Original Article

International Journal of Dental and Health Sciences
Volume 03,Issue 02

A STUDY OF FLUOROSIS AND VARIOUS MEASURES TAKEN TO CONTROL IT IN RAJASTHAN

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ABSTRACT:

Fluoride is the most exclusive bone seeking anion owing to its affinity for calcium phosphate. Up to 99% of the body burden of fluoride is found in bone. Presence of fluoride in drinking water is both beneficial and detrimental to the consumer. Low levels of fluoride in drinking water results in incorporation of fluoride in to teeth during the formative years of children, which makes the teeth resistant to decay and development of dental caries. However, mottling of teeth may occur when the concentration increases more than 1.5 mg/l. Longterm intake of water containing excessive concentration in the range of 2 to 10 mg/l causes skeletal fluorosis, in which the bone structure is affected causing bone deformation and crippling joints and muscular pains, thus posing a serious health hazard. The states of Rajasthan, Andhra Pradesh and Gujarat are the states in which all the districts are endemic for fluorosis. A total of 62 million people of which (6 million children) are affected by fluorosis in India.

The state of Rajasthan contains almost half of the villages that have the highest levels of fluoride in the country. Most of the children living in these communities have yellow, stained teeth and their elders are mostly crippled. After the success of the UNICEF pilot project using domestic defluoridation units (DDUs) at household levels, the Government of Rajasthan in 2005 adopted this technology and implemented a similar project throughout the state called the Rajasthan Integrated Fluorosis Mitigation Programme (RIFMP).

Key words: Fluorosis, Fluorosis Mitigation Programme.

INTRODUCTION:

Ground water is the most appropriate and widely used source of drinking water and over 90 per cent of the drinking water demand is met by groundwater.

Fluorine, is necessary for human life. Fluoride exists naturally in water sources. Fluorine being the most electro-negative element and most active than any other ion has a great affinity for living tissues and more for bone . Fluorine in drinking water is totally in an ionic from and hence it rapidly and passively passes through the intestinal mucosa and interferes with metabolic activities of the living system.

Fluoride is widely distributed in soil, water, vegetation and sea foods. Groundwater sources such as dug wells, shallow and deep hand pumps may contain excess fluoride where minerals like fluorite, cryolite, biotites and fluoroapatite are present in rocks. The source of flouride in groundwater is mainly due to fluoride bearing minerals.

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It is present in the form of Fluorspar (CaF_2), Cryolite (Na_3AlF_6) and Fluoroapatite ($Ca_3(PO_4)_2Ca(F.Cl)_2$. The various stones present in Rajasthan are Calc Schist, Gneisses, Biotite Schist, Sandstone, Mica, Quartzite, Limestone Biotite, Amphibiotite etc. The water which passes through these stones has high fluoride concentration. Modern agricultural practices, involving fertilizers and pesticides also contribute towards the same.

Fluorosis is a worldwide problem .As per WHO 20 percent of the fluoride affected villages in the world are in India. Fluoride with high concentration in groundwater has been reported in 18 states of India. About 60 million people including 6.5 million children are affected with dental and skeletal fluorosis. In India, fluoride contaminated water is creating many health problems.

It is beneficial if its concentration is within the range of 0.5 to 1.5 mg/l. Low fluoride enhances the development of caries. Concentration below 0.5 mg/l causes dental caries, especially to the children. Concentration above 1.5 mg/l leads to dental and skeletal fluorosis. Thus, the fluoride concentration in drinking water is just like two-edged knife;both at higher and lower concentration it is not safe. About 96% of the fluoride in the body is found in bones and teeth. Fluoride is also essential for normal mineralization of the bones and formation of dental enamel.

The permissible limit of fluoride in drinking water as per **WHO** guidelines is upto **1.5mg/lt**, **IS:10500** is **1.5mg/lt**, **BIS: 006** is **1.2 mg/lt** and as per **ICMR** is **1mg/lt**. Excess amount of fluoride in drinking water leads to mottled teeth, dental caries, stiffened brittle bones and joints, metabolic disorders and even paralysis in advanced stages. The only remedy for the fluorosis is to remove excess fluoride from water. The various Deflouridation techniques are Nalgonda technique, Contact Precipitation, Bone Charcoal, Activated Alumina, Reverse Osmosis, Ion Exchange Methods and Electrodialysis. The INDION JALSHUDDHI fluoride removal process and Domestic Defluoridation Units(DDU) has been developed keeping in mind the problems of rural India with respect to lack of awareness, low literacy level and lack of skilled operators.

In view of above, A study was done to determine fluoride content in the ground water, to study its effect on dental and other problems and review the various measures taken by concerned authorities and in particular the Government of Rajsthan.

DESCRIPTION & ANALYSIS OF FLUOROSIS IN RAJASTHAN:

The state has extreme climatic and geographical condition and has minimum recorded rainfall of the country. Rajasthan suffers both the problems of quantity and quality of water. In most part of the state groundwater is either saline or has high nitrates and fluoride content.

Groundwater is the major source of drinking water and over 94% of the drinking water demand is met by it. The aerial extent of Indira Gandhi Canal System has been extended upto Bikaner.

Having no perennial surface source for drinking water, the state is dependent chiefly on groundwater and its level is going 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. Epidemiological factors like water chemistry, demographic, climatic, geological variations and nutritional profile of the community and high mean annual temperature of the area all contribute to the problem.

As there is an 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 in 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.

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. The fluoride concentration in water depends on porosity of rocks and soils, speed at which the water flows and complexation of fluoride with other ions such as Al, Be, Si, Ca, Bo, Iron.

The Anthropogenic Sources of Fluorides come next to Sulphur dioxide (SO_2) 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 (SiF_4). 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. 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 "the arid climate with high evaporations and insignificant natural recharge have accelerated the strengthening of fluoride concentration in the groundwater. 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."

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 {$Ca_3(PO4)_2$} in the bones. 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. Fluoride present in food is organically bound and is not toxic. The districts of Nagaur, Bhilwara, Jodhpur, Jaipur, Ajmer, Jaisalmer have high prevalence of dental and skeletal fluorosis.

The details of the Districts with various fluoride levels in ground water is given in Table 4

The Prevalence of dental fluorosis of various villages where fluoride level is more than the permissible limit (As per Deans Fluorosis Index) (Graph 1)

The distribution of various grades of fluorosis on various age groups shows the pattern shown in Graph 2

RAJASTHAN INTEGRATED FLUOROSIS MITIGATION PROGRAMME (RIFMP)

Implementing agencies:

Public Health Engineering Department (PHED), the local government body responsible for water pipeline construction installations and sanitation issues identified 23,000 hamlets with fluoride levels above 1.5mg/l.

Having a look at such a huge problem, the UNICEF initiated a small scale project in a district-Dungarpur where a Domestic Defluoridation Unit (DDU) unit was provided to all families at a nominal price. The NGO's were responsible for the installation, water testing and regeneration services of DDU's in all households. The NGO's were also responsible for organizing promotional activities such as wall paintings, slogans, dramas. A local facilitator, called animator was appointed to establish and maintain the DDU's, ensuring its use by motivating the local people, water testing and regenerating exhausted AA in approximately five hamlets.

Evidence of success led the Rajasthan government to initiate the statewide RIFMP.

The RGNDWM was given the task to assist local communities to maintain sources of safe drinking water,and ensuring the supply of potable water to the population.

As there was an increase in the coverage of water sources, the quality of water has decreased. A survey found 60 percent samples had unacceptable organic value, while 40 percent had coliform generally from feces. Around 80 percent of governments supply is dependent on ground water which is increasingly getting chemically contaminated. The National Rural Drinking Water Quality Monitoring and Surveillance Programme (NRDWQM & SP) is a large – scale programme under RGNDWM that was started to provide greater community access to clean drinking water. Its main objectives was to decentralized monitoring and surveillance of all drinking water sources in the state by the community; creating awareness among the rural people, building the capacities of the Panchayats to use the field test kit and take up full Operation and Maintenance for water quality monitoring of all drinking water sources in their areas.

PROJECT INTERVENTION:

RIFMP's mission is to provide safe drinking water to the community using four successive components.

DOMESTIC DEFLUORIDATION UNITS.

Firstly, Animators.

Secondly, Awareness.

Thirdly, Encourage villagers to use alternative/traditional water collection methods such as rainwater harvesting, since those were natural techniques in getting access to defluoridated water.

Finally, families would then have DDUs installed into their homes for use. RIFMP provided free DDUs to families living below the poverty line (BPLs) and charged a small fee for DDUs to families living above the poverty line (APLs).

The Programme was implemented in three phases based on the levels of fluoride found in the local water supply. Phase I included areas with a level of fluoride in the drinking water above 5.0 mg/l. Phase II, where the concentration of fluoride ranges from 3.0 to 5.0 mg/l, while Phase III worked in communities with fluoride levels from 1.5 to 3.0mg/l.

RIFMP Phase I started in March 2005 by covering 500 hamlets with a population of less than 100, and fluoride level more than 5 mg/l. In May 2006, the program was extended to 2,143 villages (regardless of size) in 12 districts. In Phase II of RIFMP, an expected number of 5,056 villages and hamlets were covered and the rest in Phase III.

MATERIALS AND METHODS:

Studies about RIFMP intervention were carried out keeping four main areas of concern.

Economic status: whether APL or BPL

Caste groups: SC, ST and Backward Class or other groups.

Geographic location: distance of village from district centres.

Awareness levels: meaning access to information about fluorosis, defluoridation techniques and other related project information.

Based on this definition of social exclusion, the team determined the research objective should be to document the outputs of the project in terms of awareness, access, quality, and delivery of services. The first was whether RIFMP was a socially inclusive project or not and if not, why not, whether all economic strata people were benefitting through it or not. Whether the socially backward classes like SC, ST and Backward Class have access to it or there is any discrimination and finally whether the location of village from the centre or distant to reach for animator has any bearing on the outcome of defluoridation in the concerned area.

The team began preparing for work by formulating a three-stage approach. The first stage involved a review and preparation of research activities like interviewing the PHED chief engineers in charge of RIFMP, and studying intervention, secondary data, evaluation. The second stage included a ten-day field visits where they visited villages over course of days to meet community members, undertake interviews with key actors and completed household questionnaires. The blocks and habitations were chosen using stratified random sampling technique from a list of villages. The third stage included an analysis and review of data and report writing.

RESULTS AND DISCUSSION:

There are several positive attributes to the project. The first line of attack is to reach out to the most isolated and smallest communities. Secondly, by assisting families that live below the poverty line the government has been successful in helping marginalized segments of society. The nature of the project encourages dialogue and collaboration between local government and local NGOs.

There are some challenges faced like division of families into APL or BPL. The categorization is based on national poverty line criteria, but it's not an accurate one. Many a times the division is influenced by the Panchayat members and local officers. Those APL families closer to BPL feel its unaffordable. Since the BPL families are getting free of cost, they do expect the same or wait till the next classification, or delay it expecting to get it free later.

Geographical exclusion existed in terms of distance between animators home and regeneration centres..The farther the village from animators house, the poor the results. The animator could not pay more visits there and they also couls not come to the centre for regeneration, repair or to change the filters.

There is no social exclusion among the different caste groups when it comes to social awareness activities implemented in the field. All castes within a village or hamlet are equally aware or unaware of Fluorosis and the benefits that a DDU will bring. There is greater usage and value placed on the DDUs in areas where there are higher levels of social awareness activities.

There was a question of sustainability because of closing down of regeneration centres and ending of contracts for NGO and animators which had a negative impact. It was also found that, the more the local governments (sarpanch,panch's) were involved, the better the response from villagers.

RECOMMENDATIONS:

The RIFMP project should be used as a model for future government projects. Having an animator located within the village will help beneficiaries to keep on top of all necessary check-ups for the DDUs. Provide them with incentives so they are motivated. Charge BPLs a small fee for the purchase of DDUs. This will ensure that they will value and take care of the device. Setting up grievance units like a suggestions/complaint boxes in villages. Another suggestion is to build the capacity of local leaders or self-help groups about fluorosis and regeneration, so they can keep track of those with fluorosis, deal with social marketing of DDUs and regeneration of AA.

The following are some recommendations for local NGOs:

APLs have not purchased DDUs as they do not understand its worth. NGOs to work as facilitators and help the community to make correct decisions based on informed choices. Again the animators can be given incentives for every DDU sold. This will motivate them to be more proactive in selling the DDUs. Levels of awareness has to be increased. Media/social marketing experts should to be hired to develop a social marketing strategy. Organize study trips for persons from villages at risk to meet with people that are severely affected. Encourage people who have benefited from the project to work as resource persons.

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TABLES & FIGURES:

Table 4. Detail of Fluoride Affected Villages in Rajasthan

S.No.	Name of District	Total Number of			No. of Villages/ Habitation Where F> 1.5			No. of Villages/ Habitation Where F> 3.0		
		Villages	Habitation	Total	Villages	Habitation	Total	Villages	Habitation	Total
1	Ajmer	985	952	1931	654	371	1025	352	232	584
2	Alwar	1946	2449	4395	537	342	879	155	68	223
3	Banswara	1431	3175	4606	293	551	844	35	60	95
4	Bharatpur	1345	549	1894	529	81	610	152	11	163
5	Barmer	1623	2780	4403	597	221	818	181	68	249
6	Bhilwara	1566	963	2534	678	318	996	392	227	619
7	Bikaner	580	366	946	84	2	86	7	0	7
8	Bundi	826	332	1158	42	9	51	3	0	3
9	Chittorgarh	2173	904	3077	115	48	163	14	9	23
10	Churu	926	199	1125	240	8	248	27	1	28
11	Dholpur	551	983	1534	142	157	299	22	18	40
12	Dungarpur	846	681	1527	127	225	362	30	55	85
13	S. Ganga nagar /Hanumangarh	4437	4190	8627	425	418	844	149	129	273
14	Jaipur/ Dausa	3140	7518	10758	1187	1795	3172	491	739	1230
15	Jaisalmer	518	1172	1690	300	184	484	96	65	161
16	Jalore	666	823	1489	369	107	476	115	45	160
17	Jhalawar	1448	124	1572	42	5	47	15	3	18
18	Jhunjhuinu	824	208	1032	96	3	99	15	1	16
19	Jodhpur	860	2801	3661	314	99	413	59	8	67
20	Kota / Baran	1881	288	2169	44	0	44	17	0	22
21	Nagaure	1374	1972	3346	778	147	925	322	42	364
22	Pali	904	651	1555	242	83	330	69	34	103
23	Swaimadhopur/ Karoli	1464	2191	3655	452	263	725	121	69	190
24	Sikar	931	2401	3332	331	471	792	125	144	269
25	Sirohi	446	92	544	176	5	181	43	1	44
26	Tonk	1019	881	1900	516	209	724	199	71	270
27	Udaipur/Raj Samand	3179	5561	8740	431	497	923	74	81	155

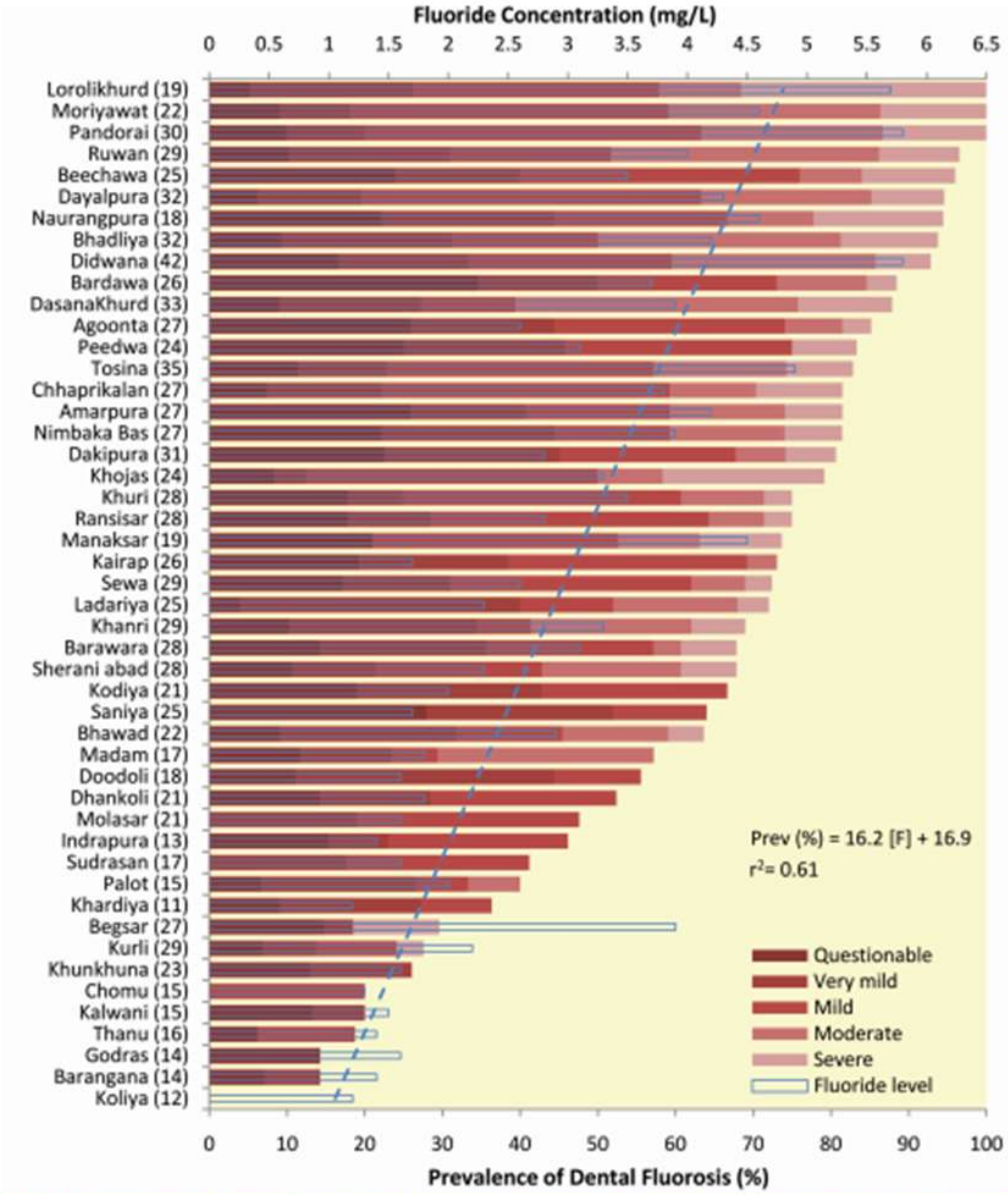
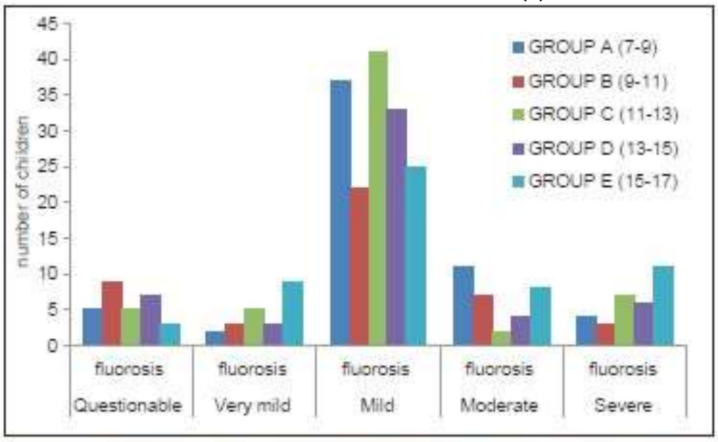


Figure 1: Prevalence of dental fluorosis in 48 villages where fluoride level in the water was >1 mg/dL (the red stacked bars) stratified by severity according to Dean's classification (Table 1). The number in parenthesis following each village represents the number of people studied in that village. The blue bars depict fluoride concentration in each village (use the top axis to read the values). The dashed blue line is the linear regression line with prevalence of dental fluorosis as dependent variable and fluoride concentration as independent variable.



Graph 2: Distribution of sample according to age group and grades of fluorosis

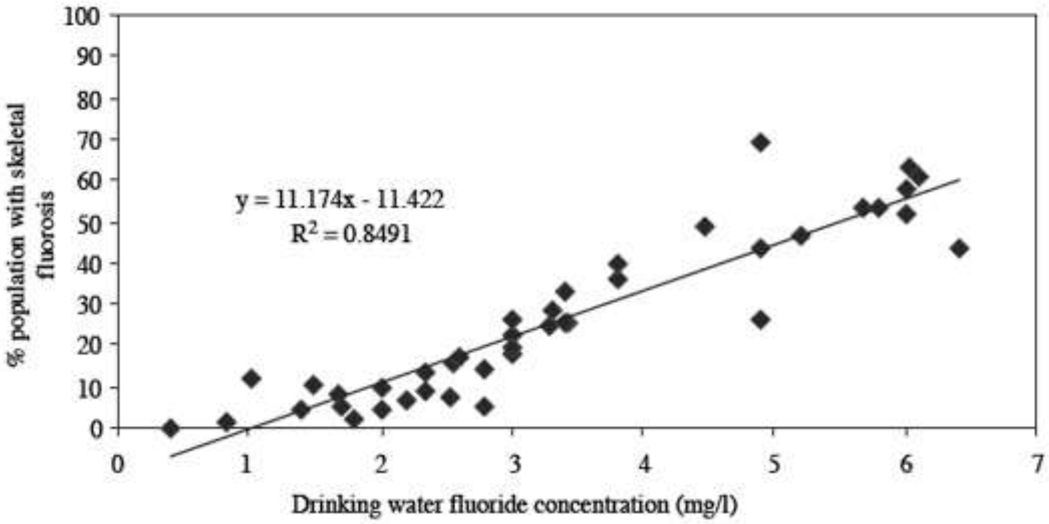
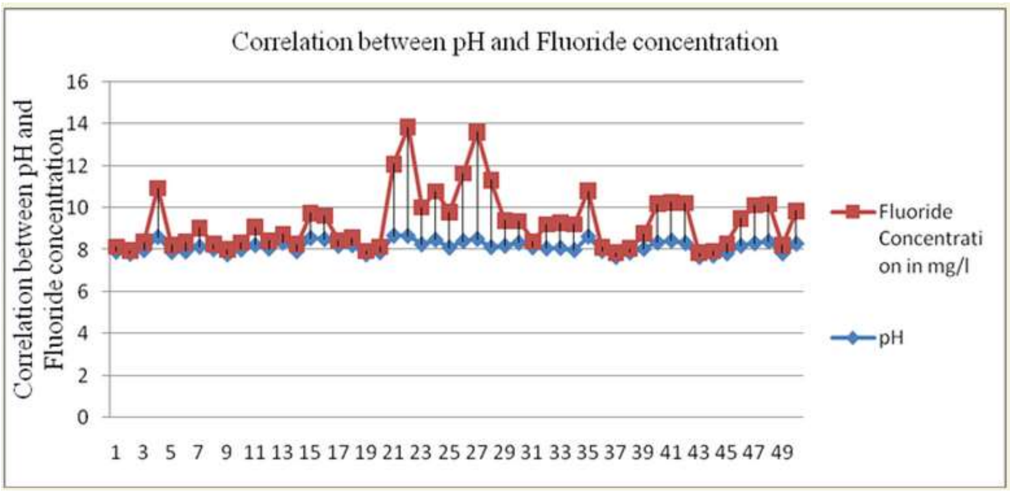


Figure 2 | Exposure-response relationship for skeletal fluorosis and reported drinking water fluoride concentration.



Villages having excess fluoride	Districts of Rajasthan (Drinking water sources having fluoride >1.5 ppm)
Up to 10%	Shri Ganganagar, Bundi, Kota, Chittor Garh, Jhalawad
10 to 20%	Bikaner, JhunJhunu, Udaipur, Dungarpur
20 to 40%	Churu, Sikar, Karoli, Dausa, Alwar, Jaipur, Bharatpur, Swaimadhopur, Dholpur, Banswara, Serohi, Badmer, Jodhpur, Pali, Ajmer
> 40%	Jaisalmer, Nagaur, Jalore, Bhilwara, Tonk
To be confirmed	Hanuman Garh , Rajsamand, Baran