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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.

Flag Boshielo Dam fish shown to be unsuitable for human consumption

The Department of Agriculture Forestry and Fisheries, now called the Department of Agriculture, Land Reform and Rural Development, is developing a policy on fisheries potential of selected South African dams. One of these is the Flag Boshielo Dam in Limpopo. This dam receives most of its water from the Olifants River catchment, one of the most polluted river systems in South Africa. The results of a recent Human Health Risk Assessment, performed by research partners for the Water Research Commission, confirm that metals have been bio-assimilated into the muscle tissue of fish from the dam, and that for certain metals, e.g. lead, antimony, chromium and cobalt, the levels in muscle tissue are such that an adult consuming even a modest 150 g portion once a week may be placing themselves at a serious health risk. The risks associated with consuming fish from Flag Boshielo Dam are almost three times those for the Phalaborwa Barrage in the neighbouring catchment. If the trend of increasing pollution levels in the Olifants River mainstem continue, the study predicts that the risks to human health posed by the consumption of contaminated fish will also increase.

Background



According to Statistics South Africa, nearly 21% of South African households experience food insecurity. The SDG: 2030 and National Development Plan aim to eliminate poverty and increase food security, particularly in rural areas by 2030.

South Africa has more than 4 700 dams constructed primarily for domestic, agricultural and industrial water supply. Government has proposed that these water storages be developed for inland fisheries and aquaculture in order to increase food security.

Fish are a vital source of food for many of the world's people, especially low-income groups, as they are a rich source of protein, micronutrients and essential fatty acids, cheaper than other protein sources, and available from local lakes, rivers and impoundments. The north-eastern regions of South Africa have been found as having the highest fisheries potential for inland fisheries.

The low production potential of South Africa's inland water bodies precludes the development of industrial or large-scale commercial fisheries on inland waters, however, a combination of recreational, small-scale subsistence and artisanal fisheries for livelihood purposes is considered the optimal model to maximise socio-economic benefit of inland fisheries in South Africa.

The then Department of Agriculture, Forestry and Fisheries initiated an Inland Fisheries Policy. However, the consumption of fish harvested from contaminated inland waters could result in detrimental long-term health impacts.

Flag Boshielo Dam, located on the main stem of the Olifants River, had been proposed as a suitable location for the development of a fishery. A subsequent WRC project was undertaken to determine the fishery potential of this impoundment.

The conclusion of this study complemented a previous WRC project, which identified that the concentrations of selected metals in fish from impoundments in the Olifants River system exceeded safe consumption limits and were potentially detrimental to the health of communities who regularly consumed fish from these dams.

These studies recommend that the Department of Agriculture, Agriculture, Land Reform and Rural Development and the Department of Environment, Forestry and Fisheries as new accountable fisheries Departments heed the warnings generated from this work and ensured that the draft Inland Fisheries Policy makes provision to “establish product quality and safety programmes for freshwater fisheries foods which conform, as far as possible, with relevant local standards and, as far as possible, with international standards.”

These standards are shared by the Department of Health in the food for human consumption. However, understanding of the dynamics of metal accumulation in fish muscle tissue and the environmental processes that drive them is insufficient to construct models to allow the fisheries managers to predict when the fish captured from an impoundment would be safe for human consumption.

There is, therefore, a need to investigate the seasonal dynamics of metal concentrations in fish muscle tissue and to identify environmental drivers of the observed patterns.

Therefore, the aim of the latest WRC study was to evaluate seasonal fluctuations in the metal concentration in muscle tissue of fish from the Flag Boshielo Dam in order to establish guidelines for the safe consumption of fish from contaminated impoundments, if at all.

The results of the project are expected to contribute information in policy development for the inland fisheries on South Africa’s water storage impoundments beyond the study site. This study excluded pesticides, emerging pollutants, microplastics and fate of all these contaminants once consumed. These remain as other research gaps for the future studies.

Approaches and main results

This study used a combination of analysis of historical data, two-and-a-half years of field data collection. Historical data from the then Department of Water and Sanitation for the Olifants and Elands rivers and Flag Boshielo Dam was compiled and analysed to establish whether patterns existed. The dynamics of river flows and selected water

physico-chemical parameters were explored.

Multivariate regression was applied to evaluate seasonal fluctuations in the metal concentration in fish muscle tissue. Three fish species, *Oreochromis mossambicus*, *Labeo rosae* and *Schilbe intermedius* were chosen for the study due to their abundance in the Dam and because these species occupy different niches within the system, with the first two species currently targeted by subsistence fisherman (local community members).

The results of the muscle tissue metal analysis for 19 metals were used to evaluate the risk to human health posed by the consumption of fish from Flag Boshielo Dam. The risk assessment assumes the consumption of a single fish meal of 150 g muscle tissue once a week by a 70 kg adult to calculate the average daily dose for the respective metals.

The average daily dose is then compared to the reference dose determined to be a safe exposure to the metal. A Hazard Quotient, which is the average daily dose divided by the reference dose, was calculated. A hazard quotient greater than one (1) indicates an unacceptably high risk to human health for weekly consumption of the meal.

The hazard quotients for each metal are summed to calculate the hazard quotient for the fish species. Again, hazard quotients greater than 1 indicate an unacceptably high risk to human health for weekly consumption of the fish species.

Metal concentrations in fish muscle tissue were lower in the 2016-2018 dry cycle than in the 2010 wet cycle. During this dry cycle, long-term consumption of these species from the Dam posed less of a risk (hazard quotients less than 1) to human health than those consumed from the same dam in the 2010 wet cycle. However, consuming fish from the Flag Boshielo dam is still not recommended for consumption regardless of water levels.

Conclusions and recommendations

This project has demonstrated that developing a model to predict when the fish from an impoundment are safe for human consumption is a far from trivial exercise. Therefore, in order to implement the food security monitoring from the Inland Fisheries Policy, the Department will require direct sampling of the fish captured from the impoundments where inland fisheries have been developed.

Government has proposed Flag Boshielo Dam as a potential site for the establishment of an inland fishery and

aquaculture ventures. **However, based on the available evidence, the dam is not suitable for the establishment of inland fisheries or aquaculture ventures due to the health risks posed by long-term consumption of metal contaminated fish.**

The current utilisation of fish from the impoundment by subsistence fishermen poses a complex problem that requires a solution. Subsistence fishermen currently capture fish from the impoundment for personal consumption and as an income source.

Fish captured from the impoundment are sold locally and possibly to buyers beyond the local. The current informal subsistence fishery is largely unquantified but could provide an important source of income and protein for the local rural community.

Daily, and weekly, consumption of fish from the impoundment should be strongly discouraged as this could pose a significant long-term health risk to the consumers. However, discouraging regular consumption of fish from the impoundment could counteract the benefit of utilising fish as a protein supplement in protein deficient communities.

The communities were informed of the long-term health risks likely to result from regular consumption of fish from this dam.

Policy recommendations:

The then DAFF has proposed Flag Boshielo Dam as a potential site for the establishment of an inland fishery and aquaculture ventures. However, based on the available

evidence, the Flag Boshielo Dam is not suitable for the establishment of inland fisheries or aquaculture ventures due to the health risks posed by long-term consumption of metal contaminated fish.

The potential threat that pesticides, and other organic compounds, pose to the ecological functioning of the Olifants River and its impoundments, including the edibility of fish, needs to be investigated.

At present, the only South African guideline for metals in meat are from a 1972 Act and limited to five metals; viz. As, Cd, Pb, Hg and Sn (Department of Health, 2004). These guidelines are in serious need of revision.

A medical survey of the communities consuming fish from Flag Boshielo Dam should be undertaken, using data from local clinics and questionnaires, to determine whether the adverse health effects of metals can be identified in the communities.

In addition, blood samples of community members who regularly consume fish from the impoundment should be screened to determine whether there are traces of metals. A nutritional assessment using questionnaires should also be conducted to determine the importance of fish in the diet of the communities surrounding Flag Boshielo Dam.

Associated project:

The fisheries potential and fitness of fish for human consumption in Flag Boshielo Dam, in Limpopo (WRC Project No. 2544). For more information, contact WRC Research Manager, Bonani Madikizela at Tel: (012) 761 9300 or Email: bonanim@wrc.org.za.