Investigating the link between water quality and microbiological safety of selected fruit and vegetables from farming to processing stages

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Aim and Study Design

- Aim to investigate the link between water quality and microbiological safety of fresh, minimally processed, and frozen fruit and vegetables.

- Irrigation river and dam water quality was analysed in the context of assessing any link with the fresh produce up to-, at-, and after-harvest, as well as at the point of sale.
Study sites

• Water and produce samples were collected from selected sites in five provinces in South Africa, i.e., Gauteng (4 sites), KwaZulu-Natal (3 sites), Limpopo (2 sites), North West (3 sites), and the Western Cape (5 sites).
Samples

• Irrigation water sources included rivers, boreholes and dams, as well as agricultural spray water.
• Irrigation methods included overhead irrigation (pivot and sprinklers), drip irrigation and micro-irrigation systems.
• Different types of farming systems (commercial, small- and large-scale) were investigated and produce supplied for the local and international export market was assessed.
Irrigation water: Microbial contamination hazard risk

Increasing risk

• potable/rain
• groundwater (deep wells)
• groundwater (shallow wells)
• surface water
• raw or inadequately treated wastewater
RESULTS

• Summary of the main findings
Irrigation water

• Microbial analysis

*E. coli* exceeded the DWAF (1996) guidelines of ≤1000 CFU/100mℓ for crops that are eaten raw. High in primary irrigation water, however reduced in micro-irrigation pipes, drip-irrigation and overhead irrigation pivots water.

*Salmonella* spp. was isolated from 22% of irrigation water samples tested from a selected site with no *E. coli* O157:H7 or *Listeria* spp. detected. *E. coli*, hepatitis A virus, sapovirus and norovirus suggested that the contamination was most likely of human origin-posing a health risk to the end user of irrigated produce.
Physico-chemical analysis

BOD

Positive correlation between the biological oxygen demand (BOD), temperature and pH, and the turbidity levels in the water

TDS

Total dissolved solids (TDS) recorded were within the recommended range of 1000 mg/l for drinking water and 40 mg/ml for irrigation water as specified by the World Health Organisation

COD

There was a positive correlation between the TDS and the chemical oxygen demand (COD) levels in the irrigation water from two farms in KwaZulu-Natal. It was concluded that the *E. coli* counts could have been influenced by TDS and COD in irrigation water from one of the farms.
• COD and TDS
  - Two parameters of water that influenced the survival of total heterotrophic bacteria (THB), *E. coli*, *Salmonella* spp. and *L. monocytogenes* in the irrigation water sources on both farms.
  - COD values recorded exceeded those recommended by the World Health Organization (WHO) of 10 mg/l with a significant positive correlation between the COD levels, the THB, *E. coli* and *Salmonella* counts in the water samples.
Fresh produce analysis

Hazard characterization

Microbial levels on crop surfaces - higher in the field compared to the product at the end of the supply chain. *E. coli* and diarrhoeagenic *E. coli*, as well as viruses (NoV GI, NoV GII, and HAV) were isolated from fresh produce at certain stages along the supply chain.

Fruit (tomatoes, peaches, pears, strawberries), vegetables (lettuce, spinach, cabbage, onions and broccoli), herbs (parsley, basil) as well as processed produce (fruit salad and frozen vegetables).

Fresh produce with the highest microbial contamination were leafy vegetables (lettuce and spinach). Swine NoV GII.18 was detected in strawberries. This was the first report of swine NoV’s in South Africa - possibility of zoonotic NoV infection.
Impact of irrigation method

• The findings of this study demonstrated that irrigation methods that minimize direct contact of the contaminated water with the edible part of the plant lowered the risk of contamination to the fresh produce.
Impact of the study on stakeholders

- DOH
- DAFF
- Umgeni Water
- Consultants/NGO
- Retailers
- Farmers
Implementing recommendations from the study

Agricultural chemicals can be used in the supply chain to reduce foodborne-pathogen-associated hazards, but the fact that some of the chemicals can support pathogen growth should be taken into consideration in a risk assessment strategy for each crop.

Fix the source of the problem
Preventative strategies- Continued regular monitoring of irrigation water sources must be implemented with a view to developing a database of information and an early warning system.
Need for updating applicable regulations
It is clear from the findings that a database for the presence of foodborne pathogens should be established, maintained and relevant information provided to consumers, retailers, producers and exporters.

Effective management systems should further be developed, based on adequate statistically designed sampling plans, sampling methods and intervals to provide a clear national picture of the status of microbial safety of fresh produce.

Revision of current microbiological guidelines for irrigation water and fresh produce based on scientific data (including actual natural microbial levels and pathogen presence/absence) are needed.
Sampling methods
New Rapid, sensitive and accurate tests are being developed that will change the diagnostic platforms for microorganisms.

Best farming and manufacturing practices
Systematic and regular pipe maintenance should be adopted. Strategies to decontaminate agricultural water is also important and should be investigated and scientific findings adopted by industry.

Risk assessment approach
Commodity-specific supply-chain management systems and guidelines, based on scientific data (including actual natural microbial populations and pathogen presence/absence) should be developed.
Conclusion

• No support for the hypothesis that there is a direct link between irrigation water quality and the microbiological safety of fresh produce and fruit
• Need for HCD, relevant and appropriate technologies, greater sector interface
• Climate change impacts
• HACCP based production
• Knowledge gaps
• Inadequate funding for water research
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