Study of dental fluorosis in subjects related to a phosphatic fertilizer plant environment in Chhattisgarh state

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Through a local dental clinic 32 exfoliated human teeth samples related to 32 persons of a phosphatic fertilizer plant environment were collected from two categories, workers of the plant, and non-workers but residents of the plant township area. For comparative study, seven exfoliated teeth samples from uncontaminated subjects were also collected. Other environmental receptors like, air, water and soil samples of the study were also analyzed for fluoride content. Plant workers have shown a higher presence of fluoride in their exfoliated teeth compared to non-worker and uncontaminated category. Levels of fluoride content were found to be: worker category, 248-8891; non-worker category, 259-4852; and, uncontaminated category, 35-157 µg/g of dry weight of teeth samples.

Keywords: Dental fluorosis, Fluoride, Particulate matter pollution, Fertilizer plant

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Introduction
Fluorosis is a serious health problem caused by ingestion of fluoride in excess through air, water and food. Fluoride is prevalent in about 22 countries, of which, India, Pakistan, Bangladesh and Sri Lanka are in SAARC region. The disease is wide spread in 15 Indian states affecting about 25 million people1. Based on field studies, endemic fluorosis is recognized as a public health problem in these states. Survey conducted during 1991-93 under Rajiv Gandhi National Drinking Water Mission (RGNDWM), 7,228 excess fluoride and 3,977 saline inhabitation were identified in different states 2.

Higher concentration of fluoride (up to 74.6 µg) in respiratory tracts washouts of residents and workers in the age group of 25-60 years of phosphatic fertilizer plant and its township area has also been reported3. Chronic fluoride intoxication (Fluorosis) has been observed in villagers and animals of Udaipur district of Rajasthan where drinking water contains 0.3-7.0 mg/l fluoride4. The prevalence5 of dental caries is negatively and dental fluorosis is positively correlated with fluoride concentration in the environment and also fluoride content in teeth samples has been found to be (dry weight basis): Bhilai region, 225-2890; Shillong region, 160-595; and, Delhi region, 3-52.5 µg/g. Fluoride levels in drinking water (0.39-3.5 ppm), have been correlated with dental fluorosis with fluoride levels in drinking water6. Health hazards have been associated with fluoride population near industrial sources. Dust pollution from phosphate mines is the cause of extensive dental fluorosis in several hundred children living within 1-1.5 km area of the mine7.

The present work was undertaken to evaluate the concentration of fluoride levels in the exfoliated human teeth samples obtained from 32 subjects and their relationship with the fluoride levels of different environmental receptors like air, water and soil. The subjects were either workers of the phosphatic fertilizer plant and/or residents of its adjoining areas within 5 km distance from the plant located in Chhattisgarh state, India. For comparison purpose, teeth samples from uncontaminated subjects who were residing more than 100 km away from any fluoride emitting industry were also collected.

Materials and Methods

Sample Collection
(A) Teeth Samples
Through a local dental clinic, 32 exfoliated teeth samples from 32 persons (18 males, 14 females) of a
phosphatic fertilizer plant and its environment were collected during January–May 2002. Age, sex, location of residence with respect to the plant were also recorded. The subjects were divided into three categories:

(i) Workers of phosphatic fertilizer plant;
(ii) Non-workers but residents of the fertilizer plant township area; and
(iii) Uncontaminated subjects.

These categories were further divided into male (21-81 y-old) and female (14-71 y-old) categories. For comparative study, 7 exfoliated human teeth samples from uncontaminated areas were also collected from 7 males living more than 100 km away from any industrial units for category-III (Table 1).

(B) RSPM Samples

Samples of Respirable Suspended Particulate Matter (RSPM) were collected using Respirable Dust Sampler (RDS, Envirotech make APM 450) at six selected sites around the fertilizer plant. Three sites (at 2, 4 and 7 km from the plant) were decided at prevailing wind direction; one site (2 km distance) was decided at opposite to prevailing wind direction and other two sites were (each at 2 km distance) on the perpendicular to wind direction. Detailed method of air sampling is available elsewhere.

(C) Soil and Water Samples

To investigate the possible source of fluoride contamination in human teeth, water and soil samples were also collected for fluoride analysis. Six soil samples (100 g each) and six drinking water samples corresponding to all six air-monitoring stations were collected from adjoining areas.

Chemical Analysis

(A) Teeth Samples

The samples of exfoliated teeth were immersed in a strong KOH solution to remove adhering surface impurities and then washed thoroughly with double distilled water. Each sample was separately powdered, weighed and then ashed at 400-500°C in a platinum crucible. The ashed matter was subjected to distillation in H₂SO₄ medium and the fluoride in the distillate was measured using SPADNS [Sodium 2-(Para-sulfophenylazo)-1, 8-dihydroxy-3, 6-naphthalene disulfonate] and Zirconyl acid reagent following the standard methods of chemical analysis at 525 nm in a Spectrophotometer (EI make). All the chemicals and glassware used were BDH (AnalR grade) and superior quality Borosilicate, respectively. Levels of fluoride so found in teeth samples were correlated with the age of the subjects and their correlation coefficient values (Table 1).
(B) RSPM Samples

Four circles were punched out from each of the three exposed filter papers of three measurements of 24 h sampling. Filter papers were subjected to distillation in \( \text{H}_2\text{SO}_4 \) and, in the distillate, fluoride was measured using SPADNS and Zirconyl acid reagent following the standard methods of chemical analysis. 

(C) Soil and Water Samples

The soil samples were air-dried, passed through a sieve (6 mm), partitioned and then 100 g quantity was retained. The soil samples were heated in oven at 110°C for 3 h and then weighed quantity (1 g) was subjected to distillation in concentrated \( \text{H}_2\text{SO}_4 \) and, in the distillate, fluoride was determined as described earlier. Similarly, water sample (50 ml) was also distilled in \( \text{H}_2\text{SO}_4 \) medium and then fluoride concentration was determined using SPADNS (Table 2).

Results and Discussion

The results provide discernible patterns of accumulation of fluoride in exfoliated human teeth showing distinct impacts of the environment to which the subject belonged. The data also show a marked difference in the accumulation of fluoride between the plant workers and non-workers related to the selected phosphatic fertilizer plant environment. The fluoride levels (248-8891 \( \mu \)g/g, dry weight), found in the teeth samples of contaminated categories (I and II), were at low fluoride level (below 778 \( \mu \)g/g) in exfoliated teeth from younger group (below 30 y), and high (845-8891 \( \mu \)g/g) in older group (above 30 y). However, this could not be taken as the single decisive factor resulting in the total damage or rejection of the teeth of the subjects. In uncontaminated category, fluoride found in exfoliated human teeth samples was in the range of 35-157 \( \mu \)g/g.

A good positive correlation was established between age of the subjects and levels of fluoride in exfoliated human teeth samples from contaminated category. The value of correlation coefficient (r), so found between age and fluoride concentration in category-I, is 0.858 in females and 0.830 in males. A poor correlation is obtained for uncontaminated (0.436) and category-II males (0.351). No relationships could be established between the fluoride levels in exfoliate human teeth and the sex of the subjects in all the three categories.

Thus, fluoride concentration is within permissible limits in drinking water and a very low concentration of fluoride is obtained in soil samples. However, identification of sources of fluoride accumulated in human teeth samples is beyond the scope of present work but ambient air may be the most probable factor for accumulation of fluoride because of inhalation and ingestion of fluoride loaded particulate. High intake of calcium through water and food leads to a reduction in prevalence of fluorosis.

Conclusions

Fluoride is released into air in gaseous state (as hydrogen fluoride and silicon tetrafluoride) and in solid particles. The particles fall on, and the gases are absorbed by vegetation near the fluoride emitting industry. Ingested fluoride (96%) that accumulates in the bodies of animals is incorporated into the crystal structure of bone and tooth mineral. Most of that fluoride, which is ingested with food or water and not deposited in the bones, teeth and other calcified tissue, is excreted in the urine within hours of ingestion. Thus, it is not surprising that fluoride mainly affects the teeth and bones.

It may be concluded that the health of workers and the residents of the studied phosphatic fertilizer plant are at risk through exposure by inhalation of fluoride loaded particulate matter and gases. Indian Factory Act 1948, as amended in 1987, places a responsibility on factory management [Section 7-A (2) (e) and 41-F] to ensure that workers should not be at risk of ill-health as a result of the work they perform. Hence, regular monitoring of the working environment of the plant to ensure that the levels of fluoride and other pollutants in and around the plant are within prescribed limits is recommended.

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