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TECHNICAL BRIEF

# HEALTH AND WATER

## Mercury levels in SA water resources: A national survey

A WRC-funded study aimed to increase our knowledge of current and potential mercury pollution of South Africa's water resources.

## The threat of mercury pollution

Mercury (Hg) is known to be one of the most toxic heavy metals in the global environment. It is environmentally persistent and commonly occurs in three major forms: elemental mercury ($Hg^0$), inorganic mercury ($Hg^{2+}$) and organic mercury, an example of the latter being methylmercury (MeHg).

Furthermore, mercury undergoes complex physical, chemical and biological transformations in the environment. While being transported through the atmosphere, $Hg^0$ can undergo photochemical oxidation to reactive $Hg^{2+}$ and subsequently be deposited on soils and in lakes, rivers and the sea. Methylation of $Hg^{2+}$ by reducing bacteria is prevalent in anoxic habitats, following which the mercury is subject to uptake by aquatic organisms, resulting in high mercury concentrations in fish and chronic low level exposure of humans. Contamination by mercury is, in fact, more widespread than contamination by other metals, partly due to atmospheric transport and/or bio-magnification through the food chain, which enables it to reach fish and humans higher up the food chain.

Very few reports have been published on mercury emissions and their impacts on South Africa's water resources. One report suggested that mercury emissions from sources in South Africa, mostly related to coal combustion and gold mining, contribute more than 10% to global mercury emissions, and that the country ranks second to China on the list of major mercury polluters on a global scale.

However, a more recent report refined the estimates and indicated substantially lower mercury emission levels. Most South African studies concerned with the impact on water resources have been undertaken in response to mercury spills or accidents, such as the recent spill of mercury-contaminated effluent into the Mngceweni River, KwaZulu-Natal.

## Potential sources of mercury pollution

It is likely that emissions of particles which release mercury into the environment will be at a high level in those regions of South Africa where industries such as power generation and cement production rely on the combustion of coal. South Africa currently operates ten coal-fired power stations, with a further three, temporarily 'mothballed' plants, due to become fully operational during the next decade. Most of these are concentrated in or close to the Olifants Water Management Area (WMA) in Mpumalanga Province, which also mines approximately 83% of South Africa's coal.

By contrast, the South African cement industry, comprising at least 10 cement production units and 12 milling and blending facilities, is geographically well-distributed across the provinces and WMAs of the country. Coal is currently regarded as the only economically available kiln fuel in South Africa, with cement production units slowly moving away from high-quality coals to lower quality coal and other organic materials.

Urban areas in the different WMAs are also potential sources of mercury contamination of water resources because of effluent discharges from wastewater treatment works or industry into local water resources.

## Gaps in understanding of the mercury threat

In South Africa, the anthropogenic activities that lead to the release of mercury to the atmosphere, the subsequent deposition of mercury to water resources, and impacts of mercury on water quality have not been adequately characterised and are poorly understood. Yet, such understanding is fundamental to assessing the seriousness of the mercury problem in South Africa and to supporting future government initiatives aimed at controlling local emissions, such as the initiatives already taken, or about to be taken, in the USA, Europe and elsewhere in the world.

Better understanding would also provide insight into the degree to which mercury may be responsible for compromising the health of the country's water ecosystems, which provide the essential ecosystem goods and services underpinning all aspects of social and economic development. Finally, adequate understanding of the sources, transport and fate of mercury under South African conditions would provide a sound basis for national-level strategic decisions on mercury management.

An important initial step towards assessing and gaining an adequate understanding of the likely sources and levels of mercury and the impacts of mercury on South Africa's water resources has been to undertake a broad-scale national survey of mercury levels in South African water resources. Specific objectives have been to survey the concentrations and speciation of mercury in water, sediments and biota in priority South African water resources, assess the degree of compliance of measured mercury levels with national and international guidelines, consider the degree to which mercury may be a problematic pollutant in South Africa and create local capacity relating to mercury sampling and analysis.

## The initial survey

Selection of the surface water resources to be sampled was facilitated by considering existing data on mercury pollution and local knowledge on potential mercury sources, water resource usage and sensitivity of local ecosystems. Selection criteria also related to the proximity of the water resource to likely sources of mercury and the likelihood of mercury entering the resource.

At least one water resource was selected within each of the 19 WMAs in South Africa, with the resource sampling sites also chosen on the basis of their proximity to likely mercury emission sources. The survey focused primarily on coal-fired power stations and kiln operations for cement production, because these are likely to be the major sources of mercury entering South Africa's water resources. However, urban areas, where virtually all water resources receive discharges of treated (and occasionally untreated) wastewater of municipal and industrial origin, were also considered.

## Findings

In all, surface water, sediment and biota samples from 65 sites in the 19 WMAs were collected from 2007 to 2009 and successfully processed. Only limited sampling was carried out in some of the WMAs, thus preventing a fully representative picture of the overall state of the WMA in respect of the presence of mercury in the aquatic environment from being obtained. Nevertheless, the results obtained were adequate for the achievement of the objectives of this preliminary study and have provided a broad overview of mercury prevalence.

### Mercury in water resources

The lowest concentrations of aqueous total mercury (TotHg) (< 1 ng/ℓ) were found in the Luvuvhu/Letaba, Middle Vaal, Lower Vaal, Upper Orange, Gouritz and Olifants/Doring WMAs. The highest TotHg concentration (> 20 ng/ℓ) occurred in the Upper Vaal WMA. In the case of the aqueous methylmercury concentrations, the lowest concentrations (< 0.1 ng/ℓ) occurred in the Luvuvhu/Letaba, Crocodile (West) & Marico, Usutu to Mhlatuze, Thukela, Middle Vaal, Lower Vaal, Mzimvubu to Keiskamma, Gouritz, Olifants/Doring and Breede WMAs. The highest methylmercury concentration (> 2 ng/ℓ) was found in the Inkomati WMA.

### Mercury in sediments

The total mercury (TotHg) concentrations in sediment samples were lowest (< 1 ng/g) in the Luvuvhu/Letaba, Thukela, Middle Vaal, Upper Orange, Olifants/Doring and Breede WMAs. The highest TotHg concentration in sediment (> 200 ng/g) occurred in the Inkomati WMA. The lowest methylmercury concentrations (< 0.1 ng/g) in sediments were found in the Thukela, Mzimvubu to Keiskamma, Olifants/Doring and Breede WMAs, while the highest (> 2 ng/g) occurred in the Olifants and Inkomati WMAs.

### Mercury in invertebrates and fish

The lowest methylmercury concentration (< 10 ng/g) in invertebrate samples occurred in the Crocodile (West) & Marico WMA. The highest methylmercury concentration (> 200 ng/g) in invertebrates was found in the Mvoti to Umzimkulu WMA. Only limited data were available for fish since no fish were collected in the Crocodile (West) & Marico, Usutu to Mhlatuze, Thukela, Upper Orange, Gouritz and Breede WMAs. The lowest methylmercury concentrations (< 50 ng/g) were found in the Upper Vaal, Middle Vaal, Lower Vaal, Fish to Tsitsikamma and Olifants/Doring WMAs. The highest methylmercury concentrations in fish (> 200 ng/g) occurred in the Inkomati and Mvoti-uMzimkulu WMAs.

## Conclusions

On the basis of the measurements obtained in this study and a comparison with available national and international guidelines, mercury does not seem to be at problematic levels except at a few sites. Guideline levels were exceeded in three WMAs, namely Olifants, Upper Vaal and Inkomati, whereas high mercury concentrations were also obtained for samples from the Mvoti-uMzimkulu WMA.

Even though the national coverage possible in this study was limited, the fact that certain water resources have mercury concentrations exceeding international guideline levels does suggest that mercury contamination may be cause for concern in some parts of South Africa.

The true level of concern that is warranted will, however, only be established once further, more comprehensive, surveys of these water resources have been undertaken. The initial broad-scale study has yielded specific guidance for the more intensive and definitive sampling programme that ought now to follow. In addition, the inclusion of groundwater samples in future surveys is strongly recommended.

**Further reading:**
To obtain the report, *A National Survey of Mercury Levels in South African Water Resources* (**Report No:1754/1/10**) contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; E-mail: orders@wrc.org.za; or Visit: www.wrc.org.za