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PROCEEDINGS

PREVENTION OF FLUOROSIS IN SRI LANKA

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PREVENTION OF FLUOROSIS IN SRI LANKA

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CONTENTS

GEOCHEMISTRY OF FLUORIDE - AN OVERVIEW

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Abstract: Fluorine is considered as an essential element though health problems may arise from either a deficiency or an excess of fluorides. Much of the fluoride entering the human body is from water though in the case of most other trace elements required by man, food is the principal source.

Fluorides in the surface and groundwater are derived from fluoride rich rocks and minerals among which granites, alkalic rocks, volcanic ash, bentonites and phosphatic fertilisers are more important. Certain plants notably tea are also known to absorb significantly high concentrations of fluoride from soil and water.

In Sri Lanka, the Dry Zone has been shown to contain excess fluorides in the surface and groundwater resulting in higher incidences of dental fluorosis. Areas in the Anuradhapura and Polonnaruwa districts in particular are known to contain fluoride levels far exceeding the WHO danger levels.The influence of climate in the geochemical cycling of fluoride is markedly seen in Sri Lanka where similar rock types in the two climate zones yield vastly different fluoride levels in the associated groundwater.

Tooth enamel is composed principally of crystalline hydroxyl apatite where fluoride is absent in the water supply. However, where fluoride is present in the water supply, some of the ingested fluoride ions are incorporated into the apatite crystal lattice of tooth enamel during its formation, causing the enamel to become harder and possibly discolour. Recent research has shown that further understanding of the mechanism of dental fluorosis requires more comprehensive information about the effects of fluoride on the ionic composition of the fluid phase, the nature of the initially precipitating mineral(s), the interactions between crystals and matrix proteins and the enzymatic degradation of proteins.

INTRODUCTION

The application of geochemistry to health has commenced only recently and there appears to be vast possibilities for the geochemist to make extremely useful contributions to geomedical studies in Sri Lanka. Sri Lanka offers an ideal opportunity to the geochemist in view of the fact that the vast majority of the people are intimately associated with the physical environment, over 80% of the population still obtaining their drinking water supplies from sources other than central water supplies. The geochemistry of the physical environment therefore governs to a very great extent the general health of these people and geographic distributions of certain diseases are clearly observed. Further, out of the 10 great soil groups, 9 are found in Sri Lanka and this affords an opportunity to the geochemist to correlate health with soil chemistry.

Relationships between the geochemical environment and human and animal health are particularly complex and progress in establishing association and causation between geochemical factors, health and disease requires rigorous interdisciplinary research.[1]

Regional geochemical maps are proving to be of immense value in delineating areas of mineral deficiencies and toxicities. The geographical distribution of certain diseases clearly indicate the important role played by climate, nature of rocks, soils and other environmental factors that control the geochemical pathways of essential chemical elements. The application of geochemical maps in investigations on human and animal health are more successful in tropical countries of the developing world where the effect of the lithosphere and hydrosphere on humans and animals is far more pronounced. The close association with the immediate physical environment brings about close correlations between mineral status and health. Among such examples are fluoride and dental health, iodine and goitre, selenium and disorders in livestock, etc. For grazing livestock, deficiencies of Co, Cu, I, Fe, Mn, Se and Zn together with excesses of Cu, F, Mn and Mo have been recognized.[2] It is also known that As, Pb, Cd, Hg and Al are toxic to animals.

Geomedicine is a relatively new discipline which analyzes the impact of environmental factors on the geographical distribution of some human and animal diseases. Due to the vast improvements made particularly in analytical chemistry, extremely minute quantities of chemical elements in the environment can now be made and correlation between mineral status and health better understood. Apart from the abundance of individual chemical elements in rocks, soils, water and plants the antagonism and synergism between different elements in human health are now being studied. It is suspected for example that selenium can, to some degree, neutralise the toxicity of cadmium. Further, it is the ionic species that is far more important, than the total concentration of an element. In the case of chromium, Cr^{3+} is considered essential in nutrition while Cr^{6+} is considered to be toxic. The latter is often linked to the incidence of cancer in workers from chromium based industries.

The correlation of fluoride in the environment most notably in the surface and groundwater with dental health is one of the most marked correlations, and one that is of national importance.[3] This paper deals with the general geochemical cycling of fluoride in the environment with potential application for studies on human health.

FLUORIDE IN ROCKS AND MINERALS

Table 1 gives the fluoride-rich minerals associated with granitic materials. It is known that granitic rocks are particularly rich in fluoride-bearing minerals. The geochemistry of the fluoride ion (ionic radius 1.36 A) is similar to that of the hydroxyl ion (ionic radius 1.40 A) and there can be easy exchange between them. Extensive research has been carried out on the fluoride-hydroxyl exchange in geological materials.[4-7] Fluorapatite $Ca_5(PO_4)_3F$ and hydroxylapatite $Ca_5(PO_4)_3OH$ are isomorphic end members in the apatite solid-solution series $Ca_5(PO_4)_3OH, F$. Human and other animal teeth are composed mainly of hydroxylapatite, whereas fossil shark teeth are composed mainly of fluorapatite. The substitution of hydroxyl$^-$ by fluoride ion results in the replacement of hydroxylapatite in teeth and bones by fluorapatite. Fluorides in the surface and groundwater are derived from

1. Leaching of the rocks rich in fluorine, e.g. granites 750 ppm; alkalic rocks 950 ppm; volcanic ash and bentonites 750 ppm; phosphatic fertilisers 3.0-3.5%.
2. Dissolution of fluorides from volcanic gases by percolating groundwaters along faults and joints of great depth and discharging as fresh and mineral springs.

3. Rainwater, which may acquire a small amount of fluoride from marine aerosols and continental dust.
4. Industrial emissions, such as freons, organo-fluorine and dust in cryolite factories.
5. Industrial effluents.
6. Run-off from farms using phosphatic fertilisers extensively.

The solubility of hydroxylapatite and the composition of the saturation solution depend strongly upon the solid content of the slurry; that is upon the amount of surface area of solid hydroxylapatite in contact with the solute. Generally the solubility of hydroxylapatite does not respond to additions of calcium and phosphate ions. Further, the presence of other ions such as Na^+ and Cl^- in the solute matrix leads to a decrease in solubility and at pH values greater than 8.0, the solubility of hydroxyl apatite rises sharply.[8]

Table 1 : Fluoride rich minerals.

Name	formula	F (wt %)
Fluorite	CaF_2	47.81-48.80
Cryolite	Na_3AlF_6	53.48-54.37
Fluocerite	CeF_3	19.49-28.71
Yttrofluorite	$(Ca,Y)(F,O)_2$	41.64-45.54
Gagarinite	$NaCaYF_6$	33.00-36.00
Bastnasite	$Ce(CO_3)F$	6.23- 9.94
Synchisite	$CeCa(CO_3)_2F$	5.04- 5.82
Parisite	$Ce_2Ca(CO_3)_2F$	5.74- 7.47
Pyrochlore	$NaCaNb_2O_5F$	2.63- 4.31
Microlite	$(Ca,Na)_2Ta_2O_6(O,OH,F)$	0.58- 8.08
Amblygonite	$LiA(PO_4)$	0.57-11.71
Apatite	$Ca_5(PO_4)_3(FClOH)$	1.35- 3.77
Herderite	$Ca(BePO_4)(F,OH)$	0.87-11.32
Muscovite	$KAl_2(AlSi_3O_{10})(OH,F)_2$	0.02- 2.95
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	0.08- 3.50
Lepidolite	$KLi(Fe,Mg)Al(AlSi_4O_{10})(F,OH)$	0.62- 9.19
Zinnwaldite	$KLiFe^{2+}Al(AlSi_3O_{10})(FOH)_2$	1.28- 9.15
Polylithionite	$KLiAl(Si_4O_{10})(FOH)_2$	3.00- 7.73
Tainiolite	$KLiMg_2(Si_4O_{10})F_2$	5.36- 8.56
Holmquistite	$Li_2(MgFe^{2+})_3(AlFe^{3+})_2(Si_2O_{22})(OH,F)_2$	0.14- 2.55
Hornblende	$NaCa_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH,F)_2$	0.01- 2.90
Riebeckite	$Na_2Fe_3{}^{2+}Fe_2{}^{3+}(Si_4O_{11})_2(OH,F)_2$	0.30- 3.31
Arfvedsonite	$NA_3Fe_4{}^{2+}Fe^{3+}(Si_4O_{11})_2(OH,F)_2$	2.05- 2.95
Ferrohastingsite	$NaCaFe_4{}^{2+}(Al,Fe^{3+})(Si_6Al_2O_{22})(OH,F)_2$	0.02- 1.20
Spodumene	$LiA(SiO_3)_2$	0.02- 0.55
Astrophylite	$(K,NA)_2(Fe^{2+},Mn)_4(TiSi_4O_{14}(OH)_2$	0.70- 0.86
Wohlerite	$NaCa(Zr,Nb)O(Si_2,O_7)F$	2.80- 2.98
Tourmaline	$Na(MgFe)_3Al_6(BO_3)_3(Si_6O_{18})(OH)_4$	0.07- 1.27
Sphene	$CaTiSiO_5$	0.28- 1.36
Topaz	$Al_2SiO_4(OH,F)_2$	13.01-20.43
Yttrobrithiolite	$(Ce,Y)_3C_2(SiO_4)_3OH$	0.50- 1.48

Fluorine, the most reactive of the halogens is associated with many types of mineral deposits and hence is a good indicator of mineral deposits.[9] The geochemical dispersion haloes of fluorine from mineral deposits are often detected in ground and surface waters, stream sediments and soils. The higher concentrations of fluoride in water and soil are therefore often the result of the occurrence of mineral deposits in the vicinity. The fluorine chemistry of granitic material is relevant to economic prospecting in granitic terrains since fluorine is associated with Sn-W-Mo and REE-Zr-Ta-Be deposits, with Li-Rb-Cs pegmatites, rare-metal greisens and albitized granites and is ultimately responsible for fluorite and cryolite deposits. Fluorine is located in :

1. F-rich minerals such as fluorite, apatite, etc.
2. Replacing OH and O ions in muscovite (mean 0.1-0.3%), biotite (mean about 0.7%), hornblende (mean about 0.2%) and sphene (range 0.1-1.0%).
3. Solid and fluid inclusions - micas and feldspars, fluid inclusions in quartz.
4. Rock glasses - obsidians and pitchstones.

FLUORIDE IN GROUNDWATER

In the case of most trace elements required by man, food is the principal source. Much of the fluoride entering the human body is however, obtained from water. The geochemistry of fluoride in groundwater is therefore of special importance in investigations on distribution patterns of dental caries or dental fluorosis.

This is of particular importance to Sri Lanka in view of the fact that the vast majority of the population does not have modern pipe-borne water systems. Instead they depend entirely on dug and deep wells, rivers, lakes and canals for their domestic water requirements.

Table 2 shows the level of fluoride in groundwater and their impact in health. Even though the W.H.O. has set a danger limit of 1.5 mg/l fluoride for drinking water, in tropical countries where on account of the higher temperatures prevailing the amount of water consumed may be higher resulting in a greater intake of fluoride. Figure 1 illustrates the main high fluoride bearing groundwater areas in Sri Lanka.

It is important to realise that the degree of weathering and the leachable fluoride in a terrain is of greater significance in the fluoride concentration of water than the mere presence of fluoride-bearing minerals in the soils and rocks. Christensen and Dharmagunawardhane[10] considered the Ca-Mg carbonate-bearing rocks in the Matale Polonnaruwa districts as a good sink for the fluoride ion. The leachability of fluoride from carbonate concentrations is controlled by (a) pH of the draining solutions (b) alkalinity (c) dissolved CO_2 and pCO_2 in the soil. Ramesam and Ragagopalan[11] who studied the fluoride ingestion in arid and semi arid areas as shown in figure 2.

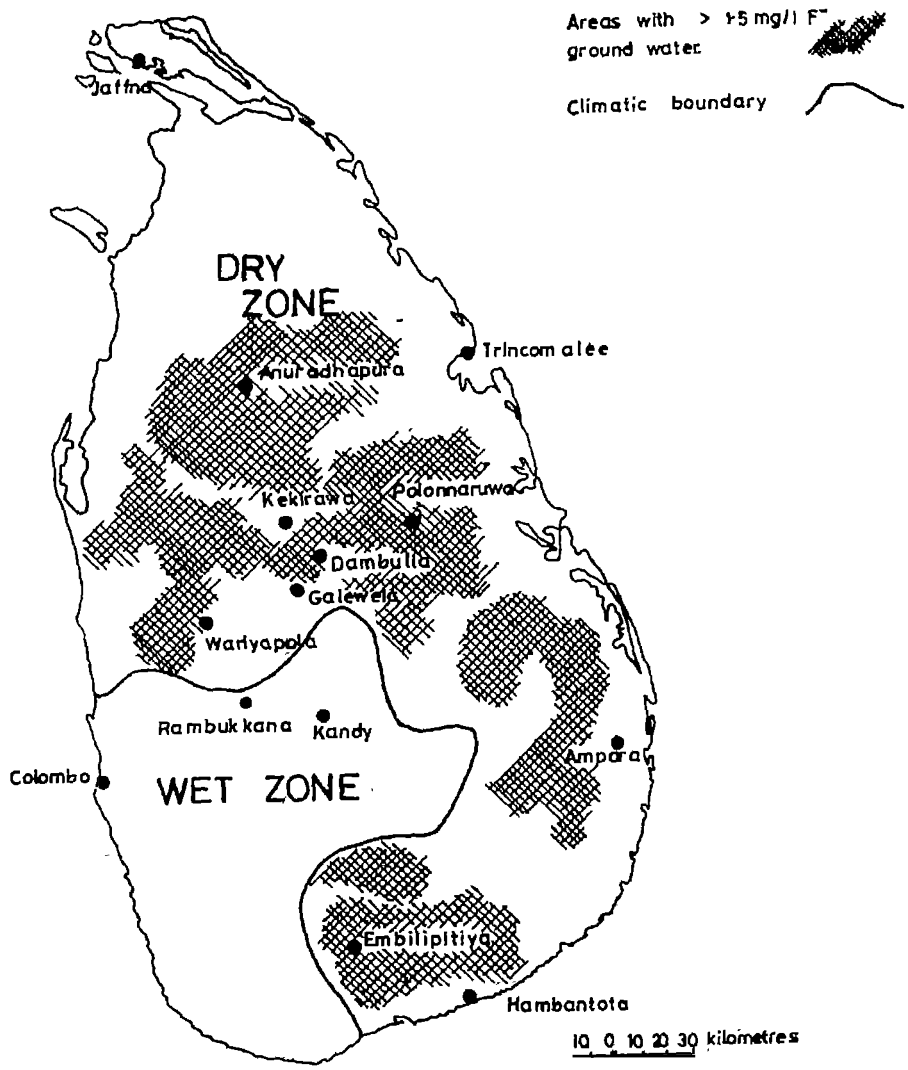

Figure1: High fluoride bearing groundwater areas in Sri Lanka.

Table 2: Impact of fluoride on health (After World Health Organization, Geneva 1971, International Drinking Water Standard).

Concentration of fluoride (mg/l)	Impact on health
Nil	Limited growth and fertility
0.0-0.5	Dental caries
0.5-1.5	Promotes dental health resulting in healthy teeth, prevents tooth decay
1.5-4.0	Dental fluorosis
4.0-10.0	Skeletal fluorosis (pain in back and neck bones)
>10.0	Crippling fluorosis

Figure 3 compares the fluoride content in groundwater from different rock types under dry and wet conditions in Sri Lanka.[12] Irrespective of the rock types, the groundwater remains low in fluoride in the Wet Zone while in the Dry Zone, fluoride reaches levels as high as 10 mg/l. It is particularly relevant to note that while drinking water with high levels of dissolved iron, which has both a colour an objectionable taste, water containing excess fluoride is colourless and tasteless, chemical analyses being required to detect its presence.

FLUORIDE IN PLANTS

Certain plants are known to accumulate fluoride excessively (eg. tea 100 - 760 ppm, elderberry upto 3600 ppm). Most plants have 0.1 to 10.10 ppm fluoride (dry weight), whereas forage plants generally have high fluoride contents (1-300 ppm).

ROLE OF FLUORIDE IN BIOMINERALISATION

Detailed studies on chemical and biochemical studies on fluorotic dental tissues have been conducted with the objective of elucidating the role of fluoride in biomineralisation, understanding and predicting the pathogenic situations in the long-term process of tooth formation and establishing criteria for the public health use of fluoride.

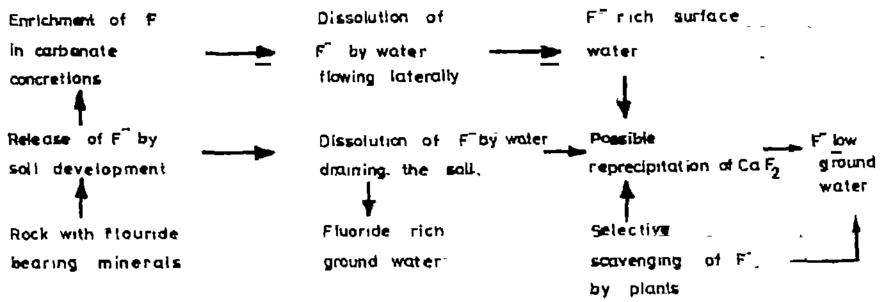

Figure2: Fluoride ingestion.

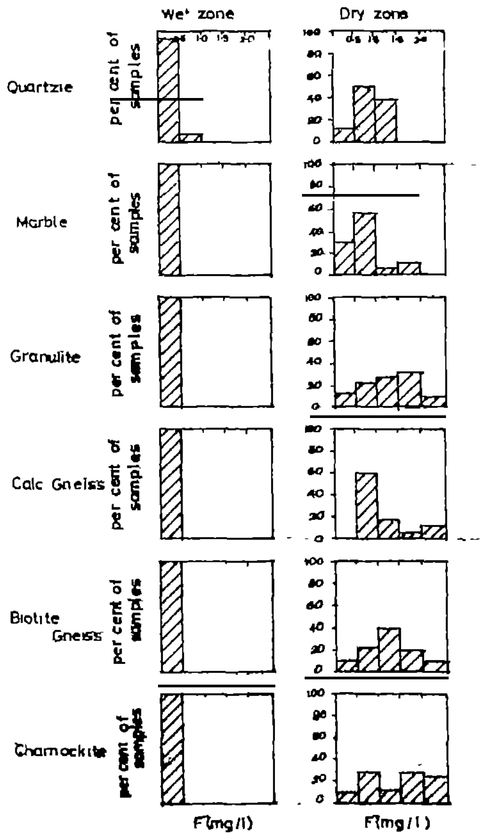

Figure3: Fluoride content in groundwater from different rock types.

Tooth enamel is composed principally of crystalline hydroxylapatite when fluoride is absent in the water supply. When fluoride is present in the water supply, some of the ingested fluoride ions are incorporated into the apatite crystal lattice of tooth enamel during its formation causing the enamel to become harder and possibly discolour. The substitution of fluoride for hydroxyl ion proceeds since fluorapatite is more stable than hydroxylapatite under most conditions.

Figure 4 illustrates the changes in the mineral protein and water contents of enamel tissue with developmentable advancement.[13] Cellular activities are known to control the entire process of enamel mineralization, namely :

1. Synthesis and decretion of matrix proteins.
2. Transport of mineral lattice ions.
3. Removal of degraded products.

Aoba[13] observes that the most distinctive feature of mammalian amelogenesis, in contrast to dentinogenesis and osteogenesis, is that the secreted matrix proteins are degraded in-situ and removed almost completely from the tissue during the developmental stages. He further observes that another unique feature of enamel mineralisation is that, after rapid precipitation of thin-ribbon precursors, mineralisation advances gradually by growth of the formed crystals (especially their thickening) rather than by proliferation of the crystals.

It is known that the increase in severity of dental fluorosis directly reflects on increase in fluoride concentration in the enamel.[14] Evidence presented by Richards et al[15] show that the fluoride content of erupted fluorotic enamel represents fluoride acquired during tooth formation and that once tooth formation is completed, further uptake of fluoride prior to eruption may be negligible. The maximum fluoride content of the enamel tissue is attained in the early development stages, while its apparent content per tissue weight decreases with the advancement of mineralization.[16-18]

The unique properties of fluoride include :

1. increasing the driving force for precipitation of calcium apatite in the form of free ions in media.
2. stabilising the apatite crystals when it is incorporated.
3. enhancing the adsorption affinity of proteins - both enamel proteins in developing enamel and salivary proteins in the oral cavity.[19]

The enhancement of protein adsorption onto fluoridated crystal surfaces is explained by the higher stability of the crystalline lattice brought about by the fluoride ions. The enhanced stability implies a lower surface free energy and hence a weaker interaction of the surface with the water molecules, which should be displaced prior to adsorption of protein molecules.

FLUORIDE AS A GEOINDICATOR

In several tropical countries notably those in Asia and Africa, there is a high incidence of dental diseases caused by an imbalance of fluoride ingestion from drinking water. In China, which is one of the countries affected by endemic fluorosis, both in terms of incidence and severity, Zheng and Hong[20] estimate that those affected by fluorosis may total more than 30 million.

Parts of northern Tanzania are known for their high fluoride waters and endemic fluorosis.[21] The range of fluoride concentrations in the waters in various regions of Tanzania differs markedly, depending largely on the bedrock composition. Aswathanarayana et.al.[22] reported that the highest average contents occur within the northern volcanic regions (Arusha 3.5-78.0 mg/l, Kilimanjaro 0.4-2.8 mg/l, Mara 0.9-8.0 mg/l) and in some central regions (Singida 0.7-24.0 mg/l), whereas contents were generally low in coastal regions (e.g. Mtwara 0.20-0.9 mg/l). If the WHO level of a maximum of 1.5 mg/l for drinking water is accepted, most of the waters in these parts of Tanzania must be regarded as unsuitable for drinking.

In Sri Lanka, groundwaters in large parts of the Dry Zone are also known to contain high fluoride contents.[3] Fluoride-bearing minerals such as biotite, hornblende, apatite and fluorite are abundant in rocks in this terrain. Several parts of the North Central Province have groundwater with fluoride concentrations in the range 1-7 mg/l, and there is clear evidence of endemic fluorosis in the children living in these areas.

In parts of the Indian Peninsula, high fluoride groundwater is also common and constitutes a serious health problem.[23] At least 1 million people in India are known to be subject to excessive intake of fluoride.[24] In parts of Andhra Pradesh, Karnataka and Tamil Nadu, fluoride concentrations of as much as 20 mg/l have been recorded in groundwater.[25] Skeletal fluorosis is also common in parts of India where water fluoride levels exceed 5 mg/l.

One key issue of relevance to geoindicators that needs to be investigated in detail is the determination of the optimal levels of fluoride in drinking water for hot and dry tropical climates. The WHO guidelines for the upper limit of fluoride in drinking water has long been regarded as unsuitable for tropical countries. As shown by Meyers,[26] levels up to 1.5 mg/l in drinking water in temperate climates produce only questionable and mild fluorosis of no public health risk. However, in a tropical country such as Kenya, on the other hand, it has been shown[27] that even fluoride of 0.1-1.0 mg/l in drinking water produce a very high prevalence and severity of dental fluorosis. The recent work of Warnakulasuriya et al[28] in Sri Lanka adds further evidence that in hot dry climates, there can be dental fluorosis even where groundwater contains fluorides less than 0.3 mg/l. It was shown that among those consuming drinking water -1.0 mg/l fluoride, 32% of the children had mild and 9% severe forms of dental fluorosis. This work provides further reasons to change the WHO guidelines for the upper limit of fluoride in drinking water.

Based on the work of Warnakulasuriya et.al.,[28] the author recommends that this level be 0.8 mg/l for those living in hot, dry tropical countries. Here the mean air temperature is high and the amount of water consumed is higher than in temperate countries, with the result that the actual fluoride ingestion is high, even if the groundwater fluoride levels are relatively low. As shown in Figure 5, the Community Fluorosis Index (CFI) may be a better candidate as a geo-indicator for dental health. The CFI is an index which takes temperature into account, and is based on the premise that the amount of water consumed is higher in hotter climates. Thus, even with low groundwater contents, because of the higher intake of water the fluoride ingested may have a similar effect to that of lower intake of high fluoride water in cooler climates. It should also be noted that deficiency in fluoride causes dental caries, and a minimum level of 0.5 mg/l in water is recommended.

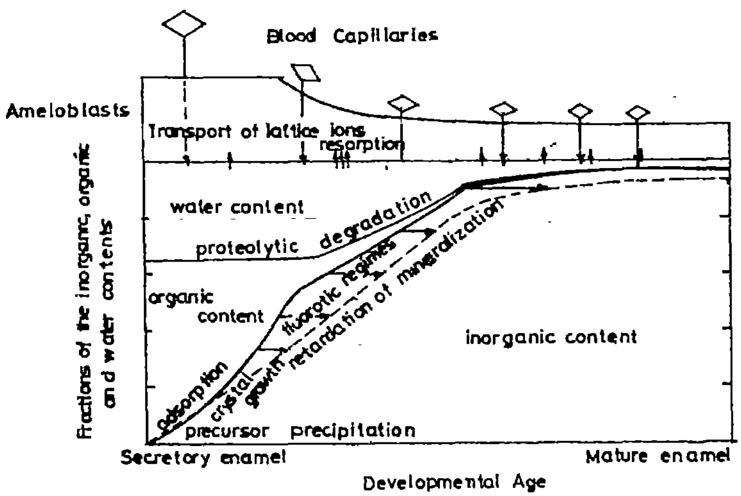

Figure4: Mineral protein and water content of enamel tissue.

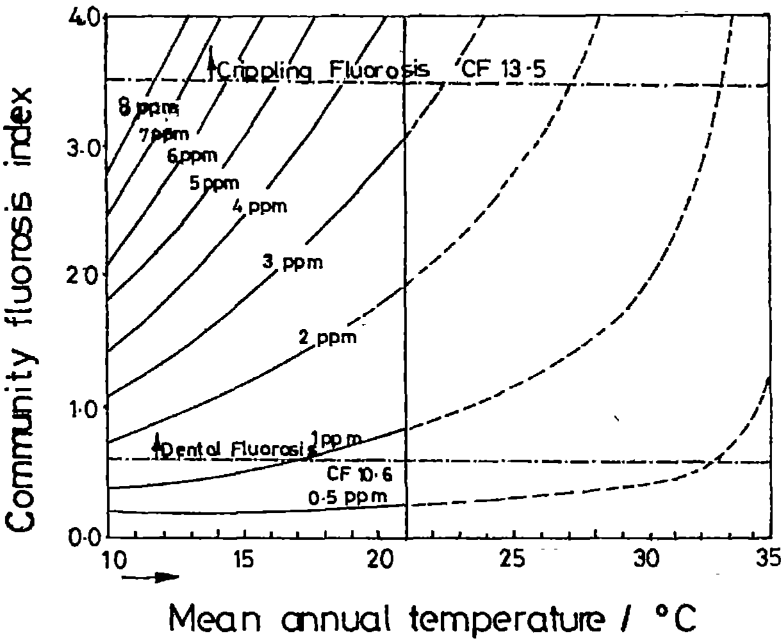

Figure 5: Community fluorosis index.

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HYDROGEOLOGICAL FACTORS CONTRIBUTING TOWARDS FLUORIDES IN WATER

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Abstract: High fluoride content in groundwater is a main water quality problem in many parts of the island specially in dry zone areas. This paper describes the geological and hydrogeological factors contributing the fluoride content in water. The natural fluoride content in water in different areas vary with the source of water, geological formation of the area and the rainfall and amount of water loss through evaporation

With the available data in NWS&DB, the correlation between fluoride content and pH values, Total Hardness, Calcium Hardness, Alkalinity and the Electrical conductivity is discussed. The climatic condition of the area play an important role with the fluoride content in groundwater, as rainfall influence not only recharge to the subsurface but also its chemical composition. Similarly the temperature in the area effect the quantity of drinking water intake by local population.

During the preparation of Master Plan for Water Supply and Sanitation in Anuradhapura district, field studies were carried out to improve understanding of Fluoride occurrence as a result of the naturally given factors such as geological and hydrogeological regimes.

The results obtained from the fluoride studies indicate that the concentration of Fluoride in groundwater displays a dynamic behavior associated with the variations in space and time of the geochemical and hydrochemical environment. The field study showed that considerable variations in Fluoride concentrations may be experienced within a small area which opens the possibility of locating water source with acceptable Fluoride contents even within high Fluoride areas.

The field study also demonstrated that one possibility of locating wells with low Fluoride content is to take advantage of seepage from surface water bodies.

INTRODUCTION

High fluoride content in groundwater being a main water quality problem in many parts of the island[1] specially in Dry zone areas in Anuradhapura District, a study was carried out to estimate the extent of the problem. Detailed studies were done to improve understanding of fluoride occurrence as a result of the naturally given factors as geological and hydrogeological regimes.[2]

The study comprised the following activities:

1. Initial sampling from three villages, followed by selection of one village with high fluoride content for detailed investigations.
2. Detailed investigation involving sampling of water from both dug wells and tubewells, collection of soil samples for desorptive tests, and drilling of experimental boreholes.
3. Groundwater level & quality monitoring programme in 175 Agricultural wells in Anuradhapura District.

In addition to the detailed studies on fluoride reported in this paper the general occurrence and distribution of fluoride in the district is presented and discussed.

SOURCES OF FLUORIDE

There are three potential sources of fluoride in the Anuradhapura district; overburden, basement and fracture in the basement. In the overburden the probable sources for fluoride are secondary mineral phases such as clay minerals and Fe-and Al-hydroxides, formed through intensive weathering of bedrock.

In the bedrock potential sources of fluoride are most likely fluorite, apatite and micas, especially biotite. In fractures fluoride could stem from fluorite and other secondary, low temperature mineral phases precipitated on the walls of the fractures.[3]

An attempt to correlate the fluoride analysis with geology was done by plotting 643 well locations from the NWS&DB water quality sampling programme on scale 1:63,500 geological maps from the Anuradhapura district, and thereby obtaining information on the probable host-rock. Only 540 wells of the 643 analyzed for fluoride could be plotted, due to lack of geological information. It was found that approximately 98% of the wells occur in only three rock types; Charnockitic rocks (195), hornblende-biotite gneisses (300) and granite rocks (32).

The results, displayed in frequency distribution diagrams, are shown in figure 1. Both the fluoride contents in the charnockitic rocks and hornblende-biotite gneisses display log-normal distributions, typical of trace elements in the geochemical environment. Hornblende-biotite gneisses, though, have a higher proportion of anomalous F-values than the charnockitic rocks.

The fluoride distribution in the granite rocks is abnormal. Wells in this rock type apparently contain the highest frequency of F-values below 0.5 mg/l F and at the same time a high frequency of F-values in the range of 1.5 - 2.0 mg/l F. However, with the low number of samples (32) this distribution is not statistically significant, and many more samples would be required to verify a possible anomalous distribution of fluoride in granite rocks, although this is considered unlikely.

FLUORIDE GEOCHEMISTRY

A great number of factors influence fluoride solubility, mobility and precipitation in the saturated zone and in view of this the best starting point for a discussion of anomalous fluoride occurrences (relative to the Sri Lankan Standard 1.5 mg/l F limit) in the Anuradhapura district is to observe the range of anomalous fluoride values, shown in figure 2. The reason for doing so is that below a certain critical value of F in solution one type of geochemical processes prevails, while above this value other limiting conditions control F solubility.

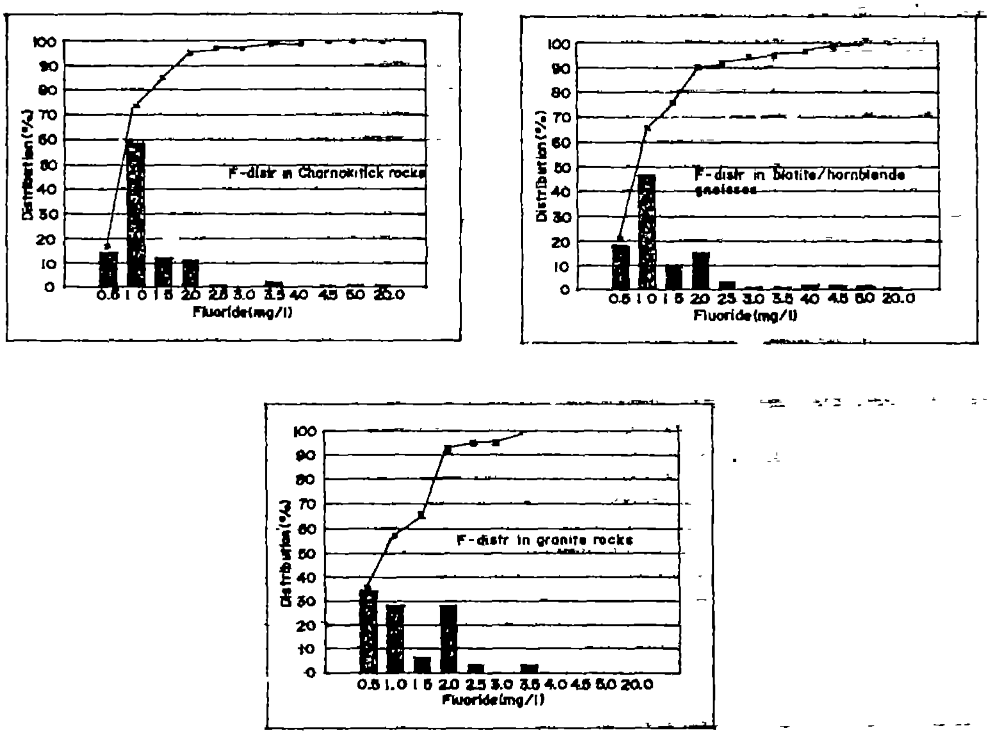


Figure 1: - Distribution of fluoride in charnockitic rocks, gneisses, and granitic rocks.

The critical value of fluoride in solution is around 10-11 mg/l F. At and above this concentration the solubility of fluoride is primarily controlled by the solubility of fluorite (CaF_2), Calcite ($CaCO_3$), and - assuming pH values in the range 5 to 9 - the activity of Mg^{++} and Na^{+}. Below 10-11 mg/l F pH is also a limiting factor, but in addition a number of factors related to absorption and desorption are important, e.g.presence of Fe - and Al-hydroxides and clay minerals. Furthermore, ion exchange processes related to apatite ($Ca_5[PO_4]_3[OH,CI,F]$), if present, can influence the concentration of F in solution.[4]

Evaporate conditions may give rise to increased fluoride concentrations, and the solubility of a halite such as villaumite (NaF) may become important. If the concentration of fluoride reaches the critical value then once again the solubility of fluorite etc. controls fluoride in solutions. Thus the two sets of geochemical conditions may grade into oneanother,and the above should only be taken as a generalized introduction to low temperature fluoride geochemistry.

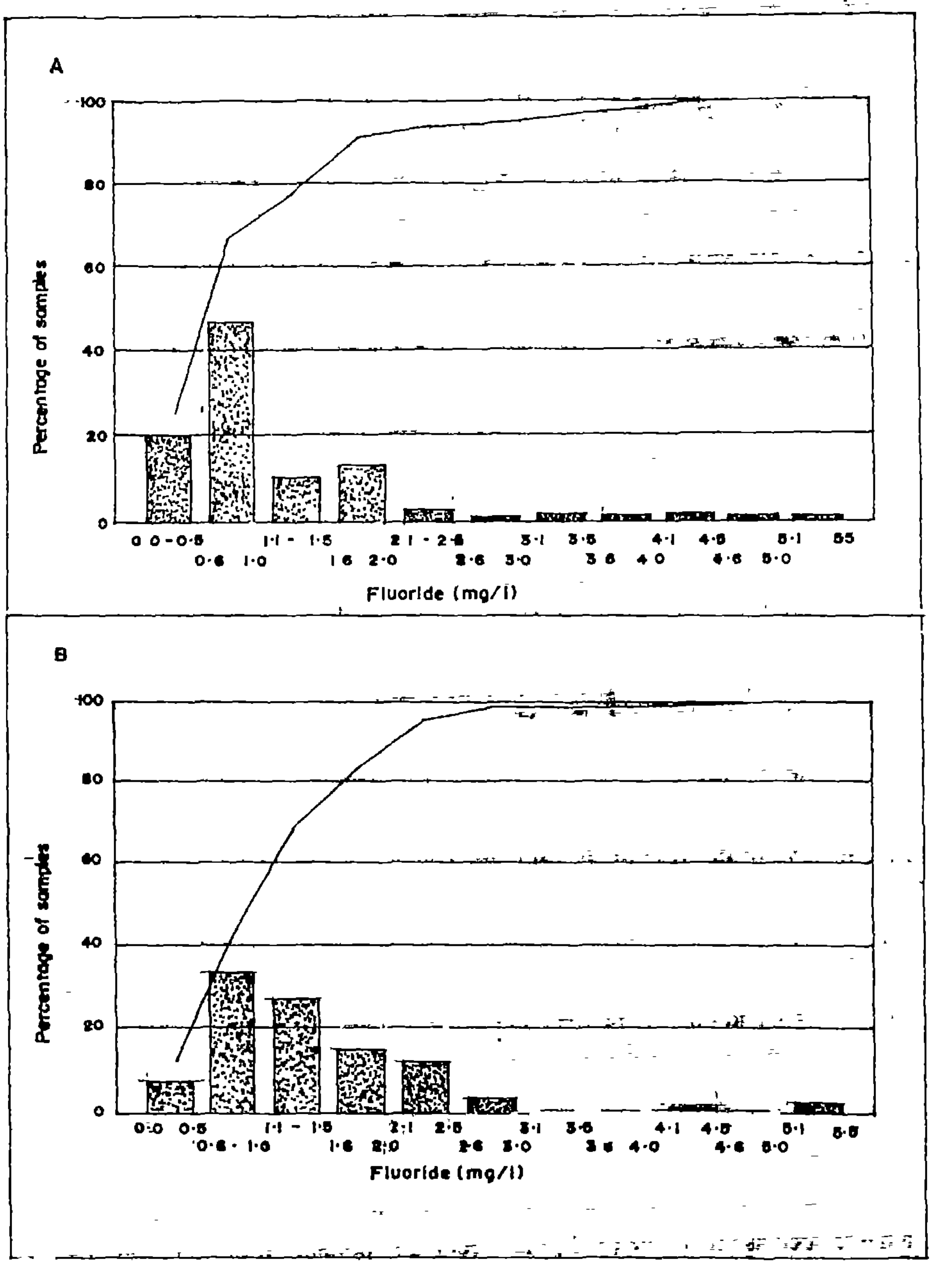


Figure2: Fluoride content in water from the NWS & DB sampling programme (A) and the master plan sampling programme (B).

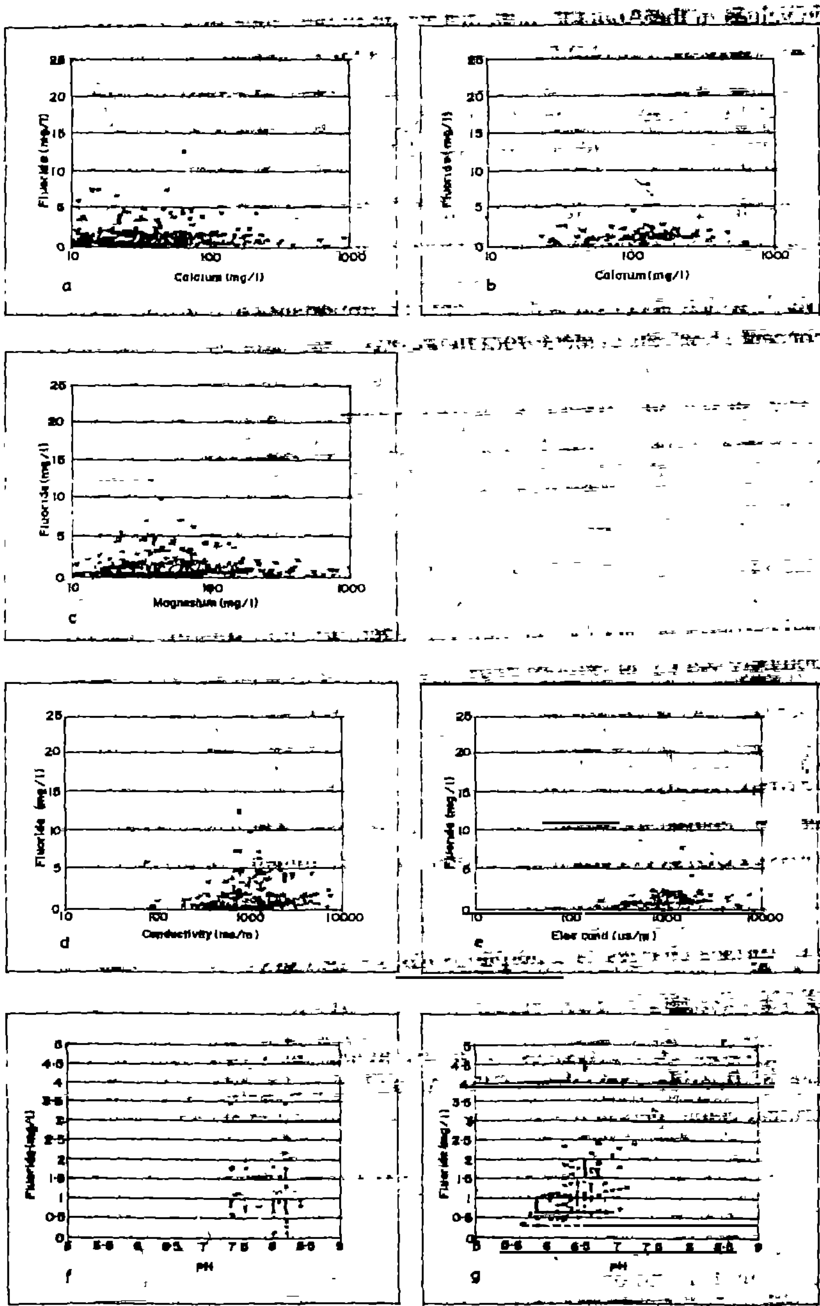


Figure3: Fluoride vs Ca, Mg, Conductivity and pH.

From the distribution frequency diagrams (Figure 3) it is apparent that anomalous fluoride values in the Anuradhapura district lie in the range of 1.5 - 10 mg/l. Consequently, the main processes governing fluoride solubility should be pH-controlled adsorption, desorption through ion-exchange. The exchanging ion is typically the hydroxyl-ion (OH). The activity of dissolved solids in water including Ca^{++} and Na^{+} may also affect the concentration of fluoride in solution due to possible complexing.

The apparent insignificance of fluorite and calcite solubility on the fluoride concentration in the Anuradhapura district is indicated from figure 3 (a and b). Plots of fluoride concentration versus Ca show no correlation at all. The lack of complexing between F and Mg^{++}, which is considered a potentially important complexing agent at both high and low F concentrations , is evident from figure 3c.

The effect of overall dissolved solids, here illustrated by the conductivity measurements in figure 3 (d and e), also display an apparent complete lack of correlation, suggesting that the behavior of F is independent of other ions in solution, i.e. complexing is not important.

However, note should be taken of the fact that the NWS&DB analytical programme and the present sampling programme do not include analysis of sodium (Na), which, as mentioned earlier, may act as a complexing agent for F in solution, and could influence the correlation between F and conductivity.

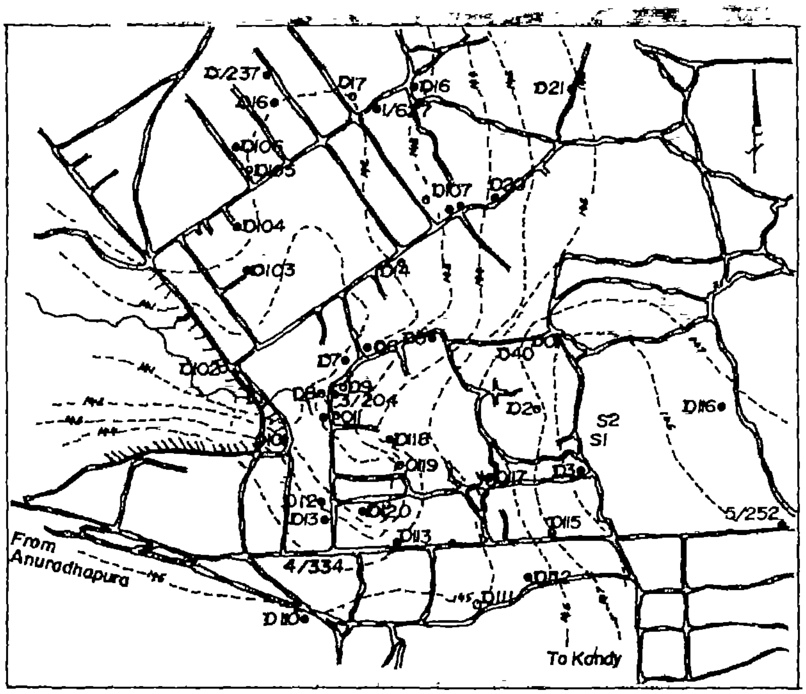
Also shown is a plot of F versus pH for the two sampling programmes (Figure 3f. and 3g). Only the present sampling programme shows a correlation (The lack of correlation in the NWS&DB samples may reflect the handling of samples after sampling, as it is possible that some time elapsed between sampling and analyses. Oxidation of e.g. iron and degassing through loss of CO_2 could effect the laboratory measurements of pH).

The positive correlation between F concentration and pH is probably related to changes in surface charges of amorphous hydroxides, but is more readily understood when discussed in relation to the fluoride field study below.

To conclude the presentation of the graphs in figure 3. It is suggested that the occurrence of fluoride anomalies in the Anuradhapura district primarily are controlled by "below critical value" geochemical processes , such as ion-exchange.

FLUORIDE FIELD STUDY

Three villages were selected in high fluoride areas of Anuradhapura district based on already existing data and on prevalence of dental fluorosis among children in the area. After sampling representative wells from the three areas, the village with highest fluoride



LEGEND

TUBE WELLS .... •

DUG WELLS ....

GROUNDWATER CONTOUR - - -141 - - -
(M. ABOVE M.S.L.)

Figure4: Water leval contours and sampling points.

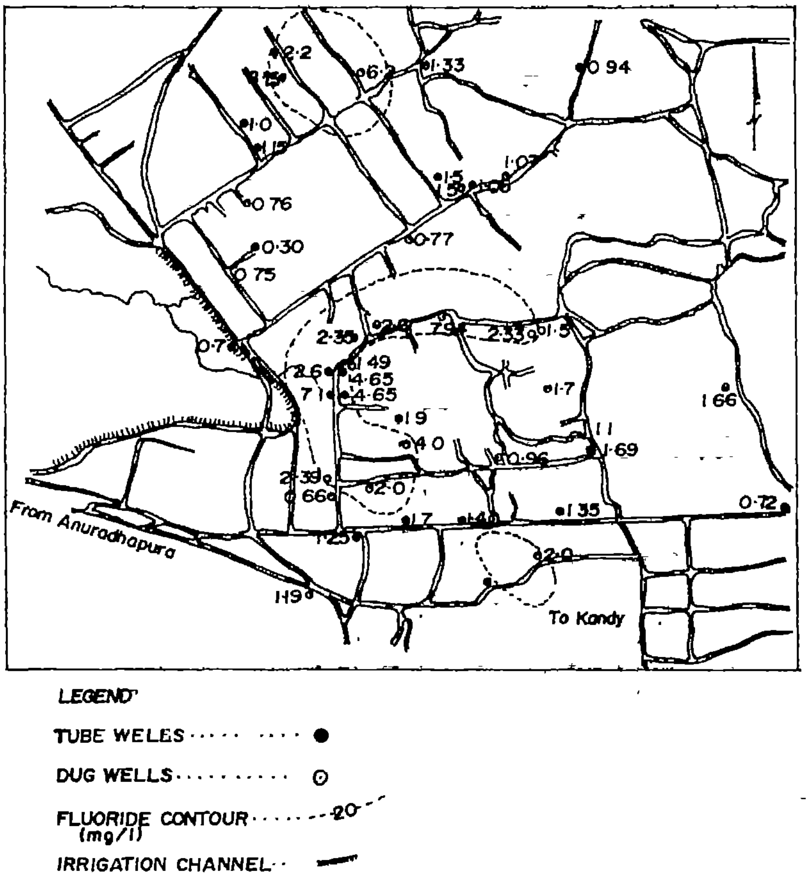


Figure5: Fluoride values in wells.

concentration in the samples was selected for detailed investigation. In this village area (Henawatta) 3 km^2 ENE of Anuradhapura town a field study was carried out comprising sampling of groundwater from both dug wells and tubewells in addition to sampling of soil samples in 5-8 m deep profiles from the walls of three selected dug wells. The area comprising around 5 km^2 was selected because it is characterized by anomalous concentrations in groundwater. The aim of this preliminary investigation was therefore on a more detailed scale to study possible mechanisms leading to locally anomalous concentrations of fluoride.

It should also be emphasized that while some dug wells show high fluoride contents, up to 8 mg/l, neighboring wells only 300-400m away may only contain less than 1 mg/l, illustrating that anomalous fluoride values are not necessarily a regional phenomena, but may be highly localized.

Fluoride in groundwater

Water samples were collected from 38 dug wells and 6 tube wells in the village Henawatte 3 km^2 ENE of Anuradhapura town. The locations of the sampling points and fluoride concentrations are shown in figures 4 and 5.

The groundwater contours shown on this map are based on the measured elevation of the ground level minus water level of the sampling points, with respect to a fixed arbitrary datum in the area.

Anomalous fluoride values occur in the northern central and southern parts of the area and the highest measured concentration is 8.15 mg/l F. It is seen from the map on figure 5. that high fluoride areas appear to be located in areas of groundwater discharge (down gradient). The consequently unexpected low fluoride concentration in the groundwater discharge area in the west may be explained by the presence of an irrigation canal which contributes to the dilution of groundwater through seepage in to the overburden. It has also been observed that the elevation of groundwater is influenced by this irrigation canal.

The apparent implications of figures 4 and 5 for the fluoride distribution in this specific area are as follows. Overburden within a small recharge area is characterized by high background values, which during rainfall is leached from the soil and transported to areas of groundwater discharge. Combined with evaporation these two factors could be important mechanisms in concentration of fluoride in localized areas.

Fluoride in dug wells/tubewells

The fluoride content in groundwater from water supply boreholes and experimental boreholes in the area was also measured for observing the situation in tube wells. The fluoride levels of borehole water appeared to be consistent with the fluoride concentrations in the dug wells in the vicinity of the boreholes (Table 1).

The similar values in boreholes and nearby dug wells indicate that there can be a good hydraulic connection between the water bearing horizons of dug wells and tube wells or contribution from fluoride sources are more or less the same for both well types.

Water samples were collected from different depths of the experimental boreholes. Samples were collected during drilling whenever a water bearing horizon was encountered. It was difficult to observe any correlation of the fluoride content with different depths. It was however clear that there is an effect on the total fluoride concentration in the samples due to the differences in geological formations. Mixing of water from the overburden as well as from different fractures made the identification of zones with low and high fluoride content difficult. One experimental well was pumped at a constant rate for 3 hrs. and samples were collected at every 15 minute intervals. The fluoride concentration of the water samples obtained are as shown below in figure 6.

It is seen from the figure that fluoride concentration fluctuates during pumping but without any definite order of magnitude. This situation may be explained by the fact that ground water even within a short distance can have different fluoride concentrations depending on the solubility of fluoride in water under the prevailing conditions within the aquifer. When pumping is continued the water from distant parts enters into the well so that discharge water from the pump shows fluoride concentration corresponding to those areas.

Together with fluoride, some other chemical parameters in the water samples were also analyzed during pumping. These parameters however did not show any fluctuation with a noticeable order of magnitude.

FLUORIDE IN SOIL

Parallel with the water sampling programme, a soil sampling programme was carried out to assess the desorptive potentional of the soil with respect to fluoride. In other words, how much fluoride can rain water potentially leach from the overburden.

Most of the dug wells in the study area were inspected and the composition of the bedrock determined. In the study area the rock type is typically biotite rich hornblend-biotite gneiss sometimes grading into a schist and with occasional intercalations of thin bands (cm) of granitic/pegmatitic composition.

Table 1: - Fluoride concentrations in tube wells and dug wells.

Borehole No.	5/232	4/334	3/204	3/201	FT1	FT2	FT3	1/627
Fluoride content in bore-hole water	0.72	1.25	4.65	1.05	1.1	2.9	0.75	5.5
Fluoride in nearest dug wells	1.06	1.70	4.65	1.50	1.69	7.9	0.30	6.2
Dug well No.	D116	D113	D11	D19	D3	D5	D103	D17

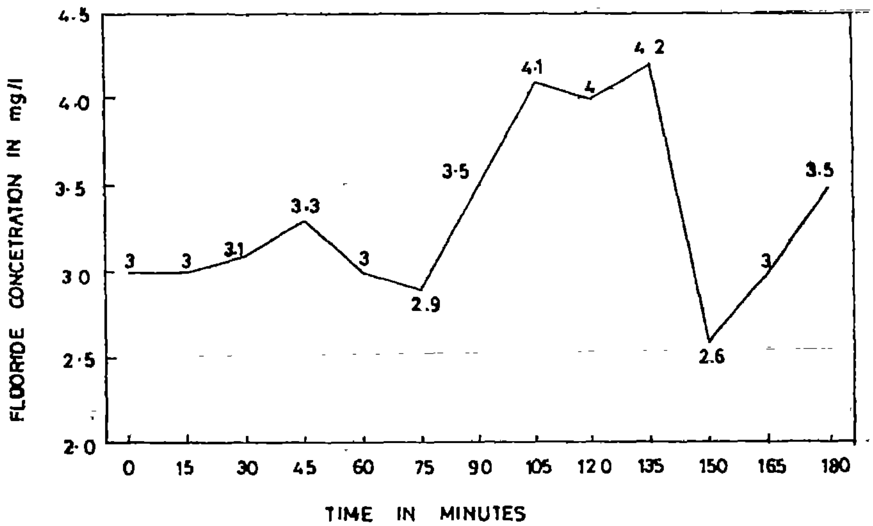


Figure 6: - Fluoride fluctuation during pumping.

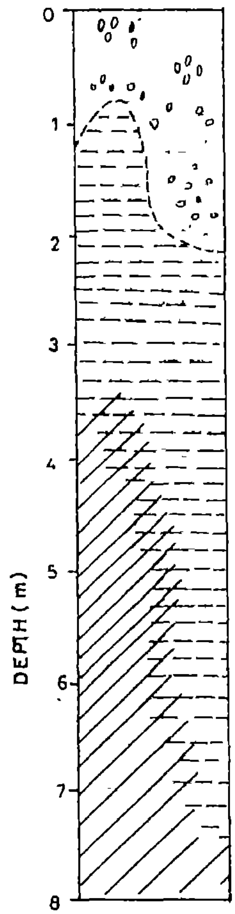
The soil sampling was done in three dug wells taken to be representative of the area, and in each dug well wall were taken at 1 m intervals. A generalized profile of the dug well and soil/rock characteristics is given in figure 7. The profile shows that hematite stained red-earth, typically sandy-gravely loam, occurs in the upper 1-1.5 m of the profile. Then follows a 2-5 m thick zone of highly to moderately weathered bedrock, with a sandy - gravely texture. A relatively thin zone to slightly altered or unaltered bed rock.

A simple analytical procedure was chosen consisting of placing a known quantity of soil sample (10 g) in 90 ml of de-ionized water for 1 hr, and stirring every 10 minutes. Thereafter a water sample was collected and analyzed for fluoride and pH. The samples were then left for 48 hrs. and again a water sample was taken and analyzed for fluoride and pH. The results are shown in Table 2.

The desorption experiment shows that after 1 hour fluoride concentrations in the deionized water range from less than 0.1 to 0.28 mg/l corresponding to a maximum of leachable fluoride from soil of 2.8 mg F/100 g soil. The greatest desorption occur in the red-earth, while low values are associated with sandy, biotite highly weathered bedrock. After 48 hours the result is an increased desorption of between 0.2 and 0.56 mg F/l corresponding to a maximum leachable fluoride of 5.6 mg F/100 g soil. The pH after 48 hours lies around 6.5 ± 0.75.

Studies of desorption of fluoride from soil are limited, but available data from investigations in India show that desorption values after 48 hours of leaching lie in the range of 0.25 - 1.5 mg F/100 g soil. Compared to these values the results from this investigation indicated a tendency towards the red earth as having a high desorption potential with respect of fluoride, while the desorptive capability of weathered bedrock appears to be lower. The desorptive capability of the red earth may well be due to the presence of Al-hydroxides, as it is found the OH will readily exchange for loosely F absorbed on the surface of amorphous Al-hydroxides, one of the products of weathering in tropical climates. This relationship between OH and F may be the prime reason for the observed correlation between pH and F (Figure 3g).

Other sources of fluoride such as fractures remain to be investigated. The existence and possible influence of fractures as e.g., conduits for groundwater flow and thus concentration of fluoride in areas of limited extent, should not be disregarded. Meanwhile, the present results give a first indication of a potential source of fluoride and also a possible transport mechanism which ultimately gives rise to localized areas of groundwater with anomalous fluoride contents.



Soil/rock characteristics

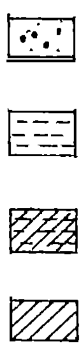
Top soil : max.1-0.2 cm thick and distinguished from red earth by a darker colouring, possible due to organic content.

Red earth : Sandy to gravely loam with characteristic hematite staining. Often contains horizons with mm-cm large quartz nodules. Generally 1-2 m thick.

Weathered bedrock : Generally highly weathered bedrock. Sandy to gravely texture. Consists of Kaolin, albitized feldspar, Fe-hydroxides and biotite/leucoxene. Spotted, light yellow brown.

Weathered bedrock : Moderately to slightly weathered bedrock often containing relict structure such as foliation. Typically albitized, biotite hornblend gneisses, stained with Fe-hydroxides.

Slightly to unaltered bedrock: Biotite hornblende gneisses.



Red earth

Highly weathered bedrock

Moderately weathered bedrock

Slightly weathered-To unaltered bedrock

Figure 7: Generalized dug well profile

Table 2: Results of leaching of soil samples.

Sample	Depth (m)	Over burden	1 hr (mg/100g)	48 hr (mg/100g)	pH (48 hrs)
S1-1	0.5	Red Earth	2.5	4.0	6.00
S1-2	1.5	Red Earth	1.8	3.4	5.80
S1-3	2.4	S1-3	2.1	3.0	5.80
S1-4	3.5	Weath Br.	2.1	2.9	5.75
S2-1	0.3	Red Earth	1.3	1.9	5.30
S2-2	1.3	Weath Br.	1.3	3.0	5.20
S2-3	2.3	Weath Br.	1.2	2.3	5.10
S2-4	3.3	Weath Br.	1.1	2.1	6.55
S2-5	4.3	Sl.We.Br.	1.7	4.1	6.85
S3-1	0.1	Top soil	1.0	2.6	6.50
S3-2	1.0	Red Earth	2.0	5.6	6.15
S3-3	2.0	Red Earth	2.8	5.4	6.00
S3-4	5.0	Weath Br.	2.0	3.0	7.35
S3-5	5.5	Weath Br.	1.0	2.1	7.40
S3-6	6.5	Weath Br.	1.5	2.8	7.15
S3-7	7.5	Weath Br.	<1.0	2.5	7.25
S3-8	8.5	Sl.We.Br.	<1.0	2.4	7.25

CONCLUSION

The obtained results from the fluoride studies indicate that the concentration of fluoride in groundwater displays a dynamic behavior associated with the variations in space and time of the geochemical and hydrochemical environment. This was illustrated by both the leaching experiments which showed different soil types desorption abilities.

The field study showed that considerable variations in fluoride concentrations may be experienced within a small area. This opens the possibility of locating water sources with acceptable fluoride contents even within high fluoride areas. However, further studies are necessary to find whether such water sources maintain a low fluoride concentration throughout or whether it changes significantly with time.

The field study also demonstrated, that one possibility of locating wells with low fluoride content is to take advantage of seepage from surface water bodies.

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FLUOROSIS AFFECTED PATIENTS IN SRI LANKA

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Fluorosis can manifest as dental fluorosis and skeletal fluorosis. Low concentrations such as two parts per million of fluoride in water can cause dental mottling and is easily recognised. Ingestion of water and foods grown in areas of high fluoride content of eight parts per million or more, for a long period (over twenty years) cause bone fluorosis, with characteristic radiological features of increased bone density (osteo-sclerosis), ligamentous, calcification or ossification, marked osteophytosis are seen mostly in the vertebral column and pelvis. Long bones are less affected with cortical thickening and calcification of inter-ossean membranes. Diffused osteoscerosis is not due to density of fluoride deposited but due to reactive increased bone deposition and decreased bone resorption.

Many patients in endemic areas can be asymptomatic although they have bone changes of fluorosis. Therefore, fluorosis may not be clinically obvious till advance stage of crippling fluorosis. Radiology provides the only means of diagnosis of early and relatively asymptonalic stage of the disease. On set of symptoms and degree of disability due to skeletal changes are related to the concentration of fluoride in water, length of exposure, poor nutrition and hard manual labour.

Some details of seven patients diagnosed by radiological features are given in table 1.

Although no statistics are available for the incidents of skeletal fluorosis in Sri Lanka, fluorosis could become a health hazard to the population living in the endemic areas for a long period.

Only treatment which will be helpful for these patients will be reduction of fluoride intake for a long duration, either by change of residence or by supplying them with low-cost defluoridation methods. Prevention of disease occurring in the younger population living in these areas are specially important. Since change of residence will be difficult when dealing with large populations, only solution left with will be use of defluoridators.

It is known that people living in areas of water containing less than four parts per million, none developed bone fluorosis. Areas less than one part per million of fluoride content will prevent dental caries and there is less incidence of age related osteoporosis in people living in areas of high fluoride content.

Table 1: Details of patients.

Case	Age (yrs)	Sex	No. of years lived in the area	Present symptoms
1	62	M	57 yrs - Jayanthipura	back-ache and stiffness (10-12 yrs) to recent on set of chest pain
2	65	M	40 yrs - Medirigiriya	back-ache, loss of appetite and weight
3	44	M	22 yrs - Kekirawa	neck pain and numbness below neck and weakness of all four limbs, inability to walk (Cervical Myelopathy)
4	42	F	22 yrs - Kekirawa	neck pain
5	70	M	50 yrs - Mihintale-50	severe bone pain, stiffness and restricted movement
6	66	M	Girandurukotte	back-ache
7	57	M	>20yrs - Kithulhitiyawa	back-ache
8	43	F	Kekirawa	back-ache and inability to walk (Dersel Myelopathy)

TREATMENT OF FLUOROSED TEETH

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Abstract: Dental fluorosis has been reported from various parts of the world. In Sri Lanka, it has been reported mainly in the North Central Province. Once dental fluorosis occurs it is seen as an unaesthetic stain which sometimes intensified to a brown or blackish stain, specially regulated to the permanent anterior incisiors. This causes a great problem to the clinician who is faced with the dilemma when treating these patients.

Several treatment modalities such as jacket crowns, veneeres, chemical and light cure composites and vital bleaching methods have been tried. Out of these methods, jacket crowns and veneers are not very practical in Sri Lanka, due to the lack of laboratory facilities and other expensive equipment. Although light cure composites restorations are considered as more convenient methods, the cost invloved for this is so high, thereby making it impossible for the poor patient to obtain this kind of expensive treatement.

In this paper, a research study carried out on vital bleaching in treating these patient are described. In this study, ten different bleaching methods were tried in order to identify a simple and inexpensive treatment technique which is suitable for Sri Lanka, where it could benefit several of thousands of poor affected people.

INTRODUCTION

Dental fluorosis has been reported from various parts of the world. In Sri Lanka it has been reported mainly in the North Central Province , where the prevalence rate is 55 to 77 per cent in the 7 to 20 year old school children.[1,2] In addition Galewela, Kekirawa, Wariyapola[3] and Embilipitiya[4] had been identified as endemic areas of dental fluorosis. Furthermore all these above mentioned areas have been shown to contain high levels of fluorides in drinking water.[5,6] Dental fluorosis is seen as an unaesthetic stain which sometimes is intensified to a brown or a blackish stain, specially relegated to the permanent anterior incisors. This causes a great problem to the clinician who is faced with a dilemma when treating these patients.

Several treatment modalities such as Jacket crowns, veneers, chemical and light cure composites and vital bleaching methods have been tried. Out of these methods Jacket crowns and veneers are not very practical in Sri Lanka, due to the lack of laboratory facilities and other expensive equipment. Although light cure composite restorations are considered a more convenient method, the cost involved is prohibitive and beyond the reach of the poorer patients.

In this paper, a research study carried out on vital bleaching in treating these patients is described. In this study, ten different bleaching methods were tried in order to identify a simple and inexpensive treatment technique which is suitable for Sri Lanka, where it could benefit several of thousands of poor people afflicted by this malaise.

METHODOLOGY

This research project was formulated on the following four basic factors.
1. Evaluating the effect of a weak acid which is freely available in our country.
2. Evaluating the effect of a relatively stronger acid which is freely available.
3. Effectiveness of a bleaching agent.
4. Usage of non-toxic concentrations of reagents to make it easy to use.

The ten different bleaching methods experimented are given below.

Method 1 :

a) Application of 30% orthpohosphoric acid on the labial surface of the experimental tooth. Leave for two minutes.
b) Wash off with water for 30 seconds and polish with pumice, made into a slurry with water, using rubber cup and a slow hand piece at 1000-2000 rmp.
c) Application of non-acidulated fluoride gel on the labial surface of the tooth for three minutes.

Method 2 :

a) Application of 30% orthophosphoric acid on the labial surface of the experimental tooth. Leave for four minutes.
b) Wash off with water for 30 seconds and repeat steps (b) and (c) given in Method 1.

Method 3 :

a) Application of 30% orthophosphoric acid on the labial surface of the experimental tooth. Leave for two minutes.
b) Wash for 30 seconds with water.
c) Application of 10% hydrogen peroxide solution on the labial surface of experimental tooth. Leave for five minutes.
d) Repeat the steps (b) and (c) given in Method 1.

Method 4 :

a) Application of 30% orthophosphoric acid on the labial surface of the experimental tooth. Leave for four minutes.
b) Repeat the steps (b), (c) & (d) given in Method 3.

Method 5:

a) A 9% solution of hydrochloric acid, made in to a slurry with pumice,rubbed on the liable surface of the experimental tooth. A serrated metal instrument with a little cotton wrapped at the end was used, to rub the slurry on to the tooth surface.
b) continue rubbing for 40 seconds.
c) Wash for 30 seconds with water.

d) Steps (a), (b) and (c) repeated for a maximum number of five times until an improvement is seen.
e) Polish with pumice, made into a slurry with water,using rubber cup and a slow hand piece at 1000-2000 rpm, as previously done in Method 1.
f) Application of non-acidulated fluoride gel on the labial surface of the tooth for three minutes.

Method 6 :

a) A 18% solution of hydrochloric acid, made into a slurry with pumice, rubbed on the labial surface of the experimental tooth, using the same device as stated in Method 5, Step (a).
b) Continue rubbing for 40 seconds.
c) Repeat the steps (c), (d), (e) and (f) given in Method 5.

Method 7 :

a) A 36% solution of hydrochloric acid, made into a slurry with pumice, rubbed on the labial surface of the experimental tooth, using the same device as stated in Method 5, step (a).
b) Continue rubbing for 40 seconds.
c) Repeat the steps (c), (d), (e) and (f) given in Method 5.

Method 8:

a) Repeat steps (a), (b), (c) and (d) stated in Method 5.
b) Application of 10% hydrogen peroxide solution on to the labial surface of the experimental tooth - leave for five minutes.
c) Wash off with water for 30 seconds and polish with pumice made into a slurry with water using rubber cup and a slow hand piece at 1000-2000 rpm, as previously done in Method 1, Step (b).
d) Application of non-acidulated fluoride gel on the labial surface of the tooth for three minutes.

Method 9 :

a) Repeats steps (a) and (b) stated in Method 6.
b) Repeat this for a maximum number of five times until an improvement is seen, while washing for 30 seconds with water after each rubbing of the acid.
c) Application of 10% hydrogen peroxide solution on the labial surface of the experimental tooth - leave for five minutes.
d) Repeat steps (c) and (d) in Method 8.

Method 10 :

a) Repeat steps (a) and (b) stated in Method 7.
b) Repeat this for a maximum of five times, until an improvement is seen, while washing for 30 seconds with water, after each 'rubbing' of the acid.
c) Application of 10% hydrogen peroxide solution on the labial surface of the experimental tooth - leave for five minutes.
d) Repeat steps (c) and (d) stated in Method 8.

RESULTS

Out of the ten different methods tried, the method that involved a relatively stronger acid, which is hydrochloric acid with or without the bleaching agent (Hydrogen peroxide) gave satisfactory results. When the severity of the discoloration was more intensified, the concentration of the relatively stronger acid also had to be increased, in order to obtain good results. In summary the usage of 18% - 36% hydrochloric acid made into a slurry with pumice gave good results with moderately severe cases of fluorosis.

CONCLUSION

This study shows that unaesthetic stains on teeth due to dental fluorosis can be removed with an application of 18% - 36% hydrochloric acid followed by 10% hydrogen peroxide, specially when the stains are at moderate level.

The method described here is a much simpler and a less expensive one that could be carried out in any part of Sri Lanka by any dental surgeon. This could bring immense relief to several thousands of affected people, specially the poor income groups who cannot afford sophisticated expensive treatment.

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DEFLUORIDATION METHOD USING BONECHAR AS FILTER MEDIA

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Abstract: The filter used for defluoridation by Bone char,Gravity Floor Technique is simple in design and is fabricated in Sri Lanka using PVC pipe. The filter media provided was in the form of polythene bag containing pebbles, bone char and charcoal. There are 55 defluoridators distributed among house holders those who have children under 10 years of age. The born char very effectively reduces the fluoride rich water to acceptable level of fluoride in drinking water. More inquires are made for these defluoridators showing the success of the pilot project. It has been found that with a flow rate of 4 litres an hour, this defluoridator reduced the fluoride content of 480 litres of water from 5mg/litre to less than 1 mg/l.

INTRODUCTION

The excessive flouride level in drinking water has undesirable effect on both teeth and bones.[1] In temperate countries like USA the 'optimum' beneficial fluoride level is 1.0 mg/l, but in areas with hot climates it is less than 0.7 mg/l. Several methods have been developed from time to time for active defluoridation of drinking water. These may be divided into two basic types - those based upon an ion exchange or adsorption, and those based upon the addition of chemicals to water during treatment. The methods reported to have been. used in adsorption or ion exchange process include lime softening, alum, alum and alumina (Nalgonda technique),activated alumina, activated carbons, natural bone, bone char, bone char and charcoal (ICOH Defluoridator), natural or synthetic tricalcium phosphate, Bauxite hydroxy apatite, commercially produced ion-exhange resins, electrodialysis, reverse osmosis and various other treatment agents. Other methods include the addition to fluoride water of materials like magnesia, calcium phosphate, bentonite, fuller's earth, bentonite and diatomaceous earth. All these methods suffer from one or more of the shortcomings of high initial cost, high operation and maintenance costs, low fluoride removal capacities, lack of selectivity for fluorides, undesirable effects on water, generation of sludge, complicated procedures and complicated or expensive regeneration.

The use of bone char or unheated bone particles (bone meal) to remove excess fluoride is an old yet enduring technique. It was suggested several decades ago by investigators in Arizona who established the link between mottled dental enamel and water fluoride levels and is still promoted today for use in home based systems. It has been established that defluoridation is more efficient when bone is heated less severely. When bone is heated for a short time at a low temperature the result is black or grey material containing considerable carbonized organic matter that itself may be active in defluoridation process.

Magnesium oxide and bone meal were used in Kenya, as chemical defluoridating agents. The results showed that fluoride removal by 100mg bone meal is considerable more effective compared to the action of 100 mg magnesium oxide. The effectiveness of bone meal and magnesium oxide is directly related to the concentration of the absorbing agents and the greatest absorption takes places within 60 minutes. The water treated with bone meal was palatable and had a pH of 7.5. The quality of this water would most likely find quicker acceptance as drinking water.

Another study was conducted to improve the efficiency of the bone char method by pre-treating the water with brushite and calcium hydroxide. The aim of this study was to examine defluoridation using brushite as a source of ionic calcium and phosphate, calcium hydroxide as a source of calcium and as a pH regulator, and bone char as a nucleating material. The addition of the two salts to the water may prolong the life of the bone char indefinitely, ensure the removal of fluoride, and thus avoid the problem of determining when the bone char is exhausted.

The main objective of this research project is to reduce the incidence of Dental Fluorosis in younger children at Pathirennegama Village in Polpithigama, by providing with the defluoridation filters.

METHODS AND MATERIALS

A baseline survey was conducted to determine caries prevalence as well as to estimate the prevalence of Enamel opacities. In addition, a socio-demographic survey was conducted. In this study, water samples were collected in plastic bottles from wells in the Pathirennegama village in the Polpithigama AGA division. The wells considered for this study were shallow, deep and bore hole wells. The samples were analysed for the fluoride content using the Orion Fluoride Analyser. The same procedure was followed with respect to the well water and defluoridated water samples from 60 Inter-county Centre for Oral Health (ICOH) defluoridators distributed in Pathirennegama, in the Kurunegala district. The filter media was given to each household at the time of handing over of the ICOH defluoridator.

The household ICOH defluoridator.[2] The ICOH defluoridator for individual households developed at the Inter-country Centre for Oral Health, Chiang Mai, in Northern Thailand was fabricated and used in this study (Figure 1).

The container is made of a piece of polyvinyl chloride pipe (75 cm in length and 5 cm in diameter) with an outlet tap at the bottom and a cap with a small hole for input of water at the top. This ICOH defluoridator is assembled from materials generally available for plumbing purposes and so simple in its design that the villagers themselves can produce it.

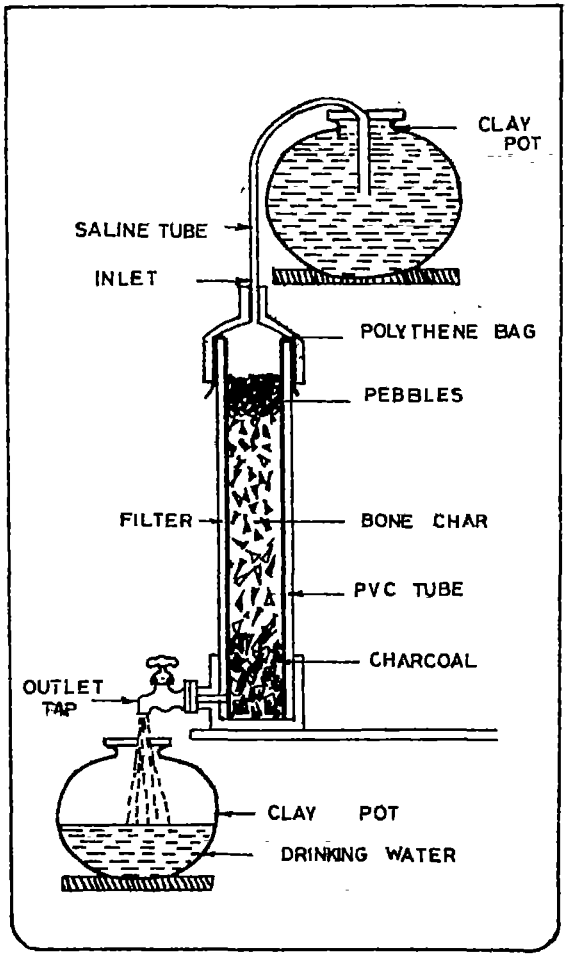

Figure1: ICOH Defluoridator.

The filter contains 300 g of crushed charcoal at the bottom for absorption of colour and odour, 1000 g of charred bone meal and 200 g of clean pebble as top layer to prevent the intermediate layer from floating. The ingredients are placed in a ploythene bag and inserted into the PVC pipe. The water from the well kept in a clay pot is siphoned to the top of the defluoridator by means of a small plastic tube (saline tube) at a flow rate of 4 litres per hour. The defluoridated water is collected into a clay pot directly under the tap.

The filter has been shown to reduce the fluoride content in 480 litres of water from 5 mg/l F or more to less than 1 mg/l F at a flow rate of 4 litres per hour before regeneration or discharge of the filter medium is needed. Defluoridation materials have to be renewed after 3-4 months of use.

RESULTS AND DISCUSSION

In the baseline survey the DDE Index (Developmental Defects of Enamel as modified by Carlson and O'Mullane, 1989) was used. The results given in table 1.1 and 1.2 showed that 85 percent of the 117 children surveyed were affected by Enamel Opacities of which most of them were diffuse opacities.[3] It was concluded that Enamel Opacities constitute a significant problem for those children aesthetically.

Table 1.1: Distribution of enamel defects (12 and 18 year-olds combined)
All opacities, demarcated and diffuse opacities in permanent teeth only.

	OPACITY TYPE		
Number and proportion	All Opacities N(%)	Demarcated N(%) N(%)	Diffuse
Children	17 (15)	49 (49) 22 (19)	
Affected Children	100 (85)	68* (58)	95*(81)

* Number do not added up to 100 because two or more ten index teeth may have had different type of opacities

Table 1.2: Distribution of enamel defects (12 and 18 year olds combined).

All opacities n - f	Demarcated n - f	Diffuse n - f
0 - 17	0 - 49	0 - 22
1 - 0	1 - 5	1 - 4
2 - 5	2 - 23	2 - 5
3 - 1	3 - 10	3 - 11
4 - 2	4 - 15	4 - 14
5 - 10	5 - 8	5 - 13
6 - 20	6 - 4	6 - 19
7 - 5	7 - 0	7 - 10
8 - 21	8 - 1	8 - 14
9 - 9	9 - 1	9 - 1
10 - 27	10 - 1	10 - 4
total=117	total=117	total=117

Note: n is the number of affected teeth per child, out of the ten permanent teeth examined and f is the frequency-number of children.

A socio - demographic survey was conducted in June, 1992, and the information related to the population of the village, the number of house - holds, type of houses, children under 10 years of age, sources of water supply for drinking and for bathing, the quality of drinking water, the pattern of drinking of tea and eating fish and the attitudes towards using bone- char for removal of excess fluoride from water were gathered (Table 2). The results show that 59.3 percent of the 64 families in the village had children below 5 years of age. 71 percent of the houses belong to the category of wattle and daub type indicating the low income pattern of the villagers. 83 percent of villagers used well water as main source.

Table 2: Socio-demographic survey.

01.	Average number of household member per house Range 02-12 Minimum=02 Maximum=12	=4.7
02.	Families with children under five years Average number of children under five years per family	= 59.3% = 0.8
03.	Type of house Houses with wattle and daub Houses with brick walls	 =71.2% =28.8%

04.	Source of water	
	People using well water	= 83.1%
	People using any other source of water	= 16.9%
05.	Method of storage	
	Households using clay pots to store water	= 55.9%
	Households using aluminium pots to store water	= 54.2%
	Households using plastic containers to store water	= 0.0%
	Households using both clay and aluminium pots	= 10.1%
06.	Quality of water	
	Water samples with sediments	= 50.9%
07.	Quantity of water	
	Water used by a household per day	= 19 litres
	Average water used by a person per day	= 4.1 litres
	Range = 31 litre - 70 litre per household	
08.	Acceptance of bone-char	
	Households which accepted/agreed to use water filtered through bone-char	= 95 %
	Households which refuse to water filtered through bone-char	= 0.05%
09.	Cooking	
	Households reported using water four drinking and cooking	= 91.5%
	Households using a different source for cooking	= 8.5%
10.	Bathing	
	Households using same source for drinking and bathing	= 10.2%
	Households using different sources for bathing	= 89.9%
11.	Tea cups	
	Average number of tea cups per family	= 15.4%
	Average number of tea cups per person	= 3.3%
12.	Food/Fish	
	Frequency of consumption of fish per week per family	= 2

The table 3 shows the results of water samples analysed at 25 ^{0}C prior to implementation of the ICOH defluoridator programs. All the wells had fluoride rich water ranging from 1.4 mg/l to 5.0 mg/l.

Table 3: Fluoride content of wells.

Well No.	Fluoride (as F), mg/l
01	5.0
02	1.8
03	3.6
04	4.2
05	4.1
06	2.0
07	1.9
08	1.5
09	1.4
10	1.6

Awareness program was carried out at the village school, chaired by the Chief Priest of the Buddhist Temple and defluoridators were distributed to the beneficiaries. Initially water samples were collected from the inlet and the outlet of the filters on monthly basis and the results are given in tables 4 to 8, where A and B refer to fluoride levels after and before defluoridation, respectively.

In some instances the fluoride removal was not sufficient indicating the importance of changing the filter media from time to time. The field health workers assisted by reminding the beneficiaries to change the filter media at appropriate intervals. The defluoridator usage may be interrupted by leaking the tap, broken tap and carelessness of the beneficiary. These drawbacks were eliminated to a certain extent by the help of volunteer group leaders in the community by attending to repairs on the spot. The blockage of the inlet saline tube was quite common. This has to be replaced with a new one after 3 months of use due to the scaling of the tube wells.

Table 4: Water samples analysed using Orion Meter on 03.07.93.

Defluoridator No.	Concentration of Fluoride (mg/l) at 25 ^{0}C	
	B	A
39	3.02	2.54
41	3.17	2.56
45	3.07	0.12
43	3.09	1.15
44	3.05	1.35
46	3.15	0.65
42	3.83	0.75
10	3.78	0.33
11	7.30	6.78

Table 5: Water samples analysed using Orion Meter on 19.10.93.

Defluoridator No.	Concentration of Fluoride (mg/l) at 25 ^{0}C	
	B	A
19	4.10	2.81
07	3.10	1.92
57	0.43	0.04
50	0.45	0.19
53	0.25	0.13
51	0.43	0.32

Table 6: Water samples analysed using Orion Meter on 11.07.94.

Defluoridator No.	Concentration of Fluoride (mg/l) at 25 ^{0}C	
	B	A
54	0.20	0.10
11	0.20	0.10
24	3.20	0.10
26	3.00	0.50

Table 7: Water samples analysed using Orion Meter on 09.02.95.

Defluoridator No.	Concentration of Fluoride (mg/l) at 25 ^{0}C	
	B	A
57	0.44	0.03
22	0.23	0.03
05	0.14	0.03
11	0.25	0.24
49	0.47	0.15
54	3.10	0.86
20	2.10	0.33
23	3.20	0.39
10	2.30	0.78
19	3.20	2.40

Table 8: Water samples analysed using Orison Meter on 09.09.96.

Defluoridator No.	Concentration of Fluoride (mg/l) at 25 ^{0}C	
	B	A
06	1.50	0.38
14	3.50	3.50
22	2.50	1.65
23	2.35	0.65
47	0.53	0.35
50	0.49	0.35
52	4.10	0.69
53	0.53	0.42
54	0.39	0.26
62	0.32	0.28

CONCLUSIONS

1. High acceptability for the defluoridator.
2. There is increased awareness among the people of the area about the cause of mottled enamel.
3. More inquiries for the defluoridators are coming from the people of the area.
4. Beneficiaries say that they can drink soft water and also can cook dhal and rice conveniently.
5. Some adolescents say that their already mottled teeth are getting whiter.
6. Some beneficiaries say, that their abdominal symptoms were reduced.

Acknowledgment

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LOW COST DEFLUORIDATION USING BROKEN PIECES OF BRICKS AS FILTER MEDIA

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Abstract : In recent studies, it was shown that more than fourty percent of wells has fluoride rich water in the north central province. The fluoride content of more than 1 mg/l was considered as fluoride rich water in these wells. In addition, medical reports reveal that skeletal fluorosis patient has been identified in Sri Lanka.

In the present method discussed in this study, upward flow technique has been used to get more retention time in the defluoridator. In addition, easily available, freshly burnt bricks broken into pieces has been used as filter media in these defluridators. There are 300 defluoridators in operation in different villages such as Olukaranda, Mahaelagamuwa, Madatugama, Eppawala, Talawa, Talpotha and Patunagama in North Central Province.

The results clearly shows that this low cost method could be easily carried out in order to get defluoridated water. The beneficiaries themselves were trained to change the filter media in time in order to get best out-put from these defluoridators. The efficiency level of these fluoridators changes from 85 percent removal at the start and tapers down to 25 percent removal at the end of the cycle.

INTRODUCTION

Knowledge of fluoride concentration in drinking water has become essential because of its ugly stained teeth appearing on children especially of the age group 10-20 years. Fluoride concentration of 0.1 to 0.8 mg/l prevents dental caries, where as higher than 1 mg/l leads to malgrowth and certain health problems known a dental and skeletal fluorosis. The earlier work carried out by the researchers in this field has drawn a fluoride map of Sri Lanka which had been used as guidance in selecting fluorosis areas.[1]

MATERIALS AND METHODS

In the present study water samples were collected in plastic bottles from student population in rural schools of Anuradapura and Polonnaruwa districts while carrying out awareness programmes with respect to fluorides. The wells considered for this study were shallow, deep and bore hole wells. These samples were then brought to the laboratory and were analysed for fluoride levels using colorimetric method (Spands reagent) using DR/2000HACH spectrophotometer.

Occasionally these samples were cross checked with fluoride ion analyser available at the Biochemistry laboratory of the Medical Faculty of the University of Peradeniya. The same procedure was followed with respect to the well water and defluoridated water samples from 300 defluoridators distributed in north central province during 1994 to 1996.

RESULTS AND DISCUSSIONS

The table 1 shows the fluoride contents of the wells from North Central Province. The limit of fluoride content of water of 1 mg/l is considered as safe for human beings.

The data shows that in these areas more than 40 percent of these wells has fluoride rich water. In some areas such as Patunagama, Olukaranda more than 65 percent of wells with fluoride rich water.

Table 1 : Fluoride content of wells in mg/l

Date	Name of school	Total number of wells	Percentage		
			>2.0	2.0 - 1.0	<1.0
94-04-27	A/ Olukandara Vidyalaya	24	33.3	45.8	20.9
95-06-28	A/ Maha Elagamuwa Vidyalaya	55	12.7	18.1	69.2
95-07-26	A/ Murungahitikande Vidyalaya	38	15.8	28.9	55.3
95-07-28	A/ Kele Amunukola Vidyalaya	33	6.1	21.2	72.7
94-10-28	P/ Lankapura Vidyalaya	40	37.5	20.0	42.5
95-05-05	P/ Galamuna Vidyalaya	21	23.8	28.8	47.4
95-05-06	P/ Patunagama Vidyalaya	60	43.3	25.0	31.7
95-09-07	P/ Hingurakdamana Vidyalaya	133	11.3	42.1	46.6
96-03-27	p/ Girithalegama Vidyalaya	16	6.2	37.5	56.3
96-05-17	P/ Chandanapokuna Vidyalaya	68	23.2	18.8	58.0

The fabricated defluoridator is shown in figure 1. Subsequently, the defluoridators [2-4] were distributed among villagers by the staff of National Water Supply and Drainage Board. In selecting beneficiary families, special emphasis was placed on selecting children of age group of less than five years in a family. Once the village was selected the defluoridators were distributed irrespective of their family income and level of education, but the assistance was sought from the field health officer of the village concerned. This criteria was helpful because of long duration of monitoring required nearly five years to see the results of this programme. It is to be understood here that all of the 300 house holders selected for this study, that only 30 were using bore hole hand pump wells.

The case study, defluoridator No. 20 at Thibbatuwawa is shown in figure 2. These trials were run at the beneficiaries household using laterite and broken pieces of

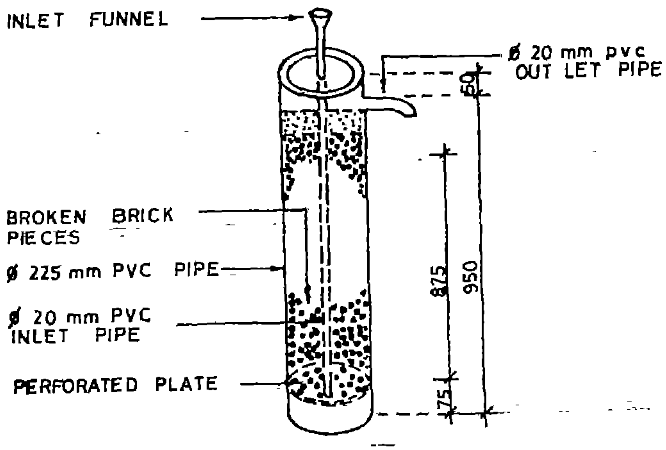

Figure1: Low cost defluoridator.

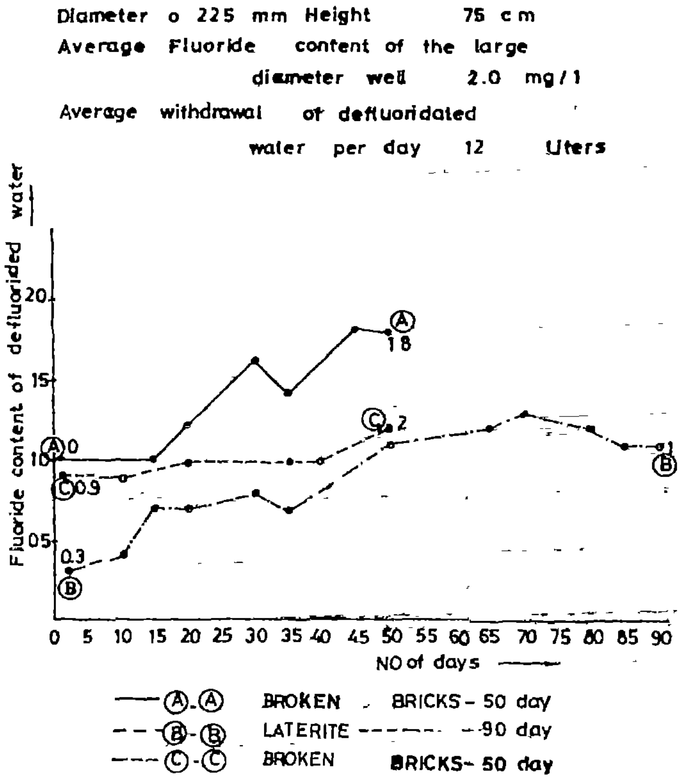

Figure2: Defluoridator no. 20 at Thibbatuwawa.

bricks as filter media.[2] The average fluoride content of the well was 2 mg/l. The life span of the filter medium laterite was longer than that of broken pieces of bricks.

Figure 3 shows the case study defluoridator No. 42 at Thibbatuwawa. The average fluoride content of the well was 5 mg/l. In this instance, larger diameter PVC pipes of 280 mm was used as defluoridator. Average daily withdrawal of the defluoridated water was 8.0 litres because of high fluoride content of the well and the family consisted of parents and one child. In this instance, freshly burnt broken pieces of brick has been used with a special emphasis on sizes of the broken pieces of bricks.

Table 2 shows the case study of defluoridator No. 46 at Mahaelagamuwa. The special significance of this household was that the bread winner, farmer was suffering from skeletal fluorosis, bed ridden, 46 years of age according to the medical reports available with him. The fluoride content of the well was 7.0 mg/l and had been using for last 20 years.

The householder was persuaded to change the source of water and able to find an alternative source close to his house, a well containing an average fluoride content of 1.36 mg/l. The data show that he had been using the defluoridator No. 46 in excellent manner by changing the bricks at the appropriate time intervals.

Table 2 : Performances of the defluridator 46.

Dates of operation	Number of days in operation	Fluoride content of filtered water	
		start	end
94-11-26 95-04-05	135	0.24	0.86
95-04-15 95-05-30	50	0.32	0.59
95-06-01 95-11-15	178	0.74	0.70
95-11-30 95-07-22	230	0.18	0.61

Note: The defluoridator has been used very well and the filter media changed in time.

The table 3 shows several defluoridators run by beneficiaries at Olukaranda. In the column 4 of this table gives the fluoride content of the defluoridated water at the time of changing filter media. The case of defluoridators No. 41 and 14 it was observed that fluoride contents at the time of changing were high. The defluoridator No. 41 well has a minimum fluoride content of 3.02 mg/l and a maximum of 3.68 mg/l with an average fluoride content of 3.25 mg/l during the study period. Similarly defluoridator No. 14 has a minimum fluoride content of 0.76 mg/l and a maximum of 2.46 mg/l. It shows that the filter medium has to be changed at the appropriate time depending on their consumption rate. All the other defluoridators had changed their filer medium on time showing that villagers could manage these defluoridators on their own.

The column 5 of this table gives the fluoride removal efficiency of these deflurodators. The advantage of these defluoridators were that fluoride removal efficiency varies in the range 80 to 30 percent. In other words, it does not completely remove fluoride from the fluoride rich water. It is a known fact that certain amount of fluoride in the range 0.5 to 0.8 mg/l is required for human body. It was interesting to note that the defluoridator No. 09 has run for 326 days, the recent being this particular well has a minimum fluoride content of 0.20 mg/l and a maximum of 1.42 mg/l during the study period. The changing of filter medium in these areas can be generalized as shown in table 4.

This research study started in 1994 to be continued at least till 2000. The performance and acceptability of some of the defluoridators to the village community for the last 2 1/2 years is summarised in table 5. Sixty defluoridators out of a total of 300 were closely monitored even collecting water samples weekly. The defluoridators at Olukaranda were monitored very closely in a manner where the beneficiaries maintained a record book of water samples collected from each household on a weekly basis. However at present only monthly samples are taken from these defluoridators since these have been in operation for more than 2 years. The level of efficiency of these defluoridators in Olukaranda are very high and 19 of them are in working order out of a total of 20. The defluoridators in Polonnaruwa are monitored once in three months and their performance have been quite satisfactory showing an acceptability rate of about 90 percent.

The main disadvantage of this defluoridator is the difficulty in obtaining the outer shell PVC pipe of 225 mm diameter in the village market. The PVC pipes have to be obtained from the manufacturer and is only available in 6 m length and cost for this is around 4000 rupees which is an enormous amount for these poor recipients. However 6 defluoridators could be fabricated from this single pipe length and the services of a skilled fitter is required. Thus the recommendation is to made this defluoridator out of cement and bricks as shown in figure 4 thereby minimise the cost drastically. The minimum cost had been worked out to be about 1000 rupees for a 100 litre capacity tank.

Table 3 : Fluoride Removal Percentages of the defluridators.

I	II	III	IV	V
06	94.09.08-95.10.05	250	0.83	65.5 - 21.7
09	94.11.07 - 95.10.05	326	1.26	29.1 - 11.3
11	95.03.20 - 95.08.30	160	1.23	76.2 - 35.3
12	94.09.10 - 94.04.15	220	0.87	49.3 - 33.0
13	94.11.17 - 95.03.20	124	0.77	82.7 - 40.3
26	95.05.10 - 96.12.30	235	1.43	77.6 - 31.3
41	95.01.02 - 95.03.28	87	2.30	76.7 - 29.2
10 (A)	94.09.26 - 95.02.20	155	0.65	72.6 - 22.6
14 (A)	95.05.21 - 96.02.07	270	2.47	74.4 - 39.5
29 (A)	95.04.21 - 95.08.25	120	1.40	53.9 - 37.2

I Defluridator number
II Period
III Operation days
IV Fluoride content at the outlet at the end of the cycle
V Percentage of the fluoride removal

The changing of filter medium in these areas can be generalised as shown in table 4.

Table 4 : Life Span of Filter Medium in Months.

Fluoride content of the well in mg/l	Broken pieces of freshly burnt bricks	Laterite
1 - 2	3 - 4	5 - 6
2 - 3	3	4
3 - 4	2.5	3
4 - 5	1	2

Table 5 : Comparison of Performance of the Defluoridators.

Village	I	II	III	IV	Remarks, Monitoring aspects
A/ Olukaranda	20	19	01	00	Beneficiaries were asked to collect water samples every week at the beginning
P/ Talpotha	10	04	04	02	Visited once in 03 months
P/ Patunagama	31	22	07	02	Visited once in 03 months

I Number of defluoridators
II Changed filter media on time and usage good
III Changed filter media at irregular intervals and unsatisfactory
IV Abandoned

CONCLUSIONS

1. The cement-brick tanks are more appropriate for defluoridators at village levels than PVC pipes.

2. The village community is able to prepare and change the filter medium since the bricks are freely available in village, thus achieving village level operation and maintenance (VLOM status).

3. This defluoridator has the capacity to reduce fluoride rich water of 5 mg/l to 1 mg/l. thus conforming to WHO/SL standards of drinking water for fluorides.

4. Awareness programmes and follow-up services are required to achieve sustainability.

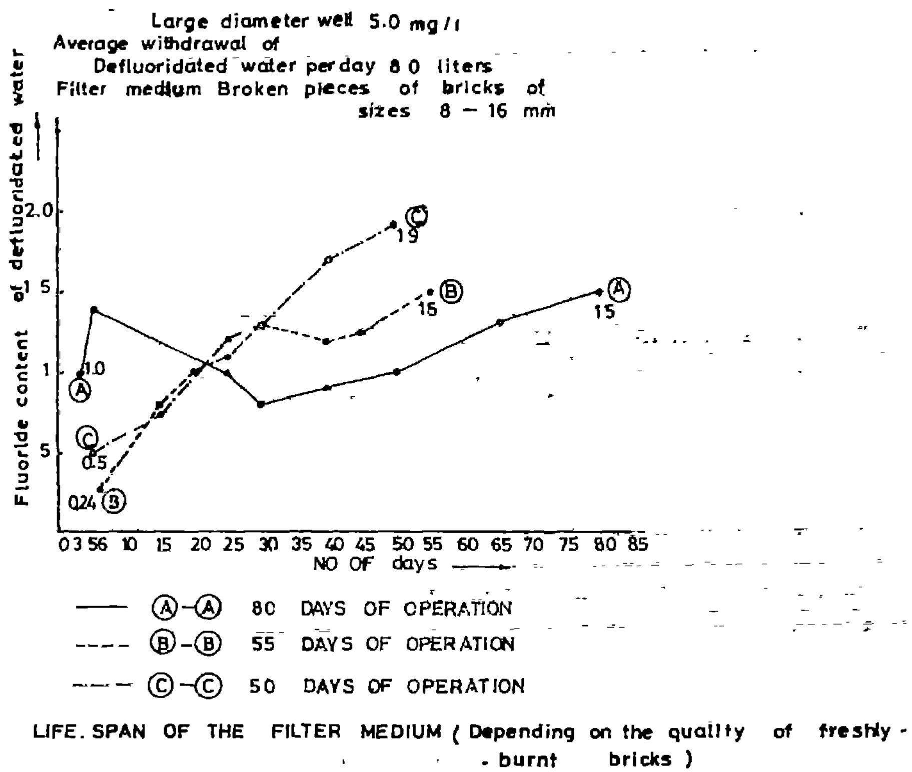

Figure3: Defluoridator no. 42 at Thibbatuwawa.

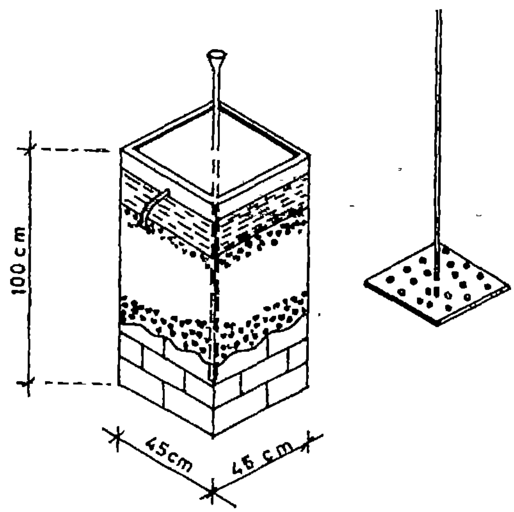

Figure4: Defluoridator made out of bricks and cement.

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COMMUNITY ATTITUDE REGARDING FLUOROSIS AND LOW COST DEFLUORIDATORS

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Abstract : High content of fluoride in drinking water sources especially in the dry zone of Sri Lanka has been identified as a cause for dental and skeletal fluorosis. Based on the field experience, it has been revealed that a significant percentage of people live in the dry zone have been subjected to such health problems, and the number of cases has considerably increased during the past. Unsightly, ugly stained teeth is a severe outcome of the dental fluorosis and it could be identified as serious social problem especially for the younger generation in the dry zone of Sri Lanka. In order to arrest this situation , a low-cost domestic defluoridator has been introduced on pilot scale and this study has been undertaken to observe the views of the community about the usage and attitude regarding these defluoridators.

The criteria adopted in collecting field data for this study was conducting interviews with household beneficiaries, community based organizations, primary school teachers and family health workers for the qualitative assessment. Also the method adopted was by collecting data from beneficiaries with questionnaires using random sampling basis for the quantitative assessment.

In conclusion, it can be stated that majority of the people feel that ugly stained teeth is a acute social problem. The usage of defluoridators has been well adopted by the rural community than by the semi-urban community. It is desirable to provide these defluoridators to low-income families , because they are already burdened with other socio-economic problems. The changing of filter media by the beneficiaries has been accepted by the greater part of the community.

INTRODUCTION

High content of fluoride in drinking water has been identified as a cause for dental and skeletal fluorosis especially in the dry zone of Sri Lanka. Field observations have revealed that a significant percentage of people living in dry zone are subjected to such health problems and the rate of increase of victims has considerably increased. Unsightly teeth is the severe outcome of the dental fluorosis and it could be identified as a serious social problem especially among younger generation.

A domestic defluoridator has been introduced by National Water Supply & Drainage Board as an appropriate low cost solution for the said problem. 400 of these defluoridators have been distributed during 1994 - 1996 among rural community in the North Central Province on pilot basis to introduce the defluoridators to the community. A study was undertaken to evaluate the success of the pilot programme by observing the views and attitudes of the beneficiaries on the usage of the defluoridators.

The objective of this study was to evaluate the effectiveness of the defluoridator on fluorosis prevailing in the North Central Province. The following components were used in this evaluation.

1. Fluorosis

Does the community realize that the fluorosis is an acute health problem.

2. Usage and maintenance of the defluoridators.

The level of usage and maintenance of the defluoridators by beneficiaries and the correlation of the social features such as level of education, family income, affordability for the maintenance of the defluoridators.

3. Awareness

Usefulness and effectiveness of the current awareness programmes and strategies.

RESULTS AND DISCUSSION

Geographical features of the study area

North Central province is a part of dry zone in Sri Lanka which covers 10473 Sq.km of land area which is 14 per cent of the entire land area in Sri Lanka . The population density of the province is very low compared to other provinces of the country.

Annual average rainfall is 1200 mm and average temperature is 27.3 ^{0}c in Anuradhapura district. A high percentage of wells having fluoride rich water have been identified along a track from Habarana extending in North-Western direction passing South of Anuradhapura city towards the Western part of the district and also in the Eastern, Central part of the district (Figure 1).

About 400 numbers of domestic defluoridators were distributed up to date within the Anuradhapura and Polonnaruwa district and out of which 118 numbers have been taken in to consideration only from Anuradapura district for this study. Details of such distribution is given in Table 1.

Socio economic situation

Average income of the most families in Anuradhapura district is less than Rs. 700 per month. They are living on subsidies given by government. Main occupations of these families are farming and chena cultivation.

The estimated population of this district is 0.75 million (1994). 92 per cent of population live in rural areas. 67 per cent of the population facilitated pure drinking water from tube wells, water supply schemes and protected dug wells. 60 per cent of the population have satisfactory sanitation facilities.

Villages selected for this study are situated close to rural towns such as Kekirawa, Thalawa, Eppawala and also close to major road net work. Main drinking water source of these families are shallow and deep dug wells and hand pump wells.

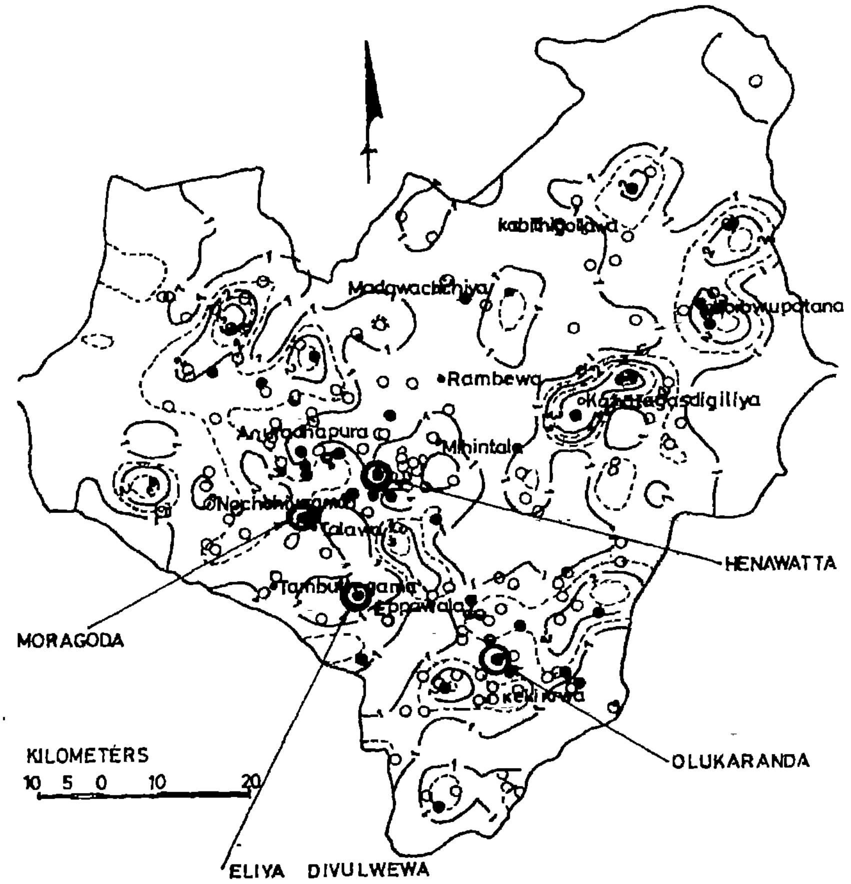

Figure1:Geographical distribution of fluoride concentration in Anuradhapura district and study area.

Table 1 : Distribution of defluoridators.

Village	Nearest Town	Implementation period	Number of defluoridators	Study sample
Olukarada	Kekirawa	April 94	32	08
Henewatte	Anuradhapura	June 94	10	08
Moragoda	Thalawa	Dec 95	20	08
Eliyadivulwewa	Eppawela	June 96	56	08
TOTAL	-	-	118	32

The sample population of the study area (32 families) could be divided according to age groups and sex as given in table 2.

Table 2 : Age and sex classification.

Age in Years	Percentage of Population	Percentage of Sex	
		Male	Female
0 - 5	19	9	10
6 - 12	18	8	10
13 - 17	9	4	5
18 - 35	34	17	17
> 35	20	10	10
Total	100	48	52

The age group below 5 years could be considered as the target group for this study because of their vulnerability on dental fluorosis. Hence it is important to concentrate on the 19 per cent to see the success of this defluoridator programme.

Study criteria

1. The following methods have been adopted to collect necessary field data for this study.

2. Data collected from beneficiaries through questionnaires adopting random sampling mechanism. For this, quantitative assessment, about 30 per cent of stratified random samples were taken out of 400 defluoridators. Apart from that 10 numbers of beneficiaries were interviewed for the qualitative assessment.

3. Interviews were conducted with random samples of following categories for the purpose of qualitative assessment.
   - beneficiary groups
   - office bearers of village level community based organizations (CBO)
   - Pre / Primary school teachers

Study constrains

This study was carried out within a short period to evaluate the beneficiary response and attitudes in connection with the usage and the maintenance of domestic defluoridators. In general social behavior on a particular aspect might have seasonal and time dependent variation. Hence limitations of time for the study was a constraint and it is proposed to continue similar exercises with a considerable time interval.

Although the domestic defluoridators were distributed in Anuradhapura and Polonnaruwa districts which cover only part of the dry zone as a representative sample under the pilot programme. The study mentioned herein is only limited to the evaluation of pilot programme within the Anuradhapura district. As a result, the analytical data might have some deviations with respect to the application in the entire dry zone.

In social studies comparisons are being made with a control group to obtain better understanding of the ground situation. However under this study control groups have not been selected due to the limitations of resources within the National Water Supply and Drainage Board (NWS&DB).

Attitude of the community on fluorosis

It is the duty of a social researcher to make an attempt to investigate the reality of the community feelings on fluorosis. In other words it is important to see whether the rural community has realized by themselves the acuteness of the health hazard due to fluorosis. Hence some direct and indirect questions were asked from sample groups to evaluate the situation. Table 3 shows the beneficiaries preview of the fluorosis problem.

Table 3: Direct Questioning Tabulation.

Fluorosis is an acute health problem	Response percentage
YES	44
NO	31
No Idea	25

Table 4 gives the beneficiaries attitude towards the other health problems in the study area.

Table 4 : Indirect Questioning Tabulation.

Order of priority on health problem	Beneficiaries response percentage
Priority on other health problems such as Malaria, Diarrhoea, Viral fever etc.	77
Priority on fluorosis.	4
Not clear on priority.	19

According to the classification of the above sample survey, it is clear that the beneficiary groups do not have a clear mind on the acuteness of fluorosis. Even though the direct questioning have satisfactory results, the real feelings are indicated from the low priority given at indirect questioning. Hence it could be stated that user preview on fluorosis is to have a minor affect to their day to day operations and by which they consider this as a low priority health effect.

Usage of low cost domestic defluoridator

Though the defluoridators have been distributed among the selected (or prioritized) community groups, it is important to see whether the defluoridated water is used for drinking and cooking in order to achieve the desired objective of having clean teeth for the next generation. On the other hand proper changing of the filter medium at the recommended time period is also important. These two features are correlated with the other social factors to analysis the position. Table 5 gives the result of the field test.

Table 5 : Usage of defluoridators.

Usage of Defluoridated Water	Percentage
Drinking and Cooking	66.0
Drinking only	19.0
Not used	15.0

Usage related to level of ncome

The level of income has some relationship with the usage pattern, that is, where the income is high , usage of defluoridated water for the correct purpose is also high. In this group none of them has discarded the defluoridators as shown in Table 6 Column 4. In the low income group drawing less than Rs. 2000 per month 23 per cent of defluoridators were not in use.

This shows that the families who have comparatively low income might have other priorities on their hard life than giving weightage on filter maintenance.

Table 6 : Usage pattern.

Monthly income in rupees	Group percentage	Usage pattern as percentage		
		Drinking & Cooking	Drinking only	Not used
<2000	41.0	62.0	15.0	23.0
2001 - 3000	12.0	100.0	-	-
3001 - 4000	20.0	57.0	15.0	28.0
4001 - 5000	9.0	100.0	-	-
>5000	18.0	40.0	60.0	-
	100.0	66.0	19.0	15.0

The usage the defluoridators has been well adopted by the temporary house type beneficiaries than the other groups. This infer that the technique of defluoridation has been well communicated to the people concerned. The type of houses was correlated with the usage pattern as shown in Table 7.

Table 7 : Type of houses using defluoridators.

House type	Group percentage	Purpose of defluoridated water usage in percentages		
		Cooking & Drinking	Drinking only	Not used
Temporary	53.0	76.0	18.0	6.0
Semi-permanent	3.0	100.0	-	-
Permanent	44.0	50.0	21.0	24.0
	100.0	66.0	19.0	15.0

It is important to evaluate whether the usage pattern has any correlation with the level of education .The usage of defluoridated water for correct purpose with the level of understanding and awareness is tabulated in Table 8.

Table 8: Education level and usage pattern.

Level of education	Group percentage	Usage of defluoridated water		
		Cooking & Drinking	Drinking only	Not used
Higher education above grade 11	31.0	80.0	20.0	-
Secondary education grade 6-10	59.0	68.0	16.0	16.0
Primary education grade 0-6	10.0	-	33.0	67.0
	100.0	66.0	19.0	15.0

A comparatively higher percentage of user groups who have used the defluoridated water for the correct purpose are in the categories of secondary and higher education levels. Users who have only primary education are mostly not obtained the proper benefit from the defluoridators. Hence it is clear that there is a need for more awareness programmes to educate community for the usage of defluoridated water correctly. Further more , the regular maintenance of the said defluoridators are also connected with the proper awareness of the end users.

Awareness & implementation strategies

Different implementation strategies have been adopted under the pilot programme to introduce the defluoridators. Along with that, different options were taken in to consideration to launch the awareness programmes for beneficiary groups. The basic implementation models are listed below.

1. NWS&DB as a key player
2. NWS&DB as a facilitator and introduced through community based organisation (CBO)

Implementation steps have some differences based on the level of authority. Such differences could be identified from the following chart in Table 9.

Mode of awareness

Study of the user perception on awareness adopted in the process is also important in the context of developing a suitable communication systems to convey the message to the community.

In the beneficiary point of view the methodology they received regarding the defluoridation would be categorised as in Table 10.

The highest percentage being 59 per cent indicates that the most effective awareness strategy for the implementation of this programme is through village school awareness programmes.

Table 9: Implementation steps

Through CBO (responsibility)	Implementation steps	Direct NWSDB (responsibility)
CBO leader	First hand information	By individual
CBO	Request NWSDB	By individual
CBO, NWSDB Health personnel	Conduct village awareness meeting	NWSDB Health personnel
NWSDB	Analyse water samples	NWSDB
NWSDB, CBO	Select / Identify beneficiaries	NWSDB
NWSDB,CBO	Distributed filters	NWSDB

Table 10 : Mode of communication.

Beneficiary preview	Percentage
Through neighbours	30.0
School awareness programmes	59.0
Other source	11.0

The highest percentage being 59 percent indicates that the most effective awareness strategy for the implementation of this programme is through village school awareness programmes.

CONCLUSION

The following conclusions are made in this study for the continuation of this work.

1. Representative sample to be obtained to cover the entire dry zone.
2. Seasonal and time dependent social factors to be studied in depth with comparatively long duration of field observations.
3. Analytical results to be compared with the similar factors of a control group for its validity.
4. Awareness programmes through village schools could be more beneficial.
5. Joint implementation through village level community based organisation for the implementation is more advantageous.
6. Application of proper selection criteria for selecting beneficiaries to include the children below 7 years.
7. Some level of subsidy is essential for the low income groups in order to encourage the usage of defluoridators.
8. Close follow up action and monitoring of defluoridators are essential in working with primary educated , low income groups.

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SYMPOSIUM ON PREVENTION OF FLUOROSIS IN SRI LANKA DISCUSSION AND RECOMMENDATIONS

It was decided to introduce individual house-hold defluoridators in the affected areas of Sri Lanka. Large scale community-operated plants are less practical because there would be difficulties to arrange the cleaning responsibility. Further, community plants are more expensive than individual ones as reported by some foreign countries. The cost of an individual defluoridator is thousand rupees.

The awareness of the fluorosis problem in Sri Lanka can be enhanced thorough proper publicity. The activities such as educational programmes, workshops, seminars, distribution of pamphlets etc. should be organised by the National Water Supply & Drainage Board, Sri Lanka Association for the Advancement of Science, Institute of Dental Services and related institutes especially in the affected areas. The enrollment of other interested parties such as Non Government Organisations and private sector has to be encouraged.

Additionally, the political authorities such as Cabinet Ministers and Provincial Council Ministers should be contacted and made aware to accept defluoridation of drinking water as a policy matter. The Ministry of Health should take the initiative to take that policy decision, and the implementation of the policy by the Government would be the next step. At implementation, economical factors should be considered, and one suggestion is to subsidise defluoridators depending on the income of the family.

Pilot programmes should also be continued while the above stated process is being carried out. The outcome of such programme will be known after about five years. The National Water Supply and Drainage Board needs support from the Department of Health, Non Government Organisations, Department of Education, Community Leaders, etc. on this matter, to eradicate fluorosis from Sri Lanka.

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