Embedding
PROJECT

POLLUTANTS

Metals:

A GETTING STARTED GUIDE

Brandon Toews
Stephanie Bertels

Metals

A GETTING STARTED GUIDE

Prepared by Brandon Toews and Stephanie Bertels.

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ABOUT THIS SERIES

This guide is part of our series of Getting Started Guides that supports your company to develop an embedded sustainability strategy. Each guide tackles a specific sustainability sub-issue and explores what your company needs to do to support the resilience of the environmental and social systems around you.

In each guide, we address relevant trends, system thresholds, key concepts, key actors, and key resources. We also offer guidance on how to address the impacts of decisions and activities in your operations and value chains as well as developing credible goals and outlining key corporate actions and internal targets that can help to provide clarity on the work ahead.

We recommend you read the first guide in the series, Getting Started Guides: An Introduction, which explains our overall approach and the value of setting a clear strategy anchored in your company's most material issues. It also explains how you can leverage process-based interim targets to clearly outline and track the specific actions that your company needs to take to achieve its high-level goals.

A complete list of focus areas and sub-issues can be found in our guide Scan: A Comprehensive List of Sustainability Issues for Companies.

This guidebook addresses **Metals**, which is part of the broader sustainability issue of **Pollutants**.

1 SETTING THE STAGE – THE LEGACY AND FUTURE OF METAL POLLUTION

Unmanaged and improperly managed metal pollutants are contaminating the air, water, and soil and accumulating in living organisms with negative impacts for human and ecosystems health. Increasing levels of metals pollution also have significant economic impacts and reduce the productivity, cleanliness, liveability, and overall resilience of communities. Human and ecosystem exposure to metal pollution has significantly increased over the past century resulting from the growing use of metals in industrial, agricultural, domestic, and technological applications, along with land use changes and airborne emissions.

Although many metals are essential to proper biological functioning in plants, animals, humans, and other organisms, all metals are toxic in excess. Essential metals may build up in biological systems and become a significant health hazard. Others – such as lead, arsenic, and mercury – are non-nutritive and therefore not required in supporting healthy organic functions. For some of these metals there is no safe limit for exposure.

Despite decades of international action, exposure globally to toxic metals is pervasive, and persists at crisis levels. Metals are persistent in the natural environment, and new research indicates that vast stretches of land globally have been contaminated from a combination of factors, including industrial pollution and the erosion of bedrock. It is estimated that anywhere from 900 million to 1.4 billion people worldwide could be exposed to elevated levels of at least one toxic metal, with 14%-17% of global farmlands potentially affected.

UNICEF estimates that 1 in 3 children – up to 800 million globally – have blood lead levels at or above 5 µg/dl (an elevated level, especially for children, that is associated with potentially adverse health effects), and lead exposure alone was attributed to more than 1.5 million deaths globally in 2021. Further, an estimated 140 million people in at least 70 countries are drinking water containing arsenic at levels above the WHO provisional guideline value of 10 µg/L (4, 5) – consistent with recent statistical modelling which suggests between 94 and 220 million people are at risk of exposure to elevated arsenic concentrations in groundwater. Also of noteworthy concern has been the discovery of toxic metals in foods, such as baby food and rice.

Airborne metal contaminants are a key contributor to global air pollution. Toxic metal particles, such as arsenic, lead, mercury, cadmium, chromium, and nickel stemming from industrial processes, vehicle exhaust, and coal combustion can become attached to particulate matter (PM2.5) and travel long distances before settling back to the ground or water. Air pollution is the largest environmental cause of disease and premature death and the second highest risk factor for noncommunicable diseases. It is estimated that the combined effects of ambient (outdoor) and household air pollution are associated with 8.9 million premature deaths annually, with ambient air pollution accounting for 5.7 million deaths worldwide and indoor pollution accounting for 3.2 million deaths. Of these deaths, more than 90% occur in low- and middle-income countries.

Air pollution is now recognized as the single biggest environmental threat to human health. Airborne metal contaminants also have negative impacts on ecosystem health.

The crisis of metals in our air is inextricably linked to metals in our water. Pollutants contaminate water through effluent and leachate, such as from insufficient urban wastewater treatment, agricultural run-off, and industrial pollution, and airborne metals can find their way into water bodies as they return to the earth through gravity or precipitation.

Water can be contaminated by metals and metalloids such as lead, mercury, and arsenic. These pollutants can accumulate in ground, surface, and coastal waters that communities use for drinking, bathing, growing and gathering food, and countless other everyday activities, and can expose people to a broad range of health risks. The accumulation of these compounds in water, along with the toxic stress they cause, can have long-lasting implications for aquatic ecosystems, human health, and more.

Pollutants in waters are also exacting a heavy toll on human health. UNEP reports that only 56% of all monitored water bodies worldwide are classified as having good ambient water quality, and the Lancet reports that pollutants in water are responsible for 1.4 million deaths annually.

We provide further insights into pollutants in Pollutants in Air and Water: A Getting Started Guide and Water Quality: A Getting Started Guide.

UNDERSTANDING THE KEY SOURCES OF METAL POLLUTANTS

The metals contaminating our air, soil, water are diverse, and they originate from a variety of sources.

Metals are naturally occurring elements that are found throughout the earth's crust, and while they can be released into the environment through natural phenomena such as from soil erosion, rock weathering, forest fires, and volcanic eruptions, most environmental contamination and human exposure result from human activities.

Major anthropogenic sources of metal pollution include industrial processes, such as mining, smelting, and iron and steel production; fossil fuel combustion; agriculture; untreated sewage sludge; waste incineration; leachate from landfills, such as from e-waste; and wildfire suppressants. The range of industrial, technological, medical, and domestic applications of metals have led to their wide distribution in the environment.

Environmental contamination also occurs from atmospheric deposition. Metals entering the atmosphere from tailpipe and stack emissions or from evaporation can precipitate onto land and water, and often far from where they were first emitted. Nearly all human uses of water can result in water pollution, and heavy metals are one of the foremost sources of water pollution around the world. Insufficient urban wastewater treatment, agricultural run-off, and industrial pollution are worsening water quality around the world. Toxic compounds such as mercury and arsenic can accumulate in ground, surface, and coastal waters

Data from the World Health Organisation (WHO) indicates that 99% of the global population is exposed to unhealthy levels of pollution and is breathing air that exceeds WHO guideline limits, with communities in low- and middle-income countries facing the highest levels of exposure. Additionally, low-income and minority communities are significantly more likely to be situated near areas where waste management activities and impacts are located, and as a result, these communities are much more likely to suffer from exposure to dangerous pollutants. These pollutants can accumulate in ground, surface, and coastal waters that communities use for drinking, bathing, growing and gathering food, and countless other everyday activities, and can expose people to a broad range of health risks. The accumulation of these compounds in water, along with the toxic stress they cause, can have long-lasting implications for aquatic ecosystems, human health, and more.

Of particular concern is the topic of e-waste. Some research suggests that e-waste plays a considerable role in the release of metal pollutants to the environment, despite comprising a relatively small portion of solid waste globally. Metal pollution stemming from discarded electrical and electronic equipment, such as computers, mobile phones, and household and industrial equipment, is on the rise. A record 62 million metric tonnes (Mt) of e-waste was produced in 2022 (up 82% from 2010), and it is on track to increase another 32%, to 82 million tonnes, by 2030. Meanwhile, less than a quarter of e-waste is documented as having been properly collected and recycled, leaving USD $62 billion worth of recoverable resources unaccounted for and increasing pollution risks to communities. The Global South faces particular risk, where e-waste has the lowest rate of proper management and disposal and where the Global North has sent the majority of its electronic waste for decades. Compounding the problem of e-waste, many electronic products are disposed of before their end-of-life, and very few electronics find their way to a formal recycling unit. Most electronic products end up in landfills or are incinerated in a waste-to-energy process.

UNDERSTANDING AND ADDRESSING THE IMPACTS OF METAL POLLUTION

Certain regions of the Earth have naturally high concentrations of metals, and disturbances in these areas can increase erosion and mobilise these metals. Human activities redistribute and concentrate metals in areas that are not naturally metals-enriched, and this can result in metal pollutants contaminating the air, water, and soil. If these metals are biologically available at toxic concentrations, they can have significant impacts on the health and wellness of nature and communities.

Both short- and long-term exposure to metal pollution can create health problems. Metals are considered to be systemic toxicants, meaning they can affect many organs and systems, or the body entire, rather than one specific site, and even at lower levels of exposure. Exposure to metal pollution is associated with a broad range of chronic and acute health conditions, including cardiovascular and respiratory diseases; reproductive, neurological, metabolic, and immune system disorders; adverse perinatal outcomes; and cancers. Metals such as lead, arsenic, mercury, and cadmium can accumulate in soil, impacting soil structure and reducing its quality, fertility, and agricultural productivity. They can also disrupt soil microorganisms involved in nutrient cycling, affecting plant growth and development, and can be absorbed into the tissues of plants and bioaccumulate in animals as they move up the food chain.

To address these impacts, governments, industry leaders, and non-governmental organisations have collaborated – and continue to collaborate – to drive action.

Adopted in 1983, the Cartagena Convention aims – in part – to reduce heavy metal pollution through its Protocol concerning Pollution from Land-based Sources and Activities (LBS Protocol), which includes heavy metals and their compounds among Primary Pollutants of Concern. Signatories agree to "…establish assessment and monitoring programmes, carry out environmental impact assessments, develop information systems, consider transboundary movements of pollution, and promote education and awareness for pollution prevention, reduction and control."

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was signed in 1992 to control and reduce the movement of hazardous waste between nations, and especially to restrict the transfer of hazardous waste from more developed to less developed countries.

The UNECE Protocol on Heavy Metals was adopted in 1998 under the Convention on Long-range Transboundary Air Pollution, and required parties to reduce cadmium, lead, and mercury emissions from industrial sources, combustion process, and waste incineration.

Nation states adopted the Stockholm Convention on Persistent Organic Pollutants in 2001, which helps protect human health and the environment from dangerous long-lasting chemicals – including Mercury – by restricting and ultimately eliminating their production, trade, and use.

The Kyiv Protocol Pollutant Release and Transfer Registers was adopted in 2003 and is the only legally binding international instrument on pollutant release and transfer registers (PRTRs). The Protocol provides a solid legal framework for enhancing public access to information on inventories of pollution from industrial sites and other sources.

The Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade was adopted in 2004 and aims to promote shared responsibility and cooperative efforts in the international trade and environmentally sound use of hazardous chemicals, such as lead and mercury compounds.

Adopted in 2013, under the auspices of the United Nations Environment Programme (UNEP), the Minamata Convention on Mercury built upon the 1998 Protocol on Heavy Metals and further elevated the issue of mercury pollution. This global treaty includes provisions that relate to the entire life cycle of mercury, such as controls and reductions across a range of products, processes, and industries where mercury is used or released into the environment.

Other notable agreements and initiatives include the Global Alliance to Eliminate Lead Paint, established in 2009; the WHO and the Food and Agriculture Organization's (FAO) efforts to implement safe exposure levels for food in the Codex Alimentarius, or "Food Code," in 1992; the Partnership for Clean Fuels and Vehicles (PCFV), which launched a successful campaign to end the use of leaded petrol on a global scale; and the Alliance for Clean Air, which was launched by the World Economic Forum to help businesses measure heavy metals and other air pollutant emissions across value chains and to create emission inventories.

Most recently, world leaders agreed to the Global Framework on Chemicals, which presents strategic objectives and targets to protect people and the environment from chemical pollution. The Global Framework on Chemicals supersedes the Strategic Approach to International Chemicals Management (SAICM), which identified lead in paint and hazardous substances in electronics (including lead, mercury, and other metals) as emerging policy issues.

THE RISK TO BUSINESS

Metal pollution matters for business. Across a broad range of industries, businesses are facing credible and mounting risks from the declining societal acceptance of pollutants, an increase in abatement and pollution management costs, legislative and regulatory changes, and growing risk of legal challenges and litigation from parties that have suffered harm, loss, or damage from pollution.

Metal pollution has direct impacts on the workforce. Exposure results in increased hospital admissions, emergency room visits, and restricted activity days. Although it is difficult to determine the exact impact of metal pollution on the workforce, around 1.2 billion workdays are lost globally each year due to air pollution, due in part to metal particulates, and this could reach 3.8 billion days by 2060. As of 2021, lead alone is estimated to account for more than 33 million disability-adjusted life years (or DALYs) lost to disability worldwide. Employees breathing polluted air are much more likely to get sick and experience reduced cognitive performance.

More broadly, metal pollution has a significant impact on economies. Toxic metals are major and costly contaminants in both air and water globally. They contribute to an estimated USD $6 trillion in annual global health costs due to air pollution, including global GDP declining by 5% due to health impacts, lost productivity, and reduced life expectancy, as well as risking an estimated USD $77 billion due to water-related supply chain issues, including contaminated water. Further, the World Bank estimates that deteriorating water quality is a key factor in reducing economic growth and exacerbating poverty by nearly one third in some countries.

Businesses have a crucial role to play in protecting people and nature by eliminating metal pollutants from their own operations and in their value chains. Companies need to understand how their operations and value chains may be directly or indirectly contributing to metal pollution and the cascading effects these impacts may have on their business, society, and the environment. They need to review and rethink their processes to limit, and ideally eliminate, the release of metal contaminants from their operations, value chains, and/or products; invest in innovation; and work with policymakers and peers to advance the resilience of key systems.

Note. Sustainability issues are generally systemic issues, because they are deeply interconnected and rooted in complex environmental, social, and economic systems. In these guides, a system threshold is defined as the point at which the resilience of an environmental, social, or economic system becomes compromised. This occurs when the total impacts imposed on the system exceed its capacity to assimilate those impacts.

SYSTEM THRESHOLD

There is a limit to the concentration and volume of pollutants that the Earth and particular ecosystems and communities can withstand before their resilience and well-being are significantly – and perhaps irreversibly – eroded. Novel entities are one of the nine Planetary Boundaries that support and regulate Earth's systems. Research suggests that the boundary for what is considered a safe operating space for novel entities has already been breached.

In the pursuit of a corporate strategy that addresses the issue of metal pollutants, it is important for your company to determine appropriate and defensible limits within which it must function. Identifying the limits above which particular metal pollutants in air and water impact human health and nature – let alone threaten environmental, social, and/or economic collapse – is an urgent priority.

As an example of sources of information to guide your understanding of limits, the WHO provides evidence-informed, quantitative, health-based recommendations for acceptable levels of exposure for many metals.

Although no safe level of exposure may exist for some metals, key authorities may recommend limits that reflect the challenge of eliminating exposure entirely. For example, the WHO has recommended a limit of 10 µg/L for lead and arsenic. Such limits have been designated as provisional, given the practical difficulties in removing lead and arsenic from drinking water. However, every effort should be made to keep concentrations as low as reasonably possible and below guideline values when resources permit.

KEY TOPICS ASSOCIATED WITH METALS:

- Lead
- Arsenic
- Cadmium
- Mercury
- Other toxic metals

2 KEY CONCEPTS

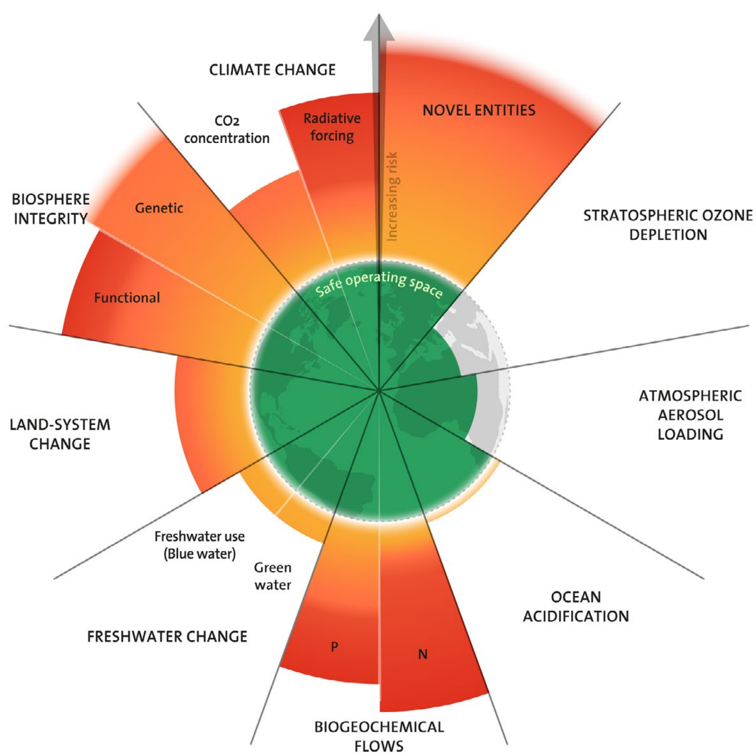
THE BOUNDARY FOR NOVEL ENTITIES

The Earth is comprised of ecosystems that are vulnerable to change and have limited ability to support various ecosystem services, such as filtering and purifying air, water, and soil. Without our support, this capacity may be irreversibly reduced.

As humans, we have altered the world around us by introducing **novel entities** whose impacts and long-term consequences we often do not understand. "Chemical pollution" was included as one of the Stockholm Resilience Centre's nine planetary boundaries and was later renamed to "novel entities." Novel entities can be understood as "new substances, new forms of existing substances, and modified life forms," including "chemicals and other new types of engineered materials or organisms not previously known to the Earth system as well as naturally occurring elements (for example, heavy metals) mobilized by anthropogenic activities."

As shown in the diagram below, we have introduced more novel entities than the world can safely incorporate.

Breaching the threshold of the planetary boundary for novel entities threatens the resilience of our global environment by destabilising the Earth's systems and causing irreversible damage. It also affects the status of other planetary boundaries. For example, toxic quantities of metals can impact the health of plants and wildlife and compromise biosphere integrity.



Source: The Nine Planetary Boundaries, by Stockholm Resilience Centre, 2025

HEAVY METALS

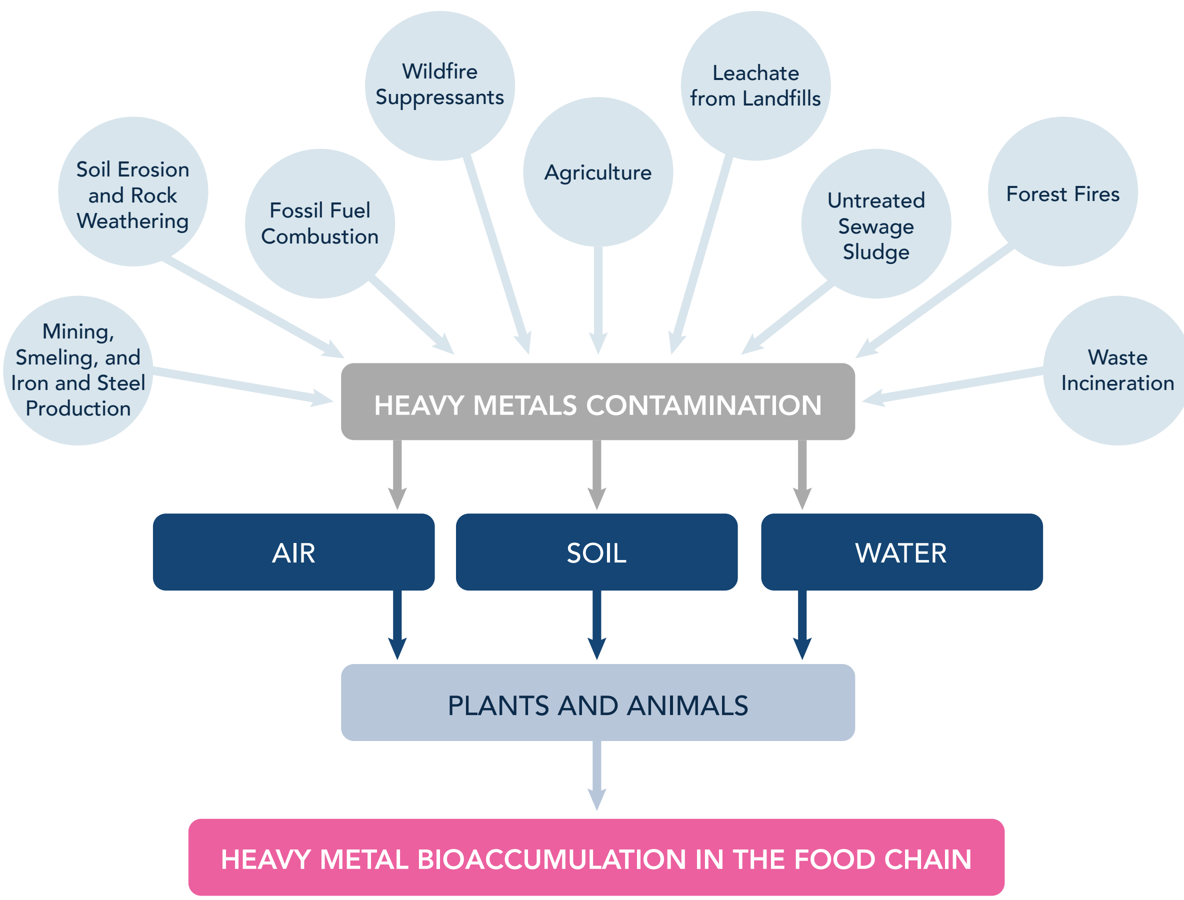
"Heavy metals" is a broad, controversial, and potentially misleading term. The International Union of Pure and Applied Chemistry notes that no authoritative definition exists; that oftentimes the term "heavy metals" is used in regulations and legislation without specifying what it covers; and that the range of metals it refers to depends on the definition used.

Although definitions can vary widely, "heavy metals" commonly refers to metals with relatively high densities and atomic number or weight, and with notable toxicity. "Heavy metals" may also refer to metalloids, such as arsenic, that are able to induce toxicity at low levels of exposure.

Also, although the term "heavy metals" is often used to specifically refer to "toxic metals" (rather than ones that are necessary for biological functions, if only in trace quantities), it is worth remembering that all metals are toxic to humans and the environment in excess.

TRANSBOUNDARY TRANSPORT AND BIOACCUMULATION

The effects of metal pollutants can be felt far away from their source because they can enter the air and water currents that circle the globe. The dynamic nature of our atmosphere, hydrosphere, and other geochemical cycles means that pollutants can travel far from their original source and can also disperse or concentrate in unpredictable ways – a phenomenon referred to as **transboundary transport**. Metal particles can travel considerable distances from their source, depositing on soil, surface waters, and plants through rain and snow. Metals can also penetrate soils and contaminate groundwater.



Unlike organic compounds, metals do not biodegrade and cannot decompose, and so their impacts may be felt for a long time. Metals accumulate in the environment and, in a process called **bioaccumulation**, within the organisms that live there. For example, bacteria in aquatic environments convert inorganic mercury into methylmercury, which is then absorbed by algae and other organisms at the base of the food chain. This reduces nutrition, damages their health, and reduces their metabolism, which impacts their ability to feed, grow, and reproduce. These substances bioaccumulate and are passed along the food chain, increasing the concentration of harmful chemicals in the tissue of higher-order organisms.

POINT AND NON-POINT SOURCES

Metals enter the environment – such as surface waters – from both **point** and **non-point** sources resulting from a wide range of human land use practices. A point source is a direct input from a discrete source, such as contaminated effluent being directly discharged from a factory or sewage plant into surface water. Non-point source pollution comes from a diffuse area, making it harder to pinpoint a specific source. Non-point sources include atmospheric emissions and land uses that contaminate water, land, and soil, such as runoff from urban and suburban areas. Additionally, naturally metals-enriched regions (or regions with legacy contamination) can become non-point sources when human activities change the land and expose rock and soil to erosion.

CHEMICALS OF MAJOR PUBLIC HEALTH CONCERN

Although all metals are toxic in excess, some are considerably more dangerous than others. Lead, arsenic, cadmium, and mercury are considered by the WHO as being among the top ten chemicals of major public health concern.

Lead is a naturally occurring bluish-gray metal present in small amounts in the earth's crust. Although it occurs naturally in the environment, human activities such as the burning of fossil fuels, mining, and manufacturing can contribute to the release of high concentrations of lead.

Lead is primarily used in the production of lead-acid batteries, and can be found in alloys, pigments (both in paints and cosmetics), munitions, fishing equipment, and in devices to shield from x-rays. Exposure mainly occurs from inhaling or consuming lead-contaminated dust particles and aerosols (such as from deteriorating household paints); ingestion of lead-contaminated food and water; lead in the workplace; lead use in hobbies, traditional medicines, and cosmetics; and through dermal contact. Although industrial use of lead has significantly declined since the 1970s (especially in relation to decreasing or eliminating lead in paints, ceramic products, caulking, plumbing systems, solder, and gasoline), communities continue to face health consequences related to a legacy of lead-contaminated paint (and therefore homes), dust, and soil.

Lead is the most systemic toxicant and affects many organs in the body. No safe level of lead exposure has been established. Lead is distributed to the brain, liver, and kidneys, and it is stored in the teeth and bones, where it can accumulate over time. Once taken into the body, lead can cause permanent damage to the neurological and cardiovascular systems. Acute exposure to lead can result in irreversible damage to the brain and kidneys and cause gastrointestinal disease, and chronic exposure can cause adverse effects on the hematopoietic system, central nervous system, endocrine system, and reproductive system, among others. The International Agency for Research on Cancer (IARC) also considers lead to be a probable human carcinogen; lead exposure is known to induce gene mutations.

Young children are particularly vulnerable to the toxic effects of lead, which can have neurodevelopmental effects even at low levels of exposure. This can lead to permanent intellectual disabilities, behavioural disorders, increased antisocial behaviour, and reduced educational attainment, and at higher levels can damage children's brain and central nervous system, causing coma, convulsions and even death. Exposure to lead is also of special concern for women, particularly during pregnancy; lead absorbed by pregnant mothers is readily transferred to a developing fetus.

Arsenic is found naturally in the environment in organic compounds, which are generally formed by bacteria in a process called methylation. Elemental arsenic, however, is a grey, brittle metal that is rarely found in nature. Natural erosion, volcanoes, and mining activities are the primary sources of arsenic in the environment.

Arsenic is used industrially as an alloying agent, as well as in the production of glass, pigments, textiles, paper, metal adhesives, batteries, electronics, and ammunition. Historically, arsenic was used as a fungicide, insecticide, and feed additive, as well as for pressure-treating wood and in pharmaceuticals, but these uses have been largely discontinued.

Arsenic may be inhaled, ingested, or absorbed through the skin. Contaminated food and water used for drinking, food preparation, and food crop irrigation present the greatest threat to public health from arsenic, but humans can also be exposed to contaminated air and soil and in relation to industrial activities.

Inorganic arsenic is highly toxic and a confirmed carcinogen, and is the most significant chemical contaminant in drinking-water globally. Acute arsenic poisoning can be fatal, and long-term exposure can cause bladder, lung, and skin cancer, as well as other skin diseases. Arsenic has also been associated with pulmonary disease, cardiovascular disease, and diabetes, and in utero and early childhood exposure has been linked to adverse impacts on cognitive development and increased mortality of both infants and young adults.

Mercury is a shiny, silver-white, naturally-occurring element that is found in soil, air, and water. It is the only metal that is liquid at room temperature, and is unique in that it exists or is found in nature in three forms: elemental, inorganic, and organic. Mercury may be released into the environment by natural weathering of rocks, forest fires, evaporation from soils and surface waters, and volcanic activity. However, human activities are the primary source of mercury pollution, including pollution from mining, refining gold and silver ores, waste disposal and incineration, smelting of mercury-containing ore, the operation of coal-fired plants, and numerous industrial processes, such as the production of caustic soda and chlorine.

The industrial demand for mercury peaked in 1964 and began to sharply decline after 1980 when the US imposed federal bans on mercury additives in paints, pesticides, and fungicides, as well as the reduction of its use in batteries. Nevertheless, it is still commonly used in thermometers, barometers, batteries, electrical switches, fluorescent bulbs, pharmaceuticals, skin-lightening products and cosmetics, and dental amalgams.

Humans are also exposed to forms of mercury through food contamination, such as methyl mercury from fish and shellfish consumption. Additionally, mercury is unique among metals in that it can evaporate from surface water and soil. Once in the atmosphere, mercury can travel to another location where it condenses in rain or snow. When conditions warm, mercury can once again evaporate. This repeating cycle of evaporation, transportation, and condensation is called the "grasshopper effect," and it allows mercury to transport over long distances.

Mercury is a pervasive environmental neurotoxicant with a wide range of adverse health effects, including permanent nervous system and kidney damage; toxic effects on the lungs, skin, eyes, and the digestive and immune systems; and complications in the development of children in utero and early in life, with an elevated risk for miscarriages, spontaneous abortions, stillbirths, and low birth weights.

Cadmium is a bluish-white metal that is naturally found in the Earth's crust and oceans. Although volcanic activity and rock weathering can release cadmium into the environment, anthropogenic activities contribute substantially to current cadmium emissions. The primary causes of cadmium pollution include fossil fuel and coal combustion; industrial activities such as mining and smelting; phosphorous fertilisers and sewage sludge; and sources related to the production, use, disposal, and recycling of cadmium and cadmium-containing products.

Cadmium is mainly used in the production of batteries; alloys; coatings and plating; pigments in plastics; glasses; ceramics and paints; solar cells; and PVC stabilisers, among other products and materials.

The most common sources of exposure include contaminated foods, cigarette smoke, and work environments (particularly from welding and soldering). Environmental contamination and the continued use of cadmium in industrial applications has led to a dramatic increase in human exposure to cadmium over the past century, as cadmium accumulates in the soil and food chain, affecting crops, animals, and humans.

Cadmium is non-nutritive and extremely toxic to humans and the environment, even at very low exposure levels. It is a carcinogen by inhalation, a severe pulmonary and gastrointestinal irritant, and can be fatal if inhaled or ingested. Chronic exposure also risks kidney, bone, and lung disease.

Other toxic metals and **(heavy) metals of concern** include chromium (particularly hexavalent chromium, an extremely toxic and carcinogenic compound), nickel, antimony, selenium, cobalt, silver, gold, and manganese, among others. Although some of these are essential nutrients and required in trace amounts for proper biological functions, such as copper, tin, and zinc, they can be toxic at higher concentrations. Others, such as beryllium, barium, and thallium, play no known role in any biological functions, and even limited exposure can have adverse health effects. Some of these metals may also bioaccumulate.

3 KEY PLAYERS

A wide range of organisations play a role in measuring and managing metal pollutants in air and water.

The World Health Organisation (WHO) publishes evidence and guidance on health outcomes associated with exposure to metal pollution and – more broadly – monitoring and reporting on global trends and changes in pollutants in air and water at the national, regional, and global levels. The WHO provides fact sheets on toxic metals; guidance on health-based limits for occupational exposure; practical guidelines on chemical hazards in water and air – such as arsenic, mercury, and lead – that are used as the basis for regulation and standard setting world-wide; and more.

The UN Environment Programme (UNEP) has launched several initiatives to address metal pollution, including the Minamata Convention on Mercury and the Global Alliance to Eliminate Lead Paint, and promotes global action on air and water pollution and health. They publish resources on sustainable practices for managing materials that release metals into the environment, such as e-waste, and provide data on the status of pollutants globally. They provide guidance on air quality standards, such as their guide on Ambient Air Quality Legislation, as well as data, monitoring, stakeholder engagement, and other forms of guidance and support for water quality management initiatives.

The Clean Air Fund is a global philanthropic organisation working with governments, funders, businesses, and campaigners. They provide grants to NGOs, charities, research organisations, and campaigners; run programmes and projects to tackle air pollution on a global scale, including lead and mercury particulate; and work with partners to generate accessible and actionable data.

The Alliance for Water Stewardship (AWS) is a global membership collaboration that contributes to the sustainability of water resources through the adoption of a universal framework for the sustainable use of water – the International Water Stewardship Standard. The framework helps water users to understand their impacts on water, including water quality impacts from pollutants, and offers guidance to achieve good water stewardship practices.

The Science Based Targets Network (SBTN) provides Nature Hubs that offer guidance on setting science-based targets for land and fresh and marine water. SBTN has also published detailed methodologies for companies to assess and prioritise impacts on freshwater quality and quantity.

4 COMMITTING TO TAKE ACTION – MID- AND LONG-TERM GOALS

Committing to take action on **Metals** can include addressing many of the key topics listed above. The mid- and long-term commitments that your organisation elects to make should be based on your identified priorities, areas of greatest impact, and your capacity to undertake the work required. It is important to note that this section does not provide all possible mid- and long-term goals related to this issue, but rather a sample of the goals that were most frequently adopted by companies in our research.

Common mid- and long-term goals and/or commitments on **Metals** include variations of the following:

Long-term goal: Eliminate the use of metals in our products

- 100% of toxic metals and metalloids present in our products and production processes will be phased out by 20[XX]
- Restrict and replace metals of high concern with verified non-toxic substances by 20[XX]

Long-term goal: Zero impact on air and water quality from our operations by 20[XX]

- 100% of industrial emissions are safely abated or captured by 20[XX]
- Achieve zero discharge of untreated wastewater by 20[XX]
- Implement screening for impurities and fugitive pollutant emissions at all facilities by 20[XX]
- Support the responsible development of local air quality assessment and wastewater collection and treatment systems

Long-term goal: Continuously reduce our impact on the environment along our entire value chain

- Achieve 100% safe, screened chemistry at all strategic value chain facilities
- Require key suppliers to engage with vendors and implement appropriate safe chemistry standards and practices

Are you setting new goals or interested in benchmarking your goals against leading practice? To help advance progress in credible corporate sustainability goals, the Embedding Project maintains a public goals database containing leading sustainability goals and commitments set by large companies globally. Explore our Sustainability Goals Database for more mid- and long-term goals on ***Pollutants****.*

5 HOW TO GET THERE – PROCESS-BASED INTERIM TARGETS

Note. The following proposed timelines are only for guidance and are based on the pace outlined by other companies. The timeframe for actions and work for each step needs to be embedded in your organisational context, which may require different time allocations.

The sequence outlined below assumes that your company has significant impacts on **Metals** within its direct operations and that you will begin to engage with your value chain after learning and taking action to get your own house in order. Companies with greater impacts within their value chain may (and likely should) opt to engage with value chain partners at a much earlier stage.

YEAR 1: UNDERSTAND ISSUES RELATED TO METAL POLLUTION

Understand the safe thresholds (if any) for the pollutants that derive from your operations and your value chain and clarify the legal requirements for compliance in the regions where you operate. Ideally, much of this work will have already been completed as a part of your organisation's regulatory compliance processes.

If you operate in regions or areas where regulations are lacking, aim to understand what action would be necessary to preserve and enhance the health and wellness of key social and environmental systems.

Explore how your industry, your operations, and your value chain may impact air and water quality. There are many different types of metal pollutants – if you are unsure of where to begin, you may want to start by building your understanding of metal contaminants of particular public health concern, with a special emphasis on lead, arsenic, mercury, and cadmium. Identify (and consider prioritising) these metal pollutants, and further your understanding of air and water quality factors as they become relevant to your operational context, such as transboundary transport and bioaccumulation.

It is worth noting that much of the work related to water quality will occur concurrently within a broader water quality strategy – further guidance on key approaches to addressing pollutants in water can be found in Water Quality: A Getting Started Guide.

YEAR 1: GATHER DATA AND ESTABLISH BASELINES

Review your current polices and processes regarding chemicals management and pollution control. Aim to understand your current systems, narrative, and the culture that exists around managing chemicals to minimise the risk of harm to workers, communities, and the environment.

Determine current metal pollution levels using existing air quality data from public sources and by gathering data on air and water quality at your work sites, including both potential point sources (such as stack emissions, wastewater discharge, or waste disposal) and non-point sources (such as chemical runoff and seepage) of metals.

This process may require measuring a range of indicators for air and water quality linked to your operations to understand where you currently stand at a site-level. For each industry and company, the indicators measured will vary based on their operational impacts. Leverage your learnings related to relevant air and water quality issues to understand what parameters you should measure to establish a baseline and support effective future decision-making. Depending on the scope and scale of contaminants and their sources, your company may need to develop and implement a comprehensive process of continuous (and mobile) monitoring, using a combination of air quality sensors, real-time air and/or water pollution maps and exposure calculators, and data processing and modelling tools. You will also want to assess for potential gaps in monitoring.

For organisations whose products may release metals into the air or water in later parts of their lifecycle, such as electronics, it is crucial to understand and quantify the impacts of these products at the point that they may enter environmental systems. Proper waste management may be outside of your company's direct control once these products are purchased by customers. It is therefore crucial that you identify, estimate, and document how these contaminants may impact the environment to better understand and focus your efforts where they are the most relevant.

Examples of process-based targets for Year 1:

- By 20[XX], we will understand local and international regulations, standards, legislation, and associated commitments related to metal pollution in air and water
- By 20[XX], we will understand potential air and water quality issues associated with our industry, our operations, and our value chain, including the primary source(s) of metal pollutantion.
- By 20[XX], we will gather data to assess air and water quality impacts from our sites and operations.
- By 20[XX], we will gather data on the state of air and water quality in the regions where we operate.
- By 20[XX], we will establish air and water quality baselines and trends.

YEAR 2: UNDERSTAND THE RISKS OF METAL POLLUTION

Metal pollution has significant implications for businesses. Public awareness of environmental issues and expectations for action are growing, and companies are under increasing scrutiny. Organisations face stricter environmental laws and risk disclosure requirements, with non-compliance increasingly likely to result in legal action, fines, and damage to reputation. They also face physical risks, such as impacts on employee health and climate change-related impacts that may be exacerbated by metal pollution, such as reduced plant and forest health. Your company needs to understand these pollution-related risks and the knock-on effects they can have on other issues.

YEAR 2: IDENTIFY BEST PRACTICE AND AREAS OF IMPROVEMENT

Identify industry, regional, and/or catchment-specific guidance on best practices to reduce impacts on air and water quality in your operations. While this will look different for each industry, region, and catchment context, it can include aspects such as implementing clean technologies that reduce stack emissions, improving or redesigning operational processes to improve waste and wastewater management, shifting to clean modes of power generation and cleaner heavy-duty diesel vehicles and low-emissions vehicles and fuels.

CASE STUDY:

Companies across the industrial spectrum continue to experience the consequences of failing to adequately assess and prevent heavy metals contamination in their products or the release of metal pollution from their activities. Over twenty lawsuits alleging heavy metal contamination have recently been consolidated into a national, multi-state lawsuit against major retailers and baby-food manufacturers, including Walmart, Gerber, Beech-Nut, and Campbell Soup Co., and Amazon is facing a lawsuit over the sale of rice contaminated with arsenic and other metals. Procter & Gamble is facing a class action lawsuit over lead in tampons. Mining companies routinely face lawsuits and public backlash over heavy metal contamination, such as Teck paying millions of dollars in fine over selenium contamination in Canadian and American waterways; Imperial Metals facing charges over the failure of the Mount Polley tailings pond dam, which led to one of the worst pollution disasters in Canadian history; and Vale facing a lawsuit over heavy metals contamination affecting Xikrin Indigenous Peoples in Brazil.

Examples of process-based targets for Year 2:

- By 20[XX], we will establish a measurement process to better understand and track our impacts on air and water quality from our direct operations and quantify baselines.
- By 20[XX], we will have undertaken air and water quality baselines in all of our direct operations.
- By 20[XX], we will understand air and water quality-related risks in our operations.
- By 20[XX], we will identify relevant best practice for ensuring air and water quality.
- By 20[XX], we will identify air and water quality-related risks related to the design and manufacturing of our products.
- By 20[XX], we will identify air and water quality-related risks related to the use and end of life of our products.

YEAR 3: SET TARGETS

Set site-based and/or catchment-specific targets that will align your organisation with the levels of air and water quality needed to ensure resilience and wellbeing – these should aim to bring your activities in line with national or local thresholds and goals for the region or catchment. At a minimum, these targets should be informed by WHO standards and align with WHO air and water quality guidelines. Your targets should also be guided by the precautionary principle, meaning that where there is a risk of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

While there may be several actors influencing air and water quality in the regions where you operate, leverage the social, economic, and technical information that you have to determine your 'fair share' of the effort. For example, WWF provides guidance on setting science-based water targets, and the Science Based Targets Network's (SBTN) freshwater science-based targets explore goal-setting for freshwater pollution.

YEAR 3: DEVELOP AN ACTION PLAN

Target your efforts on processes and sites that have the greatest impact on air and water quality and prioritise improvements that are the easiest to implement to jumpstart the process. Train employees on assessing impacts to air and water quality and engage them within the planning process to support the uptake of your action plan at the site level. Establish processes and methodology to effectively track and analyse impacts on air and water quality to evaluate your progress.

CASE STUDY:

Apple reduces e-waste by fostering material recovery from end-of-life products and in-process scrap. This also includes free recycling of waste electronics from consumers. This helps to reduce the need to mine new materials and prevents metals from being landfilled or otherwise disposed of in ways that threaten the release of pollutants into the environment.

Examples of process-based targets for Year 3:

- By 20[XX], we will determine progressive targets at appropriate levels (e.g. site-level or catchment-based) for air and water quality impact, such as quantity of metal pollutants discharged from operations (PPM), or [X]% of industrial wastewater reused.
- By 20[XX], we will develop an action plan to reduce our impacts on air and water quality.
- By 20[XX], we will understand and either develop or adopt physical, biological, or chemical remediation methods for reducing the concentration of metals in the environment from our activities.

YEAR 4: EXTEND YOUR LEARNINGS TO YOUR VALUE CHAIN

For many companies, the greatest impacts on air and water quality from metal contamination reside within their value chain. Leverage your learnings from your efforts in your operations to reduce air and water quality impacts throughout your value chain. Share your air and water quality targets and insights with suppliers to encourage a greater understanding of impacts, the risks they pose to the business, society, and nature, and the importance of action. Prioritise engagement with suppliers that have the greatest impacts and aim to co-develop solutions such as wastewater recycling or rethinking of materials and/or processes used to minimise adverse impacts on air and water quality.

YEAR 4: SUPPORT SYSTEM-WIDE CHANGES

Explore where your organisation has a broader role to play in improving air and water quality in the areas where you operate, and especially in areas with vulnerable people. Identify industry and/or local initiatives where your organisation's participation and contributions may help to foster greater impact. Much of the work related to reducing and eliminating pollutants is underpinned by the availability of robust and accurate data. Exploring whether and how your company can support improved data collection and monitoring can also be an important pathway towards broader industry and system-wide changes.

CASE STUDY:

The International Council of Mining and Metals (ICMM) participates in government-led partnerships to transfer low- to no-mercury technologies into the artisanal and small-scale mining sector to reduce impacts to human health.

Examples of process-based targets for Year 4:

- By 20[XX], we will work with our suppliers to support the uptake of practices that reduce metal pollution across our value chain, including enhanced waste management practices.
- By 20[XX], we will identify industry, local, and/or international collaboration opportunities to support systemic change towards reducing and eliminating metals in air and water.

RESOURCES

GUIDANCE

UNDERSTANDING POLLUTANTS IN AIR AND WATER

The WHO Global Air Quality Guidelines provide guidance on thresholds and limits for key air pollutants that pose health risks. These guidelines are developed through a transparent, evidence-based decision-making process, and provide interim targets to promote a gradual shift from high to lower concentrations of pollutants. The AQG also explains good practices for the management of certain types of particulate matter.

The new Global Framework on Chemicals provides a vision for a planet free of harm from chemicals and waste. Based around 28 targets, the framework outlines a roadmap for countries and stakeholders to collaboratively address the lifecycle of chemicals, including products and waste. It features a range of actions to ensure that a broad cross-section of stakeholders from governments, industry, international technical agencies, and civil society can support positive change on key topics, such as phasing out the most harmful chemicals, advancing circularity, and strengthening capacity-building, particularly in countries with insufficient enforcement regimes.

The Stockholm Convention on Persistent Organic Pollutants is a multilateral environmental agreement to protect human health and the environment from such harmful chemicals. This site is your one-stop shop for learning more about POPs, such as mercury. It provides essential information on initial and newly identified POPs; reports and decisions from the Convention; and brochures, leaflets, fact sheets, guidance manuals, and other publications.

TAKING ACTION ON POLLUTANTS IN AIR AND WATER

The Practical Guide to Chemical Management Due Diligence in Supply Chains was created by the Responsible Business Alliance to provide you with a standardised, due diligence process template for managing chemical risks. It reflects RBA member companies' experiences and learnings and seeks to promote a collective understanding among businesses, governments, non-governmental organisations (NGOs), workers' organisations, employers' organisations, the public, and other stakeholders on best practices for responsible chemical management conduct to safeguard workers' health and the environment.

These Factsheets on Water Quality Parameters from the Environmental Protection Agency (EPA) can help you to become familiar with common parameters for monitoring water quality. The fact sheets explore aspects of water quality such as temperature, dissolved oxygen, pH, turbidity, nutrients, macroinvertebrates, e. coli, metals, and habitat conditions. Each factsheet examines key questions related to why and how measurements are made for the parameter in question, what can affect the parameter (positively or negatively), and the challenges of using the parameter.

The Alliance for Water Stewardship (AWS) Standard can help you to understand your water impacts and to work collaboratively and transparently for sustainable water management within a catchment context. The standard has five steps: 1) gather and understand, 2) commit and plan, 3) implement, 4) evaluate, and 5) communicate and disclose.

This Business guidance on the assessment of wastewater-related impacts from WBCSD can help your company to better understand and manage the impacts of untreated and partially treated wastewater. It provides a standardised, 5-step process for measuring, valuing, and managing the impacts of wastewater generated by your operating sites or those of suppliers.

TOOLS

Developed through a collaboration of the Stockholm Environment Institute, Climate and Clean Air Coalition, and the Inter IKEA Group, this Practical Guide for Business Air Pollution Emission Assessment has been created to help companies quantify air pollutant emissions across their value chain. The assessment enables businesses to create a global overview of their impact on pollution and to establish a baseline for setting credible targets.

The WHO's Air Pollution Data Portal can help you to quickly access data and databases, factsheets, interactive tools, and key publications on ambient and household air pollution.

The Global Environment Monitoring System for Freshwater (GEMStat) provides water quality data from around the world on a wide range of parameters, including metals contamination.

The Wastewater Impact Assessment Tool from WBCSD aims to provide a site-level assessment of the pressures resulting from the industrial activities, allowing users to visualise the impacts of wastewater.

Explore more curated resources on Metals on our website.

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