Monitoring Safely Treated Domestic Wastewater Flows

A Methodological Note for SDG indicator 6.3.1

World Health Organization

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CONTENTS

1 INTRODUCTION

Sustainable Development Goal (SDG) indicator 6.3.1 is defined as the proportion of domestic and industrial wastewater flows that are safely treated. The indicator is estimated using official country data on flows that are: generated by households and various sectors of the economy; collected in collection systems; delivered to treatment facilities; and safely treated at these facilities. The SDG global database for the indicator is updated routinely by UN-Habitat and the World Health Organization (WHO) who serve as custodians for global monitoring. WHO is responsible for global reporting on the domestic component of the indicator (WHO is also co-custodian for the related SDG indicator 6.2.1a) while UN-Habitat is responsible for the total and industrial wastewater components. The United Nation's Statistical Division (UNSD) serves as a co-custodian for the indicator as it maintains a database of wastewater statistics.

Untreated wastewater can contain various hazardous substances such as pathogens, organics, nutrients, and heavy metals. Public health, food security, and the function and sustainability of ecosystems can be affected when water resources are degraded by such substances. These negative consequences can be minimized through the adequate collection and treatment of wastewater prior to discharge to the environment. Many different types of collection and treatment facilities exist that employ a range of methods and technologies for removing hazardous substances. Wastewater flows may be collected in centralized or independent collection systems, most commonly sewers and septic tanks, respectively. After collection, wastewater flows may be treated in one of three classifications of treatment facilities that are relevant to global wastewater monitoring: 1) centralized (often referred to as 'urban') wastewater treatment plants (WWTPs) that typically treat large quantities of wastewater delivered via sewers;[1] 2) 'other' wastewater treatment plants (OWWTPs) that typically treat flows from industrial or large-scale facilities; and 3) independent (decentralized) treatment facilities. Independent treatment facilities can include septic tanks with leachfields or soak pits, as well as more sophisticated decentralized wastewater treatment systems (DEWATS) that may service individual properties or small clusters of households and communities.

Wastewater management and its monitoring are an important part of sustainable development. Under SDG indicator 6.3.1, methodologies for global monitoring have been established to track global, regional, and national progress on wastewater treatment over time. For the domestic wastewater component of the indicator, WHO employs a methodology that is distinct and separate from that employed by UN-Habitat for the monitoring of total and industrial wastewater. The two methods are independent and produce figures that are not directly comparable. Domestic wastewater in principle includes flows generated by residential settlements and services (such as businesses and commercial facilities). However, at present, the monitoring of domestic wastewater for SDG purposes is restricted to flows from households only. Data on wastewater flows derived from services are not commonly reported by countries, as many have not compiled the requisite data at the national level. Therefore, the terminology used in the remainder of this note refers to *household* flows rather than domestic.

The proportion of household wastewater safely treated is referred to as a global, regional, or country estimate. The term *'estimate'* is used, as it is not possible to directly measure many aspects of wastewater flows generated and safely treated. Rather, the estimates published by WHO reflect an estimation of the true proportion using available data. Wastewater is considered to be safely treated if it is discharged in compliance with relevant standards or treated to a level commensurate with secondary (or higher) processes. A glossary of terms and definitions related to the global monitoring of household wastewater is presented in Annex A.

The aim of this methodological note is to describe WHO's methodology for household wastewater monitoring under indicator 6.3.1 to aid data collectors, data managers, and other stakeholders to understand how global,

[1] And in some cases wastewater or faecal sludge transported by truck

regional, and country estimates have been computed. Demonstrative examples are used throughout this note to convey the various aspects of the methodology in practical terms – referring to the latest publicly available Excel country files published by WHO that present country-specific data, their sources, calculations, and country estimates.

2 METHODOLOGY

2.1 DATA COLLECTION, VALIDATION AND REPORTING

WHO maintains an internal database for the monitoring of household wastewater comprising twenty-two data input variables, across 235 countries, areas and territories around the world. A data collection drive is conducted every two years to update the database with official national data and estimates. Data are eligible to be used for the computation of a country estimate if they are nationally representative, their corresponding definition aligns with the global methodology, and they are indicative of conditions for a given year within a period of ten years from the year of the progress update. Only the most recent data point for each variable is used for the computation of a country estimate. As a result, a country estimate represents a snapshot of the most recently reported conditions and may be computed using data for different years across the data input variables. However, the published country estimates are reported for the year of the update itself rather than the year(s) associated with the data. Official national data are not typically available for all twenty-two input variables for a given country. Therefore, WHO employs standard assumptions to substitute for missing data and complete the calculation of the estimates. To limit the influence of the assumptions, country estimates are only published if certain minimum data coverage requirements are met.

Using the twenty-two data inputs, an additional eighteen variables are calculated, for a total of forty variables related to wastewater generation and treatment. These have been assigned sequential codes from 1 to 40 and can be identified throughout this methodological note and country-specific Excel files in brackets (i.e., variable 27 is represented as [27]). The data corresponding to these variables are classified as one of the following four data types:

1. **R**eported data (denoted as '**R**') that have been compiled from official national statistics;
2. **E**stimated data (denoted as '**E**') that have been computed using statistical methods (i.e., regression techniques) and published at global level (such as population);
3. **A**ssumption-based data (denoted as '**A**') that have been selectively used in place of missing reported or estimated country data; and
4. **C**alculated data (denoted as '**C**') comprised of totals and sub-totals.

Annex B presents a list and summary of all forty variables.

Typical providers of official national data include National Statistical Offices (NSOs), wastewater utilities and their regulators, and/or relevant government ministries (such as Ministries of Environment). Additionally, data are also compiled directly from among several global and regional environmental questionnaires and databases, namely:

1. Eurostat Environment Database (relevant to countries of the European Union) and OECD Environment Database (relevant to OECD countries that are not part of the European Union) in accordance with the OECD/Eurostat Joint Questionnaire on Inland Waters; and
2. UNSD/UN Environment Programme (UNEP) data collection on environment statistics (relevant to all other countries not covered in the Eurostat and OECD databases).

WHO encourages focal points from all NSOs to submit relevant official national data on wastewater statistics to their country's corresponding environmental questionnaire above. The use of these standardized

questionnaires promotes consistency, accuracy, and harmonization of global wastewater statistics. However, not all countries submit data to their respective questionnaire and the data in these databases only satisfy some of the twenty-two data input variables used for global monitoring. Therefore, WHO also compiles data directly from other national sources such as NSO websites, survey reports, downloaded data extracts, and sector reports.

WHO coordinates the data collection drives with the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP) which serves as the global custodian for the monitoring of SDG Indicator 6.2.1a on safely managed sanitation services. Some national data sources can be used for both SDG Indicator 6.2.1a and Indicator 6.3.1. Data compilation activities are therefore coordinated and harmonized to ensure that both indicators reflect the latest, most consistent, and most accurate data available.

Once a data drive has been completed, relevant national stakeholders are invited to participate in a country consultation during which the data and estimates may be reviewed, revised, and validated. Subsequently, the country estimates are finalized and global and regional aggregate estimates are computed. The final estimates associated with the update are submitted to the SDG global database maintained by UNSD. End-users can publicly access the estimates and data via the SDG global database, a separate dashboard dedicated to SDG6 maintained by UN-Water, the Excel country files published by WHO, and the indicator 6.3.1 progress reports published every three-years..

The accuracy of the global, regional, and country estimates is a product of the accuracy of the national data sources used and any assumptions employed in place of missing data. While WHO can strive to ensure that data align with the definitions used for global monitoring, its capacities to assess the accuracy of officially reported national data remain extremely limited. To address this limitation, WHO supports some NSOs and relevant national actors with capacity building initiatives for wastewater monitoring – particularly among low-income countries or those commencing or expanding their monitoring efforts.

2.2 CONCEPTUAL FRAMEWORK FOR HOUSEHOLD WASTEWATER MONITORING

Most of the twenty-two data input variables (excluding variables [1] to [7] which are used for some countries to calculate total household wastewater generated [8]) are summarized in the conceptual framework for household wastewater monitoring presented in Figure 1 – across the stages of wastewater generation, collection, delivery to treatment, treatment, and discharge. From left to right, [8] represents the total volume of household wastewater generated for a given year, variables [9] to [13] represent the proportions of the population associated with various types of sanitation facilities, [14] to [18] represent the volumes collected and not collected, [19] to [28] cover the proportions delivered to treatment (either WWTPs or septic tanks) and subsequently safely treated. Variables [37] to [39] represent the volumes safely treated associated with sewer and on/off- septic tank flows. Finally, variable [40] represents the country estimate itself (proportion of household wastewater safely treated). The conceptual framework represents an adaptation of a broader flow diagram for overall wastewater monitoring (including total and industrial flows and associated components generated by relevant sources and treated at relevant facilities), as presented in Annex C, and including variables particular to the UNSD, OECD, and Eurostat data instruments.

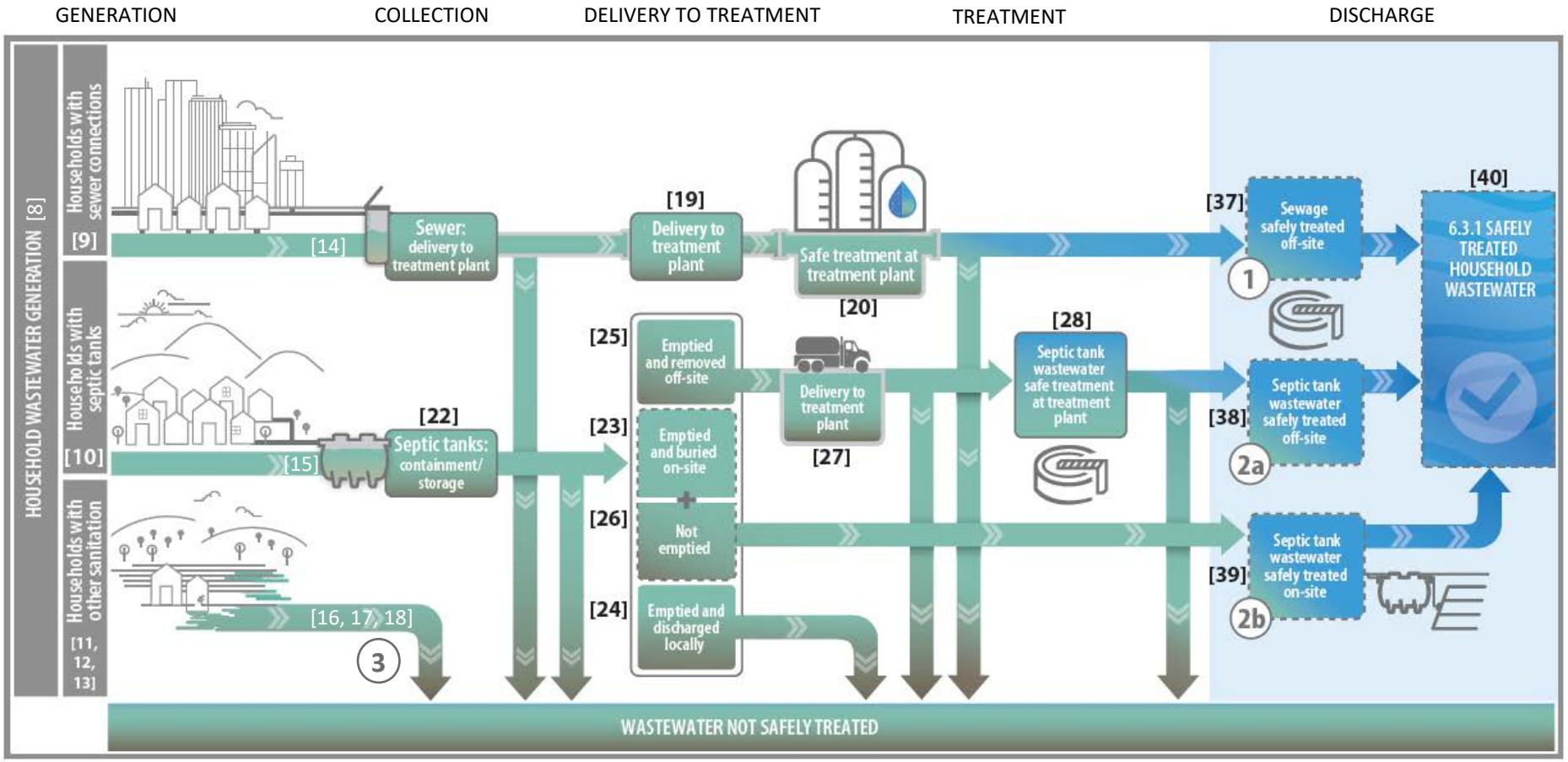


Figure 1 – Conceptual framework for the global monitoring of household wastewater flows safely treated under SDG Indicator 6.3.1

2.3 GLOBAL, REGIONAL, AND COUNTRY ESTIMATES FOR THE PROPORTION OF HOUSEHOLD WASTEWATER SAFELY TREATED

The proportion of safely treated household wastewater – also referred to as the global, regional, or country estimate – is computed using Equation 1:

$$STWW\_PCT = \frac{STWW\_VOL}{GEN\_VOL} \qquad \text{(Equation 1)}$$

where,

- *STWW_PCT* is the global, regional, or country estimate[2] represented as the proportion of safely treated household wastewater (%; [40]);
- *STWW_VOL* is the total volume of safely treated household wastewater (million m^3/year; [36]); and
- *GEN_VOL* is the total volume of household wastewater generated (million m^3/year; [8]).

2.4 ESTIMATING TOTAL HOUSEHOLD WASTEWATER GENERATED

Estimates of the total volume of household wastewater generated [8] for a given country or territory are derived through one of two methods, either:

1. Directly reported data (R) from official national statistics; or
2. Internally calculated data (C) based on six data input variables.

Box 1 presents an example country file where Method 1 has been employed. For countries and territories where directly reported total volumes have not been compiled, the internal estimation method (Method 2) has been employed using Equation 2:

$$GEN\_VOL = POP \times \{POP\_WATON\_PCT \times USE\_WATON\_AVG + POP\_WATOFF\_PCT \times USE\_WATOFF\_AVG\} \times USE\_TO\_WW\_PCT \qquad \text{(Equation 2)}$$

where,

- *GEN_VOL* is the total estimated volume of household wastewater generated (million m^3/year, [8])
- *POP* is the total population of the country or territory [1];
- *POP_WATON_PCT* is the proportion of the population whose primary water supply is an improved water source located on-premises (%, [2]);
- *POP_WATOFF_PCT* is the proportion of the population whose primary water supply is an improved water source located off-premises (%, [3]);
- *USE_WATON_AVG* is the average domestic water use for households with their primary water supply located on-premises (litres/capita/day, [4]);
- *USE_WATOFF_AVG* is the average domestic water use for households with their primary water supply located off-premises (litres/capita/day, [5]), and
- *USE_TO_WW_PCT* is the ratio of household water used to household wastewater generated.[3] (%, [7])

[2] Based on countries and territories recognized by WHO (n=235) and SDG regions (n=8) as defined by UNSD. Other regional aggregates are also generated, including for WHO regions, World Bank income groups, least developed countries, landlocked developing countries, and small island developing states

[3] In the country files, the total volume of household water consumed is separately and firstly calculated [6], after which USE_TO_WW_PCT [7] is applied to determine the volume of household wastewater generated [8]. In Calculation 2 these steps have been combined for simplicity.

BOX 1: Direct reporting of the total volume of household wastewater generated by official national sources (Method 1).

Data on household wastewater flows generated are presented in Part A as shown here in Germany's 2023 country file. In this example, Germany has reported the generation of 5,121.6 million m^3/year of wastewater by households (Method 1) represented by data type 'R'. This statistic was reported by the German NSO to Eurostat via the Joint Inland Waters Questionnaire, from where it was compiled by WHO. Variables [1] to [7] are not used (and are shaded in grey accordingly) because [8] has been directly reported and the internal calculation (Method 1) is unnecessary.

Variable name	Variable ID	Value	Units	Code
Country/territory population	[1]	83,369.84000	Population (1000s)	E
Location of drinking water supply (proportion of the population)				
On-premises*	[2]	100.0	Percentage	E
Off-premises*	[3]	0.0	Percentage	E
Household water used				
On-premises* (average)	[4]	121.6	Litres/person/day	R
Off-premises* (average)	[5]	20.0	Litres/person/day	A
Volume of household water used	[6]	3,700.28698	Million m3/year	C
Household wastewater generated				
Proportion of household water use converted into wastewater generated	[7]	80.0	Percentage	A
Volume of household wastewater generated	[8]	5,121.58984	Million m3/year	R

Data type 'R' for 'Reported'

Grey shading of variables [1-7] in the country file, indicating that they were not used for the calculation of variable [8]

When countries have not directly reported the total volume of household wastewater generated, this variable is calculated using Method 2. The proportion of the population and corresponding water use associated with on and off premises water supplies are separately accounted for because households with on-premises water supply are more likely to use larger quantities of water than those that fetch water from off-premises. Estimates of the proportion of households with on- and off- premises water supply are available for nearly all countries from the JMP. Box 2 presents an example from a country file where Method 2 has been employed.

BOX 2: Calculation of the total volume of household wastewater generated (Method 2)

The total volume of household wastewater generated [8] can be calculated based on variables [1] to [7] as using Equation 2, as shown in Belarus's 2023 country file.

Variable name	Variable ID	Value	Units	Code
Country/territory population	[1]	9,534.95000	Population (1000s)	E
Location of drinking water supply (proportion of the population)				
On-premises*	[2]	99.2	Percentage	E
Off-premises*	[3]	0.8	Percentage	E
Household water used				
On-premises* (average)	[4]	101.8	Litres/person/day	R
Off-premises* (average)	[5]	20.0	Litres/person/day	A
Volume of household water used	[6]	351.81765	Million m3/year	C
Household wastewater generated				
Proportion of household water use converted into wastewater generated	[7]	80.0	Percentage	A
Volume of household wastewater generated	[8]	281.45412	Million m3/year	C

[8] Data type 'C' for calculated, as [6] x [7]

[7] No reported data were found, therefore the standard assumption was used

[6] Calculated as [1] x {[2] x [4] + [3] x [5]} x 365 / 1000

[5] No reported data were found, therefore the standard assumption was used

[4] The National Statistical Committee reported domestic water use per capita in 2021

[2], [3] Nearly all households in Belarus have their main water supply on-premises (JMP 2022)

[1] Estimated population of Belarus (2022 Revision of World Population Prospects)

2.5 ESTIMATING HOUSEHOLD WASTEWATER COLLECTED BY TYPE OF SANITATION FACILITY

After the total volume of household wastewater generated has been established using either Method 1 or Method 2, the total is then disaggregated into wastewater streams classified by collection type:

Stream 1: Households connected to sewers [14];
Stream 2: Households connected to septic tanks [15];
Stream 3: All other households [16-18].

The flow paths associated with Streams 1, 2, and 3 are represented on the left side of Figure 1.

For the purposes of SDG 6.3.1 monitoring on household wastewater, only flows that have been generated by households with sewer or septic tank connections are classified as being collected and have the potential to contribute to proportions of *safely treated* household wastewater. Sewer and septic tank facilities (and the treatment systems they are typically connected to) are more likely to be designed and operated with the intention of safely treating and discharging wastewater flows. Wastewater flows associated with households with all other types of sanitation (e.g. pit latrines) or no sanitation at all (practicing open defecation) are considered not collected (and therefore not safely treated) in their entirety and regardless of their handling, storage, conveyance, and discharge. While well-designed pit latrines may adequately manage excreta and blackwater, they do not manage other forms of household wastewater such as greywater.[4]

The disaggregation of the volume of wastewater generated [8] is computed as a function of the proportion of the population corresponding to Streams 1 [9], 2 [10], and 3 [11-13] as estimated by the JMP as part of SDG indicator 6.2.1. This disaggregation is performed in one of two ways, depending on whether the volume of wastewater generated [8] has been reported directly by national sources (Method 1) or has been internally calculated (Method 2).

Method 1: For countries and territories where the total volume of household wastewater generated [8] has been directly reported, its volumetric disaggregation into wastewater streams [14-18] is calculated proportionally to the population represented by each wastewater stream [9-13].

Method 2: For countries and territories where the total volume of household wastewater generated [8] has not been directly reported, the disaggregation of wastewater generated into wastewater streams accounts for the fact that households with on-premises water supply are also more likely to have more advanced sanitation facilities, such as sewers and septic tanks. First, volumes of wastewater generated by households with on- and off- premises water supplies are separately calculated (based on [1-7]). Subsequently, the volume of wastewater generated that corresponds to households with on-premises water supply is iteratively distributed to wastewater streams that require high to low volumes of water to operate (i.e. sewer > septic tank > other sanitation). Once the fraction of on-premises water supply derived wastewater has been fully distributed, then the distribution of the off-premises fraction commences from the wastewater stream in which the allocation of the on-premises fraction ended. The distribution of the off-premises fraction continues until the remaining volume of wastewater generated is fully allocated across the wastewater streams. Box 3 describes this calculation in further detail. The resulting disaggregation across [14-18] between Method 2 and Method 1 only significantly differs when the proportion of households with off-premises water supply [3] is significant (more commonly the case among low- or lower-middle-income countries).

[4] In principle, if nationally representative data were available about safe management of wastewater (including greywater) among households without sewer connections or septic tanks, for example through soak pits, some portion of these flows could also be counted as safely treated for 6.3.1 monitoring. However, to date no such nationally representative data have been identified.

BOX 3: Disaggregation of total household wastewater generated across the wastewater streams

Household sanitation facility coverage					Household wastewater generated by sanitation facility type					
Type of sanitation facility	Proportion of population [%]				Volume [million m3/year]			Proportion of volume [%]		
Stream 1: Sewers	[9]	74.1%	E		[14]	210.05400	C	74.6	C	[14] / [8]
Stream 2: Septic tanks	[10]	11.9%	E		[15]	33.82850	C	12.0	C	[15] / [8]
Other improved facilities	[11]	13.5%	E		[16]	37.33775	C	13.3	C	[16] / [8]
Unimproved facilities	[12]	0.4%	E		[17]	0.23387	C	0.1	C	[17] / [8]
Open defecation	[13]	0.0%	E		[18]	0.00000	C	0.0	C	[18] / [8]
				Total:	[8]	**281.45412**	C	100.0	C	

Wastewater streams

Proportions of population (estimates by the JMP, 2022)

Total volume of household wastewater generated [8]

Disaggregation of the total volume of household wastewater generated

The disaggregation of [8] into volumes by stream via Method 2 is demonstrated as follows for sewers [14], using the Belarus country file as an example. As [9] < [2] (refer to Box 2 for the data associated with variables [1] to [8]) the entire volume of household wastewater attributable to households with sewer connections is associated with on-site water supply and the corresponding water use of 101.8 litres/person/day. Therefore, [14] is computed as:

9,535 [1] x 74.1% [9] x 101.8 [4] x 365 x 80% [7] = 210 million m^3/year

2.6 SAFELY TREATED HOUSEHOLD WASTEWATER

2.6.1 OVERVIEW

The calculation of the total volume of household wastewater *safely treated* (*STWW_VOL* [36]) is dependent on two key concepts, as represented in Figure 1:

1. Delivery of collected flows to a treatment facility;
2. Safe treatment and discharge of flows from the treatment facility.

2.6.2 WASTEWATER DELIVERY TO TREATMENT

Once the volumes of wastewater generated by households with sewer connections [14] and septic tanks [15] have been calculated (equivalent to the volumes collected in sewer lines and septic tanks, respectively), the proportions of each that are *delivered* to treatment facilities are subsequently determined. For the sewer wastewater stream (Stream 1), flows that are collected in sewers but are discharged directly to water bodies without treatment (due to the lack of existing WWTP facilities, storm overflows in combined sewer systems,[5] or bypasses of WWTPs due to dysfunctionality or systems operating above capacity) are classified as not delivered to treatment. The proportion of collected sewer flows that are delivered to WWTPs is represented by variable [19].

For the septic tank wastewater stream (Stream 2), most flows consist of a liquid wastewater fraction that is treated by the septic tank system itself. The solid fraction of fecal sludge which accumulates in tanks represents a minority of the wastewater flows, which requires periodic emptying and further treatment. For septic tank wastewater flows (Stream 2) to be considered *'delivered to treatment'* the following conditions must hold true:

1. Flows must be effectively contained in a well-designed, maintained and functioning system which does not regularly or intermittently contaminate the surface environment,[6] as characterized in [22];
2. The liquid fraction must be adequately treated in the septic tank system through infiltration into a soak pit or leach field, while the solid fraction (fecal sludge) must either be:
   i) Emptied and buried on-site [23];
   ii) Stored in situ (unemptied in the tank; [26]) (Stream 2a); or
   iii) Emptied and removed off-site by a service provider [25] and delivered to a WWTP [27] (Stream 2b).

Aspects of household wastewater delivery to treatment are depicted in Figure 1 and represented in Part C of the country files - an example of which is presented in Box 4.

[5] Sewer systems that collect and combine both rainwater stormflow and sewage in the same conduit

[6] Septic tank effluent pipes may discharge directly to open drains or to the open ground, rather than into the ground through leach fields or soak pits, or directly into sewers. Systems may also overflow due to poor maintenance or flooding. Flows associated with such conditions are considered not contained and not delivered to treatment (and therefore not safely treated).

BOX 4: Delivery and treatment of wastewater flows

Part C of the country file presents the variables associated with delivery to treatment and subsequent safe treatment, an example of which is presented below for Belarus.

Delivery to treatment

The proportion of sewer flows delivered to WWTPs [19] was not reported for Belarus, and therefore the standard assumption of 100% was employed. For septic tanks, the proportion of septic tank flows associated with septic tanks that did not properly contain wastewater and/or faecal sludge [22] was also not reported, and the standard assumption of 50% was used. A Multiple Indicator Cluster Survey was administered in 2019 – led by the National Statistical Committee – and included survey questions on septic tank emptying [23-26]. Regarding off-site disposal of fecal sludge, an estimated 3% of septic tanks had their fecal sludge unsafely disposed of to the surrounding local environment while 84% were emptied by a service provider with the sludge taken away. The proportion of septic tanks for which this sludge was delivered to a WWTP was not reported, and a standard assumption of 100% was employed.

Variable name		Variable ID	Value	Units	Code
Stream 1: Sewer wastewater flows					
	Volume of sewer wastewater generated	[14]	210.05400	Million m3/year	C
	Sewer wastewater as a proportion of total household wastewater generated	--	74.6	Percentage	C
	Proportion delivered to treatment plants	[19]	100.0	Percentage	A
	Proportion of delivered that is safely treated (by compliance) at treatment plants	[20]	99.8	Percentage	R
	Proportion of delivered that is safely treated (by technology) at treatment plants	[21]		Percentage	
Stream 2: Septic tank wastewater flows					
	Volume of septic tank wastewater generated	[15]	33.82850	Million m3/year	C
	Septic tank wastewater as a proportion of total household wastewater generated	--	12.0	Percentage	C
	Proportion of tanks with wastewater collected and contained	[22]	50.0	Percentage	A
Stream 2a: Septic tank wastewater treatment and off-site disposal					
	Proportion of tanks with faecal sludge emptied and discharged locally	[24]	2.7	Percentage	R
	Proportion of tanks with faecal sludge emptied and removed off-site	[25]	84.1	Percentage	R
	Proportion of tanks with faecal sludge removed off-site and delivered to off-site treatment plants	[27]	100.0	Percentage	A
	Proportion of tanks with faecal sludge delivered to and safely treated at off-site treatment plants	[28]	99.8	Percentage	A
Stream 2b: Septic tank wastewater treatment and on-site disposal					
	Proportion of tanks with faecal sludge emptied and buried on-site	[23]	7.4	Percentage	R
	Proportion of tanks with faecal sludge not yet emptied	[26]	5.7	Percentage	R

Safe treatment

The proportion of sewer flows delivered to WWTPs and subsequently safely treated [20] was reported to be 99.8% by the National Statistical Committee in terms of meeting Belarus' wastewater discharge compliance requirements. Countries may report treatment either with respect to compliance with effluent standards [20] or by treatment technology [21]. Where available, WHO gives preference to [20] over [21], and therefore [21] is left blank in the Belarus country file.

In Belarus, no data on delivery of fecal sludge to treatment plants [27], or subsequent treatment [28], were reported. In such cases, [27] is assumed to be 100%. If sewer flows are greater than septic tank flows (which is the case in Belarus), the methodology assumes the same performance for septic tank flows safely treated at WWTPs as for sewer flows safely treated at WWTPs. Therefore, [28] equals [20] but [28] is coded as an assumption.

The volume of household wastewater in sewers that is delivered to WWTPs [29][7] is determined using Equation 3:

$$SEW\_DEL\_TRT\_VOL = SEW\_VOL \times SEW\_DEL\_WWTP\_PCT \quad \text{(Equation 3)}$$

where,

- $SEW\_DEL\_TRT\_VOL$ is the volume of household wastewater from sewers delivered to WWTPs (million m^3/year; [29]);
- *SEW_VOL* is the volume of household wastewater generated by households with sewer connections (million m^3/year; [14]); and
- *SEW_DEL_WWTP_PCT* is the proportion of household sewer wastewater that is delivered to WWTPs (%; [19]).

Data on the proportion of household sewer wastewater delivered to WWTPs [19] is most often computed in population-based terms (and used as a proxy for volumetric flows) as the ratio of the proportion of households connected to WWTPs to the proportion of households connected to sewers.[8] Occasionally, data on [19] can be derived from volumetric data, but only in cases where it be reasonably assumed that the ratio of total urban wastewater generated to that delivered to WWTPs serves as valid proxy for household flows. For those countries where [19] has not been reported, a default assumption of 100% is employed.[9]

In Stream 2a, where septic tank derived fecal sludge is transported off-site, the volume of septic tank wastewater delivered to treatment [30] is calculated as the product of the volume collected in septic tanks [15], the proportion contained [22], the proportion where fecal sludge has been emptied and removed off-site [25], and the proportion of removed fecal sludge that has been delivered to a treatment facility [27], as per Equation 4:

$$SEP\_OFF\_DEL\_TRT\_VOL = SEP\_VOL \times SEP\_CONT\_PCT \times SEP\_OFF\_EMPT\_PCT \times SEP\_OFF\_DEL\_WWTP\_PCT \quad \text{(Equation 4)}$$

where,

- $SEP\_OFF\_DEL\_TRT\_VOL$ is the volume of septic tank wastewater for which fecal sludge has been emptied and delivered to a treatment facility (million m^3/year; [30]*);*
- SEP_VOL is the volume of septic tank wastewater generated (million m^3/year; [15]);
- SEP_CONT_PCT is the proportion of septic tank wastewater contained (% [22]);
- $SEP\_OFF\_EMPT\_PCT$ is the proportion of contained septic tank wastewater for which fecal sludge has been emptied and removed off-site (%; [25]); and
- $SEP\_OFF\_DEL\_WWTP\_PCT$ is the proportion of contained septic tank wastewater for which fecal sludge has been emptied, removed off-site and subsequently delivered to a treatment facility (%; [27]).

In Stream 2b, where septic tank derived fecal sludge remains on-site, the volume of septic tank wastewater delivered to treatment [31] is a function of the proportion contained [22] and the combined proportion for

[7] Note: This variable is not equal to the total volume of wastewater inflow at WWTPs, which would also include flows from non-household sources.
[8] These two variables are commonly reported by countries to the UNSD/UNEP Environmental and OECD/Eurostat Joint Inland Waters questionnaires.
[9] This assumption is likely to be more accurate in high income countries and potentially less accurate in low- and middle-income countries where sewers may more commonly discharge directly into the environment.

which fecal sludge has been either: 1) emptied and buried on-site [23]; or 2) not yet emptied (remaining stored in situ in the septic tank system) [26], as per Equation 5:

$$SEP\_ON\_DEL\_TRT\_VOL = SEP\_VOL \times SEP\_CONT\_PCT \times [SEP\_ON\_BUR\_PCT + SEP\_ON\_NOEMPT\_PCT] \quad \text{(Equation 5)}$$

where,

- *SEP_ON_DEL_TRT_VOL* is the volume of septic tank wastewater for which fecal sludge remains on-site and is considered delivered to treatment (million m^3/year; [31]);
- *SEP_VOL* is the volume of septic tank wastewater generated (million m^3/year; [15]);
- *SEP_CONT_PCT* is the proportion of septic tank wastewater contained (%; [22]);
- *SEP_ON_BUR_PCT* is the proportion of contained septic tank wastewater for which fecal sludge has been emptied from the tank and buried on-site (%; [23]); and
- *SEP_ON_NOEMPT_PCT* is the proportion of contained septic tank wastewater for which fecal sludge has not yet been emptied and remains in situ (resides within the tank system) (%; [26]).

Reported data on septic tank containment are uncommon, but for some countries are derived from sanitary inspection programmes. Efforts are being made to systematize the assessment of containment and integrate into routine data collection instruments.[10] In the absence of reported data, an assumption that 50% of septic tank wastewater flows are effectively contained can be used.

Septic tank emptying and fecal sludge disposal conditions are characterized by four variables (which sum to 100% for the sub-set of households with septic tanks), as follows:

1. *SEP_ON_BUR_PCT* [23];
2. *SEP_LOCAL_PCT* [24] (the proportion of contained septic tank wastewater with fecal sludge emptied and disposed of locally to the surrounding environment);[11]
3. *SEP_OFF_EMPT_PCT* [25]; and
4. *SEP_ON_NOEMPT_PCT* [26].

Reported data on the prevalence of septic tank emptying and fecal sludge disposal characteristics are relatively common, and are typically derived from household surveys (and occasionally from septic tank inspection programmes).[12] Efforts have been made by the JMP to standardize the terminology and methods used in such household questionnaires to promote international comparability and support global level monitoring. Standardized household questions associated with septic tank emptying are presented in Box 5. Answer options and their corresponding data input variables for global wastewater monitoring are also presented.

Calculations for the volumes of wastewater delivered to treatment in each of wastewater streams 1, 2a, and 2b are presented in Part D of the country files, an example of which is presented in Box 6.

[10] Notably the safely managed on-site sanitation (SMOSS) pilot programme administered by the JMP (https://washdata.org/monitoring/sanitation/safely-managed-on-site-sanitation)
[11] Considered to not be safely treated, and therefore does not appear in Equation 5
[12] Notably the global Multiple Indicator Cluster Surveys, and the Demographic and Health Surveys

BOX 5: Standard containment related emptying questions and answer options from the Multiple Indicator Cluster Survey 7 and corresponding mapping onto household indicator 6.3.1 variables

1. Has your ***<containment>*** ever been emptied?
    a. Yes, emptied
    b. Never emptied
    c. Not emptied but covered and left undisturbed when full
    d. Don't know

    [(SEP_ON_NOEMPT_PCT [26]) = b + c + d]

2. If yes, the last time it was emptied, where were the contents emptied to?
    a. Removed off-site (to treatment / unknown) ***(SEP_OFF_EMPT_PCT [25])***
    b. Removed to a waterbody, open ground, field or elsewhere
    c. Buried in a covered pit at or near household (in situ)
    d. Buried in an uncovered pit
    e. Emptied by the household, to an uncovered pit, open ground, water body or elsewhere
    f. Other

    [(SEP_LOCAL_PCT [24]) = b + d + e + f]

    [(SEP_ON_BUR_PCT [23]) = c]

BOX 6: Household wastewater flows delivered to treatment

Part D of the country file presents the computations for the total volume of sewer [29], septic tank with off-site fecal sludge [30], and septic tank with on-site fecal sludge [31] delivery to treatment, for which an example is given for Belarus below.

Variable name	Volume [million m3/year]			Proportion of total household wastewater generated (%)			Proportion of volume generated in each wastewater stream (%)		
Stream 1: Sewers delivered to wastewater treatment plants	210.05400	C	[29] = [14] x [19]	74.6%	C	[29] / [8]	100.0%	C	[29] / [14]
Stream 2a: Collected in septic tanks with faecal sludge delivered to off-site wastewater treatment plants	14.23025	C	[30] = [15] x [22] x [25] x [27]	5.1%	C	[30] / [8]	42.1%	C	[30] / [15]
Stream 2b: Collected in septic tanks with faecal sludge delivered to on-site treatment	2.22725	C	[31] = [15] x [22] x ([23] + [26])	0.8%	C	[31] / [8]	6.6%	C	[31] / [15]
Total delivered to treatment	**226.51150**	C	[32] = [29] + [30] + [31]	**80.5%**	C	[32] / [8]	-		-

Computations of household wastewater volumes delivered to various forms of treatment

Supplemental statistics (proportion by total generated and by total in each wastewater stream)

Variables [29] through [32] are calculated through simple arithmetic combinations of variables that have previously been calculated. A few supplementary statistics, without variable numbers, are calculated for convenience: the proportion of each household water stream which is delivered to treatment, either as a fraction of total household wastewater flows [8], or as a fraction of the volume collected in sewers [14] or septic tanks [15].

2.6.3 WASTEWATER TREATMENT

Once the volumes of household wastewater delivered to treatment facilities associated with wastewater streams 1 [29], 2a [30], and 2b [31] are calculated, the corresponding proportion of delivered wastewater that is *safely treated* is determined. For flows associated with household wastewater delivered to treatment to be subsequently classified as safely treated, they must either pass through secondary or higher treatment processes or meet relevant discharge standards. In the absence of such data by compliance with discharge standards, the proportion of flows treated by secondary or higher processes (which are more commonly reported) are accepted and used as a proxy.[13] The volume of sewer wastewater that is safely treated is therefore determined as follows, in Equation 6:

$$SEW\_STWW\_VOL = SEW\_DEL\_TRT\_VOL \times SEW\_ST\_WWTP\_CMP/TCH\_PCT \quad \text{(Equation 6)}$$

where,

- *SEW_STWW_VOL* is the volume of household wastewater from sewers that has been safely treated (million m^3/year; [33]);
- *SEW_DEL_TRT_VOL* is the volume of household wastewater from sewers delivered to WWTPs (million m^3/year; [29]), and
- *SEW_ST_WWTP_CMP/TCH_PCT* is the proportion of household sewer wastewater delivered to WWTPs that has been subsequently safely treated - [20], by compliance and [21], by technology/treatment process.

Wastewater treatment performance data for sewer flows commonly originates from WWTPs themselves and are aggregated to national level by a country's wastewater regulator, relevant line ministry, or NSO. WWTPs may be classified by the highest level of treatment technology or process that they employ, and total annual throughput for the WWTP would then be assigned to this corresponding level of treatment. For treatment performance by compliance, the proportion of wastewater effluence tests passing or failing at facility or regional/national level may be used to determine the proportion of national flows in compliance. Data on volumetric flows may be indicative of total urban wastewater (combined domestic, industrial, runoff wastewater in sewers), rather than household flows. However, as these wastewater flows are generally homogenized in sewers, their respective proportion safely treated should be approximately the same. Finally, wastewater performance data may be reported in terms of the proportion of the population connected to WWTPs with different levels of treatment processes. In such cases, proportions of population can be used to infer proportions of volumes, as a proxy.

Annex D presents an overview of septic tank (and corresponding solid fraction) treatment processes and methods and their corresponding level of treatment. In Stream 2a, where septic tank derived fecal sludge is transported off-site, the volume of septic tank wastewater safely treated is a function of the proportion of that delivered to treatment facilities which are subsequently safely treated [28]. The volume of septic tank wastewater for which fecal sludge is safely treated off-site is determined as follows, in Equation 7:

$$SEP\_OFF\_STWW\_VOL = SEP\_OFF\_DEL\_TRT\_VOL \times SEP\_OFF\_ST\_WWTP\_PCT \quad \text{(Equation 7)}$$

where,

- *SEP_OFF_STWW_VOL* is the volume of safely treated septic tank wastewater for which fecal sludge has been safely treated at treatment facilities (million m^3/year; [34]);

[13] Primary treatment alone is not considered safe treatment in most cases – the only exception being discharges conveyed through a long ocean outfall.

- *SEP_OFF_DEL_TRT_VOL* is the volume of septic tank wastewater for which fecal sludge has been emptied and delivered to treatment facilities (million m^3/year; [30]); and
- *SEP_OFF_ST_WWTP_PCT* is the proportion of septic tank wastewater for which fecal sludge has been delivered to treatment facilities and subsequently safely treated (%; [28]).

Wastewater treatment performance data for septic tank derived fecal sludge (at WWTPs or separate treatment facilities dedicated to fecal sludge) [28] is extremely rarely reported by countries – due to the difficulty in its measurement or estimation and the lower priority typically applied to septic tank data compared to sewer data. When data on [28] are not available, reported data from either [20] or [21] can be used as a proxy – inferring that treatment performance of sewer wastewater flows at WWTPs would be approximately equal to that of fecal sludge flows. However, this assumption is only employed when total septic tank flows [15] are not dominant in the country (i.e. are less than that of sewer flows [14])

In Stream 2b, where septic tank flows have been contained and fecal sludge remains stored in situ or is buried on-site, all volumes are assumed (for the purpose of the estimation) to be safely treated. Volumes of sludge remaining unemptied in septic tanks do not pose and have not posed an emptying or post-emptying related risk. For septic tanks where sludge has not been emptied, the performance of the septic tank can be impaired, leading to unsafe containment (as commonly evidenced by overflow or the clogging of leach fields). Likewise, some septic tanks are not connected to infiltration systems, and discharge effluent directly to the environment. Such circumstances should not be counted as safely treated, and would be captured in the containment variable [22]. However, if the wastewater is effectively contained, then all flows through septic tanks with infiltration systems, that have never been emptied are counted as safely treated.

Septic tank flows associated with fecal sludge that has been emptied and buried on-site are counted as 'safely treated' on the basis that some treatment has already occurred in the tank and additional treatment will occur after burial (culminating in a level of treatment commensurate with secondary or higher processes).[14] The volume of safely treated septic tank wastewater for which fecal sludge is safely treated on-site is therefore equal to the corresponding volume of wastewater that is delivered to treatment, as determined by Equation 8:

$$SEP\_ON\_STWW\_VOL = SEP\_ON\_DEL\_TRT\_VOL \qquad \text{(Equation 8)}$$

where,

- *SEP_ON_STWW_VOL* is the volume of safely treated septic tank wastewater for which fecal sludge has been safely treated on-site (million m^3/year; [35]) and
- *SEP_ON_DEL_TRT_VOL* is the volume of septic tank wastewater for which fecal sludge has been delivered to on-site treatment (million m^3/year; [31]).

The methodology and calculation for safely treated on-site septic tank flows assumes that contained flows subsequently processed by the septic tank (liquid fraction) and buried or stored in situ (solid fraction; fecal sludge) are being treated to levels commensurate to secondary (biological) treatment. However, actual levels of treatment depend on the characteristics of each septic tank system, whether an outlet pipe discharges liquids to a leach field, soak pit, or drain to sewer,[15] related operation and maintenance conditions, the soil conditions to which liquid fractions are discharged, and the safety of fecal sludge burial (which may be dependent on its composition, the depth to which it is buried and covered, and its conditions in situ). These

[14] Further research is required to understand the treatment efficacy associated with septic tank systems and faecal sludge disposal in a range of operational conditions and environments in order to confirm the appropriateness of existing assumptions or support their revision.
[15] Not always commonly constructed, particularly in high density urban areas without a public sewer network

technical and specific elements are not fully captured by on-site sanitation monitoring and remain an area for further study and refinement of the methodology.

The safely treated wastewater components of the conceptual framework are represented in Part D of the country files (an example of which is provided in Box 4). Calculations for the volumes of wastewater safely treated in each of wastewater streams 1, 2a, and 2b are presented in Part E of the country files, an example of which is presented in Box 7.

Once the volumes of household wastewater safely treated for each of wastewater streams 1 [33], 2a [34], and 2b [35] have been calculated, they are summed to calculate the total volume of safely treated household wastewater [36].

BOX 7: Calculations of total household wastewater safely treated

Part E of the country files presents the calculations for the total volume of sewer [33], septic tank with off-site fecal sludge [34], and septic tank with on-site fecal sludge [35] safely treated, for which an example is given for Belarus. In Belarus, 226 million m^3 of wastewater were calculated to be safely treated [36]. Since 281 million m^3 of household wastewater were generated [8], the resulting country estimate [40] is calculated as 80.3%.

Proportional statistics (by total generated and by total in each wastewater stream)

Country estimate

Variable name	Volume [million m3/year]			Proportion of total household wastewater generated (%)			Proportion of volume generated in each wastewater stream (%)		
Stream 1: Safely treated from sewers at wastewater treatment plants	209.62016	C	[33] = [29] x [20] or [21]	74.5%	C	[37] = [33] / [8]	99.8%	C	[33] / [14]
Stream 2a: Safely treated at septic tanks with faecal sludge safely treated at off-site wastewater treatment plants	14.20086	C	[34] = [30] x [28]	5.0%	C	[38] = [34] / [8]	42.0%	C	[34] / [15]
Stream 2b: Safely treated at septic tanks with faecal sludge safely treated at on-site treatment	2.22725	C	[35] = [31] x 100%	0.8%	C	[39] = [35] / [8]	6.6%	C	[35] / [15]
Total safely treated	**226.048**	C	[36] = [33] + [34] + [35]	**COUNTRY ESTIMATE (SDG 6.3.1): 80.3%**	C	[40] = [36] / [8]	-		-
Are data sufficient to compute a country estimate?	**Yes, since the volume of sewer wastewater generated [14] is greater than the volume of septic tank wastewater generated [15], and data on sewer wastewater treatment performance [20]/[21] are reported**								

2.7 PROPORTION OF HOUSEHOLD WASTEWATER SAFELY TREATED

2.7.1 COUNTRY ESTIMATES

The country estimate – represented as the proportion of total household wastewater generated that has been subsequently safely treated [40] – is computed as per Equation 1. Calculations for the proportion of wastewater safely treated in each of wastewater streams 1, 2a, and 2b and the overall country estimates are presented in Part E of the country files, an example of which is presented in Box 7.

Country estimates are only calculated and published if either:

1. The volume of wastewater generated by households with a sewer connection [14] is *greater* than that for those with septic tank connections [15], *and* there is reported data for the country on the proportion of household sewer wastewater delivered to WWTPs that is subsequently safely treated ([20] by compliance or [21] by technology]); or
2. The volume of wastewater generated by households with a septic tank connection [10] is *greater* than that for sewers [14], *and* there are reported data for the country on emptying conditions associated with septic tank fecal sludge [23-26].

If neither condition 1 nor condition 2 is met, country estimates are not presented nor published due to insufficient reported data. Country files are only published and made available to the public online if there is at least one reported data point related to the dominant households wastewater flow (i.e. sewer or septic).

2.7.2 GLOBAL AND REGIONAL ESTIMATES

Global and regional estimates of the proportion of household wastewater safely treated are computed based on the country estimates. For those countries and territories that do not have a country estimate (because their datasets did not meet the criteria outlined in Section 2.7.1), estimates of the proportion of household wastewater safely treated [40] are imputed (STWW_IMP_PCT) from the corresponding regional (M49 sub-region[16]) average, with country estimates weighted by total household wastewater generated [8]. The total volume of household wastewater safely treated (STWW_IMP_VOL) is subsequently calculated as per Equation 9:

$$STWW\_IMP\_VOL = STWW\_IMP\_PCT \times GEN\_VOL \qquad \text{(Equation 9)}$$

where,

- *STWW_IMP_VOL* is the total estimated volume of household wastewater safely treated (million m^3/year) based on the imputed regional average;
- *STWW_IMP_PCT* is the imputed regional M49 average for the proportion of household wastewater safely treated (%); and
- *GEN_VOL* is the total estimated volume of household wastewater generated (million m^3/year; [8]) which is available for all countries.[17]

[16] A smaller regional classification than the SDG region, and as defined by the United National Standard Country or Area Code Series M, No.49 (commonly referred to as M49; https://unstats.un.org/unsd/methodology/m49/)

[17] Recall from Section 2.2, that the total volume of household wastewater generated [8] is estimated for all countries and territories

Global and regional estimates of the proportion of household wastewater safely treated have been subsequently determined as follows in Equation 10:

$$STWW\_PCT = \frac{\sum STWW\_IMP\_VOL \ + \sum STWW\_VOL}{\sum GEN\_VOL} \qquad \text{(Equation 10)}$$

where,

- *STWW_PCT* is the global or regional estimate of the proportion of household wastewater safely treated (%),
- $\sum STWW\_IMP\_VOL$ is the sum of the imputation associated total volumes of household wastewater safely treated for all countries and territories which did not have an estimate (million m^3/year),
- $\sum STWW\_VOL$ is the sum of the estimated total volumes of household wastewater safely treated for all countries and territories in the region (million m^3/year), and

- $\sum GEN\_VOL$ is the sum of the estimated total volumes of household wastewater generated for all countries and territories in the region (million m^3/year).

Imputed country estimates are only used for the purpose of calculating global and regional estimates and are not presented as individual country estimates. For each global or regional estimation, the corresponding data coverage – represented by the proportion for which published country estimates [40] were represented within the region - are calculated across the following three dimensions:

1. Number of countries;
2. Population; and
3. Volume of household wastewater generated

Regional estimates (including for SDG regions and the world) are only presented if data coverage by volume of household wastewater generated is greater than 50%. Other variables in the conceptual framework are not imputed, and therefore summing published country volumes and computing corresponding regional or global proportions would not represent globally representative totals.

ANNEXES

ANNEX A – GLOSSARY OF TERMS AND DEFINITIONS RELEVANT TO GLOBAL HOUSEHOLD WASTEWATER MONITORING

Term	Definition
Wastewater[a, b, c]	Water which is of no further immediate value to the purpose for which it was used because of its quality, quantity or time of occurrence. Cooling water is not considered to be wastewater.
Total wastewater generated[a, b]	Total volume of wastewater generated by economic activities (agriculture, forestry and fishing; mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; and other economic activities) and households. Cooling water is excluded.
Industrial wastewater[a, c]	Water discharged after being used in, or produced by, industrial production processes and which is of no further immediate value to these processes. Where process water recycling systems have been installed, process wastewater is the final discharge from these circuits. To meet quality standards for eventual discharge into public sewers, this process wastewater is understood to be subjected to ex-process in-plant treatment. Cooling water is not considered here. Sanitary wastewater and surface run-off from industries are also excluded here.
Domestic wastewater[a, c]	Wastewater from residential settlements and services which originates predominantly from the human metabolism and from household activities.
Greywater	Household derived wastewater that has not come in contact with excreta and is typically derived from sinks, drains, laundry machines, or other non-excreta related functions and facilities.
Urban (municipal) wastewater[a, c]	Domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or runoff rain water.
Urban (municipal) wastewater collecting system[c]	A system of conduits which collects and conducts urban or municipal wastewater. Collecting systems are often operated by public authorities or semi-public associations.
Independent wastewater collecting system[c]	Individual private systems and operations in place to evacuate and collect domestic and other wastewater in cases where a collective/public/urban collecting system is not available or not justified because it would either produce no environmental benefit or involve excessive cost. This includes in particular the transport of wastewater from storage tanks to treatment plants by means of trucks.
Wastewater treatment[a]	Process to render wastewater fit to meet applicable environmental standards or other quality norms for recycling or reuse.
Other (industrial) wastewater treatment[a, b, c]	Treatment of wastewater in any non-public treatment plant, e.g. industrial wastewater treatment plants (IWWTPs). Excluded from "other wastewater treatment" is the treatment in septic tanks. IWWTPs may also be classified under ISIC 37 (Sewerage) or under the main activity class of the industrial establishment they belong to.
Urban wastewater treatment[a, b, c]	Treatment of urban or municipal wastewater in urban (centralized) wastewater treatment plants (WWTP's). Urban (centralized) WWTP's are usually operated by public authorities or by private companies working by order of public authorities. It includes wastewater delivered to treatment plants by trucks.
Independent treatment[a, b, c]	Facilities for preliminary treatment, treatment, infiltration or discharge of domestic wastewater from dwellings generally between 1 and 50 population equivalents, not connected to an urban wastewater collecting system. Examples of such systems are septic tanks. Excluded are systems with storage tanks from which the wastewater is transported periodically by trucks to an urban (centralized) wastewater treatment plant.
Primary treatment[a, b, c]	Treatment of wastewater by a physical and/or chemical process involving settlement of suspended solids, or other process in which the Biochemical Oxygen Demand

	(BOD_5) of the incoming wastewater is reduced by at least 20% before discharge and the total suspended solids of the incoming wastewater are reduced by at least 50%.
Secondary treatment[a, b, c]	Post-primary treatment of wastewater by a process generally involving biological treatment with a secondary settlement or other process, resulting in a Biochemical Oxygen Demand (BOD_5) removal of at least 70% and a Chemical Oxygen Demand (COD) removal of at least 75%. Natural biological treatment processes are also considered under secondary treatment if the constituents of the effluents from this type of treatment are similar to the conventional secondary treatment.
Tertiary treatment[a, b, c]	Treatment (additional to secondary treatment) of nitrogen and/or phosphorous and/or any other pollutant affecting the quality or a specific use of water: microbiological pollution, colour etc. The different possible treatment efficiencies ('organic pollution removal' of at least 95% for BOD_5, 85% for COD, 'nitrogen removal' of at least 70%, 'phosphorous removal' of at least 80% and 'microbiological removal') cannot be added and are exclusive.
Safely treated wastewater	Wastewater that has been treated and discharged in compliance with relevant standards, or has been treated by processes commensurate with secondary or higher treatment

[a] referenced from the Indicator 6.3.1 metadata

[b] referenced from UNSD/UNEP Environmental questionnaire

[c] referenced from the OECD/Eurostat Inland Waters Environmental questionnaire

ANNEX B – LIST OF VARIABLES USED TO COMPUTE A COUNTRY ESTIMATE FOR SAFELY TREATED HOUSEHOLD WASTEWATER

Nº	ID	Description	Units	Data type(s)	Notes
[1]	**POP**	**Country/territory population**	**Population**	**E**	**Estimates sourced from the latest revision of the World Population Prospects published by the Department of Economic and Social Affairs Population Division of the United Nations**
[2]	**POP_WATON_PCT**	**Proportion of population with drinking water supply on-premises**	**Percentage**	**E**	**Estimates published by the JMP**
[3]	**POP_WATOFF_PCT**	**Proportion of population with drinking water supply off-premises**	**Percentage**	**E**	**Estimates published by the JMP**
[4]	**USE_WATON_AVG**	**Average water used by households with on-premises water supply**	**Litres/person/day**	**R/A**	**Assumption of 120 litres/person/day if not reported**
[5]	**USE_WATOFF_AVG**	**Average water used by households with off-premises water supply**	**Litres/person/day**	**R/A**	**Assumption of 20 litres/person/day if not reported**
[6]	USE_VOL	Volume of household water used	million m^3/year	C	[1] x [2] x [4] + [1] x [3] x [5]
[7]	**USE_TO_WW_PCT**	**Proportion of household water use converted into wastewater generated**	**Percentage**	**R/A**	**Assumption of 80% if not reported**
[8]	**GEN_VOL**	**Volume of household wastewater generated**	**million m^3/year**	**R/C**	**Calculated as [6] x [7] if not reported**
[9]	**SEW_PCT**	**Proportion of the population living in households connected to sewers**	**Percentage**	**E**	**Estimates published by the JMP**
[10]	**SEP_PCT**	**Proportion of the population living in households connected to septic tanks**	**Percentage**	**E**	**Estimates published by the JMP**
[11]	**OTHIMP_PCT**	**Proportion of the population living in households with access to other improved sanitation facilities**	**Percentage**	**E**	**Estimates published by the JMP**
[12]	**UNIMP_PCT**	**Proportion of the population living in households with access to unimproved sanitation facilities**	**Percentage**	**E**	**Estimates published by the JMP**
[13]	**OD_PCT**	**Proportion of the population living in households where members practice open defecation**	**Percentage**	**E**	**Estimates published by the JMP**

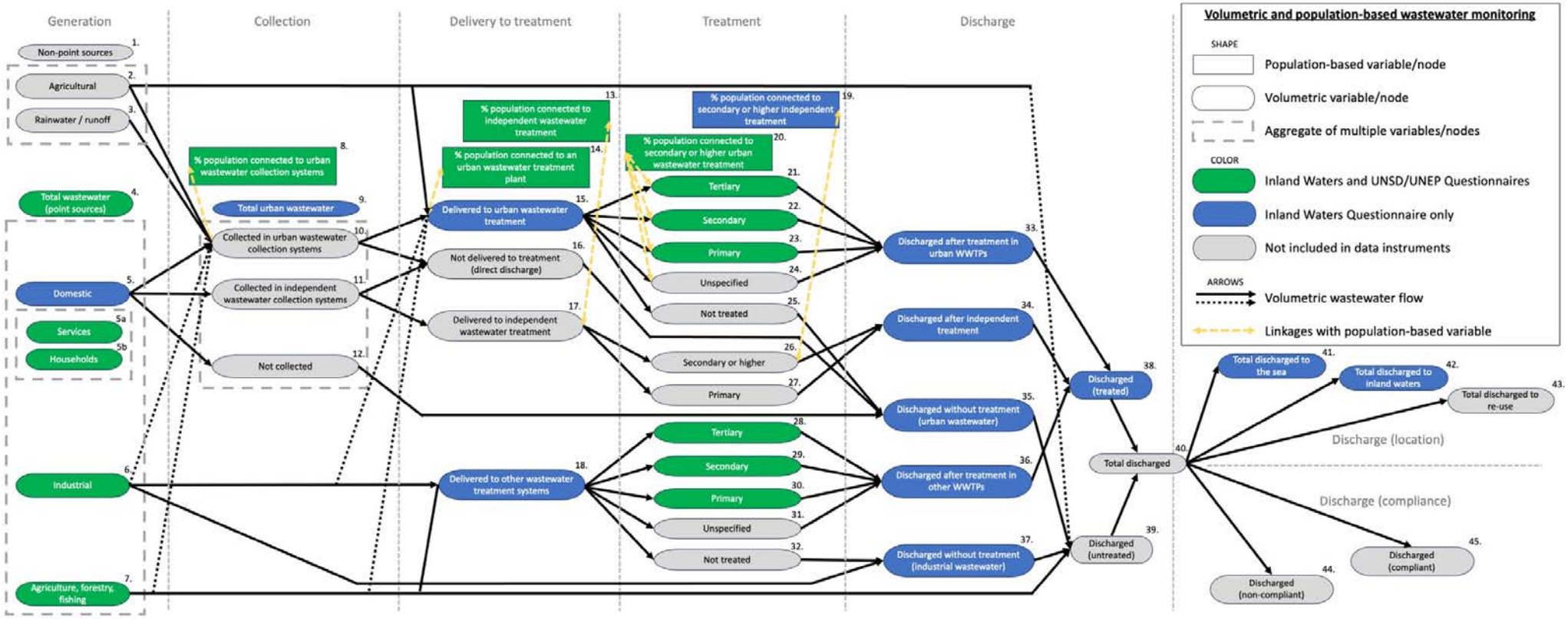
Nº	ID	Description	Units	Data type(s)	Notes
[14]	SEW_VOL	Volume of wastewater generated by households connected to sewers	million m^3/year	C	Distribution of volume generated is typically weighted by volumes associated with on- and off-site water supply as described in Section 2.5
[15]	SEP_VOL	Volume of wastewater generated by households connected to septic tanks	million m^3/year	C	
[16]	OTHIMP_VOL	Volume of wastewater generated by households with access to other improved sanitation facilities	million m^3/year	C	
[17]	UNIMP_VOL	Volume of wastewater generated by households with access to unimproved sanitation facilities	million m^3/year	C	
[18]	OD_VOL	Volume of wastewater generated by households where members practice open defecation	million m^3/year	C	
[19]	**SEW_DEL_WWTP_PCT**	**Proportion of sewer wastewater delivered to treatment plants**	**Percentage**	**R/A**	**Assumption of 100% if not reported**
[20]	**SEW_ST_WWTP_CMP_PCT**	**Proportion of received sewer wastewater safely treated (by compliance) at treatment plants**		**R/A**	**Assumption of 50% if not reported**
[21]	**SEW_ST_WWTP_TCH_PCT**	**Proportion of received sewer wastewater safely treated (by technology) at treatment plants**	**Percentage**	**R/A**	**Assumption of 50% if not reported. Redundant if [20] is reported, as corresponding data by compliance is preferred over that by technology.**
[22]	**SEP_CONT_PCT**	**Proportion of septic tanks with wastewater collected and contained**	**Percentage**	**R/A**	**Assumption of 50% if not reported**
[23]	**SEP_ON_BUR_PCT**	**Proportion of septic tanks with faecal sludge emptied and buried on-site**	**Percentage**	**R/A**	**Assumption of 0% if not reported**
[24]	**SEP_LOCAL_PCT**	**Proportion of septic tanks with faecal sludge emptied and discharged locally (not delivered to treatment)**	**Percentage**	**R/A**	**Assumption of 0% if not reported**
[25]	**SEP_OFF_EMPT_PCT**	**Proportion of septic tanks with faecal sludge emptied and removed off-site**	**Percentage**	**R/A**	**Assumption of 50% if not reported**
[26]	**SEP_ON_NOEMPT_PCT**	**Proportion of septic tanks with faecal sludge not yet emptied**	**Percentage**	**R/A**	**Assumption of 50% if not reported**

Nº	ID	Description	Units	Data type(s)	Notes
[27]	**SEP_OFF_DEL_WWTP_PCT**	**Proportion of septic tanks with faecal sludge removed and delivered to off-site treatment plants**	**Percentage**	**R/A**	**Assumption of 100% if not reported**
[28]	**SEP_OFF_ST_WWTP_PCT**	**Proportion of septic tanks with faecal sludge delivered to and safely treated at off-site treatment plants**	**Percentage**	**R/A**	**If not reported, assumption of [21]/[22] if criteria are met, or 0% if not**
[29]	SEW_DEL_TRT_VOL	Volume of sewer wastewater delivered to wastewater treatment plants	million m^3/year	C	[14] x [19]
[30]	SEP_OFF_DEL_TRT_VOL	Volume of septic tank wastewater collected in septic tanks with faecal sludge delivered to off-site treatment plants	million m^3/year	C	[15] x [22] x [25] x [27]
[31]	SEP_ON_DEL_TRT_VOL	Volume of septic tank wastewater collected in septic tanks with faecal sludge remaining on-site	million m^3/year	C	[15] x [22] x ([23] + [26])
[32]	DEL_TRT_VOL	Volume of household wastewater delivered to treatment facilities	million m^3/year	C	[29] + [30] + [31]
[33]	SEW_STWW_VOL	Volume of sewer wastewater safely treated at wastewater treatment plants	million m^3/year	C	[29] x [20] or [21]
[34]	SEP_OFF_STWW_VOL	Volume of septic tank wastewater safely treated in septic tanks with faecal sludge safely treated at off-site treatment plants	million m^3/year	C	[30] x [28]
[35]	SEP_ON_STWW_VOL	Volume of septic tank wastewater safely treated in septic tanks with faecal sludge safely treated on-site	million m^3/year	C	[31] x 100%
[36]	STWW_VOL	Volume of safely treated household wastewater	million m^3/year	C	[33] + [34] + [35]
[37]	SEW_STWW_PCT	Proportion of sewer wastewater safely treated	Percentage	C	[33] / [8]

Nº	ID	Description	Units	Data type(s)	Notes
[38]	SEP_OFF_STWW_PCT	Proportion of septic tank wastewater and faecal sludge safely treated off-site	Percentage	C	[34] / [8]
[39]	SEP_ON_STWW_PCT	Proportion of septic tank wastewater and faecal sludge safely treated on-site	Percentage	C	[35] / [8]
[40]	STWW_PCT	Proportion of safely treated household wastewater	Percentage	C	[36] / [8]; Referred to as the country estimate for domestic SDG indicator 6.3.1

Bold – Indicates the 22 data input variables for which WHO seeks to compile nationally representative officially reported estimates and/or country data

ANNEX C – FLOW DIAGRAM FOR TOTAL, INDUSTRIAL, AND DOMESTIC WASTEWATER MONITORING AS PER UNSD, OECD, AND EUROSTAT DATA INSTRUMENTS



Variable key – Flow diagram and UNSD/UNEP Environmental Questionnaire

Category	Variable	Code in Annex C	UNSD/UNEP Environmental Questionnaire – Water	
			Line in W4	Line in W5
Volume generated	Total wastewater (point sources)	4	1	
	Services wastewater	5a	8	
	Household wastewater	5b	9	
	Industrial wastewater	6	3+4+5+6+7	
	Agricultural wastewater (point sources)	7	2	
Volume treated at urban wastewater treatment plants	Primary treatment	23	11	
	Secondary treatment	22	12	
	Tertiary treatment	21	13	
Volume treated at other wastewater treatment plants	Primary treatment	30	15	
	Secondary treatment	29	16	
	Tertiary treatment	28	17	
Volume treated at independent facilities	Wastewater treated at independent facilities	17	18	
Population	% population connected to urban wastewater collecting system	8		1
	% population connected to an urban wastewater treatment plant	14		2
	% population connected to an urban wastewater treatment plant with secondary or higher treatment	20		3
	% population connected to independent treatment	13		4

Variable key – Flow diagram and OECD/Eurostat Joint Questionnaire on Inland Waters

Category	Variable	Code in Annex C	OECD/Eurostat Joint Questionnaire on Inland Waters Variables	
			Eurostat	OECD
Volume generated	Total wastewater (point sources)	4	GEN_PS	POINT_TOT
	Domestic wastewater	5	GEN_DOM	POINT_DOM
	Services wastewater	5a	GEN_SER	POINT_SER
	Household wastewater	5b	GEN_HH	POINT_HH
	Industrial wastewater	6	GEN_IND	POINT_IND
	Agricultural wastewater (point sources)	7	GEN_AGR	POINT_AGR
	Total urban wastewater	9	GEN_URB	ALL_URB_TOT
Volume treated at urban wastewater treatment plants	Delivered to urban wastewater treatment	15	TRT_URB_IF	ALL_URB_TREAT_TOT
	Secondary/tertiary treatment	21/22	TRT_URB_GE2	ALL_URB_TREAT_TOT_SEC
Volume treated at other wastewater treatment plants	Delivered to other wastewater treatment systems	18	TRT_IND_OTH_IF	ALL_IND_TREAT
	Secondary/tertiary treatment	28/29	TRT_IND_OTH_GE2	ALL_IND_TREAT_SEC
Volume discharged	Discharged after treatment in urban WWTPs	33	DIS_URB_IW_AT	ALL_URB_DIS_TREAT
	Discharged after independent treatment	34	DIS_URB_IW_AIT	ALL_URB_DIS_INDTREAT
	Discharged without treatment (urban wastewater)	35	DIS_URB_IW_NT	ALL_URB_DIS_NOTREAT
	Discharged after treatment in other WWTPs	36	DIS_IND_IW_AT	ALL_IND_DIS_TREAT
	Discharged without treatment (industrial wastewater)	37	DIS_IND_IW_NT	ALL_IND_DIS_NOTREAT
	Total discharged (treated)	38	DIS	ALL_TOT
	Total discharged to the sea	41	DIS_SEA	TOT_SEA
	Total discharged to inland waters	42	DIS_IW	TOT_INLAND
Population	% population connected to urban wastewater collecting system	8	URB_CS	TOTPUBSEW
	% population connected to an urban wastewater treatment plant	14	URB_OTH_CS	PUBTOTTR
	% population connected to an urban wastewater treatment plant with secondary or higher treatment	20	URB_OTH_CS_T2/T3	PUBBIOTR / PUBADVTR
	% population connected to independent treatment	13	IND	INDEPDTR

ANNEX D – SOLID AND LIQUID FRACTION TREATMENT PROCESSES, TECHNOLOGIES, AND LEVELS ASSOCIATED WITH SEPTIC TANK WASTEWATER FLOWS

	Faecal sludge	Wastewater and liquid fraction from faecal sludge
Treated: Advanced treatment (possible for reuse)	**Further drying/ pathogen reduction** • Extended storage • Thermophilic anaerobic digestion • Sludge incineration • Mechanical/thermal drying (e.g. Pelletiser) • Lime or ammonia stabilization • Co-composting, black soldier fly, vermi-composting **Liquid fraction >** As per wastewater treatment	**Advanced and Tertiary treatment** • Advanced oxidation • Membrane filtration • Carbon absorption • Ion exchange • Chemical oxidation • Advanced N, P removal • Disinfection **< Sludge/solid fraction** As per faecal sludge treatment
Treated: Adequate treatment	**Dewatering and/or stabilization of solid fraction** <u>Combined solid/liquid phase or septage</u> • Anaerobic pond, reactors or digestion • Mechanical dewatering (screw press, belt press) • Safe burial/storage (deep row entrenchment) <u>Solid fraction only</u> • Drying beds (planted or unplanted) **Liquid fraction >** • As per wastewater treatment	**Secondary treatment** • Aerobic suspended or attached growth (e.g. AS or trickling filters) • Anaerobic suspended or attached growth (e.g. UASB) • Waste stabilisation ponds • Wetlands **< Sludge/solid fraction** • As per faecal sludge treatment
	The levels above are the threshold for 6.2 and 6.3	
Not adequately treated	**Solid liquid separation only** • Sedimentation (settling-thickening tanks or pond) • Storage / partial treatment (septic tanks)	**Primary treatment** Screening and grit removal with • Sedimentation • Chemical precipitation • Filtration • High rate clarification Flotation
Not treated		