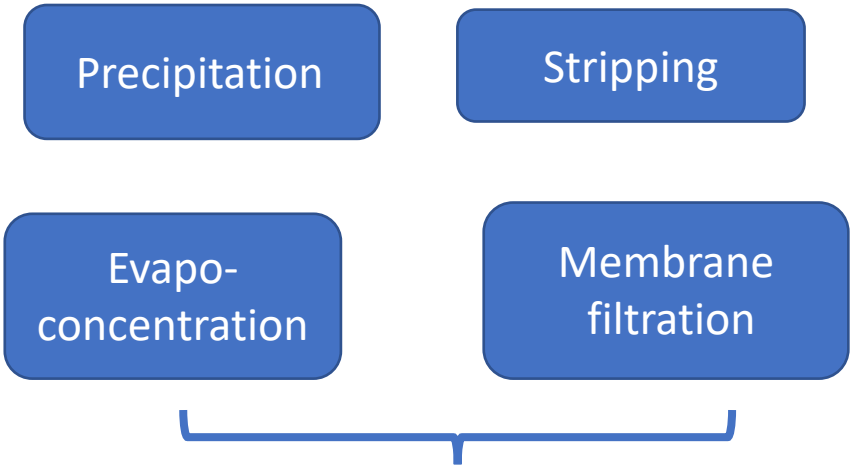
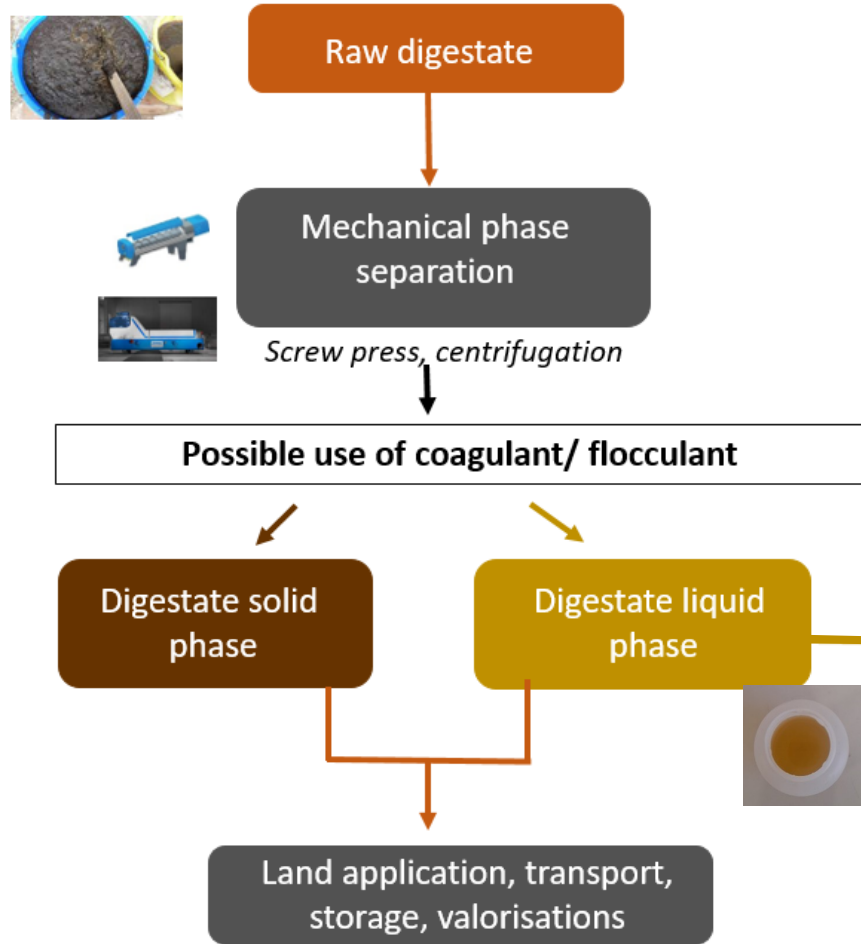
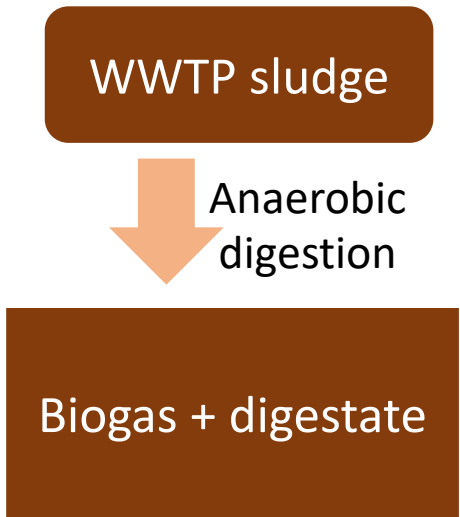



Functionalized Chitosan as a biosourced coagulant/flocculant for solid and liquid phase separation of sewage sludge digestate

S. Lèbre, G. David, C. Negrell, A. Battimelli, H. Carrère, E. Ruiz, L. Vachoud, C. Wisniewski

➤ Sludge and digestate management



 **Need of an efficient removal of solids in the liquid phase**



➤ Objective of the study

Interest of optimizing solid/liquid phase separation of digestates

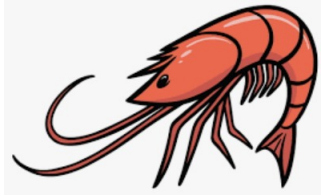
Decrease the impact of coagulants/flocculants using **natural biopolymers**



Advantages :
Produced from renewable resources
Circular economy model

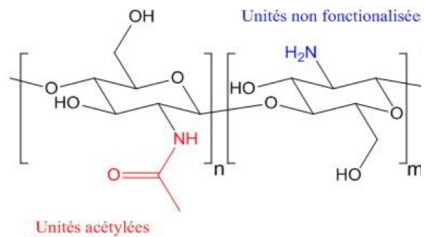
Objective: Evaluate and optimize the efficiency of a biosourced **chitosan-based** coagulant/flocculant on phase separation of digestates for the recovery of fertilising elements

➤ Experimental design with Chitosan



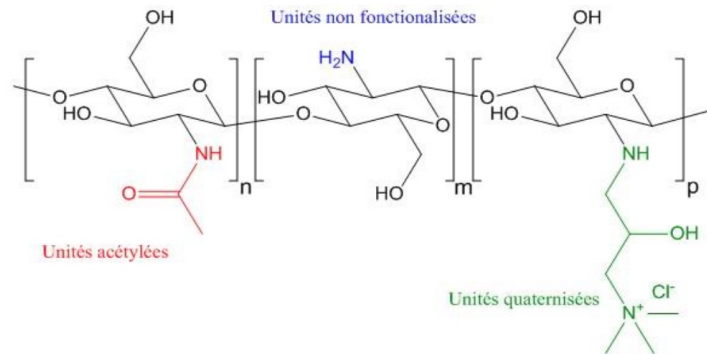
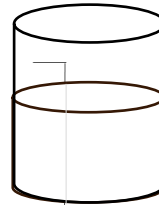
2nd biopolymer the most abundant in the world
Obtained from chitin (shrimps)

Raw Chitosan
Poor solubility in
water when pH > 6



Functionalization⁽¹⁾
Addition of a
quaternary
ammonium function

Functionalized CHitosan (CHF)
with cationic charge



Positive electric charge



Better reactivity with
colloids (negative charge)



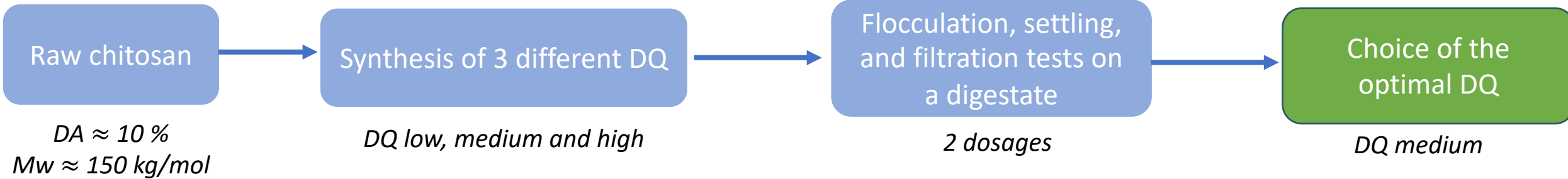
Soluble at the whole pH
range

Functionalized chitosan is
characterized by its Quaternization
Degree (DQ)

(1) Loubaki et al. (1991), Chemical modification of chitosan by glycidyl trimethylammonium chloride. Characterization of modified chitosan by modified chitosan by ¹³C and ¹H-NMR spectroscopy

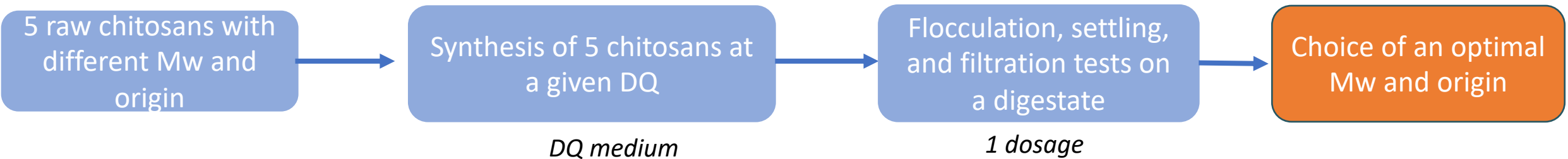
➤ Optimization of Chitosan Functionalization (CHF)

1) Effect of quaternisation degree (DQ) on digestate's dewaterability (one molar weight and origin)



Comparison to a cationic polyacrylamide (PC)

2) Effect of molar weight (Mw) and Origin of CHF on digestate's dewaterability (one DQ)



Comparison to a cationic polyacrylamide (PC)

➤ Physico-chemical parameters of digestate after coagulation/flocculation

pH

Small ↗
(+0,3 in average)

Conductivity

Small ↘
(-0,5 à -1 mS/cm in average)
more visible with chitosans

Capturing negative charges and lowering the electrical mobility of the medium⁽²⁾

Granulometry

PC : agglomeration of particles ($\approx 100 - 1000 \mu\text{m}$)

CHF : monomodal distribution ($\approx 30-85 \mu\text{m}$)⁽³⁾

Hypotheses : different flocculation mechanisms ?

Rheology

PC : viscosity ↗

↘ **CHF** :
viscosity, link with dosage but no link with DQ and Mw

Hypotheses : links with physico-chemical characteristics of digestate ?

²Sriwiriyarat et al. (2008), Feasible use of electrical conductivity for optimizing polymer dosage and mixing time requirement in sludge conditioning

³Wang et al. (2018), Advanced anaerobic digested sludge dewaterability enhancement using sludge based activated carbon (SBAC) in combination with organic polymers

➤ Effect of the flocculants on the digestate's dewaterability

Settling

Raw Digestate no settling capacity :

$$\frac{v_{liquid}}{v_{total}} = 0$$

All: Small improvement of settling
(19-29 % of $\frac{v_{liquid}}{v_{total}}$)

Filtration

All : $\frac{v_{liquid}}{v_{total}}$ of 70-85 %

CHF : Improvement of filtration kinetics

Centrifugation

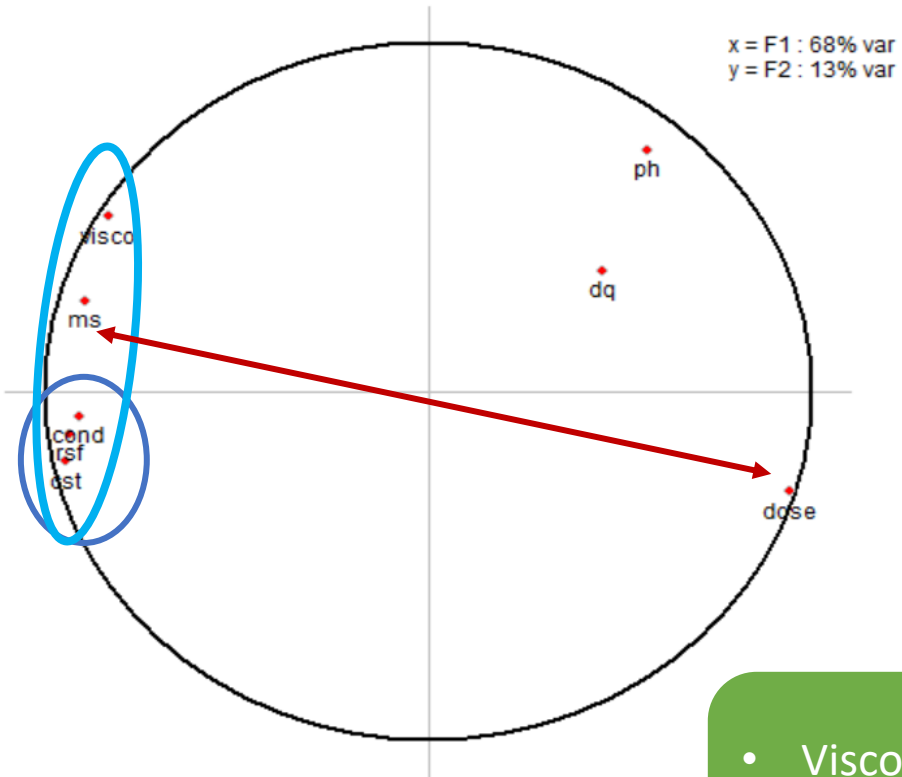
All : $\frac{v_{liquid}}{v_{total}}$ of 45-50 %

CHF : small ↗ if Mw ↗

1) Effect of quaternization degree (DQ) on digestate's dewaterability (one molar weight and origin)

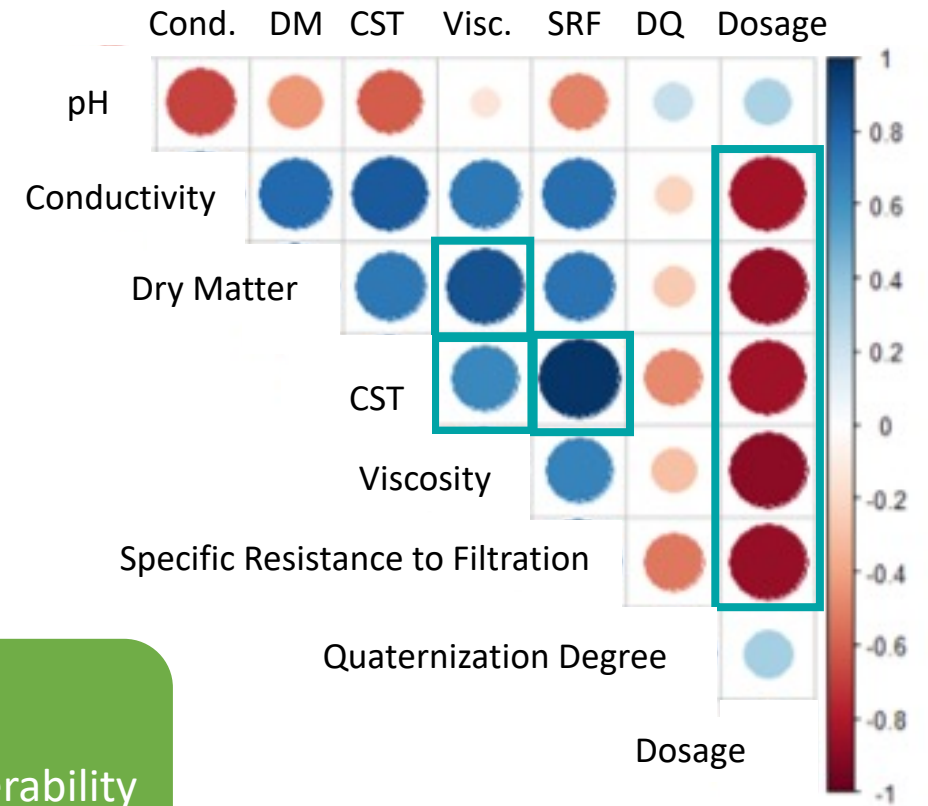
R data processing

Principal Component Analysis



- Viscosity/DM/CST
- Improvement of sludge dewaterability : correlation with dose but not DQ

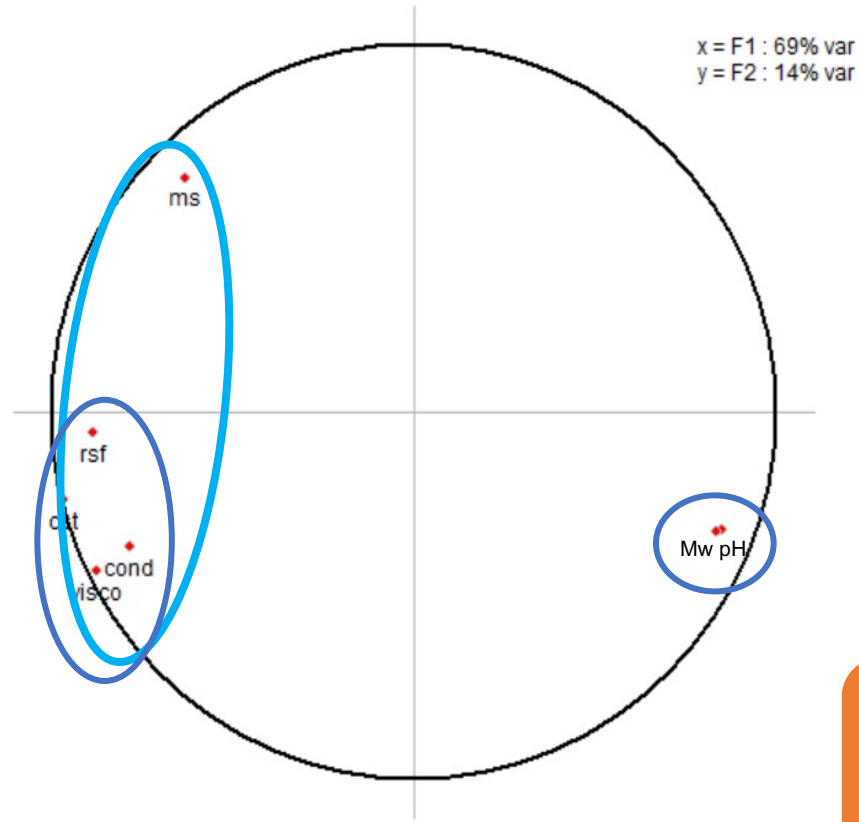
Correlation Matrix



2) Effect of molar weight (Mw) and Origin of CHF on digestate's dewaterability (one DQ)

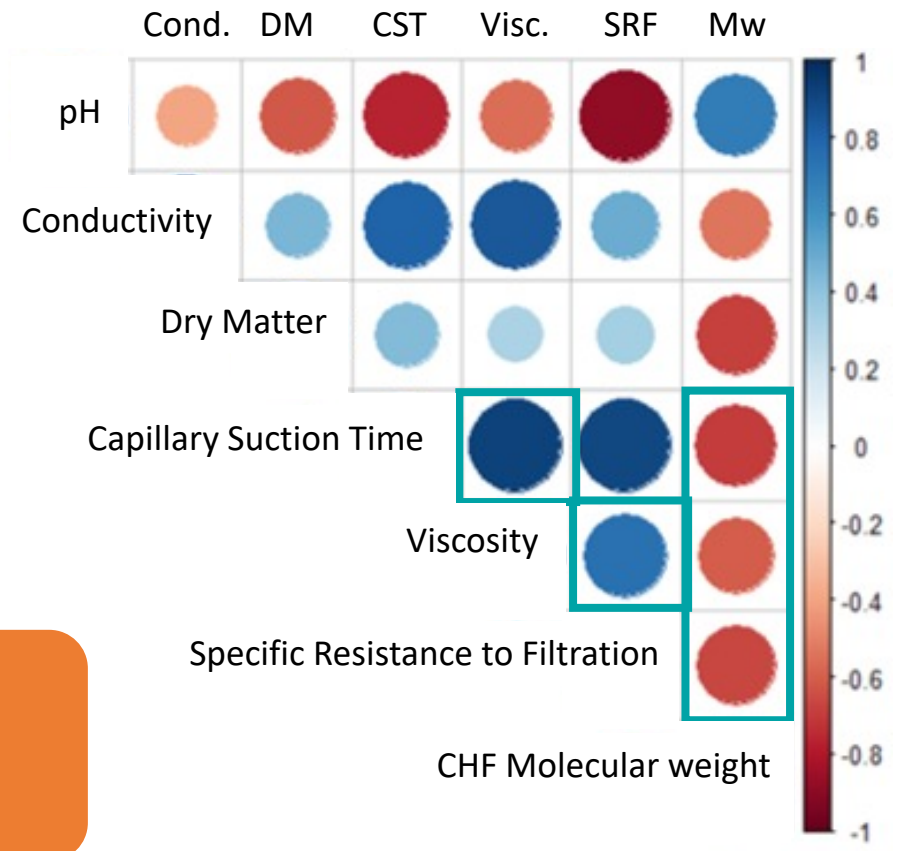
R data processing

Principal Component Analysis



- Viscosity/SRF/CST
- Improvement of sludge dewaterability : correlation with Mw

Correlation Matrix



INRAE



➤ Conclusions and future work



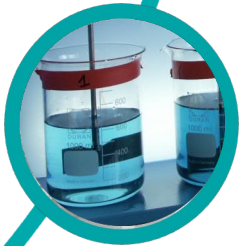
Efficiency of the functionalized chitosan

- Improves : settleability, filtration kinetics
- Efficiency : DQ and dosage, optimum for a given Mw
- Granulometry : monomodal distribution for all CHF
- Rheology : decrease of digestate's viscosity, link with the dosage



Comparison to a commercial cationic polyacrylamide

- Different results on granulometric behaviour and higher viscosity
- Suspensions difficult to homogenize due to viscosity



Outlooks with CHF

- Optimisation of dosages and centrifugation conditions
- Comprehensive study of interactions between parameters
- Tests of fertilising potential, life cycle analysis and ecotoxicology



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Thank you for attention

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Marseille, France
7 ISEBE
Postponed to
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