Assessing the Greenhouse Gas Emissions and Other Impacts of Sewage Management

Summary Report for Policymakers

ERG

Introduction

Sustainable Development Goal 6 seeks to provide access to adequate and equitable sanitation and hygiene for all, with an end to open defecation, by 2030. To achieve this goal, policymakers will consider a range of sewage management approaches. Each of these approaches have trade-offs related to public health and safety, climate change, and other environmental impacts, and policymakers will be faced with balancing these trade-offs when evaluating sewage management options. This report seeks to answer the question: which sewage management options should policy or funding organizations promote?

The United Nations' Sustainable Development Goals (SDGs) seek to achieve "peace and prosperity for people and the planet now and into the future" (UN General Assembly, 2015).

Goal 6: "Ensure availability and sustainable management of water and sanitation for all"

Target 6.2: "by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations."

Purpose of the Report

ERG conducted an assessment unpacking the environmental tradeoffs of different sewage management practices in order to inform sewage management planning and policymaking.

The goals of this analysis are to understand the environmental implications of current sanitation management practices and how future changes in management, energy supply, and population could affect key environmental issues. Sewage management decisions are made at the local or regional level, but the impacts of these decisions can range from local (e.g., eutrophication from nutrient inputs to water bodies or human health impacts from particulate matter) to global (e.g., climate change). Therefore, decisionmakers should consider environmental concerns at multiple scales when evaluating sewage management approaches. This assessment identifies appropriate considerations for decisionmakers, with the aim of positioning local decisions in a global context. This assessment will be particularly useful to local decisionmakers looking to better understand their area's contribution to global greenhouse gas (GHG) emissions and seeking insights on which methods of sewage management may reduce local contributions to global emissions levels.

Key Conclusions

One of the challenges for policymakers considering different sewage management options is compiling available data and considering all environmental and human health impacts of a given solution. Environmental and human health priorities vary from one geographic region to the next, and some impacts or benefits might be more important than others depending on the local context. When comparing the performance of different sewage management options across all metrics, policymakers should aim to move towards safe sanitation (i.e., from open defecation to safely managed) when selecting a sewage management option. Generally, our assessment concluded the following:

- Some of the poorer-performing (e.g., higher GHG emitting and nutrient discharging) sewage management types are latrines, open sewers, and (for certain impact categories) primary wastewater treatment.
- Some of the better-performing (e.g., lower GHG emitting) management archetypes are container-based systems and advanced (secondary and tertiary) wastewater treatment.
- Moving users away from latrines to other systems is generally desirable.
- Moving to primary treatment can be beneficial from a climate change perspective but may increase eutrophication.
- Moving directly to advanced treatment (i.e., bypassing primary treatment) would be beneficial from a eutrophication perspective, but has a slight negative climate consequence compared to primary treatment, and may increase contributions to ocean acidification if a carbon-intensive energy source is used.
- Improvements to wastewater treatment systems, including operational changes to increase nutrient removal while lowering electricity requirements and recovering biogas from sludge digestion to offset electricity needs, could mitigate impacts to ocean acidification.
- Container-based systems appear to perform well across most environmental metrics; in cases where marine eutrophication is not a concern, it could be useful endpoint on the sanitation ladder. However, there is a lack of information on the overall impacts associated with this option due to its low implementation to date. More research is needed on operational impacts, but container-based systems may be a promising option if urine can be managed appropriately. Options for using the solids from container-based systems, including briquetting the solids for heating, should also be further explored.
- Considering both greenhouse gas emissions (global impact) and eutrophication (local impact) suggests that a combination of container-based systems and secondary and tertiary WWTPs may be the best solution, provided each system can be improved in key areas.

Analysis and Findings

Sewage Management Approaches Compared

Approaches to sewage management range from open defecation to more safely managed methods, as illustrated by the Joint Monitoring Programme (JMP) for Water Supply, Sanitation, and Hygiene sanitation ladder concept shown at the right.[1]

Safely Managed
Basic
Limited
Unimproved
Open Defecation

ERG's assessment considered five general sewage management methods that move up the rungs of the JMP sanitation ladder. Each of these general sewage management methods have different management stages: collection; storage/emptying; transport; treatment; disposal. The management stages of each sewage management method have varying associated human health and environmental impacts.

[1] WHO and UNICEF, 2017. Progress on Drinking Water, Sanitation and Hygiene: 2017 update and SDG baselines. World Health Organization (WHO) and United Nations Children's Fund (UNICEF), Geneva, Switzerland.

Sewage Management Method	Sewage Management Stages				
	Collection	Storage/ Emptying	Transport	Treatment	Disposal
Sewer Collection Excreta are deposited in a flush or pour flush toilet and run through a drainage pipe, where they are collected into a system of pipes, transported, and either discharged directly without treatment or delivered to a wastewater treatment facility for pollutant removal. The assess-ment evaluates sewer systems with no treatment, primary treatment, secondary treatment, and tertiary treatment.	✓		✓	✓ ***Treatment included for sewer collection options except the option where sewage is directly discharged to the environment without treatment***	✓
Container Based Sanitation Collection Excreta are deposited into toilets with removable containers that are collected, stored, transported, and then emptied in a CBS facility that sends the liquids to centralized treatment and composts the solids for eventual land application.	✓	✓	✓	✓	✓
Septic System Excreta are deposited in a flush or pour flush toilet and run through a drainage pipe to an underground water-tight tank that need periodic removal of the sludge.	✓	✓	✓	✓	✓
Latrine Excreta are deposited into a collection system, generally an excavated pit, either emptied by hand or mechanically or covered with soil. The assessment evaluates lined dry pit; unlined dry pit; and lined wet pit.	✓	✓	✓ ***Transport is included for latrine options except in cases where sewage is buried on-site***		✓
Open Defecation Excreta are deposited directly onto land or into water, without any collection system or treatment.					✓

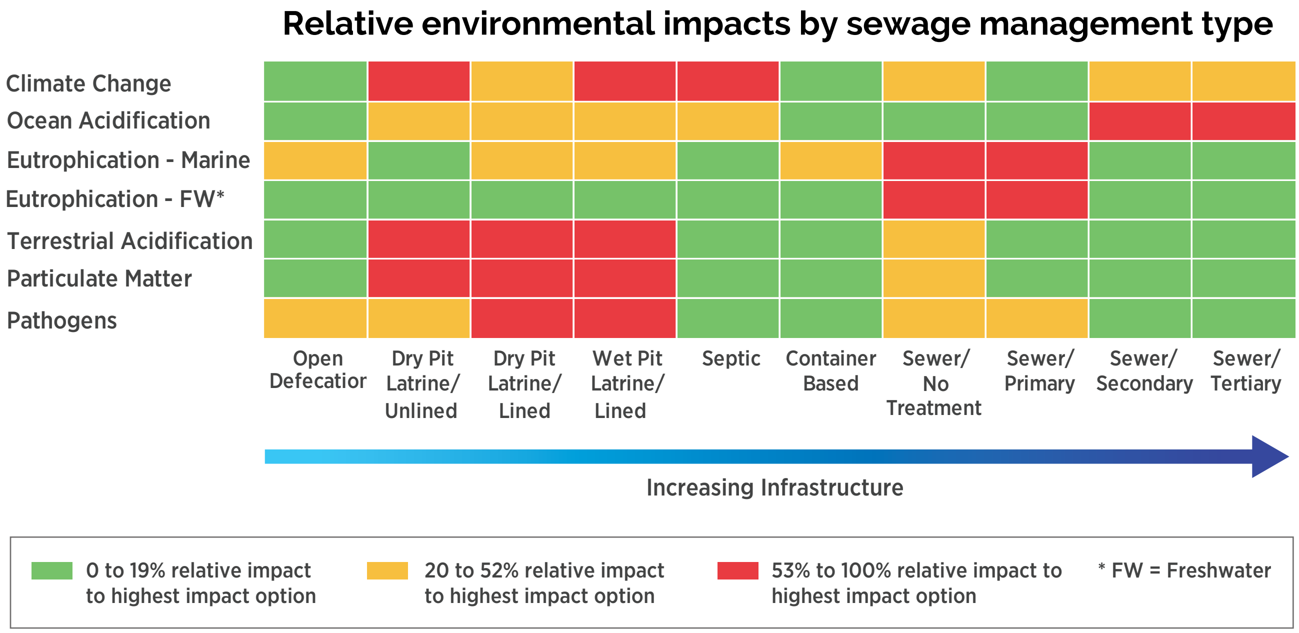
Environmental and Human Health Metrics Analyzed

The assessment evaluated the sewage management methods against six environmental and human health metrics to determine trade-offs.

Metric	Related Impacts
Global warming potential (GWP)	Represents GHG emissions that contribute to climate change and human health impacts. During storage and treatment, sewage may release methane (CH_4) and nitrous oxide (N_2O); energy used for transport and treatment releases carbon dioxide (CO_2)
Ocean acidification	Represents CO_2 emissions from sewage treatment that may dissolve in the ocean and change its pH, which may negatively affect marine life
Eutrophication	Represents surplus amounts of limiting nutrients (typically phosphorus in freshwater or nitrogen in marine systems), which results in excessive growth of algae, reducing available oxygen and causing changes in species composition, biomass, or productivity in both marine and freshwater ecosystems
Terrestrial acidification	Represents emissions such as sulfur oxides and nitrogen oxides that can lead to acid rain, which can detrimentally affect terrestrial plant life and infrastructure
Particulate matter	Represents fine particulates from combustion-based energy sources that can affect breathing and respiratory systems, damage lung tissue, and cause other human health concerns
Pathogen transmission	Represents global pathogen burdens based on pathogen shedding rates, sanitation adoption, and pathogen survival during containment and treatment that can cause disease and other human health concerns

Summary of Assessment Results

The chart below compares all impact metrics and sewage management methods evaluated in the assessment. Cells shaded red indicate a higher impact or poor performance. Cells shaded yellow indicate a moderate impact. Cells shaded green indicate low to no impact. The color coding is used to illustrate relative differences between options but is not an indication of significant statistical differences.



While some sewage management approaches perform better than others, no one option mitigates all environmental or human health metrics (i.e., contains all green cells). Policymakers should consider these results, and the findings outlined below, in the context of the sanitation ladder, with movement away from open defecation necessary for human safety and dignity.

Below is a summary discussion of the comparative assessment results by impact metric.

- For **climate change** (GHG/GWP), latrines and septic systems perform poorly (i.e., contribute greater GHG emissions); untreated sewers or advanced (secondary and tertiary) wastewater treatment plants (WWTPs) have less impacts than latrines. Latrine, septic, and untreated sewer emissions are driven by CH_4 emissions from stagnant human excreta. The secondary and tertiary wastewater treatment emissions are driven by N_2O emissions during processing, as well as electricity demands.
- For **ocean acidification**, secondary and tertiary wastewater treatment are the poorest performers, driving high emissions of CO_2 related to using the electrical grid.
- For **eutrophication** in both marine and freshwater contexts, primary wastewater treatment is the poorest performer. Primary WWTPs and sewage collection without further treatment collect and concentrate waste (and its nutrients), provide relatively little nutrient removal, and then discharge those nutrients directly into receiving water bodies.
- For both **terrestrial acidification** and **particulate matter**, ammonia emitted from stagnant excreta, particularly from latrines, is a contributor to acidification and a precursor for particulate matter. Stagnant conditions in open sewers can also lead to such ammonia.
- For **pathogens**, the systems that keep excreta on site, or do not provide much treatment, have higher potential for pathogen transmission.

Technical details of this analysis are available in the full report “Assessment of Current and Future Sewage Management: Opportunities for Changes in Greenhouse Gas Emissions and Other Impacts” available at: https://www.erg.com/sites/default/files/inline-files/ERG-sewage-GHG-technical-report.pdf.