Using simulation models to improve the management of pig slurry in Grand-Ilet (Reunion Island)

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Maximal length: 70 km from NW to SE

3,071 m

2,632 m
Too many pigs... too little land

- 51 farms
- 20 000 m$^3$/year slurry
- 100 tonsN/year
- 187 ha of which 75 ha cultivated

High N application: 1 300 kgN/ha/year

Great risk of pollution!
Prohibition threat

Support stakeholders design a collective management strategy for pig effluents
Decision 1

• Q1: Export effluents or treat them *in situ*?

  ✤ By using a GIS:
  ✤ assess the nutrient balance in the area
  ✤ identify suitable spreading areas
Balance of N from liquid manure

Costal zone

Grand-Ilet

Surplus
\[ \Sigma \geq 0 \text{ (tN)} \]

Deficit
\[ \Sigma < 0 \text{ (tN)} \]
Balance of N from solid manure

101 tons N/year deficit
Decision 2

• A1: Treating effluents *in situ*

• Q2: Which treatment process?
  – size?
  – cost?

♀By using the Macsizut spreadsheet with the stakeholders
Choosing a treatment with Macsizut

- 11 treatment plants combining 12 processes:
  - Centrifugation
  - Nitrification-denitrification
  - Filtration
  - N stripping and acid washing
  - Dehydration
  - Composting
  - ...

## Selection criteria 1

<table>
<thead>
<tr>
<th></th>
<th>Farmers</th>
<th>Cooperatives</th>
<th>State authorities</th>
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<tbody>
<tr>
<td>1</td>
<td>Low cost</td>
<td>Most treated liquid phase</td>
<td>Water authority approval</td>
</tr>
<tr>
<td>2</td>
<td>No by-product to manage on farms</td>
<td>Minimal by-products to manage</td>
<td>Minimal by-products to manage</td>
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<tr>
<td>3</td>
<td>Most treated liquid phase</td>
<td>Most treated liquid phase</td>
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<tr>
<td>4</td>
<td>Low cost</td>
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### Selection criteria 2

<table>
<thead>
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<th></th>
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<tr>
<td>5</td>
<td>Low energy consumption</td>
<td>Preserve fertilizing elements</td>
<td></td>
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<tr>
<td>6</td>
<td>Easy maintenance</td>
<td>Low energy consumption</td>
<td>Low energy consumption</td>
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<tr>
<td>7</td>
<td>Minimal ground occupation</td>
<td>Easy maintenance</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Minimal ground occupation</td>
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<tr>
<td>9</td>
<td></td>
<td>Coupling with biogas production</td>
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</tbody>
</table>
Macsizut outputs

% initial slurry

Residual N
Residual P

Running cost
Investment

€/m³

Most cost-effective: #8 centrifugation + nitrification-denitrification
NDN-SP "Val'Epure"

<table>
<thead>
<tr>
<th></th>
<th>100% privé</th>
<th>75% subv. - 25 % privé</th>
<th>60% subv. - 40% privé</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Avec amortis</td>
<td>Sans amortis</td>
<td>Avec amortis</td>
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<tr>
<td>Charges amortis. (annuités+prov. amortis)</td>
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<tr>
<td>Génie civil (6,5%, 15 ans)</td>
<td>31</td>
<td>20</td>
<td>8</td>
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<td>Equipements (6,5%, 7 ans)</td>
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<td>7</td>
<td>2</td>
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<tr>
<td>TOTAL</td>
<td>39</td>
<td>27</td>
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<td>Charges de fonctionnement</td>
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<tr>
<td>suivi annuel, bilan</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>TOTAL</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Charges de collecte</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

Coût FRF/m³ de lisier traité

| Coût FRF/m³ de lisier traité | 85 | 73 | 55 | 53 | 61 | 57 |

Rachat des co-produits

| TOTAL | 2 | 2 | 2 | 2 | 2 | 2 |

Coût de revient FRF/m³ de lisier traité

| Coût de revient FRF/m³ de lisier traité | 82 | 71 | 53 | 50 | 59 | 54 |

Coût de revient €/m³ de lisier traité

| Coût de revient €/m³ de lisier traité | 12,58 | 10,78 | 8,13 | 7,68 | 9,02 | 8,3 |
Decision 3

- A1: Treating effluents *in situ*
- A2: Centrifugation + nitrification - denitrification

Q3: What supply policy for the plant?
- when should a delivery be done?
- how much should be delivered?
- transport means?
- workforce?
- cost?

By using the Approzut dynamic simulation model with the stakeholders
Approxzut model outline

Farm reactive policy

Plan

CTP reactive policy

(s, S)

(T, Q)

inflow

outflow

Feedback

Farm Stocks

CTP Stock
Scenario simulations

2 tankers 15 m³, no holiday, random disturbances

- Planned
- Farm reactive policy
- CTP reactive policy
Policy comparison

- No overflow → reactive policies
- Efficiency (amounts, work time, kms) → same
- Slurry shortage → no holiday
- Overtime work → no holiday
- Robustness → no holiday, farm reactive
- Field implementation → planned?
Policy choice

- Farm reactive policy best

When?
- from stock level \( s_i = 65\% \)

How much?
- down to level \( S_i = 0 \)

- Priority rule: fuller-nearer-smaller first
- No holiday
- 2 full-time drivers + 1 part-time
- Information about stock levels
Decision 4

- A1: Treating effluents *in situ*
- A2: Centrifugation + nitrification - denitrification
- A3: No decision yet

- Q4: How to evaluate the whole supply chain?

By using the **Biomas** multi-agent system to simulate transfers at territorial scale
Biomas multi-agent system

Analysis tools
Parameter menu
Situated view
Mini map
Agent inspector
Simulation control
Exchange intensity
Qualitative state
Messages
Conclusions-Prospects

Choose a treatment process
MACSIZUT

Evaluate the whole supply chain at territorial scale
BIOMAS

Choose a supply policy
APPROZUT

- Devise a methodology of simulation-based decision-making with the stakeholders