POLICY BRIEF

October 2021
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.

Determining the suitability of the Sand River's water for irrigation

Given South Africa's status as a water scarce country, optimal utilisation of water in agriculture must be a top priority. In addition, pollution from anthropogenic sources threaten many of the country's water resources. A recently completed Water Research Commission (WRC) funded project, undertaken by researchers from the University of Limpopo, evaluated heavy metal and microbiological contamination of the Sand River in Limpopo, and assessed the suitability of the river's water for irrigation.

Background

Water scarcity is now a global challenge and climate change has exacerbated the situation. It is thus important for stakeholders to optimally utilise this scarce resource. Globally, 70% of the freshwater resources are used by the agricultural sector.

The WRC study provided a situation analysis of the Sand River which passes through a fast-developing urban area, Polokwane, the capital of Limpopo. This river is extensively used for irrigation of vegetables. However, this agricultural production is potentially threatened by heavy metal and microbial contamination. This was the first study of its kind being undertaken for the Sand River.

Heavy metal contamination of Sand River water

The nutrient status of the Sand River and specifically looking at both spatial and temporal variation of physico-chemical parameters in the Sand River was undertaken. Additionally, this work focused on heavy metal contamination of the Sand River water and sediments. Significantly, the geo-accumulation index is used to determine the extent to which the Sand River sediment is contaminated with heavy metals. Work was also undertaken to look at spatial and seasonal variations of heavy metals in Sand River water. It was deemed important to look at spatial variation of the heavy metals in order to assess the self-purification capacity of the river.

Results showed that the Sand River can self-purify because all the physico-chemical parameters declined downstream of the discharge point. Phosphorus levels were above the recommended limits for irrigation water.

It was further observed that Sand River water can be used to boost vegetable production because of its high nitrogen and phosphorus levels. The major ions in the Sand River water namely, sodium, potassium, chloride, calcium, magnesium and sulphate were mostly within acceptable limits at both international and local levels.

The only nutrient that exceeded acceptable limits was phosphorus. The most suitable site for water abstraction that would optimise plant growth was identified as site 5. This is the site where the large commercial tomato producing company abstracts water.

There were no detectable seasonal variations in the nutrient status of the Sand River between the rainy and dry seasons. This was attributed to intermittent discharge of poor-quality effluent that probably obliterated any seasonal variations. It was therefore suggested that stakeholders using Sand River water to irrigate crops must closely monitor the quality of the water they abstract.

The situation analysis of heavy metal contamination of the Sand River water showed that iron, manganese, cadmium, copper, nickel and zinc all fell within the target for irrigation. However, lead levels exceeded the target range at two sites. Heavy metal concentration in the sediment followed the order iron>manganese>nickel>copper>lead>chromium >cadmium. The geo-accumulation index showed that the sediment was not contaminated with any of the trace metals before and after discharge of sewage effluent since the index was below 1 for all heavy metals.

Microbiological contamination of Sand River water

This study also focused on spatial and temporal variations of the microbial load in the Sand River. It was deemed important to look at the spatial variations of the microbial load so as to determine to what extent the Sand River can self-purify. Temporal variations were also investigated between the rainy and dry season because it is normally assumed that physico-chemical parameters concentrations will vary between the rainy and dry season.

Most ***E. coli*** bacteria are normal non-pathogenic inhabitants of the intestinal tracts of humans and animals and are, therefore, commonly used as hygiene indicator (faecal origin). However, some pathogenic strains (i.e., disease-producing) are known.

The type of disease-producing ***E. coli*** bacteria are known as STEC (Shiga toxin-producing ***Escherichia coli)*** because they produce a potent toxin called Shiga toxin. In this study, the ***E. coli*** levels rose significantly after the discharge of sewage effluent. There were only marginal differences in the microbial load between ***E. coli*** levels during the rainy and dry seasons. In addition, no seasonal differences were observed in the levels of heterotrophic count, total coliforms and faecal coliforms.

This again is attributed to the intermittent discharge of poor-quality sewage effluent. Total coliforms, faecal coliforms and ***E. coli*** levels were above the stipulated South African water guidelines for irrigation use.

A field study was undertaken to determine the suitability of Sand River and borehole water for irrigation of tomatoes and onions. The field study was undertaken at the Aquaculture Research Unit of the University of Limpopo. A risk assessment study was also undertaken for people consuming vegetables that are irrigated with Sand River water.

The sodium adsorption ratio (SAR) and sodium soluble percentage (SSP) all fell within the target range for irrigation water. The hazard quotient for tomatoes was less than 1 for all the trace metals except lead. This indicates that lead can potentially be hazardous to people consuming tomatoes irrigated with Sand River water.

However, further studies must be conducted because the reference dose for lead used in this study was very low. The hazard quotient for lead in onions was also above 1. This again highlights the importance of carrying out more work so as to fully establish the potential health impacts of lead.

Microbial analysis of the tomatoes irrigated with Sand River water showed no heterotrophic, coliform, faecal and ***E. coli*** bacteria on the inside of the tomatoes. Total coliform, faecal coliforms and ***E. coli*** were also not detected outside the tomatoes irrigated with Sand River water.
However, total heterotrophic bacteria were detected outside the tomatoes. No microbes were detected inside the onions. However, heterotrophic bacteria and total coliforms were detected outside the onions. The presence of coliforms outside the onions is not a major concern as coliforms are normally expected on plants.

Suitability of Sand River and borehole water for irrigation

The suitability of Sand River and borehole water for irrigation of tomatoes and onions was assessed as part of the study. Significantly, the hazard quotient which assesses the health risk associated with consumption of tomatoes and onion irrigated with sewage effluent was investigated.

In recent years, the sewage effluent quality discharged in South African rivers has deteriorated. It is thus important to rigorously monitor microbial contamination of fresh produce harvested from sewage effluent irrigated plots. The results from this study show that the inside of the tomato was not contaminated with any microbes. This is consistent with previous studies where the drip irrigation method was used. Drip irrigation is preferred over furrow or sprinkler irrigation because the risk of contamination is reduced. Drip irrigation minimises the risk of contact between the plant and wastewater.

In the onions irrigated with Sand River and borehole water, no heterotrophic bacteria, coliforms and E. coli were detected inside the onions. However, for both borehole water and sewage effluent, heterotrophic bacteria and coliforms were detected outside the onions. Significantly no faecal coliforms and E. coli were detected outside the onions.

Organo-sulphur compounds are the ones responsible for the antimicrobial properties that are found in onions.

This project is the first study to assess the suitability of Sand River water for irrigation. The health risk assessment showed that lead is potentially hazardous to people consuming tomatoes and onions irrigated with Sand River water. It is thus important for more studies to be undertaken in other rivers and dams where sewage effluent is used to irrigate crops.

Recommendations

The phosphorus levels in the Sand River exceeded the recommended limits for irrigation use. This is attributed to the discharge of poorly treated sewage effluent into the Sand River.

However, phosphorus levels declined downstream of the sewage treatment works. The abstraction point used by a large commercial tomato producing company is appropriate because the water from that site has high nutrient levels that will not be deleterious to crops.

Most of the heavy metals fell within the target range for irrigation except for lead. An analysis of the heavy metals in the sediments indicated that sediments were not contaminated with any of the heavy metals. Seasonal variations were not detected during the rainy and dry seasons.

This is attributed to intermittent discharge of poorly treated sewage effluent. The Sand River water has extraordinarily high pathogenic bacterial loads and the water did not meet the target range for use in irrigation. Although no pathogen detection or quantification was done, the levels of faecal coliforms and ***E. coli*** (hygiene indicator) indicated that the water did not meet the target range for use in irrigation.

Assessment of the suitability of Sand River and borehole water for irrigation was determined through SAR and SSP. Both these indices fell within the target range for irrigation water. The risk assessment study showed that lead was potentially hazardous to people consuming both tomatoes and onions irrigated with Sand River water.

It is recommended that local farmers monitor the water of the Sand River because of the intermittent discharge of very poor-quality effluent that takes place. It is further recommended that pre-treatment of the water be undertaken before it is used for irrigation.

This can involve use of settlement ponds. Vegetable consumers must with time insist on quality assurance of tomatoes and onions from suppliers. This will protect consumers from eating vegetables contaminated with heavy metals and pathogenic microbes.

Related report:

Evaluation of heavy metal and microbiological contamination and assessment of the suitability of the Sand River water for irrigation in the Limpopo Province (**WRC Report No. TT 835/20**). To download this report, Visit: www.wrc.org.za