Land surface predictors of diarrheal diseases: A spatial comparison of urban slum and rural villages in southern India

Andrea Brown¹, Mark Francis², Venkat Raghava Mohan³, Rajiv Sarkar², Deepthi Kattula², Vinohar Balraj², Gagandeep Kang², Elena N. Naumova¹,²

1. Department of Civil and Environmental Engineering, Tufts University School of Engineering
2. Department of Community Health, Christian Medical College

Introduction

The rate of diarrheal diseases is high in Indian rural villages and urban slums, contributing to malnutrition and death in young children. These diseases are faecal-orally transmitted, i.e. are contracted through contact with faecal matter or from contaminated drinking water. Lack of closed sewage drainage and the open-field defecation increase the likelihood of the transport of enteric pathogens through the subsurface into the groundwater, the sole source of the public drinking water, and the probability of direct contact with pathogen contaminated soil. In this preliminary study we applied GIS and spatial analysis to explore whether soil properties are related to water quality and enteric infections.

Our main objectives were to:

- Gather soil samples from two rural and two urban slum areas in the Vellore district of southern India
- Characterize the differences in physicochemical soil properties between the rural and urban areas
- Interpolate the soil properties values across the land surface within each area
- Determine whether soil properties affect nearby water quality and/or household diarrheal rates

Data Collection

All data was collected by the Christian Medical College Department of Community Health in India. Ten soil samples were collected from each area, five from an area where children play and five from an area next to an open sewer, over a four week period in June 2011. Diarrhea cases were recorded daily from 300 households with children under five-years-old. Monthly water samples were collected from public distribution taps starting in January 2011.

Water samples tested for:
- Coliform
- Fecal Coliform
- Total Dissolved Solids
- pH
- Nitrite
- Chlorine

Soil samples tested for:
- pH
- Cation Exchange Capacity
- Moisture Content
- Porosity
- Sand, Silt, and Clay
- Ammonia
- Total Soluble Organics

Methods and Analysis

Soil characteristics were linked to geo-located locations of 300 households in rural and urban study sites, their main source of drinking water, coliform counts in nearby public drinking water taps, and recorded diarrheal disease occurrences. Standard statistical methods were used to compare the soil physiochemical properties between rural and urban study sites. ArcGIS was used to interpolate the soil properties across each area (Figure 2).

Interpolated values were reanalyzed for statistical significance in predicting diarrheal disease rates and water quality. Two models were developed, one predicting household diarrheal episodes and a second predicting the vulnerability of public taps to fecal coliform contamination. The previously created interpolation rasters were used to calculate and display overall vulnerability maps created for each site.

Conclusions

- Soil properties do vary by study area, with noticeable variation between rural and urban areas
- Lower soil moisture and higher soil pH may predict fecal matter entering the water taps
- Lower CEC may indicate the likelihood of children picking up diarrheal pathogens from the land surface
- Conclusions can be made about the impact of diarrheal disease transmission as a growing rural population moves to urban slum areas