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Prevalence of fluorosis in calves reared in the vicinity of aluminium smelter plant, Odisha

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Abstract
The prevalence of fluorosis among calves (<18 months) was carried out in the vicinity of Aluminium smelter plant in Odisha, India. The 107 number of calves were screened physically and clinically for presence of clinical signs of dental and skeletal lesions of fluorosis. Out of these, 90 animals (84.11%) were affected with dental form of the fluorosis whereas, only 10 animals (9.34%) suffered from skeletal form of the disease. The prevalence rate of disease was also investigated in different age groups of calves. Both the dental and skeletal form of the disease were higher in calves of 12-18 month of age group of animals. The biotic and abiotic samples were also analysed for their fluoride content. High fluoride content were recorded in soil, water and forages nearer to the smelter plants and gradually decreases over distance. The plasma, urine and faecal level in calves of polluted area were elevated than the non-polluted area. The present study, provided an insight of implications of industrial fluorosis on animal health and environment.

Keywords: calves, fluorosis, aluminium smelter plant, dental fluorosis

Introduction
Fluorosis is a natural or anthropological originated toxicological disease expressing in form of dental and skeletal lesions. The health hazards of fluorosis has global impact affecting more than twenty four countries including India. During last decades, numerous reports of fluorosis in animals and humans from India (Choubisa *et al*., 2012) [1], China (Cao *et al*., 1996) [2], U.S.A. (Crissman *et al*., 1980) [3], Ausrtalia (Suttie *et al*., 1982) [4] and other countries were observed. In India, common sources of fluoride intoxications are water, fodder, fluoride rich effluents, dust and smoke from aluminum smelters plants, copper, glass, enamel, iron, super phosphate fertilizers plants and brick kilns areas (Patra *et al*., 2000) [5].
Fluorosis can be classified as natural and artificial origin depending upon the source of toxicity. Pollution due to human activities like release of industrial effluent without proper treatment into water bodies, application of fertilizers, insecticides, continuous release of fluoride rich gases into the environment, mineral mixture, tooth paste, etc. are all attributed to artificial fluorosis. Whereas, presence of fluoride in ground water leads to natural or endemic fluorosis. The reports of ground water contamination and its implications on public health and animals were stated from 1937 (Shortt *et al*., 1937) [6]. As per the report of Susheela, (2001) [7], the animal and human population of fifteen states of India are at risk of fluorosis due to presence of more than 1.5 ppm of fluoride in drinking water.
Dental from of fluorosis is clinically manifested as mild to severe dental mottling, bilateral striation horizontally (light to deep yellowish colour) and light to deep brown discoloration of the anterior teeth particularly in calves. In severe forms of dental fluorosis, irregular wearing of teeth with recession and swelling of gingiva, exposed cementum of incisor roots (Choubisa *et al*., 2012) [1] leading to impaired mastication resulting in poor utilization of feed and unthriftiness (Shupe *et al*., 1987) [8]. The clinical manifestations of skeletal form of fluorosis are expressed as intermittent lameness and snapping sound of legs, wasting of body muscles and excessive periosteal exostoses of the mandibles, ribs, metacarpus, metatarsus regions (Choubisa *et al*., 2012) [1], phalanges become short, thicker, broader, porous, brittle, hence are prone to fracture. Periosteal hyperostosis or exostosis at joint or places of attachment of ligaments and tendons cause shifting pain and lameness (Radostits *et al*., 2000) [9].
The above facts encouraged us to undertake the current study, to evaluate the environmental contamination of fluoride around three km radius of smelter plant and its implications on animal health. The calves are regarded as the bio indicator of fluoride pollution

and therefore selected as target species for study of prevalence rate of two from of fluorosis.

Materials Methods

Sampling area

The present study sites are located 133 km away from Bhubaneswar city at latitude 20.83°N and longitude 85.15°. Six villages namely Bonda, Tulasipal, Gardarkhai, Kulad, Jhajharia Mahal and Languliabeda present within 3 km radius of aluminium smelter plant of Angul district of Odisha were selected for the present study.

Sample collection

The biotic and abiotic samples were collected from the selected areas. The biotic samples include blood, urine and faecal materials were collected from the above selected area. The abiotic samples include feed, fodder, soil and water.

Study of prevalence rate

The survey of prevalence rate was performed by house to house visit in early morning and evening period when the animals generally remain available. The calves were divided into three age groups of 0-6 month, 6-12 month and 12-18 month. The calves were clinically examined for the presence of characteristics signs of dental and skeletal form of fluorosis.

Estimation of fluoride level in biotic and abiotic samples

The fluoride concentration in biotic samples and abiotic samples were measured by ion specific potentiometer, using TISAB (Total Ionic Strength Adjustment Buffer) and following the method adopted by Cernik *et al*., (1970) [10] with modifications using a portable fluoride ion specific electrode (Orion Model 96-09) and ISE meter (Orion Model-290A). The detection range of the instrument is in between 0.019 and 1900 ppm. Calibration of the instrument was made using five freshly prepared working standards. The accuracy and precision of the measurements were maintained by repeated analysis of the reference standard procured from Orion Research Incorporated Laboratory, USA.

Briefly, 1 g of dried abiotic samples were kept in 10% HCl for a period of 48 h. Afterward, the sample were washed in same strength of HCl for five times to get a volume of 50 ml. Fluoride content in the abiotic samples (including faecal matter) were estimated by taking 1 ml of solution from 50 ml of washing solution of abiotic samples and 9 ml of Sodium acetate solution. For biotic samples (except faecal matter), 0.2 ml of plasma or urine were diluted with 0.8 ml of distilled water and 1 ml if TISAB solution and ionic strength of Fluoride ion was measured using portable fluoride ion specific electrode. The instrument was calibrated with 0.1 ppm, 1 ppm and 10 ppm F standard solutions.

Results and Discussion

Fluorosis has become a worldwide health problem in both animals and human beings causing severe economic losses and silent sufferings in endemic zones. In India, fluorosis is now slowly enveloping millions of Indians and livestock in both rural and urban parts of country. Due to rapid industrialization, health problems are increasing among the livestock and humans due to fluoride toxicity. As water is the major source of fluoride poisoning, animals are in greater risk of toxicity than humans because of non-availability of defluorinated water for animal consumption. Water is not the only source rather air, fodder, soil are also contribute heavily towards occurrence of fluorosis (Patra *et al*., 1999 [11]; Gupta *et al*., 2013 [12]). Emission of fluoride dust and fumes from the smelters of aluminum producing factories are the major source for fluoride pollution. Use of cryolite (trisodium hexafluoroaluminate), as a flux in conversion of alumina to aluminum, is responsible for industrial fluorosis (Susheela *et al*., 2013) [13].

This present study recorded the symptoms of fluorosis like rough body coat, stunted growth, emaciation, lameness and wasting of hip and shoulder. The dental lesions included yellowish discolouration of incisors, brown pigmentation, chalk-like dull white discoloration of incisors, wearing, mottling and pitting of enamel, abrasion of enamel and defective dental development. The skeletal lesions in the fluorotic calves (low prevalence) were found as osteophytosis of ribs, mandible, metacarpal, metatarsal and pelvic vertebrae and deformed over growth of hooves. These clinical findings were in corroboration with the findings of Sahu (1995) [14], Singh and Swarup, (1994) [15], Choubisa *et al*. (1996) [16].

In this study, the prevalence rate of dental form of fluorosis among young calves were more common than skeletal form. The deposition of fluoride in teeth start during or before eruption (Radostits *et al*., 2000) [9] and might be the reason of higher prevalence rate of dental lesions in young calves. However, skeletal lesions aroused from gradual deposition of fluorapatite crystals in bones for a longer period causing deformities. Calves are more sensitive and susceptible and less tolerant to fluoride and thus perceived as bio-indicator of fluoride pollution (Patra *et al*., 2000 [5]; Radostits *et al*., 2000 [9]; Maiti *et al*., 2004 [17] and Chaubasia, 2008 [18]). Our results, strengthen the claim by reporting the prevalence percent of 63.68 to 94.8% in different age group of calves (Table no. 01).

The fluoride level in villages closer to aluminium smelter plants possessed high fluoride level and gradually decreased over longer distance. The centrifugal spread of fluoride in effluents and aerosol emission around the plant was responsible for such a pattern. Similar trend in concentration of fluoride in soil in relation to distance from smelter plants had been reported by Muralidhara and Shastri, (2000) [19]. Similarly, the fluoride level in drinking water and fodder were recorded to be high in villages nearer to smelter. Lowering of fluoride in green fodder with increasing distance from aluminum factory may be due to decrease in fluoride content of the soil.

The present investigation highlight the effect of fluoride pollution in environmental samples and their reflection in body system. The plasma, urine and faecal fluoride level in fluoride intoxicated environment were elevated than the non-fluorotic area. The areas with high fluoride level in soil, water recorded with high fluoride level in forages. The high fluoride level in feed and forages and drinking water leads to increased plasma fluorine level in intoxicated calves. The increased ingestion of fluorine through dietary source was also reflected from the high fluoride level of faecal excretion (Table 3).

Fluoride appears readily in urine after absorption and generally the urine fluoride reflects the absorbed fluoride on same day (Gopal and Ghosh, 1985) [20]. However, the findings indicate that determination of fluoride levels in urine is a valuable tool for diagnosing early stages of fluoride intoxication, thus enabling the introduction of suitable preventive and curative measures to minimize suffering and losses in animals (Bharti *et al.*, 2007) [21]. However, fluoride concentrations in faeces indicated current fluoride intake and length of exposure and degree of absorption into systemic circulation.

Table 1: Prevalence of dental vs. skeletal fluorosis in different age group of calves around aluminium smelter plant

Age Group (Months)	Prevalence of Dental Fluorosis	Prevalence of Skeletal Fluorosis
0-6	63.6% (14/22)	0 (0/22)
6-12	84.7% (39/46)	8.69% (4/46)
12-18	94.8% (37/39)	15.38% (6/39)

Table 2: The fluoride concentrations of soil, water and green fodder (ppm) of different villages around aluminium smelter plant.

Villages	Soil (Mean F Conc) in ppm (n=19)	Water (Mean F Conc) in ppm (n=27)	Green Fodder (Mean F Conc) in ppm (n=32)
Gadarkhai	68.18 ± 6.32	1.89 ± 0.24	99.00 ± 8.97
Languliabeda	55.02 ± 8.01	1.06 ± 0.46	130.37 ± 14.21
Tulsipal	47.31 ± 5.17	1.22 ± 0.67	31.07 ± 7.66
Jharjhari Bahal	41.23 ± 9.44	1.16 ± 0.21	48.40 ± 6.45
Bonda	40.18 ± 7.36	0.30 ± 0.07	34.53 ± 7.21
Non-Polluted area	7.86 ± 1.01	0.17 ± 0.05	18.21 ± 6.14

Table 3: The fluoride concentrations of plasma, urine and faecal fluoride level (ppm) of different villages around aluminium smelter plant.

Villages	Distance from Plant	Plasma Fluoride level in ppm	Urine Fluoride level in ppm	Faecal Fluoride level in ppm
Gadarkhai	0.5 km	0.86 ± 0.08	17.36 ± 0.93	23.53 ± 1.41
Languliabeda		0.52 ± 0.24	14.64 ± 1.02	20.65 ± 0.71
Tulsipal	0.5-1.5 km	0.56 ± 0.09	14.21 ± 1.23	21.21 ± 0.98
Jharjhari Bahal		0.78 ± 0.11	16.87 ± 0.64	25.16 ± 1.01
Bonda	1.5-3 km	0. 41 ± 0.16	12.23 ± 0.68	18.34 ± 1.31
Non-Polluted area		0.084 ± 0.07	2.45 ± 0.14	9.93 ± 0.68

Conclusion

The prevalence rate of dental form of fluorosis was high and gradually increased with age of calves. The dietary ingestion of fluoride through forages, milk and drinking water were reflected in the systemic circulation and excretion rates in calves. The effect of industrial fluorosis and its indicator species (calves) were also the important findings of this current study.

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Competing interests

The authors declare that they have no competing interests.

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