Environmental pollution and chronic arsenicosis in South Calcutta

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Careless handling of industrial wastes often creates problems for human health and the environment. Chronic arsenic toxicity, resulting from household use of arsenic-contaminated water occurred in 53 out of 79 members (67%) of 17 families residing in South Calcutta close to a factory that manufactured Paris-green (copper acetoarsenite). Clinical investigation of 20 of these affected persons showed typical skin pigmentation as well as palmar and plantar keratosis in all of them, while gastrointestinal symptoms, anaemia and signs of liver disease and peripheral neuropathy were seen in many. The water used by the affected families for drinking and cooking had been taken from shallow tubewells and had arsenic levels from 5.0 to 58 mg/l (WHO permissible limit, 0.05 mg/l). Other residents in the same area whose drinking-water came from deep tubewells or from tap water supplied by the Calcutta Municipal Corporation (arsenic levels, <0.05 mg/l) were not affected. The study confirms that arsenic in the shallow tubewells was due to the waste discharged by the factory producing Paris-green.

Contamination of groundwater by arsenic may be due to industrial discharges, mining operations, or mobilization of naturally occurring arsenic in sedimentary aquifers. Such contamination has been reported in China (Province of Taiwan) (*1*), USA (Millard County, Utah) (*2*), Chile (*3*), Argentina (*4*), and Japan (Torku) (*5*).

Between 1983 and 1985, 14 villages in South Bengal were affected by chronic arsenic toxicity (*6–8*). A high level of arsenic was detected in the water from shallow tubewells (24–36 metres deep) used by those affected, but the cause of the contamination could not be ascertained. During the period July–September 1989, some residents of P.N. Mitra Lane, Behala, South West Calcutta, attended the S.S.K.M. Hospital and were found to have signs of chronic arsenic toxicity. This led us to study the problem from an environmental, clinical and epidemiological point of view.

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Reprint No. **5305**

Materials and methods

The locality from where the suspected cases of arsenic toxicity came was visited; this was close to the boundary wall of a chemicals factory which for the last 20 years had been producing the insecticide Paris-green (copper acetoarsenite). The factory's effluent in P.N. Mitra Lane was connected to a drain and a canal about 400 m away. The population around the factory (about 10 000) uses water from three sources: shallow tubewells, deep tubewells, and tap water (the last two supplied by the Calcutta Municipal Corporation). As only a few deep tubewells and taps are available in the area, many of the dwellings have their own shallow tubewells whose water has been used for many years for drinking, cooking and washing.

Soil samples, which were collected from around the factory as well as from areas near the released waste, were dried, sieved and analysed by X-ray fluorescence, electroprobe micro-analysis, and atomic absorption spectrophotometry for arsenic and copper content and chemical characterization. These procedures have been described earlier (*9–11*). Water samples were analysed for arsenic(III), arsenic(V), and total arsenic (*12*).

Thorough clinical, haematological and neurological examinations as well as liver function tests, HBsAg determinations, and urine analysis were carried out on 20 affected patients who attended the hospital. Liver biopsy was done in 3 out of 4 cases who agreed to be admitted to the hospital.

Results

In the soil (18 samples) close to the factory's effluent the concentration of arsenic was in the range of 4–19.5 mg/g and copper in the range of 13.5–26.5 mg/g. The samples were collected about 20 m from the discharge point of the effluent and nearly 200 m from the people's houses. Eight out of the 12 deep tubewells analysed had <0.05 mg arsenic per litre; four had concentrations of 0.06, 0.08, 0.16 and 0.42 mg/l. Out of the 45 shallow tubewells analysed, 17 contained arsenic in a safe level and 28 had concentrations of 0.1–58 mg/l (10 of these were >5.0 mg/l). In the tap water samples the concentration of arsenic was <0.05 mg/l. The average ratio of arsenic(III) to arsenic (V) in all the samples containing arsenic was around 1:1.

Out of the 30 houses visited, nine with 17 families were found to have cases of arsenical dermatoses; of the 79 members of these families, 53 (67%) were affected. These people, who lived close to the factory, had used water from their own tubewells for drinking and cooking. Although the remaining 21 houses were also close to the factory, the occupants had used the Calcutta Municipal Corporation's deep tubewell or tap water whose arsenic concentrations were in a safe level. Age and sex distributions of the affected cases are given in Table 1. The arsenic content in the water taken from different sources is given in Table 2.

Twenty patients were investigated clinically, their ages ranging from 1 to 69 years; the presenting symptoms and signs are given in Table 3. Typical skin manifestations were found in all of them, but pulmonary symptoms were present in 40% and neurological symptoms in 65% of cases. The haemoglobin level varied between 8 and 13 g/dl. Hepatomegaly (2–6 cm) was found in 80% of cases and splenomegaly (1.5–2.5 cm) in 35% of cases. The results of liver function tests are plotted in Fig. 1. The globulin level was found to be >3g/dl in 55% of cases; there was a mild elevation of SGOT (aspartate aminotransferase) and moderate elevation of alkaline phosphatase levels in most of the cases studied.

The liver biopsy (in 3 out of the 4 cases admitted) showed mild to moderate portal zone fibrosis with expansion in two patients who also had splenomegaly, but their liver function tests did not show much alteration. The third patient had jaundice, hepatosplenomegaly, ascites, a low serum albumin (2 g/dl) but elevated globulin (5 g/dl), SGOT (150 IU/dl) and SGPT (alanine aminotransferase) (127 IU/dl) levels, and also serological evidence of hepatitis virus B infection. The liver histology of this patient showed gross portal zone expansion and fibrosis, significant mononuclear cell infiltration

Table 1: **Distribution of cases showing arsenic toxicity, by age group and sex**

Age group (years)	No. of males	No. of females	Total
1–4	1	1	2 (3.8)[a]
5–14	2	4	6 (11.3)
15–24	1	6	7 (13.2)
25–34	13	8	21 (39.6)
35–44	5	4	9 (17.0)
45–54	1	4	5 (9.4)
≥55	2	1	3 (5.7)
Total	25	28	53 (100)

[a] Figures in parentheses are percentages of the total.

Table 2: **Arsenic content in samples collected from different water sources**

Water source	No. of samples	No. with arsenic concentration >0.05 mg/l[a]	Arsenic range (mg/l)
Deep tubewells [b] (122–228 m deep)	12	4	0.06–0.42
Shallow tubewells (24–36 m deep)	45	28	0.06–58
Tap water[b]	6	0	—
Drain close to factory effluent	1	1	1.5[c]

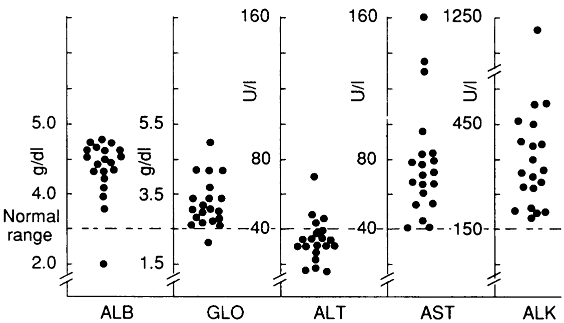
[a] 0.05 mg/l is the upper guideline value recommended by WHO for total arsenic.
[b] Installed and maintained by the Calcutta Municipal Corporation.
[c] When this sample was collected, Paris-green was not being produced in the factory.

Table 3: **Clinical features of 20 cases studied**

	No. of cases
Symptoms:	
Weakness	17 (85)[a]
Muscle aching	14 (70)
Tingling and numbness of hands and feet	13 (65)
Cough	8 (40)
Signs	
Pigmentation	20 (100)
Thickening of palms and soles	13 (65)
Anaemia	5 (25)
Hepatomegaly (2–6 cm; mean, 3.5 cm)	16 (80)
Splenomegaly (1.5–2.5 cm; mean, 2 cm)	7 (35)
Jaundice	1 (5)
Ascites	1 (5)

[a] Figures in parentheses are percentages.

Fig. 1. **Results of liver function tests on 20 patients.** (ALB, serum albumin; GLO, serum globulin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALK, alkaline phosphatase).



in and around the portal zone, and scattered necrosis in the liver lobules. The patient died of hepatic encephalopathy two months after hospitalization. The fourth patient developed lung abscess and was managed with prolonged antibiotic therapy conservatively. He also had hepatosplenomegaly and altered liver function tests, but refused to have a liver biopsy. Neuropathic changes were found by electromyography in 65% of patients with paraesthesia.

Discussion

This study shows how improper handling of industrial wastes can lead to a health hazard. Paris-green was the first pesticide to be widely used in modern agriculture (*13*) as a popular insecticide in orchards (*14*), but it is of minor importance today. The use of arsenic-containing pesticides and herbicides is now restricted owing to their toxicity and suspected carcinogenicity. Our investigations showed that the liquid waste from the manufacture of Paris-green was discharged into an open drain connected to a canal. The fact that the arsenic in the soil was due to the Paris-green in the effluent discharge is confirmed by the presence of a high amount of copper in the soil. Electroprobe microanalysis of the soil samples near the discharge point showed that out of a random 500 particles analysed in 4 soils, an average of 430 particles contained copper and 225 contained arsenic.

The source of the arsenic in the groundwater was thus the factory's effluent which contained a high level of arsenic (1.5 mg/l), the cumulative effect of which became serious over a period of 20 years. However, arsenic was not found in all the shallow tubewells and on the opposite side of the factory because of the sloping ground. The copper content was very high in the soil near the drain but was not raised in the groundwater, probably because the copper was bound by the soil while the arsenic could percolate. A high concentration of arsenic in the groundwater indicates that the arsenic could pass easily through the soil. Our study found the soil in the area to be sandy and easily penetrable.

Infectious and communicable diseases, which cause morbidity and mortality among the majority of the population in developing countries, are often associated with lack of clean water for daily use. Unpolluted subsoil water, drawn from a depth of 24–36 metres, is normally safe except when contaminated by elements like arsenic when it poses a major health problem, as previously described (*8*). Contamination of subsoil water in a city suburb of West Bengal by arsenic, the upper acceptable limit of which is 0.05 mg/l, in this investigation showed levels of 5–58 mg/l.

The main clinical features in those who drank the contaminated water were as described earlier (*6*, *7*)—skin pigmentation, thickening of palms and soles, peripheral neuropathy, and gastrointestinal and pulmonary manifestations. Liver involvement (portal zone fibrosis and moderate alteration of liver enzymes, SGOT (aspartate aminotransferase) and alkaline phosphatase) was found in some of the cases. Only those who resided near the factory and used the arsenic-contaminated water were affected.

Similar environmental pollution causing chronic arsenic toxicity was recently reported from Japan; it concerns a small area near an abandoned mine and refinery in Torku where 144 people were found to be affected (*5*). It appears that roasting of arseno-pyrites resulted in a discharge of gas containing arsenic trioxide in the period 1920–62; analysis of samples around the mine revealed a high arsenic content in the dust from roof tops (0.02–0.8%), soil (0.276%), and percolated water (0.018%). Pollution caused by the factory in our study produced much higher levels of arsenic, e.g., 1.95% in the soil.

Stringent laws are needed in developing countries so that environmental pollution will not lead to contamination of the groundwater. In addition, state health administrations should undertake the regular testing of subsoil water that is used for drinking in order to check the levels of toxic metals.

Acknowledgements

We are grateful to the Surgeon Superintendent of S.S.K.M. Hospital, Calcutta, for allowing us to use the hospital records. We also thank the staff in the Department of Gastroenterology, Institute of Post-Graduate Medical Education & Research, especially Dr A. Ghose and Dr A. Santra, and the field staff in the epidemiology section of All India Institute of Hygiene and Public Health, Calcutta, and in the School of Environmental Studies, University of Jadavpur, West Bengal, for their help in carrying out this study.

Résumé

Pollution de l'environnement et arsenicisme chronique à Calcutta-Sud

Le rejet inconsidéré de déchets industriels, en particulier de déchets dangereux, pose souvent des problèmes d'environnement et de santé publique. Le présent article décrit une étude épidémiologique portant sur des personnes résidant dans le voisinage d'une usine de produits chimiques fabriquant du vert de Paris (acétate de cupriarséniocuivre) à Calcutta-Sud, au Bengale-Occidental. Une intoxication chronique par l'arsenic a été diagnostiquée chez 53 personnes (25 de sexe masculin et 28 de sexe féminin) sur une population composée de 79 membres (67%) de 17 familles résidant dans neuf habitations voisines de l'usine. Toutes ces familles utilisaient de l'eau de boisson prise dans leur propre puits instantané de faible profondeur (24–36 mètres), et dont la teneur en arsenic était comprise entre 5 et 58 mg/l (limite acceptable supérieure établie par l'OMS: 0,05 mg/l). Les effluents de l'usine, prélevés dans un égout voisin, avaient une teneur en arsenic atteignant 1,5 mg/l tandis que des échantillons de sol recueillis à proximité de l'usine contenaient 4 à 19,5 mg/g d'arsenic. D'autres familles vivant dans le même secteur et utilisant de l'eau de boisson prélevée dans des puits instantanés publics (profondeur 122–288 mètres) ou de l'eau du robinet fournie par la Calcutta Municipal Corporation, dans laquelle la teneur en arsenic était inférieure à 0,05 m//l, ne présentaient aucun signe d'arsenicisme.

Parmi les 53 sujets atteints, 20 ont été examinés à l'hôpital. Ils étaient âgés de 1 à 69 ans, et présentaient les symptômes suivants: faiblesse générale (85%), douleurs musculaires (70%), picotements et engourdissement des mains et des pieds (65%), toux (40%). Les signes consistaient en une pigmentation typique de la peau (100%), un épaississement cutané des paumes et des plantes des pieds (65%), une anémie (25%), une hépatomégalie (80%) et une splénomégalie (35%). Le taux d'hémoglobine variait entre 8 et 13 g/dl et les tests de fonction hépatique montraient un taux de globuline supérieur à 3 g/dl dans 55% des cas. La SGOT était légèrement relevée par rapport à la SGPT et la plupart des cas étudiés présentaient une élévation modérée des phosphatases alcalines. Une biopsie hépatique pratiquée sur trois cas montrait une hypertrophie de la zone portale et une fibrose. Des modifications neuropathologiques ont été mises en évidence par électromyographie dans 65% des cas présentant des paresthésies.

Cette étude montre que les eaux souterraines sont facilement contaminées par l'arsenic déposé dans le sol par suite du rejet inconsidéré de déchets d'une usine de produits chimiques. Une évaluation des méthodes de gestion des déchets appliquées par les usines de ce type est donc indispensable pour lutter contre la pollution de l'eau dans les pays en développement.

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