# Trace element distribution in hair of local people in Bayanhongor, Mongolia

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## 1 Introduction

In Mongolia the artisanal/small-scale gold mining (ASGM) is becoming an important livelihood for local communities and also for the jobless people. On the other hand, the nation has sustained the nomadic culture since immemorial and still heavily relies on nomadism. Thus it is a pressing need to understand whether the ASGM poses health risk to the human and animals. The information is vital to the local government and communities to protect the health, environment and livestock farming in nomadic country like Mongolia. Based on this background the authors focused on the trace element distribution of human hairs utilizing the NMCC's PIXE analysis which has contributed to the ASGM issues for many years[1-3].

## 2 Study area

The survey was conducted in Bayanhongor Province, one of the most productive region of gold in Mongolia. Most of the gold is produced by the ASGM with rudimentary tools and elementary technology

(Fig. 1). Some groups of miners use a common facility where they can extract gold without using mercury (Fig. 2) but many are still using amalgamation method. Mercury is often smuggled from China and Russia and it is difficult to control the illegal trade.

The authors visited a mining site in September 2015 where they do not use mercury and also a food shop near the said site. After explaining the purpose of the study to and getting the consent from the people hair samples were collected according to the NMCC's protocol[4].

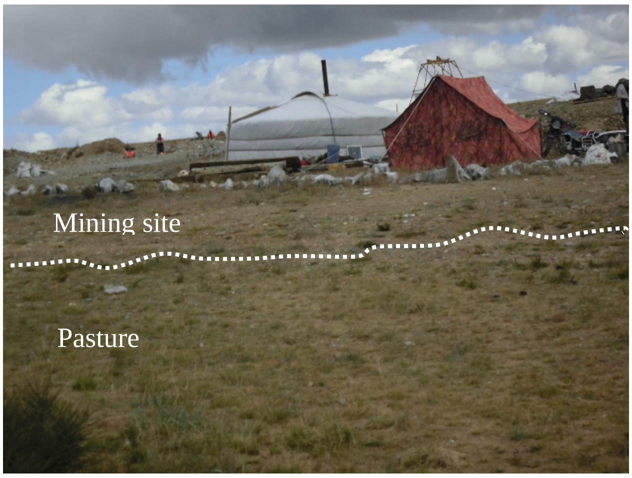


Fig. 1 Typical condition of ASGM in Mongolia

Fig. 2 An example of common ore dressing plant

## 3 Hair analysis

Seven male Ninjas, a female Ninja, a male herder, a female harder and a female cook donated the scalp hair to the authors. A strands of hair from each person was fixed on the sample holder, cleaned with aceton and then set in the vacuum chamber. The targets were bombarded with a 2.9 MeV proton beam extracted from a small-sized cyclotron at NMCC, and the emitted X-rays were simultaneously measured with two Si(Li) detectors. X-ray absorbers were used for the No. 1 detector. 500-µm-thick Mylar film was used for the food, while 300-µm Mylar was used for the hair samples.

According to the analysis the range of arsenic is from the detection limit (about 1ppm) to 17ppm and of mercury from the detection limit (about ppm) to 12ppm. Lead showed a range up to 61ppm (Table 1).

## 4 Discussion

The study showed that mercury contamination is not serious in the area but attention should be paid to the arsenic and lead poisoning (Table 1).

Arsenic anomaly was noticed both for three Ninjas and a herder. Long-term exposure to arsenic in drinking water can cause cancer in the skin, lungs, bladder and kidney. It can also cause other skin changes such as thickening and pigmentation. Exposure to arsenic in the workplace by inhalation can also cause lung cancer. Additional survey is a pressing need in the prevention of arsenic poisoning in Bayanhongor.

High level of lead is of the other concern because, even at low levels, lead can cause problems like learning disabilities, behavior problems, decreased intelligence, speech problems, decreased attention span, brain or nerve damage, poor coordination, kidney damage, decreased growth, and hearing loss.

No information is available in Bayanhongor at present for the control of health risk arising from arsenic and lead. Possible sources of the elements are ground water like reported in another area[5], ore dust from mining site and dust from the surface expression of rocks[6]. A further study should be necessary to verify the exact cause of the high level of arsenic and lead in this region.

Table 1 Trace element distribution of human hair in Bayanhongor

Upper row: values in ppm; lower row: one sigma

| # | MGHH- | MGHH-2 | MGHH-3 | MGHH-4 | MGHH-5 | MGHH-6 | MGHH-7 | MGHH-8 | MGHH-9 |
|---|---|---|---|---|---|---|---|---|---|
| Sex | F | M | F | M | M | M | M | M | M |
| Run # | 22759 | 22760 | 22769 | 22770 | 22771 | 22772 | 22773 | 22774 | 22775 |
| S | 39326 | 45215 | 44227 | 48228 | 44850 | 44759 | 40051 | 46587 | 44362 |
| | 1721 | 2094 | 3155 | 2868 | 3533 | 2885 | 1516 | 3087 | 1447 |
| Cl | 3207 | 1672 | 1109 | 2127 | 4494 | 1419 | 4657 | 3905 | 5211 |
| | 150 | 86 | 89 | 136 | 358 | 101 | 187 | 266 | 208 |
| K | 1074 | 558 | 481 | 210 | 784 | 185 | 2347 | 1693 | 23124 |
| | 60 | 38 | 46 | 30 | 70 | 27 | 103 | 122 | 783 |
| Ca | 1468 | 1056 | 156 | 783 | 379 | 622 | 766 | 630 | 1733 |
| | 47 | 34 | 7.9 | 61 | 14 | 53 | 27 | 22 | 68 |
| Ti | 59 | 50 | 44 | 7.0 | 8.6 | 22 | 15 | 9.2 | 169 |
| | 3.0 | 2.6 | 2.9 | 2.1 | 2.1 | 2.6 | 2.4 | 2.0 | 14 |
| Mn | 9.0 | 4.9 | nd | nd | 7.3 | nd | 26 | 12 | 21 |
| | 1.1 | 0.9 | | | 1.0 | | 1.5 | 1.0 | 6.8 |
| Fe | 202 | 106 | 78 | 86 | 115 | 87 | 299 | 122 | 457 |
| | 6.9 | 3.8 | 3.3 | 3.4 | 4 | 3.6 | 10 | 4.4 | 18 |
| Ni | 4.0 | 2.2 | nd | nd | 2.9 | nd | nd | nd | nd |
| | 0.8 | 0.7 | | | 0.7 | | | | |
| Cu | 28 | 27 | 18 | 15 | 20 | 16 | 21 | 15 | 20 |
| | 1.5 | 1.3 | 1.2 | 1.0 | 1.2 | 1.1 | 1.3 | 1.0 | 2.4 |
| Zn | 484 | 321 | 279 | 276 | 159 | 229 | 240 | 237 | 353 |
| | 16 | 10 | 9.6 | 9.3 | 5.7 | 8.1 | 8.4 | 8.0 | 14 |
| Ga | 4.9 | 3.0 | 1.7 | 2.8 | 2.2 | 2.4 | 1.6 | 2.3 | 5.2 |
| | 0.7 | 0.6 | 0.6 | 0.6 | 0.5 | 0.6 | 0.6 | 0.5 | 1.8 |
| As | nd | nd | 1.6 | nd | 3.0 | nd | 16 | 4.3 | 17 |
| | | | 0.7 | | 0.8 | | 1.5 | 0.9 | 2.8 |
| Br | 9.2 | 7.6 | | 4.9 | 9.0 | 22 | 7.5 | 7.3 | 7.2 |
| | 1.3 | 1.0 | | 0.9 | 1.1 | 1.9 | 1.2 | 1.0 | 2.4 |
| Sr | 11 | 8.1 | nd | nd | nd | nd | 6.6 | nd | nd |
| | 1.9 | 1.4 | | | | | 1.7 | | |
| Hg | 12 | 5.5 | 4.4 | 5.8 | nd | 4.9 | nd | 8.7 | nd |
| | 2.2 | 1.7 | 1.8 | 1.7 | | 1.9 | | 1.7 | |
| Pb | 23 | 11 | nd | 4.3 | 15 | 6.6 | 10 | 12 | nd |
| | 3.0 | 2.1 | | 1.9 | 2.6 | 2.4 | 4.2 | 2.6 | |

Table 1 (Continued)

| #2 | MGHH-10(scalp | MGHH-10(3cm | MGHH-11(scalp | MGHH-12(3-4.5cm | MGHH-13(6-7.5cm | MGHH-13(9-10.5cm | MGHH-13(12-13.5cm | MGHH-13(16-16.5cm |
|---|---|---|---|---|---|---|---|---|
| Sex | M | M | F | F | F | F | F | F |
| Run # | 22776 | 22785 | 22786 | 22787 | 22788 | 22789 | 22790 | 22791 |
| S | 36489 | 47741 | 44372 | 43370 | 46306 | 36203 | 36927 | 31233 |
| | 1777 | 3089 | 2648 | 2419 | 2267 | 1615 | 1429 | 2342 |
| Cl | 3802 | 2829 | 3941 | 2664 | 1665 | 1044 | 1422 | 1636 |
| | 191 | 194 | 243 | 156 | 94 | 56 | 61 | 149 |
| K | 3634 | 725 | 1329 | 967 | 1226 | 921 | 1020 | 1031 |
| | 184 | 63 | 90 | 64 | 74 | 51 | 46 | 108 |
| Ca | 911 | 801 | 759 | 705 | 1160 | 1106 | 1119 | 1300 |
| | 30 | 30 | 27 | 25 | 40 | 36 | 35 | 42 |
| Ti | 37 | 4.4 | 20 | 24 | 19 | 18 | 14 | 13 |
| | 2.6 | 2.8 | 2.8 | 2.3 | 3.2 | 2.1 | 1.5 | 2.0 |
| Mn | 15 | 28 | 6.3 | 7.7 | 12 | 13 | 16 | 21 |
| | 1.2 | 1.9 | 1.2 | 1.0 | 1.6 | 1.0 | 0.9 | 1.2 |
| Fe | 408 | 76 | 121 | 58 | 72 | 57 | 51 | 67 |
| | 13 | 3.8 | 4.9 | 2.7 | 3.5 | 2.5 | 1.9 | 2.7 |
| Ni | nd | nd | nd | nd | 3.4 | nd | nd | nd |
| | | | | | 1.1 | | | |
| Cu | 20 | 24 | 16 | 15 | 26 | 16 | 16 | 17 |
| | 1.2 | 1.7 | 1.3 | 1.1 | 1.7 | 1.0 | 0.8 | 1.0 |
| Zn | 284 | 219 | 251 | 199 | 358 | 230 | 247 | 267 |
| | 10 | 8.5 | 9.1 | 7.0 | 12.0 | 7.8 | 7.9 | 8.9 |
| Ga | 3.2 | 4.2 | 1.8 | 1.9 | 4.3 | 1.6 | 2.2 | 1.5 |
| | 0.7 | 0.9 | 0.7 | 0.6 | 0.9 | 0.5 | 0.4 | 0.5 |
| As | nd | 4.9 | nd | nd | nd | nd | nd | nd |
| | | 1.9 | | | | | | |
| Br | 18 | 16 | 15 | 16 | 18 | nd | 9.8 | 11 |
| | 1.6 | 2.1 | 1.8 | 1.5 | 2.0 | | 0.9 | 1.2 |
| Sr | 7.1 | nd | nd | 5.6 | 19 | 15 | 22 | 26 |
| | 1.5 | | | 1.5 | 3.0 | 1.9 | 1.7 | 2.6 |
| Hg | 6.4 | nd | nd | nd | 6.6 | 4.5 | 3.9 | nd |
| | 2.1 | | | | 2.6 | 1.6 | 1.2 | |
| Pb | 8.1 | 61 | nd | 3.9 | 8.4 | 8.4 | 7.3 | 4.1 |
| | 2.3 | 6.1 | | 1.8 | 2.8 | 2.0 | 1.5 | 1.6 |

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