

The road to sustainable sludge management

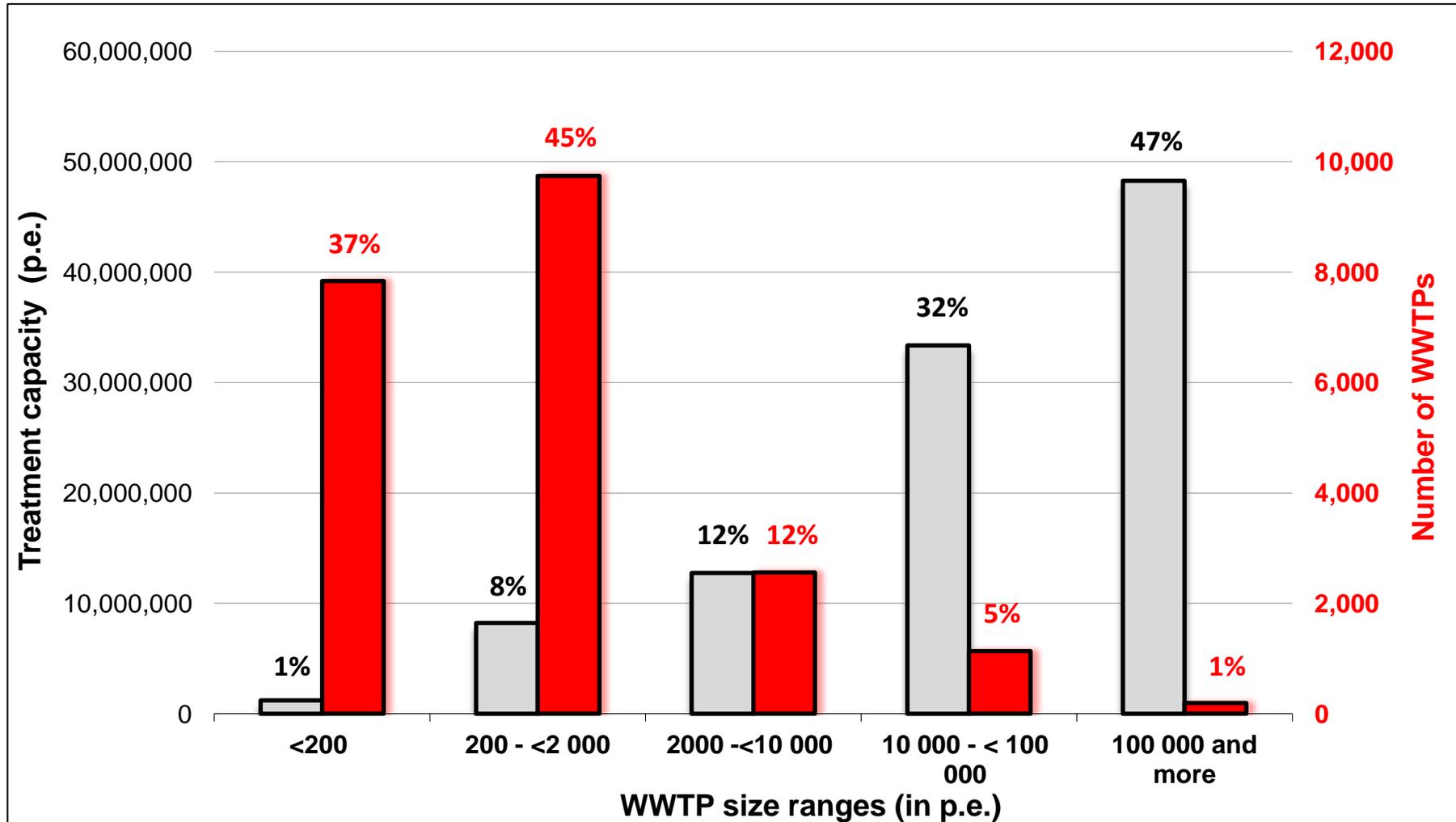
The French experience

Régis Moilleron & Julien Le Roux



Wastewater management

WWTPs in France



≈ 22 000 WWTPs

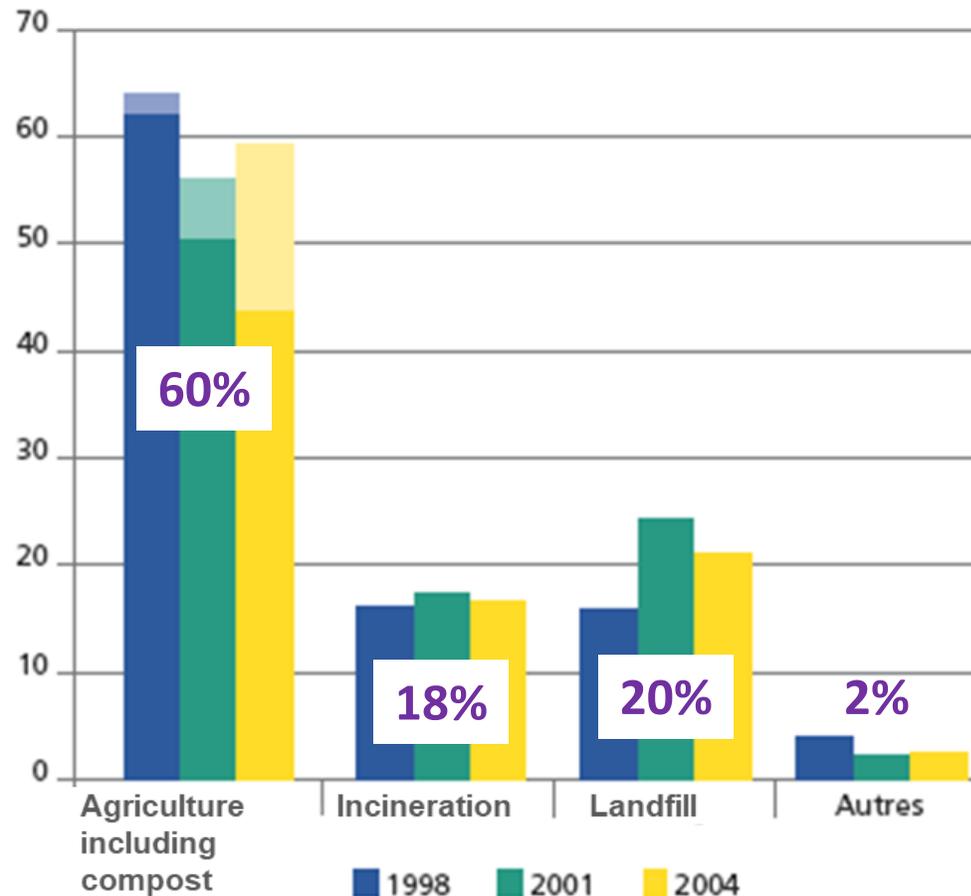
**Treatment capacity
≈ 106 M p.e.**

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

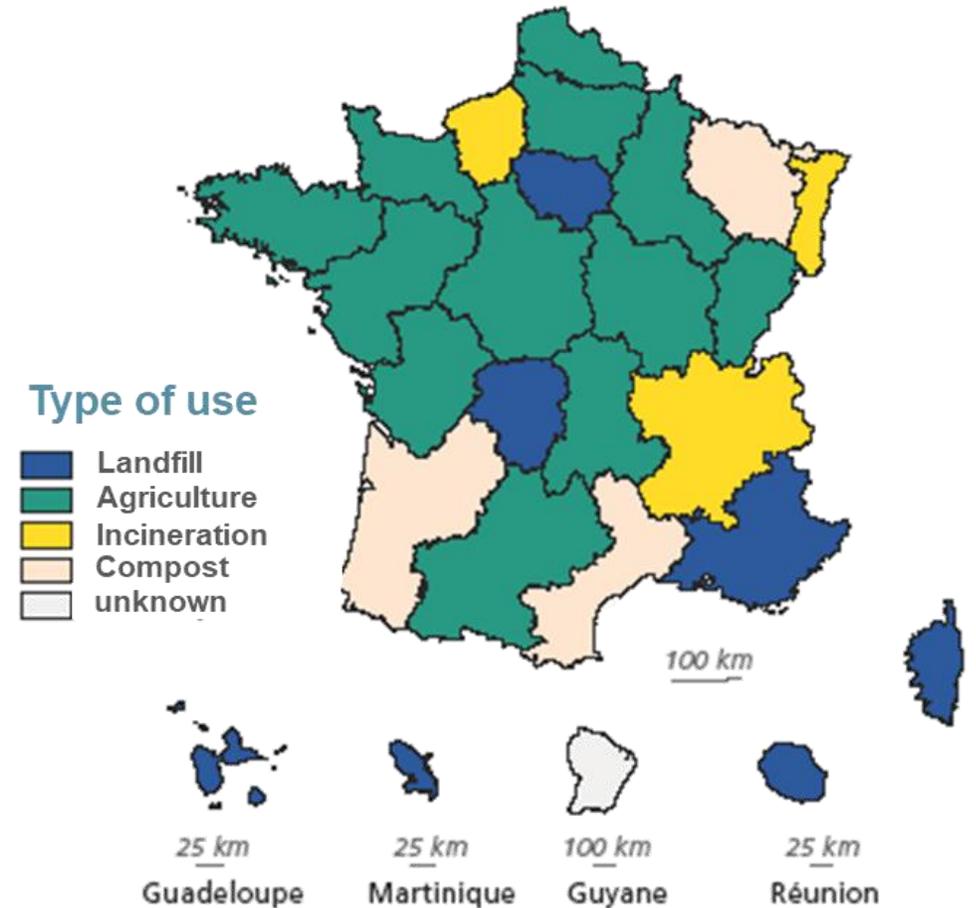
Sludge management – evolution with time

Situation in France 1998 - 2004

Uses of sludge (%)



Main uses of sludge in french regions (2004)



Source : Ifen-Scees, enquête Eau 2004.

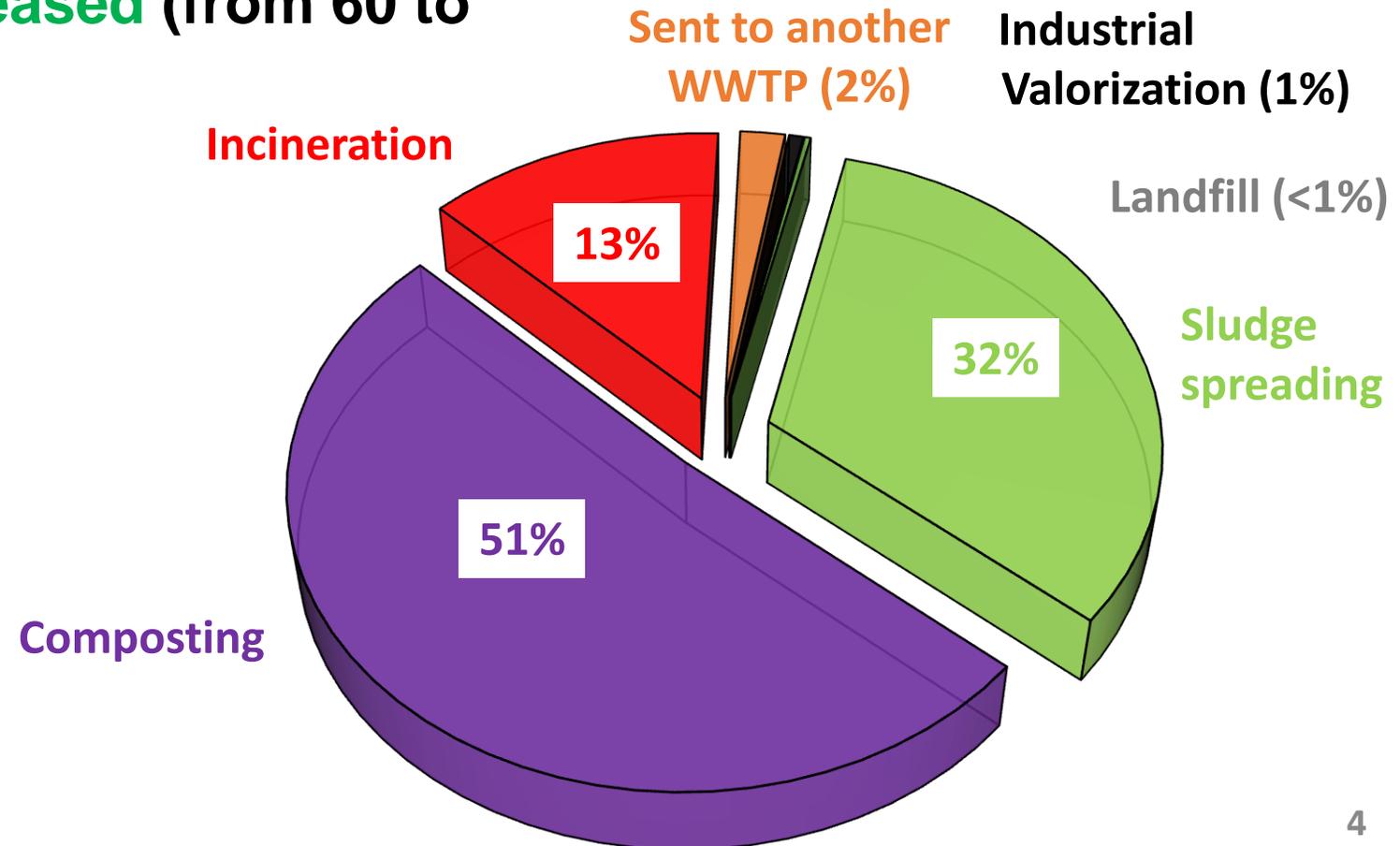
Sludge management – evolution with time

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

Chapter 5

Chapter 6

123 487 t.dw

Composting

31%

43% 2020

47% 2019

Methanization

3%

2% en 2020

4% en 2019

Chapter 10

Agricultural spreading

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

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

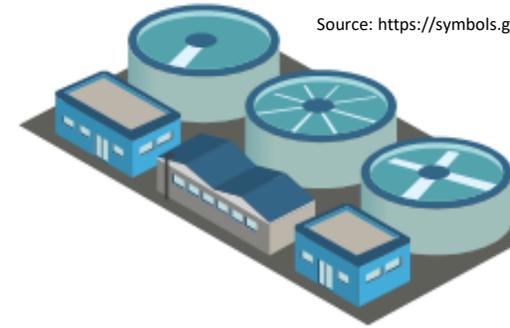
Agricultural spreading

Stakeholders

- Community (WWTP owner)
- WWTP manager

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

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



Source: https://symbols.getvecta.com/stencil_310/131_water-drinking-water-treatment-plant-1.0bfc74aa07.svg



**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

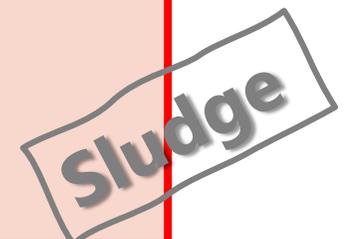
Sludge

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 ₄ ⁺ * C/N Total Phosphorous (P ₂ O ₅)* Potassium (K ₂ 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"> • Cd 10 • Cr 1000 • Cu 1000 • Hg 10 • Ni 200 • Pb 800 • Zn 3000 • Σ(Cu + Ni + Zn + Cr) 4000 • Se 25 in mg/kg.dw [threshold in mg/kg.dw] if spread on meadow | <ul style="list-style-type: none"> • Σ 7PCBs (28, 52, 101, 118, 138, 153, 180) 0.8 • Fluoranthene 5 • Benzo[b]fluoranthene 2.5 • Benz[a]pyrene 2 1.5 in mg/kg.dw [threshold in mg/kg.dw] if spread on meadow |



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 ₂ O) | g/kg | Cr | [150] |
| pH | | Na ₂ O | g/kg | Cu | [100] |
| TKN | g/kg | | | Hg | [1] |
| C/N | | | | Ni | [50] |
| Total limestone (CaCO ₃) | g/kg | Micronutrients | | Pb | [100] |
| Active limestone (CaCO ₃) | g/kg | B | mg/kg | Zn | [300] |
| CEC | cmol/kg | Co | mg/kg | | |
| Exch. Phosphorous (P ₂ O ₅) | g/kg | Cu | mg/kg | in mg/kg.dw | in mg/kg.dw |
| 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) | |
|---|------------------------|--|--|
| • Cd | 0.015 g/m ² | • Σ 7PCBs (28, 52, 101, 118, 138, 153, 180) | 1.2 mg/m ² |
| • Cr | 1.5 g/m ² | • Fluoranthene | 7.5 mg/m ² 6.0 mg/m ² |
| • Cu | 1.5 g/m ² | • Benzo[<i>b</i>]fluoranthene | 4.0 mg/m ² |
| • Hg | 0.015 g/m ² | • Benz[<i>a</i>]pyrene | 3.0 mg/m ² 2.0 mg/m ² |
| • Ni | 0.3 g/m ² | | |
| • Pb | 1.5 g/m ² | | |
| • Zn | 4.5 g/m ² | | |
| • Σ(Cu + Ni + Zn + Cr) | 6.0 g/m ² | | |
| • Se | 0.12 g/m ² | | |
| if spread on meadow | | if spread on meadow | |

Soils

Sludge

Agricultural spreading

Crop fertilization

- Doses of N, P₂O₅, K₂O 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 | | | Projected dose of fertilizing elements kg/ha | | | | | | Complementary inputs kg/ha | | |
|---------|-----------------------------------|-------------------|-------------------|---|-------------------------------|------------------|---|-------------------------------|------------------|--------------|-------------------------------|------------------|-------------------------------|-------------------------------|------------------|
| | | | | ① | | | Total | | | Effectives ② | | | ③ = ① - ② | | |
| | | | | N | P ₂ O ₅ | K ₂ O | N | P ₂ O ₅ | K ₂ O | N | P ₂ O ₅ | K ₂ O | N | P ₂ O ₅ | K ₂ 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

Composting

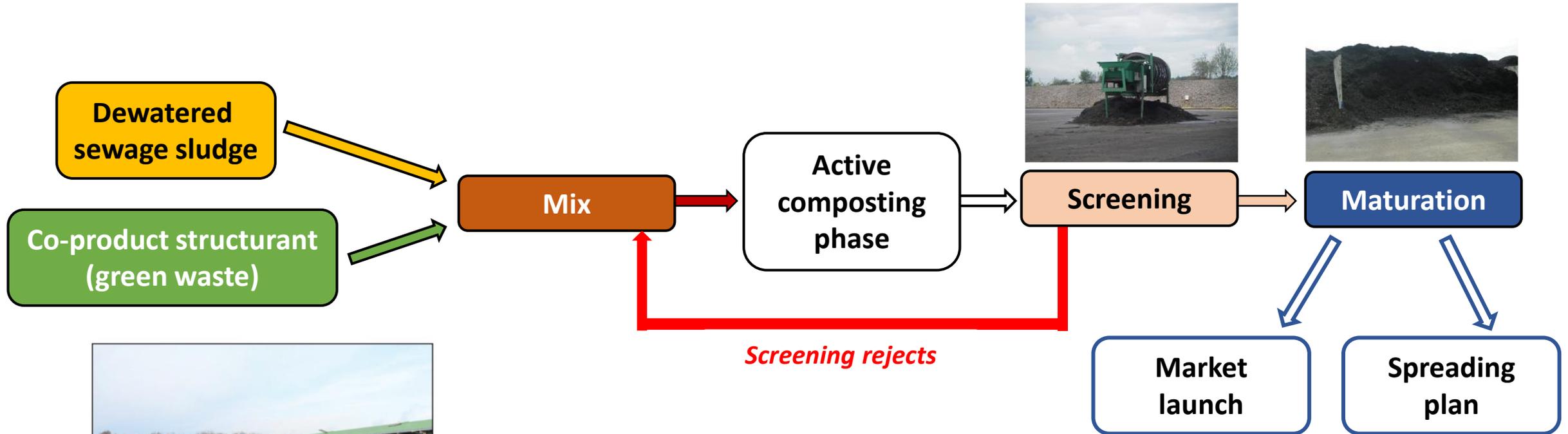
○ *Sludge-based compost*

- **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"> • Cd 10 • Cr 1000 • Cu 1000 • Hg 10 • Ni 200 • Pb 800 • Zn 3000 | <ul style="list-style-type: none"> • Cd 3 • Cr 120 • Cu 300 • Hg 2 • Ni 60 • Pb 180 • Zn 600 | <ul style="list-style-type: none"> • Σ 7PCBs 0.8 • Fluo 5.0 • BbF 2.5 • BaP 2.0 <p>in mg/kg.dw [threshold in mg/kg.dw]</p> | <ul style="list-style-type: none"> • Σ 7PCB 0.8 • Fluo 4.0 • BbF 2.5 • BaP 1.5 <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



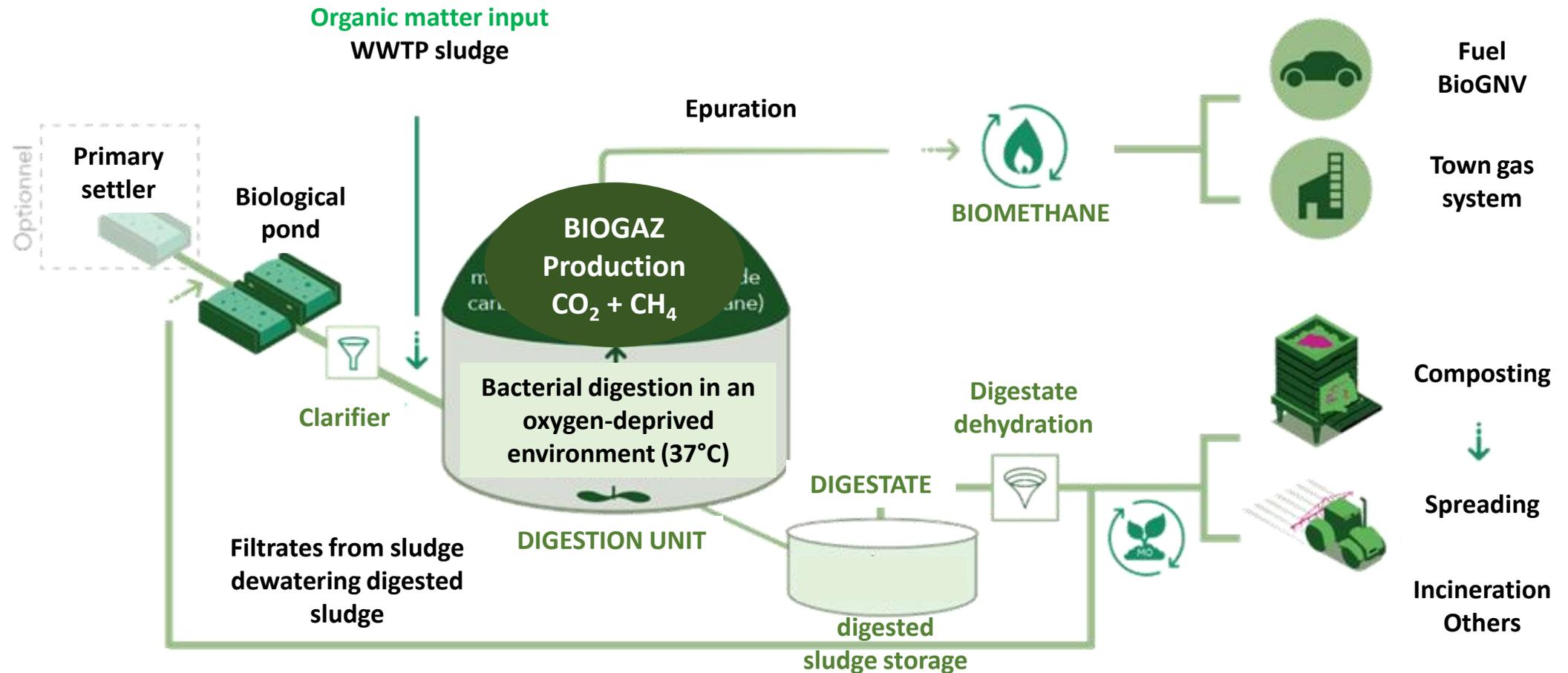
VEOLIA

← NFU 44-095

The new orientations

Methanization

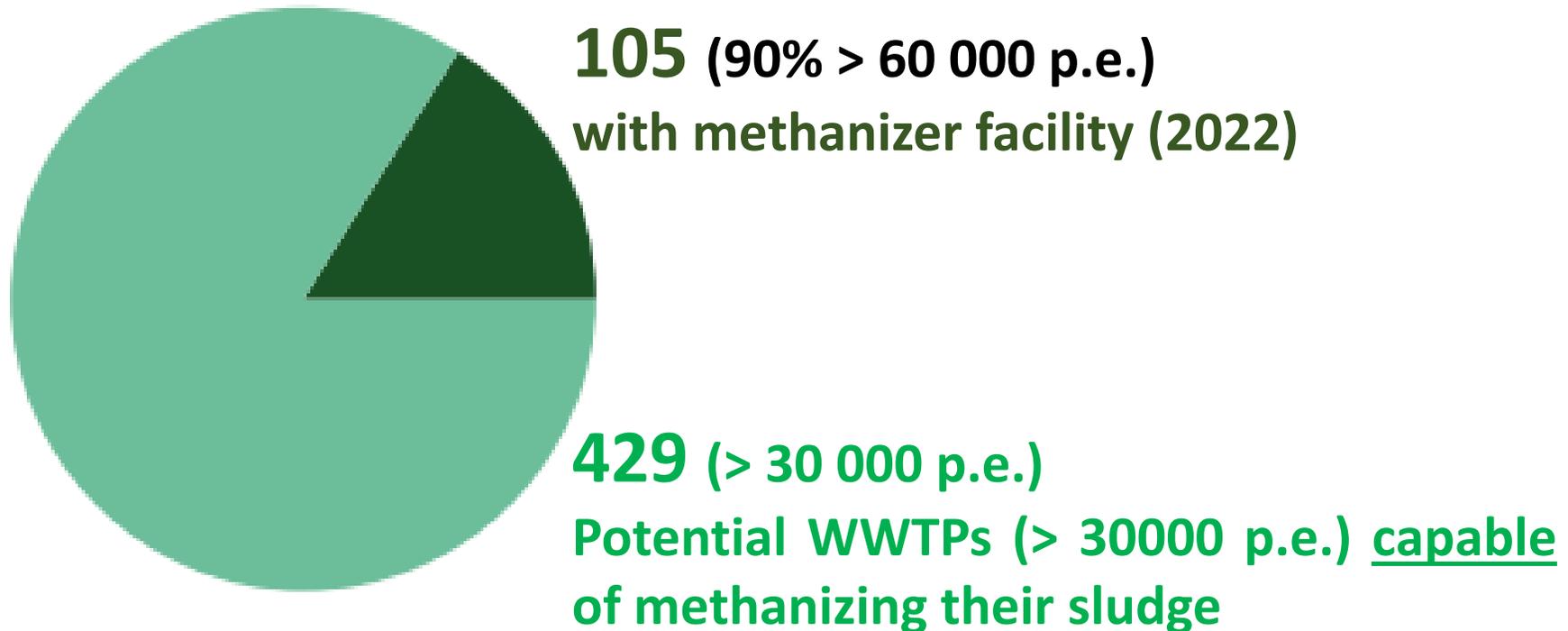
○ General principle



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



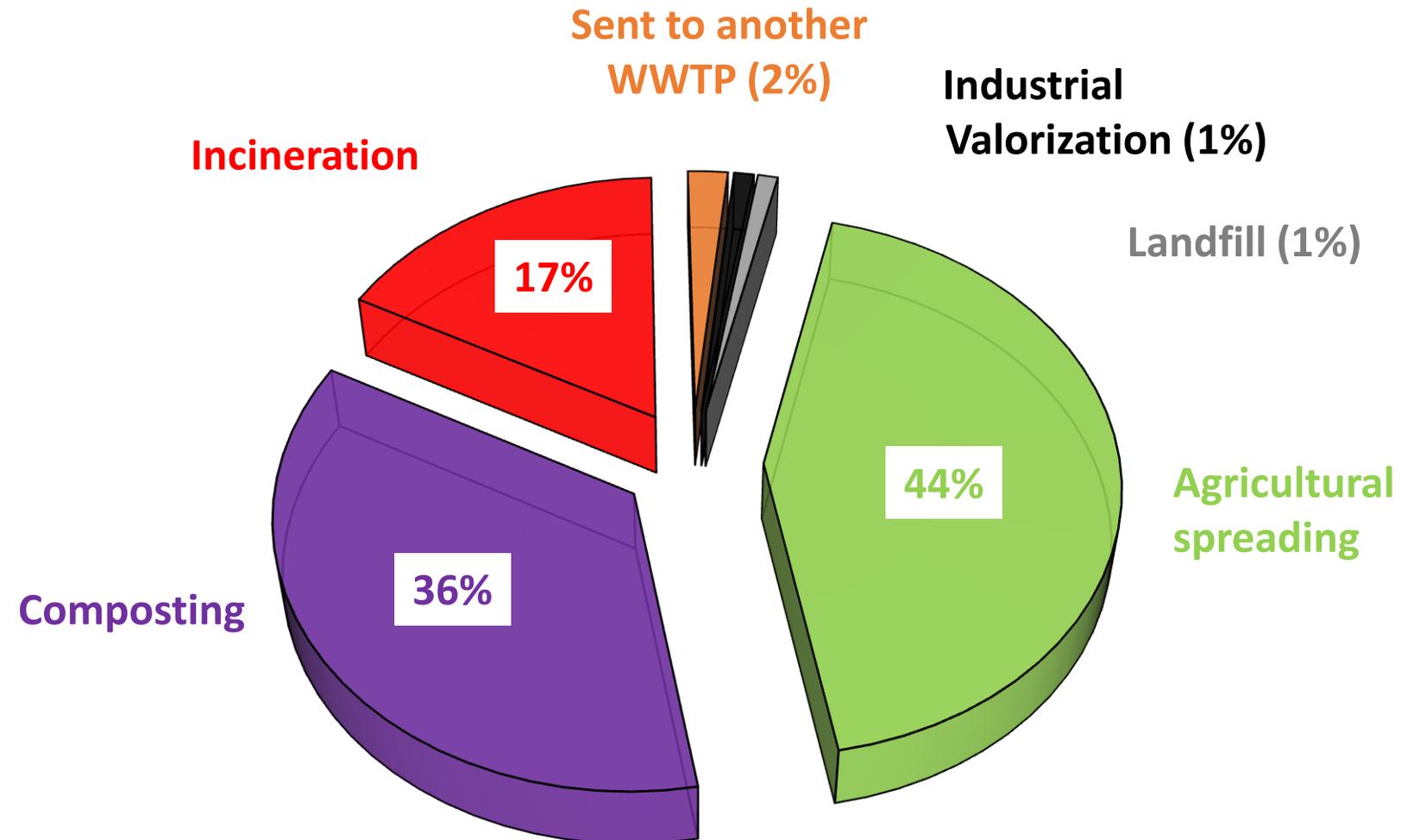
SmartWater Summer FORUM

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*.