PNOC 94

HEALTH RISK ESTIMATE FOR ARSENIC IN COMMON VEHICLES FROM A GEOTHERMALLY ACTIVE AREA

NIS Pastor, MD[a], Engr. R. Suarez[b], Engr. V. Molina[a], Engr. R. Santiago[c], J. Cueto, MD[d], V. Co, MD[a]

[a] Environmental Health Service, Dept. of Health, Sta. Cruz, Manila, Philippines
[b] Provincial Health Office, North Cotabato, Philippines
[c] Disaster Management Unit, Department of Health, Sta. Cruz, Manila, Philippines
[d] Strategic Assessment and Risk Containment System, Dept. of Health, Sta. Cruz, Manila, Philippines

Abstract

Relatively high levels of arsenic were reported in hair samples from residents of a village on a geothermally active mountain, site of a nearby geothermal project in August 1993. Concerned with the report, the Philippine Congress ordered a composite team of physicians, engineers and chemists from the Department of Health to investigate. The paper presents the initial results of investigation conducted. Various samples were collected from selected residents of the mountain villages of Sudsuhayan and Sayaban in Ilomavis, Kidapawan, North Cotabato, Philippines. Samples were tested for arsenic. The results were used in calculating health risks for arsenic in common vehicles of contamination including water,:soil and farm products from the residents. Urine arsenic levels from these residents were correlated with the amount of risk to determine the most probable pathway of exposure. Based on the results, the most probable sources of contamination in decreasing order are residence soil, farm soil, solid food and drinking water. Recommendations on how to manage unidentifiable environmental health hazards and pathways were given.

1.0 INRODUCTION

Last April 1993, an independent scientist detected 0.3 to 2.8 parts per million (ppm) arsenic in hair samples from residents of a mountain village in a geothermally active area in Mt. Apo, North Cotabato, Philippines, site of a geothermal development project (1). This was above the 1.00 ppm level which is considered normal in human hair. Concerned citizens brought the report to the Philippine Congress which subsequently ordered an investigation. A composite team from the Department of Health: University of the Philippines: the project developer, Philippine National Oil Company: and several representatives from concerned groups joined in the site inspection and sampling on October 18 and 20, 1993 respectively. The objective was to determine the veracity of the report and to determine the most probable pathway of intoxication.

2.0 METHODS AND MATERIALS

Households along the road radiating from the geothermal development were sampled randomly. Household members were interviewed with prepared questionnaires and then weighed and instructed to collect urine for the next 24 hours. Drinking water from household containers and point sources mostly springs, soil from residential and farm lots and food products from these farms if available were obtained.

Water and soil samples were analyzed for arsenic using the Silver diethyldithiocarbamate/ colorimetric method. Urine and food samples were analyzed using the Atomic Absorption Spectrophotometric method.

Once the concentrations of arsenic from the various vehicles of contamination were determined, intakes using the standard formula developed by the US Environmental Protection Agency (EPA) were estimated. The following formula was adopted to calculate the intake:

$$\frac{(\text{As conc})*(\text{contact rate})*(\text{est. freq.})*(\text{est. duration})}{(\text{body weight}) * 365 \text{ days} * 65 \text{ years}}$$

Health risk for each person was estimated by dividing intake with the reference dose (RfD) derived from the EPA's Health Effects Assessment Summary Tables (HEAST) for non-carcinogenic arsenic. Values: obtained in this manner reflected the degree of health risk a person may get when exposed to the ambient concentration of arsenic from a vehicle he contacts within a span of 1.0 year.

Health risks from the interviewees were combined. A value greater than 1.00 was considered high, while below 1.00 was classified as low. This was correlated with the level of arsenic from the 24-hour urine specimens which may indicate recent exposure. Chi-square test was used to correlate the level of urine arsenic and the combined health risk calculated for each vehicle of contamination. The statistical analysis yielded a composite risk to the group of individuals interviewed indicating the most probable pathway .through which arsenic may have reached the individual.

Geographic positions of the composite risks were located on a map to determine the spatial cluster of potential risk factors to the community and/or household relative to the geothermal site.

3.0 RESULTS

A total of 30 households were interviewed of which 18 households were analyzed. Twelve were dropped from the list because residents were unable to provide complete information. Most of the respondents (88%) belong to the tribal communities of either the Bagobos or Manobos. The ages ranged from 16 to 62 years old. On the average, most respondents had lived a mean of 25 years (range = 10 to 62 years) within the vicinity of either Sayaban, Anggi or Sudsuhayan in Mt. Apo. One young patient exhibited Mees lines and an elderly farmer has muscle atrophy.

The concentration of arsenic in parts per million (ppm) from common vehicles of contamination obtained from or near households or from point sources are shown in Table I. Arsenic concentrations from point sources of the drinking water were all below the Philippine Standard for drinking water of 0.05 ppm.

Table I. Arsenic concentrations (ppm) from common vehicles of contamination. Mt. Apo, Kidapawan, N. Cotabato, Phil., 1993

	HHold water	Food	Res. soil	Farm soil
Range	0.00-0.03	0.00-0.15	0.00-2.20	0.20-1.70
Sample Size	13	4	10	8
Mean	0.0031	0.08	0.97	0.97
Std. Dev.	0.01	0.06	0.74	0.46
Health Limit	0.05 ppm	unknown	unknown	unknown

The health risk to each household ranged between zero to as high as 1 per 1,341 persons for the various concentrations of arsenic in the different vehicles of contamination mentioned. The results are shown in Table II.

Table 11. Health risk from arsenic in common vehicles of contamination. Mt. Apo, Kidapawan, N. Cotabato, Philippines, 1993

	HHold water	Food	Res. soil	Farm soil
Individual Range	0.00-0.8	0.98-763.16	0.00-1341.46	98.04-781.25
Mean	0.11	196.66	602.42	549.10
Remarks	Not a significant health risk	Level of concern is 196 times greater than usual	Level of concern is 602 times greater than usual	Level of concern is 549 times greater than usual

The levels of arsenic from the 24-hour urine specimens ranged between 15.05 to 45.77 microgram (ug) per gram (g) of creatinine (crea) with a mean of 29.23 ug/1.0g crea. These levels were compared by the chi-square tests with the combined health risk estimate. The results are shown in Table 111.

Table 111. Arsenic levels in urine and degree of risks from common vehicles.

	Chi-square test	Remarks
HHold water	1.13	Not significant
Food	4.02	Significant at $p < 0.05$
Res. soil	7.48	Significant at $p < 0.05$
Farm soil	5.51	Significant at $p < 0.05$

If the risks are correlated'to household locations, the combined estimated health risks show that households at greatest risk clustered above the confluence of Matingao and Mook creeks (occupied by barangays Anggi and Sudsuhayan) and above the school of Sayaban.

4.0 DISCUSSION

The results used in this paper are based on preliminary 'surveys to determine exposure of the residents of Ilomavis, Kidapawan, North Cotabato to arsenic and the health risk of arsenic from common vehicles of contamination obtained from geothermally active area. Results indicate that none of the arsenic levels in the 24-hour urine samples from the subjects exceeded 50 ug/g crea, the level in 24-hour urine specimen which indicate recent exposure. Levels greater than 50 ug/g crea is considered abnormally high by medical standards (2). All persons were assymptomatic, although 1 patient has Mees lines, an indication of exposure during childhood. This person has an arsenic level of about 33.27 ug/g crea, well below the medical standard for recent exposure. **A** 52 year old farmer who is suffering from muscle atrophy has a urine arsenic level of **15.05** ug/g crea, again well below the medical standard. Muscle atrophy could be attributed to chronic exposure to high levels of arsenic. But this farmer had no laboratory confirmation of recent exposure. In-depth interview with this farmer indicated persistent use of pesticides which may lead to muscle atrophy. The use of these chemicals should be explored further, since exposure to these chemicals could also lead to signs and symptoms similar to chronic arsenic exposure.

The statistical chances for getting poisoned from chronic annual exposure to the levels of arsenic in soil from a geothermally active area was significant. The chances of getting sick reached as high as **1,341** when arsenic levels in soil near households reached 2.20 ppm. An annual chance greater than 1.0 is usually considered high especially when these persons had lived a mean of about 25 years in a geothermally active area. In this exercise, the investigators assumed a daily consumption of 25 mg of soil ingestion **(3)**. Background levels of arsenic from Philippine soil reached as high as 12.00 ppm **(4)**. **A** rock sample taken near one of these residents' drinking water contained level greater than 5.0 ppm arsenic. The variation of the levels of arsenic in soil samples may reflect peculiar geographic distributions that were beyond the present investigation to determine. Patches of high levels of arsenic may be present in the area and a detailed environmental investigation should determine the levels where human population exist.

Households at greatest risk were clustered above the confluence of Matingao Creek and Mook River and around a basketball court above a communal faucet. Arsenic concentrations from soil samples in these areas were high. Children are most prone to exposure to arsenic in soil since these are the age group that play with soil and are at risk through this pathway. Relocation of families from areas with high arsenic in soil was found to dramatically reduce the 24-hour urine levels of the chemical in some instances (2). But this may be difficult among families belonging to cultural communities who are attached to their usual environment.

Behavior modification of children's play activities away from soil contact may be the next alternative. A health program especially designed for the indigenous cultures had been proposed. This program of activities will take into account the cultural peculiarities of indigenous groups. PNOC can include this subject in their planned cultural study so that proper health interventions can be installed.

Several hotsprings are located near the area which may periodically contaminate the drinking water sources of the residents. There is no evidence for this pathway in the study as the risk from drinking water was low. However, the possibility of communication between these surface hotsprings and the shallow water table can be considered. Further study on the surface hydrology of the area is recommended.

Arsenic tests on the point sources of drinking water had varied results. Regular monitoring of these sources being presently done by PNOC must be continued. Most point sources which have been the source of drinking water of the residents for as long as many can remember do not pass the sanitation standards of the Department of Health. However, PNOC has so far developed 4 out of 19 natural springs as source of drinking water. The development of more sustainable sources of potable and safe drinking water should be seriously considered especially for the workers of the development project and traditional residents within the geothermally active area.

5.0 RECOMMENDATIONS

The following are recommended to concerned agencies:

1. Expanded arsenic analysis of soil in populated areas to locate sites of risks.
2. Inventory of cultural practices related with the vehicles of arsenic contamination.
3. In-depth study on the contribution of pesticide use on the arsenic risk.
4. Development of safe drinking water sources.
5. Study on effect of surface hydrology to drinking water sources.

6.0 REFERENCES

1. Hironaka H. Fax message to Kinaiyahan Foundation, Inc. presented as evidence to the Committee on Ecology, Philippine Congress, Sept. 28, 1993.

2. MMWR. Reduction of Children's Arsenic Exposure Following Relocation - Mill Creek, Montana 36(30)506-507. Aug. 7, 1987.

3. National Health & Medical Research Council. Australian & New Zealand Guidelines for the Assessment & Management of Contaminated Sites. Jan. 1992 p. 29.

4. Inventory analysis of geothermal sites by Phil. National Oil Company.