

# The road to sustainable sludge management

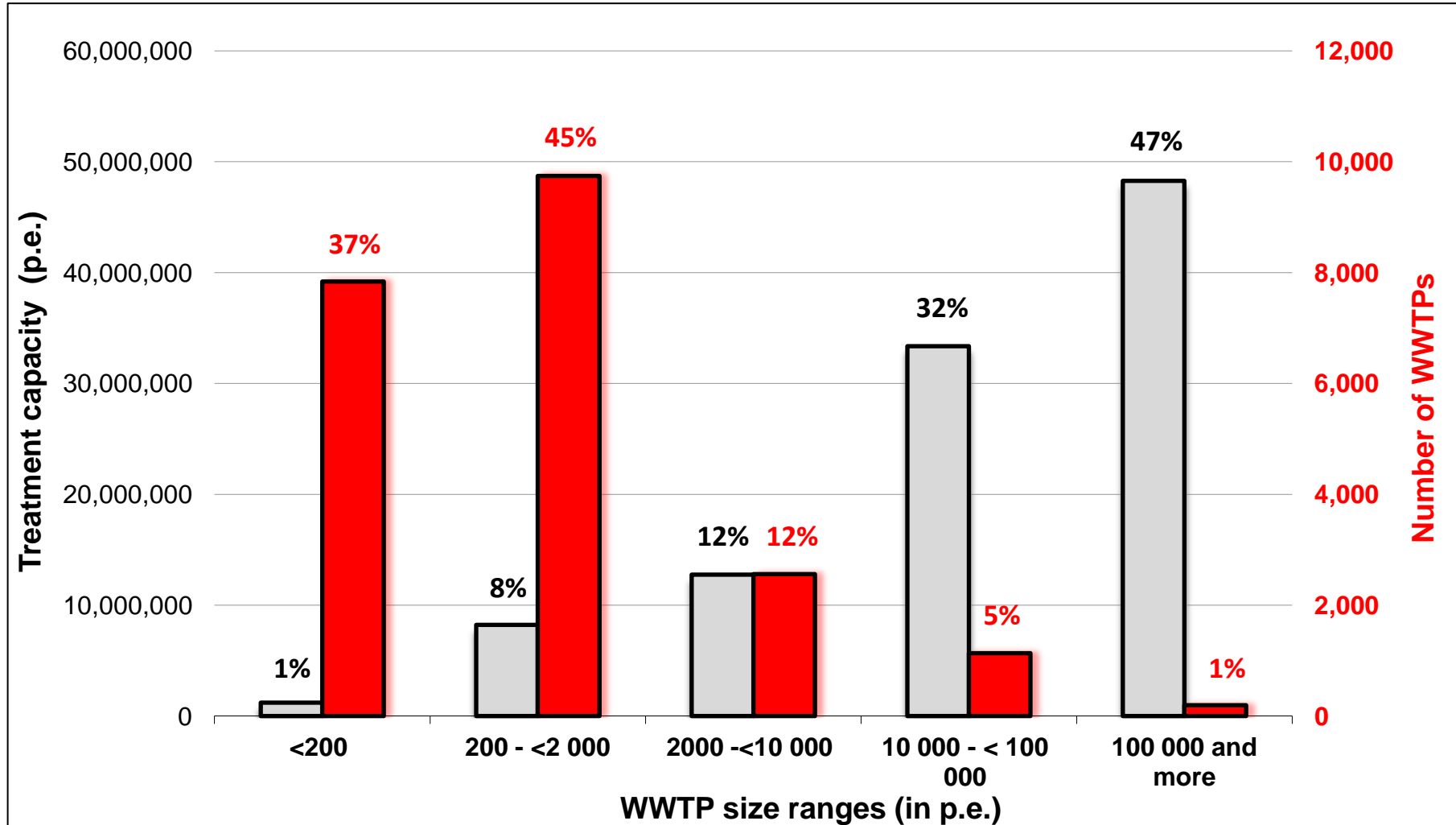
## The French experience

Régis Moilleron & Julien Le Roux



# Wastewater management

## WWTPs in France



**≈ 22 000 WWTPs**

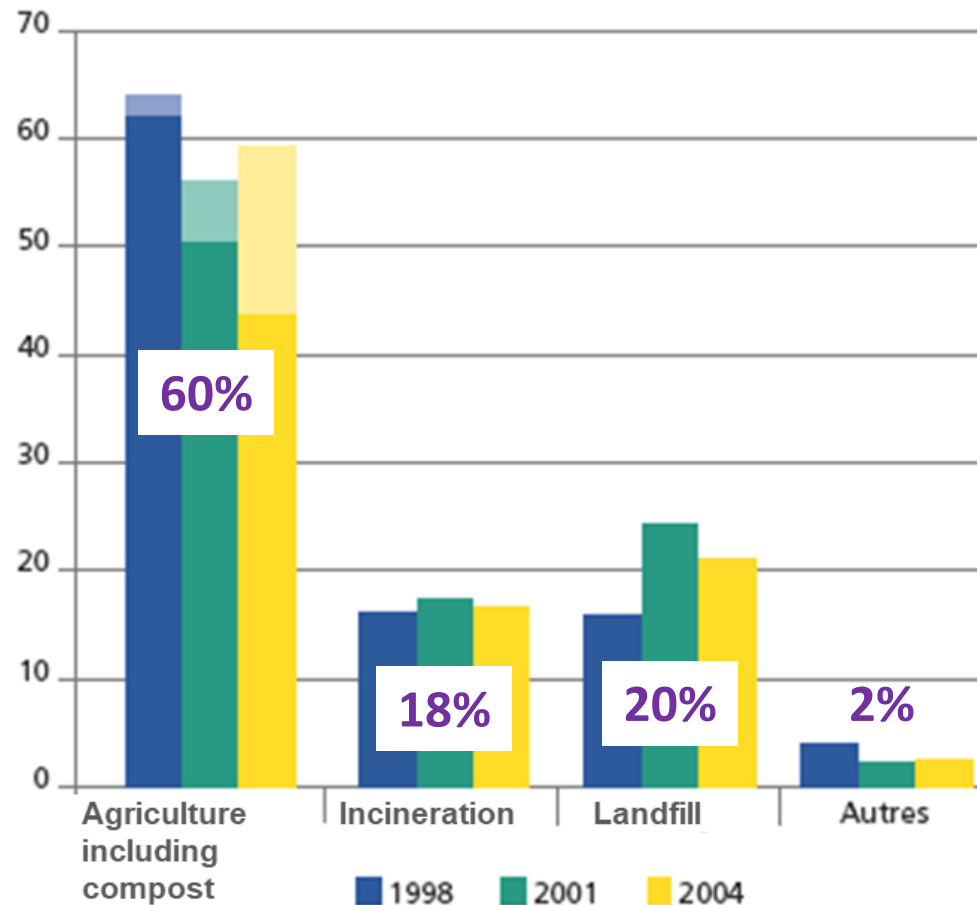
**Treatment capacity  
≈ 106 M p.e.**

**97% WWTPs  
<20 000 p.e.  
treatment capacity**

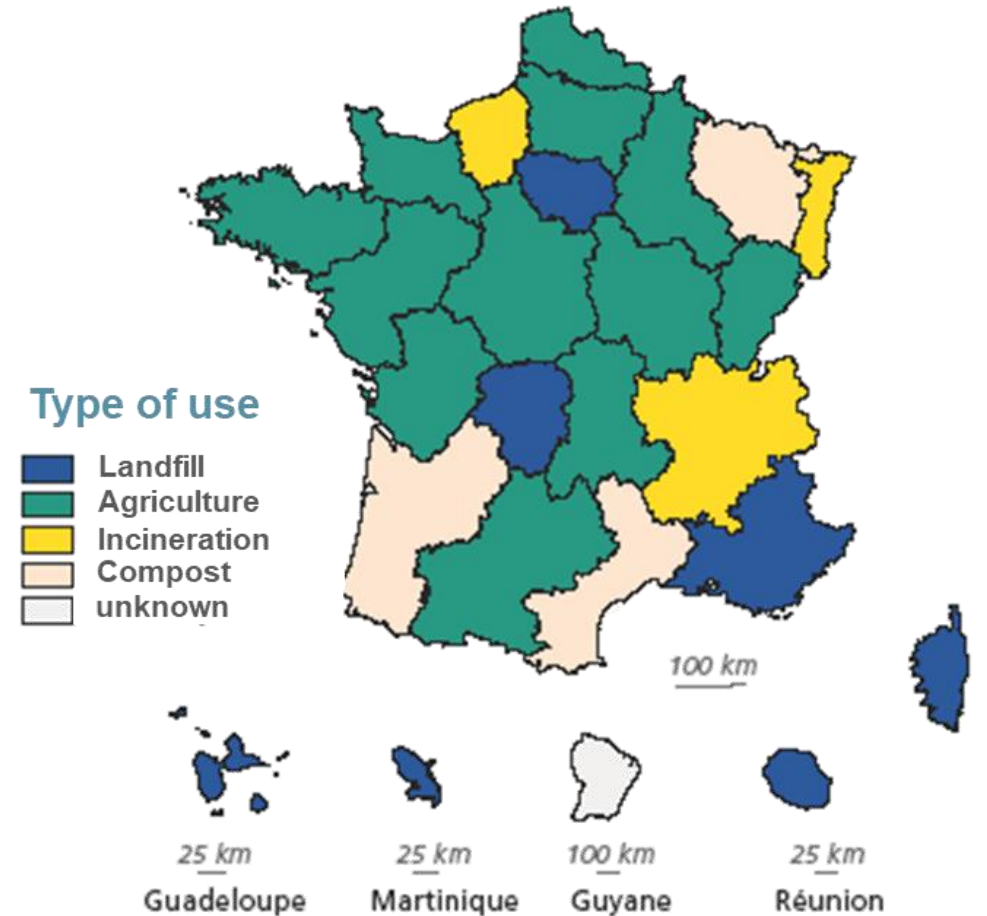
# Sludge management – evolution with time

## Situation in France 1998 - 2004

Uses of sludge (%)



Main uses of sludge in french regions (2004)



Source : Ifen-Scees, enquête Eau 2004.

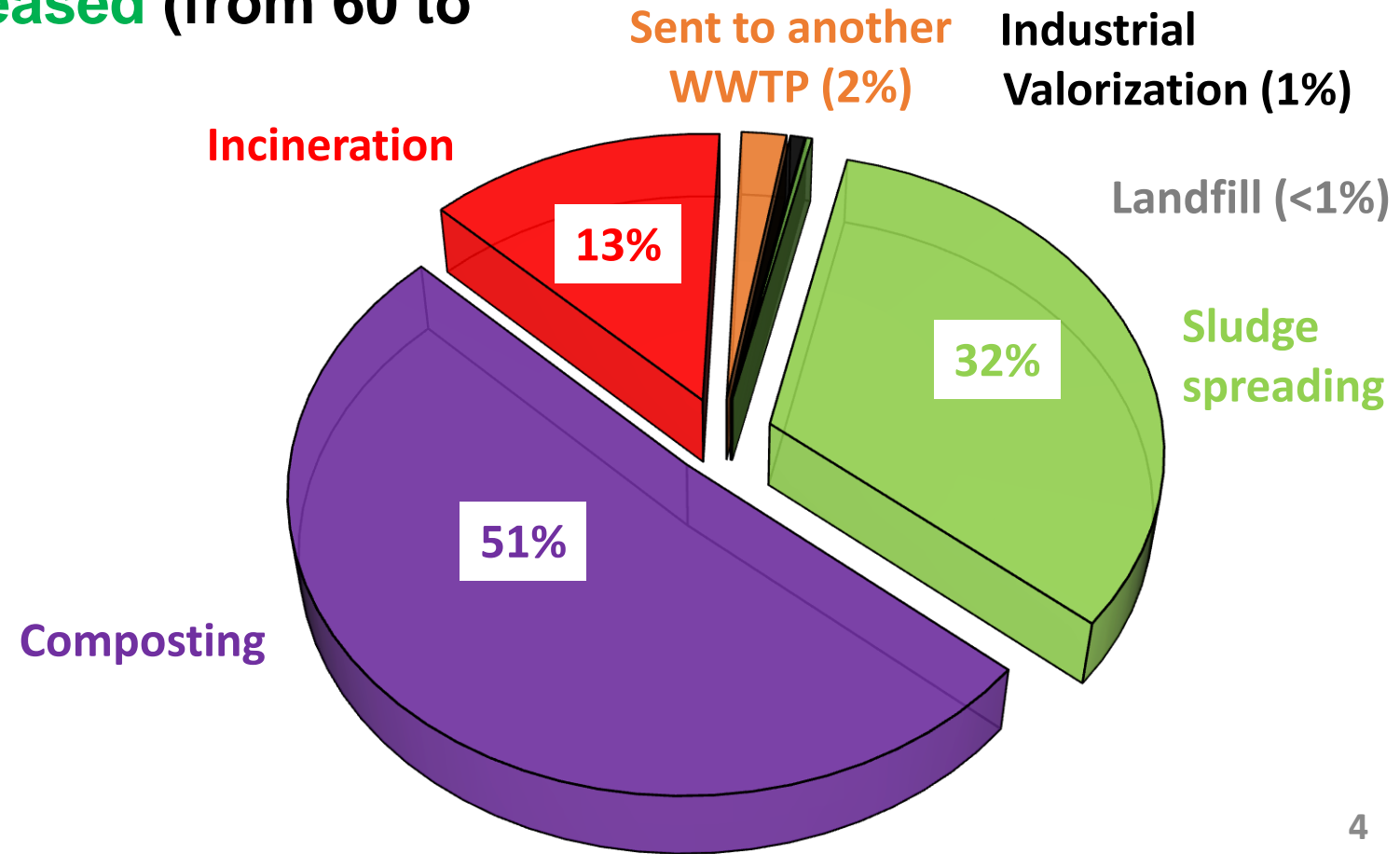
# Sludge management – evolution with time

## Situation in France 2022

- **No more landfill** (down from 20 to <1%)
- **Sludge spreading increased** (from 60 to 84%)
- **Regulations evolved**
  - ✓ Circular economy

1 028 905 t.dw for France

15 kg.dw/capita



# Sludge management

## Situation in Paris conurbation (2022)

- **Methanization (3%)**

**Cement plant**

**5%**

6% 2020

5% 2019

**Incineration**

**31%**

36% 2020

30% 2019

**Sludge spreading**

**29%**

8% 2020

11% 2019

**Composting**

**31%**

43% 2020

47% 2019

**Methanization**

**3%**

2% en 2020

4% en 2019

**123 487 t.dw**

**Chapter 5**

**Chapter 6**

**Chapter 10**

# Agricultural spreading

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## Why use sludge on soil or crops?

- **Agronomic benefits** (soil amendment or fertilizer)
- **Economic interests** (low-cost processes)
- **Environmental benefits** (waste recycling)


**However this practice must be supervised!**

... and ***started to be regulated in 1998*** to reassure consumer associations, who were concerned about the transfer of pollutants.


# Sludge management in France - Regulation

## Main regulations

### ○ European regulations

- 
- **Directive 86/278/EEC** on the protection of the environment when sewage sludge is used in agriculture
  - **Directive 91/271/EEC** concerning urban wastewater treatment (*Proposal for a Directive of the European Parliament and of the Council concerning urban wastewater treatment (recast) – Provisional political agreement between the Council and the European Parliament (03/2024)*)

### ○ French regulations

- 
- The Environment Code
  - Decree no. 93-742 on the authorization and declaration procedures provided for in article 10 of law no. 92-3 of January 3, 1992 on water
  - Decree of November 22, 1993 on the code of good agricultural practices
  - **Order of 08/01/98 on the technical requirements applicable to the spreading of sludge on agricultural land**, in application of Decree no. 97-1133 of 08/12/97 on the spreading of sludge from wastewater treatment
  - Ministerial circular of April 18, 2005, urban wastewater treatment plant sludge spreading, recommendations for monitoring compliance with regulations and informing the public
  - Decree no. 2021-1179 (14/09/2021) on the composting of sewage sludge and sewage sludge digestates with structuring agents

# Agricultural spreading

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## French regulations

- Order of 08/01/98 on *the technical requirements applicable to the spreading of sludge on agricultural land*, in application of Decree no. 97-1133 of 08/12/97 on the spreading of sludge from wastewater treatment
- Circular DE/GE no. 357 of 16/03/99 on *regulations governing the spreading of sludge from urban wastewater treatment plants*
- The Environment Code (articles R 211-25 to R 211-47)



# Agricultural spreading

## A multi-stage procedure

### ***1st stage: pre-study***

- carrying out a study
- ...
- choice of spreading method

### ***2nd stage: WWTP development***

- construction of sludge storage
- construction of thickening system

### ***3rd stage: spreading planification***

- organization of spreading operations
- signature of agreements with farmers and the organization responsible for agronomic monitoring
- submission of administrative declaration or authorization file

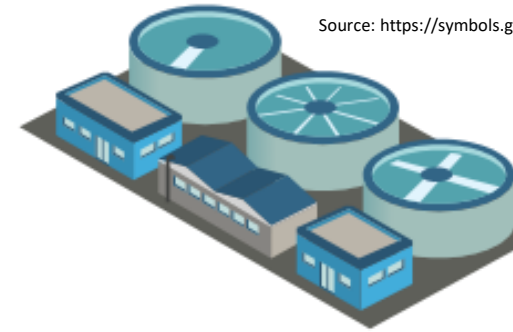
### ***4th stage: spreading monitoring***

- land application monitoring
- agronomic and sludge quality monitoring
- annual review of sludge application campaigns and projected annual sludge application program

# Agricultural spreading

## Stakeholders

- Community (WWTP owner)
- WWTP manager



Source: [https://symbols.getvecta.com/stencil\\_310/131\\_water-drinking-water-treatment-plant-1.0bfc74aa07.svg](https://symbols.getvecta.com/stencil_310/131_water-drinking-water-treatment-plant-1.0bfc74aa07.svg)

- Land application monitoring service provider
- Transport supplier
- Spreading contractor
- Landfill contractor

- Accredited analysis laboratory
- List of farmers involved in spreading campaigns



**Sludge  
characterization**



**Sludge spreading**

Source: TSM n°3 (202) p. 19

# Agricultural spreading

## General scheme

*Specific recommendations for sludge use* based on:

- A **spreading program** to define:
  - ✓ Plots & their surfaces - return period between 2 sludge applications on the same plot
  - ✓ Cropping systems (before and after sludge application)
  - ✓ Other fertilizer inputs
  - ✓ **10 years (30 t.dw/ha of sludge)**
- **Soil features:**
  - ✓ Agronomic value (N, P, OM, CEC, Ca, K, etc.)
  - ✓ Trace element contents (x7)
- **Sludge characterization:**
  - ✓ Spread quantities
  - ✓ Agronomic potential
  - ✓ Contamination by:
    - Trace metals (x7 +1)
    - PCBs (x7)
    - PAHs (x3)

Crops

Soils

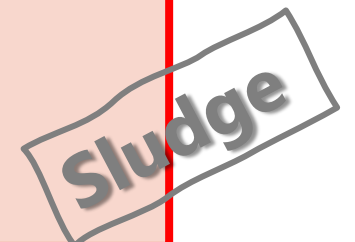
Sludge

# Agricultural spreading

## Sludge characterization

- Quality requirements for sludge to be spread (Order of 08/01/98)

Agronomic value	Trace metal contents	Organic micropollutants
Dry matter (%) Organic matter (%) pH TKN* Organic Nitrogen* NH <sub>4</sub> <sup>+</sup> * C/N Total Phosphorous (P <sub>2</sub> O <sub>5</sub> )* Potassium (K <sub>2</sub> O)* Calcium (CaO)* Magnesium (MgO)* Micronutrients : B, Co, Cu, Fe, Mn, Mo, Zn (in mg/kg.dw) * in kg/t.dw	<ul style="list-style-type: none"> <li>• Cd <b>10</b></li> <li>• Cr <b>1000</b></li> <li>• Cu <b>1000</b></li> <li>• Hg <b>10</b></li> <li>• Ni <b>200</b></li> <li>• Pb <b>800</b></li> <li>• Zn <b>3000</b></li> <li>• Σ(Cu + Ni + Zn + Cr) <b>4000</b></li> <li>• Se <b>25</b></li> </ul> in mg/kg.dw  <b>[threshold in mg/kg.dw] if spread on meadow</b>	<ul style="list-style-type: none"> <li>• Σ 7PCBs (28, 52, 101, 118, 138, 153, 180) <b>0.8</b></li> <li>• Fluoranthene <b>5</b> <b>4</b></li> <li>• Benzo[<i>b</i>]fluoranthene <b>2.5</b></li> <li>• Benz[<i>a</i>]pyrene <b>2</b> <b>1.5</b></li> </ul> in mg/kg.dw  <b>[threshold in mg/kg.dw] if spread on meadow</b>



# Agricultural spreading

## Soil features

- Not all soils can be amended with sewage sludge
- Features to be respected
  - Agronomic features
  - Trace metal contents

Agronomic features				Trace metal contents	
Parameters	Units	Parameters	Units	Parameters	Threshold
Grain size	% or g/kg	Exch. Calcium (CaO)	g/kg	Cd	[2]
Organic matter	%	Exch. Potassium (K <sub>2</sub> O)	g/kg	Cr	[150]
pH		Na <sub>2</sub> O	g/kg	Cu	[100]
TKN	g/kg			Hg	[1]
C/N				Ni	[50]
Total limestone (CaCO <sub>3</sub> )	g/kg	<b>Micronutrients</b>		Pb	[100]
Active limestone (CaCO <sub>3</sub> )	g/kg	B	mg/kg	Zn	[300]
CEC	cmol/kg	Co	mg/kg	in <b>mg/kg.dw</b>	in <b>mg/kg.dw</b>
Exch. Phosphorous (P <sub>2</sub> O <sub>5</sub> )	g/kg	Cu	mg/kg		
Exch. Magnesium (MgO)	g/kg	Fe	mg/kg		
		Mn	mg/kg		
		Mo	mg/kg		
		Zn	mg/kg		



# Agricultural spreading

## Cumulated flows provided to soils

- Maximum cumulative flow of sludge within 10 years (Order of 08/01/98)

Trace metals (maximum cumulative flow in 10 years)	Organic micropollutants (maximum cumulative flow in 10 years)
<ul style="list-style-type: none"> <li>Cd 0.015 g/m<sup>2</sup></li> <li>Cr 1.5 g/m<sup>2</sup></li> <li>Cu 1.5 g/m<sup>2</sup></li> <li>Hg 0.015 g/m<sup>2</sup></li> <li>Ni 0.3 g/m<sup>2</sup></li> <li>Pb 1.5 g/m<sup>2</sup></li> <li>Zn 4.5 g/m<sup>2</sup></li> <li>Σ(Cu + Ni + Zn + Cr) 6.0 g/m<sup>2</sup></li> <li>Se 0.12 g/m<sup>2</sup></li> </ul> <p>if spread on meadow</p>	<ul style="list-style-type: none"> <li>Σ 7PCBs (28, 52, 101, 118, 138, 153, 180) 1.2 mg/m<sup>2</sup></li> <li>Fluoranthene 7.5 mg/m<sup>2</sup> 6.0 mg/m<sup>2</sup></li> <li>Benzo[b]fluoranthene 4.0 mg/m<sup>2</sup></li> <li>Benz[a]pyrene 3.0 mg/m<sup>2</sup> 2.0 mg/m<sup>2</sup></li> </ul> <p>if spread on meadow</p>

Soils

Sludge

# Agricultural spreading

## Crop fertilization

- Doses of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O to be applied per crop
- Depend on the type of crop (wheat, maize, barley...), the sludge quality & the expected yield

- For **N** : Dose = Requirements – Supplies
- For **P** and **K** according to COMIFER (2009)

**Crops**

Culture	Expected yield q/ha t.dw/ha	Sludge t.RS/ha	Sludge t.dw/ha	Dose to be applied over the crop cycle kg/ha ①			Projected dose of fertilizing elements kg/ha						Complementary inputs kg/ha ③ = ① - ②		
							Total			Effectives ②					
				N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Wheat	50 q/ha	12,5	2,5	190	60	60	204	92	14	102	64	14	190-102 = 88	0	60 - 14 = 46



# Agricultural spreading

## Methodological guides *(in French)*

- Preliminary spreading study
- Agronomic assessment of spreading
- Pre-spreading program





# The new orientations

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## Composting

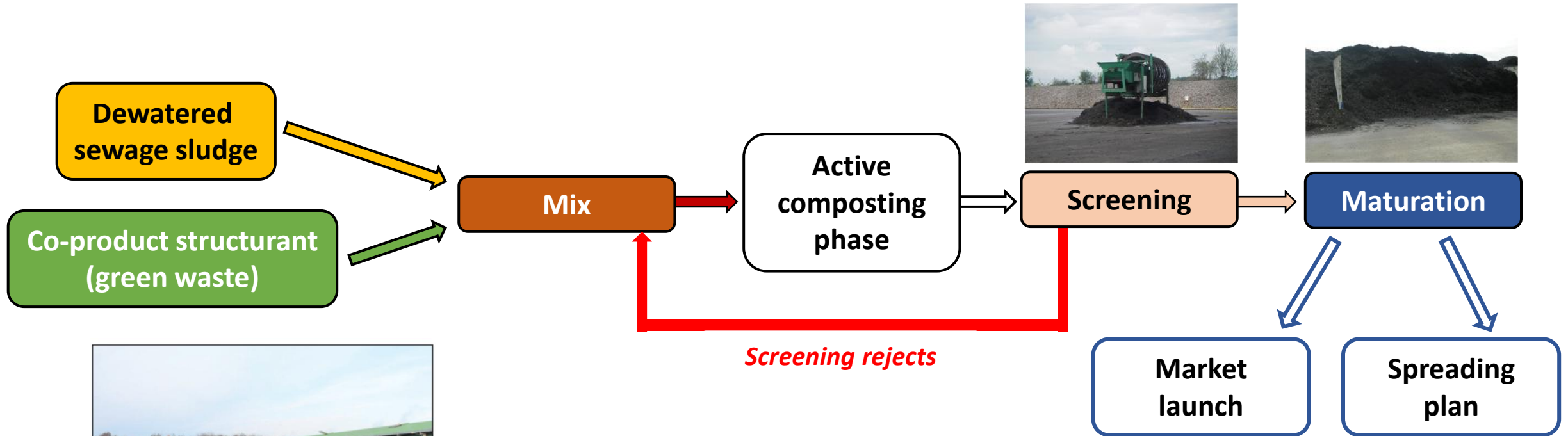
### ○ *Sludge-based compost*

- **May 2002:** approval of **AFNOR standard NFU 44-095** relating to composts containing materials of agronomic interest derived from water treatment
- Improving the final quality of products
- Greater social acceptability
- Diversifying outlets

*NF U44-095 (2022) Organic amendments - Composts containing materials of agronomic interest, derived from water treatment (French regulation)*

# The new orientations

## Typical sewage sludge composting process in France



**Sludge composting facility**

Source: TSM n°3 (202) p. 19

# The new orientations

## Composting

- **Sludge-based compost** → **vegetable gardening**

Trace metal contents SLUDGE	Trace metal contents NFU 44095	Organic micropollutants SLUDGE	Organic micropollutants NFU 44095
<ul style="list-style-type: none"> <li>• Cd <b>10</b></li> <li>• Cr <b>1000</b></li> <li>• Cu <b>1000</b></li> <li>• Hg <b>10</b></li> <li>• Ni <b>200</b></li> <li>• Pb <b>800</b></li> <li>• Zn <b>3000</b></li> </ul>	<ul style="list-style-type: none"> <li>• Cd <b>3</b></li> <li>• Cr <b>120</b></li> <li>• Cu <b>300</b></li> <li>• Hg <b>2</b></li> <li>• Ni <b>60</b></li> <li>• Pb <b>180</b></li> <li>• Zn <b>600</b></li> </ul>	<ul style="list-style-type: none"> <li>• <math>\Sigma</math> 7PCBs <b>0.8</b></li> <li>• Fluo <b>5.0</b></li> <li>• BbF <b>2.5</b></li> <li>• BaP <b>2.0</b></li> </ul> <p>in mg/kg.dw [threshold in mg/kg.dw]</p>	<ul style="list-style-type: none"> <li>• <math>\Sigma</math> 7PCB <b>0.8</b></li> <li>• Fluo <b>4.0</b></li> <li>• BbF <b>2.5</b></li> <li>• BaP <b>1.5</b></li> </ul> <p>In mg/kg.dw [threshold in mg/kg.dw]</p>

Sludge selection  
needed!

Thresholds for pathogens & treatment indicator agents (E. coli, Enterococcus, Clostridium perfringens)

# The new orientations

## Composting

- **NF U44-095 requirements**
  - **Result requirements:** on the final composition of the product, in terms of quality and safety.
    - ➔ Plant structuring is mandatory
    - ➔ The mixture must undergo an aerobic fermentation stage
  - **Monitoring requirements:** batch-by-batch traceability, from raw materials to finished products
  - **Labelling requirements:** composition, instructions for use



← NFU 44-051



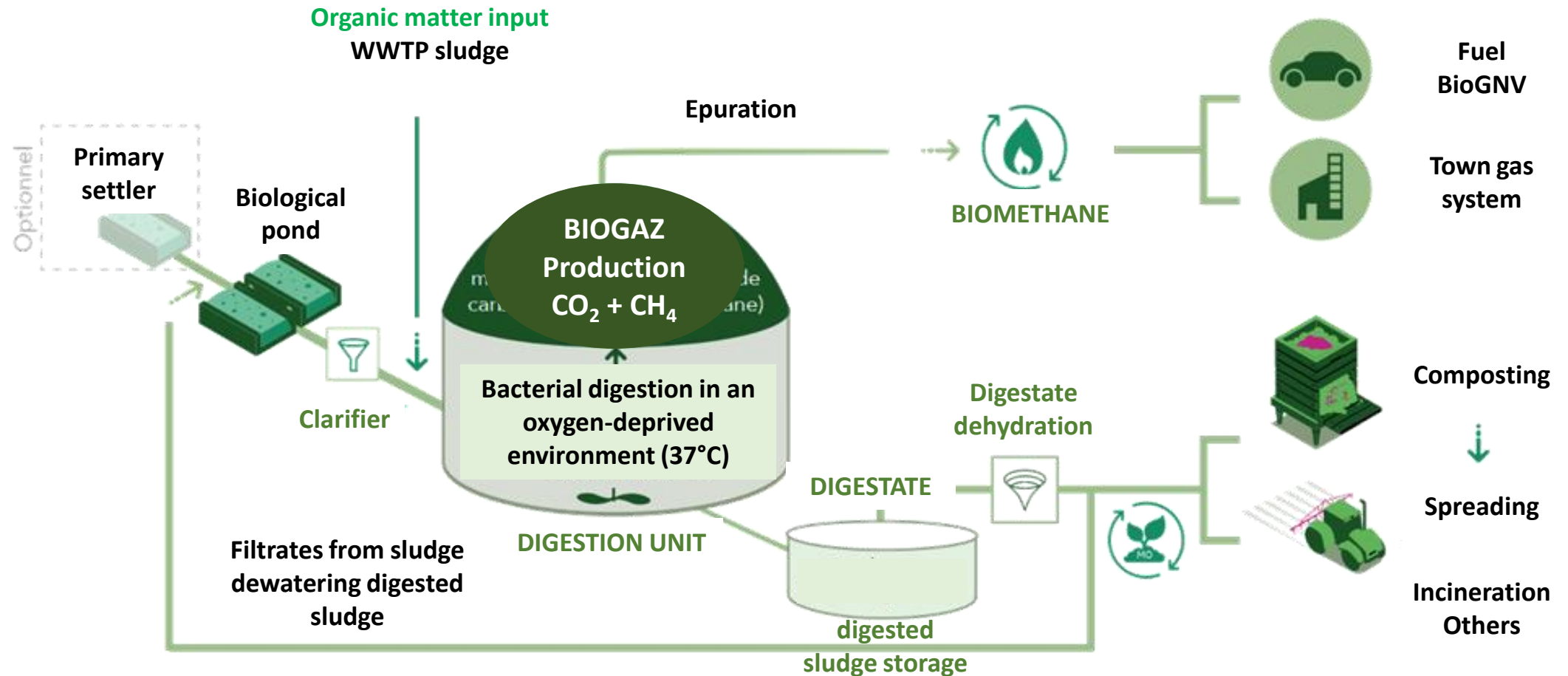
VEOLIA

← NFU 44-095

# The new orientations

## Methanization

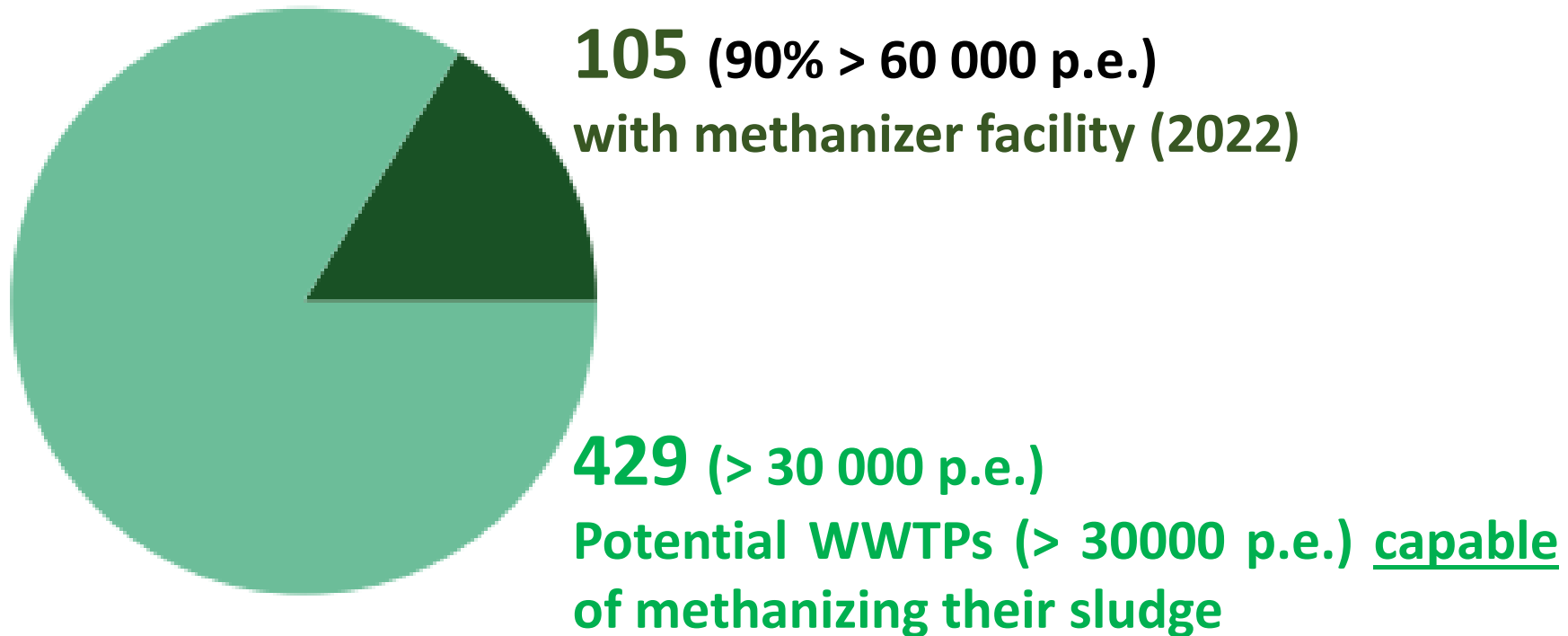
### ○ General principle



# The new orientations

## Methanization

- In France **105 WWTPs** (> 30 000 p.e.) equipped with a methanizer facility (2022)



# Conclusion

## Sludge management

- A constantly evolving process
- Over the last 40 years, *sludge management has evolved in line with the regulatory changes* brought about by Europe and France
  - landfilling has virtually disappeared
  - compost production is expanding rapidly
  - management methods linked to a circular economy approach have been favored (e.g., methanization)
- UWW Directive recast worries WWTP managers
  - due to the *introduction of new parameters for sludge characterization*, such as dioxins
  - with *more stringent thresholds for metals*

For the Paris region, 50% of the sludge can no longer be spread  
(dioxins: 20 ng/kg.dw)

Thank you for your attention!

Hvala vam na pažnji!  
Хвала на пажњи!



Smart Water Twin HEProject

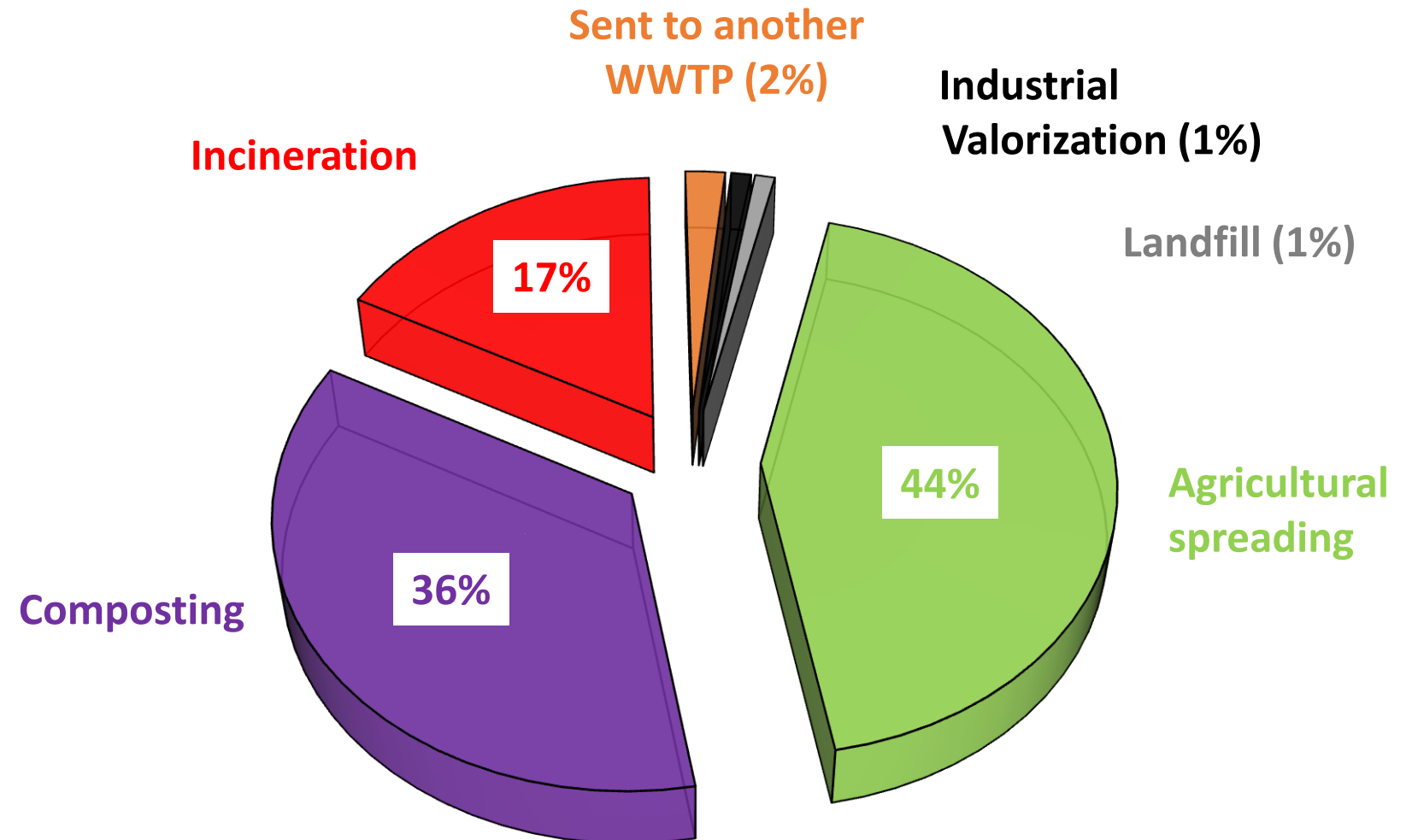


# Waste management in France - Figures

## Sludge management (2016)

800 535 t.dw

12 kg.dw/capita



# Waste management in France - Regulation

## Fate of sludge

- Article 14 (Directive 91/271/EEC )
  1. **Sludge** arising from waste water treatment shall be *re-used whenever appropriate*. Disposal routes shall minimize the adverse effects on the environment.
  2. Competent authorities or appropriate bodies shall ensure that before 31 December 1998 the disposal of **sludge from urban WWTPs** is subject to general rules *or registration or authorization*.
  3. Member States shall ensure that by 31 December 1998 *the disposal of sludge to surface waters* by dumping from ships, by discharge from pipelines or by other means is *phased out*.
  4. Until the elimination of the forms of disposal mentioned in paragraph 3, Member States shall ensure that *the total amount of toxic, persistent or bioaccumulable materials* in sludge disposed of to surface waters *is* licensed for disposal and *progressively reduced*.