An interdisciplinary approach to studying antimicrobial resistance

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Background

With a population of 1.5 billion in 2023, estimated to rise to 2.5 billion in 2050, the African continent could be home to 40% of the world's population by the end of the 21st century. Furthermore, with more than half of the population now living in urban areas, Africa is the world's most rapidly urbanising continent. The rapid rate of population growth and urban development could represent an obstacle to the attainment of SDG 6, which "seeks to ensure safe drinking water and sanitation for all, focusing on the sustainable management of water resources." We have chosen to adopt an interdisciplinary approach combining hydrology and antimicrobial resistance in order to contribute to evaluations of the sustainability of a resource which is under great pressure on the periphery of Abidjan.

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Further reading

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)02724-0/fulltext
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Antimicrobial resistance: a pernicious obstacle to the SDGs

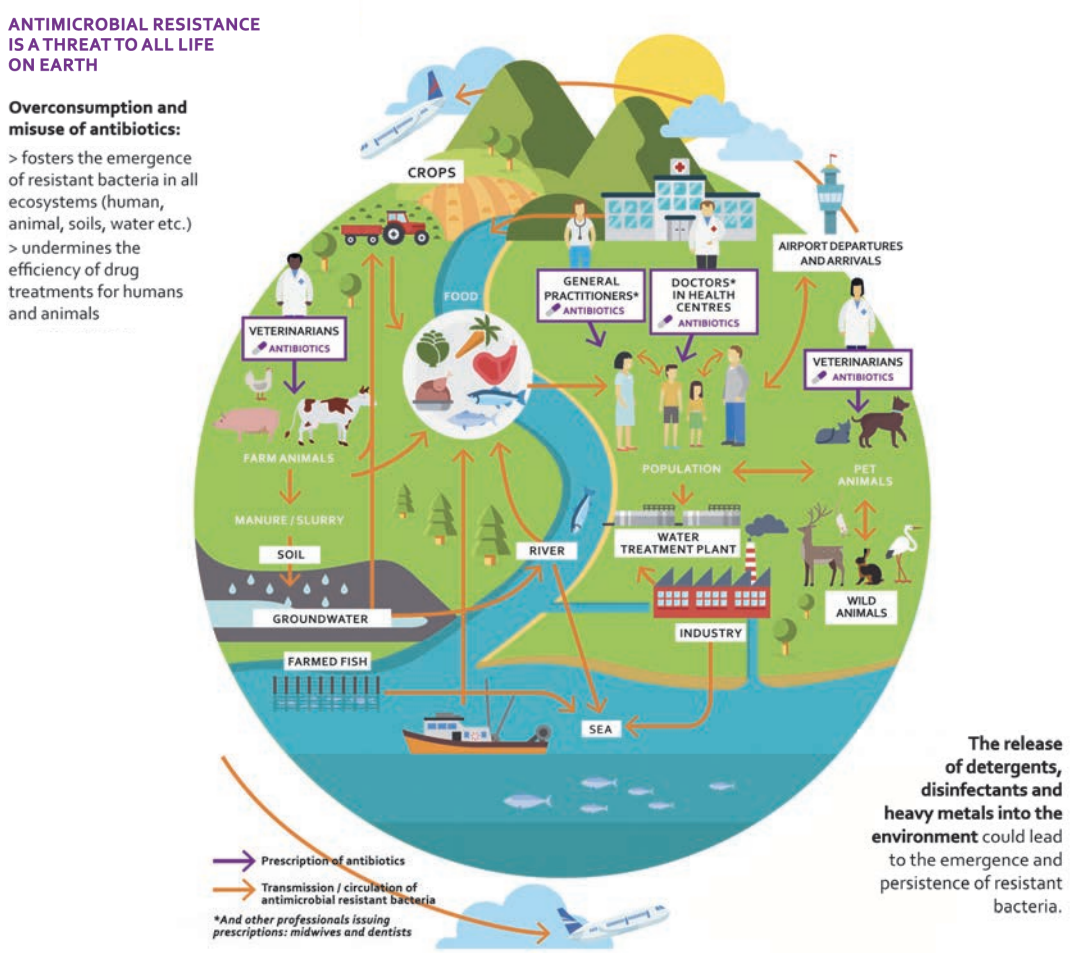
In the mid-20th century, the development of antibiotics revolutionised the treatment of infectious diseases. The golden age of antibiotics proved to be short-lived, as misuse and overconsumption rapidly exerted severe selective pressure on bacteria and led us to our current state of affairs: the development of widespread resistance (antimicrobial resistance) among pathogenic bacteria, compromising the efficacy of our therapeutic arsenal. In 2019, an estimated 1.3 million people all over the world died as a result of antimicrobial resistance. The emergence and dissemination of antibiotic-resistant pathogenic bacteria and the resistant genes they carry represent global threats which could hinder progress towards the targets of the Sustainable Development Goals unless urgent action is taken: SDG 3 "Good health and well-being" (and two of its targets specifically), SDG 6 "Clean water and sanitation" and SDG 12 "Responsible consumption and production." Like many of the major health challenges of the 21st century, the WHO believes that the widespread increase in antimicrobial resistance requires a "One Health" response. This is an intersectional, interdisciplinary problem which cannot be solved from a purely medical angle. Microbial resistance as a human health problem is increasingly closely linked to issues of animal health. For example, the French Ecoantibio project aims to reduce the use of antibiotics in the veterinary sector. Nonetheless, at time of writing, efforts to evaluate the role of environmental factors in the epidemiological cycle of antimicrobial resistance, and thus to monitor and study these environmental dynamics, remain inadequate. And yet, this knowledge would be of crucial importance to better understanding the role of environmental antimicrobial resistance in the emergence of resistant pathogenic bacteria and their impact on human health.

The place of water in a holistic approach to antimicrobial resistance

Antimicrobial resistance affects numerous ecosystems, and water plays a central role in the dissemination of resistances between microbial communities in different ecosystems. Aquatic ecosystems provide continuity between compartmentalised hydrological (surface water, underground water etc.), biotic (natural habitats for various organisms) and technological (waste water treatment, urban waste water, drinking water) milieus. As such, water is: 1) a matrix of interactions, the place where antimicrobial resistance emerges/disseminates via bacterial communities indigenous and external to the aquatic milieu; but also 2) a potential vector of antimicrobial resistance and of pathogenic bacteria in general, due to the regular daily contact between humans and water.

Water quality and ecological status in the Djibi river and Aghien lagoon

With a population of 5 million, the greater Abidjan area faces significant challenges when it comes to securing the drinking water supply. The Aghien lagoon, the only freshwater reservoir in the area, has been identified as a potential source of water for the city. Unfortunately,



The antimicrobial resistance cycle
(from https://antibioresistance.fr/grand-public).

the main tributary of this lagoon, the River Djibi, has its source in an area occupied by informal settlements where a large proportion of household waste water is discharged directly into the drainage system, or else into natural water courses without any form of treatment.

The Evidence project (Extreme rain, vulnerability and environmental risks: flooding and water contamination, 2018-2023) brought together Ivorian and French researchers from the Institut Pasteur in Ivory Coast, UMR HydroSciences Montpellier (IRD, Université de Montpellier,

CNRS, Institut Mines-Télécom) and the universities of Félix Houphouët Boigny and Nangui Abrogoua in Abidjan. Sampling and analysis of the waters of the Djibi were conducted in baseflow and overflow conditions. These readings enabled the research partners to jointly quantify the concentrations and flows of bacterial contaminants, nutrients and metallic trace elements, as well as their spatial and temporal variability. The results reveal that the dynamics of bacterial transfer mirror those of the contaminants present in particle form (in suspensions), and that the contaminants can be traced back to two key zones: the river bed (where particles accumulated between overflow periods) and urban areas (washed into the river from the streets and drainage channels during high water). In both baseflow and overflow conditions, significant quantities of pollutants are washed into the lagoon. In addition to pollutants responsible for eutrophication and numerous heavy metals associated with human activities, microbial contamination can also travel downstream into the lagoon, potentially posing a risk to human health. The territorial distribution of bacteria exhibiting worrying levels of resistance for human health has been objectively identified from the lab data. There are two scientific hypotheses which might explain the disparities of distribution recorded: a dilution effect thanks to the inflow of uncontaminated water and/or the dying off of resistant bacteria. Moreover, the inadequacy of waste water treatment infrastructure and the "unregulated" drug might also explain the presence of worrying strains of drug-resistant bacteria in the waters of urban and peri-urban rivers. Controlling these factors more effectively will be key to the fight against antimicrobial resistance. This study, based upon a One Health approach, is the first to describe the influence of run-off from a territory (drainage basin) on the presence of antimicrobially resistant bacteria at different levels, in baseflow and overflow conditions, in an urban and peri-urban aquatic milieu in Ivory Coast.

KEY POINTS

The capacity of water to act as a potential vector of pathogens towards humans is a crucial problem for many emerging countries, where lagoon waters may be used for drinking, cooking, cleaning and personal hygiene. This multidisciplinary study opens up new perspectives for original scientific projects bringing together all actors with an interest in the antimicrobial resistance cycle. Holistic approaches of this kind enable us to develop epidemiological research which remains fully attuned to environmental factors, demonstrating the potential of the One Health philosophy.

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