UN: Rising reuse of wastewater in forecast but world lacks data on 'massive potential resource'

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Amid growing competition for freshwater from industry and cities, coupled with a rising world shortage of potash, nitrogen and phosphorus, an international study predicts a rapid increase in the use of treated wastewater for farming and other purposes worldwide.

However, research shows that treated wastewater—comparable in North America alone to the volume of water flowing over Niagara Falls—is mostly unused and, in many nations, not even quantified.

Of 181 countries studied, only 55 have information on three key aspects of wastewater: generation, treatment, and reuse. Another 69 countries have data on one or two aspects, 57 countries show no information on any aspect.

As well, in countries where data does exist it is mostly outdated: almost two-thirds (63%) of the numbers are five or more years old, according to the study led by Japan's Tottori University and the United Nations University's Canadian-based Institute for Water, Environment and Health (UNU-INWEH).

As water supplies fall and stress rises in many areas, the potential resource of wastewater is being widely recognized, says the study published Sept. 5 by Elsevier journal *Agricultural Water Management*. Water demands already exceed supplies in regions with more than 40%

of the world's population and in just 12 years as much as 60% of the world's people may confront water scarcity.

Synthesizing what data there are on wastewater treatment, the study shows that, on average, high-income countries treat 70% of the generated wastewater, upper-middle-income countries treat 38%, lower-middle-income countries treat 28%. Just 8% of wastewater generated in low-income countries undergoes any kind of treatment.

In North America, of the estimated 85 cubic kilometers of wastewater generated each year, 61 cubic kilometers (75%) is treated. (A cubic kilometer is 1 trillion liters—about 220 billion US gallons). Annually, however, just 2.3 cubic kilometers or 3.8% of that treated wastewater is used.

Tables in the study detail the wastewater generation, treatment and reuse—and how up to date the numbers are—in individual countries around the world.

"From the earliest of times, most wastewater has truly been wasted. However, it is a vast resource if we reclaim it properly, which includes the separation of municipal from industrial wastewater," says UNU-INWEH Director Zafar Adeel.

"Another way of envisioning the volume of the resource potentially available worldwide each year is to imagine 14 months watching the outflow from the Mississippi River into the Gulf of Mexico."

It has been reported that wastewater today irrigates between 1.5% and 6.6% of the global irrigated area of 301 million ha (1.2 million sq. miles) and that about 10% of world food is produced using wastewater. However, according to the study, there is little data to support such claims.

In developing countries, particularly in water scarce countries, wastewater volumes are thought to have increased substantially in recent years due to rural-urban migration.

Many farmers in water scarce developing countries irrigate with wastewater because:

- It is the only water source available for irrigation year-round
- Wastewater irrigation reduces the need for purchasing fertilizer
- Wastewater irrigation involves less energy cost if the alternative clean water source is deep groundwater
- Wastewater enables farmers in peri-urban areas to produce high-value vegetables for sale in local markets.

Says lead author Toshio Sato of Tottori University, Japan: "Given the growing importance of wastewater management to the health of people and economies at local and national levels, having up-to-date basic insights into wastewater generation, treatment and reuse is an essential investment."

"The key point underlined throughout this report is the need to invest the time and resources to fill the global data gap," adds author Manzoor Qadir of UNU-INWEH. "Better data will enable the research and policy community to enhance understanding and craft effective solutions that will benefit millions of producers and consumers worldwide."

Says the study, on which Tottori University and UNU-INWEH collaborated with the International Center for Agricultural Research in the Dry Areas (ICARDA), Syria, the International Water Management Institute (IWMI), Sri Lanka, and Hazara University, Pakistan: "The country level information aggregated at the regional and global levels would help in identifying the gaps in pertinent data availability and assessing the potential of wastewater in food, feed, and fish production

at different scales."

Selected highlights

The study is the first ever to identify information gaps with respect to wastewater generation, treatment and use.

About 70% of the world's freshwater (up to 95% in some countries) is used for irrigation.

Competition for freshwater already exists among municipal, industrial, and agricultural sectors, particularly in water scarce areas. Agriculture has been yielding its share gradually to non-agricultural uses.

The combination of less freshwater allocation to agriculture and growing volumes of urban wastewater, is expected to continue and intensify, particularly in water scarce countries.

Agriculture in these countries will increasingly rely on alternative water resources, such as wastewater generated by non-agricultural activities in urban and peri-urban areas.

Under-reporting of wastewater generation, treatment and reuse might relate to fear of economic repercussions in agricultural trade due to concerns regarding food safety and phyto-sanitary measures.

Jordan's export market, for example, was impacted in 1991 when countries in the region restricted imports of fruits and vegetables irrigated with inadequately treated wastewater. Jordan implemented an aggressive campaign to rehabilitate and improve wastewater treatment plants, introduced enforceable standards to protect the health of farmers and consumers, and continues to focus on this sensitive situation, given the importance of regional and international trade.

North America

The estimated volume of wastewater generated in North America each year is about 85 cubic kilometers, of which 61 cubic kilometers are treated. (A cubic kilometer of wastewater is 1 trillion liters—about 220 billion US gallons).

Annual use of treated wastewater accounts for 2.3 cubic kilometers, which is only 3.8% of the wastewater treated in the region. Thus, while about 75% of the wastewater generated in North America is treated, only a small portion is used.

While the data describing wastewater generation and treatment are available in Canada, the data on wastewater use are not available. However, there are several projects underway suggest the use of wastewater in Canada at pilot scale.

An estimated 46% of California's annual reclaimed water use takes place in agriculture. In Florida, the proportion is 44%. Increasingly stressed water resources motivate wastewater use in Arizona, California and Texas, while limited groundwater motivates water recycling and reuse in Florida.

Latin America

Complete information on wastewater generation, treatment, and use is available from only 9 of 32 countries: Argentina, Bolivia, Brazil, Chile, Dominican Republic, Guatemala, Mexico, Nicaragua, and Peru. Even this information is relatively old as the data pertain largely to 1996-2002.

Ten countries have partial data available: Antigua and Barbuda, Belize, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Panama, Paraguay,

and Venezuela.

Only about 20% of generated wastewater undergoes treatment in the Latin American countries for which pertinent data are available, in part because many Latin American countries do not have well developed wastewater collection and treatment systems. In 8 of 15 Latin American countries, less than half the population is connected to wastewater collection and treatment systems

Rapid urbanization without sanitation facilities has caused major downstream pollution problems in this region. The urban population is projected to further increase by 130% in 2025 and by 166% in 2050

In Chile, untreated wastewater was used directly for agricultural purposes until 1992. With widespread occurrence of cholera in Latin America, the direct use of untreated wastewater was restricted in the country.

Water scarcity is not the main driver of wastewater use in most of Latin America. Rather, farmers engage in wastewater use because it provides a low-cost source of plant nutrients. Wastewater use in the region is particularly important, given that the shortages in supply of phosphate and potash fertilizers are projected to increase to 3.5 and 4.1 million tons by 2014.

Europe

Complete information on wastewater generation, treatment, and use is available for only 10 countries in Europe – Cyprus, France, Germany, Italy, Malta, Netherland, Poland, Portugal, Spain, and United Kingdom.

Most of this information pertains to the last 10 years. Partial data are available for almost two-thirds of Europe, including Austria, Belgium,

Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Greece, Hungary, Ireland, Luxembourg, Kosovo, Monaco, Montenegro, Republic of Macedonia, Romania, Serbia, Slovakia, Slovenia, Sweden, and Switzerland. No data are available for Albania, Finland, Iceland, and Norway.

Most of the wastewater generated in Europe (71%) undergoes treatment.

In southern Europe reclaimed wastewater is used predominantly for agricultural irrigation (44% of the wastewater projects) and urban or environmental applications (37% of the projects). In northern Europe, wastewater is used primarily for environmental applications and industry

Russian Federation and Independent States from the Soviet Union

Complete information on wastewater generation, treatment, and use is available for 8 countries – Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Turkmenistan, and Uzbekistan (Table 4). Partial data are available for other countries – Belarus, Estonia, Georgia, Republic of Moldova, Russian Federation, Tajikistan, and Ukraine.

The volume of wastewater treated in the Russian Federation is about 14 cubic kilometers per year. Nearly 28% of this is treated in accordance with established regulations, while the remainder is emitted in inadequately treated form into water bodies.

Middle East and North Africa

The estimated volume of wastewater generated in the Middle East and North Africa (MENA) region is 22.3 cubic kilometers per year, of which 51% (11.4 cubic kilometers per year) is treated. With the

exception of Algeria and Iraq, complete information on wastewater generation, treatment, and use is available from all countries in the region.

Treated wastewater use is essential in the water scarce MENA region. Currently, 51% of treated wastewater is used for irrigation. Some countries in the region are planning to increase the use of treated wastewater. For example, Saudi Arabia intends to increase wastewater use to 65% by 2016 (USEPA, 2012). Israel already uses 70% of the wastewater generated in the domestic sector.

High-income countries in the region use treated wastewater for agricultural and landscape irrigation. In Kuwait, only vegetables that are eaten after cooking (potatoes and cauliflower), industrial crops, forage crops (alfalfa and barely), and highway landscapes may be irrigated with treated wastewater in Kuwait.

Wastewater use represents about 10% of the Israeli national water supply and almost 20% of the water supply for irrigation

Sub Saharan Africa

Among 48 Sub-Saharan African countries, complete information on wastewater generation, treatment, and use is available from only three countries – Senegal, Seychelles and South Africa. Even this information is old, as the data from Seychelles and South Africa pertain to 2000 to 2003. The countries with partial data available are Botswana, Burkina Faso, Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Ghana, Lesotho, Mauritania, Mauritius, Namibia, Swaziland and Uganda. No data are available from the remaining 32 countries in the region.

Most wastewater goes untreated in sub-Saharan Africa, where water pollution triggers the spread of waterborne diseases such as diarrhea and

cholera. In most cases, the wastewater used for in agriculture is polluted. For example, untreated wastewater is used for irrigation in the peri-urban zones around Kumasi in Ghana, Dakar in Senegal, Nairobi in Kenya and Bulawayo in Zimbabwe.

Given the inherent uncertainty regarding wastewater quality and nutrient content, it is not possible for farmers to optimize the use of nutrients, particularly when using untreated wastewater.

Oceania

Complete information on all three aspects of wastewater is available only from Australia. The volume of treated wastewater is available for New Zealand, but the information on the volume of wastewater generated and treated wastewater used is not available. No information regarding wastewater is available from Fiji and the Solomon Islands.

About 45% of the 450 wastewater use projects in Oceania are in agriculture sector. In Australia, an estimated 0.35 cubic kilometers of treated wastewater are used annually. This volume accounts for 19% of the wastewater treated in the country and about 4% of the total water supply

In New Zealand, wastewater is used to irrigate golf courses and for industrial applications, but the volumes involved likely are small

Asia

Information on all three aspects of wastewater is available from only 5 countries – China, India, Japan, Republic of Korea, and Vietnam. Partial data are available for 14 countries, including Bangladesh, Bhutan, Cambodia, Laos, Malaysia, Maldives, Mongolia, Myanmar, Nepal,

Pakistan, Philippines, Singapore, Sri Lanka, and Thailand.

Only about 32% of the wastewater generated in Asia is treated,

Japan has adopted a comprehensive strategy for treated wastewater use. In 2009, 0.2 cubic kilometers of treated wastewater were used in the country. More than half was used for environmental purposes, such as landscape irrigation, recreation, and river maintenance. Wastewater use in agriculture and industry is not substantial, accounting only for 7% and 1% of the treated wastewater, respectively. In addition, more than 3% of the treated wastewater is used for toilet-flushing. Japan's wastewater use strategy is somewhat unique, as it is focused on meeting urban water needs, rather than providing water primarily for agricultural uses.

An estimated 1.3 million ha are irrigated with wastewater in China, while an estimated 9,500 ha are irrigated with untreated wastewater in Vietnam. At least 2% of the agricultural land around most Vietnamese cities is irrigated with wastewater, and much of that land is planted in rice.

An estimated 32,500 ha are irrigated with wastewater in Pakistan. Most of the wastewater is untreated, and yet there are no clear regulations in Pakistan regarding which crops may be irrigated with wastewater. Direct use of untreated wastewater is also common in India, where in 1985, an estimated 73,000 ha were irrigated with wastewater.

The increasing demand for plant nutrients in Asia provides an incentive for farmers and public officials to develop safe methods for distributing and managing wastewater for use in agriculture. Projections suggest that the potash supply in East Asia will be much smaller than demand by 2014.

The projected annual nutrient deficits for South Asia include 4.3 million

tons for nitrogen, 7.4 million tons for phosphorus, and 5.1 million tons for potash.

Provided by United Nations University