

Sidestream characteristics in water resource recovery facilities: a critical review

Perrine Devos ^a, Ahlem Filali ^b, Paloma Grau ^c, Sylvie Gillot ^{a,*}

^a INRAE, UR REVERSAAL, F-69625, Villeurbanne, France

^b Université Paris-Saclay, INRAE, UR PROSE, F-92761, Antony, France

^c Ceit and Tecnun, Manuel de Lardizabal 15, 20018, San Sebastian, Spain

This study is based on the collection of data from literature. This document describes the dataset organisation, the method for data collection and the value of the data. The dataset is not exhaustive and could be completed with new references.

Data description

As part of sewage sludge handling in WRRFs, sludge thickening and dewatering units result in the production of different types of sidestreams, also called reject water, which are usually recycled to the inlet of the wastewater treatment line. Even if the volumes of sidestreams are generally small, their concentrations in organic and inorganic matters may be different from the composition of the influent and may negatively impact the performance of the facilities. Relatively recent concerns arise with the overall tightening of WRRFs at created opportunities for nutrient recovery. This dataset thus compiles literature data of sidestream characteristics from different locations in WRRFs.

This dataset is available in Data Gouv repository (<https://doi.org/10.57745/FOHRHY>) into 3 files:

- 1) « sidestreams_data »: main data table with all sidestream characteristics (conventional parameters: TSS, COD, BOD₅, Ammonium, Total Phosphorus, Phosphate), ions, pH, flow and metals
- 2) List of references: complete list of references used in « sidestreams_data »
- 3) Data column description: column description of the table « sidestreams_data »

All figures presented in this document have been created with the RStudio software. The code is available in supplementary material.

The dataset contains data from 87 documents:

- 75 peer reviewed papers
- 5 technical reports
- 5 conference proceedings
- 1 PhD thesis
- 1 master thesis.

Each line of the sidestreams_data file corresponds to the concentration of one component or to the proportion of the total inlet flux of one component. It is considered in the following as one data.

Figure 1 shows the breakdown of data according to sidestream sources. The distribution corresponds to the percentage of data (percentage of lines in the file "sidestream_data") according to each sidestream source:

- anaerobic_digestion for sidestreams resulting from the dewatering of digested sludge
- biological_sludge for sidestreams resulting from the thickening of biological sludge
- primary_sludge for sidestreams resulting from the thickening of primary sludge
- THP_anaerobic_digestion for sidestreams resulting from the dewatering of digested sludge preceded by a thermal hydrolysis process (THP)

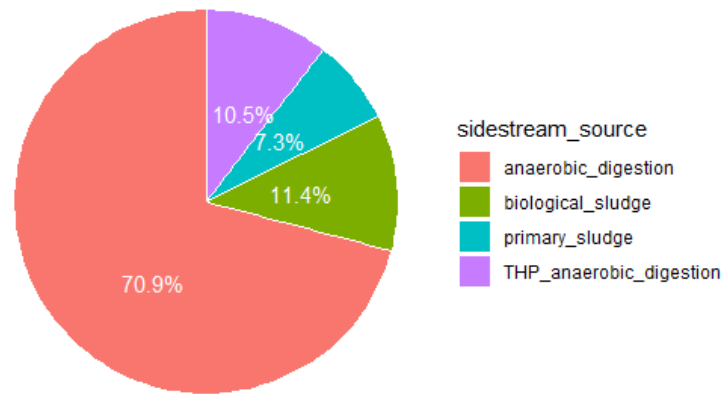


Figure 1 – Sidestream data by source.

Figure 2 and Figure 3 present the number of occurrences of the different secondary treatment types and of the different phosphorus treatment types, respectively.

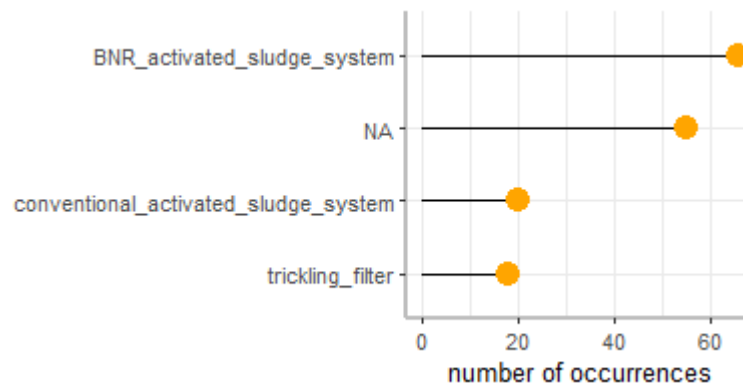


Figure 2 – Secondary treatment types included in the dataset. NA means "information not available for the sample".

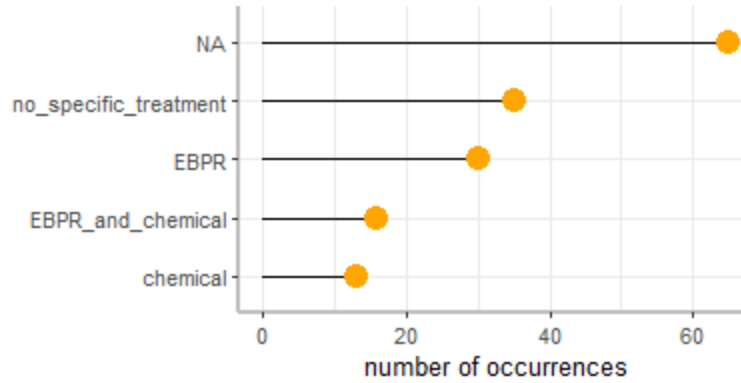


Figure 3 – Phosphorus treatment types included in the dataset. NA means “information not available for the sample”.

The different dewatering and thickening equipment types found in the dataset are presented in Figure 4, Figure 5 and Figure 6.

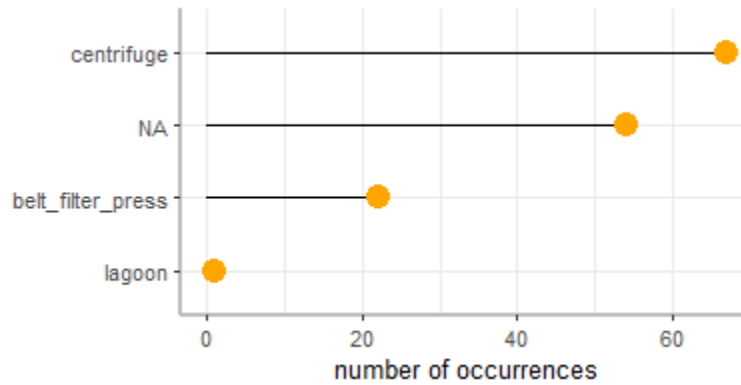


Figure 4 – Distribution of the different dewatering equipment types for anaerobic digestion sidestreams (conventional anaerobic digestion and THP anaerobic digestion). NA means “information not available for the sample”.

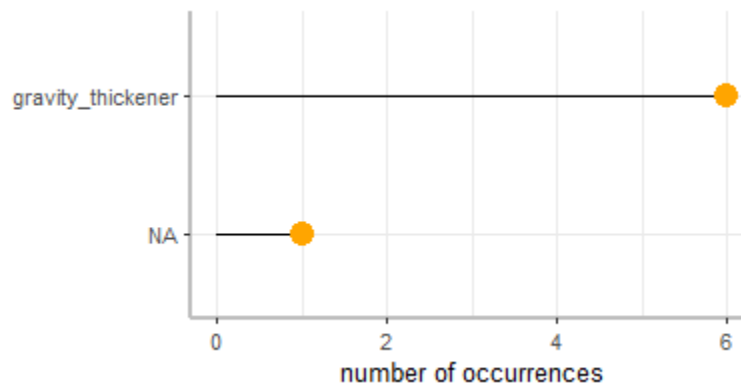


Figure 5 - Distribution of the different dewatering equipment types for primary sludge sidestreams. NA means “information not available for the sample”.

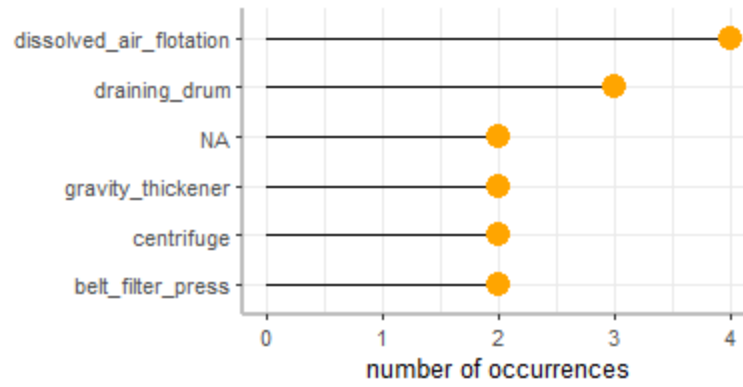


Figure 6 – Distribution of the different thickening equipment types for secondary sludge sidestreams. NA means “information not available for the sample”.

Figure 7 shows the number of occurrences of the 66 characteristics included in the dataset.

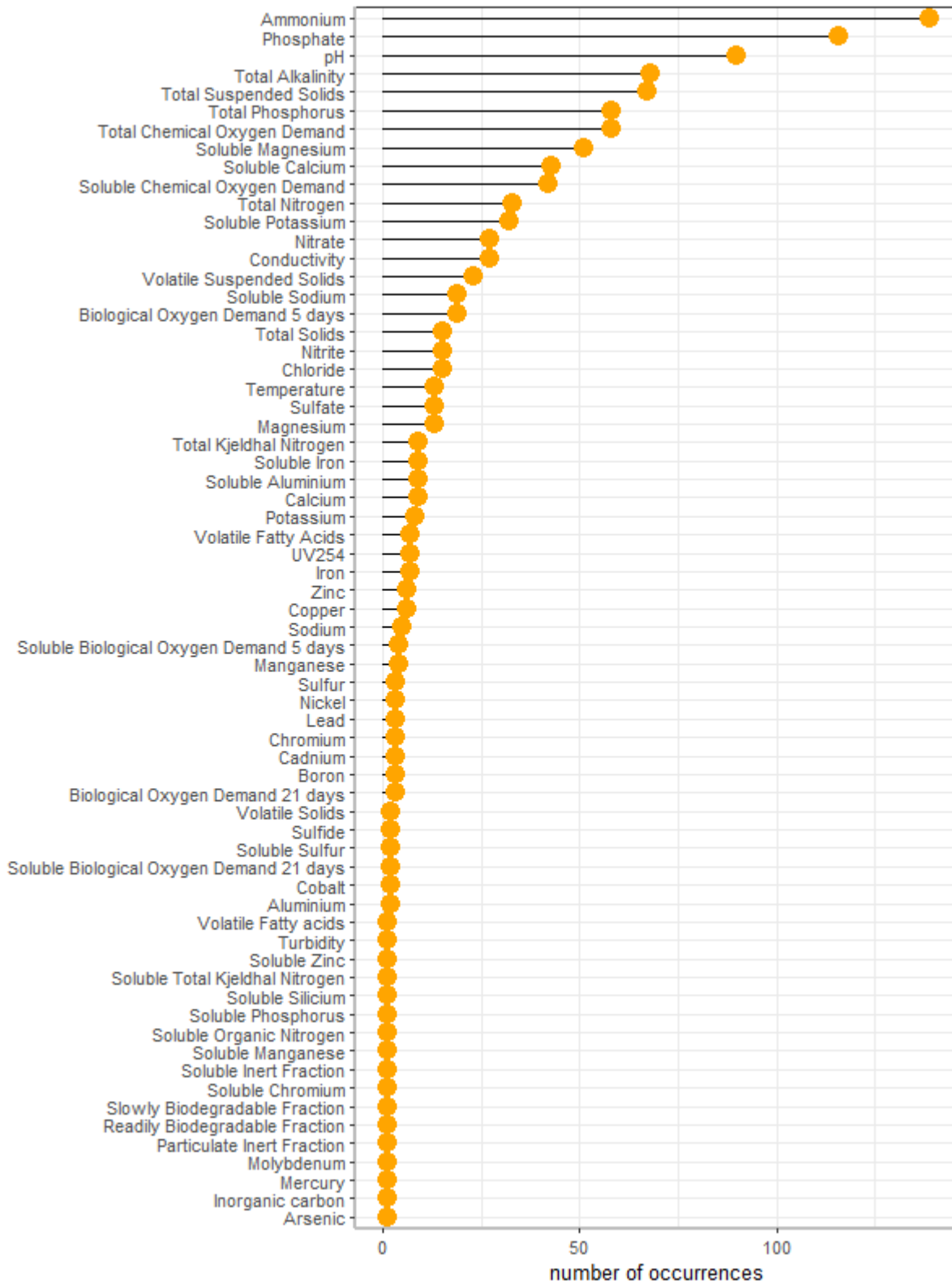


Figure 7 – List of sidestream characteristics compiled in the dataset.

Figure 8 shows the number of occurrences of the different mass flows calculated when information on flows was available both at the inlet of the WRRF and for sidestreams.

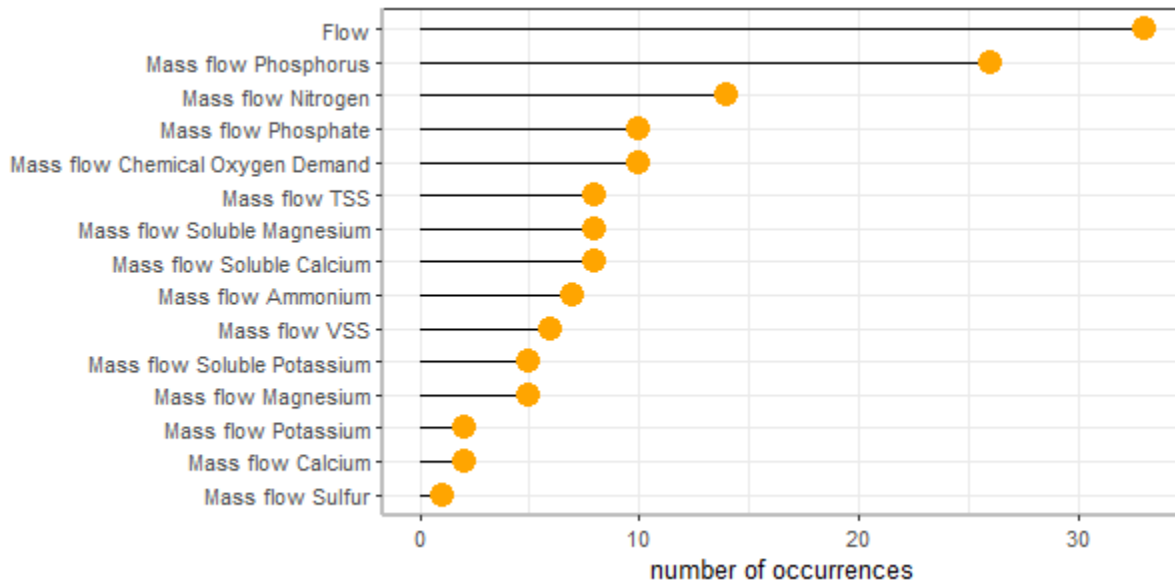


Figure 8 – List of calculated mass flows

Method for data collection

To set up the dataset of sidestream characteristics, SCOPUS database was used. The reference section of the selected research articles were also screened. Few internal documents were also used to complete the dataset.

The research query in SCOPUS was defined with a combination of expressions organised as follow:

- Publications containing the expressions related to sidestreams: sidestream, side-stream, supernatant, centrate, filtrate, reject water, sludge liquor, liquid phase or fraction, (return, recycle, dewatering, thickening, concentrated, or enriched) followed by (liquor or flow or load or flux or stream).
- Associated to the sidestreams location & context: "wastewater treatment plant" OR wwtp or "water resource recovery facility" OR sewage OR ((domestic or municipal or urban or sewage OR primary or biological or "waste activated" or digest*) PRE/1 (wastewater or effluent or sludge)

Only papers with clear information on sidestream sources were selected. Sidestreams from full-scale measurements only were included in the dataset. All characteristics of sidestreams coming from primary sludge thickening, waste activated sludge thickening, digested sludge dewatering were included. The digested sludge can be from conventional mesophilic anaerobic digestion or advanced anaerobic digestion with THP upstream of the digester.

When available, information about the WRRF configuration have been identified. These information include:

- the type of digester feed (primary sludge, biological sludge or mixed sludge)
- the type of phosphorus treatment (enhanced biological phosphorus removal, chemical, combination of biological and chemical or no treatment)
- the type of secondary treatment: activated sludge or trickling filter
- information on the thickening or dewatering equipment: centrifuge, belt filter press, draining drum, gravity thickener, dissolved air flotation
- Pore size of the filters used to characterise the soluble forms: 0.45 μm or 0.2 μm .
- Standard deviation: when available, standard deviation associated to sample size and measurement campaigns duration were provided.

The results of the analysis from the literature were not modified. Only a standardisation to express the results with the same units was carried out. If not reported, the soluble elements were assumed to be the predominant ions species for the following elements: sNa as Na^+ , sCa as Ca^{2+} , sK as K^+ , Mg as Mg^{2+} , Fe as Fe^{2+} , Cl as Cl^- , Al as Al^{3+} . When possible, the contribution of sidestreams to the total load was calculated as follows:

$$Mass\ flow_{[i]} = \frac{Flow_{sidestream} * [i]_{sidestream}}{Flow_{inletWRRF} * [i]_{inletWRRF} + Flow_{sidestream} * [i]_{sidestream}} * 100$$

Where:

- Mass flow $_{[i]}$ represents the mass flow brought by sidestreams compared to the inlet mass flows of the WRRF in %
- Flow $_{sidestream}$: flow of sidestream expressed as m³/day
- $_{[i]}_{sidestream}$: concentration of the characteristic [i] in sidestream expressed as g/L or mg/L
- Flow $_{inlet\ WRRF}$: total flow at the inlet of the WRRF expressed as m³/day
- $_{[i]}_{inlet\ WRRF}$: concentration of the characteristic [i] at the inlet of the WRRF expressed as g/L or mg/L

Value of the data

- This dataset presents a large data collection of sidestream characteristics in WRRFs. Data have been standardised (same units) and classified according to the WRRF configuration (type of secondary treatment, type of specific phosphorus treatment, dewatering or thickening equipment).
- For the first time, this dataset provides information on conventional characteristics of wastewater (e.g., Total Suspended Solids, Chemical Oxygen Demand) but also on the ionic strength, metal concentrations and organic matter biodegradability at full scale. This may be valuable for modellers or designers of sidestream treatment or recovery technologies that usually need information especially on the physico-chemical equilibria.
- This dataset allows the generation of average values and concentration ranges of the different characteristics according to the source of sidestreams and the configuration of the WRRF. This can be interesting for the development and the assessment of sidestream treatment or recovery technologies (e.g., phosphorus recovery as struvite, partial nitrification/anammox).