Topic

Evaluation of Prevalence and Changes in Antimicrobial-Resistant Fecal Organisms in Fecal Sludge and Wastewater Treatment Plants, Naivasha, Kenya

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Summary of abstract (100/100 words)

Antimicrobial resistance (AMR) is a global public health threat; sanitation systems may mitigate-or exacerbate-transmission of AMR pathogens. We quantified extended-spectrum beta-lactamase-producing (ESBL) *E. coli*, an AMR pathogen of global concern, in influent and effluent of wastewater and fecal sludge treatment plants in Naivasha, Kenya to examine AMR in fecal waste before and after treatment. We observed prevalent ESBL *E. coli* (≥5 $\log_{10}$/100mL in influent, ≥4 $\log_{10}$/100mL in effluent) with higher proportions of ESBL *E. coli*/total *E. coli* than in previous data from treatment plants in high-income countries. These data underscore the need to monitor AMR in global sanitation systems.

Introduction, methods/approaches and results (496/500 words):

Although antimicrobial resistance (AMR) is a pervasive, global threat, levels of AMR, including fecal AMR pathogens such as extended-spectrum beta-lactamase-producing (ESBL) *E. coli*, are not known across low- and middle-income countries (LMICs). Though improving water, sanitation, and hygiene (WASH) systems can prevent AMR- and non-AMR infections, WASH conditions remain poor and may even contribute to AMR spread in LMICs. For example, recent global estimates indicate about 25% of ESBL *E. coli* in feces is unsafely managed (discharged into unimproved systems or openly defecated).[1] Local sanitation systems—both onsite facilities and downstream treatment plants—need to evaluate the levels of AMR pathogens and the effectiveness of treatment prior to discharge.

In Kenya, 95% of fecal sludge is discharged into the environment without treatment. Only 17% of Kenyans have access to sewerage[2] against targets of 40% by 2022 and 80% by 2030. In Naivasha sub-county, a fecal flow study indicated that 75% of the population used non-sewered sanitation.[3] Following this, Sanivation partnered with Naivasha Water and Sanitation Company (NAIVAWASCO, which was designed to meet the sewerage processing needs of 50,000 people but was serving 143,000 across both sewered and non-sewered systems) to process the non-sewered fecal sludge and instead focus on treating wastewater.

From November 2019-March 2020, we sampled the fecal sludge treatment plant (FSTP) 10 times for influent, effluent, and biosolids (final material used to make non-carbonized briquettes used as a firewood substitute) and sampled the NAIVAWASCO wastewater treatment plant (WWTP) 11 times for influent and effluent. All samples were tested for total *E. coli*, and ESBL *E. coli* via IDEXX Colilert® (supplemented with cefotaxime for ESBL *E. coli* quantification).

In the FSTP, influent *E. coli* (total) and ESBL *E. coli* levels averaged 6.3 (95% confidence interval (CI): 6.1, 6.5) $\log_{10}$most probable number (MPN) of coliform forming units/100mL and 5.0 (95% CI: 4.7, 5.3) $\log_{10}$MPN/100mL, respectively. Effluent *E. coli* and ESBL *E. coli* levels averaged 5.2 (95% CI: 4.7, 5.7) $\log_{10}$MPN/100mL and 4.1 (95% CI: 3.7, 4.4) $\log_{10}$MPN/100mL, respectively. No biosolids samples had detectable total or ESBL *E. coli* (all < 4 $\log_{10}$MPN/100mL). ESBL *E. coli* made up 6% (95% CI: 4%, 8%; range: 1-15%) of all *E. coli* measured in influent samples, and 7% (95% CI: 3%, 11%; range: 2-26%) of effluent samples., We observed a mean decrease of 1.0 $\log_{10}$MPN/100mL in concentrations of each type of *E. coli* after treatment. .

At the WWTP, influent *E. coli* and ESBL *E. coli* levels averaged 7.2 (95% CI: 7.0,.7.3) $\log_{10}$MPN/100mL and 6.4 (95% CI: 6.2, 6.7) $\log_{10}$MPN/100mL, respectively. Effluent *E. coli* and ESBL *E. coli* levels averaged 5.6 (95% CI: 5.4, 5.9) $\log_{10}$MPN/100mL and 4.7 (95% CI: 4.4, 5.0) $\log_{10}$MPN/100mL, respectively. ESBL *E. coli* comprised 23% (95% CI: 14%, 31%; range: 8-41%) of *E. coli* measured in influent samples and 13% (95% CI: 11%, 16%; range: 3-21%) of effluent samples., We observed a mean decrease of 1.5 $\log_{10}$MPN/100mL in concentrations of total *E. coli* and 1.7 $\log_{10}$MPN/100mL for ESBL *E. coli* after treatment.

Wider Implications/ Discussion (145/200 words)

ESBL *E. coli*, an important AMR pathogen, is readily detected at high concentrations in both influent (≥5 $\log_{10}$MPN/100mL) and effluent (>4$\log_{10}$MPN/100mL). These results underscore both prevalent transmission of ESBL *E. coli* in local populations as well as minimal treatment within existing sanitation plants, suggesting high levels of environmental discharge into receiving waters. In particular, ESBL *E. coli* entering WWTP and FSTP made up proportionally more of the overall *E. coli* levels than observed in high-income settings, suggesting a need for optimizing treatment of AMR pathogens. To-date, AMR pathogens in community settings, including in sanitation systems, in LMICs have not garnered attention; however, the availability of field-practical methods, such as the WHO TriCycle or modified IDEXX methods (used here) make environmental surveillance a feasible and necessary future step in understanding AMR burden and how improving sanitation systems can reduce this burden in the environment and communities.

References

1. Berendes D, Kirby A, Brown J, Wester AL. Human faeces-associated extended-spectrum β-lactamase-producing Escherichia coli discharge into sanitation systems in 2015 and 2030: a global and regional analysis. *Lancet Planet Heal*. 2020;4(6):e246-e255. doi:10.1016/S2542-5196(20)30099-1
2. Water Services Regulatory Board (WASREB). Impact: A Performance Report of Kenya's Water Services Sector-2018/2019. 2020
3. Bohnert, K. SFD Report: Naivasha Sub-county, Kenya, 2017.