FANGHI DI DEPURAZIONE
Caratteristiche chimiche e proprietà fertilizzanti

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Chiudere il cerchio: Riuso dei biosolidi su suoli agricoli
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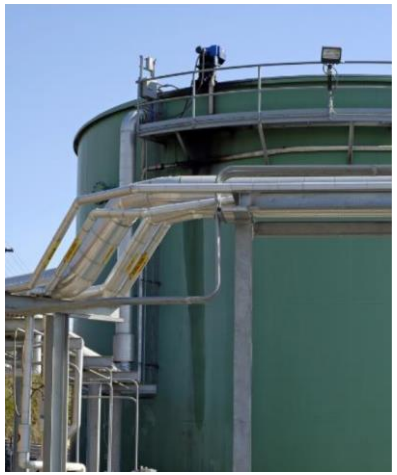
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

FANGHI di depurazione

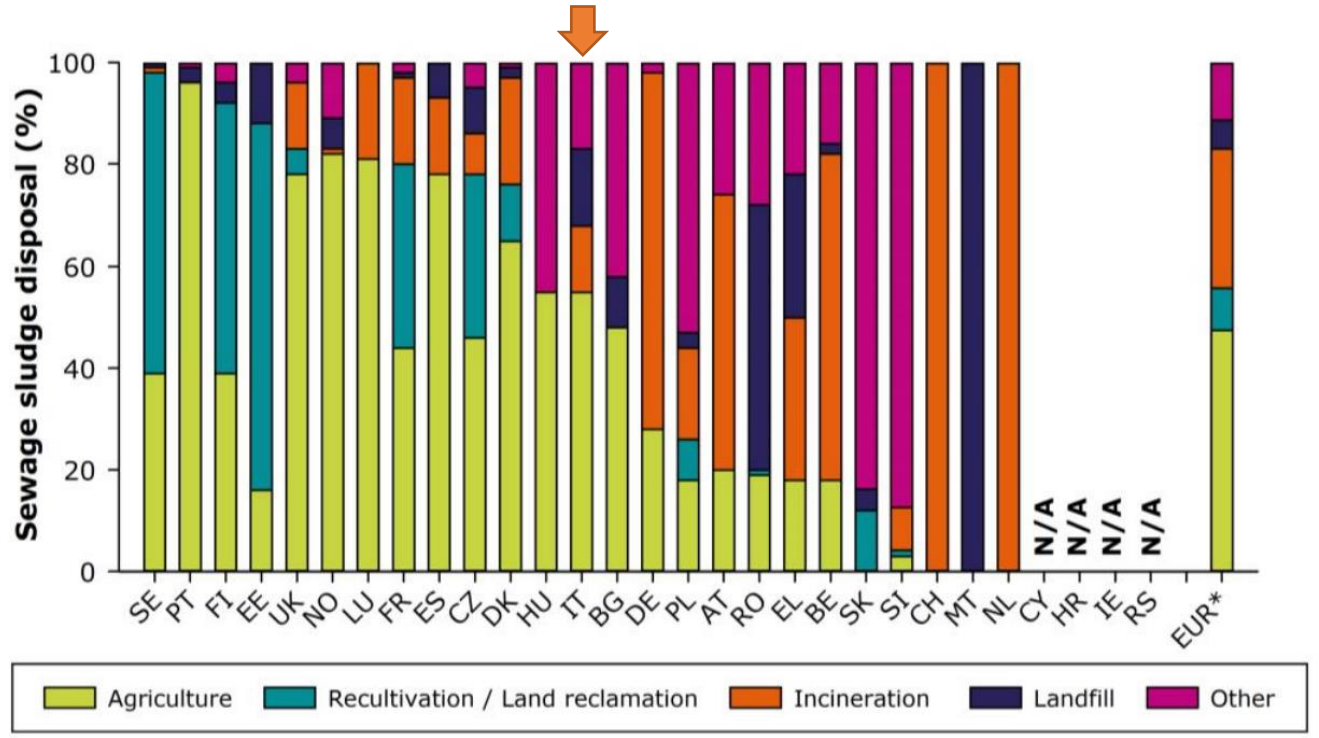
RESIDUI DERIVANTI DAI PROCESSI DI DEPURAZIONE DELLE ACQUE REFLUE PROVENIENTI DA INSEDIAMENTI CIVILI E/O DA INSEDIAMENTI PRODUTTIVI Council Directive 91/271/EEC



22.5 kg ss/abitante/anno

Europa 10M t/anno
ITALIA 1.5 M t/anno

Destinazione dei fanghi nei diversi paesi (%) (EurEAU Survey 2017)



UPCYCLING dei fanghi in AGRICOLTURA

PRODOTTI FERTILIZZANTI (D. Lgs. 75/2010)

AMMENDANTE COMPOSTATO CON FANGHI

prodotto da processo di trasformazione e stabilizzazione di reflui e fanghi (<35%) + altre matrici
pH 6.0-8.8; C>20%; C umico e fulvico > 7%; N organico > 80% dell'N totale; C/N < 25;
Assenza di *Salmonella* e *Escherichia coli*

GESSO DI DEFECAZIONE DA FANGHI

prodotto da idrolisi di fanghi mediante calce e/o acido solforico e successiva precipitazione del solfato di calcio

Can we reuse sludges in agriculture?

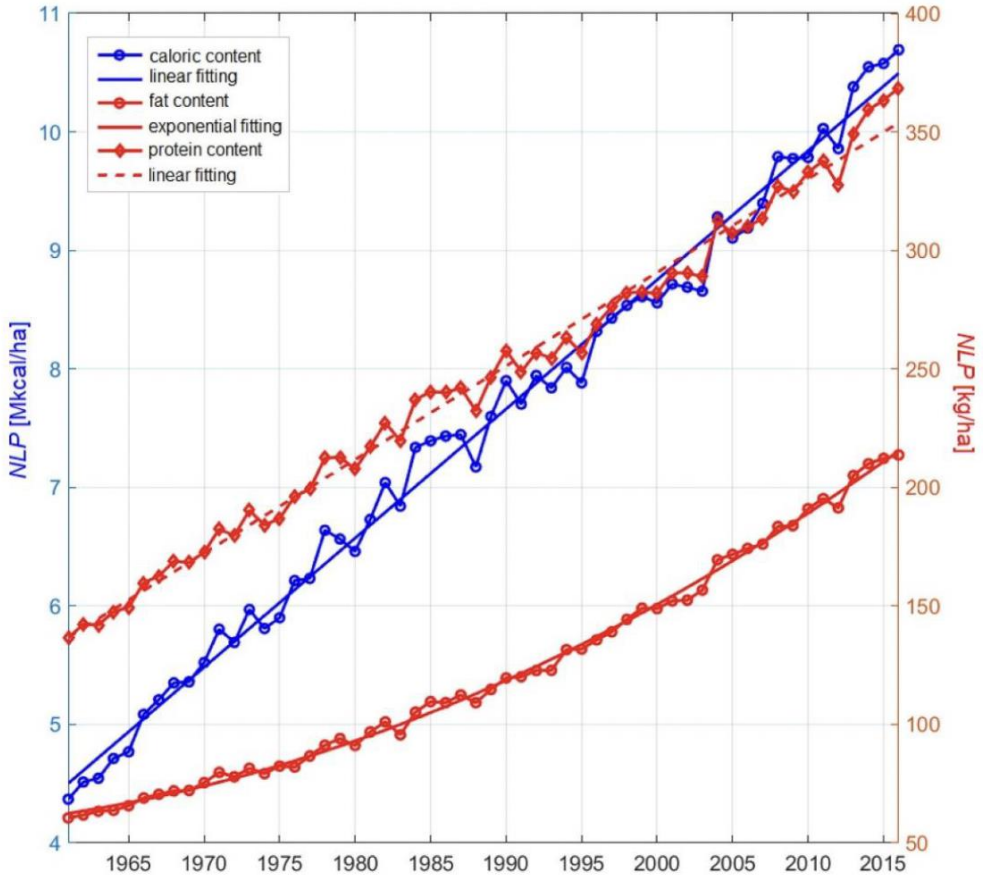
HETEROGENEOUS MATERIAL THAT IS ADDED TO COMPLEX SYSTEMS

+ Macro & micronutrients for plants
+ Organic metabolites for the soil-plant-microbiome system
+ Carbon sources that can increase C sequestration and mitigate climate change

- Contaminants: organic and inorganic compounds
- Pathogens

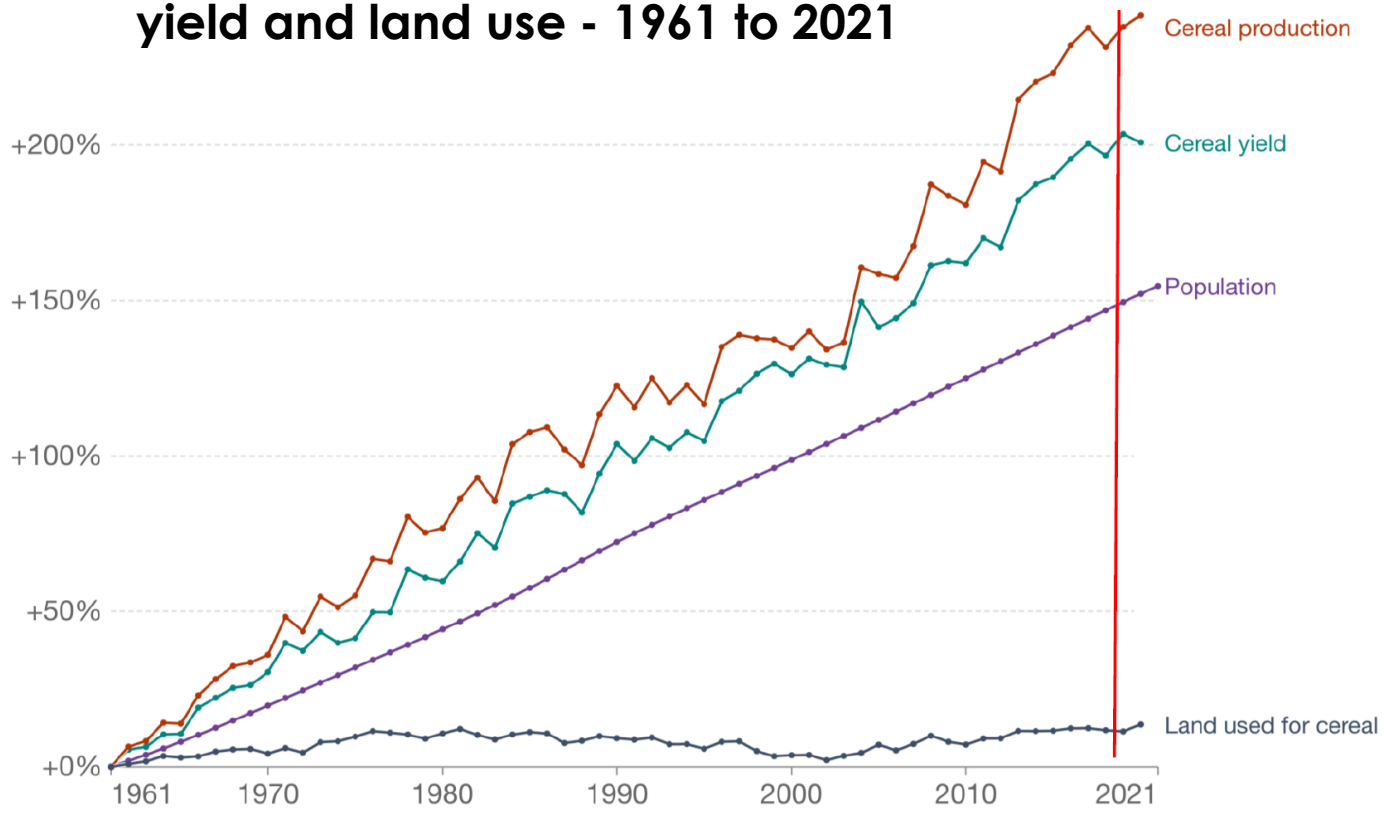
1) MACRO & MICRONUTRIENTS FOR PLANTS

Global nutrient land productivity



(Tuninetti et al. 2020)

Global Change in cereal production, yield and land use - 1961 to 2021



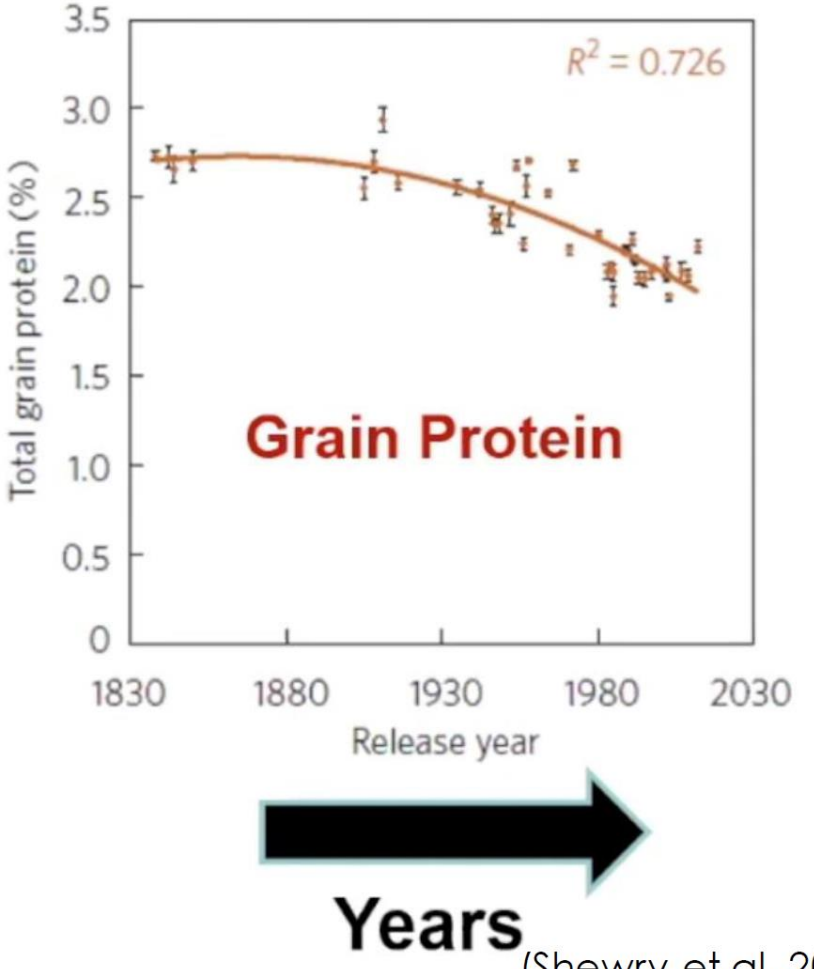
Source: Our World in Data based on World Bank, Food and Agriculture Organization of the United Nations
OurWorldInData.org/crop-yields • CC BY

1) MACRO & MICRONUTRIENTS FOR PLANTS

Agricultural soils deficient in nutrients

Element	%
N	85
P	73
K	55
B	31
Cu	14
Mn	10
Mo	15
Zn	49

Decrease of proteins in grain



(Shewry et al. 2016)

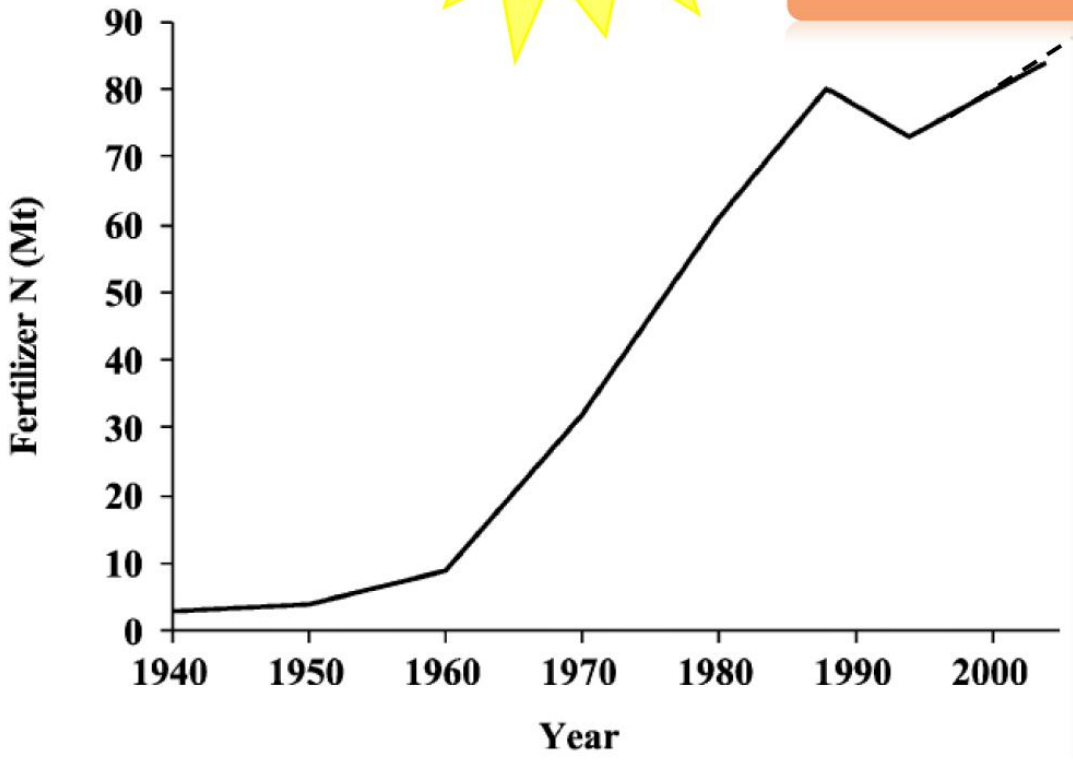
1) MACRO & MICRONUTRIENTS FOR PLANTS

NITROGEN

$N \equiv N + H_2 \rightarrow NH_3$

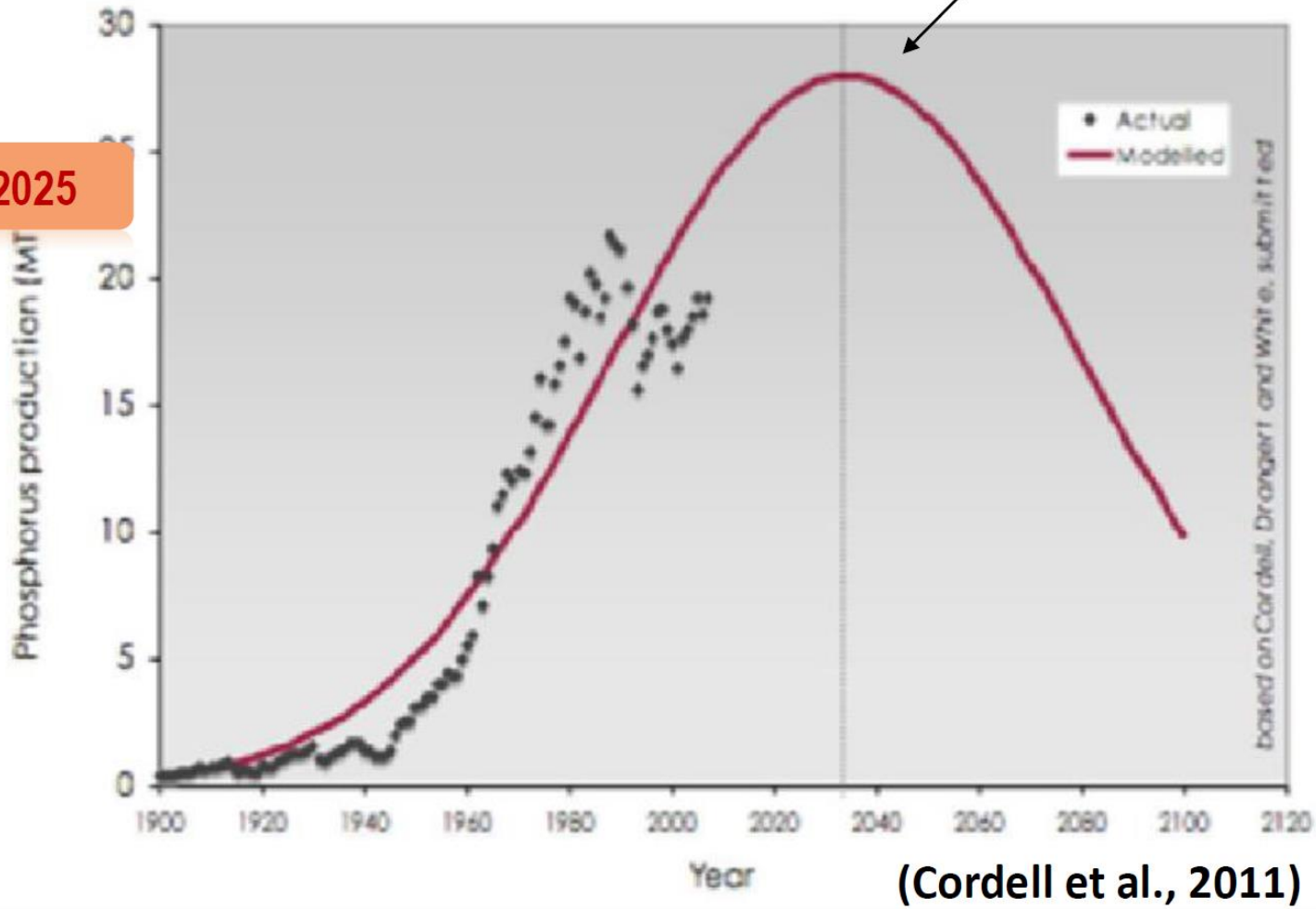
2% OF GLOBAL PETROL

130.5 Mt in 2025



PHOSPHORUS

EXTRACTION FROM MINES IS ABOUT TO FINISH



(Cordell et al., 2011)

WASTES CONTAIN MACRONUTRIENTS (N,P,K)

WASTE TYPE	C/N	N	P	K	N/P
		%	%	%	
OFMSW 1	11,7	3,6	0,3	2,2	11,0
OFMSW 2	12,2	4,0	0,5	1,8	8,2
OFMSW3	12,2	3,8	0,6	2,5	7,0
SLUDGES 1	6,6	4,3	2,7	0,7	1,6
SLUDGES2	7,2	4,3	2,4	0,4	1,8
SLUDGES 3	7,1	5,2	2,1	0,6	2,5
LEACHATE 1	9,1	0,07	0,01	6,8	6,7
LEACHATE 2	9,8	1,36	0,40	5,7	3,4
LEACHATE 3	9,8	11,78	0,80	5,3	14,7

1) MACRO & MICRONUTRIENTS FOR PLANTS

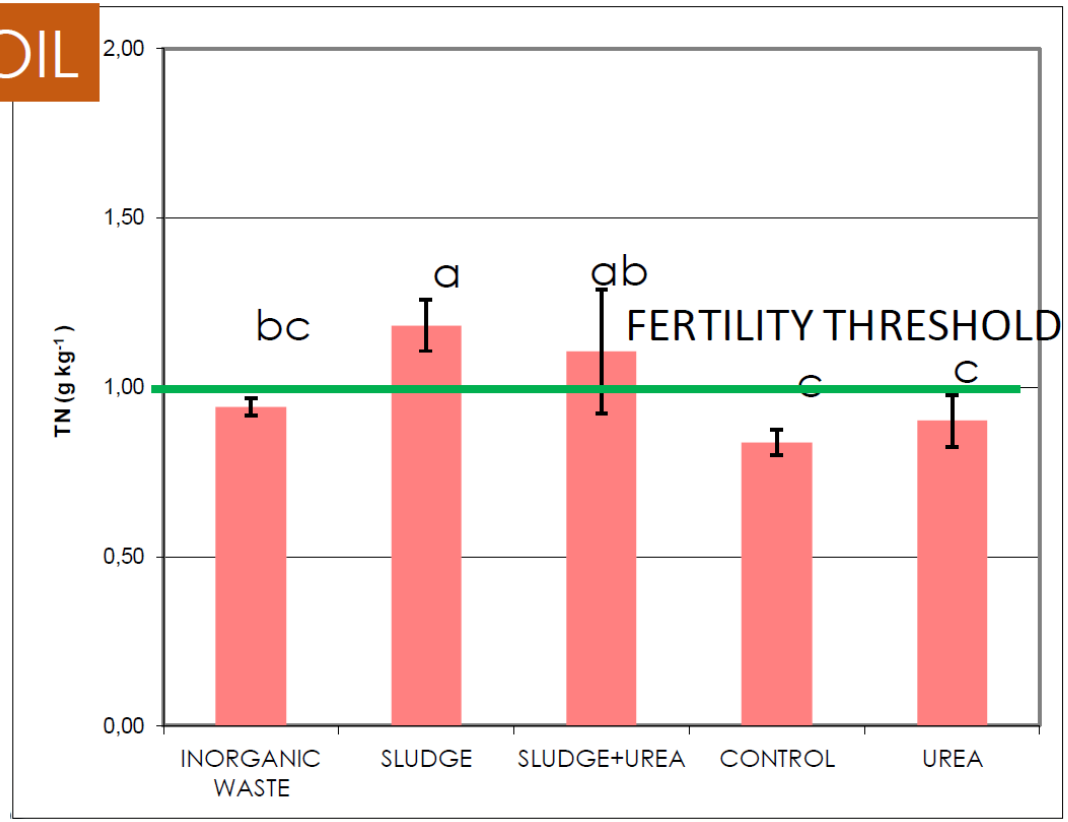
LONG-TERM APPLICATION OF SLUDGES IN RICE PADDIES

CROP

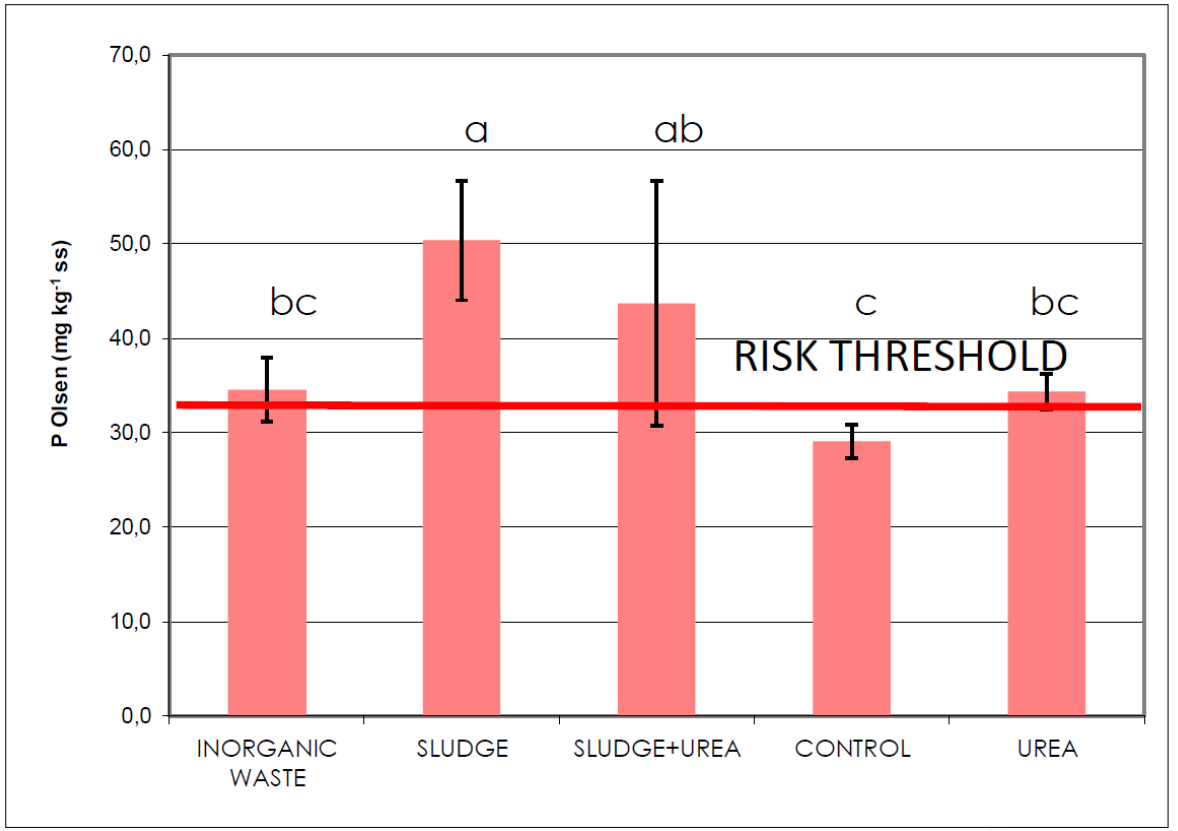
RICE PRODUCTIVITY INCREASED
SUGARS/PROTEINS REMAINED BALANCED

SOIL

TOTAL NITROGEN



SOIL BIOAVAILABLE PHOSPHORUS



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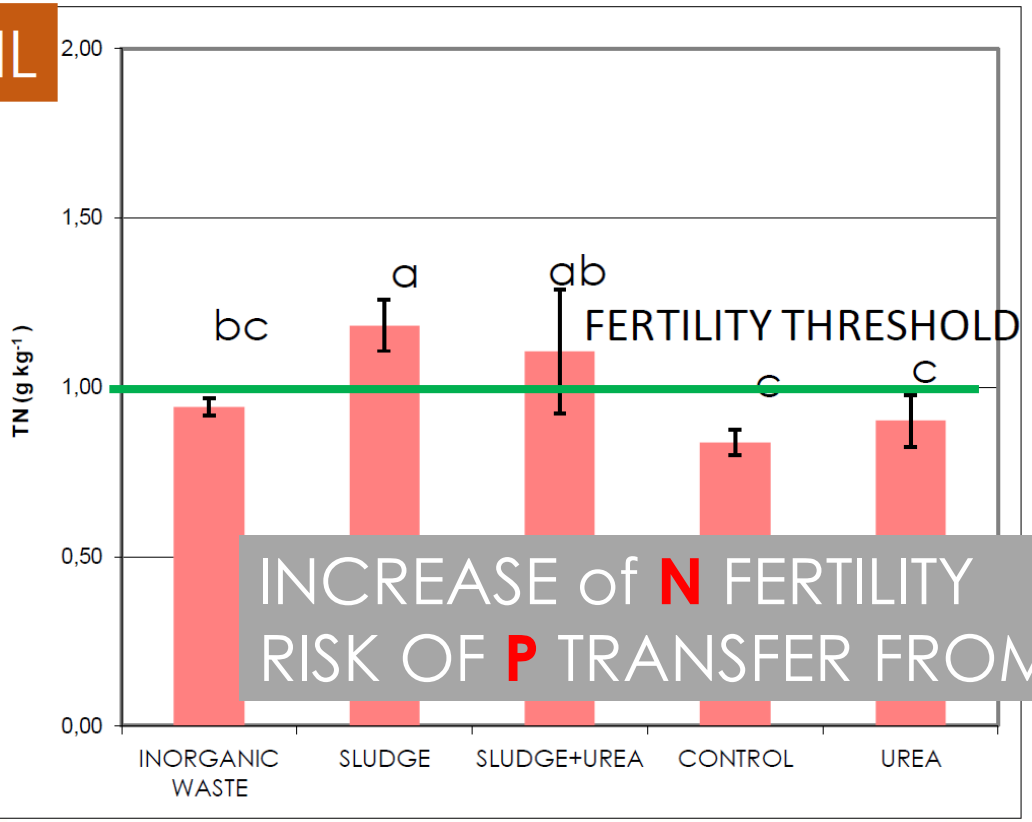

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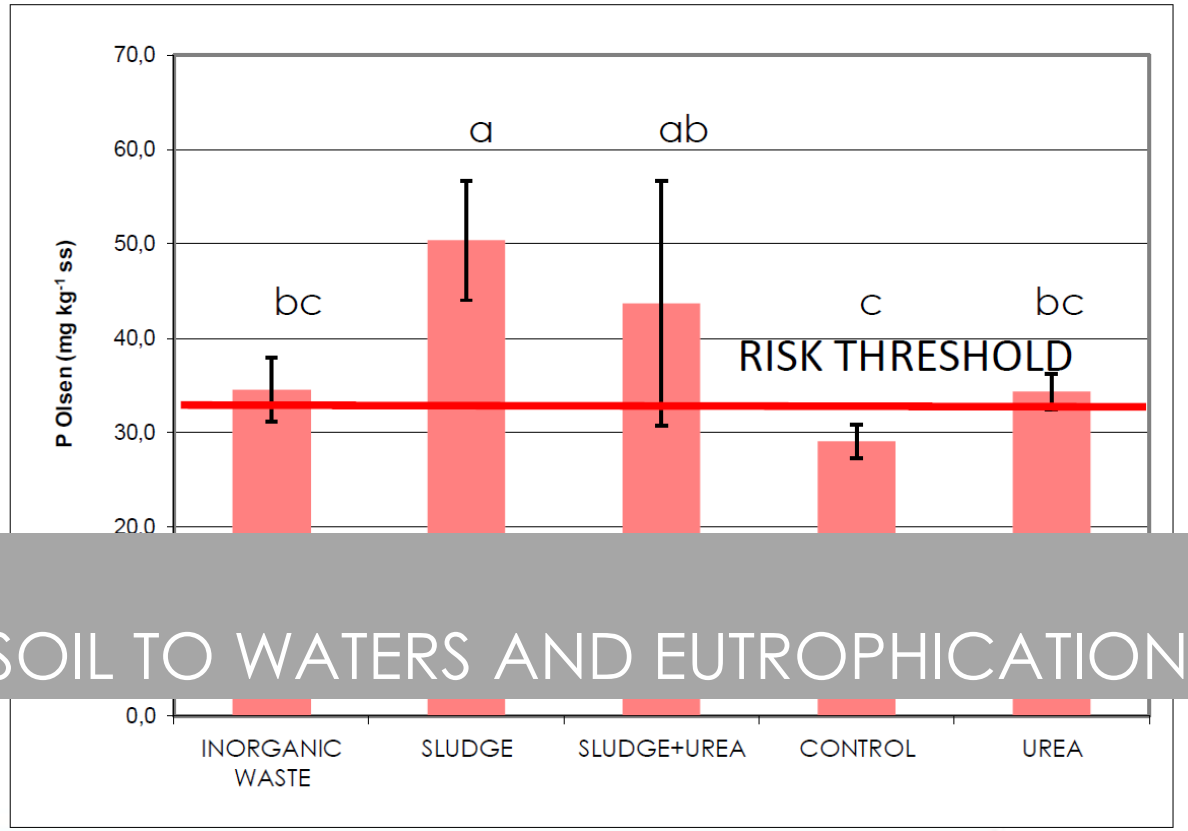

INCREASE of **N** FERTILITY
RISK OF **P** TRANSFER FROM SOIL TO WATERS AND EUTROPHICATION

WASTES CONTAIN MACRONUTRIENTS (N,P,K)

WASTE TYPE	C/N	N	P	K	N/P
		%	%	%	
OFMSW 1	11,7	3,6	0,3	2,2	11,0
OFMSW 2	12,2	4,0	0,5	1,8	8,2
OFMSW3	12,2	3,8	0,6	2,5	7,0
SLUDGES 1	6,6	4,3	2,7	0,7	1,6
SLUDGES2	7,2	4,3	2,4	0,4	1,8
SLUDGES 3	7,1	5,2	2,1	0,6	2,5
LEACHATE 1	9,1	0,07	0,01	6,8	6,7
LEACHATE 2	9,8	1,36	0,40	5,7	3,4
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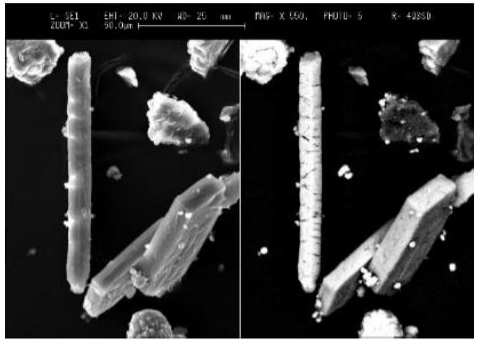
LEACHATE 2					
LEACHATE 3					

PLANT NEEDS: N/P 6-12
TECHNOLOGIES TO CORRECT WASTE N/P RATIO

TECHNOLOGIES TO CORRECT WASTE N/P RATIO

- WASTE + N FERTILIZERS → ORGANO-MINERAL FERTILIZER with STOICHIOMETRIC N/P RATIO

- WASTE SOLID/LIQUID SEPARATION



LIQUID fraction

$MgCl_2$

Seawater

Ashes

STRUVITE

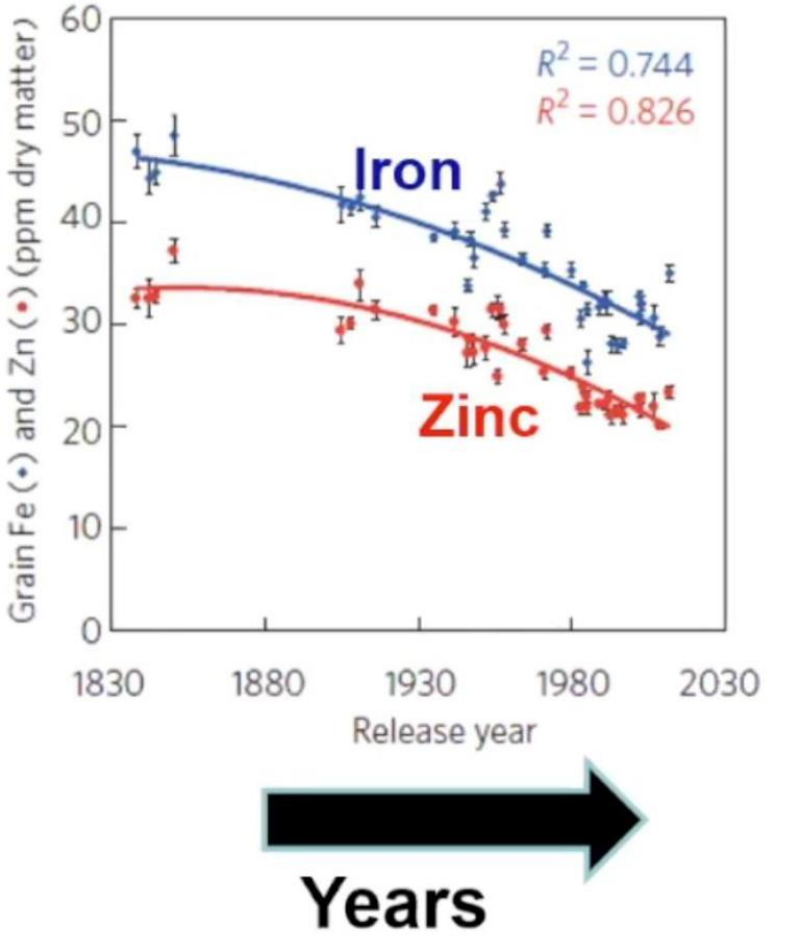
83-97% of P recovery

$MgNH_4PO_4x6H_2O$

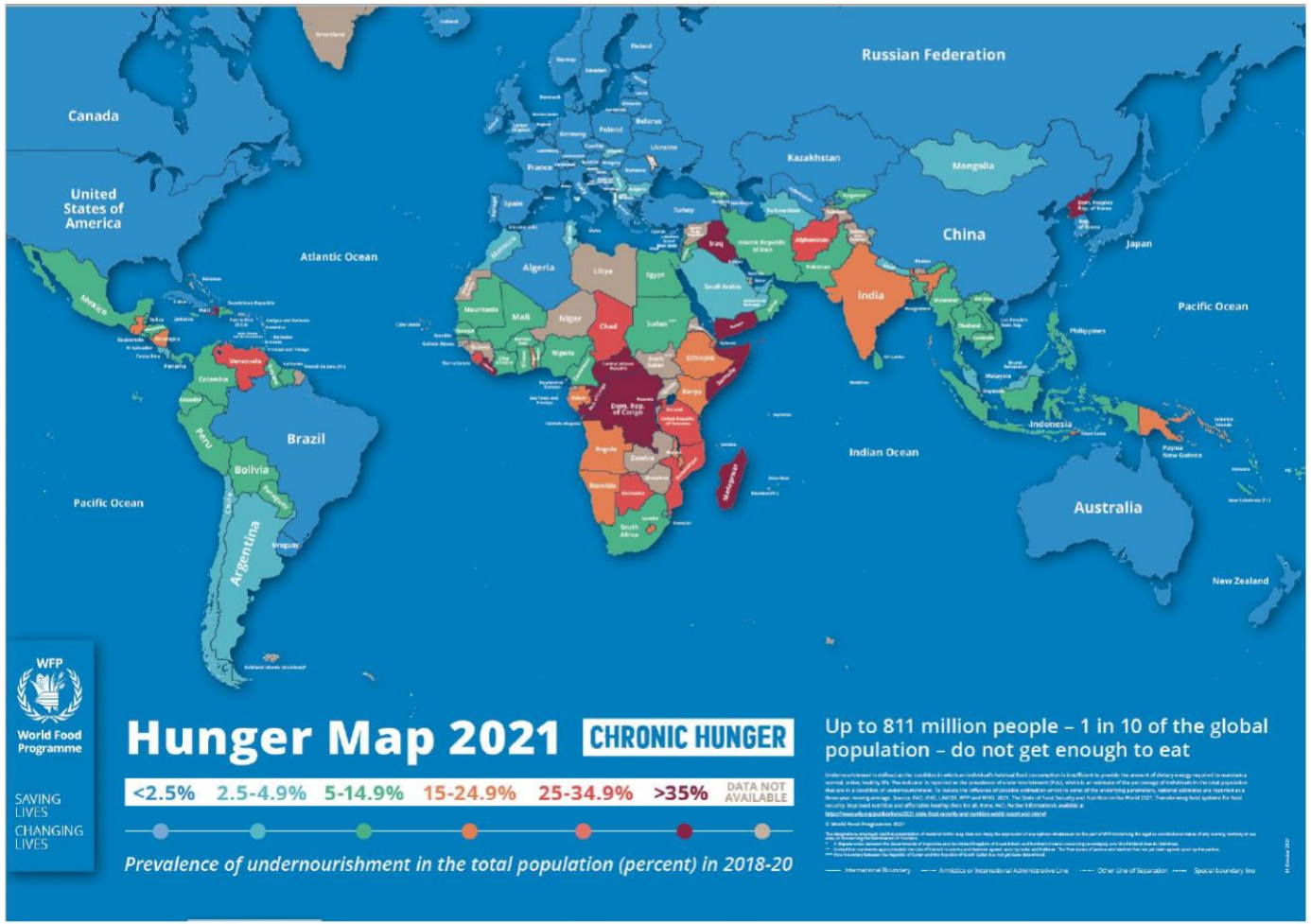
references:

- ✓ *83-90% - Desmidt et al., 2012*
- ✓ *90% - Gao, 2010*
- ✓ *88-97% - Ezquerro, 2010*

MICRONUTRIENTS IN CROPS & HUMAN DEFICIENCIES



(Shewry et al. 2016)



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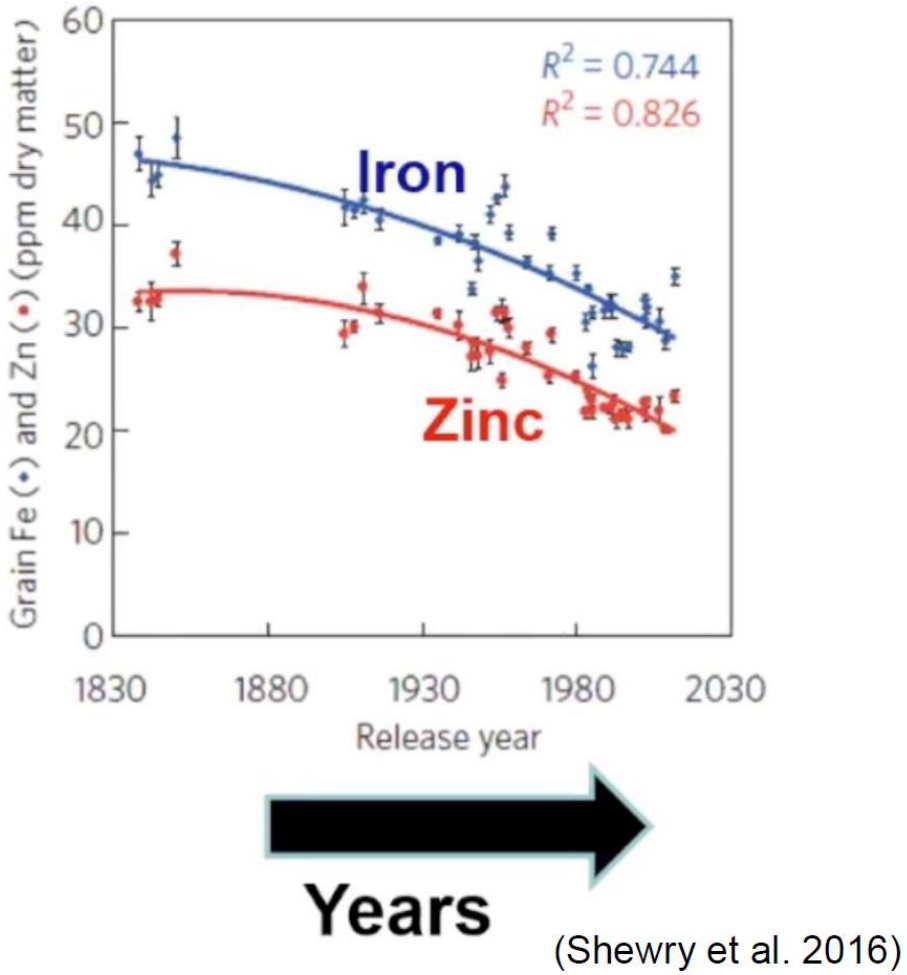

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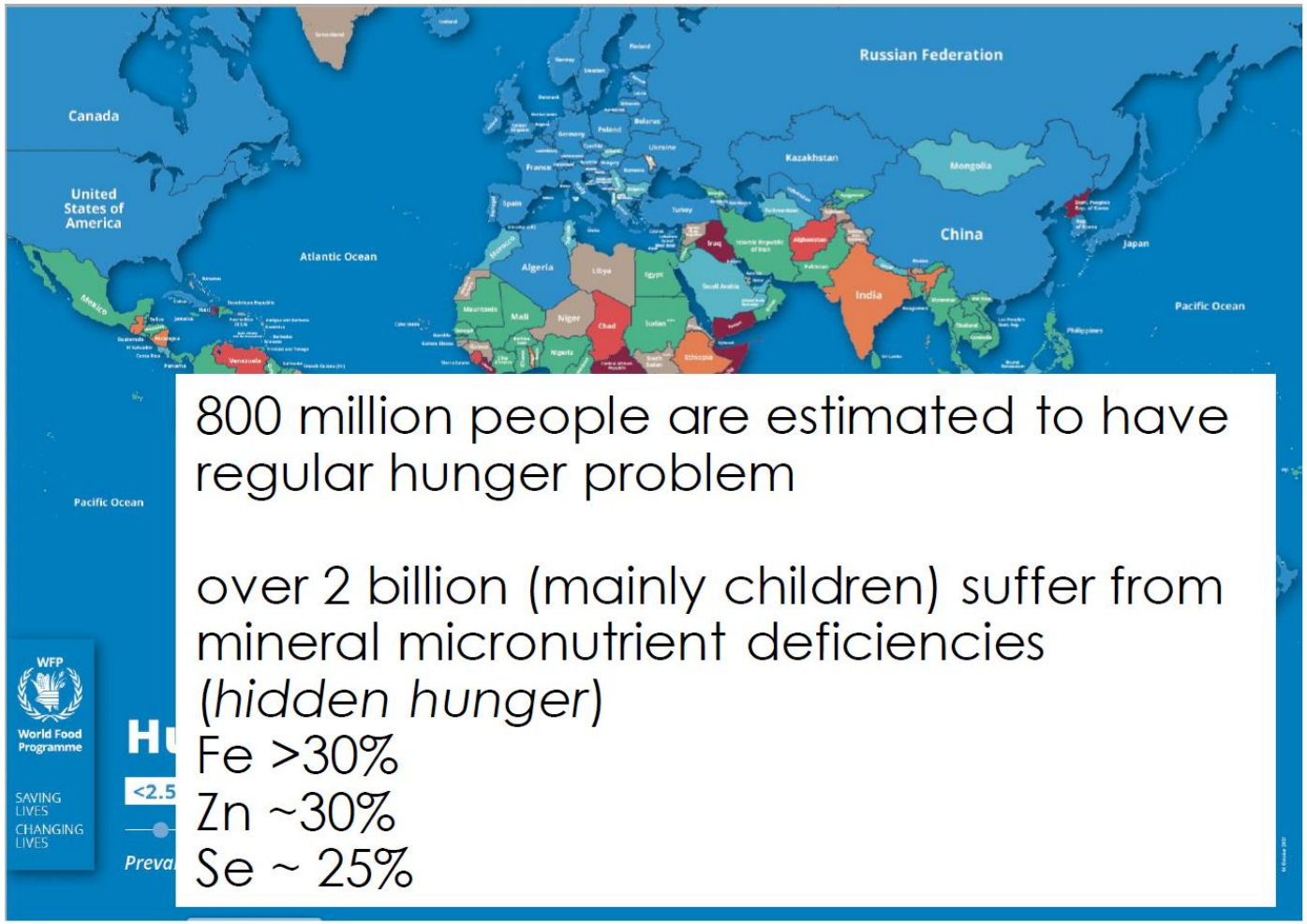

800 million people are estimated to have regular hunger problem

over 2 billion (mainly children) suffer from mineral micronutrient deficiencies (*hidden hunger*)
Fe >30%
Zn ~30%
Se ~ 25%

MICRONUTRIENTS IN CROPS & HUMAN DEFICIENCIES

MESONUTRIENTS: Ca, Mg, S
MICRONUTRIENTS: Zn, Fe, Mn, Cu, B, Si, Mo,…

WASTE TYPE	Ca	Mg	Zn	Cu	Ca/Mg
	g kg^{-1}	g kg^{-1}	mg kg^{-1}	mg kg^{-1}	
OFMSW 1	34,7	2,4	352	123	14,2
OFMSW 2	27,0	2,5	245	147	10,9
OFMSW3	15,2	1,6	132	133	9,2
SLUDGES 1	24,1	9,9	481	151	2,4
SLUDGES2	27,2	9,2	714	236	3,0
SLUDGES 3	28,9	5,2	113	243	5,5
LEACHATE 1	2,9	0,92	147	155	3,1
LEACHATE 2	11,1	8,92	356	232	1,2
LEACHATE 3	14,8	19,46	498	332	0,8

MICRONUTRIENTS IN CROPS & HUMAN DEFICIENCIES

MESONUTRIENTS: Ca, Mg, S
MICRONUTRIENTS: Zn, Fe, Mn, Cu, B, Si, Mo, Se, I…

WASTE TYPE	Ca g kg^{-1}	Mg g kg^{-1}	Zn mg kg^{-1}	Cu mg kg^{-1}	Ca/Mg
OFMSW 1	34,7	2,4	352	123	14,2
OFMSW 2	27,0	2,5	245	147	10,9
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LEACHATE 1	2,9	0,92	147	155	3,1
LEACHATE 2	11,1	8,92	356	232	1,2
LEACHATE 3					

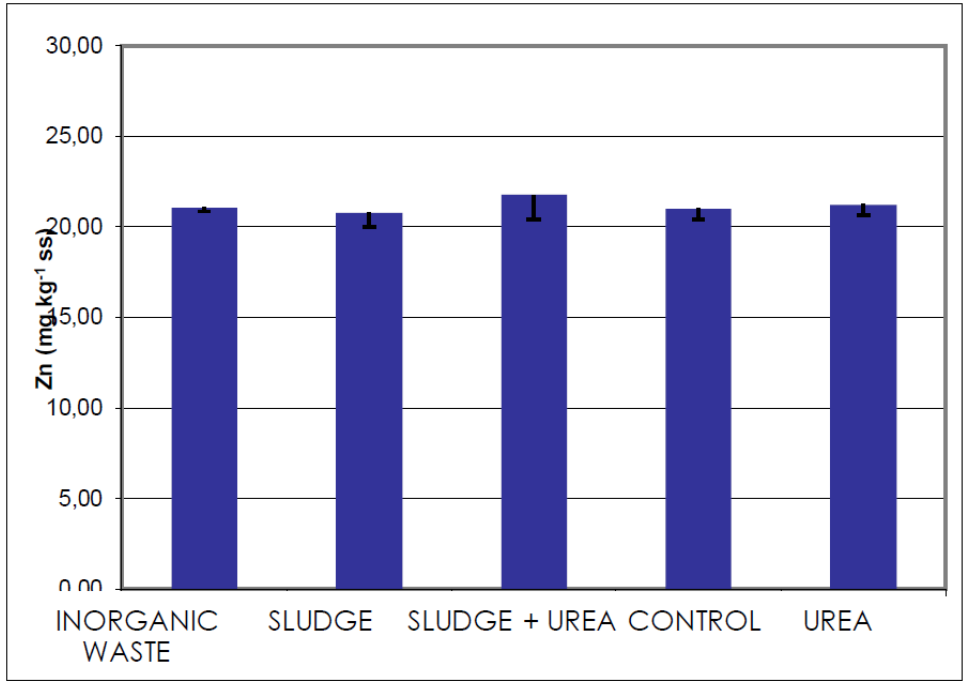
Optimal Ca/Mg ratio: 5-10
Wastes are important sources of meso and micronutrients

1) MACRO & MICRONUTRIENTS FOR PLANTS

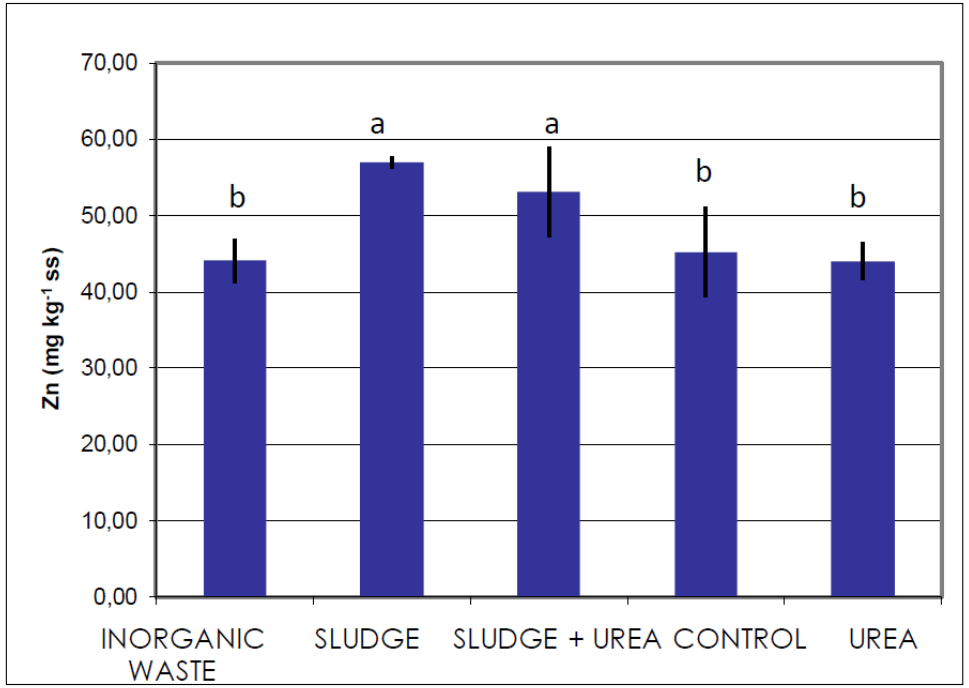
LONG-TERM APPLICATION OF SLUDGES IN RICE PADDIES

GRAIN

Zinc



SOIL



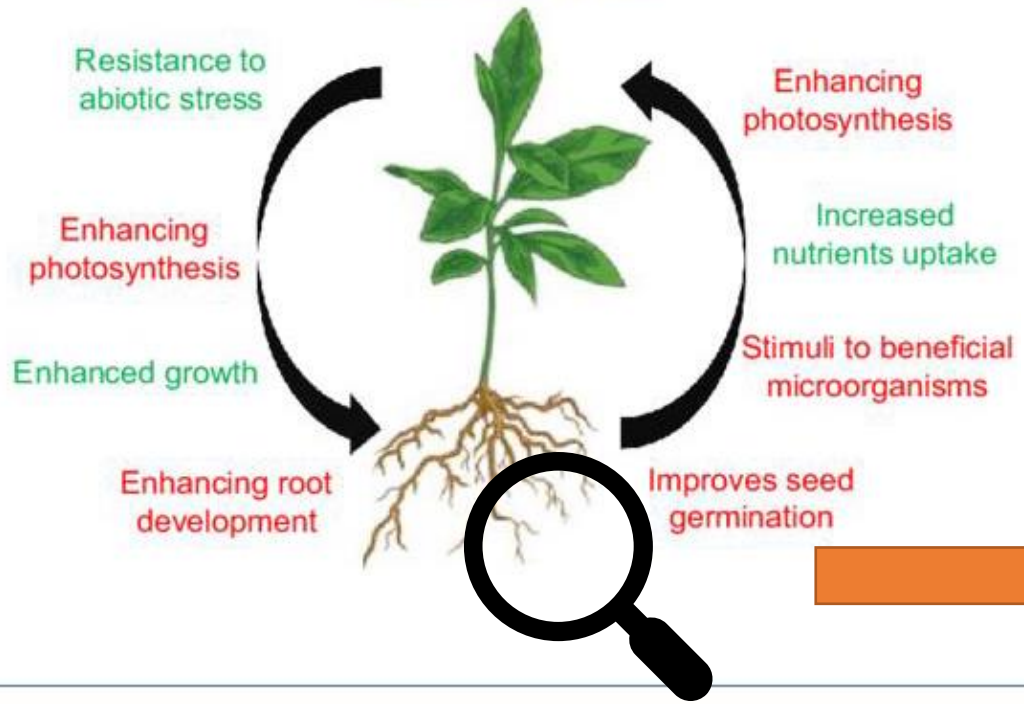
Zinc content increases in soil

2) SLUDGES CONTAIN METABOLITES

SLUDGES

METABOLITES or derived compounds

PHYTOHORMONES | PROTEINS & PEPTIDES | HUMIC SUBSTANCES



- metabolites increase nutrient availability
- favour fluxes of nutrients from soil to waters
- promote plant growth promoting bacteria
- improve microbial activity and OM degradation

2) SLUDGES CONTAIN METABOLITES

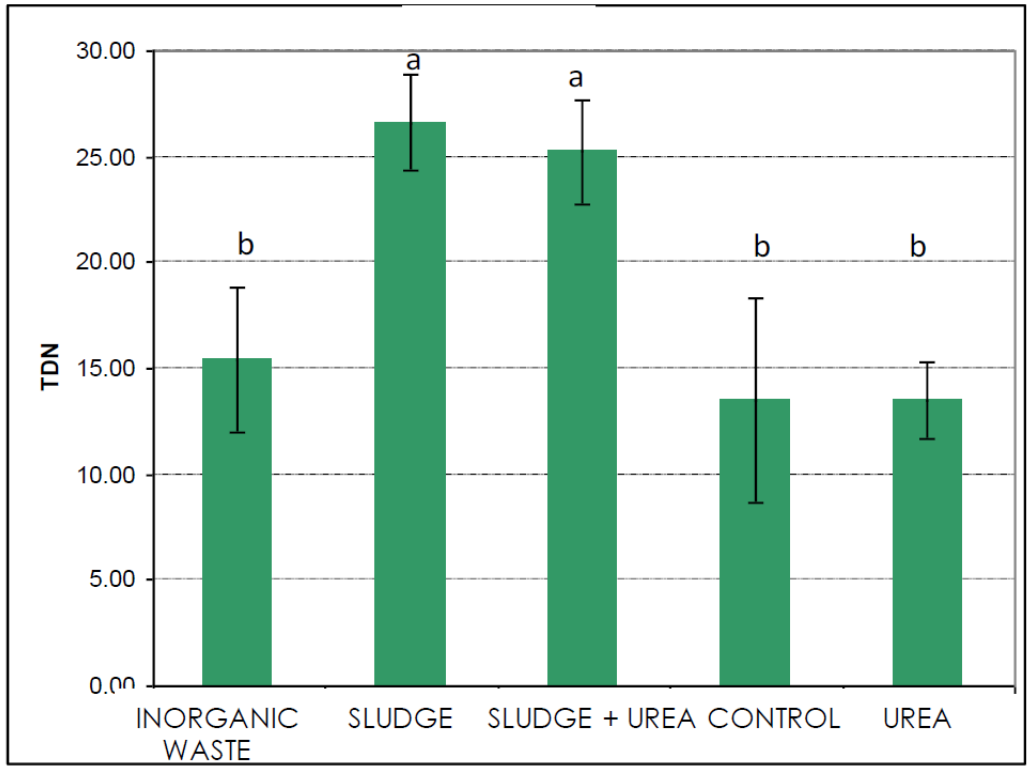
LONG-TERM APPLICATION OF SLUDGES IN RICE PADDIES

CROP

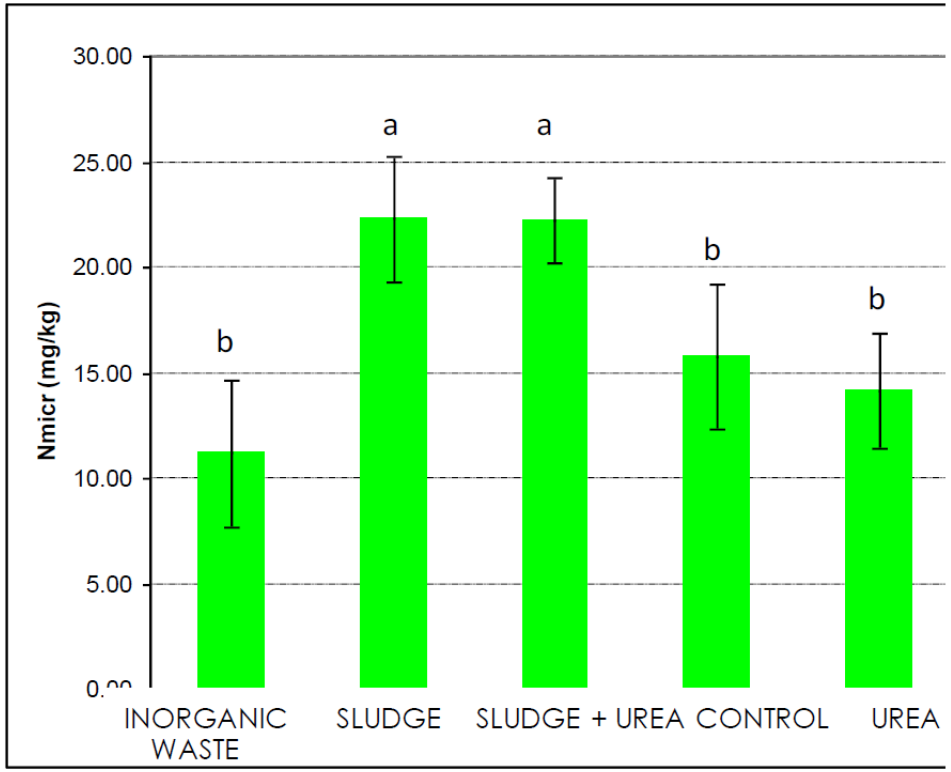
Crop productivity increases with sludge application

SOIL

TOTAL DISSOLVED NITROGEN



MICROBIAL NITROGEN



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LONG-TERM APPLICATION OF SLUDGES IN RICE PADDIES

CROP

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SOIL

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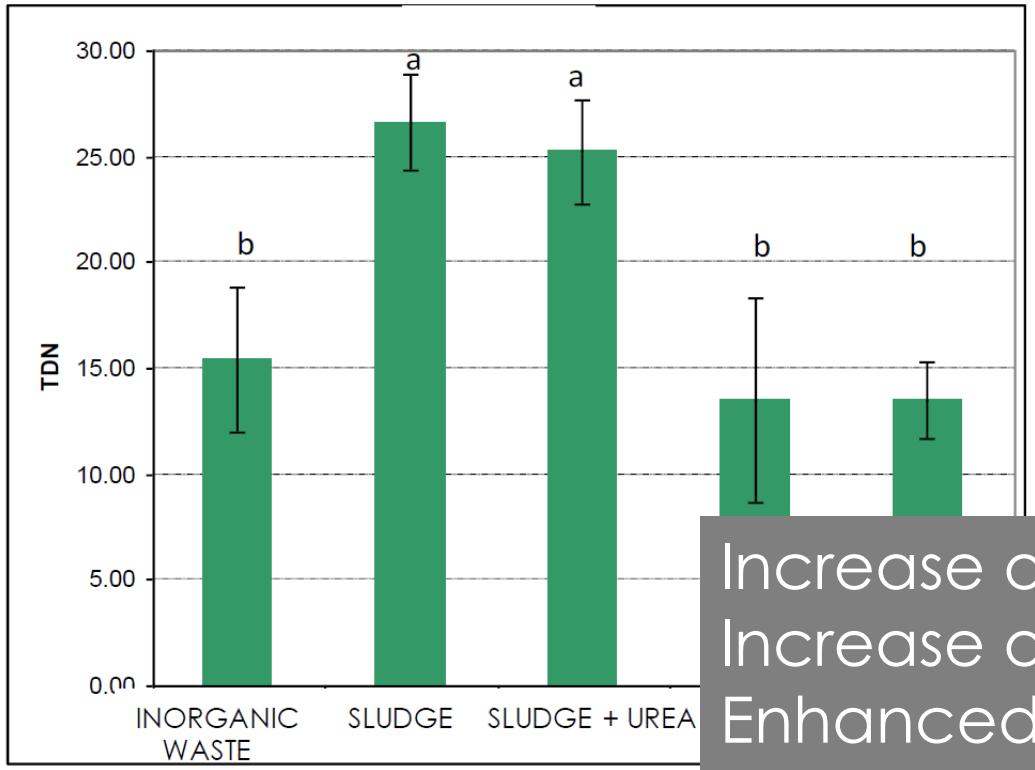
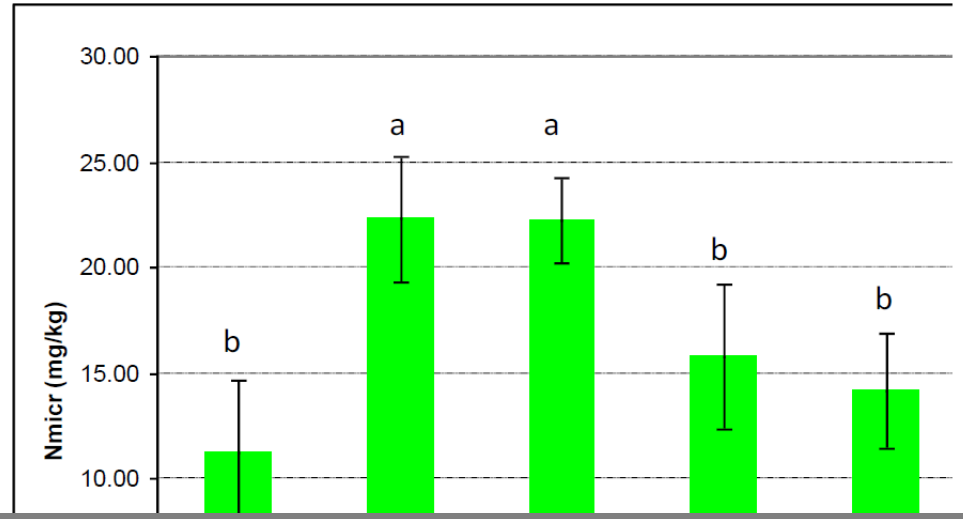


MICROBIAL NITROGEN



Increase of microbial activity
Increase of nutrient available forms
Enhanced biocycling of nutrients
C sources?

3) SLUDGES CONTAIN CONTAMINANTS

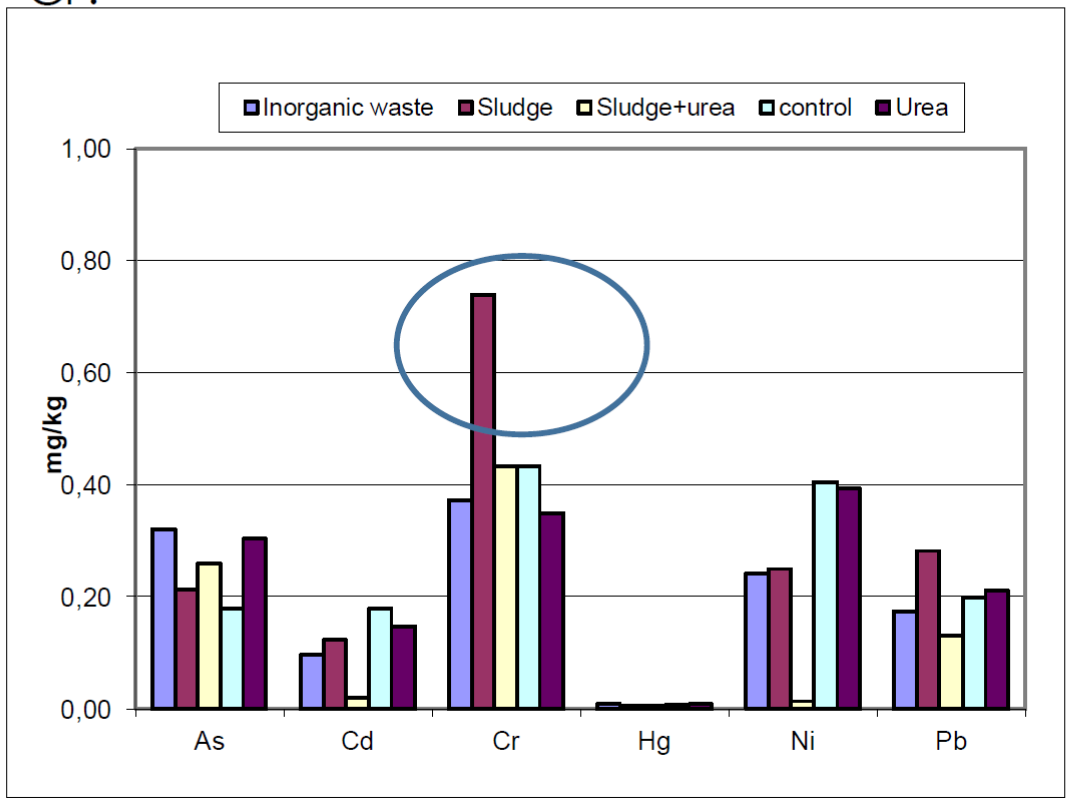
element	2010	2011	2012	
Cd (mg/Kg)	2,44 ± 0,22	2,55 ±0,02	1,0 ± 0,3	<15
Cr (mg/Kg)	133 ±7	137 ± 6	97 ± 7	<750
Hg (mg/Kg)	0,96 ± 0,03	1,19 ±0,01	0,85 ± 0,22	<10
Ni (mg/Kg)	75 ±1,0	80 ±2	54 ± 6	<300
Pb (mg/Kg)	58 ±3	78 ±1	58 ± 5	<750
Cu (mg/Kg)	151 ± 7	236 ± 6	243 ± 29	<1000
Zn (mg/Kg)	481 ± 8	714 ±36	113 ± 9	<2500
As (mg/Kg)	<0,05	<0,01	3,2 ± 0,3	<10
Cr VI (mg/Kg)	<0,01	0,32 ± 0,01	<0,01	<10

3) SLUDGES CONTAIN CONTAMINANTS

LONG-TERM APPLICATION OF SLUDGES IN RICE PADDIES

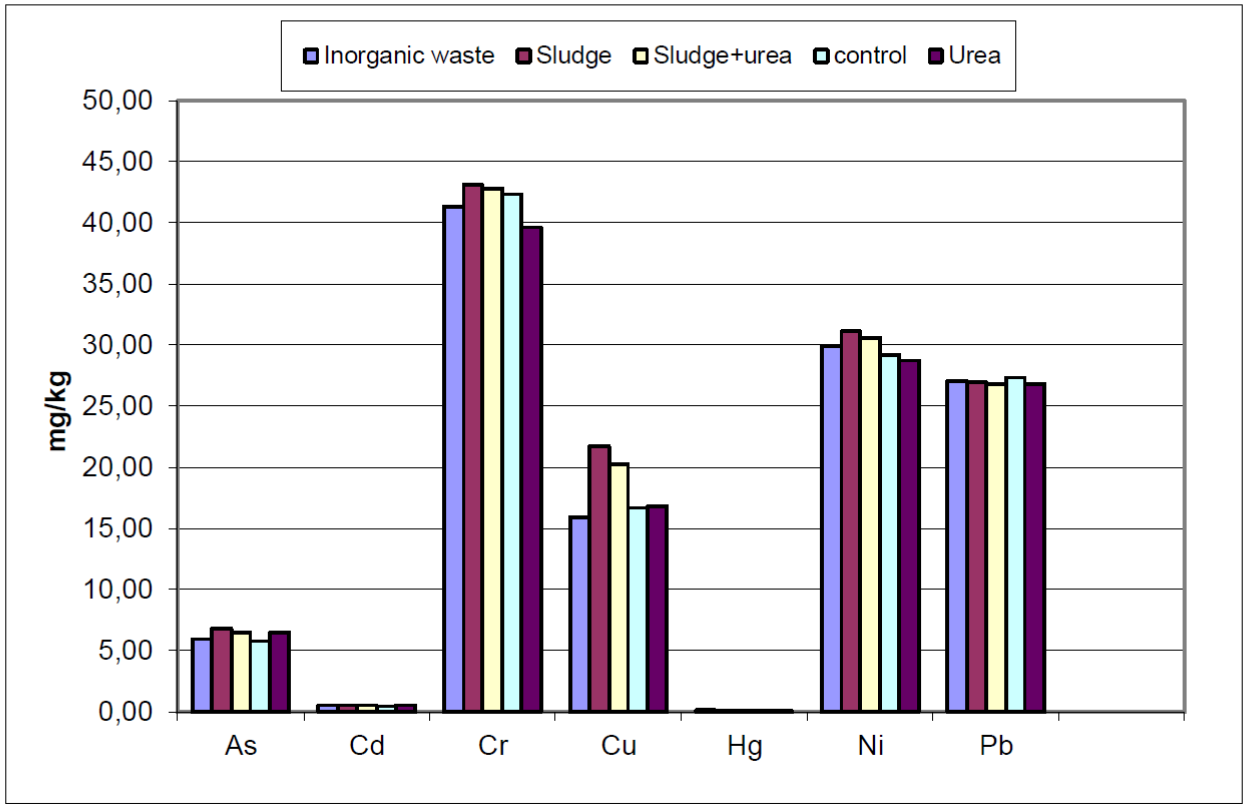
CROP

No significant differences of contaminants Cr?



SOIL

No significant accumulation of contaminants in soil



Can we or must we reuse sludges in agriculture?

HETEROGENEOUS MATERIAL THAT IS ADDED TO COMPLEX SYSTEMS

- Important sources of macro & micronutrients for plants
- Organic metabolites activate the soil-plant-microbiome system
- Carbon sources that can increase C sequestration and mitigate climate change

Contaminants can compromise their application and crop health

THANK YOU FOR YOUR ATTENTION and THANKS to…

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Marco Romani Eleonora Miniotti, Daniele Tenni, Gianluca Beltarre

Projects:

BIOENPRO 4 TO

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Codice Domanda 333-201

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