Defluoridation Of Drinking Water
Merits Of Alternative Technologies
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Defluoridation of drinking water in fluorosis-endemic areas is part of the National Programme for provision of safe drinking water. Fifteen out of 30 states and Union Territories of the Indian Republic are considered endemic for fluorosis and the defluoridation programme attempts to correct this situation.

The crippling malady of fluorosis not only affects the bones and teeth, but every tissue and organ of the body, leading to death after prolonged illness. It is a problem of public health importance. Although the disease had been known to exist in India as early as the 1930s it was not identified as a national health problem till India became independent. Perhaps the magnitude of the problem and the possible methods of preventing it were not appreciated till recently (1986) when the Government of India launched a “Technology Mission on Safe Drinking Water”. One of the thrust areas of this Mission is to control and prevent fluorosis. Provision of safe drinking water, and creating awareness among people of the dangers of excess fluoride in drinking water have now assumed an important place in this programme.

Population overgrowth necessitating augmentation of the water supply, indiscriminate digging of tube wells for exploiting ground water sources, total unawareness of the importance of water quality analysis prior to human consumption, and continued ingestion of fluoride in excess through drinking water have all contributed to the spread of the disease in recent years.

The central problem is the identification of a feasible technique for the removal of fluoride from drinking water. The technique must be suited to the rural setting and must ensure sustained availability of safe drinking water. It is in this context that a proper examination of the merits of alternative technologies available for defluoridation of water becomes necessary.

In this report the merits of alternative technologies available for removal of fluoride from drinking water sources are considered.

1. NALGONDA TECHNOLOGY USING LIME AND ALUM
Since the early 1960s the National Environmental Engineering Research Institute (NEERI), Nagpur, has been involved in research and development activities on defluoridation of water. One of the technologies which has been successfully translated from the laboratory to the field is the Nalgonda Technology. The first Community Defluoridation Plant for Removal of Fluoride from Drinking Water was erected in the district of Nalgonda in Andhra Pradesh at Kathri town, and, so the name of the technology.

In this technology, raw water is mixed with adequate lime and alum. The dose of lime depends upon the alkalinity of the raw water. If the raw water has adequate alkalinity, the addition of lime is not required. Alum solution is added after the addition of lime, stirred gently for 10 minutes and the flocs formed are allowed to settle. This process of floc formation and settling normally requires an hour. In rural areas where the people practise domestic defluoridation, the advice given is to mix the water with lime and alum and leave it overnight, so that the next morning the clean supernatant is decanted for use and is safe for consumption.

In the Nalgonda technique, besides fluoride, turbidity, colour, odour, pesticides and organic substances, if any, are also removed. Bacterial contamination is also reduced significantly.

The addition of lime or sodium carbonate ensures adequate alkalinity for effective hydrolysis of aluminium sulphate to aluminium hydroxide (that is, floc formation) and as a result, aluminium does not remain in the treated water.

Merits: It can be used both at domestic and community levels.
- Operations are possible manually.
- The chemicals are the same as those used in municipal/urban water supply schemes.
- It is cost effective.
- A variety of designs and models have already been developed by NEERI for use in different locations.
- There is considerable flexibility in design considerations, therefore location specific alterations are possible.
- Defluoridated water meets with the standards laid down by the Bureau of Indian Standards, that is, the fluoride content in water shall be lower than 1 ppm.

Drawbacks: The technology is excellent, provided the daily operations are entrusted to a trained, conscientious operator. It is important that the doses of alum and lime are determined after assessing the fluoride content and alkalinity of the raw water. It is mandatory that this dose is reassessed during extreme summer and in the rainy season, when fluoride concentration and alkalinity of the water are likely to alter. The operator should also be familiar with the speed of mixing, stirring the alum water, that it should be gentle so that the chemicals are adequately mixed, allowed to stand for one hour for the floc formation and settling. Experience shows that if the alum mixing is carried out at a greater velocity there are less chances of floc formation and a greater quantity of alum will be required for removal of fluoride which may result in residual aluminium in water.

The major cause for concern with the lime and alum technology is that if the dose of alum is not adhered to there is a possibility of excess aluminium contaminating the water. The maximum contamination of aluminium permitted is 0.03 mg - 0.2 mg/litre of water according to BIS, as an excess is suspected to cause Alzheimer’s disease.

Aluminium compounds are used for treatment of drinking water supply all over the world. Because of the concern shown about aluminium causing health hazards, alternative coagulants and coagulant aids are now being recommended.

Aluminium compounds were first used in the form of simple salts, that is
aluminium sulphate or aluminium chloride, later, during the 1970s, prehydrolysed salts known as basic aluminium polychlorosulphates (PACS) or basic aluminium polychlorides (PAC) were introduced. These second generation products have flocculant properties and could be used without flocculation additives. They also have an advantage over simple aluminium salts that they are active in a wide pH range, but chances of residual aluminium in drinking water, depending upon raw water quality, exist. For drinking water, the use of aluminium salt coagulants at the clarification stage sometimes necessitates a prior stage of pH adjustment (normally acidification) in order to meet the WHO standard for aluminium, that is, 200 µg/litre of water.

A third generation of aluminium salts has now appeared. These have high basicity or more exactly a high OH-/aluminium ratio, more than 2, which limits the aluminium residue while maintaining excellent flocculation properties. The high basicity aluminium polychlorosulphates (HB PACS) are also extremely stable with time.

While third generation chemicals are being used in water treatment plants in the West for reducing residual aluminium, in India first generation chemicals are still being used for water treatment and for removal of fluoride in the Nalgonda Technology.

2. DEFLUORIDATION OF WATER USING BONE CHAR

Deformation of drinking water using primarily bone char was developed by the Intercountry Centre for Oral Health (ICOH) Chiangmai, Dental Faculty of Chulalongkorn University, Bangkok and WHO. ICOH defluoridation is based on the filtration and adsorption principle and uses charcoal and charred bone meal. The defluoridation column (75 cm long and 9 cm in diameter) has a tap at the bottom and a cap with a small hole for intake of water at the top. The column is packed with 300 gm of crushed charcoal (the bottom layer) for absorbing colour and odour. A middle layer of 1,000 gm of charred bone meal and a top layer of approximately 200 gm of clean pebbles are added to prevent the bone meal from floating. The bone meal is of 40-60 mesh size, obtained or produced by burning bone to an approximate temperature of 600°C for 20 minutes.

Fluoride contaminated raw water is siphoned to the top of the defluoridator at a flow rate of 4 litres/hour. The defluoridated water is collected into a jar from the lower end of the column with the help of a tap. The filter, according to those who developed the system, remains active for one to three months, depending on the fluoride levels and the amount of water consumed.

In this procedure 15-20 litres of water is initially passed through the column (defluoridator), and discarded, after which the water is odourless, clean and ready for human consumption. The question that emerges in the Indian context is: can we regularly discard 15-20 litres of water every time for running through the column to eliminate the foul odour of the water due to the charred bone fat?

The ICOH defluoridation is being implemented in certain villages of Nalgonda district of Andhra Pradesh, under a project sponsored by the WHO. There was initial reluctance to use the water treated with burned bone. A major issue which is likely to emerge is on the acceptance of water by vegetarians.

As the procedure for elimination of fluoride using bone char is simple, inexpensive, and the operation and maintenance do not pose problems, perhaps certain sections of the population who are non-vegetarians may accept the water without hesitation. If so, the technology could be promoted in select areas, but it seems doubtful that this technology will be generally accepted.

3. PRASANTI TECHNOLOGY USING ACTIVATED ALUMINA

The Prasanti technology for fluoride removal using activated alumina presently being used for water defluoridation in Indian villages, originated as a result of research and development activities carried out at the Biotechnology Department at Satya Sai University for Higher Learning at Prasanti Nilayam at Anantpur District in Andhra Pradesh.

Research and development activities in the use and effectiveness of activated alumina for defluoridation have also been carried out in different institutions in recent years.

Alumina (that is, aluminium oxide, Al₂O₃) is practically insoluble in water. The solubility in acid and alkali depends upon previous heat treatment; it is scarcely attacked by strong reagents. Alumina needs to be activated for the defluoridation process. There are different grades of activated alumina indigenously available at a very nominal cost. The suitability of the grade for defluoridation depends upon the porosity and surface area of the alumina. There are other parameters which are also of importance, that is, the life of the activated alumina for defluoridation purposes. A simple procedure for regeneration is bound to emerge in course of time as the Mission would still support R & D activities in the field for perfecting the technology. There is ample scope for R & D in design and fabrication to achieve cost effectiveness.

Using the activated alumina technology, both community defluoridation plants and domestic defluoridation filters have been popularised by a commercial firm in the country.

The activated alumina plants can be attached either to handpumps or standposts in the village depending upon the source of drinking water.

Twenty-five community defluoridation plants, each serving approximately 200-400 people in a location, have been functioning satisfactorily since last year. Each plant costs approximately Rs 35,000. The regeneration and servicing of the plant is being carried out by the firm itself at an interval of one month (depending upon the water drained through the plant), at a cost of Rs 350 per servicing and regeneration of the alumina which is also being met presently through Government funds.

Besides the community defluoridation plants, approximately 500 domestic defluoridation filters are being used by people living in endemic areas for fluorosis. Each stainless steel domestic filter costs Rs 1,300-1,700 depending upon the number of containers in the filter system, that is, one, two or three and the volume of the container, that is, 6, 10, 18, or 27 litre capacity. In the filter system, the unit which is sealed with activated alumina is exchangeable for a new one for regeneration purposes for a very nominal charge, when a specific volume of water is defluoridated by the user.
One gratifying finding is that the defluoridated water quality is being monitored by the firm at frequent intervals and the records available reveal that the quality of the output water is adhering to BIS standards. It is also noteworthy that those who are using the defluoridated water specially from the activated alumina plants, show evidence of improvement of their condition even within a short period of a few weeks. As a result this technology is now gaining acceptance.

While on the one hand, agencies concerned with the provision of safe water are thus struggling to minimise fluoride intake in endemic areas, there are others who, in blind imitation of practices in vogue in countries not beset with the fluorosis problem, wish to promote unrestricted use of fluoridated toothpastes and mouth-rinses even in endemic states. Toothpastes are now increasingly being used by poor populations even in rural areas. Fluoridated toothpastes in fluoride endemic areas just do not make sense, indeed they could be a disservice. It is to be hoped that sensible decisions in this regard will not be delayed.

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References

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- Ford Foundation (India) $1,40,00 for programmes for combating vitamin A Deficiency through Dietary Improvement.
- IDRC (Canada) $1,76,750 (Canadian) for programmes of education for better living and vocational training, of rural adolescent girls.

Field Stations: NFI’s Community Action Programmes will henceforth be greatly facilitated by the establishment of two field stations.
- A rural field unit in the villages of Rajasthan adjoining Bharatpur, and
- An urban-slum unit covering some of the most depressed slums of Delhi.

These units will be headed by Dr. Sharda Jain, noted social scientist.

Publications: The following NFI publications have just been released.
- Special Publication 6: “Combating vitamin A deficiency through dietary improvement” — Edited by C. Gopalan, B.S.Narasinga Rao and Subadhra Seshadri and containing articles from 16 authors. (Price Rs 250 including postage).
- Special Publication 8: “Education for better living of rural adolescent girls” — Training modules. Vol I — Health and Nutrition (Hindi version) by Dr Saramma Thomas Mathai and Dr Sharda Jain. (Price Rs 50 including postage).

Copies can be had on payment by cheques/demand drafts in favour of “Nutrition Foundation of India”.

Task Force Meetings: Task Forces connected with the following projects met during the last quarter, to review the progress of work on the respective projects.
- “Effects of calcium supplementation on the growth performance of adolescent girls”.
- “Effects of supplementary nutrition during the last trimester of pregnancy on birth weight and subsequent growth of infants”.
- “Establishment of Well Mother/Baby Clinic and Diet / Nutrition Counselling Centre”.
- “Composite multi-centric programme for developing methodologies for combating vitamin A deficiency through dietary improvement”.

Dr D.B. Jelliffe

The passing away of Dr D.B. Jelliffe in Los Angeles on March 18 is a sad blow to the world of paediatrics and nutrition. Dick Jelliffe was a dominant figure in the field of Child Health for nearly four decades. The several books he had authored had had a profound impact on paediatricians and nutrition scientists all around the globe. His sustained campaign for the promotion of breast-feeding has been a major contribution.

His years of work in the countries of the Carribean, Africa, and in India, in the most formative phase of his illustrious career had given him first-hand knowledge and experience of the problems of the Third World. He was a visiting Professor at the All India Institute of Hygiene and Public Health, Calcutta, in the 1950s, and had earned a very wide circle of friends and admirers among Indian paediatricians and nutrition scientists. He gave the first of the series of Annual Orations of the Nutrition Society of India.

Dr Jelliffe’s success was not a little due to the strong and sustained support of his vivacious wife — Patrice Jelliffe. The “inseparable Jelliffes” had enlivened several major international paediatric and nutrition meets in the last three decades. The numerous friends and admirers of the Jelliffes around the world will ardently wish that Patrice Jelliffe, a distinguished worker in nutrition in her own right, will continue her good work in the years ahead with undiminished zeal.

C.Gopalan