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**FINAL  
REPORT ON**

**Assessing And Reducing Mercury Pollution Emanating  
From Artisanal Gold Mining - Phase I**

**Presented To  
United Nations Industrial Development Organization (UNIDO)  
Vienna, Austria**

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**22<sup>nd</sup> December, 2000**

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Assessing And Reducing Mercury Pollution Emanating From  
Artisanal Gold Mining - Phase I  
(US/GHA/99/128, Contract No. 2000/065P)

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## SUMMARY

**Background:** Mercury is used by alluvial miners to extract gold. In the process this toxic metal contaminates the environment. Thus this study is to determine the extent of mercury pollution of small-scale miners and the surrounding environment.

**Methods:** Human fluid (blood and spot urine), poultry, fish and vegetables and environmental specimen were collected from Dumasi, a Small-Scale Mining Community in the Western Region of Ghana, for inorganic mercury analysis. This was done by the Atomic Absorption Spectrophotometric (AAS) method after wet digestion with strong oxidizing acids at low temperature to avoid loss of mercury.

**Limitation:** A limitation during the analysis is the detection limit of the AAS (at 5µg/dl). Attempts to get information on the method used by the counterparts at the University of Montpellier, France was unsuccessful (see appendix 1a,b; attached). Nevertheless, differences in methods used for the analysis could result in discrepancies in the obtained results. This could be avoided if Institutions involved in the project use the same methods in future work.

### Findings

#### *Human specimen.-*

The results showed presence of mercury in all of the human blood samples (mean: 46.4µg/dl) but in 95% of the spot urine specimen (mean: 9.3µg/dl).

#### *Poultry, Fish and Vegetables.-*

Mercury was found in all the poultry, fish and vegetables samples. The highest amount was found in fish with a mean value of 96.2µg/g wet weight.

#### *Environmental samples.-*

Mercury was present in sumps (mean: 47.7µg/g) and in the soil (240.0µg/g) but was not detected in the water samples.

**Conclusion:** The mercury content of poultry, fish and vegetables indicate that the people of Dumasi may be exposed to higher levels of the toxic metal than the permissible amounts of mercury up to 75µg/day from air, water and food.

As expected mercury concentration in both blood and spot urine are much higher than the expected levels (up to 1.0µg/dl blood and up to 0.4µg/dl urine) in humans. With the exception of water samples, the environ within Dumasi is contaminated with mercury. Attempts must be made to harmonise the methods used in the analysis so as to promote comparison of results obtained among the various laboratories.

## **1. BACKGROUND**

Mercury is used by alluvial miners to extract gold. In the process this toxic metal contaminates the environment. To minimise mercury pollution of the environment through such activities the United Nations Industrial Development Organisation (UNIDO) initiated a study whose objectives are as follows:

- To monitor mercury levels in humans in a selected small-scale mining community,
- To conduct a study on the extent of mercury pollution of the surrounding environment, especially surface water, river sediments, soil, fish, poultry and vegetables,
- To improve human safety through training in new methods for more efficient gravity separation and recycling of mercury, and
- To train representatives of local offices of the Small-Scale Mining Project (Minerals Commission) in environmental management of small-scale mining operations.

On 29th February, 2000 the Noguchi Memorial Institute for Medical Research was sub contracted by UNIDO (Project US/GHA/99/128, Contract No. 2000/065P, Assessing and Reducing Mercury Pollution Emanating from Artisanal Gold Mining - Phase I) to provide the following services to advance the objectives described above:

- provide materials, supplies and stationeries for sampling and preservation of biological/environmental samples (water, sediments, soil, poultry, fish, vegetables) and human specimens to be taken by International Experts for mercury analysis,
- determine inorganic mercury levels in some of the specimens collected by the International Experts, and
- present a draft report summarizing methodologies applied and analytical results obtained.

## 2. SAMPLES

Thursday, 27th April, 2000: The NMIMR received, from the International Experts, frozen biological samples and human specimens collected at Dumasi, a small scale mining community in the Western Region of Ghana, for the determination of inorganic mercury.

These are as follows:

### **Human (93 samples)**

34 Human heparinised **blood** (5ml) samples

59 Human spot **urine** (20-50ml) specimen

(the NMIMR did not receive portions of the nail and hair specimens because the amount obtained from each subject was small and could, therefore, not be divided)

### **Poultry, Fish and Vegetable (14 samples)**

**Poultry.-** 4 samples of **chicken** (C 1 - 4)

**Fish.-** 3 samples of **tilapia** (F1/2, F1/3, F1/4)  
1 sample of **mud fish** (F1/1)

**Vegetable.-** 1 sample of **cocoyam** (V1/1)  
2 samples of **cassava** (V3/1, V4/1)  
2 samples of **plantain** (V1/2, V2/1)  
1 sample of **sugar cane** (V2/2)

### **Environmental (20 samples)**

11 **water** samples ( SW 1 - 5; W 6 & 9; BH 1, 2, 4, 6)

8 **sump** samples (SS 1 - 8)

1 **soil** sample (SB1)

### **3. METHODS**

Glassware used were acid washed as follows:

All glassware were placed in 10% nitric acid (analar) for 24 hours, and Transferred to 10% hydrochloric acid (analar) for another 24 hours. Then rinsed several times in deionised water.

#### **3.1 Wet Digestion of Specimen ( blood, poultry, fish and vegetables, sump and soil)**

1. To 1ml of blood or 1gram each of poultry, fish, vegetables, sump or soil in a 200ml Kjeldahl flask
2. A specific volume each of concentrated nitric acid and concentrated sulphuric acid (both analar grade) were added, appropriately covered and allowed to stand overnight
3. Then digested to homogenous state in a fume chamber with heating at 80°C (temperature at neck of flask was less than 50°C)
4. The content was washed into a collecting glass tube with deionised water. Centrifuged where necessary to clarify the prepared sample.

#### **3.2 Analysis for Mercury (inorganic) on Digested Specimen**

This was performed on all the samples (blood, urine, poultry, fish and vegetables, water, sump and soil) by Atomic Absorption Spectrophotometry (Shimadzu, Japan, A.A-630-12) with the following specifications:

Gas: air (working pressure, 10 kg/cm<sup>2</sup>) and acetylene (working pressure, 3.5 kg/cm<sup>2</sup>); Wavelength: 254nm; Bandwidth: 1.9 L/min; Lamp: Hollow cathode lamp (Hamamatsu electron tube).



## 4. RESULTS

### 4.1 Mercury (inorganic) levels in human blood and spot urine samples

| Sample Code | <u>Mercury Levels</u>    |                               |
|-------------|--------------------------|-------------------------------|
|             | Blood<br>µg/dl<br>(n=34) | Spot Urine<br>µg/dl<br>(n=59) |
| 1/3         | 55.0                     | no sample (ns)*               |
| 1/4         | ns                       | 16.7                          |
| 1/5         | 45.0                     | 10.0                          |
| 1/6         | 30.0                     | 10.0                          |
| 1/7         | ns                       | 5.0                           |
| 2/1         | 20.0                     | 18.7                          |
| 2/2         | 45.0                     | 16.2                          |
| 2/3         | 35.0                     | 7.5                           |
| 2/4         | ns                       | 12.5                          |
| 2/5         | 45.0                     | ns                            |
| 2/6         | 45.0                     | 12.5                          |
| 2/7         | 20.0                     | 5.0                           |
| 2/8         | 80.0                     | ns                            |
| 2/9         | ns                       | 7.5                           |
| 3/1         | ns                       | 8.7                           |
| 3/*         | 45.0                     | 10.0                          |
| 3/4         | ns                       | 7.5                           |
| 3/5         | ns                       | 8.7                           |
| 4/1         | ns                       | 6.2                           |
| 4/2         | 45.0                     | 27.5                          |
| 4/4         | ns                       | 12.5                          |
| 4/5         | ns                       | 12.5                          |
| 4/6         | ns                       | 6.6                           |
| 5/1         | ns                       | 10.0                          |
| 5/2         | 25.0                     | 6.2                           |
| 5/3         | ns                       | 8.7                           |
| 5/5         | 25.0                     | 12.5                          |
| 5/6         | 65.0                     | ns                            |
| 5/7         | ns                       | 0**                           |
| 5/8         | 40.0                     | ns                            |
| 5/9         | ns                       | 7.5                           |
| 5/11        | 65.0                     | ns                            |
| 6/3         | ns                       | 17.5                          |
| 6/5         | 30.0                     | 5.0                           |

**Results (Continued): human blood and spot urine**

| Sample Code | <u>Mercury Levels</u> |                     |
|-------------|-----------------------|---------------------|
|             | Blood<br>µg/dl        | Spot Urine<br>µg/dl |
| 10/3        | 15.0                  | 6.3                 |
| 10/6        | ns                    | 23.2                |
| 10/7        | ns                    | 10.0                |
| 10/8        | 69.6                  | ns                  |
| 10/9        | 50.0                  | 11.2                |
| 10/10       | 60.0                  | 10.0                |
| 10/11       | 35.0                  | 7.5                 |
| 11/1        | 45.0                  | ns                  |
| 11/2        | 50.0                  | 5.0                 |
| 11/3        | 45.0                  | 5.0                 |
| 12/1        | 55.0                  | ns                  |
| 13/1        | ns                    | 10.0                |
| 14/2        | ns                    | 5.0                 |
| 14/3        | ns                    | 5.0                 |
| 16/3        | 85.0                  | ns                  |
| 16/5        | ns                    | 11.2                |
| 16/6        | ns                    | 5.0                 |
| 16/8        | 35.0                  | 5.0                 |
| 17/1        | ns                    | 8.1                 |
| 17/3        | 70.0                  | 7.5                 |
| 18/2        | ns                    | 6.3                 |
| 19/4        | ns                    | 5.0                 |
| 24/3        | ns                    | 0**                 |
| 25/1        | 45.0                  | 7.5                 |
| 26/2        | 50.0                  | 8.7                 |
| 27/3        | 50.0                  | ns                  |
| 30/1        | ns                    | 7.5                 |
| 30/2        | ns                    | 5.0                 |
| 30/3        | ns                    | 10.0                |
| 32/1        | ns                    | 6.3                 |
| 36/2        | ns                    | 13.6                |
| 38/3        | ns                    | 10.0                |
| 38/4        | ns                    | 10.0                |
| 40/1        | 60.0                  | 0**                 |
| 43/1        | ns                    | 10.0                |
| 45/1        | <u>ns</u>             | <u>10.0</u>         |
| <b>Mean</b> | <b>46.4</b>           | <b>9.3</b>          |

ns\*: The NMIMR did not receive that specific specimen for that code number.

\*\* : Indicate that the obtained value is below the detection limit of the instrument at 5.0 µg/dl of mercury.

## Results (Continued)

**Human Nail and Hair.-** The absence of results on nail and hair was because the NMIMR did not receive its portion due to insufficiency of these specimens.

### 4.2 Mercury (inorganic ) levels in poultry, fish and vegetables

|                    |                               | Mercury<br>µg/g wet weight |
|--------------------|-------------------------------|----------------------------|
| <b>Fish:</b>       | Mud fish, F1/1                | 76.1                       |
|                    | Tilapia, F1/2                 | 101.8                      |
|                    | Tilapia, F1/3                 | 87.3                       |
|                    | Tilapia, F1/4                 | <u>100.0</u>               |
|                    | <b>Mean (F1/2 - F1/4)</b>     | <b>96.2</b>                |
| <b>Poultry:</b>    | Chicken, C1                   | 69.5                       |
|                    | Chicken, C2                   | 69.5                       |
|                    | Chicken, C3                   | 79.8                       |
|                    | Chicken, C4                   | <u>62.3</u>                |
|                    | <b>Mean (C1 - C4)</b>         | <b>70.3</b>                |
| <b>Vegetables:</b> | Cocoyam, V1/1                 | 43.1                       |
|                    | Cassava, V3/1                 | 46.2                       |
|                    | Cassava, V4/1                 | <u>108.1</u>               |
|                    | <b>Mean (V3/1 &amp; V4/1)</b> | <b>77.2</b>                |
|                    | Plantain, V1/2                | 80.3                       |
|                    | Plantain, V2/1                | <u>89.1</u>                |
|                    | <b>Mean (V1/1 &amp; V2/1)</b> | <b>84.7</b>                |
|                    | Sugarcane, V2/2               | 66.6                       |

## Results (Continued)

### 4.3 Mercury (inorganic ) levels in environmental samples

| Mercury, $\mu\text{g/g}$ wet weight |                  |             |
|-------------------------------------|------------------|-------------|
| Sumps:                              | SS1              | 54.0        |
|                                     | SS2              | 62.5        |
|                                     | SS3              | 36.6        |
|                                     | SS4              | 43.2        |
|                                     | SS5              | 15.6        |
|                                     | SS6              | 38.5        |
|                                     | SS7              | 100.6       |
|                                     | SS8              | <u>30.5</u> |
|                                     | Mean (SS1 - SS8) | 47.7        |

|       |     |       |
|-------|-----|-------|
| Soil: | SB1 | 240.0 |
|-------|-----|-------|

|        |                           |     |
|--------|---------------------------|-----|
| Water: | Mercury, $\mu\text{g/dl}$ |     |
|        | SW1                       | 0** |
|        | SW2                       | do. |
|        | SW3                       | do. |
|        | SW4                       | do. |
|        | SW5                       | do. |
|        |                           |     |
|        | W6                        | do. |
|        | W9                        | do. |
|        |                           |     |
|        | BH1                       | do. |
|        | BH2                       | do. |
|        | BH4                       | do. |
|        | BH6                       | do. |

**\*\* The obtained value is below the detection limit of the instrument at 5.0  $\mu\text{g/dl}$  of mercury.**

## 5.0 BUDGET

| <b>Item</b>                             | <b>Cost, US\$</b>  |
|---|--------------------|
| 1A. Project area guide                  | 27.60              |
| 1B. Home office                         |                    |
| Co-ordinator & team of Research Fellows | 2762.00            |
| Technical Staff                         | 1000.00            |
| 2. Subsistence                          | -                  |
| 3. Travel & transportation              |                    |
| Transport                               | -                  |
| Board & lodging for Co-ordinator        | 184.00             |
| 4. Reports (DHL courier service, Fax)   | 143.18             |
| 5. Other direct costs                   | -                  |
| 6. Equipment, Materials and Supplies    |                    |
| Equipment                               | 280.00             |
| Materials & Supplies                    | 814.89             |
| 7. Subcontracts                         | -                  |
| 8. Grand Total (items 1-7)              | <b>5211.67</b>     |
| Amount received from UNIDO              | US\$3500.00        |
| Amount spent by the NMIMR               | US\$5211.67        |
| <b>Amount owed the NMIMR by UNIDO</b>   | <b>US\$1711.67</b> |

Dear Prof Rambaud,

rambaud@sc.univ-montp1.fr

## **REMINDER**

### **Results On Mercury Analysis-Artisanal Gold Mining In Ghana (Phase1)**

On 13th November, 2000, I sent you e-mail on what I have learnt from Dr Beinhoff concerning some differences in the mercury results between the NMIMR and the University of Montpellier on SAMPLES OF THE SAME CODES.

I then requested information on the results and method of analysis used by the University of Montpellier. This information will help to determine where the limitation might lie.

Thank you.

My best regards

Dr. Nii-Ayi Ankrah  
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4th December, 2000

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rambaud@sc.univ-montp1.fr  
Mercury Analysis

Dear Prof Rambaud

I hope you are doing fine.

In my last correspondence with Dr Christian Beinhoff, I learnt of differences in the results of the mercury levels presented by the NMIMR and that from the University of Montpellier for samples of the same codes. I assume that you have had information of the NMIMR results.

In the presentation of the final report of the NMIMR, it will be useful to also have information on the results of the University of Montpellier on SAMPLES OF THE SAME CODES. I shall also appreciate it very much if the method of analysis used by the University of Montpellier is included in your response. This will help to determine where the limitation might lie.

Thank you very much for your anticipated co-operation.

My best regards.

Dr Nii-Ayi Ankrah

Fax: 233 21 502182

13th Nov., 2000

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