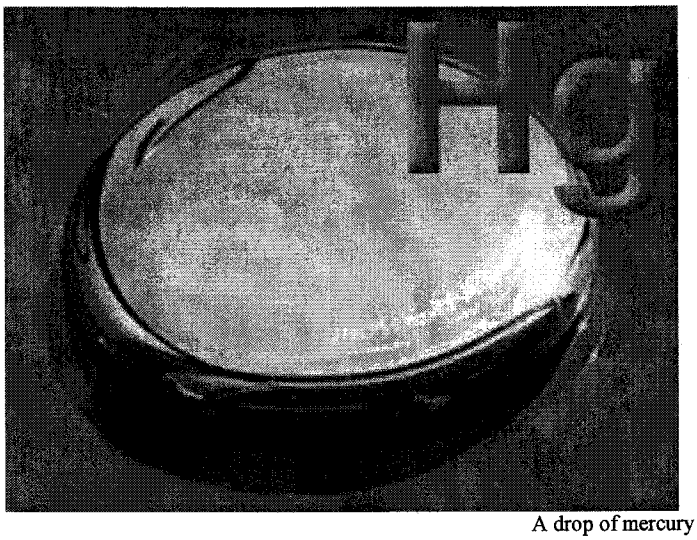
EXHIBIT 4
DATE 2.19.07
HB 586

# UNITED NATIONS ENVIRONMENT PROGRAMME

CHEMICALS

UNEP

# GLOBAL MERCURY ASSESSMENT




A drop of mercury

**IOMC** INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among UNEP, ILO, FAO, WHO, UNIDO, UNITAR and OECD

474. Combustion of waste is a major source of mercury releases to the environment. It should be kept in mind, that the source of this mercury is the mercury contents in the products constituting the waste, both in the form of intentionally used mercury and unintentional presence of mercury (either as a natural impurity or as an anthropogenic trace pollutant in the raw materials used).

475. Concerning cremation, it may be noted that crematories are normally not equipped with flue gas cleaning facilities for removal of mercury. The emissions from cremation are primarily due to the use of mercury in amalgam for dental purposes.

*Table 6.4 Mercury emissions to air - examples *1*

| **All numbers in metric tons/year (except per capita)** | **USA *7 1994-95** | **UK 1997** | **Finland 1997** | **Denmark 1992-93** | **Sweden 1995** | **Norway 1999** | **Mexico 1999** |
|---|---|---|---|---|---|---|---|
| **Intentional uses – Manufacturing** | | 1.1***8** | ***4** | | | | |
| Chlor-alkali | 6.5 | | | 0.01 | 0.12 | | 4.9 |
| Instruments manufacturing | 0.5 | | | | | | |
| Secondary Hg production | 0.4 | | | | | | |
| Electrical apparatus | 0.3 | | | 0.01 | | | |
| Batteries | <0.1 | | | | | | |
| Primary mercury production | ? | | | | | | 9.7 |
| **Intentional uses – Use of products** | | | | | | | |
| Lamps breakage | 1.4 | <0.1 | | | | 0.02 | 0.23 |
| Laboratory use and instruments | 1.0 | | | | | 0.02 | 0.02 |
| Dental preparations | 0.6 | 0.3 | | | | | 0.38 |
| **Waste treatment and disposal** | | | 0.05 | | | | |
| Waste incineration ***2** | 48.8 | 1.3 | | 1.26 ***5** | 0.09 | 0.05 | 0.03 |
| Cremation | <0.1 | 1.3 | | 0.1 | 0.28 | 0.07 | |
| Landfills | <0.1 | 0.4 | | | | | |
| Others – recycling of lamps etc. | <0.1 | | | 0.2 | 0.01 | | |
| **Mobilised Hg impurities – Manufacturing** | | | 0.09 ***4** | | | | |
| Cement | 4.4 | | | 0.14 | | 0.01 | 0.01 |
| Pulp and Paper | 1.7 | | | | | 0.005 | 0.02 |
| Non-ferrous metal | <0.2 | 3.2 | | | 0.07 | 0.16 | 13 |
| Iron, steel | | 0.8 | | 0.07 | 0.11 | 0.1 | 0.09 |
| Others – carbon black, lime etc. | 0.4? | | | | | 0.005 | 0.76 |
| **Mobilised Hg impurities – Combustion** | | 4.2 | 0.49 | | 0.21 | 0.64 | 2.2 ***6** |
| Coal (utility, industry) boilers | 66.9 | | | 0.35 | | | |
| Oil and natural gas | 10.2 | | | 0.04 | | | |
| Wood boilers | 0.2 | | | | | | |
| Others (geothermal power) | 1.3 | | | | | | |
| **Total (rounded)** | 144 ***7** | 13 | 0.62 | 2.2 | 0.9 | 1.1 | 31 |
| **Per capita (grams) *3** | 0.5 | 0.2 | 0.1 | 0.4 | 0.1 | 0.3 | 0.3 |

Notes:

1 From US EPA (1997); OSPAR (2000); Maag *et al.* (1996); Norwegian Pollution Control Authority (2001); Finnish Environment Institute (1999); Mukherjee *et al.* (2000); Mexican information submission, and KEMI (1998). The presented distribution of sources, as intentional/unintentional, was made in the submission from the Nordic Council of Ministers (sub84gov), except for Mexican numbers.

2 Covers incineration of municipal waste, medical waste, hazardous waste and sewage sludge.

3 Assumptions USA ~ 264 million capita; UK ~ 59 million capita; Denmark ~ 5.3 million capita; Norway ~ 4.4 million capita; Sweden ~ 8.5 million capita; Finland ~ 5.2 million capita; Mexico ~ 99 million capita.

4 In the reference (Mukherjee *et al*, 2000), emissions from manufacturing are aggregated and include both mercury from unintentional mobilisation and intentional uses. There are indications, however, that the first mentioned is the dominating source category from manufacturing. Total emissions from manufacturing are therefore mentioned under "Mobilised Hg impurities – Manufacturing".

5 The relatively high figure for waste incineration in Denmark in 1992-93 was caused by the widespread use of incineration for treatment for municipal solid waste in the country. In 1993, around 78 percent of all municipal solid waste in Denmark was di-

were reduced from about 33 metric tons to 6 metric tons between 1990 and 2000 (Canadian comments, comm-20-gov; Canadian submission, sub42gov).

*Table 6.1 Estimates of global atmospheric releases of mercury from a number of significant anthropogenic sources in 1995 (metric tons/year). Releases to other media are not accounted for here. *1*

| Continent | Stationary combustion | Non-ferrous metal production *5 | Pig iron and steel production | Cement production | Waste disposal *2 | Artisanal gold mining *4 | Sum, quantified sources *3 |
|---|---|---|---|---|---|---|---|
| Europe | 186 | 15 | 10 | 26 | 12 | | 250 |
| Africa | 197 | 7.9 | 0.5 | 5.2 | | | 210 |
| Asia | **860** | **87** | **12** | **82** | 33 | | 1070 |
| North America | 105 | 25 | 4.6 | 13 | **66** | | 210 |
| South America | 27 | 25 | 1.4 | 5.5 | | | 60 |
| Australia and Oceania | 100 | 4.4 | 0.3 | 0.8 | 0.1 | | 100 |
| Sum, quantified sources, 1995 ***3,4** | 1470 | 170 | 30 | 130 | 110 | 300 | 1900 +300 |
| Based on references: | Pirrone *et al.* (2001) | Pirrone *et al.* (2001) | Pirrone *et al.* (2001) | Pirrone *et al.* (2001) | Pirrone *et al.* (2001) | Lacerda (1997) | |

Notes: 1 Releases to aquatic and terrestrial environments, as well as atmospheric releases from a number of other sources, are not included in the table, as no recent global estimates are available. See chapter 6 for description of issue.

2 Considered underestimated by authors of the inventory, see notes to table 6.10.

3 Represents total of the sources mentioned in this table, not all known sources. Sums are rounded and may therefore not sum up precisely.

4 Estimated emissions from artisanal gold mining refer to late 1980's/early 1990's situation. A newer reference (MMSD, 2002) indicates that mercury consumption for artisanal gold mining - and thereby most likely also mercury releases - may be even higher than presented here.

5 Production of non-ferrous metals releasing mercury, including mercury, zinc, gold, lead, copper, nickel.

### Natural sources of mercury release

434. Natural sources include volcanoes, evaporation from soil and water surfaces, degradation of minerals and forest fires. The natural mercury emissions are beyond our control, and must be considered part of our local and global living environment. It is necessary to keep this source in mind, however, as it does contribute to the environmental levels. In some areas of the world, the mercury concentrations in the Earth's crust are naturally elevated, and contribute to elevated local and regional mercury concentrations in those areas.

435. Today's emissions of mercury from soil and water surfaces are composed of both natural sources and re-emission of previous deposition of mercury from both anthropogenic and natural sources. This makes it very difficult to determine the actual natural mercury emissions. For global estimates of natural emissions, see section 6.3.6.

436. Published estimates of natural versus anthropogenic mercury emissions show significant variation, although more recent efforts have emphasized the importance of human contributions (see for example Fitzgerald *et al.* (1998), Jackson (1997) and Lamborg *et al.* (2002)). Attempts to directly measure natural emissions are ongoing (see for example Coolbaugh *et al.*, 2002). Nonetheless, available information indicates that natural sources account for less than 50 percent of the total releases.

437. On average around the globe, there are indications that anthropogenic emissions of mercury have resulted in deposition rates today that are 1.5 to 3 times higher than those during pre-industrial times. In and around industrial areas the deposition rates have increased by 2 to 10 times during the last 200 years (Lindquist *et al.*, 1984; Bergan *et al.*, 1999; see also section 6.4 on pathways).

### 6.3.6 Global and regional release estimates

481. The total global anthropogenic and natural releases of mercury are not known with high precision. Several attempts have been made, however, at quantifying these totals. Table 6.8 shows global totals as estimated by different authors. As can be seen, the numbers are relatively uncertain. This is reasonable given the complexity of the quantification. As mentioned in section 6.3.7, generally it has not been possible to include all significant contributions to global releases in the estimates. An impression of which source types may be included and which may often be omitted can be seen in table 6.9.

*Table 6.8* *Estimates of total releases of mercury to the global environment (table presented by OECD, 1994, with estimates by Mason* et al. *(1994), Pirrone* et al. *(1996) and Lamborg* et al. *(2002) added here).*

| **Process** | **Lindquist *et al.* 1984** | **Nriagu & Pacyna 1988,Nriagu 1989** | **Fitzgerald 1986** | **Lindquist *et al.* 1991** | **Mason *et al.*, 1994 *1** | **Pirrone *et al.*, 1996** | **Lamborg *et al.*, 2002 *2** |
|---|---|---|---|---|---|---|---|
| Anthropogenic releases | 2000-10,000 | 3560 (910-6200) | 2000 | 4500 (3000-6000) | 5550 **1** | 2200 | 3000 **2** |
| Natural releases | <15000 | 2500 (100-4900) | 3000-4000 | 3000 (2000-9000) | 1650 | 2700 | 1400 |
| Total present releases | 2000-<25,000 | 6060 (1010-11,100) | 5000-6000 | 7500 (5000-15,000) | 7200 | 4900 | 4400 |

Notes: 1 Anthropogenic releases and totals: Numbers include an estimated re-emission (net increase of evasion from oceans) of 1400 metric tons/year originating from previous anthropogenic releases (new anthropogenic releases are thus estimated at 4150 metric tons/year in this study).

2 Anthropogenic releases and totals: Numbers include an estimated re-emission (net increase of evasion from oceans) of 400 metric tons/year originating from previous anthropogenic releases (new anthropogenic releases are thus estimated at 2600 metric tons/year in this study).

*Table 6.9* *Estimates of Worldwide Releases of Mercury to the Atmosphere, Soil and Water in 1983 with quantified and omitted contributions stated (metric tons per year, from Nriagu and Pacyna (1988) and Nriagu (1989) as presented by OECD (1994), presentation of summation slightly corrected and question marks added here).*

| **Source category** | **Atmosphere * min. max.** | **Water min. max.** | **Soil ** min. max.** |
|---|---|---|---|
| Coal combustion | 650 3500 | 0 3600 | 370 4800 |
| Non-ferrous metal production | 45 220 | 0 40 | 0 80 |
| Refuse incineration<br>Municipal<br>Sewage sludge | <br>140 2100<br>15 60 | no estimate | no estimate |
| Wastewater | no relevance | 0 600 | 10 800 |
| Wood combustion | 60 300 | no estimate | no estimate |
| Metal mining | insignificant input? | 0 150 | no estimate |
| Urban refuse | no estimate | no estimate | 0 260 |
| Wastage commercial prod. | no estimate | no estimate | 550 820 |
| Manufacturing processes | no estimate | 20 2300 | no estimate |
| Atmospheric fall-out | no relevance | 220 1800 | 630 4300 |
| Phosphate fertilizer production and use | insignificant input | no estimate | no estimate |
| Agricultural waste | no estimate | no estimate | 0 1700 |
| Logging and other wood wastes | no estimate | no estimate | 0 2200 |
| Dumpings of sewage sludge | no relevance | 10 310 | no relevance |
| Mine tailings | no estimate | no estimate | 550 2800 |
| Smelter slags and wastes | no estimate | no estimate | 50 280 |
| Total, quantified anthropogenic inputs, rounded<br>Mean | 900 6200+?<br>3560+? | 300 8800+?<br>4600+? | 2200 18000+?<br>10100+? |
| Natural<br>Mean | 100 4900<br>2500 | no estimate | No estimate |