OSTEO-DENTAL FLUOROSIS IN CATTLE REARED IN VILLAGES ON THE PERIPHERY OF THE ALUMINIUM SMELTER IN ODISHA, INDIA

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ABSTRACT: The prevalence of osteo-dental fluorosis was observed in 294 cattle (>2 yr of age) reared in the vicinity of an aluminium smelter in Odisha, India. Of these, 247 (84.01%) were found positive for dental lesions, with or without skeletal involvement. Dental fluorosis was more prevalent (84.01%) than skeletal fluorosis (35.37%). Biological and environmental samples collected from the study area were analysed for the fluoride ion (F) level. The mean plasma and urine F levels in the fluorotic cattle varied from 0.47±0.01 to 0.80±0.02 and 14.55±0.13 to 17.63±0.21 ppm, respectively. The F concentrations in the water, soil, green fodder, dry fodder, and concentrate (rice bran) were 0.25–3.90, 25.4–102, 13.4–165, 39.60–517.0, and 6.60–71.40 ppm, respectively. The high incidence of fluorosis in the cattle of 84.01%, increased from the value for cattle found in a 1999 study in the same area of 54.90%, indicates the persistence of industrial F pollution in the study area.

Key words: Aluminium smelter; Cattle; Odisha; Osteo-dental fluorosis; Prevalence of fluorosis.

INTRODUCTION

Chronic exposure to the fluoride ion (F) in groundwater causes adverse ill effects, not only in humans[1-3] but also in various species of domestic animals in the form of fluorosis.[4-7] Industrial fluorosis caused by the excess ingestion/ inhalation of F is a serious health problem in both man[8] and animals[9] living in the vicinity of F emitting industries. The primary diagnostic symptoms of chronic F intoxication are mottling of teeth (dental fluorosis) and osteosclerosis of the skeleton (skeletal fluorosis). The prevalence and severity of F toxicity in animals varies from place to place, even between areas having identical F concentrations in food and drinking water. Besides the amount of F ingested, the duration of exposure, age, sex, health status, stress factors, and the biological response of individuals along with other factors such as the local environment (temperature and humidity), other dissolved salts in drinking water, and the involvement of fluoridated food chains, may increase the prevalence and severity of F toxicity.[5]

The present study was an attempt to assess the prevalence of dental and skeletal fluorosis in cattle reared in villages on the periphery of an aluminium smelter plant in Odisha (India), along with the level of F in different biological and environmental samples.

MATERIALS AND METHODS

Study site: The study was conducted in villages present within a 2 km radius of the aluminium smelter plant in the Angul district of Odisha, India. Cattle reared in this area mostly thrive by grazing on free pasture as well as being supplied with paddy straw and a small quantity of concentrate in the form of rice bran.

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Screening of animals: A total of 294 cattle (>2 yr of age) of either sex reared within a 2 km radius of the aluminium smelter plant were examined clinically for evidence of mottling of teeth, bony exostoses, lameness, stiffness of joints, emaciation, etc. as signs of chronic F toxicosis. Simultaneously, samples of blood and urine were also collected from representative fluorotic animals (n=60) for the estimation of F levels.

Environmental and biological sampling: Abiotic samples (soil and water) and biological samples (green and dry fodders, and concentrates of rice bran) were collected from the selected villages during daylight hours. A total of 30 soil samples from different agricultural fields and grass lands were collected and stored in plastic bags for the estimation of F levels. Forty-four water samples were also collected in fresh clean polypropylene bottles from different drinking water sources (ponds, wells, tap water, etc.). A total of 42 green and 24 dry fodders, and 30 concentrates were collected from animal sheds and stored in polythene bags for the estimation of F content.

F measurement: The F analysis for the environmental samples was carried out by the standard method as used earlier[10] whereas, the F in the water, urine, and blood plasma samples was estimated by a specific ion electrode.[11]

RESULTS

F concentration in the environmental and biological samples: The F concentrations in the environmental and biological samples, together with their distance from the aluminium smelter, are shown in Table 1.

Table 1. Fluoride concentrations (ppm) in the environmental and biological samples and distance from the smelter plant (km)

Environmental and biological samples	Fluoride concentration (ppm) mean±SD (range)	
	Distance from smelter plant 0–0.5 km	Distance from smelter plant 0.5–2 km
Soil	68.19±7.04 (49.40–102.0)	47.50±2.78 (25.40–81.0)
Surface water	3.01±0.24 (2.40–3.90)	1.79±0.11 (1.20–2.20)
Ground water	0.93±0.07 (0.41–1.20)	0.59±0.05 (0.25–1.00)
Green fodder	98.25±31.825 (30.00–165.0)	33.88±4.16 (13.40–57.20)
Dry fodder	315.75±112.5 (114.0–517.0)	172.34±28.74 (39.60–292.0)
Rice bran	48.92±11.36 (6.60–71.40)	34.04±4.88 (16.30–58.20)
Plasma	0.80±0.02 (0.61–1.03)	0.47±0.01 (0.37–0.62)
Urine	17.63±0.21 (15.3–19.8)	14.55±0.13 (13.0–15.8)

Animal samples: The mean plasma F concentration of the cattle showed a higher level (0.80±0.02 ppm) within a 0.5 km radius of the smelter compared to the level (0.47±0.01 ppm) at a 0.5–2 km radius from the plant. The urine F level was also higher (17.63±0.21 ppm) within 0–0.5 km radius compared to the level (14.55±0.13 ppm) at a radius of 0.5–2 km from the aluminium smelter (Table 1).

Prevalence of fluorosis: Out of the 294 cattle, 247 (84.01%) were found to be positive for dental fluorosis, with or without skeletal involvement (Figures 1 and 2). The animals reared within 0.5 km of the aluminium smelter had more dental fluorosis (91.02%) than skeletal fluorosis (37.18%). Similar proportions were also observed in those 0.5–2 km from the smelter plant (Table 2). However, the percentage of animals with severe dental fluorosis decreased with increasing distance from the smelter plant (Table 2).

Table 2. The prevalence of dental and skeletal fluorosis and the distance from the smelter plant (km)

Parameters	Distance from smelter plant	
	0–0.5 km	0.5–2 km
Number of animals examined (n=294)	78	216
Number of animals positive for fluorosis (n=247)	71	176
Prevalence of fluorosis (For total sample of 294=84.01%)	91.02%	81.5%
Number of animals positive for dental fluorosis (n=247)	71	176
Prevalence of dental fluorosis (For total sample of 294=84.01%)	91.02%	81.5%
Percentage of dental fluorosis in animals positive for fluorosis (For total sample of animals positive for fluorosis 247=100%)	100%	100%
Number of animals positive for skeletal fluorosis (n=104)	29	75
Prevalence of skeletal fluorosis (For total sample of 294=35.37%)	37.18%	34.72%
Percentage of skeletal fluorosis in animals positive for fluorosis (For total sample of animals positive for fluorosis 247=42.10%)	40.85%	42.61%
Number of animals positive for dental fluorosis showing a mild dental lesion (% of animals positive for dental fluorosis)	38 (53.52%)	101 (57.39%)
Number of animals positive for dental fluorosis showing a severe dental lesion (% of animals positive for dental fluorosis)	33 (46.48%)	75 (42.61%)

Figure 1. Severe form of dental fluorosis characterised with excessive abrasion and loss of the crowns of the incisors.

Figure 2. Mature cow afflicted with skeletal fluorosis characterised by excessive bony outgrowths on the costochondral junctions of the ribs.

DISCUSSION

A rough body coat, stunted growth, emaciation, decrease in milk yield, unthriftiness, and chronic wasting were the prominent clinical findings in the

fluorotic cattle. The dental lesions included yellowish brown or chalk-like dull white discoloration of incisors, loss of crowns, cud dropping, mottling and pitting of enamel, and wearing or abrasion of teeth. The skeletal lesions in the fluorotic cattle were found as exostoses of ribs, mandible, metacarpal, metatarsal and pelvic vertebrae, swelling of joints, lameness, bending of limbs, and deformed over growth of hooves. Such pathognomic signs of chronic industrial F intoxication in cattle were also observed and reported earlier. [12-14]

The concentration of F in the soils collected from different sampling sites situated at variable distances from the smelter plant showed an inverse relation with the distance from the plant. The same result was also observed in the study conducted in the Hirakud industrial area of Odisha.[15] The high concentration of F in the soil might be due to the industrial operation emitting F.

Groundwater samples collected from the villages under study, had F levels within the permissible limit.[16] As compared to groundwater, surface water contains a high F content which might be due to the industrial emission of F and its eutrophication in water.[16-19]

A high F content was found in the different fodders and the rice bran concentrate which were collected from the study site. F is absorbed from the soil and accumulates in the plants. Earlier studies have also reported high F levels in the vegetation samples collected around a smelter plant.[19, 20]

The present work found an elevated level of plasma F in the fluorotic cattle. The contamination of feed and water with the effluents emitted by the industrial operation over a prolonged period might have been responsible for the increased F level in the blood and the resultant clinical signs of fluorosis. [13, 21] A high urinary F concentration in the fluorotic cattle was observed in the present study area which decreased with increased distance from the smelter.[13, 20]

The present study found the prevalence of fluorosis in adult cattle, reared within a 2 km radius of the aluminium smelter plant, was 84.01%. An earlier investigation from the same area reported the prevalence of fluorosis as 54.90% in cattle[22] and 36.03% and 39.2%, respectively, in sheep[23] and goats.[24] The increase in prevalence of fluorosis found in the present study might be due to gradual increase in the F concentration in the environment. The results of the present investigation also add a significant insight into the causes of industrial F intoxication.

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