

Impacts of Drinking Water and Salt Mining on the Health of Children at Al-Haroniah village, Al-Munirah District, Al-Hodeidah Governorate, Republic of Yemen

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Abstract

The purpose of this study is to determine the environmental and social links between drinking water and salt mining activities and the health of the children in Al-Haroniah village, as well as increase the awareness to environment and its effects on health of children in rural areas. Water samples, collected directly from house storage tanks and from the main water supply well of the village, as well as blood samples from disabled children were analyzed for lead and cadmium. In addition, children's health, along with their living and work places were investigated using pediatrician evaluation, questionnaires and group discussion interviews. High levels of cadmium, lead and nitrate, beyond the permissible levels of WHO for safe drinking water were found in the 29 water samples collected directly from house storage tanks and from the main water supply well of the village. These high levels of cadmium, lead and nitrate in water may be attributed to point source and non-point source pollution among which are solid waste, corrosion of galvanized pipes, runoff from waste Ni-Cd batteries, paint, color pigments and PVC products. Analysis of 20 blood samples collected from disabled and handicapped children and adults indicated high contents of cadmium and normal contents of lead confirming water pollution and environment. Clinical and social results indicate that the majority of disabled cases are deafness and aphasia, extremities deformity and mental retardation. Environmental factors, intermarriages and low socio-economical conditions may have contributed to disabilities and diseases in Al-Haroniah village.

Key Words: Lead, Cadmium, Alhakimi, Dughish, Yemen

Introduction:

Exposure to heavy metals continues, and is even increasing in some parts of the World, in particular, in less developed countries [1]. Both children and adult are susceptible to health effect from lead and cadmium [2, 3].

Studies have found that heavy metals such as mercury, cadmium, lead, aluminum, and tin affect chemical synaptic transmission in the brain and the peripheral and central nervous system. The toxic metals have been

documented to be reproductive and developmental toxins, causing birth defects and damaging fetal development, as well as neurological effects [3], developmental delays, learning disabilities,

depression, and behavioral abnormalities in many otherwise normal-appearing children. These toxic metals have been found to have synergistic negative effects on childhood development and cognitive ability. Also high exposure of lead and cadmium can cause mental retardation, disability and learning difficulties [3-6].

Lead is neurotoxin and harmful to the developing nervous systems of fetuses and young children. Extremely high blood lead levels ($>70\mu\text{g}/\text{dl}$) can cause severe neurological problems (e.g., seizure, coma, and death). Lead can cause damage to kidneys and blood system [7]. It has been found that lead can cause mental retardation, attention problems, distractibility, restlessness, and hearing impairment [8, 9]. The Center for Disease Control has found that exposure to lead is

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from soil, paint chips, drinking water, fertilizers, food, auto and industrial emissions, ammunition (shot and bullets), bathtubs (cast iron, porcelain, steel), batteries, canned foods, ceramics, chemical fertilizers, cosmetics, dolomite, dust, foods grown around industrial areas, gasoline, hair dyes and rinses, leaded glass, newsprint and colored advertisements, paints, pesticides, pewter, pottery, rubber toys, soft coal, soil, solder, baby formula using tap water, and tobacco smoke [8,9].

High levels of cadmium are found in regions with high emissions from incinerators, coal plants, or cars, as well as in shellfish, art supplies and cigarette smoke. Other common sources include rural drinking water wells, processed food, fertilizer, and old paint, food (coffee, fruits, grains, and vegetables grown in cadmium-laden soil, meats [kidneys, liver, poultry], or refined foods), freshwater fish, fungicides, highway dusts, mining, nickel-cadmium batteries, oxide dusts, paints, phosphate fertilizers, power plants, stabilizer in PVC products, color pigment, seafood (crab, flounder, mussels, oysters, scallops), sewage sludge, "softened" water, smelting plants, tobacco and tobacco smoke, and welding fumes [7]. The Environmental Protection Agency (EPA) has found cadmium to potentially cause the following health effect, nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure, bone and blood damage [10]. Also the exposure to cadmium causes Osteomalacia and Osteoporosis [1, 10].

Al-Haroniah village area is located northwest of Al-Hodeidahh city (about 65 km) few kilometers away from the Red Sea coastline. The area is part of the coastal plain; mostly flat surfaces with some scattered gypsum hills located near Al-

Qumah salt mine in the vicinity. The area soils are mostly sandy and sandy silt types of high porosity and permeability making it susceptible for contamination with harmful metals, such as, lead (Pb), cadmium (Cd) and other pollutants, that may be available on the surface, dispersing laterally and vertically through the soil layers to reach the shallow (10-25 meters) groundwater aquifer of the area. Al-Haroniah village consists of 200 houses and huts (African style dwellings). Around four hundred families are living in these houses where the population of the village is estimated around 3,000 people.

Hence, the purpose of the study is to determine whether a relation exists between the observed disability in children of Al-Haroniah village and the quality of both water sources and salt mines focusing on the toxic Lead and Cadmium elements.

MATERIALS AND METHODS

Twenty-nine water samples were collected from Al-Haroniah village main water supply well and houses' storage tanks using polyethylene bottles following the standard procedures for collection of water samples. Two water samples were collected from the main water supply well at Al-Munirah town, one from the drinking storage tank of Al-Qumah mine, four from the storage tanks of the two neighboring villages and the rest were collected from houses selected randomly at Al-Haroniah village. The samples collected were analyzed for lead, cadmium, nitrate and phosphate using Atomic absorption Spectrophotometer available at Sana'a Water and Sanitation Local Corporation. An additional two water samples from the main source were tested for parasites using standard microscopy.

Due to the general homogeneity of the Rock salt samples collected from the bedrock of Al-Qumah mine, only two samples that appear to be different on the basis of color were chosen and kept for analysis. The two samples were analyzed for purity, lead and cadmium.

Twenty disabled/ handicapped children were generally checked up by a pediatrician and blood samples were collected. Blood samples were kept in a cooler and separation of serum was done on the same day. Serum samples were stored in cryogenic vials and transported frozen to Sana'a within four days to be analyzed for lead and cadmium using Atomic Absorption Spectrophotometer.

Villagers, village leaders, health center officers, rehabilitation unit workers, district officers and some children (the same 20 individuals that were checked by the physician) as well as ten other families with normal children were interviewed by a social researcher using questionnaires and group discussion followed by observations of dwellings and work places of the villagers, disabled and handicapped children. All available information related to the subject of study were collected and reviewed.

RESULTS

Analysis of Water Samples and Rock Salt Analyses of 29 water samples collected from Al-Haroniah area showed high levels of nitrate (>50 mg/l), cadmium (>0.003 mg/l) and lead (>0.01 mg/l) (Figures 1 & 2). On

the other hand, analysis of the two rock salt samples indicated that the white salt is of a higher purity than the gray salt (92% vs. 85%) and the cadmium and lead levels were normal [11] (Table 1), even when they are compared with WHO levels. Microscopic testing of two water samples collected from the main water source showed the presence of parasites, mainly *Giardia* (data not shown).

Analysis of Blood Samples

Analysis of 20 blood samples withdrawn from the disabled children showed normal blood lead levels for all samples, except for one sample that had a higher than normal value (14 μ g/dl) (Figure 3). In contrast, nearly all such samples had shown higher than normal cadmium blood levels.

Clinical examination of the same 20 patients indicated the dominance of three main disabled groups of children (Figure 4). The first group consists of 8 cases of mentally retarded individuals, the second group includes 7 cases of deafness and the third group comprises 3 cases of Poliomyelitis. The remaining 2 cases are peripheral deformity (Figure 4).

Social Analysis of Disabled and Diseased Cases

Several meetings were performed in Al-Haroniah village; Al-Munirah town and Al-Qumah salt mine. Such interviews were conducted with officials, community leaders, health workers, villagers and workers including individuals and groups in Al-Qumah salt mine. Several general assumptions were indicated by individuals and groups about causes of disabilities and diseases, especially in Al-Haroniah village and other areas in Al-Munirah district. Among such assumptions were:

- Marriages between relatives and cousins
- Malnutrition of mothers and children.
- Spread of diseases like meningitis and malaria as well as lack of basic health.
- Other factors such as mishandling of the delivery of children or the use of medicines by mothers without consultation of physicians.
- Water diseases and environmental factors.

Information collected from the health center in Al-Munirah town showed the number of disabilities to be about 172, of which 22% were in the town of Al-Munirah and 20% were in Al-Haroniah village which has one third of the population of the Al-Munirah town (Data not shown). 1,770 cases had visited the health units during the first quarter of the year 2004. Several diseases are spreading in Al-Munirah district including Malaria (25%), Tuberculosis (TB) (23%),

and Diarrhea and skin diseases (27%) (Data not shown). 55% of the cases were males and 45% were females. About 54% of the cases were children and young people. The rest of the cases extend between the ages of 15 to 44 years and even older (Data not shown).

Pertaining to education, the number of students reached about 6,600, half of which were females. Most of the students are poor where males tend to work for few days in the market in order to help their families. The system of education was weakened during the last few years because of the lack of qualified teachers and lack of supervision. Many students became dropout and left schools to work in marginal jobs, even before they reached the age of 15. Such children are usually subjected to risks and exploitation by others, either through child labor or slavery migration to neighboring countries.

Table 2 shows the number of cases by sex and type of disability. The males represent 43% of cases and females 57%. With respect to types of disabilities, it was found that 40% had deafness and aphasia, 23% had problems related to extremities and 14% had paralysis. Mental retardation represented 10% of the types of disabilities.

Table 3 illustrates the number and percentage of disabilities and the number of families who have such cases. About 30 cases of disabilities are distributed among 22 families. 73% of these families have only one handicapped, include 16 cases males and females (53%). 18% of the families have 2 handicapped include 8 cases (27%). The rest of the families have 3 handicapped as indicated in the table.

Table 4 shows the relation between disabilities and intermarriage of relatives. 41% of families had intermarriage relationship and had 15 handicapped cases representing about 50% of the sample. In contrast, 59% of the families had no family relationship between parents, yet have 50% of the handicapped cases.

Children mortalities within the families of disabled children were about 34% for children of less than one year (Data not shown). However, the average number of mortalities for non-disabled is relatively more. It is also obvious that the average percentage of children mortalities of families of disabled is relatively more between males than females, but the opposite is true for the families of non-disabled (Data not shown). The number of families of non-disabled children has an average family size between (8-11 individuals), where males' number is more than that of females (Data not shown). Intermarriage between relatives of non-disabled children accounts for about 50% of the families (Data

not shown) which is similar to the percentage estimated for families of disabled children.

DISCUSSION

Environmental analyses in this study showed high levels of cadmium and lead in water samples. High range values (with an average levels of 0.075 mg/l and 0.053 mg/l for cadmium and lead, respectively) were found in the four water samples of the main water supply well of the region. A moderately high range values (with average cadmium and lead levels of 0.147 mg/l and 0.098 mg/l, respectively) correspond to that found in the water sample collected from the drinking water storage tank of Al-Qumah salt mine. The extremely high range values (with average cadmium and lead levels of 0.199 mg/l and 0.066 mg/l, respectively) correspond to that in the water samples collected from the storage tanks of 24 houses in Al-Haroniah area. Hence, the average cadmium level in the water samples collected from the storage tanks of Al-Haroniah houses was twice that in the water sample collected from the storage tank of Al-Qumah salt mine or that of water samples collected from the main water supply well of the region. Both average cadmium levels still highly exceeding the WHO limit for safe drinking water by more than 25 times. Similarly, the average lead levels in the water samples collected from the main water supply well or from the storage tanks of houses exceeds the WHO limit by nearly six times, and for Al-Qumah water sample, the average lead exceeds WHO limit by nearly ten times.

The high levels of cadmium and lead in drinking water may be attributed to many factors among which: excessive use of shellfish in diet, and from the corrosion of galvanized pipes, runoff from waste Ni-Cd batteries, paints, color pigments and PVC products. The sources of cadmium are all readily available in the area in the form solid waste piles dumped by residents, and occupying spaces reaching several hundreds square meters. This is in line with previous reports showing cadmium compounds to be used as stabilizers in PVC products and color pigments. Also, Shellfish, cigarette smoking and phosphate fertilizers are found to be major sources of cadmium [3].

The sources of lead in the region can be from soil, paint chips, drinking water, fertilizers, food, auto emissions, batteries, canned foods, dust, crops grown in lead contaminated soil, gasoline, leaded glass,

pesticides, pottery, rubber toys, tobacco smoke and corrosion of household plumbing systems. All these materials can be sources for lead by means of leaching down through the sandy soil reaching the shallow (10-20 meters) groundwater aquifer of the area. Another potential source of lead in the area is the remains of military maneuver events conducted for several decades, where tons of ammunition and explosives were used. Explosives used in salt mining activity for decades can be direct sources of contamination for humans by ingestion, or for groundwater by leaching.

Despite the high lead levels in water used by residents of Al-Haroniah, normal blood lead levels were reported in this study for the disabled children and young adults. This may be either due to the possibility that lead was measured in serum instead of whole blood, or the amount of lead accumulated in the body was not high enough to be measured. As reported in one study [3], lead accumulation in the body, replaces iron in blood causing Anaemia. Therefore, the serum is most likely depleted from lead where most of the lead is removed with the red blood cells (RBC's) during separation. In contrast, the higher than normal values of cadmium appearing in blood serum is attributed presumably to not being affected by separation of red blood cells, hence, the serum contained relatively higher amounts of cadmium compared to that of lead. In the other hand, the high level of the nitrate in water that exceed the WHO limit, may be attributed to human activities such as overuse of chemical fertilizers and improper disposal of human and animal wastes. These fertilizers and wastes are sources of nitrogen-containing compounds which are converted to nitrates in the soil. Nitrates are extremely soluble in water and can move easily through soil into the drinking water supply [12].

Analysis of the social aspects of this study, one may focus on the following:

1. The result of study of 9 families with 22 intermarriages showed the presence of 15 disabled children. However, the study of 13 other families without intermarriage relations has also shown the presence of 15 disabled. Moreover, samples selected from non-disabled families also showed the existence of intermarriages between these families, therefore implying that other factors are also contributing in disabilities appearance. Other factors like malaria and infectious diseases may contribute to the cause of disabilities. Statistics from Al-Munirah district for the first quarter of 2004 indicate spreading of several diseases between children that are 1-14 years of age.

2. Families of disabled children seem to be poor and work in marginal jobs including children. Most families lack basic needs including food. They get less protein and rarely eat vegetables, fruits and meat and depend mostly on unbalanced meals. On the other hand, non-disabled families indicated that they relatively have better conditions than others especially with respect to income and housing.

3. Interviews with community leaders imply weakness in health policies and lack of health workers and physician in Al-Haroniah village, as well as, in other areas of Al-Munirah district. Hence pregnant women and children receive less health care in Al-Haroniah village and several women die due to mishandling of delivery of children. In addition facilities including first aid and transfer of women and children to nearest hospitals are not available. Such conditions may increase the possibility of appearance of more disabilities and diseases.

4. Spread of cases of disabilities varies from one area to another. About 10% of the families in Al-Haroniah have disabled. However, around half of this percentage is estimated in Al-Munirah town alone. Preliminary information gathered from the nearby area, Alkushairia village (38 families) indicates that families have around 14 cases of disabled children. Nine of the cases are deaf and mute and the rest have deformities of legs.

CONCLUSIONS

We can conclude that the high levels of cadmium and lead detected in most water samples collected from Al-Haroniah village and vicinity imply potential environmental hazard existing of point source and non-point source pollution in the region. The high blood levels of cadmium detected in sample study confirm pollution of water and environment. Measurement method of lead may have obscured detection of lead in higher amounts. Clinical and social results indicate that the majority of disabled cases are deafness and aphasia, extremities deformity and mental retardation. These may be attributed to environmental factors, intermarriages and poor socio-economical conditions. Lack of knowledge, absence of health awareness in the community of Al-Haroniah village and weak or poor health management and policies may also play a role in the appearance of disabilities and diseases. Further research is needed to determine the crucial role and dominance of each factor.

Recommendations:

Several recommendations are suggested:

1. Protection of workers and children from the risk and problems of salt mining at Al-Qumah
2. Improvement of educational services in Al-Munirah district including poor families.
3. Implementation of comparative research related to disabled children in Al-Munirah district and other areas of Al-Hodeidah governorate.
4. Improvement of health policies concerning disabled children in Al-Munirah district, Al-Hodiedah governorate and other areas.
5. Results of this study should be considered to facilitate information sharing and collaborating partnership building among concerned governmental and nongovernmental parties.
6. A plan for management of solid waste disposal sites is essential and need to be implemented.
7. Further research into the environmental factors contributing to cadmium and lead pollution of drinking water in the region is recommended to confirm the results of this study and to determine the proper ways of reducing contamination of soil and groundwater with cadmium and lead.

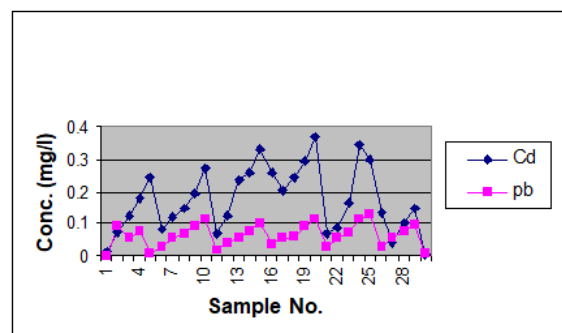


Figure 1. Cadmium (Cd) and lead (Pb) in water samples of Al-Haroniah village.

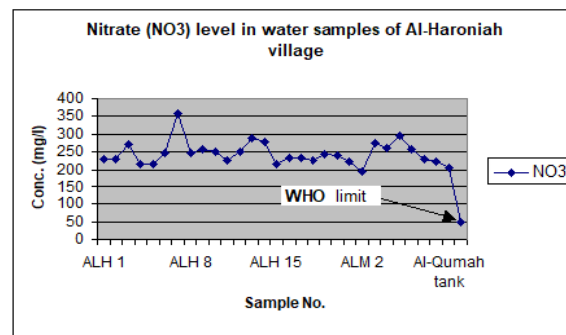


Figure 2. Nitrate (NO₃) levels in water samples of Al-Haroniah village and adjacent areas

Table 1. Analysis of salt samples from Al-Qumah mine near Al-Haroniah village * = Cd + = Pb (Source: Salt Quality and Refining Technology)

Parameter	Unit	White Salt	Grayish white Salt
Purity	%	92	85
PH at 20 C	-	7.30	7.42
Nitrate	mg/kg	0.4	0.6
Phosphorus	mg/kg	12.8	28.9
Cadmium (Cd)	mg/kg	0.26	0.18
Lead (Pb)	mg/kg	0.60	0.66
Normal levels for Cd and Pb	mg/kg	0.5*, 2+	

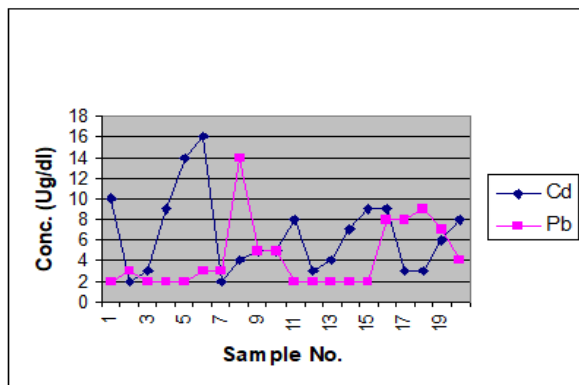


Figure 3. Cadmium (Cd) and lead (Pb) in blood (serum) samples of patients from Al-Haroniah village.

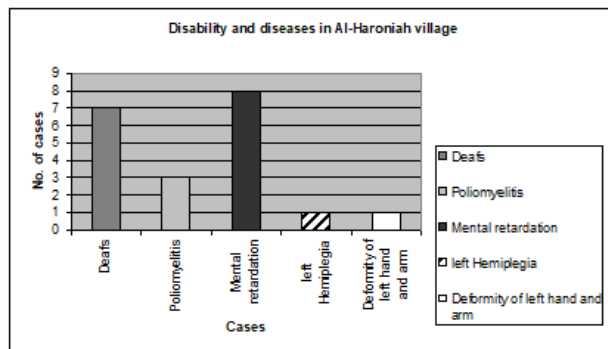


Figure 4. Disability and diseases in Al-Haroniah village.

Table 2. Types of disability related to sex in Al-Haroniah village.

Type of disability	Male	%	Female	%	Total	%
Handicapped in extremities	1	3	6	20	7	23
Paralysis	3	10	1	3	4	14
Poliomyelitis	1	3	1	3	2	7
Deafness and aphasia	7	23	5	17	12	40
Mental retardation	1	3	2	7	3	10
Epilepsy	0	0	1	3	1	3
Other	0	0	1	3	1	3
Total	13	43	17	57	30	100

Source: Interviews of disabled individuals and families (Nov.2004).

Table 3. Grouping of families according to their handicapped and sex in Al-Haroniah

Families	Number of families	%	Number of handicapped		Total	%
			Male	Female		
Families have one handicapped	16	73	6	10	16	53
Families have tow handicapped	4	18	4	4	8	27
Families have three handicapped	2	9	3	3	6	20
Total	22	100	13	17	30	100

Table 4. The number of handicapped in families and relative relations between parents.

Type of families	No.	%	No. of handicapped		Total	%
			Male	Female		
Families have relative relationship between parents	9	41	7	8	15	50
Families without relative relationship between parents	13	59	6	9	15	50
Total	22	100	13	17	30	100

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