Mitigating Methane from the Waste Sector

a Global Health Strategy

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THE GLOBAL CLIMATE & HEALTH ALLIANCE

About GCHA

The Global Climate and Health Alliance (GCHA) is the leading global convenor of health professional and health civil society organizations addressing climate change. We are a consortium of health and development organizations from around the world united by a shared vision of an equitable, sustainable future, in which the health impacts of climate change are minimized, and the health benefits of climate solutions are maximized. GCHA works to elevate the influential voice of the health community in policymaking to address the climate crisis.

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All interviewees were informed of the purpose of the interview and how the information from the interview would be used. Oral consent was given and no interviewees received compensation for their engagement with the research.

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https://climateandhealthalliance.org/initiatives/methane-health/

1 Introduction

Many of our daily activities and societal needs produce waste, which must be safely and efficiently managed to protect our health, environment, and our climate. Waste should be a resource to be reused, recycled, and recovered for continued use for human needs. Despite the clear benefits of improved waste management for human health and for the environment, increasing population growth, rapid urbanization, increasing population density, and limited funding for waste management and wastewater treatment infrastructure and operations all contribute to current challenges facing the waste sector. The waste sector contributes 3 percent of total global greenhouse gas (GHG) emissions[1].

In addition to degrading the environment and contributing to negative health outcomes from a lack of proper sanitation and waste management, the waste sector, including wastewater and municipal solid waste, contribute one fifth of global anthropogenic methane emissions. Methane is a powerful GHG that is accelerating global warming and worsening air quality by contributing to the formation of ground-level ozone, a toxic air pollutant. Co-pollutants and additional health impacts are often associated with waste management activities, including landfill slides, plastic pollution, and landfill fires [see **Overview Report** for how methane impacts human health]. Recognizing the importance of a rapid and deep reduction in methane emissions as a key component of limiting global warming, 150 countries have now signed the Global Methane Pledge, launched in 2021. Signatories to the Pledge have committed to collectively reduce methane emissions by 30 percent by 2030 relative to 2020 levels[2].

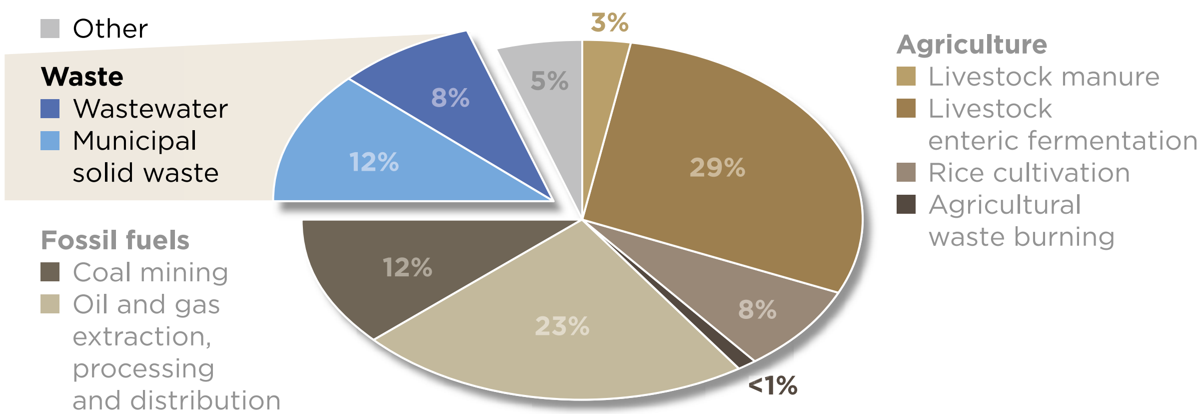
This report examines the sources of methane emissions from waste and wastewater, the associated human health benefits of methane reduction solutions, and examines solutions to reduce methane at the international, national, and local levels. This report is part of the Global Climate and Health Alliance's *Mitigating Methane, A Global Health Strategy* report series, which aims to bridge the knowledge gap on the intersection of methane and human health.

2 Methane Sources from the Waste Sector

Municipal Solid Waste

Municipal solid waste contributes to roughly 12 percent of global anthropogenic methane emissions (see **Figure 1**)[3]. Methane emissions from municipal solid waste come from the decomposition of organic waste, such as food waste and yard waste, in anaerobic (low-oxygen or oxygen-free) environments. The amount of methane produced depends on the organic content present in waste, the amount of moisture in the waste, and the oxygen levels.

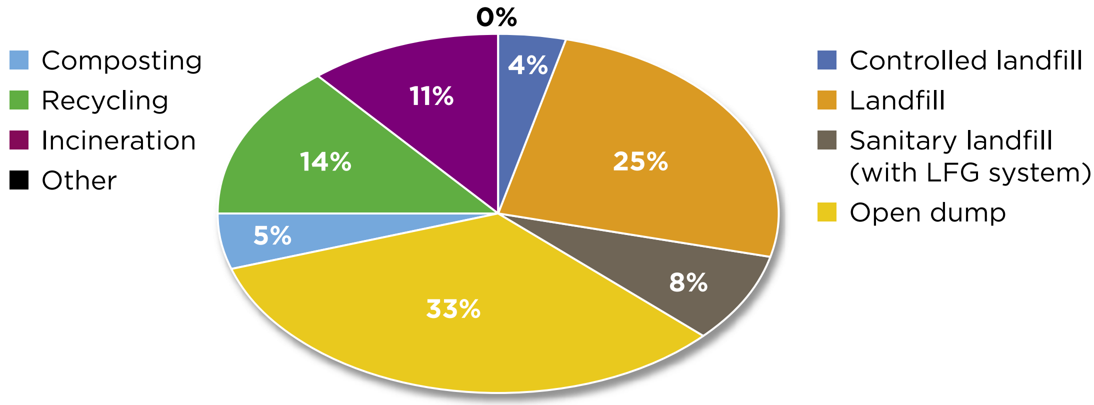
Figure 1: Anthropogenic Methane Emissions from the Waste Sector



Source: United Nations Environment Programme and Climate and Clean Air Coalition (2021). Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions. Nairobi: United Nations Environment Programme

Methane can be emitted at any stage of the solid waste management process, from waste collection, treatment, to final disposal at landfills. First, infrequent waste collection can increase the risks of waste disposal at open dumpsites, resulting in methane emissions. Globally, the open dumping of waste is the most common waste disposal method, especially among low-income countries with inadequate waste collection services (see Figure 2)[4]. Second, while treating organic waste, including composting and anaerobic digestion (AD) facilities that convert organic waste into useful energy, can reduce methane emissions, methane leakages can occur at treatment facilities that are not regularly and adequately maintained. Furthermore, facilities with inadequate capacity to handle large organic waste volumes may store decomposing organic waste in open air, resulting in the direct release of methane into the atmosphere. Finally, organic waste disposal and decomposition at improperly managed landfills and dumpsites produces and releases landfill gas, which consists of methane.

Figure 2: Global Solid Waste Management Approaches



Source: Kaza et al. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.

Improving overall solid waste management can not only cut methane, but also other air, water, and soil contaminants detrimental for human health and the environment. For example, improving overall waste collection frequency by optimizing collection routes and deploying cleaner and more efficient collection vehicles not only reduces methane by preventing open dumping, but also reduces carbon dioxide and black carbon emissions from diesel-fueled collection vehicles. Installing landfill gas collection systems at landfills not only reduces and captures methane, but also decreases the risks of methane-ignited landfill fires, which result in black carbon, carbon dioxide, and particulate matter emissions. Implementing other landfill management measures, such as daily cover, compaction, and liners, can prevent leachate — liquid that drains or "leaches" from landfills — from entering groundwater and soil.

Wastewater

Wastewater contributes to approximately 8 percent of global anthropogenic methane emissions[5]. Methane emissions from wastewater come from the decomposition of human waste and other organic waste under anaerobic conditions in wastewater storage or sewage systems. In areas that lack sanitary sewage systems and household plumbing, pit latrines and open defecation can produce methane and contribute to increased rates of infection, disease, and pathogen transfer.

Most high-income countries rely on centralized aerobic (oxygenated) wastewater treatment systems to treat wastewater. While these systems produce smaller amounts of methane emissions, they produce large volumes of biosolids — nutrient-rich organic materials — which can emit high amounts of methane. Low-income countries either have no wastewater collection and treatment systems, or high methane-emitting anaerobic treatment systems such as lagoons, septic systems, and pit latrines.[6]

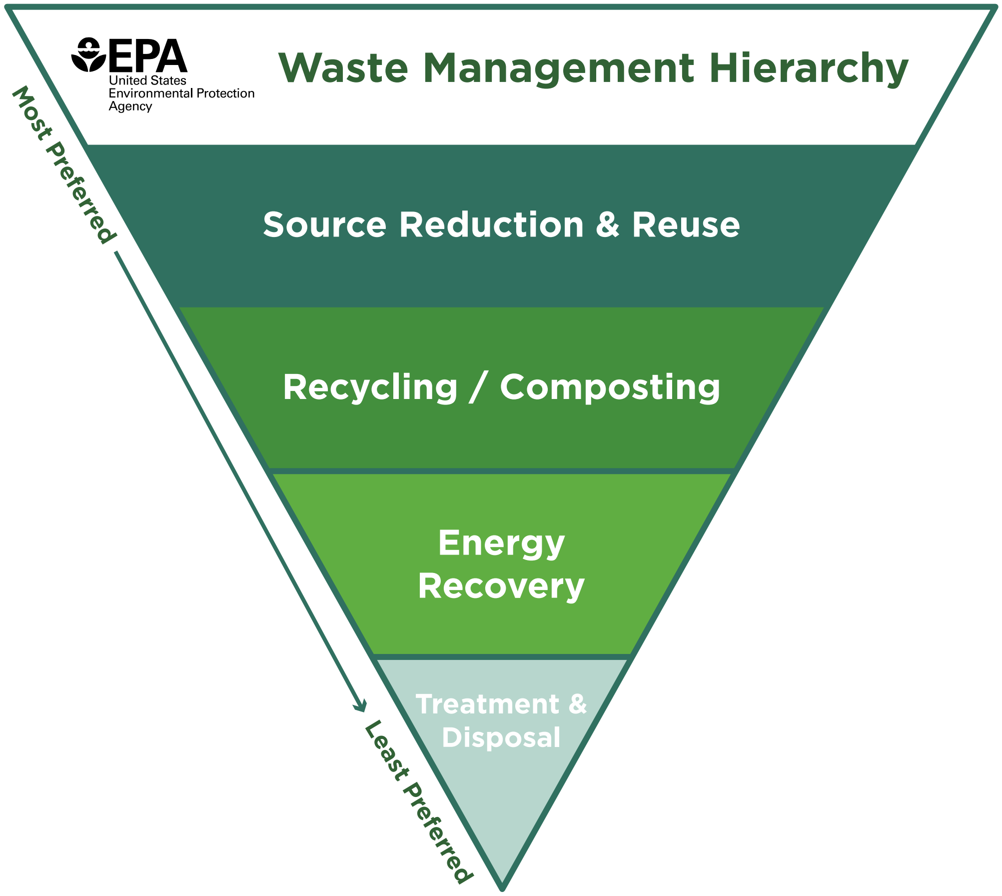
3 Methane and Health: Waste Sector

“There isn’t a great deal of attention to the fact that [much] of the population of the globe doesn’t have sewer access…and on-site sanitation is actually an extremely important form of sanitation management, especially in the Global South. [Human] waste is managed via poorly controlled underground disposal and pit latrines where the anaerobic decomposition of the waste will produce large amounts of methane. From a global equity perspective, these are not the countries that are significant contributors to climate change and they should not be responsible for addressing the problem through innovations in their own sanitation sector.” –Matthew Reid, Cornell Engineering, Interview

Targeted technical solutions for reducing or capturing methane generated by the anaerobic decomposition of organic waste at landfills, open dumpsites, wastewater storage, and sewage systems can reduce the formation of tropospheric ozone, a harmful air pollutant. Tropospheric ozone leads to adverse health outcomes, such as cardiovascular diseases, asthma, respiratory illness, and premature death. Roughly 1 million people die prematurely every year because of exposure to tropospheric ozone[7] [see the Overview Report for more information on how methane impacts health]. According to the Global Methane Assessment, implementing solutions to reduce waste methane could avoid 45,000 deaths from ozone, 135,000 emergency room visits for asthma symptoms, avoid 5 metric tonnes of crop losses, and avoid 13 billion hours work hours per year[8].

Transformational changes to improve solid waste and wastewater management and sanitation would not only mitigate methane, but also avoid the health impacts associated with improperly managed waste. Creating systems in alignment with the waste hierarchy[9] (Figure 4), where waste is minimized and where waste that cannot be minimized is used as a resource, is an effective way to improve solid waste management around the world[10]. Avoiding and reducing waste at the source is the most preferred step in the hierarchy because it prevents both methane emissions and other GHGs from improperly managed waste, and reduces raw material extraction, transport, and processing.

Figure 3: Waste Management Hierarchy



Source: U.S Environmental Protection Agency (n.d.) Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries.

Human Health Benefits of Improved Solid Waste Management Systems

Improving solid waste management reduces methane emissions and provides tremendous co-benefits for health, especially for marginalized and vulnerable populations that reside close to waste treatment or disposal sites, or work in the waste sector. The health benefits include:

- Avoid physical injuries, avoid respiratory infections, heart disease, stroke, and lung cancer associated with air pollution[11], such as the toxic smoke created from waste burning and landfill fires, which contain black carbon, carbon dioxide, and particulate matter, improved lung health and quality of life, especially for vulnerable and marginalized populations and communities living near sites. Improved waste management would help reduce the 7 million premature deaths attributed to air pollution globally[12].

- Avoid odor exposure, infection and disease from insects, rodents, and scavenging animals, and reduced pollution pathways in surface and groundwater caused by open dumping and unsanitary landfills. Diverting organic waste from landfills, and managing landfills with landfill gas collection, daily cover for waste, and liners in place to prevent leachate migration into groundwater can both mitigate methane and improve the overall health and livelihoods of communities surrounding landfill sites.

- Avoid physical injuries from landfills that are not engineered and rehabilitated to be resilient to extreme weather events and sea-level rise caused by climate change. For example, landfills that are not tightly compacted increase the risks of landfill slides and cause injuries and even casualties. In 2017, a garbage landslide in Addis Ababa, Ethiopia killed 116 people and buried dozens of homes surrounding the landfill[13].
- Avoid waterborne and foodborne diseases from the ingestion of water contaminated with leachate.
- Reduce the health impacts from producing and consuming fossil fuels as a source of energy by using biogas created by processing of organic waste through anaerobic digestion or capturing waste from landfills [see the **Energy Sector** report and GCHA's From Cradle to Grave brief].
- Improve nutrition and food security by improving soil quality and availability of soil amendments via composting and anaerobic digestion.

> **"Residents talk about not sitting on their porch [due to landfill odors], which is a normal activity in a rural community ... so there's this restriction on how you can use your property. You know, folks talk about not wanting to invite friends over for cookouts, or not wanting their grandkids to come over because they're concerned they may be exposing them to harmful airborne pollutants or contaminants in the water. If a landfill doesn't have [liners and leachate collection systems] in place, then chemicals and biological agents can enter into the groundwater."** –Dr. Courtney Woods, University of North Carolina at Chapel Hill, Interview

The technical solutions on the following page primarily relate to waste management operators and local and regional governments with the expertise, funding, and mandate to implement suggested changes. Not all solutions will be applicable for every context or setting.

Topic	Solutions	Human Health Co-Benefits of Reducing Methane and Improving Solid Waste Management
Organic waste diversion and treatment	• Aerated composting of organic waste • Anaerobic digestion of organic waste and wastewater sludge/ biosolids • Production of biogas for energy via anaerobic digestion	• Avoid cardiovascular diseases, asthma, respiratory illness, and premature death from exposure to methane-driven tropospheric ozone • Avoid waterborne and foodborne diseases from ingestion of water contaminated with leachate • Improve nutrition and food security by improving soil quality and availability of soil amendments via compost and anaerobic digestion • Avoid the health impacts from producing and consuming fossil fuels as a source of energy
Reduce the amount of methane produced in landfill waste	Reduce methane-producing conditions by: • Reducing the moisture content of waste via daily cover and tarps which prevent rainwater intrusion • Discontinuing or limiting leachate recirculation if relevant to operations • Implement LFG capture systems for flaring or energy production	• Avoid cardiovascular diseases, asthma, respiratory illness, and premature death from exposure to methane-driven tropospheric ozone • Avoid the health impacts from producing and consuming fossil fuels as a source of energy
Dumpsite and landfill improvements	Rehabilitate existing dumpsites and/or create new engineered sanitary landfills that abide by current best practices for reduction in open burning, containment of air and water pollutants, and protection of human and environmental health.	• Avoid physical injuries, respiratory infections, heart disease, stroke, and lung cancer are associated with air pollution, such as the toxic smoke created from waste burning and landfill fires Mitigation of ground and surface water contamination. • Avoid odor exposure, infection and disease from insects, rodents, and scavenging animals, and reduced pollution pathways in surface and groundwater caused by open dumping and unsanitary landfills • Avoid physical injuries from landfills that are not engineered and rehabilitated to be resilient to extreme weather events and sea-level rise caused by climate change

Case Study: Nigeria's Waste Methane Reduction Goals Would Save Lives

Nigeria has a 2018 National Action Plan to Reduce Short-Lived Climate Pollutants that includes a goal to recover 50 percent of methane from landfills by 2030 and reduce 50 percent of methane from open waste burning by 2030.

Nigeria's growing population and increasing urbanization make waste collection and treatment, that are often privatized, an ambitious and expensive task. Megacities such as Lagos are making progress on rehabilitating dumpsites, such as the Cleaner Lagos Initiative's work to turn the Olusosun dumpsite into various waste-to-wealth projects[14], yet much work remains to be done.

Highlighting the economic and energy benefits of LFG systems and biogas production could increase support for policy implementation and offset operational expenditures following initial expenses. The U.S. EPA estimates that typical LFG biogas energy projects can have direct economic impacts of $2.15 - $4.35 million in expenditures and 6-15 jobs created, while indirect impacts can range from $4.8 - $10.9 million in economic output and 20-55 jobs created[15].

The country estimates that full implementation of the 22 priority measures identified in the 2018 Action Plan would result in an 83 percent reduction in black carbon emissions by 2030 compared to a 2010 business-as-usual scenario and reduce national methane emissions by 61 percent. This would also result in an estimated 7,000 fewer premature deaths from air pollution by 2030[16].

Human Health Benefits of Wastewater Treatment and Sanitation Solutions

Wastewater treatment and access to sewage or sanitary collection reduces methane emissions and provides tremendous co-benefits for health, especially to communities currently lacking sanitary wastewater management solutions and infrastructure. Health benefits include:

- Avoid infections and diseases caused by exposure to untreated wastewater that contain pathogens. In 2016, the Centers for Disease Control and Prevention (CDC) estimated that inadequate sanitation and unsafe drinking water contributed to 829,000 global mortalities, representing 60 percent of global diarrheal deaths that year[17]. By 2030, it is projected that the global population without access to sewer connections will increase to 5 billion, primarily in the Global South, and especially in Africa and Asia[18].

- Improve hygiene, reduce rates of diarrhea, and limit the spread of diseases such as cholera, typhoid, hepatitis, Ebola, and polio caused by the improper treatment and separation of waste from water used for drinking, cooking, medical facility use, and other sanitation activities[19].

- Avoid waterborne and foodborne diseases, as well as physical injuries from wastewater infrastructure vulnerable to climate impacts. Engineering and rehabilitating pit latrines, wastewater treatment plants, and other sources of sewage for resilience to climate-related extreme weather events and sea-level rise resulting from climate change can avoid emergency events such as waste contamination of aquifers, drinking wells, reservoirs, and streets and homes resulting from flooding and water intrusion.

- Improve nutrition and crop yield from the recovery of nutrients from safely treated wastewater. This supports populations with increased access to affordable and nutritious diets which otherwise would be limited by the expense of purchasing fertilizer[20]. Other waste treatment solutions, such as a growing medium for insects used as animal feed, also provide co-benefits to health in the form of improved resource recovery for enhanced nutrition and diet.

The table below summarizes the health co-benefits of methane reduction using technical solutions. Not all solutions will be applicable for every context or setting.

Topic	Solutions	Human Health Co-Benefits of Reducing Methane and Improving Wastewater Treatment
Organic Waste Treatment (for centralized or existing systems)	• Install biogas capture systems at existing open air anaerobic wastewater lagoons. • Create new aerobic or covered treatment lagoons. • Upgrade residential and industrial wastewater treatment with two-stage treatment techniques such as AD with biogas recovery followed by aerobic treatment.	• Avoid cardiovascular diseases, asthma, respiratory illness, and premature death from exposure to methane-driven tropospheric ozone • Improve hygiene, reduce rates of diarrhea, and limit the spread of diseases such as cholera, typhoid, hepatitis, Ebola, and polio caused by improperly managed wastewater • Avoid waterborne and foodborne diseases, as well as physical injuries from wastewater infrastructure vulnerable to climate impacts. • Improve nutrition and crop yield from the recovery of nutrients from safely treated wastewater.
Organic Waste Treatment (for rural or new systems)	• Decentralized collection services using transportable sealed latrine containers. • Thermophilic composting of waste (breaking down wastewater through the use of heat-loving bacteria). • Systems to use waste as feedstock for black soldier fly production, which can in turn be used as animal feed.	

Case Study: Potential for Wastewater Emissions Reductions in Indonesia

Indonesia's large population and developing infrastructure make it the largest emitter of wastewater methane globally, and the third largest emitter of methane in the waste biogas sector21. It is estimated that 31 percent of the country's rural population uses pit latrines as a primary source of wastewater treatment[22].

Increasing population growth and urbanization present a challenge to local governments' ability to establish and maintain infrastructure. Current regulations place the onus of wastewater treatment on local authorities, who may lack technical expertise and funding for advanced wastewater treatment plants and landfills[23].

Government funding and training for the creation of modern, centralized wastewater treatment plants would allow for sludge to energy and biogas usage. Centralized facilities would require improvements in sewer infrastructure in many cases, however, which increases costs and timelines.

Improved access to wastewater treatment and sewage would reduce the health burdens of exposure to sewage and contaminated water sources, especially for rural populations without current sewage treatment or access. In addition, the use of anaerobic treatment methods with gas collection systems producing biogas for energy could reduce the greenhouse gas emissions from wastewater by 52–87 percent compared to business as usual24, representing large opportunities for both emissions reduction and alternative energy production.

Case Study: Resource Recovery Potential for Indian Wastewater

India is a leading emitter of methane from wastewater and solid waste and has been active in mandating policies for separation and treatment of organic waste, such as the 2016 Solid Waste Management Rules[25] which require source separation for all waste generators, and the Waste to Energy program, which incentivizes biogas programs.

Progress is being made towards reducing methane emissions from solid waste, but access to wastewater treatment and sewage remains limited for the larger population. All wastewater treatment plants in India combined could handle only 37 percent of the sewage generated by the country, and many of these may require upgrades or repairs[26]. Additionally, the necessary space, funding, and technical requirements for this infrastructure remain a challenge. While improvements are being made, as of 2010 an estimated 50 percent of the country (652 million people) still relied on open defecation as their primary means of waste disposal, giving India the highest per capita rate of open defecation globally[27].

While continuing to operate organic waste separation and biogas programs, local and national agencies should begin incentivizing creation of new and expanded wastewater treatment plants, sewage systems, and biosolid sludge-to-energy biogas programs.

An estimated 54 percent of India faces high to extremely high water deficits[28], making improved wastewater treatment a key strategy for conserving and ensuring safe access to freshwater supplies. Wastewater treatment plants that make use of thermal hydrolysis (a process that prepares waste for efficient AD) and AD treatments may be able to produce biogas for energy use, purified freshwater for agriculture and industry, and digestate for agricultural fertilizer and land amendment, thus not only improving health and reducing emissions, but also providing sources of energy and water.

4 Ways Forward: Methane Mitigation Solutions and Health Benefits

Addressing methane emissions from the municipal solid waste and wastewater sectors through overall system improvements is crucial to combating climate change and addressing existing public health concerns. Luckily, most solutions for methane reduction are feasible and cost-effective and can result in resource conservation benefits, emissions reductions, and improved health outcomes. This creates an opportunity for solutions-oriented conversations with policymakers, calling on them to support waste sector methane mitigation solutions. It will also be important to monitor progress to keep local authorities and facility operators accountable.

International actions focus on increasing global awareness, calling for financing mechanisms for technical solutions, and policy support from multinational organizations. Below are some actions the health community can take to drive the implementation of methane mitigation strategies that improve health and health equity around the world.

- Galvanize existing international action on waste methane mitigation and improved waste management via:
  - Support and advocacy for inclusion of methane and waste sector emissions abatement goals in country nationally determined contributions (NDC) updates under the Paris Agreement.
  - Promote and elevate concerns addressed under the UN Global Plastics Treaty, especially those surrounding plastic waste as a risk to public health by blocking sewers and drainage systems during heavy rainfall events, which can lead to waste contamination of drinking water and bodies of water and adverse health outcomes.
  - Build off of existing international waste treaties, such as the Basel Convention, to integrate health benefits and opportunities into waste management approaches.
  - Improve international and domestic preferential capital flows towards the sector, and establish monitoring, verification and reporting systems to track the progress of such investment flows and measure and report impacts.
- Promote sector-specific solutions:
  - Advocate for funding and technical support to improve and bolster climate resilient infrastructure in the solid waste and wastewater sectors, especially in low- and middle-income countries and high climate-risk regions. Limiting the risk of waste contamination to water sources can aid health systems in decreasing the burden of waterborne disease outbreaks.

- Support implementation of international sanitation and waste protocols for non-hazardous waste, especially protocols aimed at closing and rehabilitating open dumpsites.

"A lot of the [waste sector] work we're doing has direct or indirect health impacts, but we have not really worked with the [health community]. We need to bring them to the table because they are important stakeholders when you're designing these [waste] policies. Nobody is trying to look at what other health impacts this is having [on the city] - an open dump, for example, what are the indirect costs? How does it affect the budget? It also affects the municipality's healthcare costs, right? And that's something which is unfortunately not taken into consideration." –Vishwas Vidyaranya, Ambire Global, Interview

National actions center on informing national environmental and health agencies and decision-makers about the near- and long-term health benefits of national-level methane mitigation actions. The health community can call on these agencies and decision-makers to prioritize the actions discussed below.

- Target key data gaps and prioritize mitigation actions:
  - Address the information gap in methane emissions data at the facility level by promoting awareness of this challenge.
  - Prioritize methane mitigation and improved waste management at waste and wastewater facilities located near population centers.
  - Integrate solid waste management (SWM) and water, sanitation, and hygiene (WASH) health impacts and mitigation measures into Health National Adaptation Plans (HNAPs). If none exists, coordinate the creation of national waste and national wastewater action plans.
- Improve existing solid waste management by:
  - Monitoring disease outbreaks and contamination levels associated with solid waste to identify and address primary waste sites of concern. In addition to proactive monitoring by site operators (managed landfills) and municipal or environmental agency officials (dumpsites), policies which investigate community complaints provide the opportunity to address environmental justice considerations.
  - Implementing organic waste management and food waste diversion solutions to reduce the amount of methane-generating organic waste in landfills and dumpsites.
  - Adopting strong policies and regulations to divert food waste and build awareness among policymakers about the health benefits of food waste reduction policies. (Refer to the Food and Agriculture report for more information).

- Improve existing wastewater management by:
    - Monitoring disease outbreaks and contamination levels associated with wastewater to identify and address primary wastewater sites of concern. Identify source-point wastewater methane sites for remediation and improved infrastructure.
    - Enacting policies that improve access to sanitary sewage and treatment for residential and industrial sources of wastewater.
    - Enacting and enabling policies to limit stormwater runoff and sewage overflows into freshwater and the environment.

> **"Constructing wastewater treatment plants has been the biggest infrastructure deficit in sanitation services in a lot of countries. The health effects of this are very high if you're talking about vectors and diseases that can be spread by just having open sewer networks. But what we have seen is the [open] endpoint discharge is contaminating the soil and water bodies, which is basically coming back into your food systems so that is a big cause of concern for disease, but also polluting food systems...and we're talking about agricultural economies in a lot of these countries."** –Vishwas Vidyaranya, Ambire Global, Interview

> **"We're looking at mechanisms for Executive action to support improvements in environmental justice issues, and so I might advocate for folks in states or other parts of the world where it may be difficult to get laws passed, that Executive action might be one avenue for effective change. I also never will diminish the importance of communities being organized. There's certainly an important role for our local, state, and Federal government, [however] a lot of the change that has happened at those levels is a result of impacted communities organizing to implement accountability measures and demand change."** –Dr. Courtney Woods, University of North Carolina at Chapel Hill, Interview

Local actions at the workplace and community level include immediate actions the health community can take to mitigate methane and co-pollutants from the waste sector and address associated health risks. Some examples may include:

- Increase community and patient engagement around solid waste management and water, sanitation, and hygiene:
    - Communicate to decision-makers and media outlets about the health impacts of improper waste management from landfills, dumpsites, and wastewater sites and the health co-benefits of improving these services.

- Inform patients about the health impacts of improper solid waste management and water, sanitation, and hygiene and methods to reduce or prevent harm from exposure to waste pollution (e.g., solutions to minimize landfill fires).
- Encourage health screening for those living nearby or working in landfills, informal dumpsites, and wastewater treatment facilities and latrine sites.

- Advocate for policies which improve solid waste management and water, sanitation, and hygiene:
  - Build awareness and support for improved sanitary waste and wastewater management and methane mitigation, including consideration of options which use biogas as an alternative energy source.
  - Advocate for climate resilient infrastructure for solid waste management and water, sanitation, and hygiene as a means towards mitigating the risks to the health system in severe weather and precipitation events which may lead to flooding and waste contamination.

Case Study: Funding Waste Emissions Reductions in the Philippines

In the Philippines, municipal solid waste contributes 60 percent of the country's GHG emissions from waste, with the rest from wastewater[29]. In Manila, the capital city of the Philippines, only an estimated 70 percent of the 8,000+ tons of municipal solid waste produced daily is collected[30], while the remaining waste is dumped, burned, or enters waterways and streets.

In 2019, the Philippines released its National Strategy to Reduce Short-Lived Climate Pollutants (SLCPs), which sets goals for 50 percent of landfills to have LFG capture systems and 24 percent of organic waste to be diverted to composting by 2030, relative to 2010 levels[31]. Integrated waste management which makes use of the 3R (reduce, reuse, recycle) strategy is effective at reducing waste generation and disposal when consumer and government support can be achieved.
Local governments often lack funding and technical expertise in solid waste management and methane mitigation[32].The use of GHG reduction credits, such as emission reduction purchase agreement (ERPA) credits created by the Kyoto Protocols' Clean Development Mechanism, provide one source of funding to implement country's National Strategy to Reduce SLCPs.

For example, in 2015, the Land Bank of the Philippines and the World Bank's Carbon Partnership Facility agreed to an ERPA for the purchase of certificates of emissions reductions from livestock farms, which has resulted in 70 pig farms introducing wastewater biogas systems to capture manure methane[33]. As part of the same program, the Montalban and Payatas landfills implemented LFG collection systems which mitigated 498, 793 tons of CO_2 and generate biogas electricity as an alternative to fossil fuels[34]. Elsewhere, the city of Cebu was able to reduce its municipal solid waste generation by 30 percent over three years via integrated solid waste management solutions that incorporate stakeholders and encourage a collaborative approach[35].

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