affirmation, or by the acceptance of testimony without proof.

8.4.1.2 Advantages and safety of fluoridation have not yet been scientifically proven in definitive fashion

A comprehensive study and critical analysis of the research results used by government authorities as a basis for the decision to adopt fluoridation of water as a means of reducing dental caries have disclosed that the scientific proof of the alleged benefits and safety of the procedure is not conclusive. The reduction of 60% in dental caries claimed for this method has not been substantiated by properly controlled studies.

Moreover, most of the recognized and qualified experts in research on fluorides have come out categorically in favour of a policy of fluoridating drinking water, despite the fact that data on some important aspects of the problem remain incomplete.

Nearly all the sources of information immediately available on the scientific

aspects of the problem are biased; even the reviews and books by authorities with a reputation for competence have not always sufficiently analysed the data used in formulating a fluoridation policy.

8.4.1.3 Scarcity of genuinely independent studies on fluoridation (34)

The best way to decide which expert is right is to make an independent study of the scientific documentation on which opinions are based. But because of the vast amount and complexity of the scientific literature published on the effects of fluoride (some 16 000 publications), this task is beyond the capacities of most people. Even a person with the necessary scientific background at the most could study summaries and reviews of articles and other compendia prepared from the original scientific sources. It is unfortunate that most reviews of articles and books on the subject of fluoridation are biased either for or against; this does not provide a way of solving the

dilemma posed by the divergent interpretations of experts.

8.4.1.4 Alternative methods to fluoridation for preventing dental decay have not been objectively considered (35)

There is already ample evidence that at the community level there are a number of ways of approaching the problem of controlling tooth decay. There are a number of practical and feasible techniques, especially with children. But because of the political climate surrounding the debate on fluoridation, most communities are unable to examine the alternatives carefully and calmly and weigh the advantages and disadvantages of each of them.

Opinions about the different methods which can be used for community control of dental caries are sharply divided between supporters and opponents of fluoridation; those in favour of it tend to exagerate its advantages and to emphasize the

negative aspects of the alternatives that might be considered, while those who oppose it argue in favour of one or other of the alternatives that to them seem definitely superior to fluoridation. The main argument of those who support fluoridation is that most of the alternatives are voluntary. However, those who oppose fluoridation are prepared to accept a control method that is less effective and perhaps a little more costly in order to preserve freedom of choice and to avoid the long-term harmful effects of fluoridation on human health.

8.4.1.5 The public participates in decision-making on fluoridation in a limited way only (36)

Normally, the public should participate in the decision-making process about the use of fluoridation. But some very thorough studies have shown that just the opposite is the case.

According to data compiled by the U. S. Public Health Service, in 1970 4 834 American communities used artificially fluoridated water. In 3 464 of these communities the decision to fluoridate was an administrative one, that is, it was the city council, the water board or some other administrative body that made the decision. The question whether to fluoridate or not was submitted to the public in only 390 communities before being accepted. Generally speaking, when the question was submitted to the public by way of referendum, it was turned down in 60% of the cases (666 requests out of 1 139 were defeated). In California, data showed that fluoridation was rejected in 64 of the 76 cases where it was submitted to the public for approval.

It is undeniable that the main reason people support fluoridation is their conviction that fluoridation of drinking water is a valuable public health measure,

simple, inexpensive and one that should be used to reduce dental caries in the community. Moreover, they generally accept the assertions of the influential national organizations that this measure is completely safe and there is no valid or sufficiently important reason why public drinking water should not be fluoridated.

These same people who support fluoridation and, more especially, those who are members of the health professions, believe that fluoridation is essentially a scientific problem rather than a political one and they are inclined to believe that the opinions of their experts, and the recommendations of authorized bodies like the Public Health Service and the American Dental Association, should be accepted by the community. It often goes against the grain to allow the general public to decide a complex scientific question, and many of them are convinced that such questions should not be decided by referendum. In most of their campaigns they first try to get agreement on fluoridation by

administrative means. They accept the referendum route only if they are forced to it by their opponents or by political groups that have the authority to institute fluoridation.

8.4.1.6 The type of body which should be set up so that the public can participate more fully and effectively in debates and decisions on fluoridation (37)

According to Groth, in principle the public should be involved in the process of deciding whether or not drinking water is to be fluoridated. When a public agency receives a request to install a system of fluoridation or to hold a referendum on the subject, Groth recommends the formation of a special citizens' committee, with comprehensive representation, to study the problem in depth using a multidisciplinary approach, to consult the public through public hearings and to inform the authorities responsible of the results.

> On the basis of the experience and the studies of the SPE in this field, the committee is convinced of the soundness and the profitability of this kind of collaboration and fully supports this kind of citizen participation (38).

8.5 CONCLUSIONS

1. After 30 years of use, controlled fluoridation of drinking water to prevent dental caries remains primarily a North American phenomenon. In 1977, 212.7 million people, or about 9% of the world's population, were using this procedure.

2. Of this total, the combined populations of the United States, Canada and Mexico using this process totalled more than 132.5 million.

3. On the other hand, in 30 European countries only 15.5 million people were using artificially fluoridated water out of a total population of 700 million, or 2%.

4. Most Western European countries do not have legislation making fluoridation of drinking water compulsory.

5. The Netherlands and Sweden have repealed laws making fluoridation obligatory.

6. Canada is among the countries using fluoridation extensively. In 1977, 8 557 554 people, or 37% of the population, used fluoridation.

7. In 1977, the Department of Health and Welfare carried out a study in 79 groups of municipalities across Canada to determine whether or not fluoridation of water supplies increases the risk of death from cancer among residents of these regions. The study covered the period from 1954 to 1973 inclusive. No significant difference was noted between municipalities with fluoridated water supplies and those without. However, this study has been criticized as noted under 8.2.1.2.

8. In a brief submitted to the Minister of the Environment in 1971, STOP raised serious questions about the environmental effects of adding another chemical substance to the Quebec water system which is already highly polluted.

9. The organization was further disturbed because neither the government nor any international body had

succeeded in establishing a safe upper limit for the daily intake of fluorides in adults and in children.

10. STOP concluded by asking whether the intake of fluorides from food and drink (excluding water) was not sufficient to protect the teeth, since there was little difference between absorbing fluorides from water and from food.

11. Since available scientific data for precise evaluation of the ecological effects of fluoridation of drinking water are clearly inadequate, the Conseil consultatif de l'environnement recommended, in August of 1975, immediate establishment of a research program to evaluate as precisely as possible the effects of fluorides on the environment, and more particularly on aquatic flora and fauna.

12. Several professional associations, representing among others dentists, doctors and chemists, prepared briefs supporting artificial fluoridation of drinking water for presentation to the parliamentary committee before the adoption of Bill 88, in June 1975. They emphasized that this measure would result in a noticeable reduction of the incidence of dental caries

in Quebec and that it involved no danger for public health.

13. About 1 060 240 people in Quebec now use fluoridated water.

14. In December 1975, 105 334 000 people in the United States were using fluoridated water.

15. Since it was first instituted thirty years ago, artificial fluoridation of drinking water to reduce dental caries in the United States has been marked by continuing scientific and political conflict. From the outset, the struggle has been between two opposing camps: those in favour of fluoridation and those against it. This polarization continues today, as does the debate among scientists.

16. There has as yet been no definitive scientific proof of the alleged advantages and safety of artificial fluoridation.

17. The courts have almost always ruled in favour of fluoridation to prevent dental caries. They have further ruled that the states are within their rights

in using their powers to realize this objective.

Mention, however, should be made of a recent American decision in this matter: Paul W. Aitkenhead v. Borough of West View (Court of Common Plea, Allegheny County, Penn., GD-4585-78, November 17, 1978). The bulk of the evidence submitted indicated that fluoridated water could be carcinogenic.

18. Alternative methods of fluoridation to reduce dental caries have not always been objectively considered, nor have they been properly used.

19. The public has taken only a limited part in the decision-making process before application of fluoridation.

20. It has been proposed that a consultative body made up of duly qualified citizens be formed to hold public hearings on the subject, so that the people can participate fully in the decision on the best way to proceed under the circumstances.

8.6 RECOMMENDATIONS

The committee recommends:

1. that within the ministère de l'environnement there be set up a centre responsible for collecting, preparing and distributing scientific and technical information on current research activities and programs in force in the field of fluoridation of drinking water;

2. that this information be freely distributed and made available to interested researchers, to those responsible for the management of current programs, and to the general public;

3. that all necessary, relevant information be made available so that the general public will be able to take part in the development of policies and in making decisions about planning for and implementing fluoridation of drinking water;

4. that a consultative body of duly qualified citizens be set up to hold public hearings on the subject;

5. that a scientific policy be worked out to develop and

implement the necessary scientific criteria to establish standards for the scientific management of fluoridation programs;

6. that a team of experts be designated to review in depth and make critical analyses of the findings used by government authorities in arriving at the decision to fluoridate drinking water;

7. that the research program on fluoridation of drinking water include a study or studies on alternative fluoridation methods to prevent dental caries.

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CONCLUSIONS AND RECOMMENDATIONS

In carrying out its mandate, the committee took a comprehensive and multidisciplinary approach. The many questions raised on the subject of fluoridated water supplies are part of a wide range of much deeper problems linked to an increase in fluorides and their effects on public health and on the environment. Artificial fluoridation of water supplies is in fact only one of the many fluoride sources to which people, animals and plants are increasingly exposed; fluorides are also absorbed from water, air and food and from specific sources resulting from the industrial use of fluorides.

The committee began with as comprehensive a study as possible of fluorides and their effects on health and the environment.

It then conducted a more detailed study on some of the technical, ecological, medical and administrative problems linked to fluoridation of water supplies selected according to their importance and urgency.

In this last part of the report, the committee has grouped together all the conclusions and recommendations which resulted from the detailed analysis of these different problems. We have followed the general plan outlined in the introduction to the report.

1. CHAPTER 1: PRESENCE AND EFFECTS OF FLUORIDES IN THE ENVIRONMENT

The first chapter of this report looked briefly at the sources of fluorides and their effects on the environment and revealed that:

1. The fluoride ion is the most dangerous atmospheric pollutant next to sulfur dioxide and ozone.

2. The number of industries using fluorides and fluorine compounds increases each year.

3. The ever-growing and almost universal practice of water fluoridation in North America adds one more source to the many existing natural and artificial sources.

4. An increase in the fluoride content of processed food and beverages has been noted in areas supplied with fluoridated

water.

5. The difference between harmless and dangerous doses of fluoride is slight and there is no doubt that in fluoridated regions, and elsewhere, doses higher than the dose considered safe are frequently ingested.

6. Given the various and often highly toxic fluoride sources to which humans and the ecosystems are exposed, it is important to establish just how much fluoride is being gradually ingested in order to prevent cumulative effects and the onset of long-term toxicity from repeated absorption.

7. The synergetic effects of general fluoridation and the serious threat they pose to human health and the natural environment must be studied and fully understood.

The committee therefore recommends:

1. Studies on fluoride sources and their effect on public health and the environment

The committee recommends that a long-term research program

be launched to determine with accuracy:

1. the location of fluoride sources in the environment in Québec;

2. their means of diffusion;

3. their effect on public health and the environment.

The reader will find more specific recommendations on this subject in chapter three of this report which deals with the protection of ecosystems.

The committee recommends that the Bureau d'études sur les substances toxiques (BEST) conduct these studies so that it can identify the system by which fluorides exert their toxic effects, evaluate its intensity and work out the measures required to effectively control fluoride pollution.

More specifically, BEST's plan of action would be focussed on determining the relative influence of both man-made and natural sources, reducing these sources and informing and inviting the public to participate in these activities (1) (2).

2. Studies on the synergetic effects of fluorides

The committee recommends that studies be conducted on the additive effects or synergetic interactions of fluorides and atmospheric contaminants such as ozone or sulfur dioxide which could aggravate the long-term effects of atmospheric concentrations on human health and that of animals and plants.

This program would also be the responsibility of the Bureau d'études sur les substances toxiques.

3. Studies on total fluoride consumption

The committee recommends that a survey be conducted to compute the total fluoride intake of Quebecers from the various existing sources.

4. Suspension of fluoridation of water supplies

The committee recommends that artificial fluoridation of water supplies be suspended until such time as the studies recommended in this chapter and elsewhere in the report have been carried out so that a complete and in-depth evaluation can be made of the impact of water fluoridation on public health and environmental quality.

2. CHAPTER 2: INDUSTRY AND THE EMISSION OF FLUORIDES INTO THE AIR

This chapter, devoted to industrial emissions of fluorides into the air, showed that:

1. The emission of fluorides by industry is an important source of environmental pollution, both in the atmosphere and in the work place for employees in certain categories of plants.

2. Recent surveys have shown that the total amount of fluorides in the air (2.5 mg/m^3) is very often exceeded in the work place of employees in aluminum plants.

3. Pollution originating in industry caused by emission of fluorides into the air can also affect human beings as well as animal and plant life in the vicinity of these industries.

4. Recent studies have shown that the norms established for dust in the air have frequently been exceeded and that the levels of fluoride gas exceeded the amounts established as objectives for a residential or industrial zone.

5. Studies on the concentration of fluorides in fodder revealed that the norms established to protect livestock against the toxic effects of fluorides were exceeded. The health of cattle thus exposed was seriously affected and milk production diminished.

6. Finally, in the case of plant life, these studies also showed that certain species were damaged in such a way that their growth could be impaired and their ornamental value lessened.

Consequently, the committee makes the following recommendations:

1. that adequate measures be taken to protect the health of workers in aluminum plants and wherever they are exposed to other industrial sources of fluorides;

2. other recommendations include the following:

    1. medical supervision of workers;

    2. protection of public health;

3. public medical supervision;

4. a program of studies on the intake of fluorides and their effect on human health;

5. a program of epidemiological and experimental studies on the mutagenic, teratogenic and carcinogenic effects likely to affect people exposed, in some cases, to amounts of fluorides constituting a considerable danger to their health.

These recommendations are outlined in detail in the last section of chapter two of this report, devoted to the study of the emission into the air of fluorides of industrial origin.

3. CHAPTER 3: EFFECTS OF FLUORIDES ON THE ENVIRONMENT AND PROTECTION OF ECOSYSTEMS

The third chapter, devoted to the study of the effects of fluorides on the environment and the protection of ecosystems, showed that:

1. The harmful effects of fluoride pollution on animals and vegetation can be considerable.

2. There is great variability in the toxic effects of fluorides on vegetation. The most sensitive plants can be affected by a week's exposure to about 1 ppb (part per billion) of this element. The most tolerant develop necroses only when exposed to concentrations twenty times as strong.

3. Domestic animals fed on fodder containing fluorides ultimately show signs of intoxication known as fluorosis. In addition to its own cytotoxic properties fluorine, because of its affinities for calcium, disturbs the ossification process and causes arthritis.

4. It is generally recognized that the exposure of living organisms to concentrations of fluorides result in an accumulation of fluorides. It can then cause serious biochemical and morphological alterations of these organisms.

To correct these deficiences, the committee makes the following recommendations:

1. Physicochemical studies

The committee recommends that studies be made on the

hydrological behaviour of fluorides in an aquatic environment. Studies will be needed on:

1. the capacity and mechanisms of dispersal of fluorides in this environment;

2. the currents of the principal waterways which receive the flouride effluents and the behaviour patterns of municipal effluents in the waterways to discover whether dilution is effective and in what percentage;

3. the tendency of fluorides to form combinations with suspended particles and sediment;

4. the capacity of fluorides to react with other substances.

2. Studies on biological elements

The committee recommends that a long-term research program be undertaken on the effects of fluorides on certain biological elements in various aquatic conditions as follows:

1. the identification of different sources of fluorides, a description of how they spread and a precise assessment of their effects on the environment at all food

chain levels (see the recommendations made on this subject in the section devoted to recommendations in chapter one);

2. the accumulation potential of fluorides in aquatic food chains;

3. the effects of fluorides on fresh water vertebrates.

3. Finally, the committee recommends that the introduction of any form of artificial fluoridation of water be postponed until a scientifically precise assessment has been made from these studies on the impact of such a measure on animal and plant life.

Naturally, this decision should take into account other factors concerning water fluoridation discussed elsewhere in this report.

4. CHAPTER 4: EFFECTIVENESS OF FLUORIDATION IN PREVENTING DENTAL CARIES AND ITS SECONDARY EFFECTS

The fourth chapter of this report, which examines the effectiveness of artificial fluoridation of drinking water to prevent dental caries and its secondary effects, reveals that:

1. The scientific value of studies on dental caries is being questioned because of the great number of variables, all of which can influence the research results in important ways and which are not controllable.

2. A number of strictly controlled studies have shown that there was a considerable increase in the amount of fluorides in water, food and in the atmosphere, and that people exposed daily absorb an amount greater than the 1 to 2 mg considered safe by the WHO.

3. Fluorine is highly toxic for the human organism, and there is only a very thin line dividing the acceptable level from the toxic level.

4. Dental fluorosis seems to be a first indication of fluorine intoxication in the population. It has been noted that the seriousness of the disorders and many diseases caused by

fluorine increases proportionately with the degree of intoxication.

5. Recent studies have shown that fluorides have mutagenic properties, and that even a low level of fluorides can cause changes in the genetic material of cells.

   These data are very significant because mutagenesis is a first evidence of carcinogenesis in the body.

6. Extensive retrospective epidemiological studies, embracing large population segments observed over a number of years, have shown significant correlation between the cancer mortality rate and artificial fluoridation of drinking water.

   The results of these studies are extremely important because they are closely related to the mutagenic properties of fluorides; this has been demonstrated by scientific experiments under the most rigid controls (58).

7. Many cases of intoxication caused by artificially fluoridated water have been diagnosed and cured after a return to drinking water that is not fluoridated. These medical experiments were very scientifically controlled, and have been published in medical journals.

Consequently, the committee recommends:

1. that a research program on the basic mechanisms of dental caries be set up;

2. that a survey be made to determine the amount of fluorides the population absorbs daily from all existing sources of fluoride;

3. that a monitoring system be set up to ensure that the fluoride content of food and drink is evaluated and controlled on a continuing basis, and that it does not exceed the maximum acceptable level;

4. that the results of these analyses be distributed to the public so that everyone can take an active part in preventing diseases related to chronic fluoride intoxication;

5. that the standards used for fluorine control with a view to protecting the quality of drinking water be made the subject of multidisciplinary studies and that they be based on scientific criteria that take into account the ecological, medical, juridical and socioeconomic aspects of the standards to be applied;

6. that these standards be periodically evaluated and revised;

7. that a long-term program of epidemiological studies and research experiments be made on the mutagenic, teratogenic and carcinogenic effects of fluoridated water on public health;

8. that persons who absorb a higher than normal quantity of fluorides, such as those with kidney deficiencies, those affected by polydipsia, diabetics and those on dialysis, remain under constant medical supervision, and that the total amount of fluorides they take in be strictly controlled;

9. that a suitable program of professional and technical training be set up for health professionals and technicians on the subject of fluoridation of drinking water and its medical implications, with emphasis on the prevention of this form of intoxication;

10. finally, after careful consideration of all the evidence, the committee recommends the indefinite suspension of the application of Bill 88 until there has been time to examine and to apply, with scientific precision, all the recommendations on the short and long-term risks for the population of a program of water fluoridation;

Moreover, in a more general perspective, this reevaluation of the problem of artificial fluoridation of drinking water should take into account the effects that the application of this measure, when combined with the effects of all other fluorides, would have on public health and the quality of the environment.

5. CHAPTER 5: STANDARDS FOR DRINKING WATER AND PROBLEMS RELATED TO FLUORIDATION

Chapter 5, which deals with water quality and the problems connected with maintaining the optimum concentration of fluorides during fluoridation, brings out the following facts:

1. Strict adherence to the recommended standards for fluoridation is difficult to achieve.

2. Major variations in distribution systems and their components add important difficulties to maintaining so-called optimum concentrations for preventing dental caries.

3. Comprehensive studies have shown that the standards control system is not effective.

To correct this situation, the committee recommends:

1. that specific studies be made of the technical problems connected with the standards for controlling fluoridation of drinking water so as to ensure efficient management;

2. that these studies be multidisciplinary and based on scientific criteria that take into account the ecological,

medical, juridical and socioeconomic aspects of the standards to be applied;

3. that the objectives and suggested standards take account of the needs and characteristics of the regions concerned;

4. that the citizens be invited to take part in these studies and be kept informed of the standards in force so that they will be in a position to intervene with the responsible authorities when they see these standards are not being properly applied;

5. that the proposed standards be applied to private and public water supplies;

6. that the standards be included in executory directives and made public;

7. that the standards be periodically revised in the light of available new scientific data;

8. that a surveillance system be set up to ensure effective application of the established standards;

9. that the fluoridation program be periodically revised to

ensure that the quality standards used are in conformity with the proposed objectives;

10. that a suitable agency be designated, or set up if necessary, to define the objectives, review the scientific criteria, and refine the standards to be used to protect public health and the quality of the environment;

11. finally, the committee recommends that Bill 88 (Division IV of the Public Health Protection Act) be suspended until these recommendations and other pertinent recommendations in other parts of the report have been considered and applied.

6. CHAPTER 6: LEGISLATION

Chapter 6, which looks at Canadian laws on the artificial fluoridation of public water supplies as a preventive measure against dental caries, revealed that:

1. Each province has its own legislation authorizing the fluoridation of water supplies.

2. There is a risk of conflict in the application of section 26 of the Public Health Protection Act (RSQ 1977 c. P-35)

and the regulation respecting water supplies for human consumption under the Environment Quality Act (RSQ 1977 c. Q-2).

The committee recommends that:

1. section 26 of the Public Health Protection Act and the regulation respecting water supplies for human consumption (Environment Quality Act) be revised in order to reconcile the two standards in accordance with the technical requirements.

7. CHAPTER 7: JURISPRUDENCE

Chapter 7, which studies jurisprudence relating to the fluoridation of drinking water, revealed that:

1. On only two occasions has Canadian jurisprudence dealt with the question of fluoridation. The issue on both occasions was to determine the extent of the powers conferred by the provincial legislatures on the municipalities in order to decide whether the municipalities did indeed have the power to fluoridate drinking water.

2. American courts of justice have always pronounced themselves in favour of fluoridation as a weapon against tooth decay.

3. A recent noteworthy case (Paul W. Aitkenhead v. Borough of West View, Court of Common Plea, Allegheny County, Penn.) presented weighty evidence that fluoridation of drinking water could be carcinogenic.

The committee recommends:

that a coherent government policy be adopted which would reconcile the recent law recognizing the fundamental right to physical integrity and the earlier law which foists fluoridation on all citizens without dissenting voices being heard on an issue affecting the health of the public.

8. CHAPTER 8: FLUORIDATION OF DRINKING WATER

The eighth and last chapter, dealing with the use of fluoridation of drinking water, has disclosed the following facts:

1. After being in use for thirty years, controlled fluoridation of drinking water to prevent tooth decay remains predominantly a North American development.

2. Most of the countries of Western Europe have no legislation requiring artificial fluoridation of drinking water.

3. Canada is among the countries using fluoridation on a large scale.

4. At present, 1 060 240 people in Quebec are supplied with artificially fluoridated water.

5. From the outset, more than thirty years ago, the use of artificial fluoridation to reduce dental caries in the United States has been marked by persistent conflict, both scientific and political. From the beginning, the fight has been conducted by two opposing camps: those in favour of fluoridation and those against it. The polarization still exists, as does the scientific dispute.

6. In general, the courts have always ruled in favour of fluoridation to prevent dental caries. But mention should be made of a recent American decision in the case of Paul Aitkenhead v. Borough of West View, Court of Common Plea, Allegheny County, Penn. The evidence submitted indicated that fluoridation of drinking water could be carcinogenic.

7. Alternative methods to reduce dental caries have not always been considered objectively, nor have they been properly used.

8. The public has only participated to a limited extent in the decision-making process before application of fluoridation.

In view of the above data, the committee makes the following recommendations:

1. that a centre be set up within the ministère de l'Environnement to collect, prepare and distribute scientific and technical information on current activities in research programs in the field of fluoridation of drinking water;

2. that this information be circulated freely and placed at the disposal of interested researchers, those responsible for management of current programs, and the general public;

3. that all necessary, relevant information be made widely available so that the public will be prepared to take part in the development of policies and in decisions about planning for and implementing fluoridation of drinking water;

4. that a consultative body of qualified citizens be established to hold public hearings on the subject;

5. that a scientific policy be prepared as the basis for developing and implementing the scientific criteria required to establish standards for the scientific management of water fluoridation programs;

6. that a team of experts be designated to review in depth and make critical analyses of the findings which were the basis of government decisions to apply fluoridation of drinking water;

7. finally, that the research program on fluoridation of drinking water include a study, or studies, on alternative methods of fluoridation to reduce dental caries.

BIBLIOGRAPHY

1. Anon. Annual Report of the activities of the Bureau d'Etudes sur les substances toxiques for the year 1977-78. SPEQ.

2. Anon. Events force toxic substances issue. Environmental Science & Technology. Vol. 8, No. 5, May 1974.

APPENDIX I

ADVISORY COMMITTEE ON THE FLUORIDATION OF WATER SUPPLIES

Dr. J. Benoît Bundock, M.D. (chairman)

Madame Pierrette Petit, Sociologist

Mr. Clément Audet, Engineer (public health engineering)

Dr. Pierre Morin, Biochemist and Doctor in experimental medicine

Mademoiselle Sylvie Fortin, Lawyer

Mr. Michel Lamontagne, Biologist

Mr. Léopold Gaudreau, Biologist

Mr. Conrad Anctil, Engineer (civil engineering)

Mr. Robert S. Poisson, Engineer (metallurgy)

Mr. Gilles Bernier, Engineer (chemical engineering)

Country	As of	Serving	First adjusted	Information source
Argentina (Est.)	Mar. 1978	0.5 mil.	1969	(1)
Australia	Sept 1977	9.0 "	1956	Aust. Dent. Assn.
Brazil	Mar. 1978	10.5 "	1953	(1)
Canada	Dec. 1976	8.5 "	1945	Cdn. Dental Assn.
Chile	Dec. 1973	4.1 "	1953	(1)
Colombia	Mar. 1978	10.0 "	1953	(1)
Costa Rica (Est.)	Mar. 1978	0.5 "	1976	(1)
Cuba (Est.)	Mar. 1978	0.1 "	1974	(1)
Curaçao	Mar. 1978	0.2 "	1968	(1)
Czechoslovakia	Dec. 1974	1.7 "	1958	(3)
Ecuador (Est.)	Mar. 1978	1.0 "	1961	(1)
England & Wales	June 1973	4.0 "	1955	Brit. Dent. Assn.
Ger. Dem. Rep.	Dec. 1975	1.2 "	1952	(2)
Guatemala (Est.)	Mar. 1978	0.5 "	1961	(1)
Hong Kong	Dec. 1974	3.9 "	1961	Féd. Dentaire Int.
Ireland	June 1971	1.4 "	1964	Irish Dent. Assn. Jrnl
Malaysia	Dec. 1975	4.0 "	1966	(2)
Mexico	Dec. 1977	3.3 "	1960	(1)
New Zealand	June 1974	1.5 "	1954	New Zealand Dent. Assn.
Nicaragua	Mar. 1978	0.5 "	(Natural F.)	(1)
Panama (Est.)	Mar. 1978	1.0 "	1950	(1)
Paraguay	Jan. 1971	0.5 "	1961	(1)
Poland	Dec. 1974	2.3 "	1967	(2)
Singapore	Dec. 1974	2.2 "	1958	Féd. Dentaire Int.
USA	Dec. 1975	105.3 "	1945	US Fluor. Census 1975
USSR (Est.)	Dec. 1974	30.0 "	1960	(3)
Venezuela (Est.)	Mar. 1978	5.0 "	1952	(1)
		212.7 million		

Notes:
(1) Correspondence from Pan American Health Organization, March 1978
(2) Statement by delegate to 28th World Health Assembly, May 1975
(3) Statement accredited to European Org. for Promotion of Water Fluoridation

A service to the public
from the Fluoridation Officer
Canadian Dental Association

April 1978

APPENDIX 3

TABLE 1

FLUORIDATION IN CANADA - COMMUNITIES HAVING A WATER SUPPLY SYSTEM WITH FLUORIDE LEVELS ADJUSTED OR NATURALLY OCCURRING

DECEMBER 31, 1976

A	B	C	D	E	F	G	H	J	K
Province or Territory	Population[1]	Population having water supply system[2]	% having a water supply system	Communities and population having adjusted fluoride levels		Communities and population having naturally occurring fluoride		Total communities with fluoridation	
	Total	(000)	C/B	Comm.	Pop.(000)	Comm.	Pop.	Comm.	Pop.
T.-N.	557 725	324	58.1	5	49	1	2 400	6	52 335
Î.-du-P.-É.	118 229	43	36.9	2	20	0	0	2	20 843
N.-É.	828 571	470	56.7	26	332	0	0	26	332 155
N.-B.	677 250	356	52.5	6	88	2	6 068	8	88 691
QUÉ.	6 234 445	5 354	83.9	71	753	16	18 736	87	772 366
ONT.	8 264 465	7 122	86.1	116	5 063	50	92 162	166	5 155 381
MAN.	1 021 506	794	77.7	44	665	6	2 224	50	667 912
SASK.	921 323	573	62.2	101	330	6	2 866	107	333 496
ALB.	1 838 037	1 372	74.6	52	767	54	49 523	106	817 004
C.-B.	2 466 608	1 975	80.0	30	287	0	0	30	287 099
YUKON	21 836	15	68.7	1	11	1	200	2	11 800
T.duN.-O.	42 609	25	58.6	6	18	0	0	6	18 472
CANADA	22 992 604	18 423	80.1	460	8 383	136	174 181	596	8 557 554

1. Statistics Canada Census, June 1, 1976

2. Acknowledgments to the Environmental Protection Service, Environment Canada.