Food and Agriculture Organization of the United Nations

Global database on municipal wastewater production, collection, treatment, discharge and direct use in agriculture

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Abstract

This paper describes the rationale and method to setup and feed the FAO global database on municipal wastewater production, collection, treatment, discharge or direct use in agriculture. To feed the database the best available sources of information have been reviewed, including peer-reviewed papers, proceedings of workshops, conferences and expert meetings, global or regional databases, as well as country briefs, national reports and direct communications by country government officials and experts. Data from these sources is selected, analyzed, validated and harmonized based on criteria and rules developed for accuracy and consistency of the information. The validated data are integrated in the online country database of AQUASTAT, FAO's global information system on water and agriculture, so as to have updated information on availability and use of secondary and non conventional sources of water.

1. Introduction

1.1. Why a global database

Population growth and socio-economic development have rapidly increased water demand which, together with renewable but finite water resources and climate change, is resulting in an increasing number of regions facing water scarcity and chronic droughts.

In consequence, the conservation of freshwater through the use of non-conventional sources of water, such as wastewater, for agriculture is becoming an increasingly relevant option. Indeed, even if uncontrolled and unplanned use of diluted wastewater in agriculture has always existed, in recent times the number of wastewater treatment and reclamation projects for direct and planned use in agriculture has grown fast.

Nevertheless, knowledge on the global extent and evolution of the use of wastewater in agriculture in its different forms – planned or unplanned, direct or indirect, treated or untreated – is still very incomplete and uncertain.

The aim of this global database is to provide the best available national-level data on municipal wastewater production, collection, treatment, discharge or direct use in agriculture. This database is done within the framework of AQUASTAT, FAO's global information system on water and agriculture, which now includes a thematic section, dedicated to municipal wastewater, at http://www.fao.org/nr/water/aquastat/wastewater/index.stm.

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1.2. Scope of the database

The information collected on municipal wastewater production, collection, treatment, discharge and use in agriculture is on a national level. In its first stage, it is restricted to 'direct use' of municipal wastewater, that is, deliberate use of treated or untreated wastewater as a source of water and/or nutrients/fertilizers for an economic or beneficial purpose such as irrigation, urban gardening, aquaculture, etc. In other words 'direct use' refers to treated/untreated wastewater that is used without first being returned to the environment and mixed with other freshwater, which is called 'secondary freshwater'.

In comparison to other existing wastewater and sanitation databases, such as those from the World Health Organization (WHO), United Nations Development Programme (UNDP), Organization for Economic Cooperation and Development (OECD), European Environment Agency (EEA) and the European Commission (EC), that focus on percentage of sanitation coverage or pollution loads, the present FAO global database focuses on the **volume** of municipal wastewater production, collection, treatment, discharge or direct use in agriculture at a national level. The reason for choosing volume as the parameter is to facilitate the integration of these data in the water resource and water use accounts in the different countries.

1.3. Target audience

The database is addressed to all those interested in having national, regional or global overviews on the subject. This may include public officials, practitioners and researchers working in national or international organizations, and particularly those dealing with water resources management, wastewater management and agriculture, in particular urban and peri-urban agriculture.

1.4. Aim of the paper

This paper describes the methodology used to build up the global database. In particular, it describes the variables included in the database, their definitions, the sources of information reviewed, the data selection criteria, the quality control and validation rules followed.

2. Setup of the wastewater database: from production to use

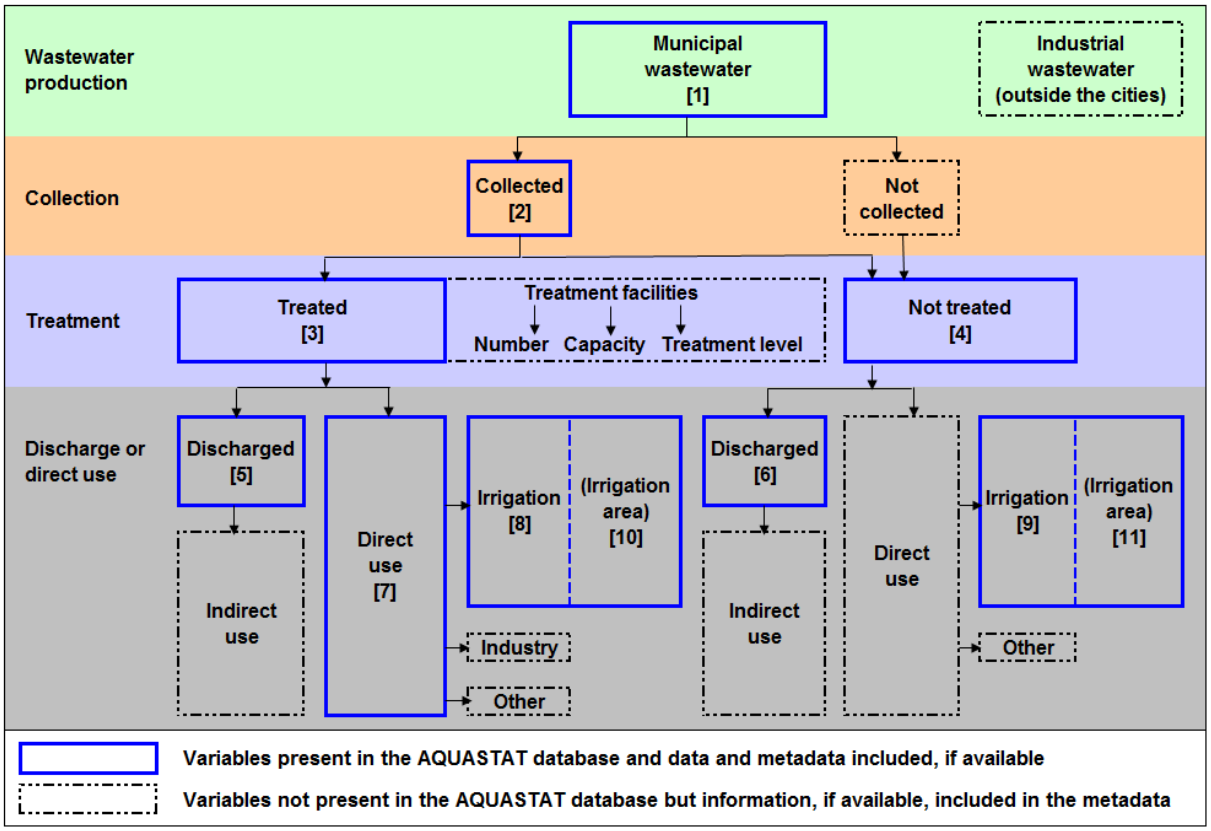
The diagram on the next page illustrates the flow of wastewater from production to use. The variables squared in blue are available in the AQUASTAT country database. The definitions of the different variables are provided in the next section.

3. Definitions of terms and variables

Following are the definitions of each variable as per the diagram on the next page as well as of other relevant terms. The reference number allocated to each variable in the diagram is given in square brackets.

Produced municipal wastewater [1]: Annual volume of domestic, commercial and industrial effluents, and storm water runoff, generated within urban areas.

Produced industrial wastewater: Annual volume of industrial effluents generated outside urban areas. This includes those effluents from peri-urban industries that are not connected to the urban drainage or sewer system and that, therefore, discharge their effluents directly into water bodies, with or without prior treatment. Cooling water is not considered to be wastewater for purposes of this database.



Not collected municipal wastewater: Annual volume of produced municipal wastewater that is not collected by any formal, collective or independent, collection systems, like a sewer network or septic tanks. This wastewater normally drains in informal urban drainage canals or percolates into the ground.

Collected municipal wastewater [2]: Annual volume of municipal wastewater collected by municipal wastewater sewers or other formal collection systems. This category considers the following collection systems:

- *Independent:* individual private systems in place to evacuate and collect domestic and other wastewater in those cases where an urban collection system is not available. This includes the collection of wastewater by pit latrines and septic tanks. (Eurostat, 2008).
- *Collective:* systems that collect wastewater from dwellings, commercial or industrial facilities by planned municipal sewer systems (Asano *et al.*, 2007).

Treated municipal wastewater [3]: Annual volume of effluents from functional municipal wastewater treatment facilities, including primary, secondary or tertiary effluents after primary, secondary or tertiary treatment respectively:

- *Primary treatment:* physical and/or chemical process involving settlement of suspended solids, or other process in which the BOD5 (the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter) of the incoming wastewater is reduced by at least 20 percent and the total suspended solids of the incoming wastewater are reduced by at least 50 percent before discharge (Eurostat, 2003). Primary treatment processes can include: i)

sedimentation tank, ii) septic tank, iii) skimming, iv) chemical enhanced primary treatment.

- *Secondary treatment:* process generally involving biological treatment with a secondary settlement or other process, resulting in a BOD (biochemical oxygen demand) removal of at least 70 percent and a COD (chemical oxygen demand) removal of at least 75 percent before discharge (Eurostat, 2003). The following processes are characterized under secondary treatment: i) aerated lagoon, ii) activated sludge, iii) up-flow anaerobic sludge blanket, iv) trickling filters, v) rotating biological contactors, vi) oxidation ditch, vii) settling basin digester.

  For the purpose of this database natural biological treatment processes are also considered under secondary treatment as the constituents of the effluents from this type of treatment is similar to the conventional secondary treatment. Natural biological treatment refers to the process other than conventional wastewater treatment (primary, secondary and tertiary). This treatment makes use of natural bio-chemical processes to treat wastewater. The treatment can include the following: i) waste stabilization pond, ii) constructed wetlands, iii) overland treatment, iv) nutrient film techniques, v) soil aquifer treatment, vi) high-rate algal pond, vii) floating aquatic macrophyte systems.

- *Tertiary treatment:* process in addition to secondary treatment of nitrogen and/or phosphorous and/or any other specific pollutant affecting the quality or a specific use of water: microbiological pollution, colour etc. This treatment is meant to remove at least 95 percent for BOD and 85 percent for COD and/or a nitrogen removal of at least 70 percent and/or a phosphorus removal of at least 80 percent and/or a microbiological removal (Eurostat, 2003). Tertiary treatment process can include the following: i) membrane filtration (micro-, nano-, ultra- and reverse osmosis), ii) infiltration/percolation, iii) activated carbon, iv) disinfection (chlorination, ozone, UV).

Number of municipal wastewater treatment facilities*:* Total number of functional municipal wastewater treatment facilities.

Capacity of municipal wastewater treatment facilities: Total installed annual capacity of the functional municipal wastewater treatment facilities.

Not treated municipal wastewater [4]: Annual volume of not collected municipal wastewater, or collected municipal wastewater but discharged without any prior treatment. Municipal wastewater collected by not maintained independent collection systems, like soak pits or septic tanks, are considered as not treated municipal wastewater. Effluents from non-functional wastewater treatment facilities are also included here.

Treated municipal wastewater discharged [5]: Annual volume of effluents from functional municipal wastewater treatment facilities directly discharged to water bodies (i.e. inland or coastal waters) without any specific direct human use.

Not treated municipal wastewater discharged [6]: Annual volume of not treated municipal wastewater discharged directly to water bodies (i.e. inland or coastal waters) without any prior treatment.

Direct use of treated municipal wastewater [7]: Annual volume of treated municipal wastewater utilized deliberately and directly, i.e. with no or little prior dilution with freshwater during most of the year, for human uses. This includes irrigation, aquaculture, industrial

processes (cooling and process waters) and municipal purposes (toilet flushing, street cleaning, recreational).

Direct use of treated wastewater for irrigation purposes [8]: Annual volume of treated municipal wastewater applied artificially and directly, i.e. with no or little prior dilution with freshwater during most of the irrigation period, on land to assist the growth of crops, fruit trees, planted forests, gardens, golf courses and landscaping.

Area equipped for irrigation by direct use of treated wastewater [9]: Total land directly irrigated by treated municipal wastewater with no or little prior dilution with freshwater during most of the irrigation period. This area includes irrigated land for crops, fruit trees, planted forests, gardens, and landscaping.

Direct use of not treated wastewater for irrigation [10]: Annual volume of not treated municipal wastewater applied artificially and directly on land, i.e. with no or little prior dilution with freshwater during most of the irrigation period, to assist the growth of crops, fruit trees, planted forests, gardens and landscaping.

Area equipped for irrigation by direct use of not treated wastewater [11]: Total land directly irrigated by untreated municipal wastewater with no or little prior dilution with freshwater during most of the irrigation period. This area includes irrigated land for crops, fruit trees, planted forests, gardens and landscaping.

4. Data sources

Data collection is based on a desk study/literature review. By the time this paper was produced more than 90 country briefs, databases, technical reports, peer-reviewed books, and publications and presentations by national authorities and experts in seminars have been reviewed (see section 6), and this number will increase in future updates. Data collection considers three different scales, these were:

Global initiatives that compile information on wastewater such as databases, for example the *OECD Environmental Data Compendium 2006-2008* (OECD, 2008), and books, such as *Water reuse: an international survey of current practice, issues and needs* (Jimenez and Asano, eds, 2008) and *Wastewater use in irrigated agriculture: confronting the livelihood and environmental realities* (Scott, Faruqui and Raschid-Sally, eds, 2004)

Regional sources such as the *National Inventories for Wastewater in Latin America*[4] and the databases of Eurostat and EEA. These sources also include technical reports from international organisations such as *Water in the Arab world* (World Bank, 2009) and *A regional overview of wastewater management and reuse in the Eastern Mediterranean Region* (WHO, 2005).

National sources on wastewater in specific countries. This information was mostly collected through technical reports and country briefs provided by national governments, such as *Report on the state of the environment, China* (Ministry of Environmental Protection, People's Republic of China, 2009), publications, and presentations by national authorities and experts at seminars and workshops.

5. Data selection and validation

5.1. Data selection

[4] Los inventarios nacionales de las aguas residuales en América Latina, http://www.bvsde.paho.org/bvsaar/e/proyecto/inve_nac.html

The multiplicity of sources makes it essential to segregate and select the most reliable data and thus criteria for selection of data is needed. The criteria used is:

a. Data should be in concurrence with the definitions for the variable
b. Data should be scientifically sound

Generally, in the case of contradicting data from two different sources for the same year, and that meet the above criteria, the selection is based in the following order of preference: (1) national agencies, (2) peer-reviewed journals and publication, and (3) databases and other sources.

5.2. Data validation

As the data selected comes from many different sources, over the course of time, inconsistencies may occur, for example an unacceptable high difference in municipal wastewater produced between one year and the following year. As the data collected may be from two different but reliable sources, it is difficult to judge which one is correct, so the validation of all the data becomes essential.

Data is validated in relation to a time span from 1958 to 2012, based on the assumption that mainly the annual volume of wastewater produced, but probably also the annual volume collected, treated, discharged or directly used, should - unless justified, such as for example due to contraction in the municipal population growth - show incremental increase as water use would rise over time.

Data is also validated in relation to various stages of the wastewater cycle, i.e. wastewater production (assumed to be the highest volume), wastewater collection, treatment and direct use (lowest volume of water).

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