Heavy Metal Contamination Trends in an Urbanizing/Industrializing Low Income Country

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ABSTRACT

Rapid industrialization and global population growth have increased the number of people living in urban areas worldwide. Developing countries, have seen tremendous increases in their industries over the past decades, which generated both positives and negative effects on their people, environment, and economy. One of the negative impacts of industrialization is industrial pollution and the increase in the number of pollutants released into the environment_ in this case, heavy metals. Heavy metal contamination is an alarming problem that many Developing countries are becoming aware of and trying to address. Heavy metal direct or indirect consumption may result in several health effects in the body, including damage and alteration of normal functioning of organs such as the brain, kidney, lungs, liver, and blood, which later result into acute or chronic diseases. This case study will look at heavy metal contamination cases in Rwanda in different drinking water sources. The focus of this case study will be on some common heavy metals released from industrial waste: Lead, Manganese, Iron, Cadmium, Zinc, and Chromium.

BACKGROUND

Fig 1: Rwanda major cities

Location: Central-East Africa

Climate: Temperate tropical highland

Surface area: 10,169 square miles or 26338 square kilometers

Population in 2007: 9.3 million

Population in 2021: 13 million

Population density: 1360 people per square mile
2nd most densely populated country in Africa.

Economy: Low-income country

Agriculture: 72% of population is employed in agriculture

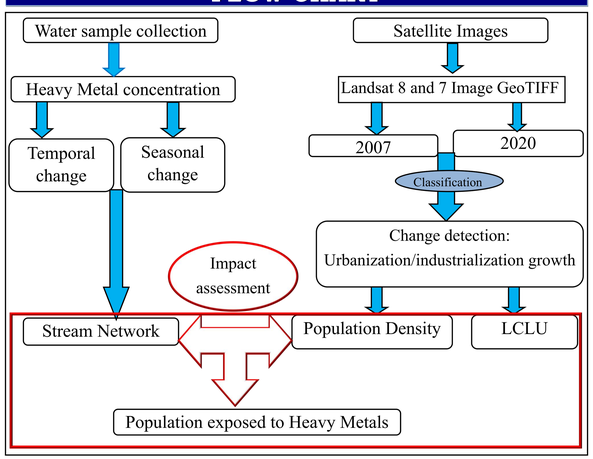
Water: Surface water is the main source for drinking water and irrigation water in Rwanda.

OBJECTIVES

This study aims to identify:

- Correlation between urbanization/industrialization and heavy metal pollution
- Areas with the highest heavy metal contamination of surface water in Rwanda
- The variation of heavy metal concentration with precipitation.
- The size of the population exposed to the contaminants.

FLOW CHART



DATA

- The data on heavy metals was from several scientific research papers on the surface water quality in Rwanda.
- 2007 satellite images were obtained from Landsat 7
- 2020 satellite images were obtained from Landsat 8.

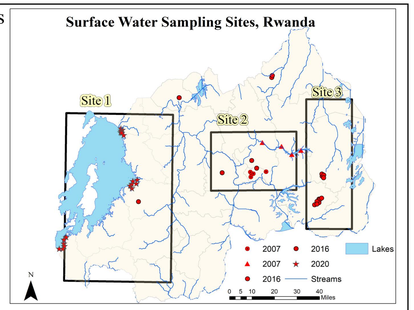
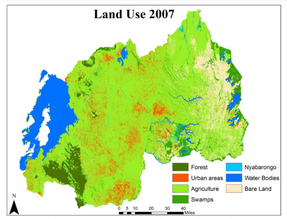


Fig 2: Sampling sites for water quality assessment

RESULTS



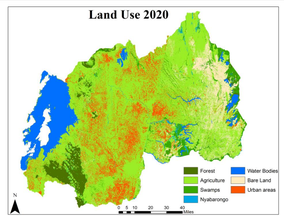


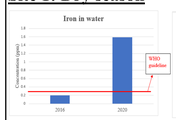
Figure 3(a-b): Landcover/Land Use (LCLU)

Urban areas 2007: 725 square miles
1876.5 square kilometers
6% of the country

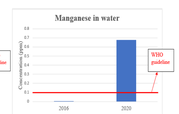
Urban areas 2020: 1280 square miles
3313.4 square kilometers
13% of the country

Progression of heavy metal concentration in surface water bodies collected at the three different sites over time, and how concentration is affected by precipitation. (Fig 4 a-l)

Site 1: Dry season

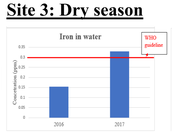


(a)



(b)

Site 3: Dry season

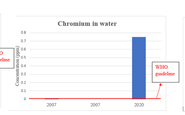


(c)

(d)

Site 2: Rainy season

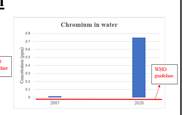
(e)



(f)

Site 2: Dry season

(g)



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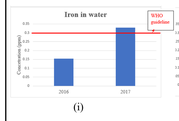

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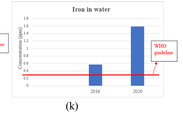

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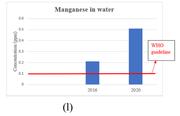


(l)

Overall Country: Rainy vs Dry season

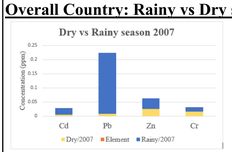


Fig 5(a-b): Effect of precipitation on heavy metal concentration in surface water.

RESULTS CONTINUED

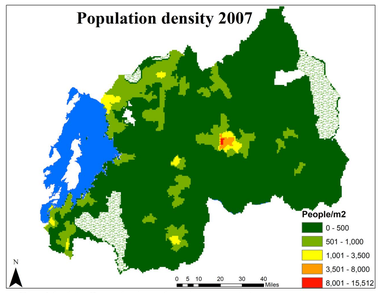
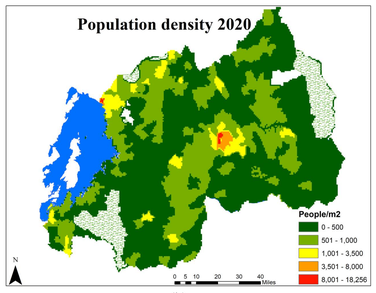


Fig 6(a-b): Population density (a)



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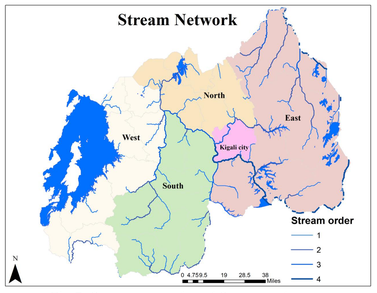
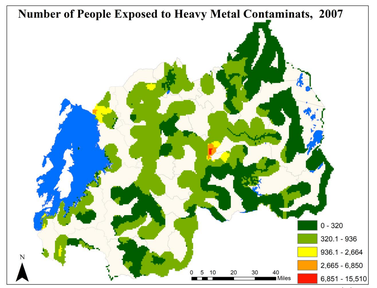
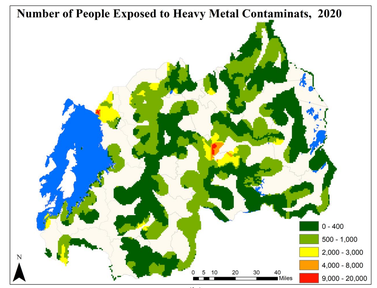


Fig 7: Stream network and Stream order



(a)



(b)

Fig 7(a-b): Population exposed to heavy metals

Number of people exposed to heavy metals directly through drinking water, and indirectly through consumption of agricultural corps irrigated with contaminated water:

Applied a 1 km buffer around drinking water and irrigation water sources:

- In 2007: 902,595 people
- In 2020: 1,483,719 people

DISCUSSION

- Rwanda has seen a 7% increase in urban areas in the last 10 years, with a high urbanization rate of 2.86% (see figure 3 a-b)
- Heavy metals concertation/pollution in surface waters has increased over the years in Rwanda, especially in urban areas.
- The concentration of heavy metals exceeds WHO guidelines for maximum permissible limit (MPL) for surface water in all surveyed sites for Lead (Pb), Iron (Fe), Manganese (Mn), and Chromium (Cr). Zinc (Zn) and Copper (Cu) were also measured and were within limits (see figure 4 a-l)
- Precipitation increases the amount of heavy metals in surface water during rainy seasons (see figure 5a-b). Rwanda's topography is very hilly, with the country's lowest altitude being at 950m above sea level which explains why most contaminants flow towards water bodies at lower elevation.
- The number of people exposed to heavy metal contaminants directly through drinking water and indirectly through consumption of crops irrigated with contaminated water has increased by 581,124 people in 13 years (see figure 6 a-b).
- People living in urban cities have the highest exposure because heavy metal pollutants are the highest at site 2, which is the largest urban city in Rwanda (see figure7 a-b).

CONCLUSION

- Urbanization/industrialization and population growth has increased the concentration of heavy metals in Rwanda's surface water.
- The latter is directly and indirectly affecting a significant number of people residing in close proximity to polluted water.
- With high urbanization rates heavy metal contamination and its impacts are expected to grow.
- Like in Rwanda's case, high urbanization rates are typical in developing countries worldwide, and those countries are also facing the negative impacts brought on by urbanization.
- Even though urbanization has long been associated with human development, recent studies show that urban settings can also lead to health problems, especially in developing countries.
- The negative health impacts of urbanization affect mostly poor populations because of their limited financial resources, as the cost of food and water is higher in cities. Half of Rwanda's people experience the negative effects of high urbanization rates, as 55% of Rwanda's population lives under the poverty line.

REFERENCE/AKNOWLEDGMENT

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