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A global indicator of wastewater treatment to inform the Sustainable Development Goals (SDGs)

Omar A. Malik [a], Angel Hsu [b,*], Laura A. Johnson [a], Alex de Sherbinin [c]

[a] Yale Center for Environmental Law and Policy, 195 Prospect Street, New Haven, CT 06511, United States
[b] Yale School of Forestry and Environmental Studies, 195 Prospect Street, New Haven, CT 06511, United States
[c] Center for Earth Science Information Network, The Earth Institute, Columbia University, P.O. Box 1000 (61 Route 9W), Palisades, NY 10964, United States

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ABSTRACT

This paper assessed an effort to create an indicator of global wastewater treatment performance to inform environmental performance and sustainable development. We compiled wastewater treatment statistics for 183 countries and constructed a first-of-its-kind global indicator for wastewater treatment performance. Although reporting definitions are inconsistent across countries, we preliminarily concluded that wastewater performance trends vary globally, regionally, and by income. Overall, the lack of consistent definitions, reporting protocols, and a central custodian for wastewater treatment data are main reasons for many challenges we confronted in constructing comparable performance measures. We suggest a standardized definition of wastewater treatment aimed at the utility level, which could be normalized and aggregated to reflect national performance. U.N. negotiators, who are designing a Sustainable Development Goal (SDG) for water that includes a metric on wastewater treatment, must consider these issues if countries are to be successful in managing wastewater and ultimately, water quality.

1. Introduction

Wastewater management has a long history in urban societies. Some of the earliest cities in Eurasia made use of building and engineering methods to conduct waste from households. During the Minoan Civilization around the second century BCE, major cities were built with both sewer and storm water drainage systems that sometimes led to irrigation channels and allowed for human waste to be used as fertilizer (Angelakis et al., 2005). The Indus Valley civilization, active in the third century BCE, was also known for its advanced sewage systems in which household waste was transported through covered conduits under city streets, sometimes with systems of holding tanks (Deleur, 2003).

Today, wastewater is a major factor for freshwater quality and human health. Wastewater is defined as water that has been used by households, industries, and commercial establishments that, unless treated, no longer serves a useful purpose and may contain contaminants (Raschid-Sally and Jayakody, 2008; UNSD, 2012, p. 196). It is comprised of water from household sinks, washing machines, and kitchen

* Corresponding author. Tel.: +1 203 432 5594; fax: +1 203 432 0237.
E-mail addresses: omar.a.malik@icloud.com (O.A. Malik), angel.hsu@yale.edu (A. Hsu), laurajohnson8424@gmail.com (L.A. Johnson), adesherbinin@ciesin.columbia.edu (A. de Sherbinin).
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appliances, as well as water flushed from toilets, and therefore contains a combination of nutrients and chemicals. Industrial contributions include carbon, nitrogen, and phosphorous nutrients, as well as pesticides and other chemicals depending on the specific industry (US EPA, 2004).

When left untreated, these nutrients and chemicals enter natural water systems where they cause harm to the environment and human health (Corcoran et al., 2010). A host of bacterial, viral, and protozoan organisms can survive in human waste and fecal matter, including *Escherichia coli* that can be present in pathogenic form in wastewater (WHO, 2011). In ecosystems, nutrient pollution can lead to algal blooms and eutrophication, due to excess nutrients allowing aquatic microorganisms to proliferate and consume all available oxygen. Eutrophication in turn can lead to fish die-offs from anoxic conditions (Corcoran et al., 2010). Humans are also at risk of shellfish poisoning from the accumulation of biological contaminants in filter-feeding organisms (Baum et al., 2013; Shuval, 2003). Other effects such as the emerging issue of endocrine disruption in organisms can occur in part due to the presence of pharmaceutical products or chemicals in waterways (Corcoran et al., 2010).

Wastewater is typically collected through sewage pipes in municipal areas. Treatment of wastewater entails a step-wise process that occurs in primary, secondary, and tertiary stages. Primary treatment involves basic screening and filtration processes to remove suspended solid waste and reduce its biochemical oxygen demand (BOD), which is an indicator to monitor water quality that assesses the amount of oxygen microorganisms must consume to break down the organic material present in wastewater (US EPA, 2012). Primary treatment can reduce BOD by up to 30% (Flörke, 2013). Secondary treatment uses biological processes to break down the dissolved organic matter remaining after primary treatment. Secondary treatment can remove up to 90% of BOD and total suspended solids (US EPA, 2004). Any additional step in wastewater treatment is considered tertiary treatment (or "advanced treatment"), which includes any purification process that continues beyond the previous steps and may require more complex technology such as ion exchange and reverse osmosis to further remove contaminants or phosphorous and nitrogen (World Bank, 2013b; US EPA, 2004).

Environmental problems occur when wastewater treatment plants do not have the capacity to treat all of the wastewater that they collect, or when they fail to adequately treat wastewater. In many cities located in developing countries, existing infrastructure may not be sufficient to treat all the wastewater it receives. This may occur when the growth of a city's population outpaces the construction of treatment facilities or when a city lacks the funds to properly maintain or upgrade existing plants over time (Mateo-Sagasta and Salian, 2012). As a result, wastewater treatment facilities may discharge partially or completely untreated wastewater directly into the environment (Corcoran et al., 2010). In Accra, the capital of Ghana, for instance, existing treatment plants were reported not operational in 2013 due to issues of capacity, therefore leading to illegal dumping wherein the waste is diverted directly into the ocean (Muspratt and Bäuerl, 2013; Murray and Drechsel, 2011). Although wastewater treatment is widely recognized as a major factor for water quality (US EPA, 2004), the UN Environment Programme (UNEP) estimates that 90% of the developing world does not treat any of its wastewater before it is released directly back into the environment (UNEP, 2010). Our study aims to provide the kind of support needed to understand such region specific characterizations.

Because of the salience of water resources to human and ecosystem health, United Nations negotiators are considering a Sustainable Development Goal (SDG) for water (Fig. 1). The SDGs are a set of goals applicable to all countries, developing and developed alike, that are set to succeed the Millennium Development Goals (MDGs) when they expire in 2015. The SDGs must be "aspirational, universal, communicable, and measurable", and they must set countries on a path toward reaching global targets between 2015 and 2030. The SDGs aim to help the world transition to a more sustainable system by presenting balanced environmental objectives and poverty reduction goals (Sachs, 2012). To that end, the Open Working Group of the UN General Assembly is facilitating high-level discussions of specific environmental themes throughout 2014, including the proposed SDG on water with a sub-goal for improved water quality through wastewater management (UN DESA, 2013; Bjørnson, 2013). As of this winter, the OWG has passed their recommendations on to the General Assembly, which will consider them in its next session in September 2015.

While the proposed sub-goal for improved water quality and wastewater management includes a goal to "reduce both the urban population with untreated wastewater and untreated industrial wastewater flows", there are currently no globally comparable data on the percentage of wastewater treatment at the national scale to aid in the assessment of this effort (Sato et al., 2013; Baum et al., 2013). Sato et al. (2013) found that information on the quantity of wastewater generated, treated, and used at the national scale is often "unavailable, limited, or outdated". It is for this reason that the baseline percentage of wastewater treatment at the global level has been poorly understood.

To address the gap in available, comparable national wastewater treatment data, this paper presents the first-ever dataset of a country-level wastewater treatment indicator at the global scale. Our immediate goal was to develop an indicator of water quality to include in the 2014 edition of the Environmental Performance Index (EPI), a biennial global ranking of country performance on a range of environmental issues (Hsu et al., 2014). A secondary objective was to evaluate the global availability of national data to assess wastewater treatment to inform current proposals for a wastewater treatment indicator in the UN SDG process. Last, we aimed to analyze global trends in wastewater treatment to inform baseline and target measurements for that process.

The paper is organized as follows: Section 2 provides an overview of the methods used to research and compile national statistics on wastewater treatment. Section 3 then discusses global dataset results, with analysis of performance and factors related to data availability and coverage. Section 4 identifies major gaps with respect to existing data to assess wastewater treatment performance, including recommendations for an ideal indicator and standardized definitions that can help facilitate future data collection efforts.