



Politechnika Wroclawska



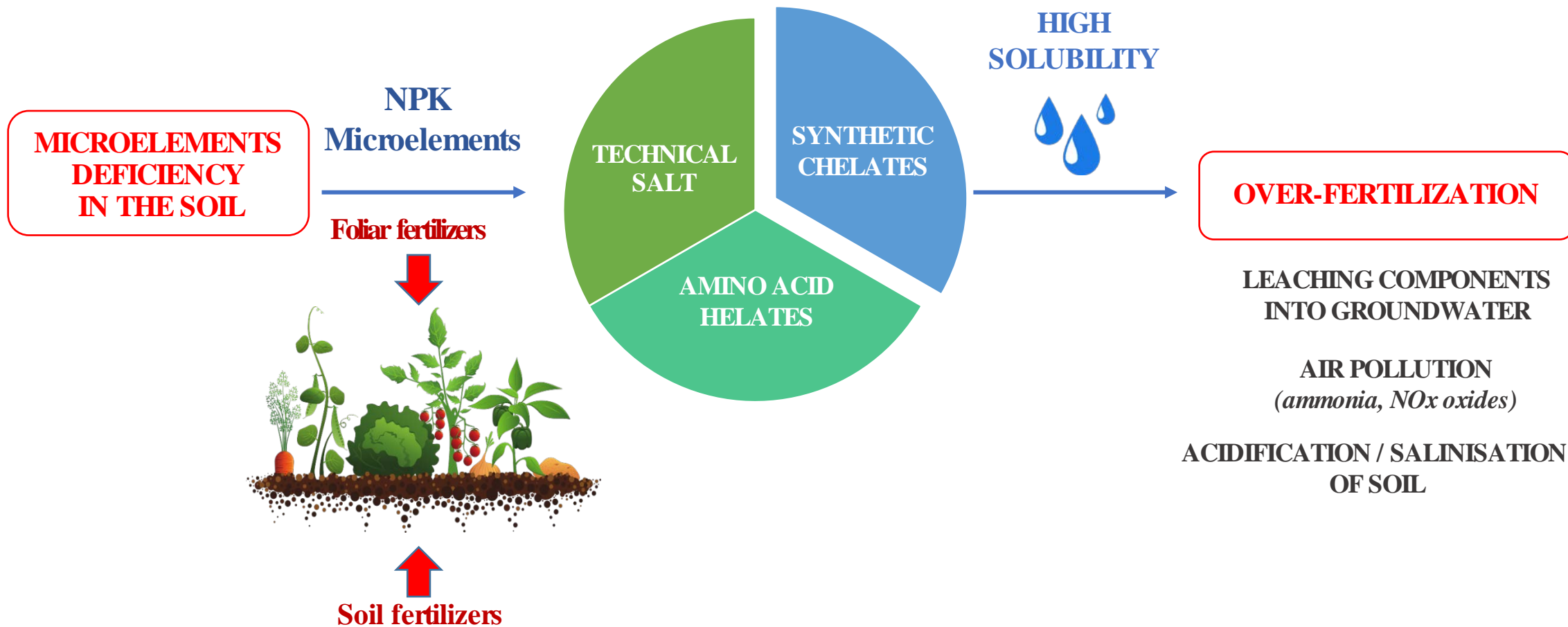
# Preparation of hydrogel capsules as macro and microelements carriers



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# TRADITIONAL FERTILISATION AND THE ENVIRONMENT



# INNOVATIVE FERTILIZERS

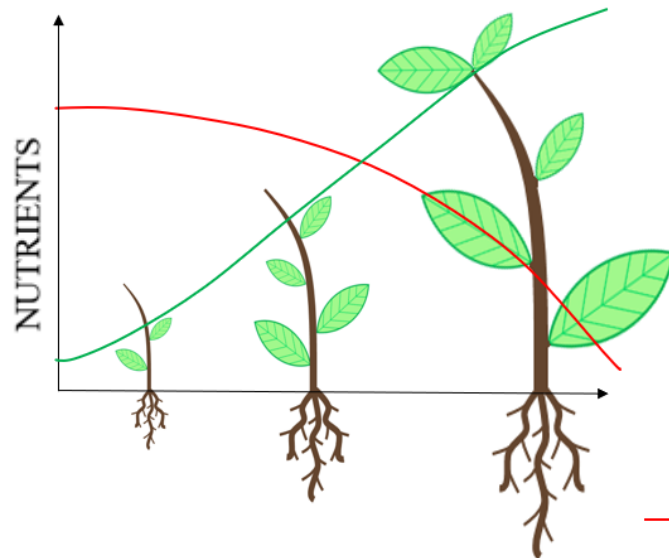


**The challenge to agriculture:**  
**PRECISE FERTILIZATION**

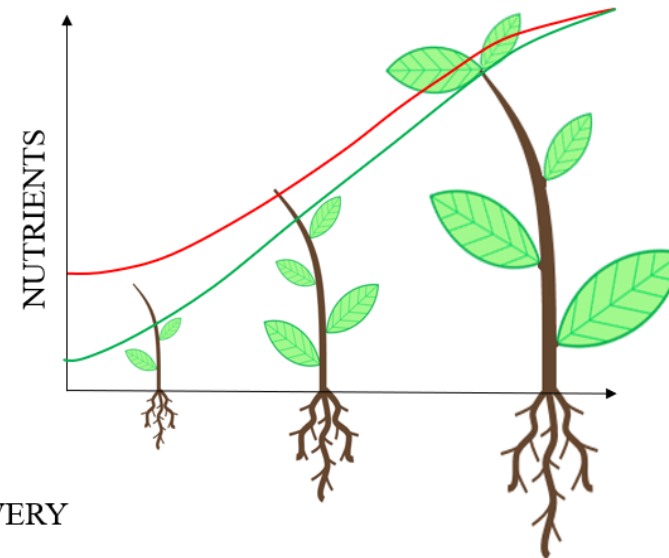


**RELEASE OF COMPONENTS  
DEPENDING ON THE PLANT  
GROWTH STAGE**

**Traditional fertilizers**



**Precise fertilization**

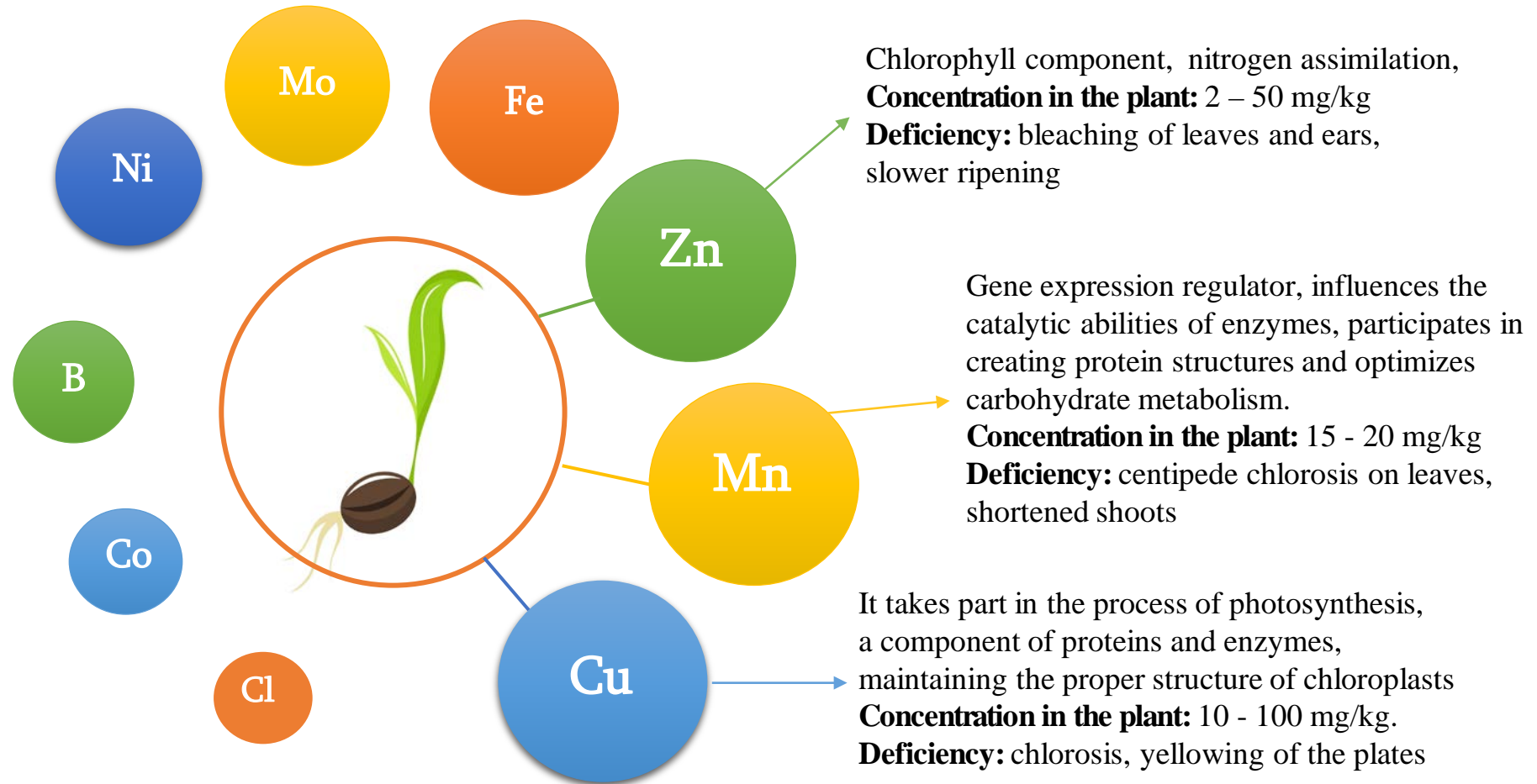


— DELIVERY  
— NEEDS

# PLANT NUTRITIONAL REQUIREMENTS



## MICROELEMENTS



# INNOVATIVE HYDROGEL STRUCTURES WITH IMMOBILIZED BIOMASS

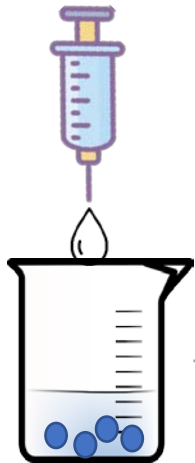


Biodegradable materials

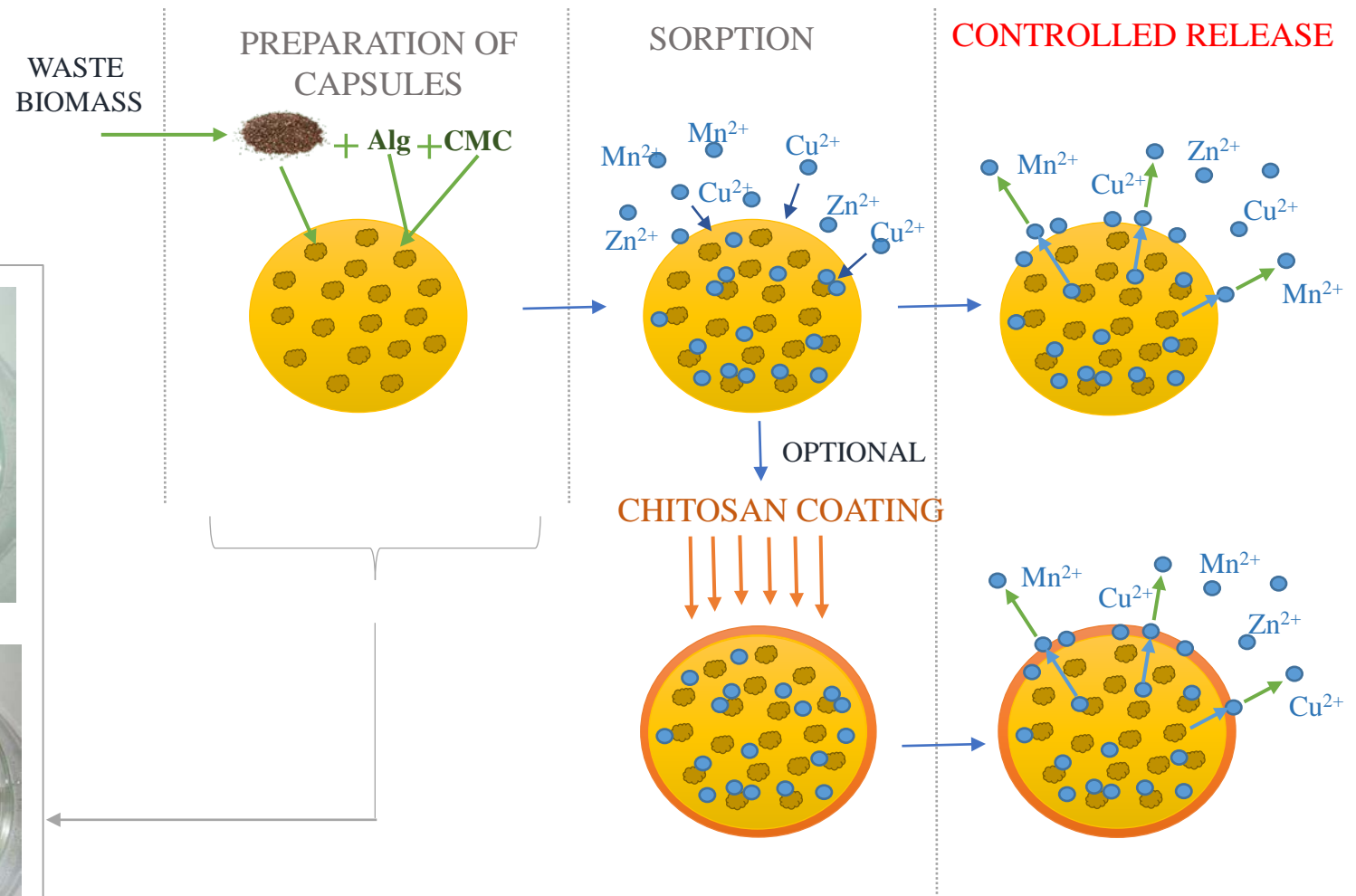
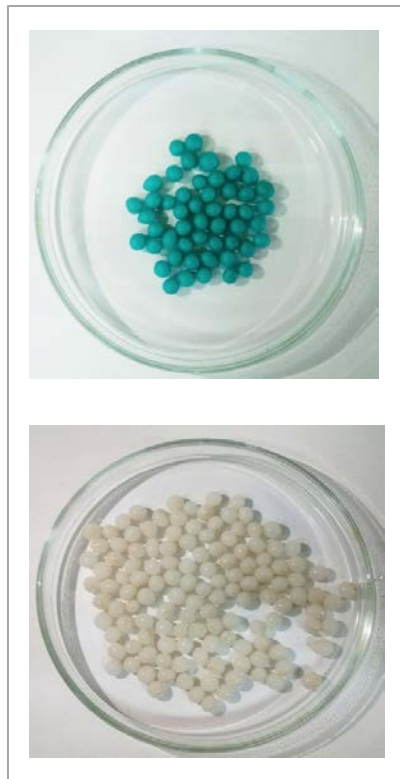
Reduction of manufacturing costs through the use of waste materials - according to the assumptions of circular economy

Sodium alginate

Biomass



Crosslinking agent  
 $\text{CaCl}_2$  0,2M



# OPTIMIZATION OF THE COMPOSITION OF THE HYDROGEL MATRIX



## THE CONCENTRATION OF INGREDIENTS

Too high



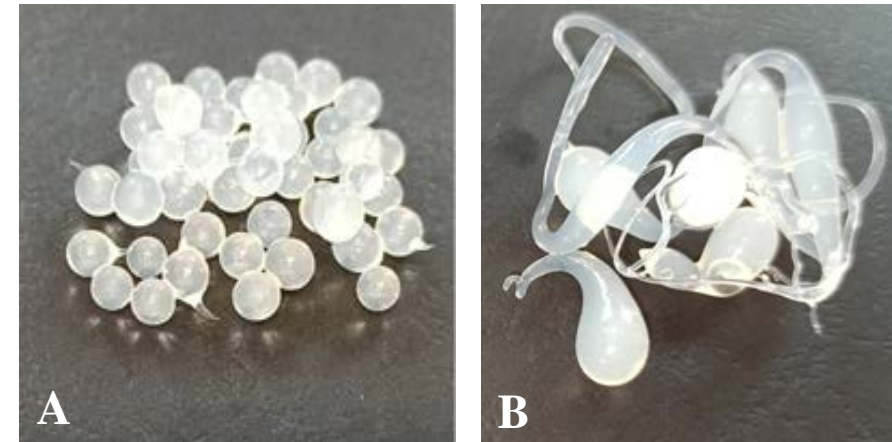
Problems at the crosslinking stage

Deformation of structures

Too low

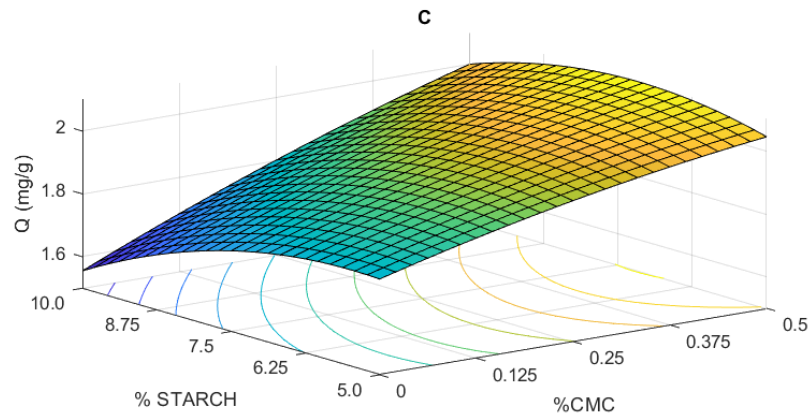
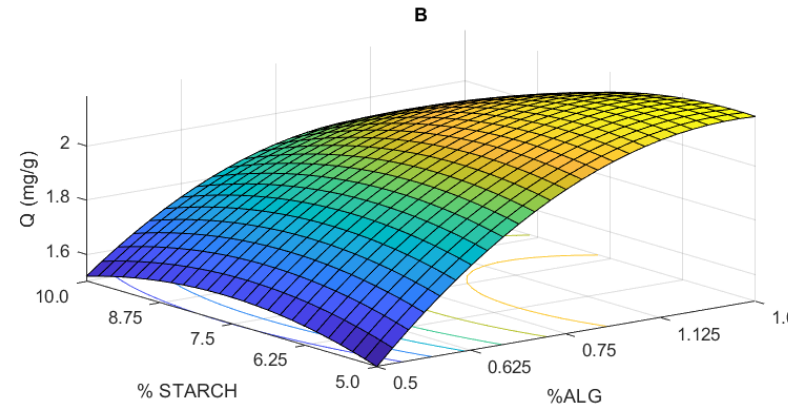
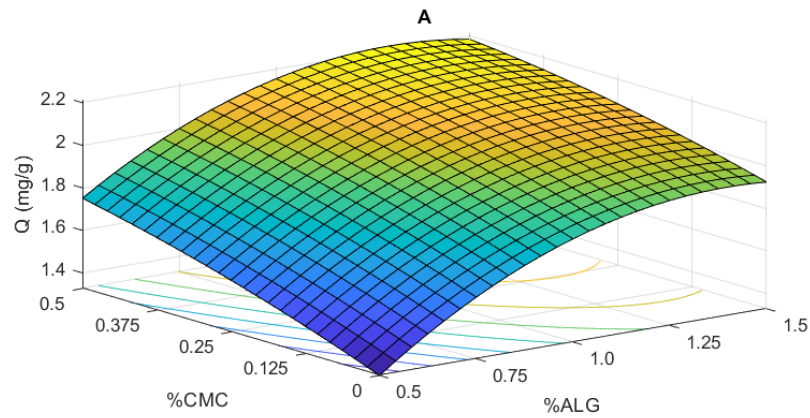


No 3D structures



**Fig. 1.** Preparation of hydrogel capsules: with an optimal concentration of sodium alginate (2% m / m) (A) and a high concentration of sodium alginate (over 5% m / m) (B)

# OPTIMIZATION OF THE COMPOSITION OF THE HYDROGEL MATRIX



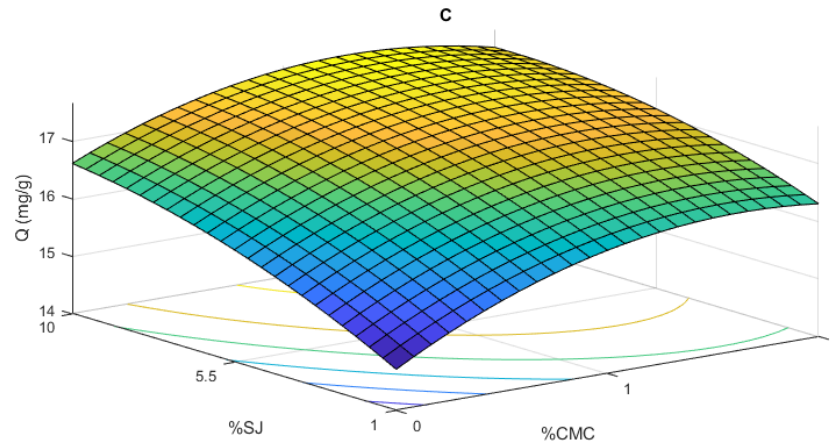
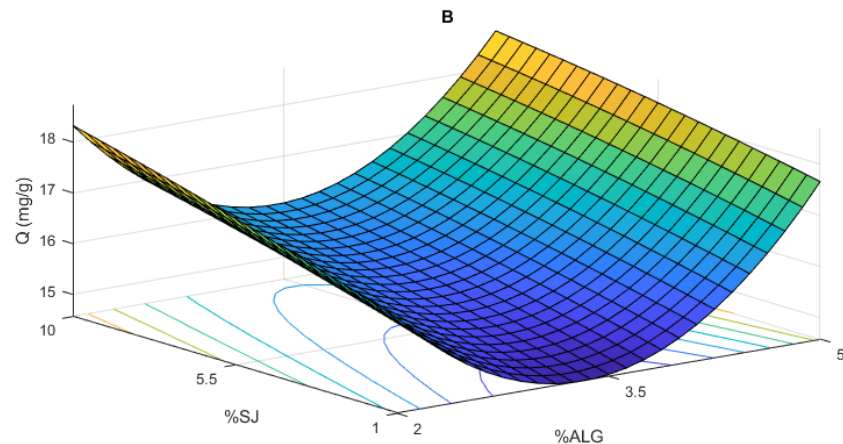
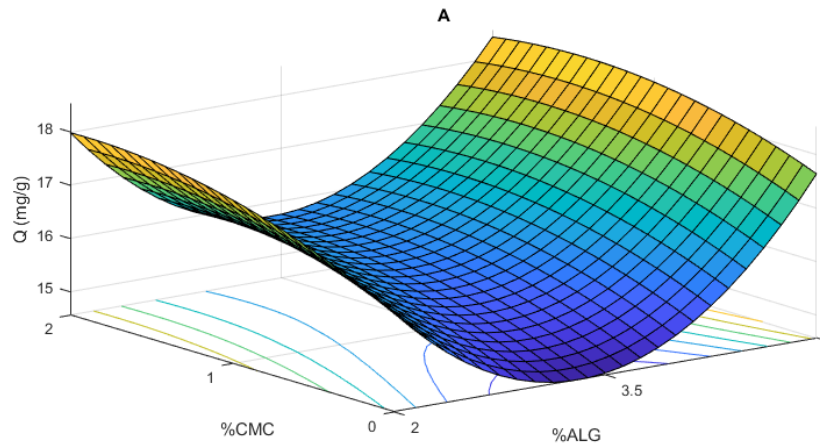
No.	Capsule type	Alginate	CMC	Starch
		% m/m	% m/m	% m/m
1.	ALG	2.0	-	-
2.	ALG/CMC	2.0	1.0	-
3.	<b>ALG/CMC/STARCH</b>	1.3	0.5	6.5

**REDUCTION OF PRODUCTION COSTS**

**Fig 2.** 3D charts of interaction on the sorption capacity of capsules of two independent variables: (A) concentration of CMC and concentration of ALG, (B) concentration of starch and concentration of ALG, (C) concentration of starch and concentration of CMC, obtained based on Box-Behnken Design



# OPTIMIZATION OF THE COMPOSITION OF THE HYDROGELS

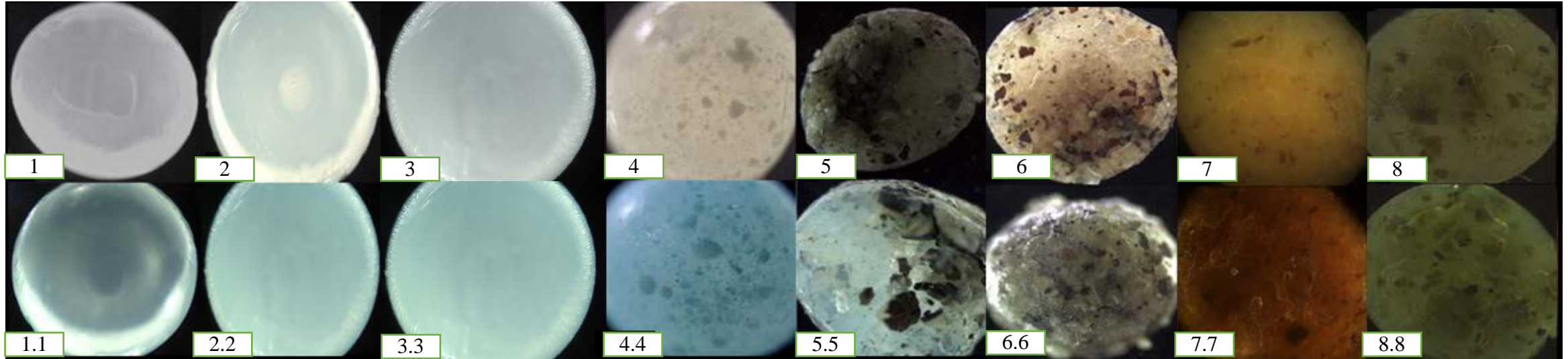


No.	Capsule type	Alginate	CMC	Biosorbent
		% m/m	% m/m	% m/m
1.	ALG/CMC/ <b>EGG SHELL</b>	5	1.2	10
2.	ALG/CMC/ <b>BLACK CURRANT</b>	2	0.5	10
3.	ALG/CMC/ <b>RAPE</b>	2	0.5	10
4.	ALG/CMC/ <b>GOLDENROD</b>	2	0.5	10
5.	ALG/CMC/ <b>ALFALFA</b>	2	0.5	10

**Fig 3.** 3D charts of interaction on the sorption capacity of capsules of two independent variables: (A) concentration of CMC and concentration of ALG, (B) concentration of ES and concentration of ALG, (C) concentration of ES and concentration of CMC, obtained based on Box-Behnken Design



# PREPARED HYDROGEL CARRIERS



$Q_{\max}=4,79$  mg/g

$Q_{\max}=7,55$  mg/g

$Q_{\max}=18,35$  mg/g

$Q_{\max}=23,50$  mg/g

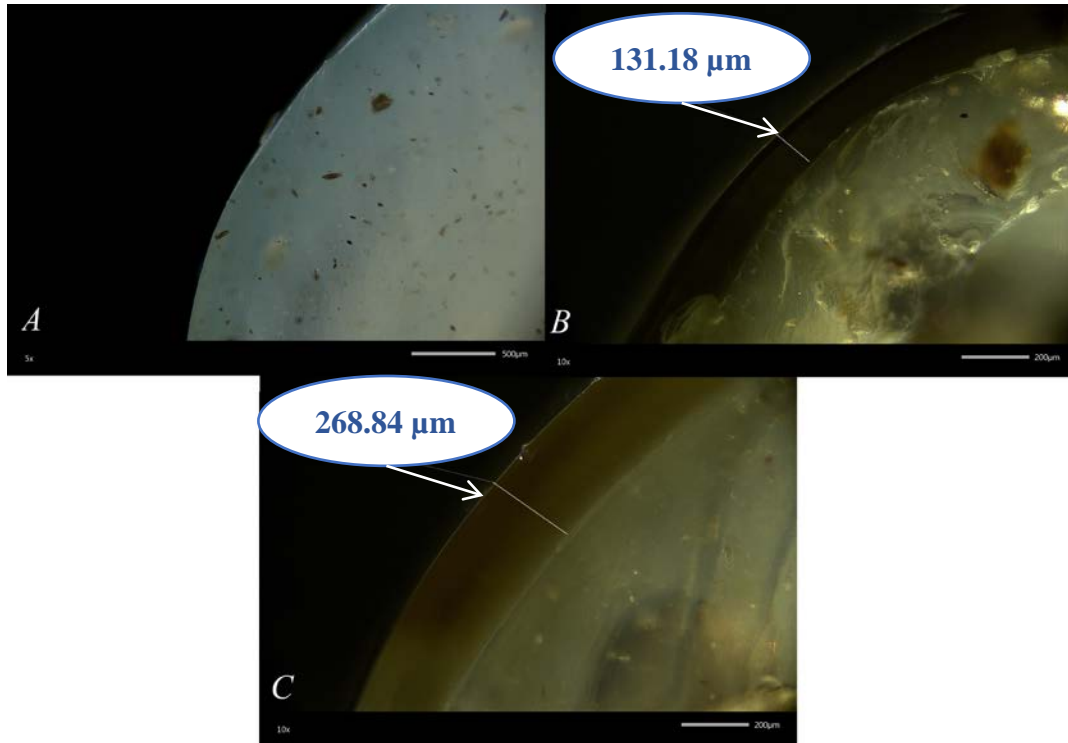
$Q_{\max}=19,40$  mg/g

$Q_{\max}=8,46$  mg/g

$Q_{\max}=7,54$  mg/g

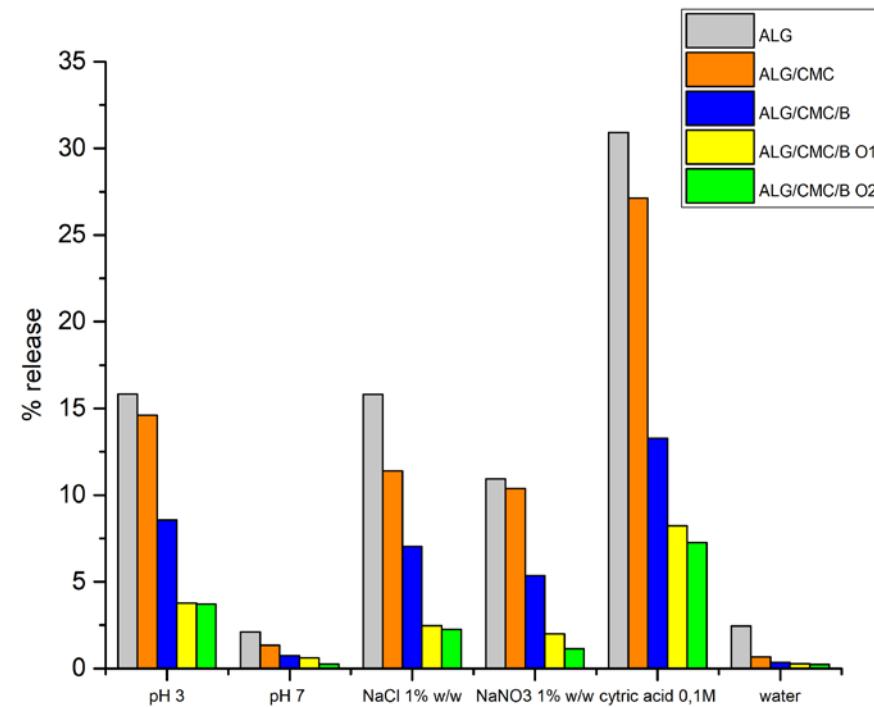
$Q_{\max}=8,98$  mg/g

# CHITOSAN COATINGS



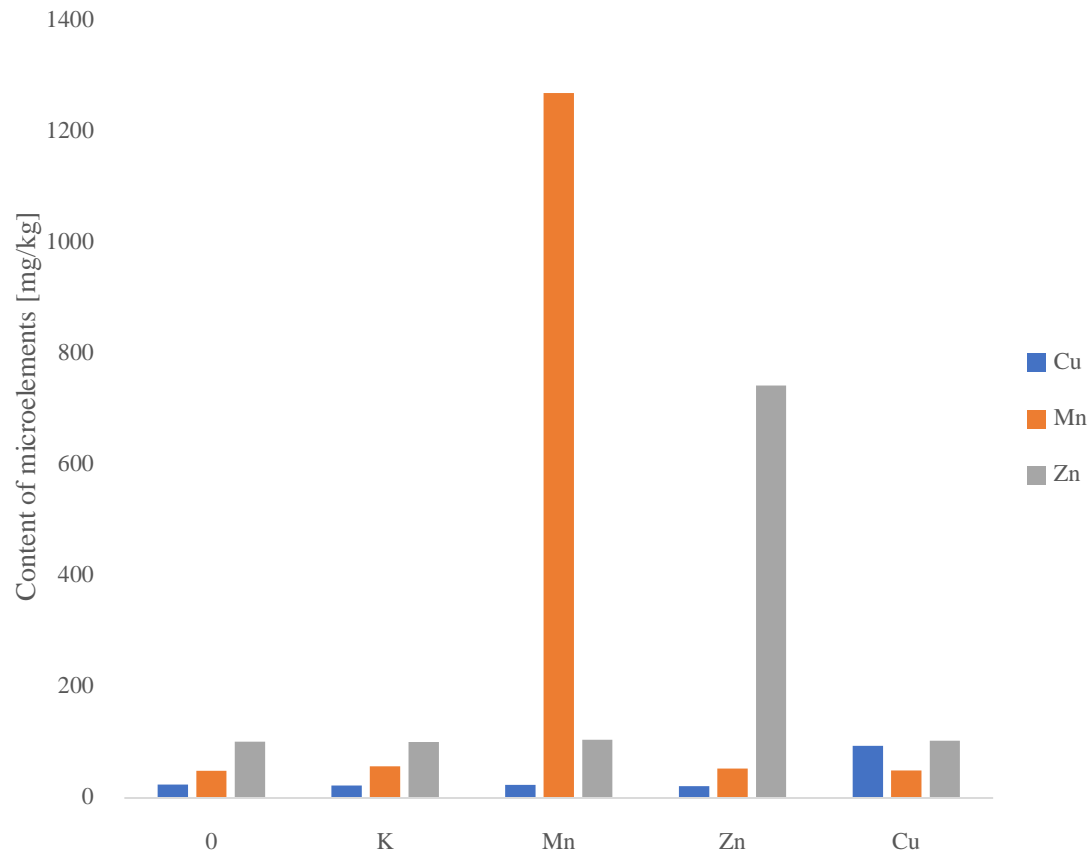
**Fig. 4.** Composite after sorption without coating (A), with 1% chitosan coating (B), with 2.5% chitosan coating (C)

CHITOSAN COATINGS → Slower release of  $\text{Cu}^{2+}$  ions

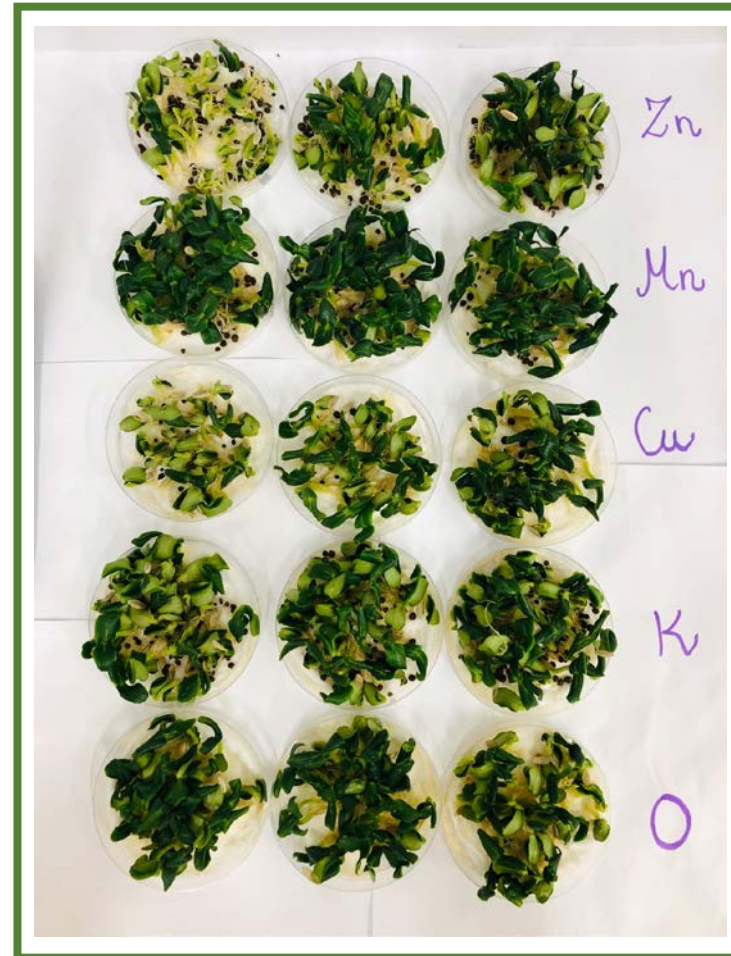


**Fig. 5.** Release of  $\text{Cu}^{2+}$  ions in various media

# GERMINATION TESTS



**Fig.6.** The content of microelements in the tested cucumber sprouts



← 10,8 mg Zn<sup>2+</sup>

← 8,19 mg Mn<sup>2+</sup>

← 1,45 mg Cu<sup>2+</sup>

← Composites without enrichment

← Control sample (no hydrogels)





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**THANK YOU FOR YOUR ATTENTION**



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Katarzyna Mikula