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Shanti Lal Choubisa *

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Review Article

Risk of Fluorosis and other Health Hazards in Humans from Coal-Fired Brick Kilns in India: People need to be Aware

Shanti Lal Choubisa [1,2*]

[1]Department of Advanced Science and Technology, National Institute of Medical Science and Research, NIMS University Rajasthan, Jaipur 303121, Rajasthan, India.

[2]Former Department of Zoology, Government Meera Girls College, Udaipur 303002, Rajasthan, India.

***Corresponding Author:** Shanti Lal Choubisa, Department of Advanced Science and Technology, National Institute of Medical Science and Research, NIMS University Rajasthan, Jaipur 303121, Rajasthan, India.Former Department of Zoology, Government Meera Girls College, Udaipur 303002, Rajasthan, India.

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Abstract

There are over 140,000 registered and unregistered coal-fired brick kilns operating in rural and urban areas in India. This coal-based industry consumes about 35 million tonnes (MT) of coal for production of heat energy every year. Since coal is rich in fluoride, when burnt, many types of fluoride-containing toxic gases such as HF, SiF4, and CF4 are emitted into the surrounding environment which not only contaminate air, soil, and water but also forest vegetation and agricultural crops on which humans often depend. If the people living nearby and the workers of the kilns are exposed to this industrial fluoride emission or pollution for a long- time, they are at high risk of developing a disease called fluorosis. In this disease, people's teeth and bones get deformed. The various fluoride-induced pathological changes in teeth and bones are called dental fluorosis and skeletal fluorosis, respectively. Acute exposure to kiln fluoride pollution can cause severe respiratory damage and other health issues like irritation and inflammation of the lungs, irritation of the eyes, nose and upper and lower respiratory tract, watery eyes, sore throat, cough, chest tightness, skin irritation, etc. But people living around kilns and workers of these industries are generally unaware of these fluoride-induced health hazards. Interestingly, the owners of most of these kilns are also careless about these health issues and do not follow preventive measures for their employees. Even the country's medical and health and pollution departments are not much concerned about the health problems caused by kiln fluoride pollution. In fact, there is a need for constant monitoring of such pollution in the country. This mini review focuses on kiln fluoride pollution and fluorosis and other health problems in people who are consistently exposed to this pollution. Through this review, the author have tried to draw the attention of the kiln's owners and the concerned departments in the country towards this burning health problem.

Keywords: brick kilns; coal; fluoride pollution; fluorosis; health hazards; workers; india

Introduction

Industrialization is one of the basic needs for the development of any nation. But it also has many side effects, one of which is pollution. Due to which soil, water, and air also get contaminated. These industries require energy to run which is supplied by electricity and natural fossil fuels like diesel and coal. In India, many coal-burning and industrial activities, such as power generation stations and the manufacture or production of steel, iron, aluminum, zinc, phosphorus, chemical fertilizers, bricks, glass, plastics, cement, and hydrofluoric acid usually discharge fluoride in both gaseous and aerosol forms in their surrounding environment which create industrial fluoride pollution [1-4]. An industrial emitted fluoride is not only contaminating the surrounding soil, air, and fresh water ecosystems, but also contaminating forest vegetation, agricultural and horticulture crops, and many other biological communities. Brick kilns are operating at various places across the country. According to an estimate, there are about 140,000 registered coal-fired brick kilns (Figure 1) in the country, not only in rural and urban areas but also in agricultural and forest areas [5]. But in many places in the country, thousands of brick kilns are operating near human settlements which are unregistered and illegal. This shows that the kiln industry in the country is not being regulated properly.

Figure 1. Old or traditional (a) and modern or fixed chimney bull's trench (b) coal-fired brick kilns in India.

The brick kiln industry consumes about 35 million tonnes (MT) of coal for energy every year in India [6]. In fact, in India, brick kilns are the second largest industrial consumer of coal after the steel industry. These fossil coals are rich in fluorine. Its concentration range is 20-500 μg g−1 in most coals, with an average value of around 150 μg g−1 [7, 8]. Fluoride content in Indian coal generally varies from 10−20 g/tonne [9, 10]. During the combustion of coal in these kilns, a large amount of toxic compounds of fluorine such as HF, SiF4, and CF4 are also released or emitted into the atmosphere along with other toxic gases and solid waste products [7, 8]. When people are repeatedly exposed to or remain exposed to kiln's fluoride emissions, it becomes toxic to their health and eventually causes fluorosis disease [1-4]. Animals also develop fluorosis if they are exposed to fluoride pollution for a long- time [11- 15]. In India, most research has been done on hydrofluorosis in humans [16-26] and various species domestic and wild animals [27-42] due to drinking fluoridated water. But the risk of fluorosis in humans due to fluoride emissions from brick kilns in India has not yet been studied. However, such studies have been reported in domestic animals in the country [43, 44]. Interestingly, neither the kiln's owners and labourers nor the Medical and Health and Pollution Control Departments are unaware of the health hazards caused by fluoride pollution due to coal-fired brick kilns in the country nor do they take preventive measures. This mini review focuses on fluoride pollution from brick kiln industries, which causes fluorosis and other health hazards among people living in their vicinity and workers working in these industries. Through this review, the author has tried to draw the attention of the brick kiln's owners and the concerned departments in the country to protect the health of workers from fluoride pollution from these kiln industries in the country.

Fluorosis and its clinical signs

It well known that excessive intake or inhalation of fluoride for prolonged period causes a serious disease called fluorosis in man [45, 46] and animals [47, 48]. Once fluoride enters the body it is absorbed by the digestive and/or respiratory tract and then eventually reaches all parts of the body through the blood. More than 50% of the absorbed fluoride is excreted through faeces, urine, and sweat, while the rest is retained in the body where it deposited in various organs. However, its maximum deposition is taking place in bones and teeth as compared to soft organs. This bio-accumulation of fluoride causes diverse pathological changes in these organs and also interfere various physiological and metabolic processes and ultimately triggers the occurrence of adverse health effects in people of all age groups. These

clinical changes induced by fluoride are known as fluorosis [1]. Various fluoride-induced abnormalities in teeth and bones are permanent, irreversible and not curable and most of them are visible. However, fluoride-induced changes in soft tissues or organs are generally reversible and disappear when the source of exposure to fluoride is removed. Based on the types of organs affected, there can be three forms of fluorosis, namely dental fluorosis (dental spots), skeletal fluorosis (bone deformities), and non-skeletal fluorosis (effects in soft organs) [45, 47]. But it is not necessary that these three forms are present in the same fluorosed individual. However, out of these forms, skeletal fluorosis is more dangerous and highly painful.

"Dental fluorosis" which is the earliest visible clinical sign of chronic fluoride intoxication in humans and animals is sensitive, indexive, and widespread in fluoride endemic areas. Clinically, it is marked by diffuse hypocalcifications that typically appear as bilateral, striated and horizontal opaque light to dark brown pigment streaks on the tooth surface (Figure 2) [45, 47]. These pigmented streaks are relatively more contrasting in appearance and are more clearly visible on the anterior teeth/incisors in children and adolescents than in older people. Dental fluorosis may also appear as light to dark brown spots, patches, and fine dots or granules on tooth enamel (Figure 2). In its severe form, marked loss of the alveolar bone supporting the teeth occurs along with recession and inflammation of the gingival tissue and excessive abrasion or irregular wear of the teeth [45, 47].

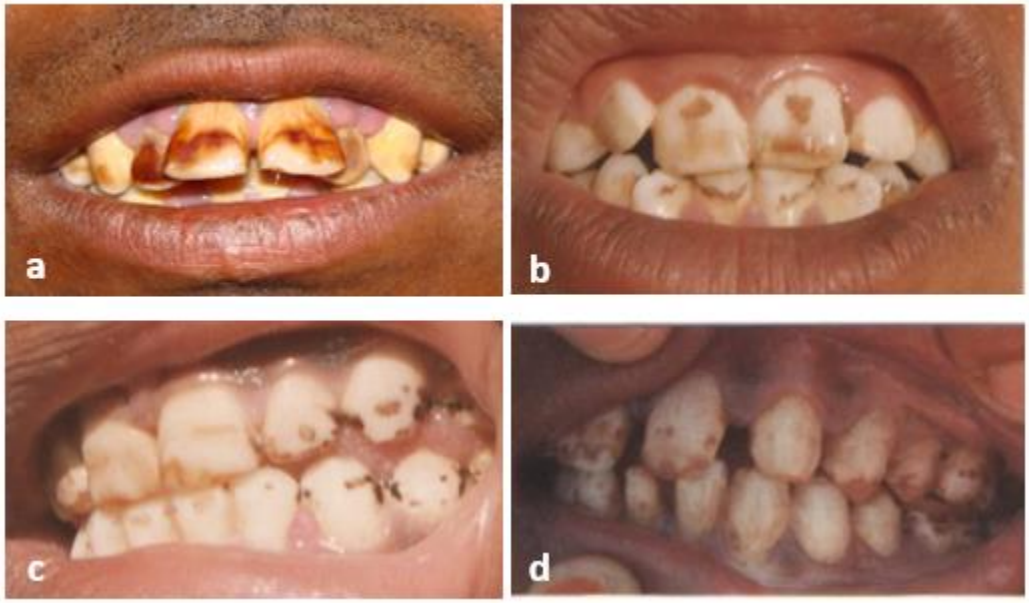

Figure 2: Various forms of dental fluorosis in individuals exposed to fluoride such as striated and horizontal opaque dark brown streaks (a), spots (b), patches (c), and fine dots or granules (d) on tooth enamel.

"Skeletal fluorosis" is of utmost importance as it reduces mobility at a very young age by causing various gradual changes in bones such as periosteal exostosis, osteosclerosis, osteoporosis, and osteophytosis [49-51]. These changes can be easily identified by radiological (X-ray of bones) [51] scans which manifest clinically as vague aches and pains in the body and joints. Excessive accumulation of fluoride in muscles also reduces movements and the condition leads to disability. In its advanced stage, neurological complications like paraplegia and quadriplegia and syndromes of genu-valgum and genu-varum are also a result of regular fluoride exposure and is the worst condition of skeletal fluorosis.

"Non-skeletal fluorosis" is the initial stage of fluoride poisoning when humans are exposed to fluoride. Various health complaints caused by fluoride such as gastrointestinal discomforts (intermittent diarrhoea or constipation, abdominal pain, flatulence, etc.), urticaria, frequent urination (polyuria), excessive thirst (polydipsia), neurological disorders, impaired endocrine and reproductive functions, teratogenic effects, renal effects, genotoxic effects, apoptosis, excitotoxicity, asthma, itching in the genitals, lethargy, muscle weakness, bronchitis with severe cough, nasal irritation, irregular reproductive cycles, abortions and stillbirths are found in people exposed to fluoride [45, 47]. These are the early symptoms of chronic fluoride poisoning in people from fluoride-affected areas.

The severity of all these pathological changes induced by fluoride is influenced by several determinants or factors besides fluoride concentration and its frequency and duration of exposure such as age, sex, habits, nutrition, chemical constituents of drinking water, environmental factors, and individual sensitivity, biological response, tolerance, and genetics [52-62]. To know the persistence of fluoride contamination in the environment, estimation of fluoride in the environmental samples like forage and fodder is the better option [63]. However, in contrast to morbidity and mortality, fluoride contents in biological samples such as milk, urine, blood serum, teeth, bones, etc. are also better bio-markers for chronic fluoride toxicosis [64,65]. For knowing the current status of fluorosis, estimation of fluoride in blood serum and urine is the most ideal and authentic way in both man and animals [66]. However, among the various bio-indicators of chronic fluoride exposure, urine fluoride concentration is generally accepted as the best indicator of endemic of fluorosis [67-69].

Fluorosis and other health problems from kiln fluoride pollution

In India, especially in rural areas, most people or villagers are aware that drinking fluoride-contaminated water causes fluorosis. But they do not know that fluorosis can also be developed or caused by coal-fired brick kilns. In fact, fossil fuel, coal contains fluoride/fluorine in different forms which during combustion releases its toxic compounds like HF, SiF4, and CF4 in

large quantities in gaseous forms into the atmosphere [6,7]. Workers working in these active coal-fuelled brick kilns and people living nearby are usually exposed to gaseous HF as well as other fluoride toxins. If these people are exposed to it acutely, it causes serious respiratory damage, including severe irritation and lung inflammation. Exposure to fluoride emissions from the kilns often causes health issues like irritation in the eyes, nose and upper and lower respiratory tract, tearing of the eyes, sore throat, cough, and chest tightness and wheezing [4, 70, 71]. If these people are exposed to it for a long- time, then they are more likely to develop osteo-dental fluorosis [1-3, 72]. But neither the people in the country nor the concerned departments like Medical and Health and Pollution are concerned about these health hazards caused by kiln industrial fluoride pollution. Even the owners of brick kilns are careless in this regard and neither do they care about the workers working in the kilns nor do they follow the preventive measures of fluorosis. Whereas toxic fluoride emissions from kilns can be protected by using full-face masks, hand gloves, aparine, full-size shoes, etc. Large-scale research surveys are also needed to know the status of toxic effects or health hazards caused by fluoride pollution from coal-burning kilns in the country.

Conclusion

There are more than 140,000 registered and thousands of unregistered coals burning brick kilns operating in rural and urban areas in India. They require energy to operate which is obtained by burning coal as fuel. During the combustion of coal, fluoride-containing toxic gases such as HF, SiF4, and CF4 are released along with solid waste in the surrounding environment. Workers and people living in the vicinity of these coal-fired kilns are generally exposed to these poisonous gases. Excessive inhalation to kilns fluoride pollution causes a variety of health hazards such as respiratory changes including severe burns and lung inflammation. Excessive exposure to fluoride emissions can also cause health problems such as irritation in the eyes, nose and upper and lower respiratory tract, watery eyes, sore throat, cough, and chest tightness and wheezing. When kiln workers are exposed to fluoride pollution for a long- time, they may also develop fluorosis. But these people are not aware of the health effects of exposure to fluoride pollution from coal-fired kilns. Therefore, preventive measures are needed to protect kiln workers from exposure to fluoride emissions, which is the responsibility of kiln owners. In addition, there is also a need for regular monitoring of kiln fluoride pollution and its toxic health effects on humans exposed to it in the country. It is highly suggested that extensive research on fluorosis and other health issues in humans and domestic and wild animals and also toxic effects in agriculture crops caused by acute and chronic exposure to fluoride pollution from coal-burning brick kilns in the country. Findings of such studies will be useful in preparation of national policy to prevent the health of people from fluoride pollution caused by coal combustion in brick kilns.

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Conflicts of interest

The author has no conflicts of interest.

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