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Fecal contamination of soil and water in sub-Saharan Africa cities: The case of Addis Ababa, Ethiopia

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ABSTRACT

Only a small proportion of Addis Ababa is served by conventional sewerage treatment systems. Most of the city relies upon on-site sanitation, while open defecation remains a common practice, especially in slum areas. This paper provides evidence of environmental pollution related to inadequate sanitation using a range of physicochemical and fecal contamination indicators and a mix of surveys of pit latrine contents, soils and water sources. Some water sources, including deep wells, show indications of fecal contamination, and soils are widely contaminated with the parasitic worm, *Ascaris lumbricoides*. Analysis of pit latrine contents shows a significant reduction in the number of *A. lumbricoides* ova with depth, but levels of ova at even the bottom of the pit suggest the need for proper sludge treatment. Wider awareness of environmental pollution gleaned from this research is intended to inform policy makers and their prioritization of actions to improve urban sanitation.

1. Introduction

Sub-Saharan Africa had achieved only 30% sanitation coverage by 2015, with only a 4 percentage point increase from 1990 (WHO, 2016). Here sanitation coverage means the percentage of people who have access to "proper sanitation", defined as a sanitation system that hygienically separates fecal waste from human contact (WHO/UNICEF, 2008). A lack of access to proper sanitation is a serious concern because of the massive disease and health burden associated with poor sanitation and unsafe solid and liquid waste disposal (UN-Water, 2014). The practice of open defecation is a primary cause of fecal borne disease transmission, with children being the most vulnerable. Reducing by half the proportion of untreated wastewater has been established as a target in the UN's recently released Agenda 2030 for sustainable development (Goal 6.3).

Addis Ababa is Ethiopia's rapidly growing capital city covering an area of 527 km^2, and with more than 3 million residents it is one of the largest cities in Africa. Over 80% of Addis Ababa's population live in slum districts with very

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poor housing, that are overcrowded and have little or no urban service provision (UN-Habitat, 2005). Only a small proportion of the city is served by conventional sewerage systems, while most areas rely upon on-site sanitation (Beyene et al., 2015). Open defecation remains a common practice especially in urban-slum areas. The small sewerage network, commissioned in 1981, currently serves only the central part of the city (Kiingi, 1998; Alemayehu et al., 2006; Van Rooijen and Taddesse, 2009). According to the Waste Water Master Plan of Addis Ababa Water and Sewerage Authority (AAWSA, 2002), this comprises about 30 km of trunk sewer and 90 km of secondary sewers, serving about 40,000 people via 1800 connections. Most households (about 75%) have pit latrines that are either emptied when full or discharge to open drains; about 15% have flush toilets and septic tanks, again often discharging to open drains; while a significant minority (about 5%) resort to open defecation (CSA, 2005). Public toilets are not common, but communal pit latrines that are shared between several households are widespread.

On site technologies can provide viable and affordable options for sanitation, but only if the entire service chain, including collection, transport, treatment and safe end-use or disposal is managed adequately (Bartram and Cairncross, 2010). Without proper fecal sludge management (FSM) systems in place the construction of dry toilets does not safely contain wastes, with most ending up directly in the local environment. There is little advice, support or standards available on the design and construction of dry latrine and other type of sanitation facilities. Households, provided they can afford to pay, can use government (utility) and private firms to empty latrine pits, but it can be a challenge to get service on time.

Diarrhea is the second most common cause of disease in Addis Ababa (Fig. 1), and in 2016 the city suffered a major outbreak of acute watery diarrhea (AWD) which has similar symptoms to cholera. The main factors contributing to the spread of AWD are open defecation and waste dumping (including feces) in public spaces, especially rivers and river banks and streams. Floods and rain, which have been above normal, spread feces in water sources, land areas and open spaces and thus increase the spread of AWD. Almost all major rivers and streams of Addis Ababa were found to contain fecal matter and were confirmed positive for disease-causing agents of AWD.

While Addis Ababa clearly faces both severe pollution- and sanitation-related health problems, there is a lack of information on the extent of fecal pollution. The aim of this research was to provide further evidence on the occurrence and survival of pathogens in the fecal sludge of dry pit latrines, and the degree of contamination of the wider environment (soil and water).

2. Material and methods

This paper presents findings from three main surveys: a survey of pit latrines to assess characteristics of fecal sludge, a survey of soils examining contamination using *Ascaris lumbricoides*, and a survey of water sources including both surface and groundwater sources and their level of fecal contamination.

2.1. Survey and assessment of pit latrine contents

Pit latrines in Addis Ababa are typically unlined and 1.5–4 m deep. They are normally dry, but water may be used in the case of some pour-flush toilets. The roof and the wall are usually made of corrugated iron sheet, and less commonly of wood with mud or concrete. The slab is usually made of mud-plastered wooden materials and sometimes unreinforced concrete (which provides a washable floor). As most city residents are poor, many shared communal toilets have been constructed by government and nongovernmental organizations to higher standards than household level pit latrines.

A total of 25 dry pit latrines in slum areas were sampled to study the parasite load in terms of *A. lumbricoides* ova and provide some indication of the risks presented by fecal sludge from such latrines. Five 5 sub-city areas were randomly selected (from a total of 10) and in each sub-city, one district was randomly chosen. In each district, five dry pit latrines in the slum areas were purposively selected (see the map at Fig. 2 and further details in Beyene et al., 2015) and considering only pit latrines with a fecal sludge depth above 1.5 m. Samples were taken from three zones: (i) from the top surface down to about 0.5 m depth (the aerobic degradation zone), (ii) the facultative anaerobic zone (0.5–1.5 m) and (iii) the anaerobic zone (>1.5 m, with samples taken 0.30–0.5 m above the bottom of the pit). The samples were collected in 500 ml polyethylene plastic

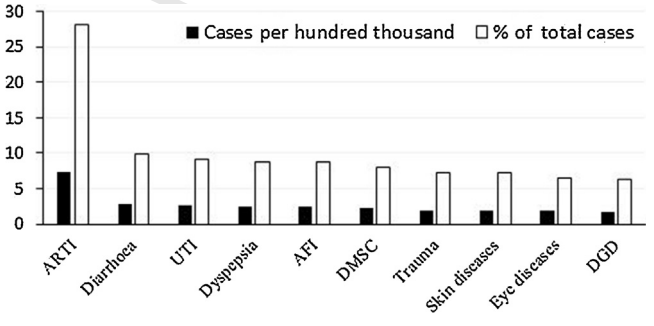

Fig. 1. Causes of morbidity in Addis Ababa in 2015/16 (data from Addis Ababa Health Bureau). Note: AURI = acute respiratory tract infection; UTI = urinary tract infection; AFI = acute febrile illness; DMSC = diseases of the musculoskeletal and connective tissues; DGD = dental and gum diseases.

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