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Impacts of Climate Change and Variability on Wastewater Management

"The sewer is the conscience of the city," Les Miserables, Victor Hugo

Summary

Wastewater is generated by a variety of uses and activities and unless treated causes pollution. The introduction of wastewater collection and treatment systems in the 19th century improved public health and underpinned economic development. The urban areas in the Caribbean Region are poorly provided for in terms of centralized sewerage systems even though improved sanitation through decentralized systems is widespread. As a result 85% of wastewater entering the marine environment is untreated. Financial constraints have prevented governments from addressing this problem but it will only get worse under climate change and climate variability. Adaptation measures which have been proposed include; factoring in greater variability in operating conditions, designing for energy and resource recovery, and wastewater reuse, a greater role for the private sector, and accessing the Green Climate Fund.

Key Points

- Wastewater management makes a key contribution to public health an development
- Provision of centralised sewage systems in the Caribbean is low; accordingly, low rates of wastewater treatment
- Wastewater systems at risk from climate change, potentially affecting economic activity and development
- Waste and wastewater contain valuable, recoverable, resources including 'new' water
- Wastewater systems need to build in resource recovery and be designed to cope with a more variable operating environment

Wastewater Management

Wastewater is water collected from households, commerce and industry after use. It can include municipal sewage effluent, industrial effluent, and urban and agricultural runoff. Wastewater usually has high pollutant levels from human waste and industry that may be harmful to human health and ecosystems. Wastewater management therefore seeks to minimise, control, and/or eliminate the risk to public and environmental health from the pollutants. Wastewater collection and treatment made the greatest contribution to human health in the 19th century[1]. It is now time to think of wastewater management as resource recovery and the generation of new water.

Wastewater Infrastructure in the Caribbean

Wastewater Collection Systems

Collection systems include underground sewer pipelines that sewage away from buildings to treatment facilities. They are usually designed to be "gravity flow" and are not usually pressurized. As a result sewer pipelines are 'leaky', allowing groundwater to infiltrate or wastewater to leak into the surrounding groundwater.

Wastewater Collection Systems in the Caribbean

In the Caribbean there are combined sewers transporting both waste and stormwater[6] as well as sanitary sewers. The Pan American Health Organization (PAHO)[2] found that 51.5% of households in the Caribbean Region lack any kind of

sewer connections and just 17% are connected to adequate collection and treatment systems. Access to a centralised wastewater system is highest in Trinidad and Tobago with 30% (2012), followed by Jamaica and Belize with 15% (2012) and 14% (2008) respectively. Most sewage systems provide only primary treatment before disposal into the marine environment. Access to decentralised wastewater treatment, however, is much higher, averaging approximately 84% in urban areas and 65% in rural areas.[3] Decentralised wastewater facilities in the Region range from household pit latrines and septic tanks to package treatment plants and piped wastewater systems.

Wastewater Treatment Systems

It has been estimated that 85% of wastewater entering the Caribbean Sea remains untreated, representing one of the main sources of nutrients in the marine environment.[4] The impact of poorly functioning sewage systems and the lack of or improper sewage treatment and disposal are also causing serious pollution of surface and ground waters. Because of the many barriers to developing infrastructure (see box), primary treatment (the screening and removal of solids and sediments) is the main sewage treatment carried out in the Region.[6] Some households in urban areas with flush toilets are connected to sewer lines, while in rural areas and some urban areas pit latrines, septic tanks and soak-aways are the usual means of sewage disposal.[6] Facultative lagoons (St Vincent and the Grenadines), package sewerage plants (Antigua) and treatment ponds (Barbados) are also in operation.[6]

Barriers to wastewater infrastructure development in the Caribbean:

- *Financial constraints*[5]
- *Inadequate legal and regulatory frameworks*
- *Fragmented approaches to and responsibility for wastewater management*
- *Limited technical and operational capacity, knowledge and awareness of low cost treatment technologies*[4]

Climate Change Concerns for Wastewater Collection and Treatment

The potential impacts to wastewater collection systems from climate change and climate variability include:

- More frequent and intense rainfall may cause more infiltration into sewer systems and they may become overloaded causing overflow events or sanitary sewer overflow (SSO).
- More infiltration into sewers from increased precipitation leading to diluted wastewater and higher volumes.
- Higher groundwater levels in coastal areas, due to sea-level rise may damage the sewer pipelines.
- Temperature increases may lead to increases in biological activity, affecting corrosion rates in wastewater pipelines. Corrosion of buried pipelines could lead to increases in pollution of groundwater sources, an important source of water supply in many Caribbean states.

- Shrinkage movement of soils due to loss of soil moisture caused by increased dry spells may stress pipe joints. Together with corrosion of pipe materials, this could result in increased leakage.
- Increased storm-related effects such as surge damage, wind damage, and flooding. These pose a direct threat to coastal wastewater infrastructures, which are usually located in low-lying areas and near the coast.

Potential climate change impacts on wastewater treatment processes include:

- Temperature effects (both negative and positive) on biological treatment processes. Higher temperature may improve treatment efficiency due to heat dependency of biological treatment processes. On the other hand, increased biological activity requires more energy and releases more methane. Warmer water temperatures will also lead to lower levels of dissolved oxygen, which impair biological processes, negatively affect aquatic ecology and result in poorer water quality in rivers, streams and the marine environment.
- Dilution effects if precipitation increases.
- Sea level rise effects if located near the coast, potentially combined with hurricanes.
- Effects on discharge of treated wastewater if sea level rises (no longer gravity flow).
- More stringent effluent requirements as base flow of receiving rivers and streams decreases.
- Reduced water volume creating potential hydraulic and corrosion issues.

Impacts also depend on the wastewater systems that are implemented, whether they are centralised or decentralised sewerage systems. Other non-climate factors, such as where people live and work, the location of infrastructure and economic assets, particularly in urban coastal areas, also influence the societal impact of climate change and climate variability, and can expose communities to a high level of hazard and damage potential. Overall, the lack of service provision with respect to sewerage systems contributes to increase levels of vulnerability to climate change impacts.

Key Climate Change and Variability Issues

Many current wastewater systems do not provide an adequate level of service that maintains and protects ecosystem services and the environment. Systems are likely to be less effective in the future.

Environmental impacts may affect the quality of fresh water resources, both surface and groundwater, which may impact public supplies and public health.

Coastal marine environment will likely deteriorate, thus failure to provide adequate wastewater management will have medium to long-term economic consequences.

Reductions in freshwater availability will increase demand for alternative potable supply sources, such as harvested rainwater and treated wastewater.

Adaptation Responses

The following responses may be employed:

- Wastewater systems should be designed to accommodate the uncertainty associated with future climate. In particular, the design volume of collection systems should likely be increased as new systems are built.
- Given concerns regarding the reliability of future water supply, consideration should be given to the reuse of treated wastewater. This can be used for many non-potable uses, such as irrigation, lawn watering, etc.
- Greenhouse gas emissions from wastewater treatment can be reduced by collecting and reusing off-gas as a source of energy.
- Wastewater management must be assigned the same level of priority as water supplies.
- Policies, standards, and regulations, as well as economic incentives, are needed to promote wastewater reuse, and encourage energy and nutrient recovery from wastewater.

- Potential financing opportunities such as through the Clean Development Mechanism (CDM) established under the Kyoto Protocol and the Green Climate Fund should be explored.
- A decentralized approach to wastewater management may also offer increased opportunities for local stakeholder participation in planning and decision-making as it may build capacity of local organizations.
- Given that uncertainties about the expense of adaptation and the potential cost of taking no action may be a barrier to investment in wastewater infrastructure it is very important that cost benefit analyses be done.

However, a successful approach to adapt infrastructure to the impacts of climate change and climate variability will be required to be:

Effective: the decision should decrease vulnerability to climate change.

Efficient: the benefits of adaptation should outstrip the costs.

Equitable: the distributional consequences should be considered.

Evidence-based: the decision should be based upon the latest research, data and practical experience as well as a better understanding of the cost and benefits and consumers' willingness to pay for the level of service provided.

Conclusions

The Caribbean region is under-provided for in terms of adequate wastewater management systems in urban areas. As a result the terrestrial and marine environments continue to be adversely impacted by pollution. Climate change will affect wastewater management systems and facilities through a variety of pathways. Facilities will be at risk from extreme events damaging the physical infrastructure; rising temperatures will affect biochemical activity within treatment processes and could also alter wastewater flows. In the future resilient wastewater management systems will have to factor in the effects of greater climate variability. It is time to stop talking of 'waste' water and start talking about resource recovery systems.

References

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