Mercury exposure –

Mamopeli Matooane and colleagues from the CSIR speaks about mercury in our environment: just how much mercury is there and what are the health risks?

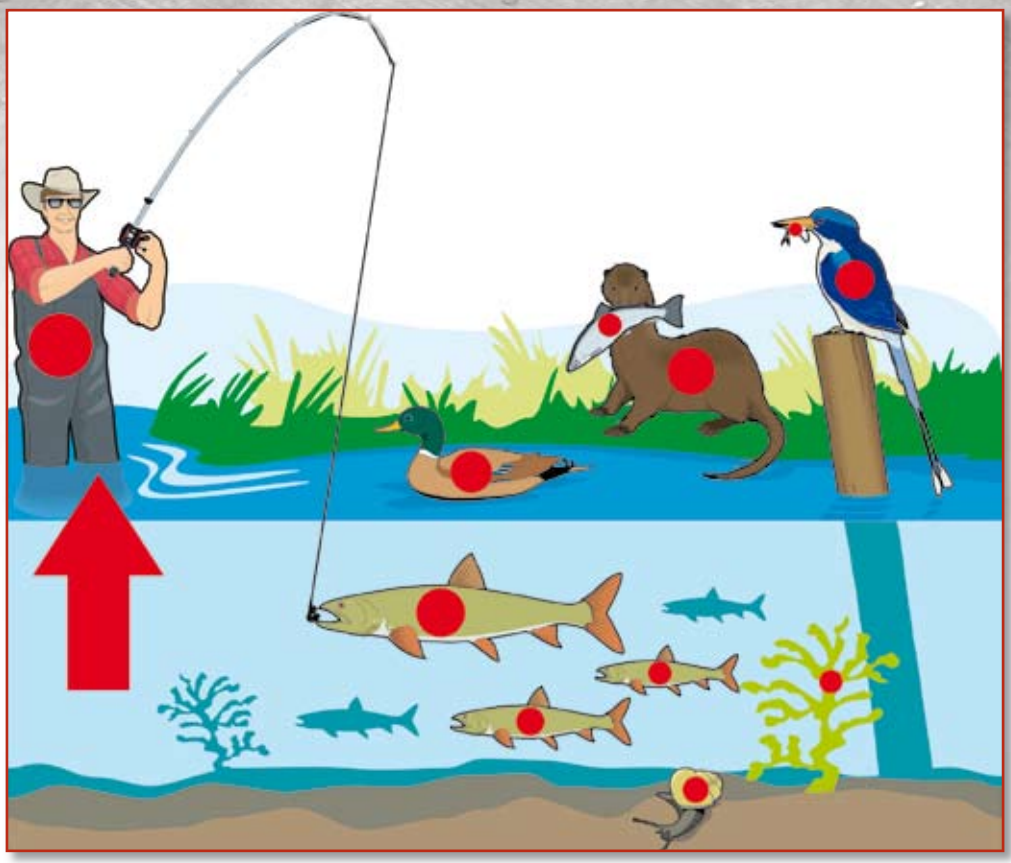

Figure 2: Bioaccummulation of methyl mercury (Environment Canada, 2004)

Table 1: Results from recent studies on mercury concentrations in air, fish and humans in the South African environment.

Media	Study	Mercury concentrations	Reference
Air	Emissions from coal-fired power plants	9.8 tons per year	Dabrowski et al., 2008
	Concentrations for a 1-hour average period	0.0387 µg/m3	Carter and Raghunandan, 2009
	Concentrations for a 24-hour average period	0.003 µg/m3	Carter and Raghunandan, 2009
Water	Freshwater mercury concentrations	Below detection limit – 0.96 ng/ l	Binedell et al., 2008
Fish	Health risk assessment	0.05 to 0.66 µg/g wet weight (ww)	Oosthuizen and Ehrlich, 2001
	Health risk assessment	0.010 - 0.498 µg/g ww	Binedell et al., 2008
	Health risk assessment	0.014 to 0.486 µg/g ww	Matooane et al., 2009
Humans	Blood/Urine (occupational exposure)	1.05 -2.28 µg/l of creatinine	Kaeteva et al., 2008
	Maternal and umbilical cord blood	Median = 1.78 µg/l (0.44 - 8.82 µg/l)	Rollin et al., 2009

Where does mercury come from?

Mercury (Hg) (Figure 1) is ubiquitous in the environment and can thus be found in all environmental compartments. It exists in different chemical forms in the environment, namely elemental or metallic Hg (Hg^{O}), inorganic Hg ($Hg2^{+}$) and organic mercury Hg (MeHg). South Africa is considered one of the major contributors to global Hg emissions into the atmosphere mainly due to coal-based power generation. Estimates suggest that stationary sources emit approximately 50 tons per year (Pacyna et al., 2006). However, there is evidence to the contrary suggesting that South Africa's Hg emissions from stationary sources are 10 times less than previously reported (Dabrowski et al., 2008).

While the debate is ongoing, Hg is released from various sources and is present in air, soil, water and biota in the South African environment and those exposed are potentially at risk of developing adverse health effects.

How can we be exposed to mercury?

Exposure to Hg occurs through the inhalation of Hg vapours, or ingestion of Hg-contaminated food or water. Mercury can also enter the body through the skin (dermal contact). However, the ingestion of Hg-contaminated food (particularly fish) remains the principal exposure route (WHO, 2003; Jiang et al., 2010).

In biological systems, inorganic Hg is transformed by microbial activity through a process known as methylation to produce organic Hg (e.g. methylmercury, MeHg), the more toxic form of Hg. MeHg is lipophilic (absorbed in the body fat), a property that allows it to bioaccumlate and biomagnify in biota. Therefore, people who regularly eat fish (such as subsistence fishermen), which may be contaminated with MeHg, are potentially at risk of developing adverse health effects associated with Hg. Fish that often contain elevated levels of MeHg are predatory fish such as tuna, kob and largemouth bass.

are we at risk?

The Periodic Table of the Elements

1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 Ce Cerium 140.116	59 Pr Prasodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Figure 1: Periodic table of elements; After UWSC, 2009.

However Hg concentrations have also been found to vary not only by the dietary habits of fish but with species age and size and location as well (Environment Canada, 2004).

In addition to subsistence fishermen, fetuses and children are especially vulnerable to Hg exposure due to their incomplete physiological development. Therefore pregnant women should avoid occupations in Hg-amalgamation, gold mining, chlor-alkali chemical industries and other industrial activities involving Hg handling, which are likely to greatly enhance Hg exposure (Mahaffey et al., 2008; Kataeva et al., 2008; Jiang et al., 2010).

What are the health effects of mercury exposure?

Once Hg enters the body it can be transported to various organs through the circulatory system. Adverse health effects associated with Hg exposure include mental retardation, cerebral palsy, deafness and blindness and effects on the central nervous system. In pregnant women, Hg can negatively affect the development of the foetus. It is also highly toxic to the brain and kidneys (WHO, 2003). The magnitude of effects is dependant on the concentration or dose received. Guidelines or reference values are often used to ascertain whether Hg exposure is excessive or negligible.

The South African reference guidelines, used by pathologists, for people exposed to mercury in the environment (excluding workplaces), are:

- Less than 5.0 µg/g of creatinine in urine
- Less than 10.0 µg/l in blood

What do we know so far about how much mercury exists in our environment?

There are very little data for Hg concentrations in the South African environment. However, some studies have tried to understand more about Hg emissions into the atmosphere, concentrations in water and biota, and potential impacts on both the environment and human health. Results for studies of Hg concentrations and exposures in South Africa are shown in Table 1.

Health impacts of mercury exposure

Few studies have investigated the human health impacts of Hg in South Africa, and those that there are have focused on subsistence fishermen. A ▷▷

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risk assessment was undertaken by combining data on Hg concentrations in fish commonly eaten by fishermen, and population data (consumption rate and body weight) to estimate potential risk. Results from these studies indicated that subsistence fishermen were at risk of developing adverse health effects due to Hg exposure.

Health risk was dependant on the species of fish consumed and location where fish was caught.

- Fish data for the the Mvoti-Umzimkulu Water Management Area (WMA) showed increased risk for all types of individuals living here and eating certain types of fish (Oosthuizen and Erhlich, 2001).
- People eating one fish meal per day of large-mouth bass found in the Steenskoolspruit River in Mpumalanga, were also shown to be at risk of high mercury effects (Binedell et al., 2008).
- Another study also showed a risk for people who ate yellowfish found in the Kaap River in the Inkomati WMA and red-breasted tilapia, banded tilapia and catfish found in the Mngceweni River in the Mvoti-Umzimkulu WMA (Matooane et al., 2009).
- Risk estimates for eating saltwater fish (found in the ocean) were also high for red roman, red panga and silverfish collected in the Western Cape (Matooane et al., 2009).
- Lastly, red roman obtained from subsistence fishermen at the Durban harbour resulted in elevated risks for people eating this fish species (Matooane et al., 2009).

These results suggest that people who regularly eat locally caught fish with elevated Hg concentrations, may be at risk.

A call for action

Mercury occurs in the South African environment, sometimes at concentrations above guideline values for human health protection, particularly sensitive individuals. People who regularly eat locally caught fish with elevated Hg concentrations are potentially at risk. However, there are no South African consumption guidelines based on the status of Hg pollution and Hg concentrations in fish to guide local consumers.

This is reason for serious concern, especially for individuals who eat fish more frequently. Since data are sparse, more studies are needed to better calculate risk. Researchers should collaborate and work with other national institutions and government organisations to address this serious health issue. □

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