Mercury Use in the Goldmining Industry

A retrospective examination of elemental mercury use in the gold mining industry of the West Coast of New Zealand in the period 1984 – 1988.

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Massey University Human Ethics Committee:

This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The researcher named above is responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher, please contact Professor Sylivia Rumball, Assistant to the Vice-chancellor (Ethics & Equity), telephone 06.3505249, e-mail humanethics@massey.ac.nz.

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Glossary.

The terms, acronyms and abbreviations below appear in this document.

< - Less than;

> - Greater than;

℃ - Degree Celsius [centigrade];

µg – microgram [10^{-6} gram];

µg/kg body weight per day – Micrograms per kilogram body weight per day; units used for describing intakes (or doses) of mercury such as intakes that are considered safe for humans.

µmol - micromole is 1 millionth of a mole;

ADI - Acceptable daily intake;

AMAP - The Arctic Monitoring and Assessment Programme;

ATSDR – USA Agency for Toxic Substances and Disease Registry;

Balance - Totality of quantitative estimates of input and output substance fluxes for a given geophysical reservoir or societal entity;

bw - Body weight;

Dry deposition – The transport of trace gases and particles to the earth's surface which is an important loss process for many reactive and soluble trace gases. It is of a continuous character independent of the occurrence or absence of atmospheric precipitation;

EC – European Community. Now called European Union with 27 member states.

EMEP – Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (under the LRTAP Convention);

ESP – Electrostatic precipitator; equipment used to reduce emissions of certain pollutants from combustion flue gases;

FAO – Food and Agriculture Organization;

FF - Fabric filter; filter type used to capture particulate matter (here: from combustion flue gases);

FGD – Flue gas desulphurization; process of/equipment for primarily minimizing emissions of sulphur from combustion flue gases;

GEF - Global Environment Facility;

Hg – Mercury;

Hg^0 - Elemental mercury;

Hg^{2+} - Divalent mercury - the dominating mercury form in organic and inorganic mercury compounds. In the atmosphere, mercury species with divalent mercury are more easily washed out of the air with precipitation and deposited than elemental mercury;

Hg_p - Particulate mercury - mercury bound in, or adsorbed on, particulate material. In the atmosphere, particulate mercury is deposited much faster than elemental mercury;

IARC - International Agency for Research on Cancer;

ILO - International Labor Organization;

IPCS – International Programme on Chemical Safety;

kg – kilogram;

l or L – Litre;

LC_{50} - Lethal concentration, 50%; concentration of toxic substance in a medium (for example water) at which 50% of the individuals in the toxicity test sample die; a unit used to describe the level of toxicity of a substance to a specific species, for example fish;

LD_{50} - Lethal dose, 50%; dose (intake) of a toxic substance at which 50% of the individuals in the toxicity test sample die; a unit used to describe the level of toxicity of a substance to a specific species, for example in laboratory tests on mice, birds or other animals;

Life-time - In atmospheric physio-chemistry: Time during which the first order processes (or totality of the first order processes) of scavenging results in mercury species mass reduction in **e** times in a geophysical reservoir; for a reservoir with homogeneous mercury species distribution the life-time is equal to the ratio of the mass contained in the reservoir to scavenging rate. Since the mass of mercury in the reservoir left to be reacted or removed decreases over time, the amount reacted or removed per unit of time decreases in a natural logarithmic fashion. For example, a lifetime of mercury of one year, does not mean that it would all be gone in one year if emissions were zero. It means that the rate of removal at the start of the time period in terms of mass per unit time would remove it all in one year, but since the rate of removal decreases as the mass of mercury left decreased, the amount of mercury left after one year would be (1/e) times the initial mass, where "e" is 2.71828183 defined to 8 decimals. In descriptions of life-cycles of products: The time span from when the product is put into use (usually time of purchase) until it is no longer used or discarded;

LNB – Low-NO_x burner; utility boiler combustion technology designed specifically to generate relatively low levels of nitrogen oxides;

Load - The intensity of input of pollutants to a given ecosystem from the environment; atmospheric load - the intensity of input from the atmosphere;

LOEL - Lowest observed effect level (also called **LOAEL** – lowest observed adverse effect level); for toxic or other effects imposed on organisms or experienced by humans;

LRTAP Convention – Convention on Long-Range Transboundary Air Pollution;

MBL – Marine boundary layer; the air right over the ocean surface, where exchange of mercury between the two compartments takes place;

MethylHg or MeHg – Methyl mercury;

Metric ton or tonne – 1000 kg;

mg – milligram (10^{-3} gram);

Mol or mole - is the atomic weight of a molecule of the chemical in grams. E.g. 1 mole of mercury is 200.59g.

MRL – Minimum risk level; term used in evaluation of risk of toxic effects from various chemicals (such as methylmercury) on humans; the MRL is defined by US ATSDR as an estimate of the level of human exposure to a chemical that does not entail appreciable risk of adverse non-cancer health effects (see section 4.2);

MSW – Municipal solid waste;

MW – Megawatt a unit of electrical power;

MWC – Municipal waste combustor;

MWh – Megawatt-hour is a unit of energy most commonly used to express amounts of energy.

Natural emission - Input to the atmosphere, which is not connected with current or previous human activity;

NEMA – National Electrical Manufacturers Association (in the USA)

ng – nanogram (10^{-9} gram);

NGO - Non-governmental organization;

NOEL - No observed effect level (also called NOAEL – no observed adverse effect level); for toxic or other effects imposed on organisms or experienced by humans;

NRC – National Research Council of the United States of America is under the auspices of the National Academy of Sciences (NAS), the National Academy of Engineering (NAE), and the Institute of Medicine (IOM). The NAS, NAE, IOM, and NRC are part of a private, no-profit institution that provides science, technology and health policy advice under a congressional charter signed by President Abraham Lincoln that was originally granted to the NAS in 1863. Under this charter, the NRC was established in 1916, the NAE in 1964, and the IOM in 1970. The four organizations are collectively referred to as the National Academies

OECD - Organization for Economic Cooperation and Development;

pg – picogram (10^{-12} gram);

POPs - Persistent Organic Pollutants;

ppb – parts per billion;

ppm - parts per million;

Pre-industrial state - A conventional term implying the state of the natural [mercury] cycle before the beginning of human industrial activity; in Europe the beginning of a noticeable production and consumption of mercury is related to medieval centuries;

PS - Particle scrubber; equipment designed to reduce emissions of particles from combustion flue gases

Re-emission - Secondary input to the atmosphere from geochemical reservoirs (soil, sea water, fresh water bodies) where mercury has been accumulating as a result of previous and current human activity;

RfD – Reference dose; term used in evaluation of risk of toxic effects various chemicals [such as methylmercury] on humans; the RfD is defined by US EPA as an estimate [with uncertainty spanning perhaps an order of magnitude] of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime;

SCR - Selective catalytic reduction; equipment designed to reduce emissions of certain pollutants from combustion flue gases;

SDA - Spray dryer adsorber system; equipment designed to reduce emissions of certain pollutants from combustion flue gases;

Slag – A substance produced by mixing chemicals with metal that has been heated until it is liquid in order to remove unwanted substances from it.

SNCR - Selective non-catalytic reduction; equipment designed to reduce emissions of certain pollutants from combustion flue gases;

TLV - Threshold limit values are guidelines [not standards] prepared by the American Conference of Governmental industrial Hygienists, Inc [ACGIH] to assist industrial hygienists in making decisions regarding safe levels of exposure to various hazards found in the workplace. They reflect the level of exposure that the typical worker can experience without an unreasonable risk of disease or injury. TLVs are not quantitative estimates of risk at different exposure levels or by different routes of exposure;

Torr - Is a non-SI unit of pressure defined as 1/760 of an atmosphere;

TWA - Time weighted average. The average exposure to a contaminant that a worker may be exposed to without adverse effect over a period such of an 8 hour day or 40 hour week. E.g. mercury vapour TWA is 0.05 µmol/m^3;

UN - United Nations;

UNCED - United Nations Conference on Environment and Development;

UNEP - United Nations Environment Programme;

US EPA – Environmental Protection Agency of the United States of America;

USA – United States of America;

Wet deposition - Flux of substance from the atmosphere onto the underlying surface with atmospheric precipitation;

WHO - World Health Organization.

Properties of mercury.

Atomic number: 80

Density: 13.5336 grams per cubic centimetre

Melting point: -38.83^0C [234.32K] -37.89^0F

Description: Silvery, odourless, heavy liquid

Molecular formula: Hg

Molecular weight: 200.59 g / mol

Period number: 6

Group number 12

Boiling point: 356.7 ℃ [629.88^0 K] 674.11℉

Phase at room temperature: Liquid

Element classification: Metal

Vapour pressure: 0.002 torr @ 25℃

Vanderwaals radius: 0.157nm

Solubility: Soluble in concentrated nitric and hot sulphuric acid; dissolves to some extent in lipids

CAS number: 7439-97-6

Oxidation states: +2, +1

Inhalation reference exposure level: 0.09 mg / m^3

TWA : 0.05 mg / m^3