

Arsenic

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Arsenic levels in man are commonly measured in tissues such as hair and fingernails, which give an indication of long term accumulation. In general, in the absence of extrinsic deposition, hair levels greater than 5 parts per million (ppm) are considered to indicate a possible hazard to health. Arsenic may also be measured in urine. Urine levels are indicative of acute, or short-term exposure rather than chronic exposure. In general, urine levels greater than 100 parts per billion (ppb) represent a health hazard, but levels 20 times this may follow ingestion of pentavalent arsenic in seafood such as crab, lobster, shrimp, etc.

Arsenic is widely found in a combined form in igneous rock throughout the world. In the N.W.T. it is most frequently associated with gold-bearing ores in which there is often a major content of arseno-pyrite, an insoluble mineral that contributes little if any arsenic to the food chain under normal circumstances.

Arsenic becomes a health problem when native arseno-pyrite is changed to arsenic trioxide during ore roasting and smelting. Arsenic trioxide (As_2O_3) volatilizes and is readily dispersed in the atmosphere unless meticulous care is directed towards its recovery.

During the early years of gold extraction from mines in the Yellowknife area huge quantities of arsenic were released to the atmosphere because no effort was made to trap arsenic trioxide and dispose of it in a safe fashion. Devilliers & Baker (1973) estimated that up to 11 tons of arsenic trioxide per day were liberated into the atmosphere through the stacks in the late 1940s. Much of this fell back to earth in the immediate neighbourhood of the producing mines.

Subsequent to that time several processes have been used, with steadily increasing efficiency, to entrap and retain arsenic trioxide, so that today estimated daily losses to the environment are less than 10 kg (20 lbs.) per day, an amount of little health significance to residents of the area.

Certain problems have, however, been produced by the entrapment procedures because the arsenic produced was concentrated and thus caused local "hot-spots" of intense arsenic pollution. For example, wet scrubbers used in the Con Mine resulted in a concentrated, arsenic-containing slurry that was disposed of into Arsenic "Ponds" on Con Mine property. The "Ponds" remain to this day, although no arsenic has been fed into them since the cessation of the roasting process at Con Mine about 10 years ago. They probably contain about 29,000 tonnes (32,000 tons) of dry arsenic trioxide (Soniassy and Brown 1980).

In the Giant Mine, where ore is still roasted, particulate arsenic-containing material is extracted in electrostatic precipitators, and condensed arsenic trioxide is collected from the cooled exhaust gases in a large bag-house from which the arsenic is led away either for purification reprocessing or to storage in sealed underground stopes. This collection procedure, though it virtually eliminates the exterior hazard, results in a work environment in which a small number of employees find themselves in a highly contaminated area where they must wear protective clothing, use a controlled breathing apparatus, and practice rigorous personal hygiene to avoid excessive arsenic intake. Despite all these measures, the bag-house workers constantly have urine arsenic levels that approach or exceed recommended maxima. Hair arsenic in these workers, and in some others in less exposed situations, is usually very high, probably as a result of external contamination of the hair shaft by airborne arsenic-containing dust.

In 1966 Medical Services carried out an intensive survey of the inhabitants of the City of Yellowknife.

The survey was a carefully designed and elaborate investigation into all aspects of possible arsenic effects in both city residents and mine workers. The findings (Devilliers & Baker 1973) were substantially negative with the only definitive evidence of arsenic toxicity being dermatoses of sweaty areas in some individuals working in areas of high exposure to arsenic. No long term effects of arsenic toxicity were detected either in the gold mine workers or in the citizenry.

In 1975, following allegations made on the CBC radio program "As it Happens" the Yellowknife arsenic question was reopened and a preliminary survey of arsenic levels in hair was carried out on a sample of 705 residents of the town. The sample contained mine and mill workers, native people, and long term residents. The results (Tables 1 to 4) demonstrate that the general population of Yellowknife was not abnormally exposed to arsenic (Eaton 1975). Adult males not employed at the gold mines and adult females wherever employed showed no abnormally high arsenic levels. High levels were found in some employees at Giant Mine who were associated with the bag house, the cottrell or the roasters, and in some laboratory workers, pipefitters, etc. whose duties took them into high dust areas of the mill. Underground workers in general showed levels that were not elevated or only moderately higher than the average. In addition some children and youths, particularly males, from both Indian and white families, had a modest elevation.

The high levels in a few children were probably a result of external contamination. The same may be true for many of the high levels in mill employees. However, there is a distinct possibility of a toxic hazard for bag-house and roaster workers and possibly also for those in the laboratory.

In a second phase of this study all individuals showing hair levels in excess of 10 ppm were invited to undergo a thorough medical examination and the majority availed themselves of the opportunity. This part of the study showed that the children and laboratory workers who had high hair levels had low urine levels thus confirming that their high hair levels resulted from external contamination rather than ingestion or inhalation.

As a result of this inactivity the news media once again became involved, this time at the behest of the unions, who saw that they had a problem, and the Indian population, who believed that they had a problem but had not. Rhetoric flowed in print and on the air waves to the pronounced embarrassment of the Federal Ministry of Health. To attempt to resolve the dilemma, and to temper the heat, the Canadian Public Health Association (CPHA) was commissioned by the then Minister of Health to undertake a review of the entire Yellowknife arsenic story and to make recommendations for the future. An independent three-man task force, which was appointed early in 1977, gathered evidence and held hearings in Yellowknife and Ottawa and published a final report in December, 1977 (CPHA 1977). Although the

TABLE 1

FREQUENCY OF OCCURRENCE OF VARIOUS HAIR ARSENIC LEVELS IN 350 NON-NATIVE MALES BY AGE GROUP. YELLOWKNIFE, FEBRUARY, 1975.

	Age Group											
PPM Arsenic	0-4	5-9	10-	15-	20-	30-	40-	50-	60-	70+	Unknown	Total
0.0-0.9	1	1	3	12	14	11	5	4	1	2	1	55
1.0-4.9	2	13	24	18	35	24	34	19	11	2	4	186
5.0-9.9	—	3	4	2	8	9	11	6	1	1	2	47
10.0+	—	—	—	4	14	15	14	6	4	1	4	62
Total	3	17	31	36	71	59	64	35	17	6	11	350

Although bag-house workers had elevated urine levels indicating excessive arsenic intake, the levels were lower than those usually associated with clinical toxicity, and no chronic arsenicism was demonstrated.

Although these investigations identified a work hazard, jurisdictional problems seemed to make it impossible at the time to take effective action. Responsibility for health and safety in mines and associated above-ground buildings was vested in the Department of Indian and Northern Affairs (DINA) under the N.W.T. Mining Safety Ordinance. Although Medical Services perceived the hazard and actually increased the inspectorate to allow for coverage of such industrial situations, they had no legislative authority to insist on control measures. Though both Giant and Con Mine had been co-operative in the course of the investigation and were taking steps on their own to rectify deficiencies which they perceived there was no mechanism for supervision by Medical Services.

report revealed nothing that was not already known it provided a set of guidelines that enabled a number of departments of government to work with each other, and with the mines and unions, to develop a code of conduct within the industry that might be expected to reduce the residual hazard.

The task force also mounted an electromyographic survey of residents of Yellowknife and, for comparison purposes, of Hay River which has a similar population mix but no arsenic. Though hampered by indifferent support by the groups allegedly most interested they found no evidence of arsenically-induced nerve conduction deficit in the City of Yellowknife (CPHA 1978).

Another spin-off from the Task Force report was an investigation of the arsenic content, and hence the safety as food, of vegetables grown in the Yellowknife area. As might be expected no level of arsenic was observed that would render

TABLE 2

FREQUENCY OF OCCURRENCE OF VARIOUS HAIR ARSENIC LEVELS IN
292 NON-NATIVE FEMALES BY AGE GROUP. YELLOWKNIFE, FEBRUARY, 1975.

PPM Arsenic	Age Group										Unknown	Total
	0-4	5-9	10-	15-	20-	30-	40-	50-	60-	70+		
0.0-0.9	—	1	19	10	37	46	39	29	6	3	6	196
1.0-4.9	2	17	21	7	9	8	13	5	5	1	3	91
5.0-9.9	—	1	1	—	1	1	—	—	—	—	—	4
10.0+	—	—	—	—	1	—	—	—	—	—	—	1
Total	2	19	41	17	48	55	52	34	11	4	9	292

such vegetables unfit for consumption. This was a notable improvement from findings 20 or more years previously when leafy vegetables, as well as berry fruits had been classed as unfit for consumption as a result of arsenic contamination of surfaces, and was a direct reflection of the massive reduction in airborne emissions that had occurred (Soniassy 1978).

Finally, in a study that is still incompletely analyzed, the Canadian Association of Smelter and Allied Workers (CASAW), with the collaboration of Giant Mine and the three full-time bag-house workers launched a 90-day study of arsenic excretion as a reflection of work activities, protective devices employed, and diet. One of the most striking

findings was a huge increment in arsenic excretion following ingestion of marine crustaceans such as shrimp or lobster. These animals show tissue arsenic levels of 50-60 ppm or more, which however, is in an organic form, is not toxic to man, and is rapidly excreted in the urine. However, such findings vitiate biological monitoring of arsenic-exposed workers unless diet is controlled, or at least taken fully into account (Braid 1978).

Data generated by this study are being reviewed by the statistical team of the Canadian Centre for Occupational Safety and Health. Their findings are awaited with keen anticipation.

TABLE 3

FREQUENCY OF OCCURRENCE OF VARIOUS HAIR ARSENIC LEVELS IN
24 NATIVE MALES BY AGE GROUP. YELLOWKNIFE, FEBRUARY, 1975.

PPM Arsenic	Age Group										Total
	0-4	5-9	10-	15-	20-	30-	40-	50-	60-	70+	
0.0-0.9	—	—	—	—	1	1	—	—	—	2	4
1.0-4.9	—	—	1	1	4	2	—	1	2	1	12
5.0-9.9	—	—	1	1	2	1	—	—	—	1	6
10.0+	—	1	1	—	—	—	—	—	—	—	2
Total	—	1	3	2	7	4	—	1	2	4	24

TABLE 4

FREQUENCY OF OCCURRENCE OF VARIOUS HAIR ARSENIC LEVELS IN
37 NATIVE FEMALES BY AGE GROUP. YELLOWKNIFE, FEBRUARY, 1975.

PPM Arsenic	Age Group										Total
	0-4	5-9	10-	15-	20-	30-	40-	50-	60-	70+	
0.0-0.9	—	—	1	3	9	2	—	—	—	—	15*
1.0-4.9	—	1	1	2	3	1	3	1	3	—	15
5.0-9.9	—	1	2	2	—	—	1	1	—	—	7
10.0+	—	—	—	—	—	—	—	—	—	—	—
Total	—	2	4	7	12	3	4	2	3	—	37

* Includes 3 female Inuit.