PRINCIPAL COMPONENT ANALYSIS OF RAW DOMESTIC SEWAGE

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Collaborations

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- INP Toulouse
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- LCA Laboratoire de Chimie Agro-Industrielle
- Laboratoire de Génie Chimique

Companies

- Veolia Eau
- Itren

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Context and objective

Context
On site sanitation = decentralized sanitation
In France → 13 millions of people

On site sewage facility (OSSF)
Context and objective

Context
On site sanitation = decentralized sanitation
In France → 13 millions of people

Objective
What are characteristics of raw wastewater from single houses?
1. Methodology (1)

Sites description

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3 adults</td>
</tr>
<tr>
<td></td>
<td>1 child</td>
</tr>
<tr>
<td></td>
<td>2 babies</td>
</tr>
<tr>
<td>B</td>
<td>2 adults</td>
</tr>
<tr>
<td></td>
<td>1 adolescent</td>
</tr>
<tr>
<td>C</td>
<td>2 adults</td>
</tr>
<tr>
<td></td>
<td>2 adolescents</td>
</tr>
<tr>
<td>D</td>
<td>2 adults</td>
</tr>
<tr>
<td>E</td>
<td>5 adults</td>
</tr>
<tr>
<td>G</td>
<td>2 adults</td>
</tr>
</tbody>
</table>

Number of occupants was comprised between 2 and 6 persons

Second home

Construction on the same model

Buffer tank (200L) → Septic tank → Vegetal media filter

Sampling of wastewater
Raw domestic wastewater sampling

Wastewater was directed into the buffer tank by using a T tube. It permits not only to evaluate the volume discharged but also to homogenize. Wastewater was pumped to an 1m³ tank.

Sample bottles were similarly filled in three steps. A bucket was filled with the wastewater in three steps: a third at a time with mixing up water between.

1. Methodology (2)
Raw domestic wastewater analysis

1. Methodology (3)

- Sampling
  - before entry into septic tank
  - during 24h
  - for a whole week
- Two campaigns were performed on each site

<table>
<thead>
<tr>
<th>Parameter</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>mgO₂.L⁻¹</td>
</tr>
<tr>
<td>Biological Oxygen Demand (BOD₅)</td>
<td>mgO₂.L⁻¹</td>
</tr>
<tr>
<td>Ammonium (NH₄⁺)</td>
<td>mgN.L⁻¹</td>
</tr>
<tr>
<td>Total Phosphorus (Pₜₜ)</td>
<td>mgP.L⁻¹</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>mg.L⁻¹</td>
</tr>
</tbody>
</table>

Normalised methods
Accredited laboratory
Domestic wastewater uses

• At the start of each campaign:
  → Questionnaire was distributed in order to collect information concerning usages of water over the week
  → It permits to collect data on:
    - Number of toilet flushes
    - Number of machine washes
    - Number of meals
    - Number of showers
2. Results on raw domestic wastewater (1)

Daily loads

- Mean volume: 90 L/d/hab
- Measured volumes are 1.5 less than those used to test OSSF
- Mean organic load comparable to the person equivalent definition
  - More concentrated effluents on the field
Concentrations results

- Variation in concentrations between different samples taken over one week at the same site
- Variation in values from one site to another
- Variation in concentrations between the two campaigns for the same site
  - Site A: average concentration divided by 2 from one campaign to the other

→ Not common behavior: study on possible correlations between results
Principal component analysis

- PCA is a mathematical procedure:
  - To summarize a table using a small number of factors while retaining the maximum amount of variability present in the initial data set.

Representation of the data set in a reduced space without losing too much of the information.
PCA results – First part

- Data coming of all France
- 185 samplings
- 6 parameters per sampling

Data Matrix: 1 110 data
2. Results on raw domestic wastewater (4)

PCA results – First part

- Data coming of all France
- 185 samplings
- 6 parameters per sampling

Data Matrix: 1 110 data

F1-F2 ~ 75 % initial inertia
2. Results on raw domestic wastewater (5)

**PCA results – First part**

- Representation of parameters in correlation circle:
  - A parameter is all the more well represented as it is near the edge of the circle
  - Two collinear parameters are significantly correlated
  - Two orthogonal parameters are significantly uncorrelated

![Diagram showing PCA results with F1: 54.6% and F2: 20.7% of initial inertia, and grouping parameters into "nutrient" and "organic" groups.]

**F1-F2 ~ 75% initial inertia**
2. Results on raw domestic wastewater (6)

PCA results – Second part

- Data coming from questionnaires
- 169 samplings
- 9 parameters

Data Matrix: 1 521 data

- \(\text{NH}_4^+\) are correlated with the number of showers, meals and toilet flushes.
- Tot-P and the number of machine washes not correlated with other parameters
- TSS, COD and BOD are not correlated with the data from the occupants’ daily behavior

F1: 50.5 %
F2: 15.9 %
F1-F2 ~ 66 % initial inertia
Conclusions (1)

What are characteristics of raw wastewater from single houses?

- Person equivalent definition is used to dimension and test on site sewage facilities / Single house domestic effluents are more concentrated
  → It must be taken into account to avoid malfunctions
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What are characteristics of raw wastewater from single houses?

- Person equivalent definition is used to dimension and test on site sewage facilities / Single house domestic effluents are more concentrated
  → It must be taken into account to avoid malfunctions
- Concentrations of the different parameters analyzed, show that wastewater discharged by the occupants is very variable:
  - From one habitation to another
  - Between days of week for the same habitation
  - Between the two campaigns for the same family
  → It is impossible to obtain a raw domestic wastewater characteristics ‘benchmark’ model
Conclusions (2)

What are characteristics of raw wastewater from single houses?

- Principal component analysis shows:
  - 3 groups / 3 behaviors:
    - «organic» group → COD, \( \text{BOD}_5 \) and TSS
    - « nutrient » group → \( \text{NH}_4^+ \) and \( P_T \)
    - Volume

  → In order to characterize raw domestic wastewater, it is necessary to monitor at least one parameter of each group.
    *For example: Volume, \( \text{NH}_4^+ \) and COD or \( \text{BOD}_5 \)*

- The ammonium ions are clearly linked to the number of meals, showers and toilet flushes
- The total phosphorus parameter is depending on the number of machine washes
Thank you for your attention

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