Bull. Environ. Contam. Toxicol. (2003) 70:1170–1177

DOI: 10.1007/s00128-003-0105-2

Bulletin of Environmental Contamination and Toxicology

Asbestos Contamination in Biota and Abiota in the Vicinity of Asbestos-Cement Factory

M. S. Musthapa, I. Ahmad, A. K. Trivedi, Q. Rahman

Fiber Toxicology Division, Industrial Toxicology Research Center, Post Box No. 80, M. G. Marg, Lucknow 226 001, India

Received: 12 September 2002/Accepted: 10 March 2003

Asbestos a natural hydrated mineral silicate well known for its deadly effects of lung fibrosis, malignant mesothelioma and bronchogenic carcinoma (Mossman *et al*. 1990). Compared to the situation a few decades ago, exposure to asbestos fibre is now restricted in developed and industrialized countries, while it is mounting in the developing countries (Ramanathan and Subramanian 2001). However, the delay between exposure and the manifestation of disease is about 20-40 years and that is why the incidence of these diseases is still escalating.

Several states in India have many asbestos industries out of which 60 % are in operation and the production at present is about 2000 tones of asbestos per month (Ramanathan and Subramanian 2001). However, air pollution levels of asbestos were reported to be elevated in the areas surrounded by asbestos industries (WHO 1998). In addition, peoples living in the vicinity of asbestos mines and asbestos-related industries may be exposed to higher levels of asbestos fibres (Case and Sebastien 1987). This situation is mainly a result of difficulties in reducing the emission of fine particles of asbestos during factory operation. So, monitoring and analysis of biotic and abiotic samples in the nearby ecosystem can address many questions about source, distribution, partitioning and transport of asbestos. Globally, the information regarding asbestos burden in the ecosystem and its ecological impact has largely been unseen (NIPHEP 1989), merely few reports are indicating the adverse impact of asbestos on aquatic ecosystem (Lauth and Schurr 1983; 1984). However, increasing evidence suggests that only a test battery poised of different species and their living materials at different tropic level would enable to provide suitable discriminatory data of the environmental pollutants. So this method uses the principles of biomonitoring, using some model animal species and their living materials collected around an asbestos-cement factory. So that the information obtained on levels of asbestos in the environment can be used in combination with the known body burden to assess the potential risk of adverse health effects in population living in these areas.

MATERIALS AND METHODS

Asbestos analysis in different samples were carried out as described below by following the methodology of APHA *et al.* (1998), EPA (1993) and IS (1986).

Correspondence to: Q. Rahman

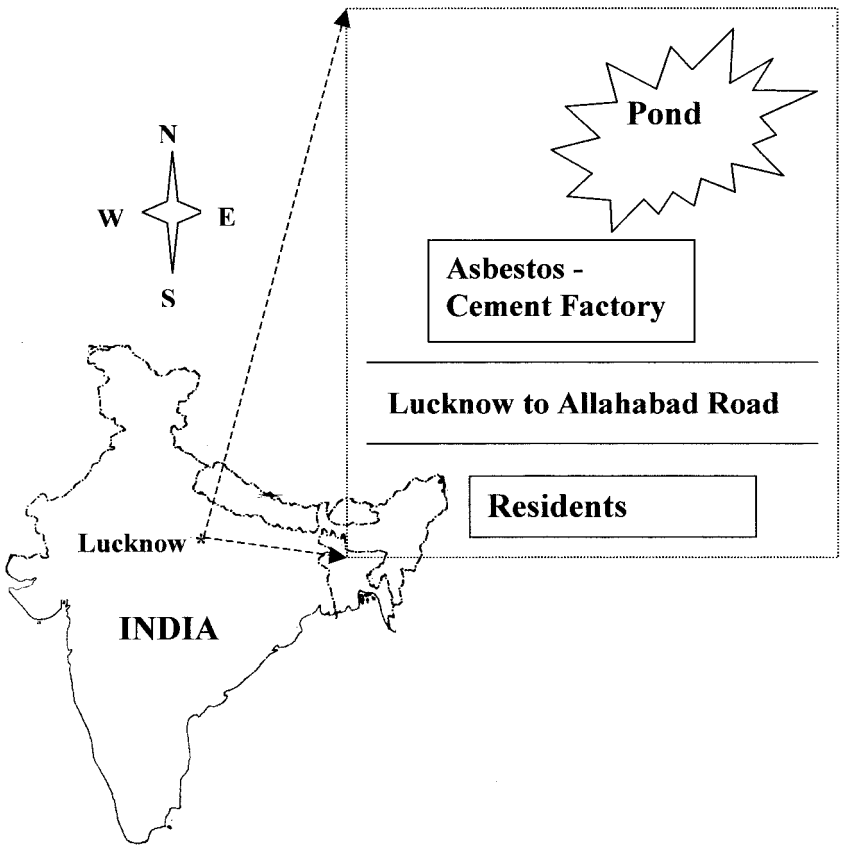

Figure 1. Asbestos-Cement factory location, Mohanlalganj, Lucknow, (India).

Soil and earthworm samples were collected at distinct sites of 0, 1, 2 and 5 Km around an asbestos-cement factory, which is located at Mohanlalganj about 25 km from Lucknow, U.P. (India) (Figure-1). Soil samples were dried at 65^0C for 3 days for further processing. Earthworms (*P. posthuma*) collected from the same soil of the deeper horizon were placed in separate petridishes on moist filter paper for 3 days to void their gut contents. Soil and earthworm samples were segregated and ashed separately according to the site of collection at 500^0C for 2 hrs in muffle microwave and the ashes were mixed with HNO_3 and further diluted with deionized water to avoid any damage to the Millipore filter during filtration process. Pond water and its sediments were collected separately from different corner of a pond, the only aquatic ecosystem exhibited near by the factory. South and west corner of the pond is located vicinity to the factory walls and the total area of the pond is around 1 ha area. These pond sediments were dried and then treated as processed by soil samples described above. Snail and Frog were also collected from the same aquatic ecosystem and were dissected out and preweighed organs were homogenized separately with known volume of 4 % sodium hypochlorite solution (NaClO) until clear digestion were made.

The pond water samples and above processed solutions of soil, earthworm, pond sediment, snail and frog samples were filtered through a Millipore membrane filter paper with pore diameter 0.8 μm (Cat no. AABP 04700, Millipore corporation, Bed ford, MA 01730, USA) which retains asbestos fibre present in the samples and is subsequently transformed on a slide and made transparent by the addition of 200-300 μl of standard immersion oil (Olympus, Japan). The transparent slides were air dried and used for asbestos analysis by phase contrast polarized microscopic (PCM) method (IS 1986). Length of asbestos fibres were measured in the range of < 10 μm, 11-20 μm, 21-30 μm, 31-50 μm and > 50 μm and relative count of fibres were also estimated in the original materials.

RESULTS AND DISCUSSION

Soil contamination by asbestos showed in Table-1, found that the samples collected from the close vicinity of the factory were revealed higher number of fibres and get diluted with increasing distance. Further lengthwise pattern of fibre content was quite varying with distance moving away from the factory, as small fibres (<10 μm) were higher in the case of 2 and 5 Km sampling site as compared to 0-1 Km site. This situation might be due to the fact that small fibres travel much distance through air compared to the longer ones. According to the Toxic Release Inventory (TRI) in 1999, the total releases of asbestos to the environment (including air, water and soil) from 87 facilities were 13.6 million pounds (TRI99 2001). Since asbestos fibres do not endure significant transformation or degradation in soil (EPA 1989), makes it moving from one tropic level to another in the ecosystem. While accounting this situation, it stresses the need to study the translocation and persistence of asbestos fibres in soil biota like earthworm, the best terrestrial animal model. The total fibres / g dry weight (dw) of earthworm samples (Table-2) were found to be decreasing in trend with increasing distance as in the case of previous table. In addition the earthworm sample collected at 1 Km distance showed 123 fibres per gram of dry weight whereas soil sample showed 67 fibres per gram of dry weight. When considering this soil asbestos concentration and the earthworm body asbestos concentration from our study, a very uniform asbestos gradient in the soil were not reflected so convincingly by

Table 1. Asbestos residues in soil samples around an asbestos-cement factory.

Sample	Total Fibres/ g dw	% of fibres in lengthwise				
		<10 μm	11-20 μm	21-30 μm	31-50 μm	>50 μm
0 Km	541	14.0 % (76)	25.3 % (137)	15.7 % (85)	18.1 % (98)	26.8 % (145)
1 Km	67	14.9 % (10)	13.4 % (9)	19.4 % (13)	23.9 % (16)	28.4 % (19)
2 Km	43	34.8 % (15)	27.9 % (12)	20.9 % (9)	11.6 % (5)	4.7 % (2)
5 km	29	37.9 % (11)	31.0 % (9)	17.2 % (5)	10.3 % (3)	3.4 % (1)

Figure within parentheses indicates number of fibre out of total fibre content.

Table 2. Asbestos burden in earthworm samples around an asbestos-cement factory.

Sample	Total Fibres/ g dw	% of fibres in lengthwise				
		<10 μm	11-20 μm	21-30 μm	31-50 μm	>50 μm
0 Km	366	30.3 % (111)	27.0 % (99)	17.2 % (63)	10.7 % (39)	14.7 % (54)
1 Km	123	31.7 % (39)	20.3 % (25)	23.6 % (29)	11.4 % (14)	13.0 % (16)
2 Km	89	32.6 % (29)	25.8 % (23)	20.2 % (18)	11.2 % (10)	10.1 % (9)
5 Km	43	34.9 % (15)	27.9 % (12)	18.6 % (8)	11.6 % (5)	6.9 % (3)

Figure within parentheses indicates number of fibre out of total fibre content.

the earthworm body asbestos concentrations. While this situation of higher fibre presence in the earthworm than the soil, obviously indicates the greater bioaccumulation of asbestos in samples collected from all the four sampling sites. Evidences from field studies by Glovinova *et al.* (1994) and Greig-Smith *et al.* (1992) showed that asbestos and metals were substantially accumulated in earthworms surviving in contaminated waste site, respectively. Further Schreier and Timmenga (1986) suggested that chrysotile load in the soil may elevate the magnesium and trace metal levels locally, whereupon plants or soil biota like earthworm selectively takes them up. In addition lengthwise measurement of fibres make evident that samples collected from all sites (0-5 Km), possessing the higher number of fibres in increasing order from >50 μm to <10μm.

Analyses of asbestos residues in various samples collected from different corner of a pond were explained in tables 3-5. Table-3 shows the pond water and its sediment contamination by chrysotile fibres. In both the samples, southern end was registered higher number of fibres followed by western, eastern and northern side of pond samples. This may be due to the fact that the former two sites are located towards or nearer to the factory. It is especially important to assess the size distribution of the fibres in the environmental media there by carrying vital role in evaluating the resultant risk. Lengthwise measurement makes evident that the higher number of fibres belongs to the group of 31-50 μm range in pond water and > 50 μm range in pond sediment samples due to the close vicinity of the factory. These data further explains the fact that the large fibres are removed from the air and water by gravitational settling at a rate dependent upon their size, but small fibres may remain suspended for long period of time.

Snails were also collected from different corner of the aquatic source and individual groups were mixed, separated randomly (4-5 numbers). As shown in Table-4 different snail organs like buccalmass, visceral spiral, rectum, foot and muscle showed different numbers of mean asbestos fibres per gram organ. Although the route of asbestos entry is not clearly understood, the present finding agrees the accumulation of asbestos fibres in the snails in accordance with the

Table 3. Asbestos residues in pond water and sediment samples near an asbestos-cement factory.

Sample	Total Fibres/ L or / g dw	% of fibres in lengthwise				
		<10 μm	11-20 μm	21-30 μm	31-50 μm	>50 μm
P. water North	282	7.8 % (22)	15.6 % (44)	18.8 % (53)	25.5 % (72)	32.3 % (91)
P. water South	304	11.8 % (36)	12.8 % (39)	18.1 % (55)	30.9 % (94)	26.4 % (80)
P. water East	287	19.9 % (57)	16.4 % (47)	12.1 % (35)	23.4 % (67)	28.2 % (81)
P.water West	298	11.1 % (33)	17.7 % (53)	16.8 % (50)	31.2 % (93)	23.2 % (69)
P. sediment North	360	5.0 % (18)	13.6 % (49)	16.9 % (61)	30.8 % (111)	33.6 % (121)
P. sediment South	420	4.5 % (19)	9.3 % (39)	13.1 % (55)	25.2 % (106)	47.9 % (201)
P. sediment East	399	3.0 % (12)	11.0 % (44)	17.5 % (70)	24.3 % (97)	44.1 % (176)
P. sediment West	404	5.0 % (20)	10.4 % (42)	12.6 % (51)	25.0 % (101)	47.0 % (190)

Figure within parentheses indicates number of fibre out of total fibre content.

finding of Glovinova *et al* (1994), who reported lesser amount of fibres than our study at different habitats snails but not from the environment of asbestos industry. Gomot-de Vaufleury and Pihan (2002) also demonstrated the bioaccumulation of various metals in snail through oral and dermal uptake from contaminated site. Table-5 explains the asbestos load in different organs of the frogs examined under three groups. Like snail the highest fibre burden was found in rectum and the lowest one was in muscle. The frog kidney also showed considerable level of asbestos fibre burden. This is further supported by Woodhead *et al.* (1983), who reported that in fish, during excretion process the fibre might get accumulated in the kidney, when exposed chronically in the environmental media. Although the total fibre content among the organs was different but individual lengthwise measurement of each ranges was quite comparable. The mean asbestos burden and lengthwise fibre burden (31-50 μm) studied under three groups of each part of the snails and frogs are the consequence of asbestos load in their living materials. Despite there might be one more possibility of translocation of fibres in frog is that some kind of frogs feed on various insects, snail, slug and earthworm in soil on land, sediment in ditches and paddy fields (Maeda and Matsui. 1989). Few reports already indicated the bioaccumulation of PCB in frog through food web (Kadokami *et al.* 2000; 2002). Thus, the bioaccumulation and passing through food web impact may first involve as direct poisoning and contamination may secondly involve as an indirect ecological effect.

Table 4. Mean asbestos residues in different organs of snails near an asbestos-cement factory.

Name of the organ	Mean* Fibre\g organ	% of fibre in lengthwise				
		< 10 μm	11-20 μm	21-30 μm	31-50 μm	> 50 μm
Buccalmass	60	13.3 % (8)	20.0 % (12)	23.3 % (14)	28.3 % (17)	15.0 % (9)
Visceral spiral	76	11.8 % (9)	19.7 % (15)	21.0 % (16)	27.6 % (21)	19.7 % (15)
Rectum	112	12.5 % (14)	23.2 % (26)	20.5 % (23)	30.3 % (34)	13.4 % (15)
Foot	40	10.0 % (4)	27.5 % (11)	20.0 % (8)	32.5 % (13)	10.0 % (4)
Muscle	21	14.3 % (3)	19.0 % (4)	23.8 % (5)	38.1 % (8)	4.8% (1)

Figure within parentheses indicates number of fibre out of total mean fibre content.

* Mean value of fibre present in the total No of organism, studied under three groups.

Table 5. Mean asbestos residues in different organs of frogs near an asbestos-cement factory.

Name of the organ	Mean* Fibre\g organ	% of fibre in lengthwise				
		<10 μm	11-20 μm	21-30 μm	31-50μm	> 50 μm
Eye	28	17.9 % (5)	24.9 % (7)	24.9 % (7)	21.4 % (6)	10.7 % (3)
Stomach + Duodenum	72	12.5 % (9)	20.8 % (15)	19.4 % (14)	27.7 % (20)	19.4 % (14)
Rectum	189	12.7 % (24)	15.8 % (30)	25.4 % (48)	33.9 % (64)	12.2 % (23)
Kidney	69	17.3 % (12)	15.9 % (11)	26.0 % (18)	27.5 % (19)	13.0 % (9)
Muscle	20	10.0 % (2)	10.0 % (2)	20.0 % (4)	40.0 % (8)	20.0 % (4)

Figure within parentheses indicates number of fibre out of total mean fibre content.

* Mean value of fibre present in the total No of organism, studied under three groups.

It is obvious from our above findings presented here that the asbestos concentration decreased with increasing distance from the factory. The bioaccumulation of chrysotile fibres in the body organ of the model animal species is the consequence of asbestos burden in their living materials.

Acknowledgments. We thank Dr. P.K. Seth, Director, for his keen interest and support in this work and to Mr. M. Ashquin for his skillful technical assistance. The financial grant from the Ministry of Environment & Forests (Govt. of India) is also gratefully acknowledged.

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