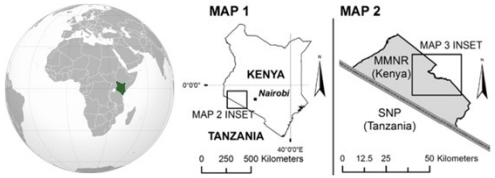
Human Health, Climate Change, and Water Quality in Kenya's Pastoral Drylands

Melvin Obadha[1,2,3], Bilal Butt[1,2,4], and Daniel Ntimama[2]

1. School for Environment and Sustainability, University of Michigan, Ann Arbor, Michigan
2. Center for Global Health Equity, School of Medicine, University of Michigan, Ann Arbor, Michigan
3. Health Economics Research Unit, KEMRI-Wellcome Trust Research Programme, Nairobi, Kenya
4. Aga Khan University, Nairobi, Kenya



Introduction

- Drylands are characterised by extreme weather conditions such as prolonged droughts, erratic rainfall, and extreme temperatures, etc. Climate change increases the frequency, magnitude, and extent of these extreme events (1,2,3,4,5).
- Intense precipitation and floods affect water quality, which increases the risk of water-related illnesses such as diarrhoeal diseases and heavy metal poisoning (6).
- Prolonged droughts lead to water scarcity, forcing communities to consume contaminated water, increasing the risk of water-borne diseases such as diarrhoea (7).
- Pastoral communities live in drylands, putting them at risk of water-related illnesses.

Methods

- BB and DN collected water samples from 11 sources during the dry season (Feb 2024) and again, from 25 sources during the wet season (Aug 2024).
- Samples were analysed (microbiological, physical, and chemical analysis) at the Crop Nutrition Services laboratory in Nairobi, Kenya.
- MO analysed 11 paired samples using medians and the Wilcoxon Signed-Rank Test.

Results

- Fecal matter and related pathogens (total coliforms, Escherichia coli, Streptococcus faecalis, and sulphate-reducing anaerobes) were detected in most water sources, with higher concentrations in the dry season compared to the wet season.
- Toxic heavy metals such as Arsenic, Cadmium, Chromium, Lead, and Mercury were not detected in all 11 water sources in both dry and wet seasons.
- Other chemicals, such as fluorides and manganese, were detected in high levels during the dry season.
- Across seasons, there was a high amount of suspended solids in the water.

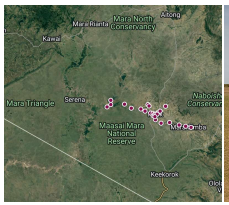
Microbial Water Properties

Microbial parameter	Dry season (median)	Wet season (median)	αKEBS guideline values (KS 05-459: Part 1:1996)	Sources (dry) > guideline value	Sources (wet) > guideline value	Wilcoxon Signed-Rank Test
Escherichia coli (mpn/100ml)	1,800	21.5	Must not be detected (250 ml sample)	Detected in 11 of the 11 sources	Detected in 8 of the 11 sources	0.008
Pseudomonas aeruginosa (cfu/100 ml)	2	Not detected	Must not be detected (250 ml sample)	Detected in 4 of the 11 sources	Not detected	Not detected
Salmonella (in 100ml)	Not detected	Not detected	Must not be detected (250 ml sample)	Not detected	Not detected	Not detected
Shigella (in 100ml)	Not detected	Not detected	Must not be detected (250 ml sample)	Not detected	Not detected	Not detected
Staphylococcus aureus (cfu/100 ml)	Not detected	Not detected	Must not be detected (250 ml sample)	Not detected	Not detected	Not detected
Streptococcus faecalis (cfu/100 ml)	40	37	Must not be detected (250 ml sample)	Detected in 11 of the 11 sources	Detected in 9 of the 11 sources	0.820
Sulphite reducing anaerobes (cfu/100 ml)	100	29.5	Must not be detected (50 ml sample)	Detected in 10 of the 11 sources	Detected in 10 of the 11 sources	0.006
Total Coliforms (mpn/100ml)	1,800	350	Must not be detected (250 ml sample)	Detected in 11 of the 11 sources	Detected in 11 of the 11 sources	0.008
Total Viable Count at 22°C (cfu/ml)	37,000	300,000	No Guidance			0.010
Total Viable Count at 37°C (cfu/ml)	40,000	300,000	100	All 11 sources exceeded guideline	All 11 sources exceeded guideline	0.014

Physical and Chemical Water Properties

Physical-chemical parameters	Dry season (median)	Wet season (median)	α KEBS guideline values (KS 05-459: Part 1:1996)	Sources (dry) > guideline value	Sources (wet) > guideline value	Wilcoxon Signed-Rank Test
Aluminium (ppm)	4.35	2.59	0.1 mg/l	7 of the 11 sources exceeded guideline	10 of the 11 sources exceeded guideline	0.668
Ammonium (ppm)	0.19	0.29	No Guidelines			0.160
Arsenic (ppm)	0.007	0.007	0.05 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Barium (ppm)	0.01	0.01	1.0 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Boron (ppm)	0.068	0.05	No Guidelines			0.547
Cadmium (ppm)	0.002	0.002	0.005 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Calcium (ppm)	48.1	28.7	250 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.003
Chloride (ppm)	168	42.1	250 mg/l	4 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.001
Chromium (ppm)	0.004	0.004	0.05 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Copper (ppm)	0.01	0.01	0.1 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Electrical conductivity (mS cm -1)	1.43	0.49	No Guidelines			0.001
Flouride (ppm)	4.03	1.46	1.5 mg/l	11 of the 11 sources exceeded guideline	4 of 11 sources exceeded guideline	0.001
Hardness CaCO3 (ppm)	155	85.9	500 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.001
Iron (ppm)	2.86	1.81	0.3 mg/l	7 of the 11 sources exceeded guideline	9 of the 11 sources exceeded guideline	0.700
Lead (ppm)	0.009	0.009	0.05 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Magnesium (ppm)	8.74	3.41	100 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.001
Manganese (ppm)	0.2	0.034	0.1 mg/l	9 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.001
Mercury (ppm)	0.001	0.001	0.001 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Molybdenum (ppm)	0.028	0.01	No Guidelines			0.002
Nickel (ppm)	0.003	0.003	No Guidelines			1.000
Nitrate (ppm)	1.86	1.33	10 mg/l	1 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.492
Nitrite (ppm)	0.033	0.033	No Guidelines			1.000
pH	8.39	7.95	6.5 to 8.5	2 of the 11 sources exceeded guideline	2 of the 11 sources exceeded guideline	0.005
Phosphate (ppm)	0.019	0.01	No Guidelines			0.531
Potassium (ppm)	23	9.77	No Guidelines			0.001
Residual Chlorine (ppm)	Not detected	Not detected	0.2 - 0.5 mg/l	Not detected	Not detected	No observations
Selenium (ppm)	0.01	0.01	0.01 mg/l	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	1.000
Sodium (ppm)	223	59.9	200 mg/l	8 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.001
Sulphate (ppm)	253	72.5	400 mg/l	4 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.002
Total Dissolved Solids (ppm)	903	310	1500 mg/l	4 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.001
Total Suspended Solids (ppm)	103	162	No Guidelines			0.002
Turbidity (NTU)	126	210	5 NTU	10 of the 11 sources exceeded guideline	11 of the 11 sources exceeded guideline	0.005
Zinc (ppm)	0.01	0.013	5 ppm	0 of the 11 sources exceeded guideline	0 of the 11 sources exceeded guideline	0.016

α KEBS is the Kenya Bureau of Standards – a statutory government agency responsible for establishing, maintaining, and enforcing standards. PPM is parts per million (1 ppm = 1mg/l)



Map 3 Sampling Locations, Narok County


Drylands at the edge of the Maasai Mara National Reserve, Talek, Narok County.


Drinking water source from an underground spring in Talek.


MO looking at one of the sources of water samples in Narok County

References: 1. Whitford, W. G. 2002. Ecology Of Desert Systems, San Diego, California, Academic Press. **2.** D'Odorico, P., Porporato, A. & Runyan, C. W. 2019. Dryland Ecohydrology, Cham, Switzerland, Springer Nature Switzerland Ag. **3.** Wang, L., Jiao, W., Macbean, N., Rulli, M. C., Manzoni, S., Vico, G. & D'Odorico, P. 2022. Dryland Productivity Under a Changing Climate. Nature Climate Change, 12, 981-994. **4.** VICENTE-SERRANO, S. M., PRICOPE, N. G., TORETI, A., MORÁN-TEJEDA, E., SPINONI, J., OCAMPO-MELGAR, A., ARCHER, E., DIEDHIOU, A., MESBAHZADEH, T., RAVINDRANATH, N. H., PULWARTY, R. S. & ALIBAKHSHI, S. 2024. The global threat of drying lands: Regional and global aridity trends and future projections. A Report of the Science-Policy Interface. Bonn, Germany: United Nations Convention to Combat Desertification (UNCCD). **5.** Wainwright, C. M., Finney, D. L., Kilavi, M., Black, E., & Marsham, J. H. (2021). Extreme rainfall in East Africa, October 2019–January 2020 and context under future climate change. Weather, 76(1), 26-31. **6.** WATTS, N., ADGER, W. N., AGNOLUCCI, P., BLACKSTOCK, J., BYASS, P., CAI, W., CHAYTOR, S., COLBOURN, T., COLLINS, M., COOPER, A., COX, P. M., DEPLEDGE, J., DRUMMOND, P., EKINS, P., GALAZ, V., GRACE, D., GRAHAM, H., GRUBB, M., HAINES, A., HAMILTON, I., HUNTER, A., JIANG, X., LI, M., KELMAN, I., LIANG, L., LOTT, M., LOWE, R., LUO, Y., MACE, G., MASLIN, M., NILSSON, M., ORESZCZYN, T., PYE, S., QUINN, T., SVENSDOTTER, M., VENEVSKY, S., WARNER, K., XU, B., YANG, J., YIN, Y., YU, C., ZHANG, Q., GONG, P., MONTGOMERY, H. & COSTELLO, A. 2015. Health and climate change: policy responses to protect public health. The Lancet, 386, 1861-1914. **7.** WORLD HEALTH ORGANIZATION. 2023. Climate change [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health [Accessed 18 October 2025].

Key Points

- **Almost all water sources were contaminated with human and animal faecal matter, exposing pastoral communities to water-borne illnesses**
- **Pastoralists frequently suffer from *Helicobacter pylori* and other gastrointestinal diseases**
- **Chemicals of significant health concern were found in high levels during the dry season**
- **Heavy metal contaminants were not detected in any of the sample water sources or across seasons**
- **Climate change will exacerbate poor water quality, leaving pastoralists even more vulnerable in the future**

CENTER FOR GLOBAL HEALTH EQUITY
UNIVERSITY OF MICHIGAN