

Impacts of Groundwater Contamination with Fluoride and Arsenic:

Affliction Severity, Medical Cost and Wage Loss in some villages of Indiaⁱ

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ABSTRACT

In India, high Fluoride concentrations in groundwater (greater than 1 mg/l – milligrams per litre) are widespread in the arid to semi-arid western states of Rajasthan and Gujarat and in the southern states of Andhra Pradesh, Karnataka and Tamil Nadu. A field research study conducted at 6 areas severely affected by Fluorosis shows that affordability of safer drinking water is related with higher income level and that the severity of Fluorosis affliction is higher for lower income levels. The cost incurred from medicines and loss of wages is a significant proportion of the earnings and has a general debilitating impact on the affected families. As compared with Fluorosis, the skin afflictions of Arsenicosis carry greater social stigma and incur higher costs on patients. In Nadia district in West Bengal, the impacts of Arsenic contamination are more severe with increasing age. Cumulatively over the entire afflicted population, both Fluoride and Arsenic contamination have a high cost on society and addressing the problem would require more attention from government agencies and society apart from individual awareness.

Key Words: Fluorosis, Arsenic, drinking water, social impacts

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INTRODUCTION

Fluoride and Arsenic are the two main contaminants in groundwater present naturally in India, China and Bangladesh in South Asia, causing a set of health symptoms known commonly as Fluorosis and Arsenicosis respectively. For many rural areas where hand-pumps and tube-wells are the only source of safe drinking water, these two contaminants have emerged to cause a serious crisis threatening public health.

Extant of Contamination

The Indian Ministry of Water Resources informs that several districts of 9 states are affected by high Fluoride concentrations (greater than 1 mg/l) in groundwater (Table 1).

However, this picture is far from being complete. Several districts of northern Gujarat like Mehsana and Patan, Dungarpur and Banswara in southern Rajasthan, and some districts in western Madhya Pradesh have now been found to have high Fluoride concentrations and newer areas are emerging from Assam (Das et al, 2003), Karnataka (Suma Latha et al, 1999; Wodeyar and Sreenivasan 1996) and Maharashtra (Babu et al, 2004). The cause of Fluoride in groundwater can be geogenic as well as anthropogenic. In most cases of natural geogenic presence of Fluoride in groundwater, Fluoride bearing minerals such as Apatite and Hornblende

are the sources. Groundwater, when exposed for long periods to such minerals leaches out some minerals, Fluoride being one of them. In deep groundwater currently mined from Mehsana, Gujarat, radioactive dating showed that this water was recharged 15,000-20,000 years ago. Long time exposure of such water to the underlying rocks causes high concentrations up to 19 mg/l in some areas (Gupta and Deshpande, 1998). Presence of high Fluoride in groundwater is therefore strongly linked to increasing exploitation of groundwater in some areas, especially the arid areas of Gujarat and Rajasthan. Apart from water, Fluoride can also be consumed through food grains for those whose staple diet included sorghum (*Jowar*) (Park, 2005, p467) or Black Salt in *daalmuth* and also from the use of Fluoridated toothpaste (Susheela, 2001, p 108).

Arsenic in groundwater is emerging as a widespread problem in the floodplains of the Ganges-Meghna-Brahmaputra (GMB). In India, many areas from West Bengal have been shown to be affected whereas Bihar is an emerging area with high Arsenic contamination (Chakraborti et al, 2003). Newer areas are suspected to be Assam, Arunachal Pradesh, Bihar, Manipur, Meghalaya, Nagaland, Uttar Pradesh and Tripura. Outside of India within GMB basins, the southern parts of Bangladesh are long affected from Arsenic just as in West Bengal. Some reports of Arsenic in Nepal Terai are also accumulating (Shresta et al, 2004). Within this larger region, there are pockets of villages that show very high concentration of Arsenic much above the WHO recommended safety limit of 10 µg/l (micrograms/litre). The Indian safety standard for Arsenic is 50 µg/l which is adopted by several other countries partly due to the possible perceived magnitude of the problem otherwise. A matter of possible surprise is that density of Arsenic present in soil is not much above that present in other regions of the world. It is the specific geochemical conditions that aid in the release of As (III) into groundwater. Arsenic release from sediments in South Asia is attributed mainly to desorption or dissolution of Arsenic from iron oxides. This happens mainly due to reducing conditions in aquifers below the

so-called redox zone or transition between oxidizing and reducing conditions a few meters below the water table. Here, the higher oxidized As (V) reduces to As (III) which is released into groundwater. The reasons for onset of reducing conditions are several: rapid burial of organic matter, high microbial activity or recent anthropogenic carbon. Some or all of these contribute to the reduction process and mobilization of As (III) which is then released into the relatively deeper groundwater that has low flow rates due to the poor hydraulic gradients in the Bengal basin. Other factors contributing to the release of As (III) is the possible competition faced by As (III) from high level of phosphates present in groundwater towards adsorption on the surface of Iron oxide. Such adsorption would demobilize the released As (III), otherwise. An excellent summary of current knowledge on Arsenic geochemistry in South Asia is a World Bank summary report (World Bank, 2005b).

Health and Environmental Impacts

Fluorosis is a crippling disorder due to entry of Fluoride in the body, which affects every organ, tissue, cells in the body, and results in health complaints having overlapping manifestations with several other diseases like gout and osteoporosis. In short, it causes Dental Fluorosis, Musculo-Skeletal Fluorosis. Fluoride damages the Pineal Gland, which secretes melatonin hormone in the brain. It also affects the reproductive systems and intelligence (Susheela, 2001). Many symptoms of Fluorosis are somewhat alike with other diseases such as Arthritis, osteoporosis etc. In villages, as told by the Medical Officers (during field surveys in Gujarat), it is very difficult to diagnose a patient properly, which requires analysis of X-ray, blood and urine by a good experienced doctor. Hence 'stamped' (the coined word used by the Government Medical Officers, Gujarat) cases of Fluorosis are not available. However, the presence of key

symptoms in people from areas that are known to be affected with high concentrations of Fluoride is a strong indicator of Fluorosis.

After several years of low level Arsenic exposure, various skin lesions appear. These are manifested by hyper pigmentation (dark spots like rain drops), hypo pigmentation (white spots) and keratosis (hardening of skin) of the palm of hands and sole of feet. After a dozen or so years skin cancers are expected. Arsenic can be transmitted not just by drinking water, but also by direct exposure to skin and hair (World Bank, 2005a). It also transmits through food grains and the possible transmit of Arsenic through summer (Boro) rice grown in the Bengal basin is an issue of debate (Duxbury et al, 2003).

Many existing studies on Fluoride and Arsenic have focused on the problem of mobilization of contaminants and some on the epidemiological aspects. Here, the focus on a broader level is to look at the impact of the problem on the society locally. In many of our field observations, we came across sole bread-earners of the family grounded due to the disease. Medical cost is a burden and above that there is decrease and in some cases an absolute inability to earn wages. This is enhanced by the stigma that these ailments carry and the general perception about them in rural areas, partly influenced by doctor's reluctance or ignorance in linking the symptoms with the cause. One important reason for hiding the ailment is also perceived genetic links amongst people, which affects marriageability amongst the youths. Some of these social impacts are measurable. Some others are intangible – loss in self-confidence, a self-enclosing of an affected pocket. What we see as common in both Fluoride and Arsenic contamination-related problems is the root cause of both, i.e. groundwater contamination and that these impacts are longer term as opposed to short-term ailments such as Diarrhoea that also emanate from water contamination. Thus, an attempt is made to measure these tangible components of

the social impacts of Fluoride and Arsenic contamination – those of medical cost and wage loss. Towards this, we proceed to first identify an affected population and measure the severity of ailment through a severity index. We attempt to see how this severity index is linked with various possible drivers – age, education, income, years of suffering etc. The cost for this affected population is measured through primary surveys.

A study of this kind was commenced in 2003 by IWMI-Tata Water Policy Programme (ITP), Gujarat, with details of villages in northern Gujarat and southern Rajasthan. Then, the same study was extended in 2004 to some more detail of the afflicted persons in affected villages. In 2005-06, a network of partner NGOs were identified from 4 other affected areas across the country for Multi-Location study by ITP, which were: Dausa (Rajasthan), Gadag (Northern Karnataka), Kolar (Central Karnataka) and Prakasam (Coastal Andhra Pradesh). The observations and analysis in this paper are arrived from the combination of these previous detailed studies of 2003-04 performed by the paper authors along with the more recent surveys conducted by our partners in 2005-06. The similar methodology of the study of North Gujarat and Southern Rajasthan has been applied along with another partner to Nadia district of West Bengal in case of Arsenic contamination. Though similar methodology is followed, this paper deals with the information of multi-location study area (mentioned above) for affliction severity, medical cost and wage loss due to Fluoride and Arsenic in groundwater.

OBJECTIVES AND METHODOLOGY

Objectives

The objectives of the study were as follows:

- a) Mapping of affliction severity
- b) Medical cost incurred by the afflicted families in treating the diseases

- c) Estimation of wage loss due to inability to work for affliction
- d) Understanding the awareness among the people about quality of water which causes Fluorosis and Arsenicosis

Research design and methodology

We have chosen villages that have been known as affected by Fluoride/Arsenic in groundwater and where there is significant occurrence of Fluorosis/Arsenicosis symptoms in the local people. This has been authenticated by obtaining fresh data on Fluoride levels or by using data from government agencies. These are the steps followed in our procedure:

Step 1: A survey of the village for basic information on family details and incidences of Fluorosis symptoms in order to choose the sample of affected people.

Step 2: Observation of all Fluorosis related symptomsⁱⁱ (Figure 8) of the affected persons and computation of the Fluorosis Severity Index (FIS).

Step 3: For affected people, getting data on medical costs spent in the last 1 year.

Step 4: For people unable to work partially or fully due to Fluorosis, getting data on past wage, current wage (if any) and possible wage currently (if there would have been no Fluorosis)

Note that there is no sampling involved in the study villages. We proceed from an exhaustive sampling and then choose those affected by Fluorosis for further study on costs involved in their ailment.

We define the FIS as:

$$\text{FIS} = \text{Total number of Fluorosis Symptoms used in the study} \quad (1)$$

(Here, we have taken the muscular and skeletal symptoms including Dental Fluorosis as symptoms for computing FIS)

$$\text{Wage loss} = \text{Wage loss of people unable to work at all} + \text{Wage loss of people who are partially able to work} \quad (2)$$

$$\text{Wage loss of people unable to work at all} = \text{Possible current annual wage from previous occupation} \quad (3)$$

$$\text{Wage loss of people who are partially able to work} = \text{Possible current Annual wage from previous occupation} - \text{Current annual wage} \quad (4)$$

We take averages of (2), (3) and (4) over the samples of affected persons to obtain the average wage loss due to Fluorosis. From the daily wage loss, we assume an annual number of working days of 100 for agricultural labor; for other occupations such as government or other service, and for business, we use the annual salary/income as reported. The costs calculation for medical costs is more straightforward and it includes the cost of doctor consultancy, medicines etc for the past one year.

Note that in the general context of social cost of Fluorosis, one would need to consider various other factors. With regard to wage loss itself, there is a cumulative impact of large proportion of affected population on the village GDP. Hard as it is to measure, we have not proceeded to explore this aspect in this present study. We have not explored the impact on cattle and then

onwards to milk productivity, draught potential etc. In our field studies, we have seen that there is a tendency to hide Fluorosis since it has a negative bearing on the marriageability of young men and women of that family. These and other intangible social costs were not added to the measurable medicine and wage loss costs that we have estimated here.

For Arsenicosis, we have followed a similar methodology as described above. The corresponding set of symptomsⁱⁱⁱ for Arsenicosis is mentioned in Figure 9. The methodology for medical and wage loss cost is the same as above. We use the similar expression for Arsenic Impact Severity:

$$\text{Arsenic Impact Severity (AIS)} = \text{Total number of Arsenicosis symptoms} \quad (5)$$

STUDY AREAS

This study has been repeated at several locations (herewith referred to as multi-location sites), namely, 2 villages of Dausa district, Rajasthan, 3 villages of Kolar, 2 villages of northern Karnataka, 1 village of coastal Andhra Pradesh and 1 village of Nadia district in West Bengal. Our partners located locally performed these multi-location studies.

Of all these sites, we have used data of all sites, except coastal Andhra Pradesh. These selected study areas of this paper are described in Tables 2 and 3 in detail. Gujarat and Rajasthan studies have been referred at required context. To note here that Gujarat and Rajasthan studies were conducted in larger areas in 25 and 35 villages respectively.

As can be seen from Figure 1, the main occurrences of high Fluoride in groundwater are in the western and southern parts of the country. In our studies, we have covered areas of medium to high concentration zones in each of these two zones. A similar analysis performed by other authors outside these two regions in Unnau district of Uttar Pradesh, (Saxena et al, 2006).

Note that the Arsenic study location in Figure 2, Nadia district lies within the Bengal basin, which extends into Bangladesh. Previously, the extent of Arsenic occurrence was supposed to be limited to the Bengal basin only, but with recent findings, the extent has been found to intrude into upstream areas of the GMB basin also. Studies of this sort are therefore needed in these other areas especially since there is scarcity of Arsenic studies on the social and economic dimensions of the problem (World Bank, 2005a).

INFERENCES FROM STUDIES

Fluorosis Studies

Fluorosis takes place after a long exposure to Fluoride-contaminated water. However Fluorosis also takes place if food intake contains fluoride, like black salt, black tea etc. (Susheela, 2001).

The acuteness of symptoms depends on the individual metabolism, nutrition, income, education, weather and socio-economic conditions of a locale. In this study there are three locations: one from Rajasthan – Dausa, and two others from Karnataka – Kolar and Gadag. Though similar is the affliction, the magnitude may vary from place to place, so to get a mapping of different locations, was one of the objectives of this study mentioned earlier.

Prevalence of Affliction

There are 1463 people from 281 households in these 3 selected study locations; of which 510 persons (35 per cent) are having at least one or more than one of the six symptoms mentioned earlier. Of these 510 people, 234 persons (46 per cent) exhibit 4 to 6 different symptoms showing the severity of the affliction, which is 16 per cent of the sample population of 1463 persons (Figure 3). Among the individual locations Gadag in Karnataka has the highest prevalence (41 per cent) of afflicted people. However the highest severity of affliction is found in Dausa, which is 58 per cent (Table 4).

Our studies as above, with the above methodology were first conducted in 2003-04 in 25 villages of Mehsana and Patan districts of northern Gujarat, and 30 villages of Banswara and Dungarpur districts of southern Rajasthan. In Gujarat, the prevalence of dental fluorosis was 36 per cent among children and adults of 28,425 study populations and 4590 (16 per cent) of the same population were afflicted by at least one of the 6 basic symptoms of fluorosis (Shah and Indu, 2004). In southern Rajasthan the corresponding figures were more than 65 per cent and 71 per cent in the study population of 6656 (Shah, Indu and Pandey, 2004). The 25 villages of Gujarat study in Mahesana and Patan districts were selected from a baseline study of Dr (Mrs) Vikas Desai (Desai, 1993). A prevalence rate was drawn from the census of these 25 villages in north Gujarat and FIS 1 to 6 was calculated. From FIS 1 to 6 we had selected 240 persons (men and women) whose FIS values were 4, 5 and 6 for a detail study of their medical cost and ability to work and loss of wages due to inability work (Shah and Indu, 2004). Whereas in the multi-location study we chose the afflicted persons from Fluoride contaminated village/s, calculated FIS and then studied the medical cost and wage loss particularly for those who were afflicted with FIS 4, 5, and 6.

Quality of Water

In these three locations of Dausa, Kolar and Gadag, the Fluoride content in water is from 1.8 mg to 12.0 mg/l. Fluoride content in the groundwater of Kolar and Gadag in Karnataka is found to be 1.8 mg/l and 6-10 mg/l respectively these are above the accepted level of 1.0 mg/l according to the Bureau of Indian Standard (BIS). Dausa in Rajasthan has reported 12 mg/l of Fluoride in groundwater. It is difficult to say when these figures were taken; however over a discussion it was said that the Fluoride contamination figures are almost same for the last 8 to 10 years may be with an unrecorded seasonal variation. One would need a more detailed monitoring to capture that aspect.

Income level of the locations

The people of all these three locations are very poor. The monthly income is Rs 412 per capita in these three locations. The poverty line income should be Rs 368 per person per month for rural India as of December 2005 (Guruswamy and Abraham, 2006) following Labor Bureau, GoI. However, this calculation is largely based on requirement of calories and obviously therefore there is hardly any provision for other essentials of life like clothings, electricity, fuels, and medical care or even for drinking water. One can therefore make a link that good nutrition, which is essential for developing resistance to Fluorosis, is a difficult proposition for these families. Thus these people are living with an income very close to poverty line.

Age and Severity of Sufferings

The severity of Fluorosis affliction is shown as FIS, which is explained under methodology. Looking to the age-wise affliction of fluorosis, it is found that more than 53 per cent people of the total sample population from all three locations is suffering from at least one of the symptoms of 1 to 6 between the age group of 16 to 40 years irrespective of their gender and 40 per cent is in the age group of 41 to 60 years (Figure 4). The people from 16 to 40 years of age are the most productive for contributing to economic development of the village as well as for the country. The details regarding age and affliction are given in Table 5 for all locations. With the pace of time, these people could become less and less active and lose their regular income – through wages. Gradually the total income or the Gross Domestic Product of the village/s gets reduced. In these three locations about 90 per cent people are suffering from the productive age group of 16 to 60 years.

Years of Sufferings

We found that the people are suffering from 1 year to 15 years in fluorosis and lastly become crippled – become immovable, some may suffer further of cancer etc. But which age group people are suffering more and how long? To understand this we have taken persons who are afflicted and impact is high like FIS 4, 5 and 6. Of the 510 afflicted people 234 (46 per cent) are found to be suffering by FIS (4 – 6) in all these location. The affliction of FIS (4-6) is found highest of nearly 58 per cent in the age group of 41 to 60 years, who were suffering from fluorosis for the last 6 to 10 years (Figure 5). Our study data were collected for one time and for the previous year/s, so it is difficult to say whether the same person is moving along his/her age group with the years of suffering. It is a static data therefore it gives a one-time scenario – what is at present, a snap shot. However there are people who are suffering more than 11 years in the

lower age group between 16 to 40 years. There are persons suffering for the last 2 years in the age group of 16 to 40 years. If there is no change in the quality of their drinking water or in nutrition these people may sooner or later lose their capacity of working and in the long run lose their income.

Family Income of the Persons

Income levels are one indicator of Fluorosis severity. Low-income levels imply poor nutrition, and less chance to access good quality water therefore, there is higher risk to Fluorosis affliction. This hypothesis is affirmed by Figure 6 in which we present the proportion of low/high severity Fluorosis patients for each income group from low (Rs.1 – 1000/month) till high income (Rs. 5000/month). We define here low Fluorosis severity as FIS = 1, 2, 3 as FIS (Low) and high severity as FIS = 4, 5, 6 as FIS (High). There is a clear trend of proportion of high severity FIS decreasing with increase in family income and vice-versa for low severity FIS (Figure 6).

One can infer from this that income has some positive role to distance the severity of fluorosis by taking some kind of health care like using coping mechanism for purifying water with different kinds of filter available in the market or with good supplementary food enriched in vitamins and proteins. People of higher income group can afford to have domestic filter to treat water or can buy safe package drinking water though the instances in these locations are very few. In one of our North Gujarat study mentioned above we found that the users of packaged drinking water or domestic filters are from higher income group of Rs 15000 per month or more (Indu, 2002). However in these study locations – SWACH in Banswara, Dungarpur and Dausa in Rajasthan, and BAIF in Karnataka have introduced subsidized filters of Activated Alumina.

These filters are effective but it requires regeneration of crystals for which service outlets are sparse, and neither do many people take this pain to regenerate. Moreover, it is said that the efficiency of the Fluoride removal decreases with regeneration and it require 50 litres of water to regenerate 5 kg of AA and the service charge is from Rs 10 to Rs 20 per regeneration, which many of them can not afford.

We adduce the following reasons for high FIS-low income relationship (Figure 6):

1. Greater poverty could be the reason for poorer access to safe water and good nutrition; hence greater risk of Fluorosis and high FIS
2. High affliction with Fluorosis, i.e. high FIS, could be the cause for lower wages, therefore lower family incomes
3. The two factors of: a) high FIS-high age (Figures 4 and 5) and b) high age-low income (from our primary field data) can inductively deduce the relationship of high FIS-low income that is observed here. So, high age probably acts as the linking variable between high FIS and low income. It is not possible, however, to confirm this causal link from just these observed relationships.

Description of Education

Among the victims of FIS (High), of all these locations nearly 69 per cent people do not have any formal education. Therefore unlike Gujarat, here education has not played any major role to prevent affliction, which we found in Gujarat study (Shah and Indu, 2004) – that is afflicted people were found less among the higher education group in Gujarat.

Medical Costs and Wage Loss

The medical expenses and wage loss were computed using equations (2) through (4) show (given under Methodology) differences across the sites (Table – 6). We also compute the relative effect of Fluorosis medical cost as proportion of family income = Average annual medical cost of Fluorosis in family / average annual family income = (average per capita medical cost * average afflicted persons/family)/ average annual family income.

Table 6 shows that Kolar has the maximum medical costs (Rs. 2807 annually) while north Gujarat's Fluorosis patients spend Rs 861 per person in a year, which is 26 per cent of their family income for medical expenses. The medical cost for Gujarat is of the year 2003. There is a hike in medicine price during the last three years and also in the wage rates. The Dausa families spend the lowest proportions (6 per cent) of their family incomes towards medical expenses. But these medical expenses are over and above the already experienced wage loss due to Fluorosis. These wage losses also mask the medical expenses in terms of the relative magnitude. In this case, we find that though Dausa patients spend the lowest proportion of their income for medical expenses, they relatively suffer the maximum wage losses. We would like to bring it to the notice that there may be some hike and hide in the figures of income here, which is human nature and we tried to resolve it from the general observations of the villages.

In Table – 6 we see that the per person medical expenses was much higher in compare to Gujarat (2003) and also the wage loss. The reasons are:

- (a) Hike in medicine price, doctor's fees and other accessory treatment like physiotherapy etc.

- (b) In some cases, it is possible that the medical expenses were incurred due to other diseases apart from fluorosis such as typhoid or malaria. During the reference year of this study there were some such cases found in Kolar and it was not possible segregate strictly the fluorosis and other disease expenses.
- (c) The wage loss is calculated on the basis of current wage rate. The current wage rate has been increased nearly by 50 per cent from the past 3 years.
- (d) One more reason that it is natural tendency among the respondents to declare their expenses and loss in wages high, understanding that they may get some relief amount from the government. However there are genuine cases also like in some villages of Gadag district in North Karnataka, a village goldsmith's used to earn Rs 10,000 per month approximately, who is suffering from fluorosis for the last 5 years – and can not work for the past 5 years. His high income has been reflected in the average figure in Table – 6.

Combining all these together, the calculated average figure of medical expenses and wage loss are shown in the Table 6.

Perception about Fluorosis

Our survey reveals that the affected people are highly aware about the cause of the Fluorosis symptoms they suffer from and also the personal and social impacts of these. From Figure 7a and c, we see that there is high level of awareness linking water quality to Dental and Skeletal Fluorosis. This is commonly observed across all study sites. That Dental Fluorosis results in loss of confidence amongst youth, especially for girls is generally agreed upon (Figure 7b), so is the fact that Skeletal Fluorosis leads to a social alienation amongst the affected persons (Figure 7d). Moreover, people feel that till a mild level of severity, the symptoms are reversible (Figure

7e) whereas the more severe symptoms are not reversible even with good quality water or medicines (Figure 7f).

For illustration of total study consider these two women of Gadag of North Karnataka area:

(A) A 26-year old women with monthly family income Rs. 3500-4000. She was diagnosed with Fluorosis 2 years back and experiences two symptoms: cannot do sit-ups or sit and walk easily. In our severity criterion, she has an FIS of 2. She had a daily wage earning of Rs. 30 and is now unable to work for the past 1 year because of Fluorosis-related immobility. Already, she spent Rs. 250 annually for medical expenses related to Fluorosis.

(B) A 50-year old women with monthly income of Rs. 2000-2500. She was diagnosed with Fluorosis 10 years back and experiences two more symptoms above the earlier patient, i.e. cannot touch chin easily or bend forward. In our severity criterion, she has FIS = 4. She has been unable to work for the past 8 years. She is no longer spending any more on medical expenses related to Fluorosis.

Looking from above persons (A) and (B) illustration, would we expect (A) to reach the level of Fluorosis severity and related problems as for person (B) at the age of 50?

Arsenicosis Studies

The location of Arsenocosis patients was from Dasdia Nonaghata village in Nadia district of West Bengal. The Arsenic Impact Severity (AIS) levels for the affected persons in this village we found larger number of people have medium severity up to AIS 1 to 3. However, here, we do not see more severity with more years of suffering. This aspect needs to be understood better with a check back on the field and to see if there are concrete reasons to expect this kind of behavior. Table – 7 shows the basic picture of the AIS of the study village and cost calculations for Arsenic afflicted persons. About 90 per cent of the total 107 people are suffering from the

age group of 16 to 60 years, the most productive age group; of them 54 per cent are from the age group of 16 to 40 years (Table – 7). Here, we see a low average annual medical expense of Rs. 969. This is due to poor affordability of medicines and the general ineffectiveness of medicines in ameliorating the disease. The wage losses, however, are high, especially for this poor area. These two costs combined therefore increase the burden on the affected population.

Per capita medical cost was calculated for the people who had reported medical expenses and not for all the afflicted people of the sample. If the medical expenses are divided by the all afflicted people then obviously it will show less amount which would be divided over the people who had not spent any medical expenses in the reference years.

Similarly, per capita wage loss was calculated for the persons who have actually lost wages due to their affliction and reported during in the survey. These figures related to the income, medical expenses and wage loss is not abnormal in that area, we have verified by the principal investigator. About medical costs, it may be said that the break up of the expenses was not taken and none could tell at this stage about what was the expenses for medicine, pathological tests and Doctors' fees etc specifically for Arsenicosis alone. Almost a similar kind of reasons received from West Bengal also as we have found from Kolar, Gadag and Dausa that the same afflicted person might have suffered by some other diseases where the segregation of expenses was not possible to that fine level. Therefore some the expenses shown may be a bit mix one.

SALIENT POINTS AND SUGGESTIONS

This study has been performed in some severely affected pockets of India where contamination of groundwater with Fluoride or Arsenic has affected a majority of the local population. Being

poverty stricken, these areas are also not able to cope with the problem and unless they migrate out of the area, they have to stay and suffer. Apart from high medical expenses, they also suffer from wage losses due to inability to work. In the Fluoride affected areas, our data shows that for these villages, 35 per cent people are affected by at least one symptom of Fluorosis. When we categorize the affliction into different levels of severity, we find that 16 per cent of the population is severely affected in these villages. We find that most of the affected people are just above the poverty line or below as is true for the majority of people of these villages. Poverty is linked with poor nutrition, which makes people more prone to Fluorosis problems. The proportion of patients suffering from high severity Fluorosis decreases with increase in family income. Looking at the age distribution of the affected people, we find that the working-age group of 16 - 40 seems to be most highly affected.

We find from our studies that there is a high medical expense on Fluorosis ranging from 6 per cent to 25 per cent of the annual income of the affected families. This is above the already existing wage losses due to the affliction, which can be more than Rs. 10,000 per year on average.

In rural India where marriage is negotiated on the basis of family's health and social status, Fluorosis in an early age matters strongly – we see that at least 25 per cent of affected people are below 30 years of age. We have observed several cases in Rajasthan where young girls look middle-aged, or even older. In the North Karnataka study area, people do not even like to express that they were suffering from some pains which might have caused by Fluoride. Our local research-partner had inquired with the local village medical shop and found that the shop used to sell more than 200 tablets of painkillers in a day. She re-visited the village and discovered that people were afraid to declare their pain due to impending daughters' marriage.

If the daughter is not getting married or married after a long time – who is going to bear this extra burden of cost in the family? How does one measure these intangible expenses?

The Arsenic problem is even more critical because of the nature of afflictions. Here we had focused our study on just one village, which was highly affected – 90 per cent of the population had some symptom of Arsenicosis. Again here, the most productive age group is highly affected. Due to the high poverty here, combined with ineffective medical treatment for the symptoms, the medical expenses are lower. This combined with the lack of any appropriate treatment system for Arsenic removal, is creating a sense of defeat amongst the sufferers.

In both cases, for Fluoride as well as Arsenic, already poverty-prone, these families are unable to afford any water treatment systems that can provide them safe quality water. Interventions also from government and NGOs on this front have not had much success apart from a few bright spots. Community-based water treatment programs have not had much acceptance. For Fluoride, a range of filters from Nalgonda-technique to Reverse Osmosis have come and gone, but the problem still remains. This persistence of condition has led to severe distrust among people for any new interventions, therefore making such efforts even more challenging.

Hints for Interventions: Salient Points Emerging from Studies

There are at successful and unsuccessful stories of intervention by NGOs in the Fluorosis affected locations, such as the intervention of Bharatiya Agro-Industries Foundation (BAIF), Sanitation, Water and Community Health (SWACH) in Rajasthan and Mytry-Defluoridation filter technologies in Andhra Pradesh. The interventions of NGOs have played a good role in some of the locations, like in Rajasthan (SWACH) or in Andhra Pradesh (Mytry), however the continuation or maintenance of the filters remain on the self motivated endeavors of the people.

As a result, public counseling and developing public motivation may be needed to bring in a long-term effect for reducing the menace of Fluorosis. They also should be aware of their food habits and be informed about the staple food, which contain more Fluoride and which contain less. The local medical practitioners should also take care to counsel about antioxidants required to avoid the effect of Fluoride, or to administer proper requirement of Calcium to people, who be affected by excess Fluoride either in food or in water. Such comprehensive programs are currently in development in some districts of the country such as at Kolar, Karnataka.

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TABLES

Table 1: Districts Affected with high Fluoride concentrations

Kerala	Palaghat Krishna, Ananipur, Nellore, Chittoor.
Andhra Pradesh	Cuddapah, Guntur and Nalgonda
Gujarat	Banaskantha, Kutch & Amreli
Haryana	Hissar, Kaithal & Gurgaon
Orissa	Bolangir, Bijapur, Bhubaneshwar and Kalahandi
Punjab	Amritsar, Bhatinda, Faridkot, Ludhiana & Sangrur
Rajasthan	Nagaur, Pali, Sirohi, Ajmer & Bikaner
Tamil Nadu	Chengalput, Madurai
U.P.	Unnao, Agra, Aligarh, Mathura, Ghaziabad, Meerut & Rai Bareli

Source: Ministry of Water Resources, GOI, <http://www.wrmin.nic.in>

Table 2: Fluorosis study areas: Some details

Location	Distance from nearest city	No. of sample families	No. of afflicted/ Total people	Fluoride Conc.: mg/l	Notes
Hingotiya, Nagal Govind villages, Dausa, Rajasthan,	9 -12 kms	71	94/389	12.0 mg/l	No packaged drinking water in use. 28.6 per cent families use AA filters given by SWACH. Poor regular regeneration of filters.
Srirampura, Guttapalya and G. Cherlopalli villages of Bagepalli Taluka, Kolar District	40 kms	110	189/513	1.8 mg/l	Only 5 families using home made filters in this area
Hirevaddati and Kalakeri villages, Mundargi Taluka, Gadag district, North Karnataka	8 kms	100	227/561	6-10 mg/l	Only 16 per cent families are using de-fluoridation filters or other simple method of filtration in this site
Marripudi village, Narsapuram taluka, Prakasam district, Coastal Andhra Pradesh	12 kms	59	112/273	20 mg/l	-no special notes-

Source: Primary survey in present study

Table 3: Arsenicosis study area

Location	Distance from nearest city	No. of sample families	No. of afflicted/ Total people	Arsenic Conc.: µg/l	Notes
Dasdia Nonaghata village, Nonaghata Taluka, Fotepur, Nadia district, West Bengal	25 kms	70	107/339	0.5-10 µg/l	Notes: 33 per cent families are using filter for removing Arsenic

Source: Primary survey in present study

Table – 4: Households, Population and Prevalence of Affliction in Three Locations

Locations	Total HHs	Tot Pop	FIS All	per cent of FIS (1-6) to Tot Pop	FIS (4 – 6)	per cent of FIS (4 - 6) to FIS (1 - 6)	per cent of FIS (4 - 6) to Tot Pop
Dausa	71	389	94	24.16	48	51.06	12.34
Kolar	110	513	189	36.84	110	58.20	21.44
NK	100	561	227	40.46	76	33.48	13.55
Total	281	1463	510	34.86	234	45.88	15.99

Source: Primary survey in present study

Table – 5: Afflicted People with FIS (1-6) by Age Groups in All Locations

	Age 1-15	Age 16-40	Age 41-60	Age 61 +	Total
Dausa	0	50	39	5	94
Dausa	0 per cent	53 per cent	41 per cent	5 per cent	100 per cent
Kolar	7	103	72	7	189
Kolar	4 per cent	54 per cent	38 per cent	4 per cent	100 per cent
NK	3	119	94	11	227
NK	1 per cent	52 per cent	41 per cent	5 per cent	100 per cent
Total	10	272	205	23	510
Total	1.96	53.33	40.20	4.51	100.00

Source: Primary survey in present study

Table 6: Comparison across sites: Fluorosis Medicine and loss of wage calculations

	North Gujarat (in 2003)	Dausa (in 2005)	Kolar (in 2005)	North Karnataka (in 2005)
Per capita annual Medical cost	Rs. 861	Rs. 1489	Rs. 2807	Rs. 1724
Per capita annual Wage loss	Rs. 4593	Rs. 11524	Rs. 8719	Rs. 12008
Afflicted no. per household	1.1	1.3	1.7	2.3
Medical expenses on Fluorosis as proportion of household income	26 per cent	6 per cent	21 per cent	16 per cent

Source: Primary survey in present study

Table – 7: Arsenicosis medicine and loss of wage calculations

Dasdia Nonaghata village in Nadia district, West Bengal	
Total no. of Households in the sample	70
Total Afflicted People	107
AIS (1 to 4) Persons (no AIS 5 and 6)	107
Per capita monthly income (Rs)	302
58 Persons are from 16 to 40 years of Age	54 per cent
38 Persons are from 41 to 60 years of Age	36 per cent
Men folks are more afflicted – 70 persons	65 per cent
56 persons are suffering from 3 to 10 years	52 per cent
Medical cost (annual) (Rs)	969
Wage loss (annual) (Rs)	12629
Afflicted no. per household	1.5
Expenses on Fluorosis as proportion of household income	7 per cent

Source: Primary survey in present study

Figure 1: Study areas for Fluorosis Impact studies

Source: CGWB website <http://cgwb.gov.in>)

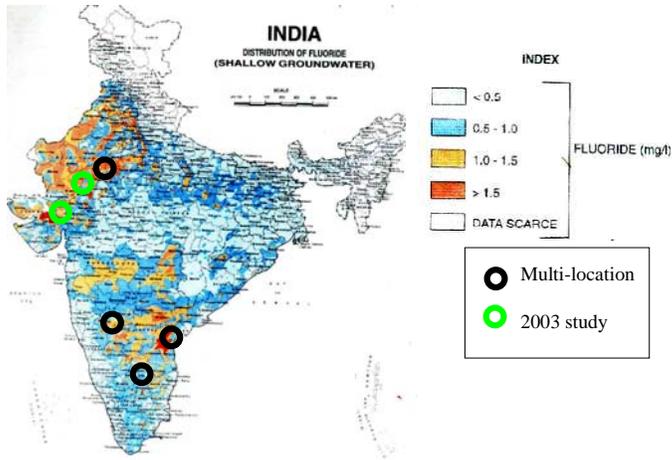


Figure 2: Study area for Arsenic Impact study.

Source: Jadavpur University URL <http://www.soesju.org>

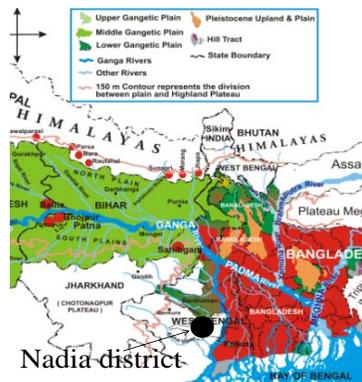


Figure 3: Percent of afflicted people in sampled population and severity of affliction

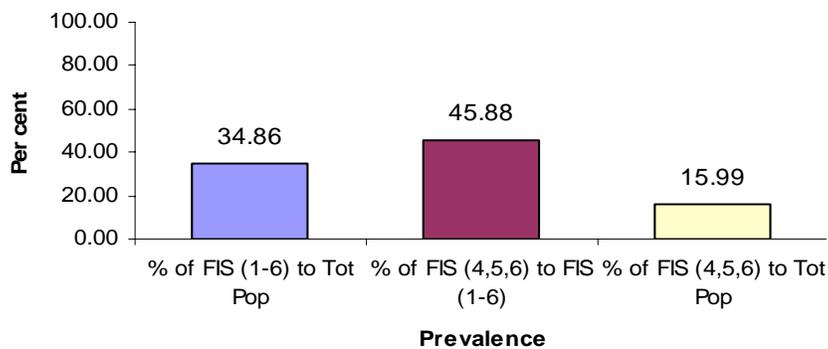


Figure 4: Percent of total afflicted people (FIS = 1-6) for all locations by age group

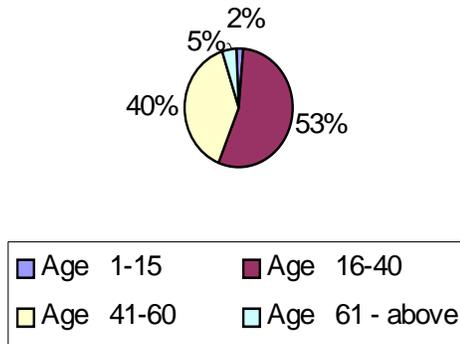


Figure 5: Years of suffering by age group in all locations

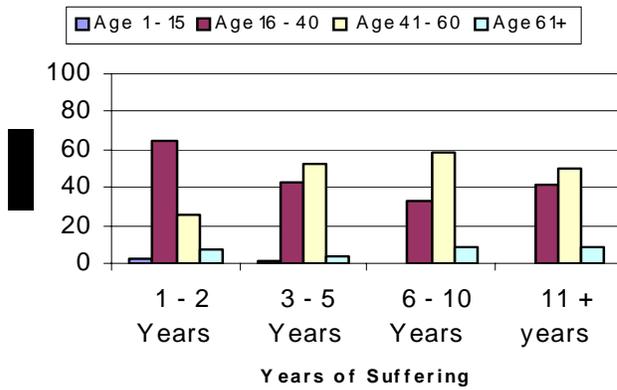


Figure 6: Percent of FIS (low) and FIS (high) by monthly income in all locations

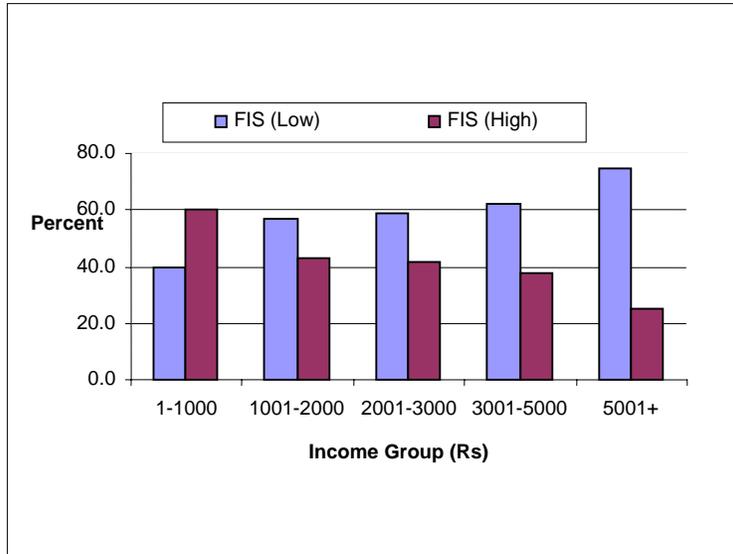


Figure 7: Comparison across sites: Perception of people towards water quality and Fluorosis

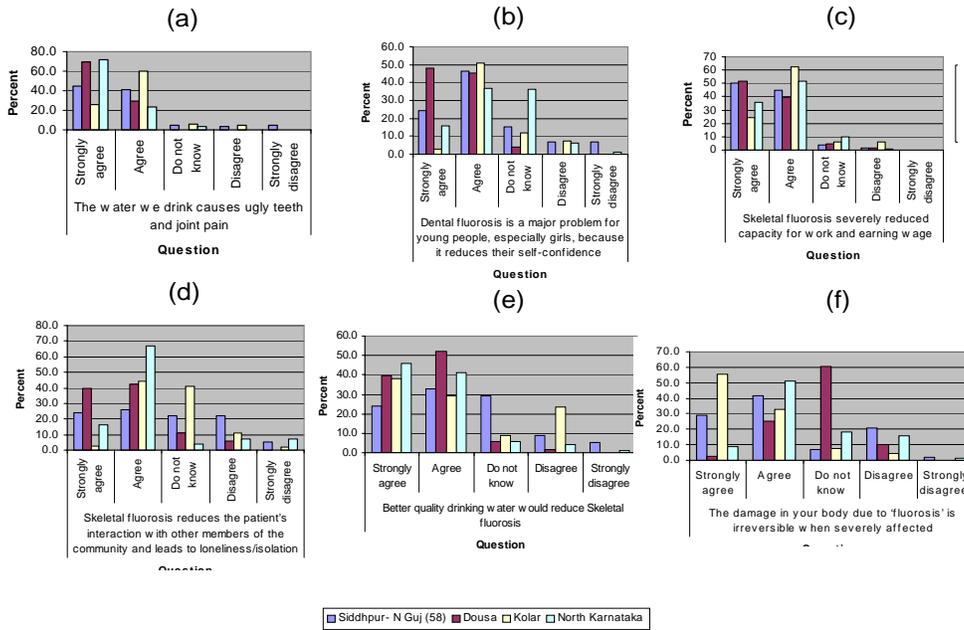


Figure 8: Fluorosis Symptoms from Susheela (2001)

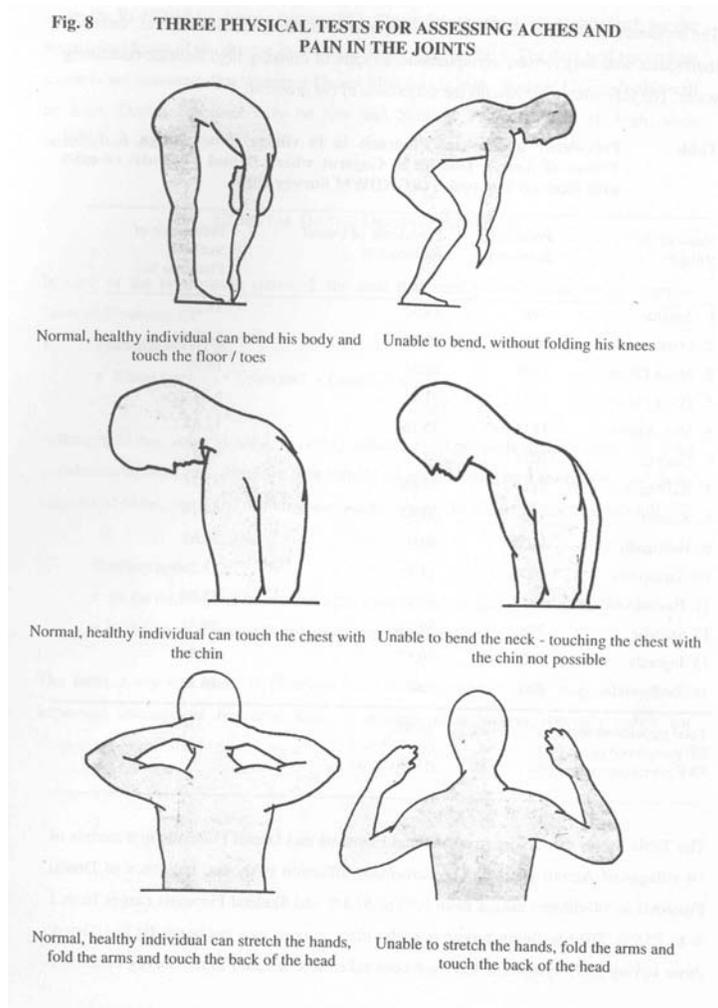


Figure 9: Arsenicosis Symptoms used for Identifying Patients

1. Do you find any spot on your body? (Keratosiis)
2. Are your palms and/or foot turned stony? (Melanosis)
3. Are you suffering from breathing trouble?
4. Are you suffering from stomach problem?
5. Are you suffering from malignancy (cancer)?

NOTES

ⁱ We thank Mr Yatesh Yadav, PRADAN, for Dausa, Rajasthan; Mr Thomas Abraham, FES, for Kolar, Karnataka; Ms. Radha Nagraj, Swaraj Foundation for Gadag, North Karnataka; Mr G Muralidhar Akshara, Network for DSS, for Prakasam, Coastal Andhra Pradesh; Mr Parthasarathi Banerjee, Kolkata, for Nadia, West Bengal studies, and also Mr. Ajay Pandey, PROGRESS for participating in our studies conducted at their respective locations. We also thank Dr. Vikas Desai, Surat Medical College who had done initial studies on Fluorosis in North Gujarat areas.

ⁱⁱ (1) Dental Fluorosis, (2) Can they touch chin with chest easily? (3) Can they bend forward easily? (4) Can they touch back of head by two hands easily? (5) Can they do sit-ups easily? (6) Can they walk or move easily? (Susheela, 2001)

ⁱⁱⁱ (1) Spots like raindrops on body; (2) Palms and/or foot turned stony; (3) Suffering from breathing trouble; (4) Suffering from stomach problem; (5) Suffering from malignancy (cancer). These are some basic initial symptoms, which we have collected from doctors at the School of Tropical Medicines in Calcutta.