Fluoride pollution of ground water [Discussion paper]

22nd WEDC Conference: *Discussion paper* New Delhi, India, 1996

REACHING THE UNREACHED: CHALLENGES FOR THE 21ST CENTURY

Fluoride pollution of ground water

K. Krrishnamohan and N. Muthukrishnan, India

AN OCCASIONAL DRONE of an aircraft flying high overhead is heard over Tummedalapadu. A sleepy hamlet comprising 70 families, Tummedalapadu is situated about 100 kms from Ongole and 12 kms from Donakonda Darsi Mandal, in Prakasam district of Andhra Pradesh. One of its inhabitants, R. Reddy — a male aged 50, cannot see the aircraft : not because he is blind but because he is bedridden and his legs are tied to the cot to prevent them from being pulled backwards due to muscular contraction. He suffers from joint pains as well, and cannot bend his neck and fingers either due to stiffness. R. Reddy has been bedridden for the last 10 years.

There are several others with varying degrees of affliction ranging from body pain, loss of sensation or numbness to brownish yellow staining of teeth. As these symptoms were similar to that of "Skeletal and Dental Fluorosis", it was decided to undertake an extensive survey of ground water in the three Mandals viz., Donakonda, Kurichedu and Darsi.

Fluorine

Fluorine is the most electronegative element in the periodic table, and was being used as early as the 18th century. Fluorine is found in the soil and the content of fluorine in the lithosphere varies between 100 and 1500 g / ton. Fluorine is found in greater abundance than chlorine, copper or lead. (Nikolaev et. al., 1972).

The majority of fluorine found in nature is present in various rocks, soils, waters, plants, other living organisms, slags and fluxes. Volcanic gases which get accumulated on the earth along with the atmospheric precipitation invariably contain hydrogen fluoride. The atmosphere contains very small amounts of fluorine.

However the content of fluorine is high in industrial areas, especially near aluminium plants and near factories manufacturing super phosphate fertilizers. The magmatic gases contain 95 per cent steam and may contain very small quantities of fluorine.

Properties of fluorine

Fluorine is a halogen and is the first element among the halogen family, the others being chlorine, bromine, iodine and astatine. By virtue of its position fluorine in the free state is more reactive than the other elements. It displaces other halogens from their compounds and also displaces oxygen from most oxides, salts and acids. Thus fluorine acts as an electron acceptor resulting in the formation of fluorides. As fluorine is very reactive it is found in both living and non living matter. (Nikolaev et. al., 1972).

Biological effects of fluoride

Fluoride is essential in small quantities for the prevention of dental caries especially in children. Therefore, it is a common practice to add very low concentrations of flouride to tooth pastes and drinking water (less than 1ppm) at places where there is a natural deficiency of flourides.

Skeletal and dental fluorosis

Skeletal fluorosis, which has a crippling effect on the individual, occurs due to the deposition of fluoride in the bones.The most sensitive effect, "tooth paste mottling", occurs at very low concentrations of 0.8 ppm to 1.6 ppm. Skeletal fluorosis occurs if 2 to 80 ppm of fluoride is ingested daily for a period of more than 10 years. (Casarett & Doull, 1986).

Storage in bones

Fluoride gets deposited in the bones, and so do lead (Pb) and strontium (St). The deposition on the bones is due to the surface chemistry of the bones where an exchange takes place between the surface of the bone and the fluid which is in contact with the bone. The "Hydroxyaptite" crystals in the bone are mainly involved in this exchange. The fluoride (F-) ions have a similar charge when compared to the hydroxyl ions (OH-) and therefore replace the OH- of the hydroxyaptite crystals and thus get deposited in the bone. (Casarett & Doull, 1986).

Survey

A survey of the ground water in 3 Mandals of Prakasam District in Andhra Pradesh was undertaken on 13th July, 1995 and 14th July, 1995. The three Mandals covered during the survey are:

- Darsi
- Donakonda
- Kurichedu

The survey was undertaken as result of a village meeting organised by a local Non-Governmental Organisation (NGO). At the meeting (which one of the authors attended), the villagers complained of symptoms typical of skeletal and dental fluorosis.

A total of 16 villages were surveyed in the three Mandals and 63 samples were collected from open wells, borewells

and from overhead and ground level reservoirs which were being used by the villagers. Along with the sample collection,the villagers from whose villages water samples were being collected were interviewed simultaneously about the effects of consuming the ground water. The signs and symptoms as described by the villagers have been summarised in a table which is available with the authors. Body pain and pain in the knees appeared to be common symptoms.

The 12 parameters that were analysed including fluoride in the water samples were : Colour, Odour, Turbidity, pH, Conductivity, Total hardness, Total Dissolved Solids (TDS), Chloride, Calcium, Magnesium, and Sulphate.

Methodology

The parameters mentioned above were analysed as per the procedure mentioned in the "Standard Methods for the Examination of Water and Waste water", American Public Health Association (17th Edition). The Fluoride content in the ground water samples was determined by the "SPADNS" colorimetric method, as prescribed by the APHS Standards.

Discussion

Chemical parameters

- 92 per cent of the ground water samples had fluoride concentrations above the desirable limit of 1 ppm.
- The abstract of the analysis for different samples showing the concentrations of fluoride is given below:-
- The concentration of fluoride in the borewells varied from a minimum of 1.30 ppm to a maximum of 7.80 ppm.
- The concentration of fluoride in the wells varied from a minimum of 0.70 ppm to a maximum of 7.20 ppm. However, it could be inferred that the maximum flouride is found in the samples collected from borewells than from wells. A graph which gives a comparision between the concentration of flouride in the water taken from borewells and wells is available with the authors.
- 7.9 per cent (5 samples) of the samples showed flouride below 1 ppm.
- 11.1 per cent (7 samples) of the samples showed flouride between 1-2 ppm.
- 81 per cent (51 samples) of the samples showed flouride above 2 ppm.

The pH of the water samples from the borewells and wells varied between 7.15 and 8.17 which is more or less neutral and within the drinking water specification of 6.5 to 8.5 (IS 10500 : 1991).

It was also found that the concentration of magnesium is higher than that of calcium in most of the water samples irrespective of whether they were collected from wells or borewells. Further, it was found that the concentration of Mg is high in samples containing higher concentration of fluoride. This may be due to the higher solubility of magnesium fluoride (87 mg/litre at 18 deg C) than calcium flouride (15mg/litre at 18 deg. C) in water. (Merckindex, 1989).

Signs and symptoms

Most of the people who exhibited symptoms of fluorosis had been residing in the village from their childhood. Similarly, children who exhibited dental fluorosis were born in the village.

Of the 16 villages surveyed, people complained of body pain, back pain in 81 per cent (13) of the villages surveyed. People complained of knee pain in 31 per cent (5) of the villages surveyed and in 50 per cent (8) of the villages surveyed. Numbness, itching, laziness, premature ageing, cold and cough were the other not so common complaints during the survey.

When correlated with the analysis reports, the health complaints from the survey indicated that the most common complaints viz., body pain, knee pain and back pain were prevalent among people who consumed water containing fluoride at concentrations of 1.10 ppm which is slightly higher than the desirable limit of 1 ppm (IS 10500 : 1991). This may be due to the chronic toxicity effect of fluoride.

Conclusion

The signs and symptoms exhibited by the villagers indicates clearly that they are suffering from skeletal / dental fluorosis.

Since there are no industries in the vicinity of these villages, the flouride in the water is probably from the earth's crust.