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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Health and communities

Investigating health risk of DDT for malaria control

A WRC-funded study investigated whether the environmental levels of DDT and DDE could contribute to adverse health effects in aquatic and other animals.

Use of DDT for malaria control

Dichloro-diphenyl-trichloroethane (DDT) is a pesticide used in control of the malaria-carrying mosquito. While banned internationally, some countries, including South Africa, have been granted restricted use for indoor residual spraying under the Stockholm Convention of 2002.

The convention allows for DDT to be produced and used for the purpose of controlling disease vectors in accordance with World Health Organisation recommendations and guidelines and when locally safe, effective, and affordable alternatives are not available. One such area is the Vhembe District Municipality of Limpopo. Here, the highest incidence rate of malaria cases occurred in Limpopo between 1998 and 2007. DDT spraying was introduced in 1945 for malaria vector control, and since 1966 DDT is being sprayed annually in this area.

Health risks of DDT use

However, DDT is an endocrine disrupting chemical (EDC). EDCs represent a diverse range of man-made chemicals discharged into the environment that mimic or antagonise the function of hormones. These EDCs may interact with physiological systems and cause alterations in development, growth and reproduction in wildlife, and particularly in exposed fish.

In terms of human health, current literature showing growing evidence that exposure to DDT and the major breakdown product DDE may be associated with adverse health outcomes, such as breast cancer, diabetes, decreased semen quality, spontaneous abortion, and impaired neurodevelopment in children.

Exposure of male embryos to EDCs during the early stages of foetal development has been linked to the increased incidences of male reproductive health disorders, including hypospadias, undescended testes, intersex, subfertility and testicular cancer.

South African studies have found that maternal exposure to home spraying of DDT may affect foetal development by increasing risk of urogenital defects by up to 33%. High levels of DDT have been found in the plasma of mothers and cord blood of babies from Limpopo Province where DDT spraying occurs.

Pilot studies examining environmental contamination with DDT in Limpopo raised concerns about the water quality and oestrogenic activity in an impoundment where DDT spraying takes place. Animals were tested that were either sharing the domestic environment or could be used as an indicator of environmental contamination. Chickens, terrestrial and aquatic birds, as well as two fish species were found to be contaminated.

The overall aim of this WRC study was to determine whether environmental levels of DDT and DDE may contribute to adverse health effects in aquatic animals. Chemical residue analysis was undertaken in water, soil, sediment and biota and biological testing for oestrogenicity was performed on water samples.

The aquatic health was determined in and around water sources in the area. The information was integrated into a scenario-based health risk analysis and the EDC assessment techniques compared and suggestions made for a South African relevant toolkit manual of tests for wider application in other spraying areas.

Several other aspects were also addressed. These included, among others, hormone analyses of oestrogenic substances such as ethinyl-estradiol (one of the main substances in birth control pills); a histomorphological study of the heart of ***Clarias gariepinus*** and ***Oreochromis mossambicus***; and testicular apoptosis as a molecular investigation to understand the process of testicular damage in the two bio-sentinel fish species inhabiting the Luvuvhu River.

Methodology

This study was conducted in the Vhembe District Municipality. All sample sites were along the Luvuvhu River, which flows through an area where indoor residual DDT spraying occurs, with the major sampling sites for fish being the Albasini and Nandoni Dams as well as the Xikundu Weir. Leafy vegetables and chicken samples were collected from the village of Tshakhuma as the reference site to the sprayed village Dididi around the Nandoni Dam.

Water and sediment samples were analysed for organochlorine pesticides (OCs), alkylphenols, phthalates, and hormones in water samples. DDT and metabolites were measured in fish fat and brain tissue as well as in vegetable leaves (pumpkin, cowpea and spinach) as well as chicken muscle and fat.

In vitro bio-assays for oestrogenicity or anti-oestrogenicity in water samples were performed by the recombinant yeast oestrogen screen and the T47D-KBluc reporter gene assay. The MDA-kb2 reporter gene assay was used to measure possible androgenic or anti-androgenic activity.

C. gariepinus and ***O. mossambicus*** were collected during four surveys from the major sites covering high flow and low flow seasons. Various indices of fish health were determined, including the use of biomarkers such as histomorphology of the heart, testicular apoptosis, computer-assisted sperm analysis and histology-based fish health assessment. The two fish species were also exposed to various environmentally relevant concentrations of DDT under controlled lab conditions.

The data for water and biological samples were used to conduct both a quantitative and qualitative scenario-based human health risk assessment. Human data of the epidemiological studies performed in this area were obtained for the health risk assessment.

Main results

Traces of DDT were found in all matrices analysed, namely water, sediment, soil, chicken and fish tissue and vegetables. Water showed oestrogenic activity, albeit low. Fish health effects, including histomorphological changes in the gills, liver, heart and gonads were demonstrated and sperm motility was impaired in higher DDT exposed waters. Community structures of fish and macro-invertebrates were influenced by DDT contamination within the Luvuvhu River.

In vivo exposure to fish to environmentally relevant concentrations in the aquarium showed no severe effects in adult ***C. gariepinus*** over a short-term period. Since DDT bioconcentrates in tissues, exposure for longer period as would occur in nature, may lead to irreversible long-term adverse effects, especially in juveniles. Good dose-related responses, similar to what were observed in the field studies, occurred in each of the controlled aquarium exposes of ***O. mossambicus***.

The predicted human health risks for both carcinogenic and toxic effects are high, with chicken and fish ingestion causing the highest risks, followed by vegetable ingestion (where DDT levels result from DDT in water used to irrigate the vegetables). Dermal exposure also results in high risks. The lowest risk is from direct exposure to water through ingestion and highlights the importance of examining all possible exposure routes when conducting a risk assessment.

Endocrine disrupting effects were also observed and can be anticipated in the exposed population with effects observed in both the human and animal population and at the cellular level.

Further reading:
To order the report, *DDT for malaria control: Effects in indicators and health risk* (**Report No. 1674/1/09**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za, or Visit: www.wrc.org.za to download a free copy.