Hazardous Fluoride Ion on Groundwater of Rajasthan State: Its Irrefutable Manifestations, Precautionary measures & Attenuation Methodologies

Bina Rani
Associate Professor, Department of Engineering Chemistry & Environmental Engineering,
Poornima College of Engineering, Jaipur, Rajasthan, India

***Abstract*-With rising in population and dwindling groundwater resources, the groundwater quality of Rajasthan is deteriorating day by day. As per WHO report, 20% of the fluoride-affected villages in the whole world are in India. Out of 33,211 fluoride-affected villages in the country Rajasthan has 16,560 villages, which is more than 51%. From these figures we can draw an inference that nearly 10% of fluoride-affected habitation in the world is in the Rajasthan alone. Drinking water with excessive concentration of fluoride causes fluorosis which progresses gradually and becomes a crippling malady in the long run. It affects young, old, poor, rich, rural, and urban population. It has attained a very alarming dimension. Rajasthan suffers both the problems of quantity and quality of water. In most part of the state groundwater is either saline or having high nitrates and fluoride content. Obviously, groundwater is the major source of drinking water and over 94% of the drinking water demand is met by groundwater. Excess fluoride concentration in drinking water has deleterious effects on human health. All the districts in Rajasthan are engulfed by the clutches of fluorosis, to a varying degree. There being no perennial surface source for drinking water, the state is dependent chiefly on groundwater and its level is deeper year-by-year due to over exploitation. As the water table is receding more and more water sources are becoming prone to higher fluoride concentration. The pattern and prevalence of fluorosis in human population are determined by a number of epidemiological factors like water chemistry, demographic and nutritional profile of the community and high mean annual temperature of the area. UNICEF has taken definite steps in collaboration with Government and NGOs, to deal with the problem of fluorosis in Rajasthan. Beside, changing dietary habits, harvesting rainwater and promoting defluoridation of drinking water at household level can yield spectacular results in this regard. Different defluoridation techniques are being tried to make drinking water free from fluoride contamination. Awareness camps are being organized all over the state to make the masses aware of ill effects of fluoride problems. The state government has also taken up various programmed action plans such as artificial recharge of groundwater, rejuvenation of traditional baoris-kunds, RWH and judicious use of underground water for drinking and other purposes. Keeping in view the underground realities, this hydrotoxicants in water supplies of different locations and the people suffering from fluorosis and other ailments were identified in specified zonal localities. Finally preventive measures and remedial strategies concerning to defluoridation have been delineated precisely.**

Keywords: defluoridation; fluorosis; antioxidants; bioadorbents; reverse osmosis; nutritional prophylaxis; clinical manifestations

I. INTRODUCTION

In recent years, great concern has been universally voiced regarding environmental pollution arising as a side effect of industrial and other human activities. In our own country, with the advent of industries, more and more toxic substances are either used as raw material or emitted during manufacturing processes in the form of dusts, fumes, vapours and gases. These pollutants ultimately dissipate in the working environment and pose occupational health hazards. Many of these chemicals are hazardous and impose chronic impact on organisms including human beings. By the very nature of their wide distribution, the halogen group of minerals, including fluorides, forms a natural part of our environment. In order to strike a balance between such an environment and general health of human population and live stock of any region, the level of fluoride concentration in potable water, food, soil and atmosphere needs to be an appropriate level. Fluorosis, though a common endemic problem of our country is more widespread and acute in Rajasthan.According to a report published on 17th November 2004 by Tribune News Service, 19 states are endemic for fluorosis viz AP (16) , Assam (2) , Bihar (5), Chhattisgarth (2), Delhi (7) , Gujrat (18) , Haryana (12) , J&K (1) , Jharkhand (4), Karnataka (16) , Kerala (3), MP(14) , MH(10), Orissa (18), Punjab (17) , Rajasthan (32), TN(8), UP(7) AND WB (4) of India. The number in perenthesis in the total number of districts confirmed for fluoride endemicity. Over exploitation of groundwater in the last 20 years, is the chief reason for the spread of a dreadful disease. The conventional belief that fluoride affects only bone and tooth has been negated as the evidences on the involvement of soft tissues of all the body are convincing. By employing SPANDS (Zr –alizarin reds-visual dye lake) method , fluoride ion concentration in wate samples of various places in Rajasthan, were determined spectrophotometrically at 570 nm.

Defluoridation of contaminated water alone doesn't bring the fluoride content to safe limit It would be necessary to overcome the toxicity of the remaining fluorides ingested other sources. This is acheieved by effecting minor changes in the diet and dietary habits of the population compatible with their social system and available resources Since soil fluorides usually originate from micas are associated with clay-sized minerals, heavy soils tend to have substantially higher concentrations than sandy soils. Fluoride enters the soil through weathering of rocks, precipitation and impure water, mainly from waste run –off and fertilizers. Since much of our food is ultimately derived from plants often grown in contaminated areas, fluoride in soil is an important source of intake. Anti- oxidants possessing antagonistic effect play prophylactic role in preventing flourosis. A malady-remedy analysis of the problem of fluorosis has to be holistic in character as the disease not only affects human beings but also plants and animals. Therefore , we need to have , as far as possible, an idea of the source of fluoride and its dispersion in the environment including land, water and air. Based on such study , an integrated approach has to be evolved to draw up a stategy for the control of this disease. In this manuscripet clinical manifestations of various degrees of fluorosis and strategies concerning to mitigation of fluoride content in water, have been delineated.

Millions of men , women and children in many states of India are afflicted by water borne fluorosis and several lac of them are crippled and are leading vegetative life. The poor and economically weaker sections having low nutritional status are affected more. The incurable disease continues to be a major public health problem and urgent preventive measure, are needed. With rising population and dwindling groundwater resources, the groundwater quality is deteriorating day by day. As per WHO report , 20 percent of the fluoride –affected villages in the whole world are in India. Out of 33,211 fluoride- affected villages in the country.

Rajasthan has 16,560 villages, which is more than 51 per cent. From these figures we can draw an inference that nearly 10% of fluoride-affected habitation in the world is in the Rajasthan alone. Drinking water with excessive concentration of fluoride causes fluorosis which progresses gradually and becomes a crippling malady in the long run. It affects young, old, poor, rich, rural, and urban population. It has attained a very alarming dimension. Rajasthan is the largest state in the country in terms of geographic spread. It has an area of 3.42 lakh Sq kms being largest state of the country having 10.41 % of the country's area and 5.5% of nation's population but has low water resources i.e. 1% of the country's resources. The state has extreme climatic and geographical condition. Rajasthan suffers both the problems of quantity and quality of water. In most part of the state groundwater is either saline or having high nitrates and fluoride content. Obviously, groundwater is the major source of drinking water and over 94% of the drinking water demand is met by groundwater. Excess fluoride concentration in drinking water has deleterious effects on human health. It causes a dreadful disease known as fluorosis, though a common endemic problem of our country is more widespread and acute in the state of Rajasthan where all the districts are engulfed by the clutches of fluorosis, to a varying degree, mainly due to presence of high fluoride content in drinking water.

There being no perennial surface source for drinking water, the state is dependent chiefly on groundwater and its level is deeper year-by-year due to over exploitation. As the water table is receding more and more water sources are becoming prone to higher fluoride concentration. It is really shocking that India has only 4 per cent of global water recourses, whereas constitutes 16 per cent of total world population. The pattern and prevalence of fluorosis in human population are determined by a number of epidemiological factors like water chemistry, demographic and nutritional profile of the community and high mean annual temperature of the area. UNICEF has taken definite steps in collaboration with Government and Non-government organizations (NGOs), to deal with the problem of fluorosis in Rajasthan. Raising public awareness regarding fluorosis has become more critical. Beside, changing dietary habits, harvesting rain water and promoting defluoridation of drinking water at household level can yield spectacular results in this regard . Different defluoridation technique are being tried to make drinking water free from fluoride contamination. Awareness camps are being organised all over the state to make the masses aware of ill effects of fluoride problems . The state government has also taken up various programmed action plans such as artificial recharge of ground water, rejuvenation of traditional baoris- kunds, water conservation, rainwater harvesting (injection well technique) and judicious use of underground water for drinking and other purposes. Flurosis is an environmental disaster being experienced by millions of people. It has also been experienced for a long time also patients, often get misdiagnosed with arthritis, spondylitis or non-specific backache.

According to nationwide study of New Delhi based Fluorosis Research and Rural Development Foundation (FRRDF), "the occurrence of fluorosis can vary among different locations having almost the same fluoride concentrations in drinking water and can be affected by factors such as climate, individual susceptibility and biological response". The study concluded that "Poor nutrition also plays an important role in aggravating endemic fluorosis", thus explaining why poor people are often the worst affected. Fluorosis is an irreversible disease and there is no cure.

According to WHO and EU specifications, fluoride more than the safe limit (0.5to 1 ppm) is considered to be toxic. In most of the villages of Rajasthan fluoride level is > 1mg/litre (1 ppm). People in several districts of Rajasthan are consuming water with fluoride concentration beyond permissible limit.

In 21st century depleted groundwater levels and deteriorated quality will be major health and environmental problem. The social, economic and environmental values associated with groundwater are often unrecognized. A large proportion of the world's population relies on groundwater as a primary source for drinking and domestic use. In recent times on account of the increase in population, urbanization, industrialization, use of fertilizers and pesticides in agriculture, there is over increasing threat to surface and groundwater quality. The tremendous use of groundwater for irrigation and other purposes has resulted sharp decline in groundwater table and changes in the natural geochemistry of groundwater. The presence of fluoride in

groundwater is human made. Over exploitation of groundwater in the last 20 years, is the chief reason for the spread of fluorosis in Rajasthan. With the coming of diesel pump sets things have changed. Farmers have started to dig deeper into the earth's crust and are literally extracting poison. Rajasthan is a classic case of falling water tables and increasing incidence of fluoride in water. Thus it appears that the situation vis-a-vis fluoride is on the rise despite substantial efforts by the Government and NGO's action plans in the field.

The situation is grim and warrants a holistic approach to ameliorate the situation and a concerted action accordingly. Fluorosis is prevalent in several districts of Rajasthan viz. Jhunjhunu, Sikar, Churu, Jodhpur, Udaipur, Nagaur, Jalore, Barmer, Ajmer, Pali, Sirohi and Dungarpur. Many people in Rajasthan have humped back due to high fluoride content in water sources in arid and semi arid zones. In arid and semi arid soils also, fluoride content is very high. Food grains obtained from these soils are also rich in fluorides. Prolonged intake of fluoride containing water stiffens the bone joints, resulting in the mottling of teeth, pain in the bones and joints and outward bending of legs from the knees (Knee-knock syndrome).

The very nature of fluoride increases danger manifold. A worrying scenario: daily ingestion of just 2mg of fluoride over a period of 20 years results in osteoporosis, arthritis, brittle bones, cancer, infertility in women, brain damage, Alzheimer's disease and thyroid disorders. Water is scarce and, in general, low quality resource in desert areas. It has been observed that in most of the cities in Rajasthan, the quality of drinking water is far below the prescribed standards. Fluorine is regularly present in water and soil besides air. It is an element of halogen group and is highly reactive (OP-2.87ev>O3) in nature. It is thirteenth most abundant element occurring in the earth's crust and has strong affinity to combine with other elements to produce compounds known as fluorides. It is, in fact, one of the most bones seeking acute toxin of notable chemical qualities and physiological properties as well. The effect of chronic fluoride intoxication is universally known as fluorosis. It continues to be a problem of public health magnitude throughout the world. The main occurrence of fluorine in rocks is in the form of fluoride bearing minerals. In our country the problem of fluorosis has become more severe in Rajasthan. This has already crippled about 3.5lac persons in the state. Many people in Rajasthan have humped back due to high fluoride content in water sources in arid and semi-arid zones. In arid and semi arid soils also, fluoride content is very high. Food grains obtained from these soils are also rich in fluorides. Prolonged intake of fluoride containing water stiffens the bone joints, particularly of spinal cord. It has an affinity with calcium and thus gets accumulated in bones, resulting in the mottling of teeth, pain in the bones and joints and outward bending of legs from the knees- (Knee-knock syndrome). As many as 200 districts in the country have a high fluoride concentration in groundwater. About 25 million people spread over 19 states are affected, while another 66 million have been described as a "population at risk", according to a WHO - UNICEF sponsored study on the countries water supply and sanitation. In accordance with WHO and EU specifications, fluoride more than the safe limit (1.5 ppm) is considered to be toxic. In water of most villages of Rajasthan fluoride level is higher than permissible limit of l.5 mg/litre. People in several districts of Rajasthan are consuming water with fluoride concentration up to 60 ppm.

II. SOURCES OF FLUORIDE IN ENVIRONMENT

Fluorine is 13th most abundant element of halogen group having At No - 9 and Mo Wt – 19, available in the earth's crust. It is the most electronegative of all the elements known to the world and exists as a diatomic molecule with a remarkably low dissociation-energy (38 k cal/mole). As a result it is highly reactive and has strong affinity to combine with other elements to produce compounds known as fluorides. It is, in fact, one of the most bones seeking acute toxin of notable chemical qualities and physiological properties as well. The effect of chronic fluoride intoxication is universally known as fluorosis. It continues to be a problem of public health magnitude throughout the world. The main occurrence of fluorine in rocks is in the form of fluoride bearing minerals. Usually the surface water does not contain high fluoride whereas groundwater may be contaminated with high fluoride content because the usual source of fluoride is fluoride rich rocks. When water percolates through rocks it leaches out the fluoride from these rocks. Fluorspar-CaF_2 (Sedimentary rocks like lime stones, sandstones), Cryolite – Na_3AlF_6 (Igneous rocks like Granite) and Fluoro-apatite – $Ca_3(PO_4)Ca(FCl)_2$ are the main rocks which are rich in fluoride.

Fluorides come next to sulphur dioxide (SO2) in the hierarchy of atmospheric gaseous pollutants. Fluorides are released in the air as gaseous hydrogen fluoride (HF) and volatile fluorides like cryolites and silicon fluoride (SiF4). These pollutants result from aluminum factories, brick kiln, pottery industries, ferro-enamel works, stacks of factories processing-ore and oil. Fluoride contamination occurs through a natural process in which fluoride bearing rocks crumble and breakdown but the process can be speeded up if the chemistry of the aquifer is disturbed. Fluoride is known to contaminate groundwater reserves globally. In India its occurrence in top aquifer system is endemic in many places of Andhra pradesh, Tamil Nadu, Karnataka, Gujrat, Rajasthan, Punjab, Harayana, Bihar and Kerala. Abnormal level of fluoride in water is common in fractured hard rock zones with pegmatite veins. The veins are composed of minerals such as topaz, fluorite, fluoroapatite, villuamite, cryolite and fluoride-replaceable hydroxyl ions in ferromagnesium silicates. Fluoride ions from these minerals leach into the groundwater and contribute to high fluoride concentrations. High profile of fluoride in shallow zone groundwater is due to the geo-chemical deposition in the vicinity of the groundwater extraction structures. The toxicity of fluoride is also influenced by high ambient temperatures, alkalinity, calcium and magnesium contents in water. Climatic conditions play a major role in deciding the extent of fluoride in groundwater. For instance a 2002 research article Fluoride in shallow aquifers in Raj Garh Tehsil of Churu district, Rajasthan-an arid environment – published in esteemed journal Current Science points out that "the arid climate with high evaporations

and insignificant natural recharge might have accelerated the strengthening of fluoride concentration in the groundwater of this (Churu district) area. In the vast geographical expanse and varied geographical set-up in Rajasthan the cause of fluoridation of groundwater are many. Some natural, some human-made. Fluoride bearing rocks are leached out due to various natural processes such as soil formation." By using zirconium – alizarin red-s visual method, fluoride content in different water samples of various places of Rajasthan were determined, spectrophotometrically. Beside this method spand's method [spand's =sodium 2 –(para – sulphophenylazo)-1,8- dihydroxy-3,6 naphathelene disulphonate] and Ion selective electrode method are also employed for fluoride determination.

III. SOURCES OF FLUORIDE FOR HUMAN, ANIMAL AND PLANT EXPOSURE

Major sources of fluoride for human exposure are: Water, Food, Air, Medicament, and Cosmetics. It is roughly estimated that 60% of the total intake of fluoride is through drinking water. 96-99% of it combine with bones, as fluoride has affinity for calcium phosphate {Ca3(PO4)2} in the bones. Other forms of fluorides are relatively less harmful. Fluoride rich food items are also a source of fluoride for human consumption, some of these are tea, fluoridated toothpaste, plants and vegetables grown in soil, rich in fluoride, pan, supari, tobacco, green garlic, onion, cabbage, soybeans, carrot, corn, potato, baking powder, egg, cow liver & kidney. Prolonged use of certain drugs has been associated with the chronic adverse effects of fluoride e.g. sodium fluoride (NaF) for treatment of Osteoporosis, Ni-fluoric acid for the treatment of rheumatoid arthirtis and the use of mouth rinses. The use of fluorides in industries can often lead to occupational exposure e. G. inorganic fluoride compounds are used in the production of aluminum and phosphate fertilizers. Cattle grazing around fluoride sources, as ceramic rocks, phosphatic fertilizer plants and aluminum factories often develop fluorosis. The toxic effects are staining, mottling and abrasion of teeth, high fluoride levels in bone and urine, decreased milk production and lameness. Animals become lethargic.

Fluoride content of water depends on the soil. Soft water contains little fluoride while significant amounts may be present in hard water. The crop plant grown in high-fluoride soils in agricultural and non-industrial area had fluoride content as high as 300 ppm. Fish-food, tea, cottonseed and some vegetables have relatively large amounts of fluoride. Fluoride present in food is organically bound and is not toxic. Some of the drugs like anti-carcinogenic drugs, drugs used for treatment of osteoporosis and related metabolic disorders, certain anaesthetic drugs, fluoridated cortico-steroids and dentine obludents contain fluoride that can be metabolized in the body.

IV. CHEMOBIOKINETICS

Fluoride present in water is in a simple form and ingested fluoride is rapidly absorbed through gastro-intestinal tract and lungs. The peaks are reached after 30 min in blood. The rapid excretion takes place through renal system over a period of 4 to 6 h. in children (3 yrs of age only) about 50% of total absorbed amount is excreted, but in adults and children over 3 years – about 90% is excreted. Approximately 90% of the fluoride retained in the body is deposited in skeleton and teeth. The biological half-life of bound fluoride is several years. Fluoride also passes through the placenta and also appears in low concentration in saliva, sweat and lacteal secretion (milk). Fluorides present other than in water are relatively less harmful. Fluoride ions from soluble inorganic fluoride compounds are rapidly absorbed. Fluoride sufficient in amount to cause mottling of primary dentition may reach through placenta. Fluoride is mainly excreted in the faeces.

V. PATHOPHYSIOLOGY OF FLUOROSIS

Ingestion of fluoride causes decrease in the ionized calcium. This hypocalcemia leads to changes in internal milieu of the body to maintain the calcium levels and leads to secondary hyperparathyriodism. The increased activity of osteoblasts in bones by activating membrane bound 3'5' cycle AMP. This increased osteoblastic activity causes increase in citric and lactic acids released from ruffled border of osteoblasts. This causes increase in H+ ion concentration, and hence lysis of lyposomes takes place. Release of lyposomal enzymes viz acid protease, collagenase, hyaluronic acid in bones and other tissues of the body catalyes the reactions favouring the depolymerisation of the glycoprotein of bones and of the cartilage. This causes breakdown of hydroxy proline, which is responsible for stabilisation of collagen triple helix. As the protein polymer desegregates, and dissolves the mineral binding capacity (mbc), also get reduced and calcium is librated, which helps in maintaining the serum calcium level. As a result the solubility of hydroxyappetite crystals also increases, causing its breakdown along with reduced laying down of collagen by reducing hydroxylation of proline and lysine. This event simultaneously led to the elevation of the serum mucoprotein or polysaccharide levels. The net result of degradation of ground substance in bones and other calcified tissues like teeth leads to symptoms of fluorosis like delayed eruption of teeth, dental fluorosis and premature ageing.

Water scarcity, instead of future oil shortages or global warming, is the greatest crisis facing humanity in the 21st century and possibly beyond. Yet there is little awareness amongst most people in the world of the current global shortage of water and what it portends for the future. According to the UN, 1.2bn people currently have no access to safe drinking water, while half of the world's population lacks adequate water purification. It's estimated that the amount of water available per person will shrink by a third during the next two decades. Scarcity of water resources is one of the most common and important limiting factors for economic and social development. In India, for example, groundwater from aquifers is being pumped at nearly twice the rate of aquifer recharge from rain fall, while both the demand for water and the country's population are expected to increase at a rate of least 50% by 2050. Fluorosis, though a common endemic problem of our country is more widespread and acute in Rajasthan. Over exploitation of groundwater in the last 20 years, is the chief reason for the spread of a dreadful disease. Millions of men, women and children in many states of India are afflicted by water borne fluorosis and several lac of them are crippled and are leading vegetative life. The poor and economically weaker sections having low nutritional status are affected more. The incurable disease continues to be a major public health problem and urgent preventive measure, are needed. With rising population and dwindling groundwater resources, the groundwater quality is deteriorating day by day. Current and looming water scarcity, the effects of environmental pollution, ground water pollution, ground water degradation and global warming on water availability, can have severe and adverse effects on the world economy, especially in developing countries. This may lead to human displacement at an unprecedented scale. It's imperative, therefore, that existing water resources are preserved and advanced treatment processes are deployed to provide potable water. This would require international agencies and governments to take several urgent measures including water management and conservation, preventing degradation of lakes and rivers, rainwater harvesting, drip-irrigation and desalination. "Water is the source of life, the sap of all things" are the words of Guru Nanak, the 15th century first Sikh guru. We must heed this message to preserve the world's most valuable and wasted resource.

VI. FLUORIDE STANDARDS

In 1984,the World Health Organization gave a guideline value of 1.5 mg/l (1.5ppm) as the maximum permissible level for fluoride in drinking water. This reflected the state of research on fluoride. A certain amount was considered good for human health but more research changed this attitude. According to UNICEF studies "fluoride has no beneficial health effects. Rather, fluoride destroys teeth. Fluoride has no role in prevention of dental caries, which is basically a bacterial disorder " WHO guideline value is unsafe for some countries. **In tropical countries such as India, people drinks more water hence consume more fluoride. Also many food items have high concentration of fluoride**. In accordance with a report of a national sanitary engineer, WHO-New Delhi "WHO only gives guide lines. The Indian Government is free to notify its own acceptable limits, the reason being that Indian population is already exposed to fluoride through many sources." During an International workshop on fluoride and defluoridation held in Cheang-Mai (Thailand) 20-24 November 2000, it was recommended that WHO should reduce its guideline value from 1.5 mg/l to 0.5 mg/l. The permissible limit as laid down by the United States Public Health (USPH) drinking water standards and Indian Standard Institute (ISI) are 1.5 mg/l and 3.0 mg/l respectively. The ISI value available for fluoride level in domestic water supplies is just double as prescribed by UPSH, obviously for no good reasons. "Setting up guidelines for fluoride in water requires carrying out large-scale epidemiological studies. No, such studies have been carried out in India", in accordance with a report of RENDWM official. The Indian government through the Bureau of Indian Standards (BIS) prescribed the acceptable limit of 1 mg/l fluoride in drinking water in 1992. But this does not mean that it is safe. Malnourished children can be affected even at fluoride levels are below 1 mg/l says Unicef. Moreover fluoride standards are canonically vague. There exists an "acceptable level" 1 mg/l. But there also exist a cause of rejection level (1.5 mg/l) the water may not be acceptable in the absence of an alternative and better source. Thus it is shocking and yet legal that the Government continues to follow the 1.5 mg/l limits in its water programmes.

VII. EXTENT OF FLUOROSIS IN RAJASTHAN

In 1947, Ajmer-Mewar, was first reported as endemic region by Shourie. Voluminous work on the subject was done by workers like Kesliwal and Solomon (1950); Bhargava (1974) and Mathur (1977) on various aspects of fluorosis. Later on, zonal labs of National Environmental Engineering Research Institute, NEERI in Jai Pur, reported high fluoride content in groundwater from different parts of Rajasthan. Geologically, there is a belt underneath Aravali range, beginning from Panch Mahal, Gujrat to Gurgaon (Harayana) and passing through southeast Rajasthan that is rich in fluorospar, cryolite and fluoroapatite. In Jarna-Khurd village 20km away from the city of Jai Pur, there are no youth. All 1200 people irrespective of age look old and have cracked teeth. Their shoulders, hips and ankles are swollen and ache all the time. It is painful to stand up, if they squat on the floor. In Jalore district of Rajasthan, the fluoride content in water has increased to 6.8 mg/l as against the permissible limit of 1.5 mg/l causing premature aging in the people. Nearly 120 out of 728 villages in the district are in the grip of fluorosis with some of the villages being the worst hit as identified by the European Commission (EC). Osteoporosis, bone deformation and yellowing of teeth are rampant. Even the unborn children are not safe. People are threateningly dependent on aquifers for their drinking needs. All over, in Rajasthan drills, borepipes, tubewells and handpumps are becoming the triuphalistic instruments to extract water of varying fluoride concentration from the deep of the earth. The area 20 km away from famous marble city

Makrana, having 60 villages has been known as Banka-Patti because most of the people of this fluorotic belt are facing skeletal deformities due to consumption of fluoride rich water. Most of the peoples of Tedhasar village of Churu district seem to be totally handicapped due to fluoride poisoning.

Table –1 Occurrence Of Excess Flouride In Rajasthan

Villages having excess fluoride	**Districts of Rajasthan (Drinking water sources having fluoride>1.5 ppm)**
Upto 10%	Shri Ganga Nagar, Bundi, Kota, Chittor Garh, Jhalawad
10 to 20%	Bikaner, Jhunjhunu, Udai Pur, Dungar Pur
20 to 40 %	Churu, Sikar, Karoli, Dausa, Alwar, Jai Pur, Bharat Pur, Sawaimadho Pur, Dhol Pur, Banswara, Serohi, Badmer, Jodh Pur, Pali, Ajmer
>40%	Jaisalmer, Nagaur, Jalore, Bhilwara, Tonk, (Total no. of villages - 9741)
Not Known	Hanuman Garh, Rajsamand , Baran

VIII. EPIDEMIOLOGICAL STUDIES

Epidemiology is the study of distribution and determinants of diseases prevalent in human beings and animals. Three aspects are important in an epidemiological study - the agent supposed to be causing the disease - the person affected by the disease (host) and - the environment in which the agent and the host interplay. The agent, host and environment in context of a given disease are called 'epidemiological triad'. Relevant factors pertaining to the agent, host and environment as far as fluorosis is concerned are described below

A. Agent

Although primarily fluoride is the agent responsible for determining the occurrence of fluorosis in the community but several factors like alkalinity of drinking water, calcium intake, vitamin C in the diet, molybdenum (Mb), aluminium (Al) and phosphates that determine the impact of fluoride on human body also influence as indirect agents in causing fluorosis.

- ***Fluorine***

Fluoride is mainly found in groundwater in which the solvent action of water on the rocks and soil of earth's curst derive it from the adjacent soil. The porosity of the rocks or soil through which water passes and the speed with which water flows, the temperature of the interaction of the rock and water, the hydrogen and calcium ion concentration, determine the fluoride content of the drinking water. Hodge and Smith (1965) have related the concentration of fluoride to the following well-established biological effects.

Table- 2 Fluoride Concentration And Related Effects

Concentration	Source	Malady
2 ppb	Air	Injury to vegetation
2 ppm or more	Water	Mottled enamel
8 ppm	Water	10% Osteo-sclerosis
20-80 mg/day	Water / Air	Crippling fluorosis
50 ppm	Food / Air	Thyroid changes
10 ppm	Food / Air	Growth retardation
>125 ppm	Food / Air	Kidney changes
>5 gms	Acute dose	Death

- ***Calcium***

Fluoride absorption is reduced to 50 per cent, if calcium in the form of calcium carbonate ($CaCO_3$) or calcium phosphate $\{Ca_3(PO_4)_2\}$ or aluminium compound is added. In such cases fluoride is bound in less soluble form and gets excreted through faeces. In areas where water is hard due to calcium and magnesium, the prevalence of skeletal fluorosis is much less. In Rajasthan, low community fluorosis index was reported form fluorotic belt where calcium intake of people was found to be high (Shiv Chandra; 1980).

- ***Alkalinity***

A direct relationship exists between alkalinity and fluorosis. Most of the water having fluoride more than 2 ppm., have lower hardness and higher alkalinity. Most of the alkalinity is found to be due to excess bicarbonates. In natural water, carbonates and bicarbonates appeared to be the main substances in leaching out fluoride from the rock forming minerals fluorospar.

- ***Phosphates***

Phosphates enhance fluoride absorption in the intestine presumable by counteracting the inhibitory action of intestinal calcium on fluoride absorption.

- ***Aluminium***

While aluminium and fluoride have synergistic effects, the aluminium as such has toxic effects on human body. Since aluminium salts have been commonly used as coagulants in water treatment, persons involved in defluoridation work must be aware

of aluminium toxicity. A small amount of aluminium may remain in treated water and transported through distribution system, without any significant loss. While permissible limit for aluminium in water is 0.2 mg/l. Extra precaution should be taken in the use of defluoridation units. Thus, there needs a precautionary approach in using aluminium salts and making water free from these salts before consumption.

- *Vitamin C*

A more severe type of mottling has been observed in children who had a low intake of vitamin C. Citrus fruits are reported to reduce the toxic effects of fluoride. Thus consumption of fresh fruit is recommended in the fluorotic belts.

B. Host

- ***Age***

With increase in age, prevalence of dental mottling and subsequently skeletal fluorosis increases in the fluorotic belts. By the end of the decade the prevalence reaches to a maximum and plateaus thereafter. Although dental fluorosis is observed in the deciduous teeth but it's prevalence starts rising form the time when permanent teeth appear. In highly endemic zones, people become endentulous in the 4^{th} and 5^{th} decade of life and large number of them develop kyphosis (curvature in spine).

- ***Sex & Migration***

In fluorotic zones males suffer more than females. In India, this is mainly attributed more to migration of females after marriage. Irrespective of to and fro migration, there is always a likelihood of women getting less victimized. There is also a hypothesis of higher consumption of drinking water by man doing strenuous physical work but women are more affected during pregnancy and breast-feeding, due to lack of sufficient calcium in the body.

- ***Occupational Status***

People involved in mining fluoride rich ores and working in aluminium industries are more likely to suffer from fluorosis. Although it is not an obvious problem in Rajasthan, but it is speculated that in Udaipur, Dungarpur, Jalore and Bhilwara, wherever the fluoroapatite is mined, fluorosis in miners is possible.

C. Environment

- ***Temperature***

The principal source of fluoride for human being is water. Water intake depends chiefly on air, temperature, which is further dependent on latitude of the place, altitude, direction of the wind and proximity to sea. In fact, the annual mean temperature would influence optimal fluoride intake to great extent. Individuals living in areas with a large number of sunny days are exposed to an additional environmental heat stress, not reflected in usual temperature measurements.

- ***Relative Humidity***

A relative low humidity tends to increase water loss, temperature being equal. It is questionable whether the differences in the relative humidity in the two areas having similar temperature may influence water intake amongst individuals living there.

IX. CLINICAL MANIFESTATIONS

Nutritional deficiencies, combined with excess fluoride intake through water, appears to create fluorosis which manifests itself as dental, skeletal and non-skeletal fluorosis.

(A) DENTAL FLUOROSIS

Mottling of teeth in children is one of the earliest and most easily recognizable feature of fluorosis. Beside a health problem, it is an aesthetic and social problem also. A yellow-white discoloration appears, which turns brown and presents itself in horizontal streaks, since new layers of matrix are added on horizontally during tooth development. In late stages, the teeth become black. They may be pitted or perforated and may even get chipped off. Lose of premature teeth (endentulous) is common in endemic areas.

- Severity of dental fluorosis in as group of children in fluorotic belt helps in determining the community fluorosis index (cfi), which depends on identifying the extent of dental fluorosis in an individual child. Dean's classification is used in identifying the mild, moderate and severe fluorosis in the teeth and a numerical grading is given by very experienced eyes.
- Habit of consistent betel (pan) and tobacco chewing also results in discoloration, which should be differentiated, from fluorosis by ascertaining the site of color change on the tooth surface and history of the patient. In dental fluorosis the discoloration, which occurs on the enamel surfaces, away from gums, can never be removed, as it becomes an integral part of tooth matrix.

(B.) SKELETAL FLUOROSIS

The skeletal fluorosis manifests initially at the beginning of adulthood and is progressive if persons continue to consume fluoride rich water. Maximum ill effects of fluoride are detected in the neck, spine, pelvic and shoulder joints. Early symptoms of skeletal fluorosis include pain and stiffness in the neck, back and major joints of the extremities. Restriction of movement commences. The stiffness steadily increases until the entire spine becomes one continuous column of bone, manifesting in a condition referred to as 'poker back'. Finally, various ligaments of the spine become ossified. The stiffness that first appears in the spine spreads to various joints of girdles and limbs. The involvement of the ribs gradually reduces the movement of the chest during breathing. The increasing immobilization of joints leads to deformities of hip, knee and other joints causing severe disability. Characteristic structural changes in a fluorosed bone as revealed in X-ray include increased bone mass density (BMD) and bony out growths. Skeletal fluorosis usually become crippling in people in the endemic regions. Symptoms developed due to pressure caused by osteophytes (bony outgrowth), narrowing of inter-vertebral space and increase in the size of vertebrae or narrowing of spinal canal lead to paralysis.

D. NON-SKELETAL FLUOROSIS

The conventional belief that fluoride affects only bone and tooth has been negated in recent years as the evidences on the involvement of soft tissues/organs/system of the body are convincing. Involvement of skeletal muscles, red blood corpuscles, ligaments, blood vessels, spermatozoa and G-I mucosa has been documented so far. In animals involvement of kidney, liver adrenals and reproductive organs have also been reported. Direct involvement of skeletal muscles in fluorosis has now been scientifically proved. Fluorosed skeletal muscles show widespread destructive changes. The other symptoms include-

- ***Gastro-Intestinal problems***

G-I mucosa is involved in the early stage of fluorosis. The main complaints are nausea (flu like symptom), loss of appetite, acute stomach pain, bloated feeling, gas formation, constipation followed by intermittent diarrhoea and headache. These complaints are considered early warning signs of fluorosis.

- ***Neurological problems***

Nervousness, depression, tingling sensation in fingers and toes, excessive thirst and tendency to urinate frequently are some of the manifestations observed in fluorotic belt.

- ***Allergic problems***

It includes painful rashes on the skin prevalent in women and children, which clear up in 7 to 10 days.

- ***Urinary-Tract problems***

Urine may be much less in volume; yellow-red in colour, and itching in urinary region.

- ***Other Troubles***

Radiographical studies show that ligaments and blood vessels get calcified. Erythrocytes (RBCs) are also affected in fluorosis. Fluoride is accumulated on their membranes, which lose in turns their calcium content. Attached red blood corpuscles do live their full life span and are likely to be eliminated by the system. Thus patients suffer from anaemia. Sperm abnormality in fluorosis results in male infertility. Oligospermia (deficiency of sperms), azoosermia (absence of sperms) and low terosterone levels in blood is very common in persons residing in endemic area consuming high fluoride in drinking water. Weakness, stiffness and pain are included in muscular manifestations.

Fluoride can damage a foetus if the mother consumes water and food with high fluoride concentration during pregnancy. It can adversely affect the IQ of children.

The above-mentioned symptoms can also be due to other reasons. Therefore, the challenge before the medical officers is to differentiate and distinguish the symptoms due to fluorosis from other reasons. Non-skeletal fluorosis can be reversed within a short span of time, if a person starts taking low/nil fluoride water.

X. NUTRITIONAL PROPHYLAXIS

In people with exposure and those with clinical and sub clinical symptoms, the only available measure as of today is eliminating the intake of fluorides. No chemical till date is capable of extracting fluoride absorbed in the body. In patients with disease symptoms, the following interventions should be practiced:

- Reduce as much as possible the fluoride through water and food.
- Practice consumption of diet rich in calcium, vitamin C (ascorbic acid), vitamin E and anti-oxidants.

A properly designed nutritional regimen can beneficially interfere with the toxic effects of fluoride. Vitamin C, vitamin E and anti-oxidants, which are beneficial and are not very expensive, can be produced in rural areas without much investment.

- **Calcium :** Milk, Curd, Yoghurt, Green leafy vegetables, Jaggery, Drumstick, Sesameseeds
- **Vitamin C :** Aanola, Lemon, Orange, Tomato, Sprouted cereals/pulses and Dhania leaves
- **Vitamin E :** Vegetable oil, Nuts, White grain cereals, Green vegetables and Dried beans
- **Anti-oxidants :** Garlic, Ginger, Carrot, White onion, Papaya, Pumpkin and Green leafy vegetables.

All the above items have antagonistic effect; thereby play the prophylactic role in preventing fluorosis.

XI. TREATMENT AND PREVENTION

Fluorosis not only affects older persons, but there are ample evidences that even newborn baby and children of younger age have also been its victims. It not only affects the body of a person but also renders them socially and culturally crippled. There is a need to develop a well thought out strategy to attack this problem, which requires an urgent attention from both medical as well as of social workers. Considerable work has been done all over the world on treatment of fluorosis. Unfortunately the results indicated that the effects of fluorosis are irreversible in children. Numerous people have conducted surveys on the problem of fluoridation and treatment option available for defluoridation processes, but however a safe efficient and cost effective defluoridation technique/process needs to be developed in order to prevent the occurrence of fluorosis.

XII. TO SUMMARIZE THREE APPROACHES ARE SUGGESTED

A. Health Education
B. Treatment of the Disease
C. Preventive Measures

A. *Health Education*

Creating awareness about the fluoride and fluorosis: the main area of interest will be

- **Creating disease awareness**: Creating awareness about the disease should be in the form of graphic presentation of the final consequences of the disease to the extent possible.

If required, live presentations of the patients who are suffering from the severe form of the disease in areas where the gravity of the problem has not reached to that extent. It may be of use to demonstrate the most severe extent of the disease and to motivate them to use the preventive or therapeutic measures.

- **Creating awareness about the sources of the fluoride**: The creation of awareness will help in implementing the need based preventive measures in the affected community.

B. *Treatment of the Disease*

Vitamin C and D, salts of Ca, Mg or Al were prescribed in an attempt to reverse these effects. Published results were, however, inconclusive and largely negative. Recent studies conducted in Rajasthan under Raj DST sponsored studies indicated that fluorosis could be reversed, at least in children by a therapeutic regimen (Nutritional prophylaxis), which is cheap and easily available. The choice of the reported therapy was logical. The presence of calcium in gut directly affects the absorption of fluoride ions and also improve serum levels as observed by Teotia et. al (1995). Vitamin D_3 in low doses enhances Ca absorption and retention without causing hypercalcemia and thus directly affects the absorption of fluoride ions. It also inhibits the excessive release of parathyroid hormone there by preventing excessive activation of osteoblasts thus preventing hyperosteoidosis and osteopenia. Ascorbic acid controls collagen formation,maintains the teeth structure and bone formation. The structures are adversely affected by higher fluoride intake.

C. *Preventive measures*

- ***Providing Defluoridaled Water for Drinking Purpose***

– Methods of defluoridation recommended so far are aimed at bringing the fluoride levels to the WHO standards.
– Desirable characteristics of defluoridation process, cost effectiveness, easy to handle, (operation by rural population) - the major sufferer - independent of input fluoride concentration alkanity, pH, temperature, no effect on taste of water, no addition of other undesirable substances (e.g. Al salts) to treat water, all these parameters must be considered for adopting any of the defluoridation process/technique.

- ***Changing the Dietary Habits***

Defluoridation of drinking water alone shall not bring the fluoride level to safe limit. It would be necessary to overcome the toxic effects of the remaining fluoride ingested through other sources. This can be done by effecting minor changes in the diet and dietary habits of the population compatible with their social system and available resources. The main aim must be to

– Restrict use of fluoride rich food
– Avoiding use of fluoride rich cosmetics
– Use of food rich in Calcium, Vitamin C and antioxidants

- ***Rain Water Harvesting: (Alternative water source)***

Fluoride affects the people and the animals as well. Therefore it is desirable that the animals should also be provided with fluoride free water for maintaining their longevity. Defluoridation of drinking water for animals will be too costly and not feasible and therefore the only solution of this problem is water harvesting. The water harvesting technology should be aimed not only to provide fluoride free water to human beings but also to animals. Rainwater storage can be a major source of fluoride free drinking water for the animals. These three-pronged attacks can prove to be a blessing for the population especially for the younger generation living in fluoride rich areas having no choice except to drink the water contaminated with fluoride and suffer the invitable consequences including permanent deformities.

XIII. COMMONLY USED DOMESTIC DEFLUORIDATION PROCESSES

Advantages and disadvantages of various commonly used processes available for defluoridation

A. *Nalgonda Process*

It looks a cumbersome technique not suitable for use by less educated population - the section that needs it the most. The process can be used only for water having a fluoride content of <10ppm & turbidity <1500ppm. There is a high residual Al content in output water. It is reported that the residual Al ranges from 2.01 ppm to 6.80 ppm. It is relevant to note that Al is a neurotoxin and concentration as low as 0.80 ppm of Al in drinking water is reported to have caused Alzheimer's disease. The ISO 10500 for drinking water sets an absolute max limit of 0.2 ppm for Al, which is well below the minimum reported in the output water, generated by this process. Also the taste of output water is generally not acceptable.

B. *Activated Alumina Process*

Reactivation of filter material is cumbersome and it can be done only with the help of trained persons generally not available in most of our villages. This process also results in high residual Al in output water ranging from 0.16 ppm to 0.45 ppm.

C. *KRASS Process*

This process differ from the known processes in its simplicity, cost effectiveness and only traces of residual Al in outlet water. There is no limit on fluoride concentration in input water.. It is a practical approach especially for our rural population.The importance of the process is a defluoridation process, which is easy to use by illiterate villagers, requires minimal involvement of technical personnel. In this process, once

the filters are laid, the only expenditure is in terms of recharging with aalum. This process have verified by CSIR and PHED of Rajasthan. The large scale, field installation KRASS's plants is under process (Agarwal et al., 1999). The parameters like fluoride concentration, temperature, pH, alkalinity, humidity and TDSs of input water do not affect this process.

D. *Other process*

Processes like electro-dialysis, ion exchange, capacitative deionization and reverse-osmosis require special equipment, power, especially trained person to operate and require maintenance and are expensive.

XIV. DESIRABLE CHARACTERISTICS OF AN IDEAL DEFLUORIDATION PROCESS

NALGONDA TECHNIQUE

√ Cost-effective
× NOT independent of input Fluoride concentration, alkalinity, pH
× NOT Easy to handle/operate by rural population - the major sufferer
× AFFECTS taste of water
× ADDS aluminum & TDS to treated water

ACTIVATED ALUMINA

× NOT Cost-effective
√ INDEPENDENT of input Fluoride concentration, alkalinity, pH
× NOT easy to handle/operate by rural population - the major sufferer
√ DOES NOT affect taste of water

× ADDS moderate aluminum to treated water

In activated alumina filters the major problem lies with recharging of the bed by acid and alkali, and, the aluminum present in treated water.

SALIENT FEATURES OF KRASS PROCESS

√ Low-cost Technique
√ Can be sited at anywhere suitable to user
√ Easy to handle/operate by rural population
√ Only one unskilled person is required
√ Independent of input Fluoride concentration, alkalinity, pH, temperature
√ Does not affect taste of water
√ Does not add any other undesirable substances to treated water
√ Filter bed recharging using alum solution
√ Can be recharged for 30-40 cycles and then discarded
√ Initial F retaining capacity of filter material not high

XV. STATE-OF-THE-ART REVERSE OSMOSIS TECHNOLOGY

The term "osmosis" describes the interaction between weakly concentrated aqueous solution and a more highly concentrated solution, separated by a semi permeable membrane. The membrane which is permeable to water molecules permits the diffusion of water from the lower concentration to higher concentration. If this natural process is reversed, say by raising the side with the higher concentration to a higher pressure, the flow of water will be in the opposite direction. Reverse osmosis (RO) is thus a pressure driven membrane process used generally to remove constituents with molecular weights above 200. It lies become a common method for the treatment of household drinking water supplies. Effectiveness of RO units depends on initial levels of contamination and water pressure. The treatment may be used to reduce the levels of various contaminants as listed such as naturally occurring substances that cause water supplies to be unhealthy or unappealing (foul tastes, smells or colors) and substances that have contaminated the water supply resulting in possible adverse health effects. RO systems are typically used to reduce the levels of total dissolved solids including fluoride, nitrate and suspended matter. RO units (Figure 1 to 7)with carbon filters may also reduce the level of some SOCs like pesticides, dioxins and VOCs like chloroform and petrochemicals. Application of the process includes purification of water for use as make-up water, desalination of seawater, concentration of milk in the dairy industries, and dehydration of the liquid food. The separating capacity of the membrane is reliable. Salts and organic contaminants of groundwater can penetrate the membrane to a very small degree but the bacteria and viruses are incapable of penetrating it. Thus the reverse osmosis process is used as a reliable process for the production of extremely pure water. RO systems, normally used to treat only drinking and cooking water supplies, may not be preferred where larger supplies are being treated. It is possible to treat fluoride rich groundwater and make it safe for drinking purposes, using a sophisticated treatment plants (Which requires regular maintenance) based on reverse-osmosis-membrane technology. Out of various technologies available for defluoridation, reverse osmosis is probably the only most versatile and accepted technology today. Which offer the opportunity to provide the water quality standards as per the recommendations of WHO and EU specifications, practically from any source of raw water.It is a multistage process, in which water is forced through a semipermeable membrane of a pore size of 0.0001 micron, which rejects all undissolved and dissolved contaminants of groundwater including fluoride up to 98%. In Rajasthan people of number of towns and villages are being benefited by getting fluoride free water from RO systems.

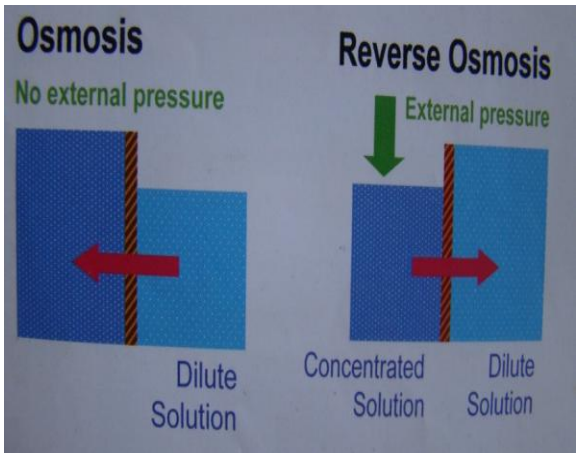


Figure 1 Schematic of Osmosis and Reverse osmosis

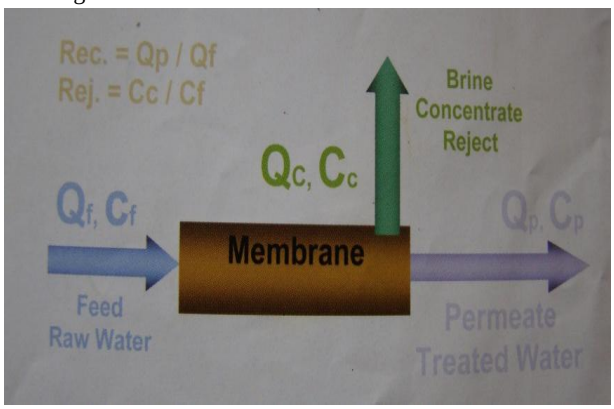
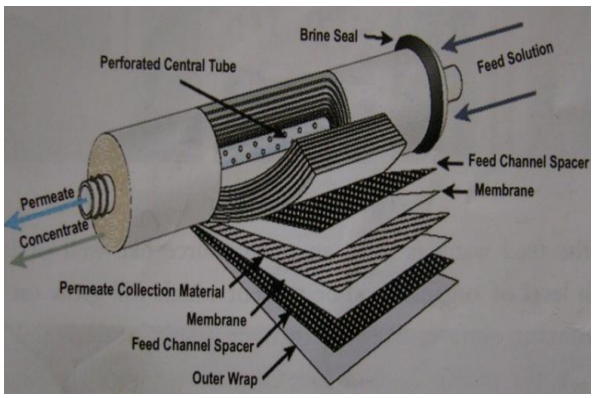


Figure 2 Schematic of major Reverse Osmosis stream

Figure 3 Reverse Osmosis rack F



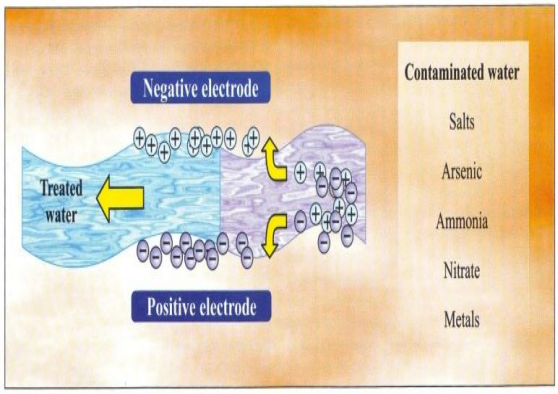


Figure 4 Major components of RO technology

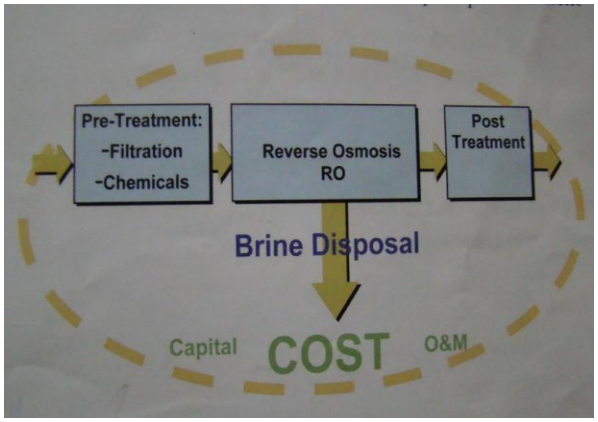
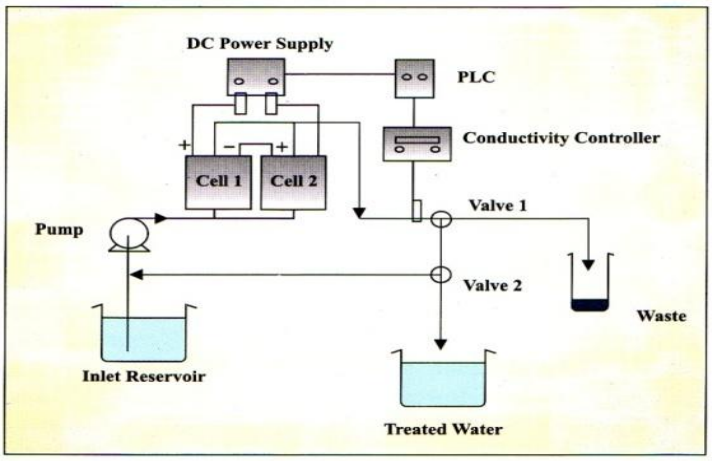


Figure 5 Steps of Reverse osmosis

XVI. CAPACITIVE DEIONISATION TECHNOLOGY

The electrochemical process called capacitive deionisation has been designed to remove ionic species form seawater, brackish water or contaminated groundwater. The main component of DesEL system is an electrostatic charging cell, which comprises carbon electrodes and acts as a capacitor (Figure 1). During the 1st stage of the process, the capacitor is energised using direct current, creating +ive and –ive charged surfaces.

Charge bearing species viz. heavy metals, ammonium salts, nitrates, fluorides, arsenic etc are attracted to and electrostatically adsorbed onto the surface of the electrodes. To regenerate the electrode surfaces, the polarity of the cell, is automatically reversed during stage 2nd, causing the capacitor to release the contaminants into the cell channels. The 3rd stage of the process is to remove the contaminants from the cell by flushing with a small amount of liquid, forming a concentrated solution.



This mode of operation allows the DesEL system to combine high water recoveries with high ion removal efficiencies. The operation potential is kept relatively low (~ 1.2V, 0-375A) so that no electrolysis reactions occur precluding breakdown of the capacitor material and the formation of secondary solid phases. In contrast with RO or ion-exchange systems, the DesEL system does not require softening or chloride removal pre-treatments. In addition, no chemical additives are required for pre-treatment or regeneration. The only pre-treatment required consists of 15µ pre-filter, which less costly than the 5µ pre-filters required for RO and ion-exchange systems. The energy consumption of a DesEL system decreases as the system capacity increases. Typically, the energy consumption ranges from 1.5 to 1.0kw/m^3 for systems treating 24m^3/day of water with initial TDS concentration of 10,000ppm. The results obtained by DesEL system indicate that this technology is more efficient and potentially more economical. The characteristics of this system exhibits high reliability and minimal maintenance requirements compared to conventional technologies (FIGure 1).Keeping in view the cost involved in defluoridating the water it is desirable that the defluoridation of water should be restricted to drinking water only. Hence the only economical and practicable choice left is domestic defluoridation. It is now desirable to test the various domestic defluoridation processes, especially in terms of acceptance by people without the need of any supervising agency and recommend suitable alternatives so that effective long-term implementation can be achieved.

XVII. CONCLUSION

The triumph in the fluoride and fluorosis mitigation achieved through persistent and consistent effects spanning over a period of 2 decades by scientists. From a variety of disciplines including the water sector and biomedical sciences across the country have made the proud. It is no small an achievement. It is the desire of very Indian that let the success achieved in the fluoride and fluorosis front be a model for those involved in dealing with other contaminants like nitrate, salinity, arsenic, heavy metals and pesticides, to be pursue a path, resulting in unquestionable victory. Several years of fundamental research on fluoride action on animal and human body tissues at the cellular and molecular levels generated a wealth of information and knowledge. The path breaking discoveries emerged through unconventional approach adopted for multidisciplinary investigations of both soft and hard tissues were a revelation. The true disease characteristics emerged, ted to early diagnostic procedures for the disease. Differential diagnoses of fluorosis from other disease with overlapping clinical manifestations become necessary. Simple tests with focus on assessing that poison levels in body fluids provided meaningful information. No sooner the disease could be correctly diagnosed at very early stages, it become necessary to eliminate / reduce the poison levels in the body fluids, leading to disappearance of health complaints that are non-responding to medication. What are the health complaints which are referred to?

First and foremost gastrointestinal discomfort with pain, constipation, nausea and loss of appetite should never be dismissed as casual. Low haemoglobin content (< 9 gm/ dl) should alert. Anaemia, depression, fatigue and muscle weakness are health complaints overlooked. It is equally important to be aware of excess thirst (polydipsia) and tendency to urinate more frequently (polyurea) can also be due to fluoride interfering with hormonal production which has adverse effects on kidney function. If any of the above health complaints is confirmed to be closed by fluoride poisoning require no medication except for practice of interventions. Withdrawal of the source (S) of fluoride entry to the body results in arrest of the progression of the disease and health complaints referred to above shall cease to exist. However, if speedy recovery is the aim, yet another intervention i.e. diet enriched by essential nutrients along with micro minerals (Zn, Cu, Mg and Se) besides vitamin C and E, and other antioxidants need to be promoted through fruits and vegetables. An enriched diet insures repair and maintenance of the damaged parts of the body, rise in haemoglobin and total recovery of the disease. It is a new era for practice of integrated disease management.

A patient of fluorosis if diagnosed correctly and early by the consulting physician and if the source of fluoride entry is through drinking water, then the responsibility lies on the Water Supply Agency to guide/ advise and direct the patient as to now to obtain 'safe water' for consumption. The intervention procedure dealing with enriched diet with nutrients and antioxidants shall be dealt with by the consulting physician. Monitoring the patient for complete recovery and assessing the impact of the practice of the interventions shall be of the responsibility of the hospital or the physician dealing with the patient. The Water Supply Agency (ies), till date have never practiced nor is aware how a patient is going to look-upon to the Public Health Engineer(s) for quality water for getting rid of the disease after obtaining the diagnosis of the disease from a physician. The present practice of indiscriminate supply of defluoridated water to the community leaving in an endemic area may not relieve those who are afflicted with fluorosis, as the fluoride entry to the body may be much more from the sources other than drinking water.

XVIII. ABBREVIATION

FRRDF (Fluorosis Research and Rural Development Foundation) ;NGO (Non Governmental Organization); OP (Oxidation Potential); UPSH (Uttar Pradesh); NEERI (National Environmental Engineering Research Institute); (EC (Electrical Conductivity); BMD (Bone Mineral Density); DST (department of Science & Technology); CSIR (Council of Scientific & Industrail resesrch); PHED (Public Health & engineering Department); VOC (Volatile Organic Compound); TDS (Total Dissolved Solid); WHO (World Health Organization); EU (European Union);RO (Reverse Osmosis); KRASS; SPANDS (4,5-dihydroxy-3-(p-sulphophenylazo) 2,7-naphtalene disulphonic acid trisodium salt); RWH (Rain Water Harvesting)

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