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Climate Centre

QUICK REFERENCE GUIDE

HEAT AND URBAN ENVIRONMENTAL ISSUES
WATER QUALITY

OVERVIEW

Unsafe water contributes to the deaths of nearly 842,000 people every year worldwide, nearly 43 percent among children under five years of age. Good water quality is essential for people's livelihoods, economic growth and development. Water pollution and low water quality are global problems, growing in complexity as countries develop economically, new contaminants emerge, rainfall becomes more variable and temperatures continue to warm. Well-known and well-researched pollutants such as fecal contaminants, and new pollutants—nutrients, plastics and pharmaceuticals—increase the risk of water pollution in both developed and developing countries.

Source: Haslick, Z. NOAA. 2017

Urbanization (and the development of slums and informal settlements) deteriorates the quality of water in urban areas by increasing the nitrate, phosphate, lead and demand for oxygen in waterbodies. Poor sanitation also impacts water quality—high rates of open defecation, particularly in urban areas where sanitary facilities are not readily available (trains, parking lots, heavily trafficked motorways), can result in fecal contamination of waterbodies, increasing harmful waterborne pathogens. (1, 4, 20, 21)

Heat also significantly reduces water quality by increasing nitrogen levels, salinity and algal bloom events. Thus, the convergence of higher global temperatures and the pressures on water quality—including land use changes, urbanization and economic development—will challenge municipal officials, particularly to manage the health effects, including water contamination and waterborne illnesses. (4, 5, 17)

Key Impacts

EUTROPHICATION
Harmful algal blooms
Neurological & gastrointestinal effects
Allergic reactions & liver damage

MICROBIAL
Increase of waterborne pathogens and incidence of diarrhea and other diseases

SALINITY
Hypertension (high blood pressure); Preeclampsia and infant mortality

Feburary 2020

This document was prepared under the Adaptation Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013 and is meant to provide a brief overview of heat's effect on urban environmental issues. The key resources at the end of the document provide more in-depth analysis. The contents of this report do not necessarily reflect the views of USAID.

HEAT, WATER QUALITY AND HEALTH

The main climate-related determinants affecting water quality include temperature and extreme storm events. Increased average temperatures—particularly, extreme heat events—and pollution of water are exacerbated within the urban landscape. Heat can impact water quality in two ways: (1) increasing the presence and concentration of chemical pollutants (e.g., nutrients and toxins) and (2) increasing the presence of microbiological organisms (e.g., bacteria and other pathogens). Both determinants can affect the health and well-being of urban populations living near and drinking from urban waterways. (8, 13, 4, 21)

IMPACTS OF HEAT

All water sources and waterbodies—surface water (rivers, lakes, streams), groundwater, and wastewater — continuously undergo complex chemical and biological processes and reactions. Temperature is the main factor affecting these reactions, and broadly speaking, higher temperatures increase the presence and concentration of potentially harmful substances in the water. Solar radiation/sunlight can also warm surface waterbodies and alter the composition and presence of both natural matter and pollutants in the water. Examples of the potential effects of heat on water quality in urban areas include the following: (5)

» Eutrophication and Harmful Algal Blooms (14, 18, 10, 5, 4, 19, 21)

- Heat combined with environmental factors (presence of naturally occurring nutrients, sunlight) increases the **eutrophication** (excessive nutrient build-up) of surface waterbodies (e.g., lakes) resulting in **harmful algal blooms**, contaminating drinking and recreational water supplies. Urban areas along the shores of lakes and rivers, with insufficiently treated human waste, and industrialized agriculture using fertilizers and manure amplify the risks of eutrophication.
- Higher temperatures and summer heatwaves boost the development of harmful blooms of **cyanobacteria**, blue-green algae, in freshwater. Heat increases the growth rate of the toxic bacteria and reduces the vertical mixing of the waterbody. As global temperatures increase, the presence and spread of new cyanobacteria species and other types of algae (phytoplankton, benthic algae, etc.) may proliferate. Cyanotoxin concentrations are typically highest where blooms accumulate, along shorelines and in downwind bays.
- Harmful algal blooms also lead to the **depletion of dissolved oxygen** in the water, killing fish and other organisms, impacting fisheries and coastal cities that depend on fish and shellfish for food.
- Crop fertilizer is one of the main causes of algal blooms. Warm temperatures combined with the **overuse of fertilizers** in highly industrialized agricultural areas may increase the nutrient load of surrounding waterways, potentially causing algal blooms downstream in cities.

» Nutrient Concentrations (23, 4, 3, 22)

- During the summer and autumn, warmer temperatures increase the presence of **nitrogen and phosphorous** in both surface and groundwater sources. Dry summer temperatures mobilize the nutrients in the soil, which are then flushed into streams and other waterbodies during the rainy season or after heavy rainfall.

» Microbial Contamination (21, 2)

- Under warmer temperatures and higher nutrient loads, waterborne pathogens and other bacteria can grow to high levels in surface water. These microbial agents originate from animal and wildlife waste and human fecal matter (from open defecation sites, wastewater systems and untreated wastewater) that seep into water through run-off or irrigation and can grow to high levels in surface waters under warmer temperatures and higher nutrient levels.
- The decomposition of these organic wastes in the water deplete oxygen levels, producing and releasing noxious gases and compounds into the water and air.

» Salinity (21, 15)

- Drought, rainfall variability and increased evaporation rates may decrease water availability and increase **water salinity**. In seasonally dry areas, shallow lakes, water storage facilities and similar waterbodies may also become brackish or saline due to evaporation.
- In summer and fall during times of low flow, especially in ponds and lakes, contaminants from road salt can accumulate and result in high levels of salt (sodium chloride). The risk of prolonged contamination in groundwater wells is higher.

CONSEQUENCES FOR HEALTH

All water sources and waterbodies—surface water (rivers, lakes, streams), groundwater, and wastewater — continuously undergo complex chemical and biological processes and reactions. Temperature is the main factor affecting these reactions, and broadly speaking, higher temperatures increase the presence and concentration of potentially harmful substances in the water. Solar radiation/sunlight can also warm surface waterbodies and alter the composition and presence of both natural matter and pollutants in the water. Examples of the potential effects of heat on water quality in urban areas include the following: (5)

Lack of access to a safe water supply increases the global health burden and increases poverty, especially in urban areas with inadequate drinking water treatment systems, lack of access to sanitary facilities and rapid population growth. Examples of the potential effects of heat on health issues related to water quality include the following: (4, 10, 11, 12, 16, 17)

- Higher average temperatures can cause short-term peaks in **waterborne pathogen concentrations** (bacteria and viruses), triggering outbreaks and the transmission of diseases associated with drinking water or eating food contaminated by these pathogens, including cholera, diarrhea, dysentery, hepatitis A, typhoid and polio. Certain waterborne pathogens can also multiply in food (especially fish and shellfish), beverages or water heating systems.
- **Cyanobacteria toxins** impact human health depending on the type of exposure (drinking, skin contact, etc.). Consumption of contaminated water can result in skin irritation, stomach cramps, vomiting, nausea, diarrhea and liver damage. Direct contact with affected water (bathing, swimming) can lead to allergic reactions (e.g., asthma, eye irritation, rashes, blisters).
- **Nitrogen** is toxic to infants and leads to methemoglobinemia or "blue baby syndrome," which starves infants' bodies of oxygen. Early exposure of children to high levels of nitrogen also stunts their growth and brain development, impacting their health and adult earning-potential.

- Intake of **saline water** results in hypertension (high blood pressure), increases the risk of preeclampsia in pregnant women and increases the risk of infant mortality.

MOST VULNERABLE POPULATIONS AND LOCATIONS

CITY RESIDENTS MOST AT RISK

Water contamination and waterborne pathogens are a risk for all city residents. However, workers, individuals and communities that are near or come in direct contact with urban waterways and/or rely on these waterbodies for drinking water are the most vulnerable to the effects of heat on water quality. These groups include: (3, 4, 11, 21)

- **Infants and pregnant women** who consume water or food with high levels of nitrogen and salt
- **Informal slum residents** living along shorelines with no access to improved drinking water
- **Laborers** working in/around waterbodies (boaters, fishermen, etc.)

GEOGRAPHICAL AREAS MOST AT RISK

While water quality is a complex problem in both developed and developing countries, a World Bank analysis of global water quality risk placed regions of Latin America (Mexico, south-central and eastern South America), North and Southern Africa, the Middle East and large swaths of South and East Asia at the highest risk of declining water quality. Most of these regions already have large urban populations and are projected to experience the greatest increases in days with temperatures above the lethal threshold of 35°C. Western Europe, the United States and Australia are also at risk, demonstrating that in some cases economic prosperity does not always correlate with increased water quality. Cities and large urban areas adjacent to and/or downstream from large surface waterbodies or in coastal areas are also exposed to the impacts of heat on water quality, specifically increasing harmful algal blooms. (4, 20, 21)

Regions that already suffer from limited access to improved drinking water and high rates of open defecation are also at risk. India, for example, not only has nearly 97 million people without access to improved drinking water, but also accounts for 59 percent of the world's population practicing open defecation. Sub-Saharan Africa accounts for more than 40 percent of the world's population without access to improved drinking water. Coupled with the pressures of urbanization and population growth, these regions have an increasingly large number of urban residents exposed to the impacts of rising temperatures and heatwaves on water quality. (7, 21)

Heat and Water Quality **VULNERABLE GROUPS**	
Populations	Infants and pregnant women
	Informal settlements and residents living near shorelines
	Boaters, fishermen and other laborers coming into direct contact with waterbodies
Geographies	South and East Asia
	Sub-Saharan Africa (particularly southern Africa)
	Middle East and North Africa

STEPS TO REDUCE RISK

This section considers how municipalities can integrate health into urban planning, investments and policy decisions to reduce the combined risk of extreme heat and air pollution on human health: (5, 18, 20, 6, 7)

- Establishing and/or improving systematic **water quality monitoring and testing** for major water sources, especially if no or limited treatment facilities are present (e.g., informal slum neighborhoods)
- Developing **drinking and wastewater treatment systems** for denitrification and cyanobacteria toxins
- **Land use policies and spatial planning** that retain forests and wetlands, preserving natural and riparian buffers that absorb nutrients that would otherwise pollute waterways and reducing the risk of "dead zones" in the water
- Increasing the use of **porous pavement materials** (driveways, sidewalks, roads) that decrease pollutant load from paved and other impervious surfaces
- Encouraging the municipal and household use of chemical, iodine, thermal, ultraviolent and/or solar technologies to **filter and treat drinking water**, reducing the prevalence of harmful waterborne pathogens
- Implementing **verification testing of waterbodies**, especially if no or limited treatment facilities are present (e.g., in informal slum neighborhoods)
- Improving **understanding of water quality**, including the quality of source waters and treatment, through research and development
- Constructing **sanitary facilities** and promoting **hygienic practices** in informal slum neighborhoods, along heavily trafficked roads and parking lots and near harbors/boathouses to decrease open defecation and risk of fecal contamination of waterways
- Developing a harmful **algal bloom management plan** with measures to prepare, detect and respond to a bloom incident. These measures include identifying and developing alternate sources of water to ensure that critical customers and utilities receive an undisrupted supply of water
- Reducing eutrophication in lakes and reservoirs through better **management of wastewater disposal** systems and **regulation of agriculture fertilizer pollution**

Key Resources

- World Bank's Quality Unknown: The Invisible Water Crisis: World Bank
- WHO's Protecting surface water for health. Identifying, assessing and managing drinking-water quality risks in surface-water catchments
- OECD's Managing Water for Future Cities: Policy Perspectives
- Air and Water Pollution: Burden and Strategies for Control (in Disease Control Priorities in Developing Countries. 2006. Jamison et al. [eds]).

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