The Irish Expert Body on Fluorides and Health
An Corpán Oilte Éireannach um Fluairídí agus Sláinte
Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

**Appraisal of "*HUMAN TOXICITY, ENVIRONMENTAL IMPACT AND LEGAL IMPLICATIONS OF WATER FLUORIDATION*" (*author Mr Declan Waugh*)**

This report by Mr Declan Waugh (hereafter referred to as "the author") is a lengthy document concerning many aspects of water fluoridation. The report is presented as the author's own work, in which he describes himself as an independent environmental scientist..

The report states "*Any opinions, findings, conclusions or recommendations expressed in this report are those of the Author and do not reflect the view of the organisations or agencies that provided information for this report.*" Insofar as the author illustrates his views with quotes from a number of important reports, it is worth bearing this statement in mind, as it appears that his views on many of these reports are in fact at variance with those of their authors. Of particular note in this regard are several misrepresentations of the views of the World Health Organisation, the EU's Scientific Committee on Health and Environmental Risks, the UK Medical Research Council and others, which are presented in such a way as to indicate that they are critical of water fluoridation when, in fact, no such conclusion was reached by any of these organisations.

The author gives the impression that there is an abundance of scientific material in existence, including recommendations from respected international and national bodies that condemn the practice of water fluoridation. This is not the case.

The author's main themes are that fluoridation is illegal, that it damages health, that it does not benefit dental health, and that it is harmful to the environment. These matters are considered in turn.

## 1. Legal matters

The author claims that water fluoridation violates at least 30 EU directives and policy documents, and is in breach of international treaties.

It is helpful that the EU Commission has addressed such concerns in its replies to the petitions made by Irish and British antifluoridation campaigners (EU Petitions 0210/2007 and 0211/2007). The EU Commission clearly does not have any difficulty in law with the practice of water fluoridation. The Commission stated in 2007:

> "*Taking into account that there is no evidence of an infringement of EU law in this case, the Commission can take no legal action*".[1]

More specifically, it ruled in 2008 that

> "*The Commission has scrutinised the practice of adding hexafluorosilicic acid to drinking water whilst adhering to the maximum permissible fluoride concentration values under the Drinking Water Directive. It confirms that it*

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

*does not see any evidence of infringements of the Drinking Water Directive, the Dangerous Waste Directive and the Medicinal Products Directive.*"[2]

The Commission also noted that there was no impediment to water fluoridation arising from international treaties:

"*It must be noted that adding fluoride to drinking water is a national decision which does not flow from any obligation under Community law.*

"*The Biomedicines Convention, focussing upon human rights and upon the involuntary application of medication has been opened for signature by the Council of Europe in Oviedo in 1997. However, the convention has not been ratified at this stage by the European Community, and for the time being it has no legal effects in the Community. Moreover, it is noted that according to the information available to the Commission, none of the EU members States which add fluoride to drinking water is a party to the Convention.*"[1]

There have been no EU Commission statements or rulings from the European Court that have defined water fluoridation as being in any ways contrary to EU or international law.

## 2. Alleged Adverse Health Effects

The author's extensive reportage on this question is based entirely on a misreading of the evidence provided by laboratory experiments in test tubes and on animals, on a misreading of the human epidemiological evidence, and on a personal theory of the author involving the action of fluoride on existing calcium and magnesium supplies in water. The author does not include in this document the many reports and reviews from respected international agencies confirming there are no known adverse effects on health from fluoridation.

(a) Animal and Laboratory experiments

Such experiments, which form the bulk of the report's references and the basis of most of its author's speculations, provide very poor levels of evidence in terms of human health. In fact, they are considered to be, at best, a starting point for human epidemiological investigations. There are a number of cautionary tales from history of reliance on data from animal experimentation, the most notorious of which perhaps was the Thalidomide disaster.

The NHS York Systematic Review of 2002, which looked at all of the worldwide evidence available on fluoridation in all languages, did not see fit to include animal or laboratory experiments in it's appraisal of the evidence. The Review explained:

"*The history of health technology development shows that there have been numerous new interventions that were promising (or harmful) in animal and*

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F: +353 1 661 8721
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W: www.fluoridesandhealth.ie

> *laboratory studies that turned out to be ineffective (or safe) when tested in humans. One example would be the drug omeprazole (Losec®) which caused gastric tumours in pre-clinical animal studies. However, such tumours have not been documented in humans, even in patients with conditions that require continuous treatment for many years. In general, when human data are available, animal or laboratory data provide far less reliable estimates of effect and, as such, do not bear significant weight on decisions about interventions. Such data will not be considered in this review.*"[3]

Furthermore, subsequent to the publication of the review, the York team posted the following comments on their website:

> "*Exposure in vitro (laboratory studies) is very different to those in vivo (real life situations). In cell culture experiments cells are exposed directly to a fluoride solution containing highly reactive unbound anions. This is very different to exposure in the body where fluoride anions have to first be absorbed through a selective barrier in the gut. Once in the body it is unlikely that many of the anions will be in a free state, their reactive nature means that they bind very readily to other molecules rendering them inactive. It is the binding of fluoride to these molecules, the ratio of free to bound anions and the way in which these agents interact with other sites in the body that should be investigated, this can only be done in vivo systems. Similarly exposure in animals may be very different from exposure in humans. Effects seen in animals may not be seen in humans, and where these effects may occur in humans it is very difficult to know at what level such effects will occur – it is usually not possible to directly correlate the dosages used in animal studies to those used in humans.*"[4]

Similarly, the American Council on Science and Health(ACSH) states that

> "*The arguments that tie water fluoridation to a whole host of health risks have little substance. Most of the studies that these arguments are based on involve either human exposure to much higher levels of fluoride than the U.S. standards, or animal studies in which the lab animals received extremely high doses of fluoride – neither of which is representative of the how the U.S. population will respond to our low levels of fluoride in water*".

Animal and laboratory experiments must be treated with a great deal of caution as they do not represent real-life situations. Rats dosed on massive amounts of fluoride do not provide a good model for humans dosed on tiny amounts. Test tube expermiments with free fluoride ions are not the same as the real life situation in the body where much of the fluoride is bound to protein or other molecules.

The bulk of the author's speculations relating to ill-health effects are based on these types of laboratory experiment, not on any evidence of actual harm to humans, animals or the environment in real world situations.

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(b) Human Epidemiological Evidence

In assessing health concerns, human epidemiological evidence is required. There are several layers of evidence with different strengths and weaknesses available, and the interpretation of the evidence is often not straightforward. Possible confounding factors have to be controlled for or explained, and the consistency with existing evidence needs to be considered.

Existing reports by competent bodies considering the health effects of water fluoridation, such as the NHS York Systematic Review 2002, the Medical Research Council (UK) 2005, the EU's Scientific Committee on Health and Environmental Risks (SCHER) report 2011 have all concluded that there is no existing evidence to state that water fluoridation is a health risk.

The author references a number of other reports to support his position and is very selective in his quotations from these reports. These reports do not call for an end to water fluoridation or demonstrate any evidence of ill health arising from water fluoridation.

For instance, the author references the National Research Council (USA) 2006 report, which actually dealt with the question of the legal limit for fluoridation in the USA, which at 4ppm is 5 times higher than the maximum fluoridation limit allowed in Irish law. In that context, the National Research Council considered potential unwanted effects at that level of fluoridation, but specifically stated:

> "*The committee did not evaluate the risks or benefits of the lower fluoride concentrations (0.7 to 1.2 mg/L) used in water fluoridation.*"[5]

The NRC further states that:

> *"In 1986, the U.S. Environmental Protection Agency (EPA) established a maximum contaminant level goal (MCLG) of 4 mg/L and a secondary maximum contaminant level (SMCL) of 2 mg/L for fluoride in drinking water. These exposure values are not recommendations for the artificial fluoridation of drinking water, but are guidelines for areas in the United States that are contaminated or have high concentrations of naturally occurring fluoride."*

Yet the author repeatedly quoted from this report without pointing out the context that its findings were relevant only to persons potentially exposed to much higher upper legal limit in the USA occurring from natural fluoride sources. (The Irish legal limit is the range of 0.6 to 0.8 ppm.)

Another example of misreporting of the literature concerns the claims made by the author in respect of osteosarcoma, a rare cancer of bone. The author reports a preliminary study from Harvard College, which suggested a link between fluoridation

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
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and this disease, but does not mention the definitive published results which showed no link to the disease[6].

(c) Author's theory on Calcium and Magnesium in water

A large part of the author's allegations of ill effect arise from his theory that the addition of fluoride to water causes a reduction in the supply of calcium and magnesium available to humans. His speculations are very extensive on this and he devotes a great deal of space in his report to this theory.

The author's thesis is that the following reactions ultimately occur in solution:

$$Ca^{+2} + 2F^{-} \rightarrow CaF_2, \qquad \text{and} \qquad Mg^{+2} + 2F^{-} \rightarrow MgF_2$$

This then, apparently, removes calcium and magnesium from the water in the form of insoluble salts, thereby rendering those served by this water deficient in these minerals.

This conjecture is evidently untrue for many reasons:

1. Fluoride does not combine with calcium or magnesium in the manner suggested by the author. Measurements of free fluoride ions (not fluoride bound in any complexes) are made at many points in the fluoridation cycle – the fluoride content in the fluoridating agent, the fluoride as it's added to the water and fluoride as it is tested coming into domestic water supplies. This free fluoride level is very consistent indicating that fluoride ions are not being removed from solution, and are not combining with other constituents to any significant degree. Fluoride ion levels are consistent both over time and over long distances in the water networks. This would not be the case if fluoride was combining in the manner suggested by the author.[7, 38]

2. The concentration of calcium ions varies between different regions in the country and also more noticeably between groundwater and surface water supplies. Groundwater tends to have significantly higher concentrations of both calcium and magnesium.

   Calcium concentration in water ranges up to 60ppm even in soft water, with hard water being classified as having in excess of 180ppm[8]. Calcium concentration in water in Ireland varies between areas, with most of Ireland having relatively hard water, although water supplied from groundwater in any area will tend to have higher calcium levels. For example, Fingal in Dublin reports calcium levels of 200-350 ppm in its two listed supplies[9]. As each calcium molecule requires two fluoride ions to remove it from solution, it can be seen that even if the report's speculation was correct, at a maximum fluoride concentration of 0.8ppm the total removal potential of fluoride ion

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

would be to reduce calcium availability by 0.4ppm, which would be insignificant.

Calcium is present in seawater at around 400ppm[10].

3. The concentration of magnesium ions in seawater is about 1300ppm[10]. Unlike calcium, it is far less prevalent in fresh water, being between 3ppm and 20ppm, with the higher range tending to be in groundwater. River water typically has a concerntration around 4ppm[11]. Again the alleged effect of fluoridation would be a maximum possible limit, in the absence of any calcium or other cation, of a 0.4ppm reduction at most if all fluoride used in water fluoridation was to disappear from solution. This would be insignificant in terms of dietary magnesium requirements.

4. The major source for calcium is food, not water. A single portion of yoghurt, milk, cheese, or fish will tend to give around 300mg of calcium per serving (8oz milk, 1.5oz cheese, small carton of yoghurt, small tin of sardines)[12]. This would be the equivalent of between 5 and 10 litres of soft water, or about 2 litres of intensely hard water. The recommended daily intake of calcium is around 1300mg per day, equivalent to the order of 30 litres of soft water or around 6 litres of very hard water.

5. The major source of magnesium is food, not water. Magnesium is widely available, particularly in leafy vegetables, nuts, chocolate, bananas, oats and breakfast cereals. A typical breakfast cereal will supply about 60mg of magnesium, or the equivalent of 15 litres of softer water or 3 litres of high magnesium water[13]. The daily recommended intake of magnesium is around 300mg per day for adults. This would equate to more than 80 litres of water per day for average water supplies, or around 20 litres in very high magnesium waters.

Thus all of the report's conjectures regarding potential effects of calcium and magnesium depletion, which form a very substantial proportion of its claims of ill health, cannot possibly be true simply due to the observed behaviour of fluoride in water, the importance of food sources, the abundance of these minerals and the relative scarcity of fluoride supplied by fluoridated water.

It is worth considering that if author's conjectures about negative health effects of low calcium and magnesium in drinking water are correct, this should have manifested itself long ago when comparing consumers of high calcium versus low calcium water sources, not only in Ireland but from countries across the world. Ireland tends to rely more on the larger volume surface water sources for most of our larger supplies and hence, most fluoridated supplies are likely to be sourced from surface water sources. Therefore even if it were true that fluoridation reduced calcium and magnesium levels, it would in most cases be doing this on a supply which had inadequate calcium

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

and magnesium to start with, which could not possibly supply adequate dietary calcium or magnesium under any circumstances.

The principal piece of Irish Drinking Water legislation (S.I. 278 of 2007) which implements EU directive 98/83 does not include a parametric value for either calcium or magnesium. If a minimum amount were needed in drinking water for health reasons it would have been prescribed by Irish and European legislation. It is of note that an earlier EU directive (80/778) and the Irish implementing legislation (S.I. 81 of 1988) set *maximum* values for calcium and magnesium and also, (but only for artificially softened waters) a *minimum* calcium value equivalent to 60ppm. The omission of these criteria from subsequent legislation seems to be in recognition that limit values (either maxima or minima) for those elements were unnecessary on health grounds.

The author makes many references to support his case from a World Health Organisation (WHO) document from 2009 entitled *Calcium and Magnesium in Drinking Water: Public Health Significance*. This document is cited as an authority in support of the author's case that fluoride depletes magnesium and calcium sources. Once again, the author has been very selective in his quotations from this document. Consider the following statements from this same document:

> "*On the basis of the findings of the World Health Organization (WHO) meeting of experts held in Rome, Italy, in 2003 to discuss nutrients in drinking water (WHO 2005), the present group focused its consideration on calcium and magnesium, for which, next to fluoride, evidence of health benefits associated with their presence in drinking-water is strongest. The present group also noted that the issue of fluoride was addressed by the Rome meeting in detail and adopted its review and recommendations (see below).*"
>
> "*Treatment and stabilization practices should ensure that the overall process does not significantly reduce total intake of nutrients such as calcium, magnesium, fluoride and others below recommended values.*"
>
> "*The recommended value for artificial fluoridation of water supplies is generally between 0.5 and 1.0 mg/l and depends upon the volume of drinking water consumed daily and the uptake of and exposure to fluoride from other sources. The WHO drinking-water guideline value for fluoride is 1.5 mg/l. Where dental caries risk is high or increasing, authorities may consider addition of fluoride to the demineralized public water supply to between 0.5 and 1.0 mg/l, but other factors should also be considered. In countries where dental health awareness in the public is very high and alternative vehicles for fluoride (e.g. fluoridated toothpaste) are widely available and widely used, a decision to not fluoridate the water would likely be of little consequence. On the other hand, in developing and developed countries where public dental health awareness in some population groups (e.g. lower income) might be*

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

> *much lower, drinking water containing fluoride at concentrations of 0.5–1.0 mg/l would be important for dental health*."[14]

This then is clearly a document which is fully supportive of water fluoridation but has been referenced as if it is the opposite.

The author also misrepresents the WHO in alleging that

> "*WHO has recommended that where the risk for skeletal and dental fluorosis is high (as is the case for Ireland with approximately forty % of the population known to suffer from dental fluorosis), fluoride levels in drinking water should be reduced to safe levels, or a lower fluoride source used, especially for young children.*"

Ireland has no reported cases of skeletal fluorosis and water fluoride levels are not high in Ireland by WHO criteria. The WHO has never recommended reducing water fluoride levels in Ireland or in any water fluoridation schemes elsewhere.

There are no known side effects of optimal water fluoridation other than mild dental fluorosis, and this effect has been known since the 1930's. Dental fluorosis is a cosmetic or aesthetic condition which refers to the way teeth look; it is not considered to be an adverse health effect.

Dental fluorosis has been shown to be generally easy to treat using painless, simple and inexpensive non-invasive methods[15, 16, 17, 18]. This is in contrast to the treatment of tooth decay which may, in some cases (particularly involving children and persons with special needs)m require hospitalisation. Furthermore, non-treatment of dental fluorosis has no health consequences, whereas non-treatment of dental decay can lead to pain, trauma, disfigurement, loss of teeth and function, problems with nutrition and growth, school absenteeism and significant financial and social cost.

## 3. Alleged lack of effectiveness

There are two aspects of effectiveness that must be considered. These are (a) "does the technology work?" and (b) "is it useful in meeting a need?". Consider, for example, a vaccine developed against a virulent tropical disease.

Suppose a vaccine is 100% effective against preventing yellow fever; everyone vaccinated will be protected completely against the disease. Its effectiveness as a public health measure in an affected country will also depend on factors such as transporting the vaccine safely to locations where it is needed and getting the public to take it up. So a 100% effective vaccine will eventually translate into a programme that is, say, 60% effective due to these other impediments. If you applied the same vaccine in Ireland it will have zero effectiveness, even if it was administered to everyone. The reason? Yellow fever is not a disease found in Ireland. Such a vaccination programme would be ineffective in Ireland, even with a perfect vaccine. So, if a study on such a

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

vaccination programme was undertaken in Ireland, it would not be correct to conclude that the vaccine was ineffective.

Water fluoridation, like all disease prevention measures, operates on the same principle. If the risk of dental decay is low, water fluoridation will not be effective, if the risk is high, it will be effective. Similar to the example above, studies on water fluoridation conducted in populations with low caries risk do not mean that fluoridation is ineffective as a technology, it means there is no need for fluoridation in that population. So we have to look at the risk of dental decay in any population before deciding on the relative benefits of fluoridation.

Data from Irish studies indicate that around one-third of 5 year olds consume sweet food or drinks between meals twice a day[19]. Sugars between meals are very damaging to teeth, so these trends are worrying. Ireland has a very high caries risk profile compared to most other European countries, in that we consume a great deal of confectionery and fizzy drinks[20].

Children in the Republic of Ireland (RoI) have amongst the highest frequency of consumption of foods and drinks sweetened with sugar when compared with 34 other countries[21]. This report notes that the lowest proportion of children consuming sweets daily was in Finland (8.9%) and the highest in Ireland (48.7%). Similarly, The Irish Health Behaviour in School aged Children (HBSC) Study (2010) showed that overall, 37% of children reported eating sweets at least once a day and 21% consuming fizzy drinks daily[22] .

The relative effectiveness of fluoridation would be expected to be quite high in a country such as Ireland with a high-risk profile as compared to some of the Nordic countries, for example, where destructive sugar snacking habits are far less prevalent, where there is significant investment in public dental services, and where other forms of fluoridation are practiced. In addition to high-risk dietary behaviour, surveys have shown that Irish schoolchildren have generally poor toothbrushing habits. There is a relatively low investment in public dental services, again in contrast to most other European countries. For example, Irish primary school children can expect to be called for a dental examination three times in their entire primary school years, whereas in Nordic countries children are typically seen twice a year, equivalent to 16 times in their primary cycle. The high cost of private dentistry in Ireland means that most parents do not bring their children to private dentists either.

The effectiveness of fluoridation in Ireland has been measured by comparing the dental health of children resident in fluoridated areas with those resident in non-fluoridated areas. Surveys have taken place on many occasions between 1984 and the most recent survey in 2006. All these studies have demonstrated that children in fluoridated areas have significantly better dental health.

The most recent national survey of children's oral health in Ireland found that of those living in areas with fluoridated water 37% of children has dental decay by the age of

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F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

5. In areas where there is no fluoride in the water, 55% of all 5 year olds have experienced dental decay[20]. The percentage of children under 18 experiencing consistent poverty has increased significantly from 6.3% in 2008 to 8.7% in 2009[23]). Reducing health inequalities is a matter of fairness and social justice. Creating a fairer society is fundamental to improving the health of the whole population and ensuring a fairer distribution of good health[24].

There is a mistaken belief that fluoridation is only concerned with children's dental health. Most of the studies on water fluoridation have been carried out on children's dental health for two main reasons. Firstly, children are much easier to study for a variety of reasons, including relatively simple residential histories compared to adults. Secondly, fluoridation as a technology has only been in existence for some 65 years, therefore we are only now seeing adults into late life who have experienced a lifetime of water fluoridation. The benefits of water fluoridation for adult dental health are now becoming clearer, particularly in relation to reduced levels of root caries and retaining more teeth into old age. Irish studies show a significant benefit to adult dental health[25]. American data also indicates a significant benefit to adult dental health. Neidell et al compared tooth loss with different degrees of lifetime exposure to fluoridated water and found a lasting benefit to adult dental health from childhood exposure.[26]

Neidell went on to state "This study suggests that the *benefits of community water fluoridation may be larger than previously believed* (my emphasis) and that community water fluoridation has a lasting improvement in racial/ethnic and economic disparities in oral health". This is due to a factor known as the Halo Effect, whereby persons living in non-fluoridated areas gain some of the benefits of fluoridation, for example by consuming products made in fluoridated areas or from visiting or working or going to school in fluoridated areas. In this regard, the North-South study of dental health in children from 2002 was of interest, as it compared three groups, namely the fluoridated and "non-fluoridated" populations of the Republic, with the population of Northern Ireland, which is non-fluoridaated and for which any Halo Effect from the South's fluoridated areas would be minimal. It turned out that the best dental health was in the South's fluoridated areas, and the worst in the North[20]. The "non-fluoridated" (i.e. possible Halo Effect) group in the Republic showed slightly better dental health than those in the North. Therefore, it is also likely that we have been underestimating the benefits of water fluoridation in previous studies confined to the Republic of Ireland.

The gold standard type of study for examining cause-and-effect in epidemiology is the Randomised Control Trial, in which at least two sets of individuals are selected at random from the population, with one set being given the test material and the second set typically being given a placebo or a comparison material. It is impossible to conduct RCTs for water fluoridation, as it would require every household in the country to be fit with a dual water supply (one fluoridated, one not) or would require people to be selected at random and then told where they must live for a period of at least 5 to 10 years. In reality, it is impossible to imagine such a scenario.

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T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

Since RCTs cannot be conducted in relation to water fluoridation, a fallacy has arisen in some commentaries to the effect that there are no good quality studies in the literature on water fluoridation. There are no RCTs, that is true; however, there is an overwhelming abundance of natural observational studies known as cross-sectional studies, where populations are compared at a point in time, and also a number of longitudinal studies, where groups are compared over periods of time. The data from these studies indicates a significant benefit from fluoridation. The degree of benefit is further complicated by the measurement one wishes to choose, and the age of the measurement, since different teeth are in the mouths of children at different ages.

## 4. Alleged Environmental Effects

The author makes many claims concerning the ultimate environmental fate of fluoride used in water fluoridation, and its potential effects on the environment. In considering these claims, it is worth bearing in mind that the fluoride is already widely available in the environment; soil contains fluoride, and the oceans of the world are fluoridated, having twice the concentration of fluoride as has fluoridated drinking water[27].

(a) Accumulation of fluoride in soil

The author claims that fluorides from water fluoridation accumulate in soil over time. He appears to ignore such factors as existing soil fluoride levels, and the effects of rain and drainage from the land in his calculations.

Existing fluoride levels in soil tend to be in the range of 200-300ppm[28]. Deeper soil tends to contain higher fluoride levels. Rainwater and other wetting removes some of this fluoride, but only a small amount. A kilogram of soil has as much fluoride as around 300 litres of fluoridated water.

Water fluoridation has been investigated regarding possible alteration of environmental fluoride levels, but no discernible effect has been noted[29]. If the author's speculations were correct, we should certainly have expected to see an increase in ambient fluoride levels in groundwater supplies and, probably, some surface water lake supplies as well since the 1960s. We have not seen this effect. When water fluoidation is interrupted, for example during maintenance work, the background level quickly reduces to minute levels, indicating that fluoride is not accumulating in the ground and has not done so in the 40 years since the introduction of fluoridation.

(b) Damage to salmon and other aquatic organisms

The author claims that water fluoridation is causing a decline in salmon stocks. He places heavy emphasis on some co-incidental effects such as the decline co-inciding with the introduction of fluoridation in Ireland.

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T: +353 1 662 9123
F: +353 1 661 8721
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The author ignores the fact that salmon stocks have declined just as quickly in Northern Ireland, Scotland, France, and many other non-fluoridating countries[30]. He contrasts the decline in the USA which is fluoridated, with what he claims is the healthier state of affairs in Canada, which he does not seem to realise is actually a fluoridating country.

There has been a general decline in North Atlantic salmon, the cause of which is unknown, but is thought to be related to global warming, changes in fresh water quality (due to silt from farming and logging, pesticides, phenols and other pollutants), overfishing, commercial fish-farming, the building of dams and other causes[31, 32, 33, 34]. As the ocean is and always has been fluoridated, it is not possible for fluoride to be a causative factor while the salmon are at sea; and yet degradation of the marine habitat is considered a major factor, probably due to surface seawater temperature changes[17]. The author conjectures that the presence of fluorides in freshwater in rivers could be a factor in salmon decline, but as mentioned, this theory ignores the decline seen in non-fluoridating countries.

The author relies heavily on a study by Damkaer and Dey from 1989, which is apparently the only study to propose a link between fluoride and salmon behaviour. This study observed the movements of salmon around a dam near an aluminium processing plant. It looked only at fluoride among the chemicals present or being discharged from the aluminium plant, so it did not control for important confounders (other factors which may be the true cause of a phenomenon) such as water temperature, oxgen saturation or turbidity, or pollutants.

Damkaer and Dey's discussion of their results says that they could not find a reason for either the fishway preference or delays in moving up past the dam. The salmon did not show a preference for higher or lower fluoride concentrations when chosing which stream to use. They showed in the results section that the fluoride concentrations from the aluminium plant could not explain the observed behaviour, yet their second discussion paragraph tells us there was "empirical and theoretical evidence" of its influence.

The simpler explanation for the effects noted by the authors is to be found in this statement:

> "*Of considerable interest, however, were indications that the generally warmer (and, therefore, less oxygen-rich) and more turbid John Day River influenced the Columbia River near John Day Dam. Physical data corroborated photographic evidence that the John Day River could influence returning salmonids as they approach John Day Dam.*"[35]

Damkaer and Dey's conclusions are inconsistent with their data, and have not been replicated in any other study.

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T: +353 1 662 9123
F: +353 1 661 8721
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W: www.fluoridesandhealth.ie

In addition, the question of wider environmental effects of fluoridation was considered by SCHER in 2011. It found that fluoridation of water supplies does not pose an unacceptable risk to the wider environment:

> "*Exposure of environmental organisms to the levels of fluoride used for water fluoridation of drinking water is not expected to lead to unacceptable risks for the environment*"[36].

The EU Environmental Objectives (Surface water) Regulations (S.I. 272 of 2009) sets a mean maximum limit value of 500 µg/l (i.e. 0.5ppm) for an inland receiving water in order to protect the aquatic environment. With dilution factors involved from rain and other water in the environment, where fluoridated urban wastewater is discharged to a body of water there is no prospect of this limit being breached in Ireland.

(c) Alleged toxicity of the fluoridating agent HFSA

The author repeatedly makes the point that the fluoridating agent, hydrofluorosilicic acid (HFSA) has never been tested for toxicological effects on humans. He goes on to contend that there is a complex chemistry involved in the addition of HFSA to water and that this results in the creation of toxic by-products.

We now know from the definitive work on this carried out initially by Urbansky and Schock (2000) and developed by Finney (2006) that this theory has no substance. There is a complete and rapid reaction between HFSA and water, and that the reaction is ultimately this:

$$\underset{\text{(HFSA)}}{H_2SiF_6} + \underset{\text{(water)}}{2H_20} \rightarrow \underset{\text{(hydrogen ion)}}{6H^+} + \underset{\text{(sand)}}{SiO_2} + \underset{\text{(fluoride)}}{6F^-}$$

The reaction is essentially complete within about 12 minutes even in worst case scenarios, but with calcium present in the water it is likely to be complete in less than 2 minutes[37]. The products of the reaction are hydrogen ions (which are removed through a process called buffering), silica (sand) and fluoride ions[38].

The contact time (the time between adding material to water and this substance reaching the first consumer) in water is considerably more than 12 minutes for HFSA. Treated water is typically held for a number of hours before being released for consumption, although in most plants it may be held for more than a day. Thus, the consumer is presented at the tap with fluoride, not with HFSA or other fluorosilicates. The toxicology of HFSA is clearly not an issue of concern for the consumer as they do not come into contact with it.

The EU's SCHER committee agreed with that the toxicology of HFSA was of no relevance:

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

> "*Hydrolysis of hexafluorosilicates, used for drinking water fluoridation, to fluoride was rapid and the release of fluoride ion was essentially complete. Therefore, the fluoride ion is considered the only relevant substance with respect to this opinion.*"[39]

The author also speculates that HFSA is contaminated with unwanted materials by stating "*It is further acknowledged that commercial SiFs are likely to be contaminated with fluosiloxanes, arsenic and heavy metals, and radionuclides, since they are waste products from fertilizer manufacture and uranium extraction from phosphate rock.*"

The author appears to be unaware that Ireland does not source its fluoride supplies from either of these industries. The fluoride added to water in Ireland is sourced as a primary product; it is mined directly from a raw material source, the mineral fluorospar (calcium fluoride, $CaF_2$). The official EU standard for HFSA, IS EN 12175:2001, controls the quality of this product and sets stringent standards for potential impurities. It is given legal force in Ireland in schedule 1 of S.I. 42 of 2007.

Even for other countries, which may be using products sourced from the other industries, the level of unwanted material is less than 1% of the permitted WHO standard. For instance, SCHER states:

> "*Hexafluorosilicic acids used as fluoridating agents may contain some impurities. Concerns have been raised about several heavy metals present as low-concentration impurities in commercial hexafluorosilicic acid. The average concentrations of arsenic, mercury, lead and cadmium present in hexafluorosilicic acid are low – between 10 and 400 mg/kg H2SiF6 (CEN 12175-2006). Therefore, fluoridation of drinking water only contributes to a limited extent to the total exposure to these contaminants (expected drinking water concentrations are between 3.0 and 16.2 ng/L). These calculated concentrations are at least two orders of magnitude below drinking water guideline values for these metals established by WHO and other organizations, and therefore are not regarded as an additional health risk.*"[40]

The Forum on Fluoridation 2002 also addressed this question, finding a similarly negligible amount of contamination:

> "*This assessment shows that, at the concentrations of the respective metals which would result in drinking water after the additive had been diluted to the upper limit of 1.0 parts per million fluoride, there would be no appreciable toxic effects. The residual metals concentrations would be a tiny fraction of the guideline values recommended by the World Health Organisation.*"[41]

The author also offers the possibility that fluoridating water may raise lead levels in water, citing a study by Masters and Coplan. SCHER disagrees, finding the possibility "highly unlikely"[42]. The Masters and Coplan paper has many very serious weaknesses, not least of which is that there was no control over very many

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

confounders, such as atmospheric lead pollution. Their finding has never been replicated by other researchers[16].

The report speculations concerning the fluoridating product are not supported in any way by the available evidence.

(d) Links to aluminium poisoning.

The author claims that fluoridation leads to an increased risk of aluminium poisoning. This claim is based on several ideas. Firstly, the author contends that aluminium can form complexes with undissociated fluorosilicates. No evidence is offered to support this claim. As previously noted, there are no undissociated fluorosilicates present in finished treated water. If such a reaction was to occur, it could only occur within the first minutes of the addition of HFSA to water. Such a reaction would have the effect of dramatically reducing the amount of free fluoride in water, an effect which could not go unnoticed by water treatment engineers.

The author then claims that aluminium increases the absorption of fluoride. However, the studies cited state do not support such a conclusion. For instance, most of the studies cited seem to be about test-tube or animal experiments. The one study quoted regarding measurements taken in man states:

> "*Inorganic elements, such as calcium, phosphorus, and magnesium, which have been shown to decrease the intestinal absorption of fluoride in animals were ineffective in man, while aluminum, given as aluminum-containing antacids, markedly decreased the intestinal absorption of fluoride and thereby decreased the retention of fluoride.*"[43]

Similarly, a report on aluminium compounds referenced by the author states quite plainly that

> "*Administration of fluoride with aluminum has resulted in decreased fluoride absorption from the intestinal tract, indicating that aluminum-fluoride complexes are not absorbed as readily as fluoride alone.*"[44]

The contentions on the action of aluminium and fluoride with each other are based on contradictory findings from animal and other laboratory experiments. Studies on human health have not produced evidence to support these hypotheses..

(e) Fluoride ingestion

All of the risks the report refers to are relevant only to the issue of enamel (dental) fluorosis. As such, these are not health risks, but are mild cosmetic effects.

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

(f) Periodontal Disease

There is no credible evidence linking fluoride and periodontal disease. The cause of the disease is not as described by the author. It is caused by the effect of plaque bacteria on the root surface of the tooth and is basically an inflammatory disease. It is not related to existing bone mineral content in healthy people.

The known effects of fluoridation in preventing root caries is thought to reduce the incidence of periodontal disease. There are three Indian studies looking at a possible correlation between periodontal disease and low and high naturally occurring fluoride levels in water. Two of the studies reported a beneficial effect of increased fluoride levels in water, while one found the reverse. The levels of fluoride in water referred to in those studies were of the order of 4 times the Irish legal limit.

## Conclusion

Water fluoridation was introduced as a public policy in Ireland in 1960. Repeated studies in Ireland have clearly demonstrated that populations served by fluoridated water have better dental health than those which do not.

It is apparent that Mr Waugh's report does not form a basis for a review of current dental health or fluoridation policies.

The EU Scientific Committee on Health and Environmental Risks (SCHER), published its 'Opinion on critical review of any new evidence on the hazard profile, health effects, and human exposure to fluoride and the fluoridating agents of drinking water' – 16 May 2011.The main conclusions of the SCHER report are that there are no known health implications from fluoridating water at levels used in the EU.

Fundamentally the Expert Body maintains that there continues to be overwhelming evidence that water fluoridation significantly benefits dental health and through this, benefits overall health. The Expert Body is satisfied having studied current peer reviewed scientific evidence worldwide that water fluoridation causes no ill effects to the health of adults or children. The recommendations that have been implemented to reduce the level in our water supplies and establish standards across all aspects of its delivery will ensure that water fluoridation continues to be a crucial, beneficial healthcare policy.

Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
W: www.fluoridesandhealth.ie

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Corrigan House, Fenian Street, Dublin 2, Ireland
T: +353 1 662 9123
F: +353 1 661 8721
E: secretariat@dentalhealth.ie
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