

Closing the nutrient cycle by
using organo-mineral
fertilizers based on secondary
raw materials



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Marocco, China, Algeria, Syria and South Africa are controlled 84% of phosphate rock reserves.

58% of potassium ore deposits are located on the territory of Canada, Belarus and Russia.

The manufacture of nitrogen fertilizers globally generates approximately 10 million tons of CO₂-eq per year.

Table 1. Main waste streams in European Union.

	Mass, Mg
Sewage sludge	9.5 (dry)
Manure	1400 (raw)
Food waste	120-160 (raw)

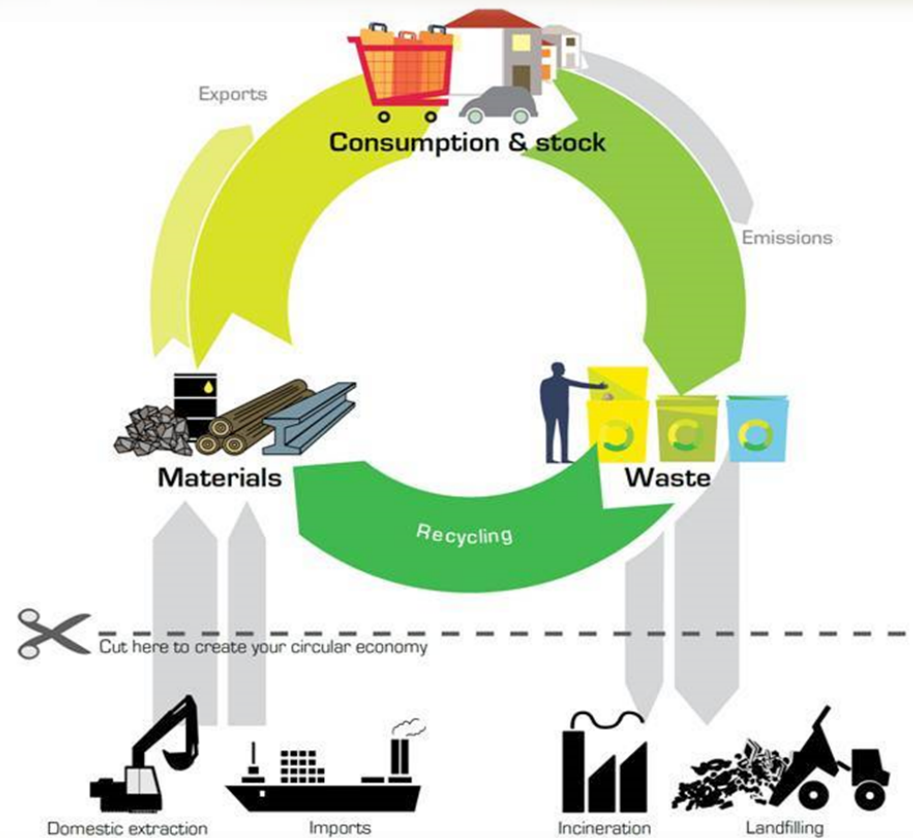


Figure 1. Circular economy concept

Table 2. Composition of poultry litter ash

N, %	0.03 ±0.01
P₂O₅, %	18.1 ±0.8
K₂O, %	24.0 ±0.8
Pb, mg/kg	19.1 ±0.4
Cr, mg/kg	122 ±3
Ni, mg/kg	110 ±8
Cd, mg/kg	5.27 ±0.10
Hg, mg/kg	0.24 ±0.01

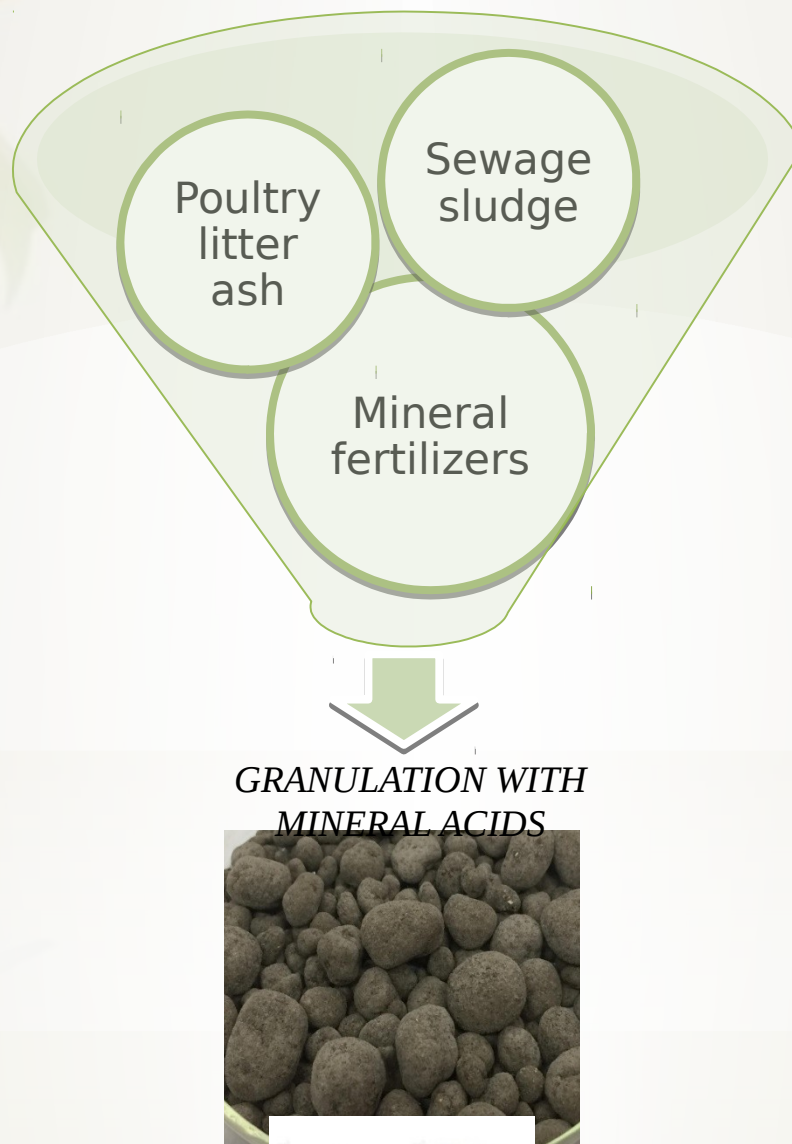


Table 3. Composition of sewage sludge

Moisture content, %	6.51 ±0.10
Organic matter, %	56.3 ±0.20
N, %	4.44 ±0.04
P₂O₅, %	7.24 ±0.05
K₂O, %	0.26 ±0.02
Pb, mg/kg	29.8 ±0.1
Cr, mg/kg	66.1 ±5.3
Ni, mg/kg	90.7 ±0.6
Cd, mg/kg	1.88 ±0.03
Hg, mg/kg	4.53 ±1.02



RAPeseed



FLAX



SUNFLOWER

Requirements for organo-mineral fertilizers according to Polish legislation

„Organo-mineral fertilizers in solid form should contain at least 20% of organic matter in dry matter of the fertilizer; in the case of declaring in them nitrogen or phosphorus, or potassium or their sum, the content of individual components must not be less than:

1% (m/m) total nitrogen (N);

0.5% (m/m) of phosphorus based on phosphorus pentoxide (P₂O₅);

1% (m/m) of potassium calculated as potassium oxide (K₂O). "

"permissible values of impurities in organo-mineral fertilizers ... may not exceed, in the case of:

chromium (Cr) - 100 mg;

cadmium (Cd) - 5 mg;

nickel (Ni) - 60 mg;

lead (Pb) - 140 mg;

mercury (Hg) - 2 mg

- per kg of dry matter of the fertilizer ..."

Table 4. Nutrient content of waste based fertilizers

	<i>N, %</i>	<i>P₂O₅, %</i>	<i>K₂O, %</i>	<i>Average NPK content, %</i>	<i>Average NPK ratio</i>	<i>Plant required NPK ratio</i>
<i>R1</i>	11.9	4.72	16.5	30.2	2.4 : 1 : 3.3	2.8-3.3 : 1-1.4 : 3.3-4.4
<i>R2</i>	11.8	4.81	15.0			
<i>R3</i>	10.6	4.32	16.3			
<i>R4</i>	7.9	4.73	12.3			
<i>F1</i>	4.33	8.87	15.3	33.3	1 : 3 : 3.3	1-1.3 : 2-2.7 : 3-4
<i>F2</i>	5.28	9.38	15.4			
<i>F3</i>	7.11	11.3	18.4			
<i>F4</i>	5.12	13.3	19.4			
<i>S1</i>	5.71	8.89	17.8	31.8	1 : 1.4 : 2.5	1-1.3 : 1-1.5 : 2-3
<i>S2</i>	7.59	8.93	16.6			
<i>S3</i>	7.05	9.64	16.0			
<i>S4</i>	6.01	6.48	16.5			
<i>Orcal</i>	4.7	2.5	1.3	8.5	3.6 : 1.9 : 1	
<i>Oskar</i>	3	3	0.3	6.3	10 : 10 : 1	

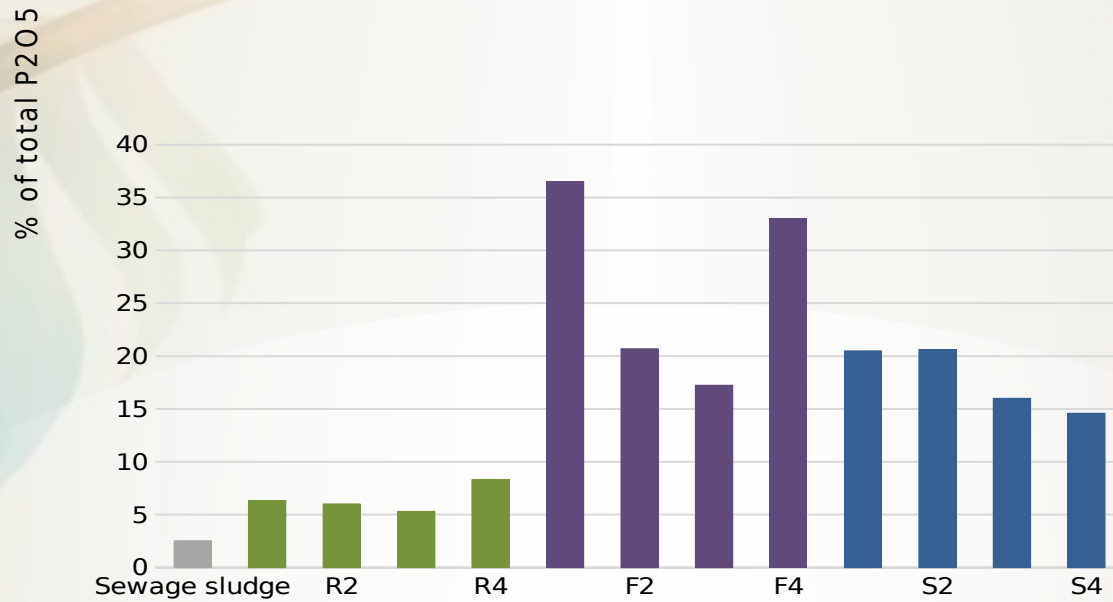


Figure 2. Content of water soluble phosphorus in waste based fertilizers

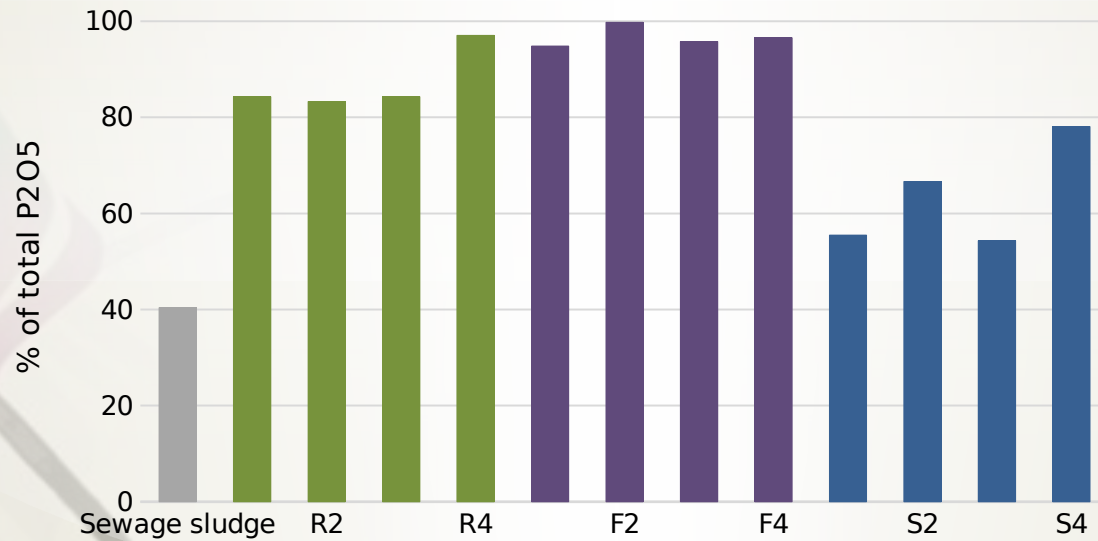


Figure 3. Content of 2% citric acid soluble phosphorus in waste based fertilizers

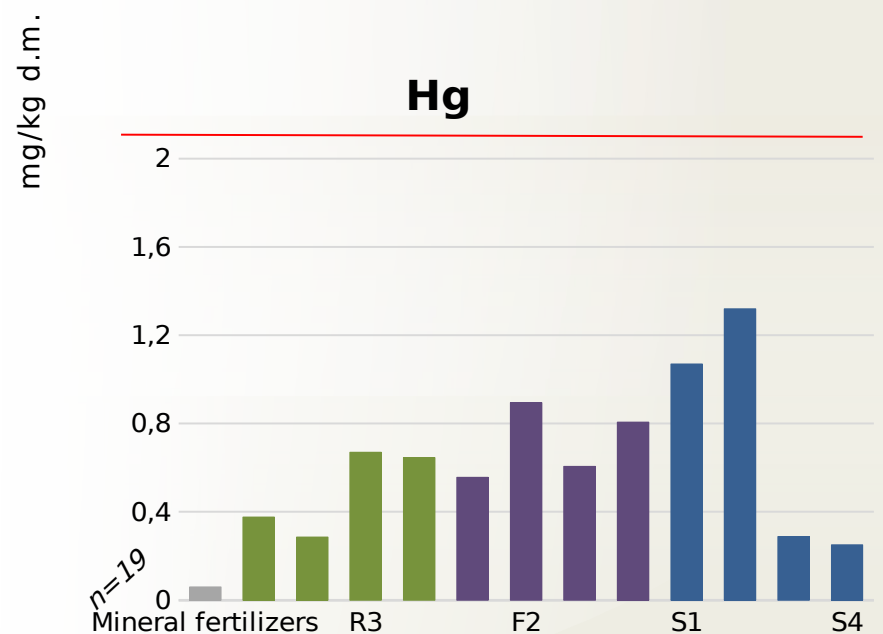
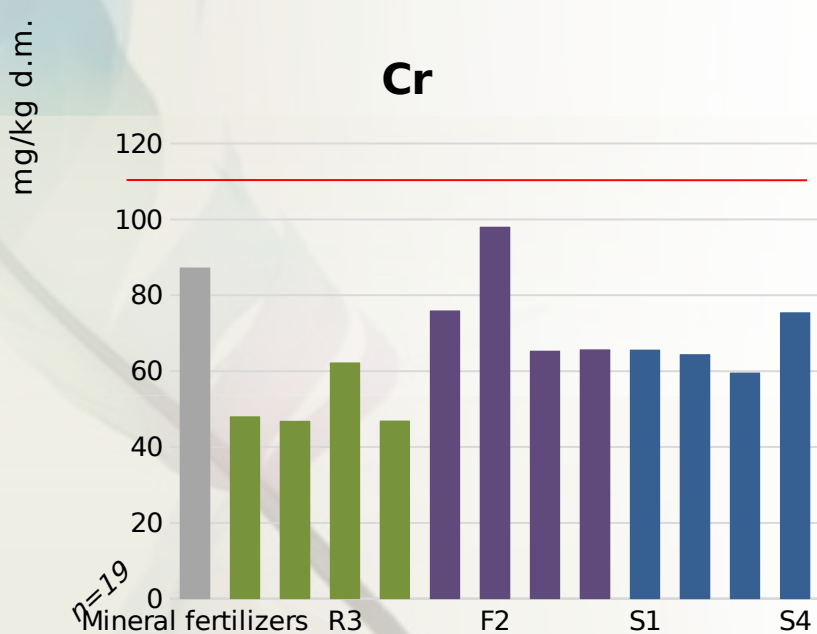
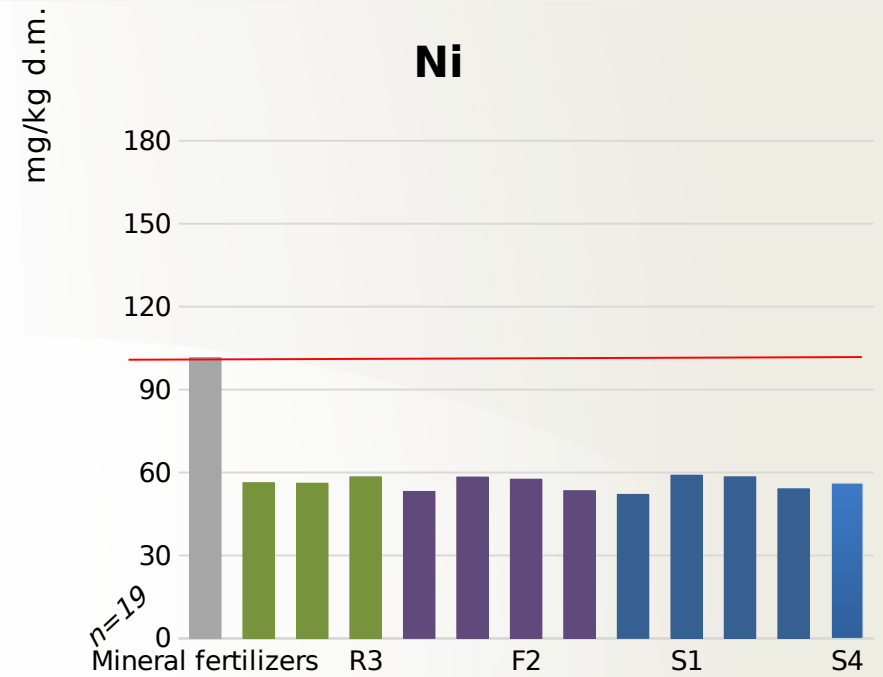
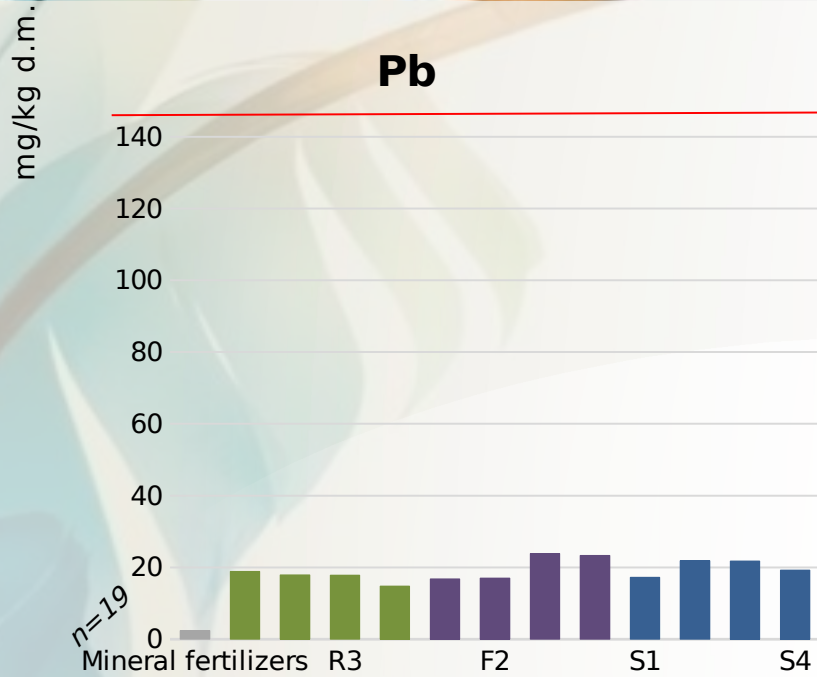


Figure 4. Heavy metal content in waste based fertilizers (red lines show limit values for organo-mineral fertilizers according to Polish legislation)

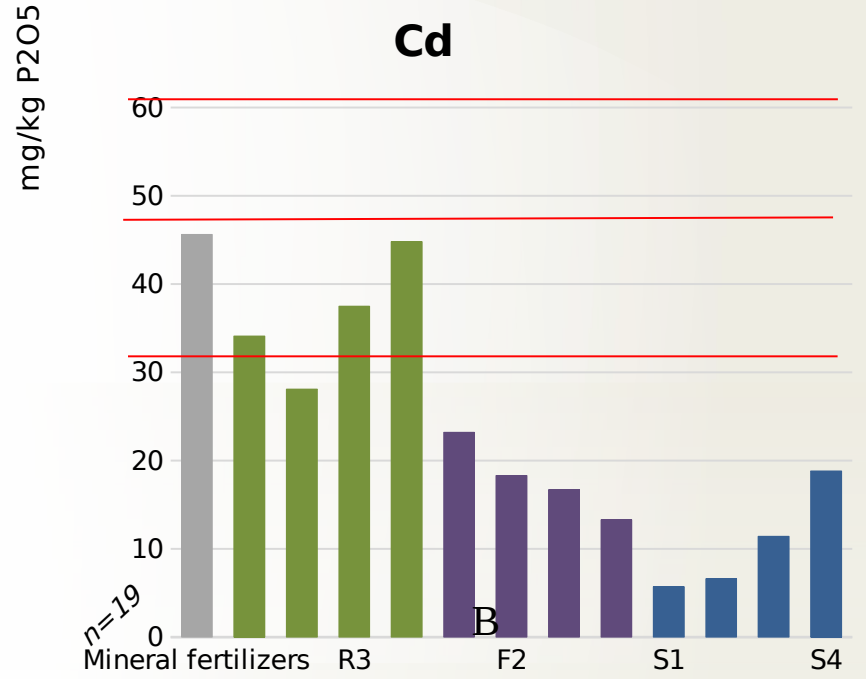
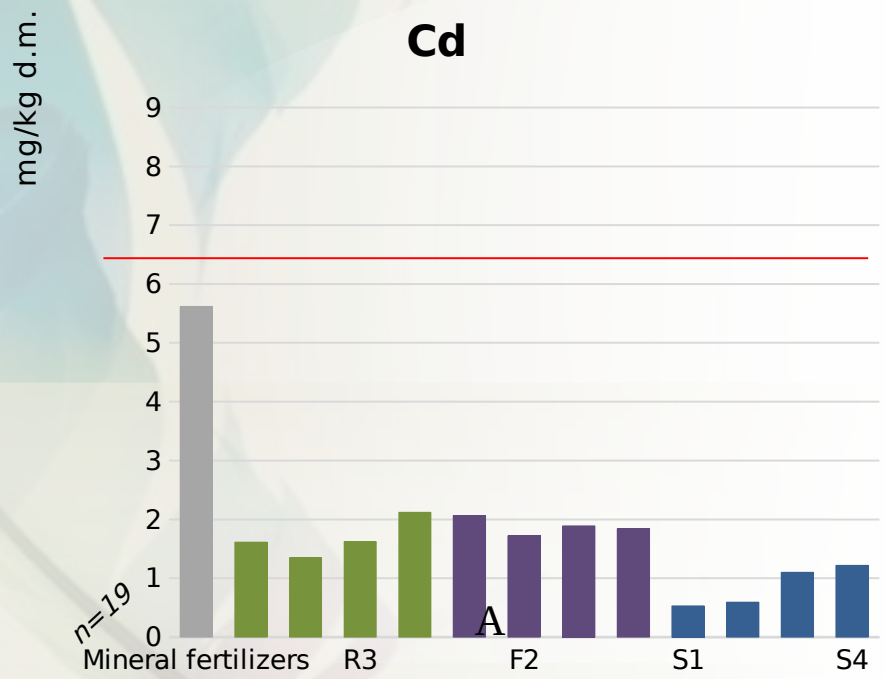


Figure 5. Cd content in waste based fertilizers (red lines show limit values for organo-mineral fertilizers according to Polish (A) and new European (B) legislation)



Figure 6. Large scale granulator for waste based fertilizers production (disk diameter = 80 cm)

Investment costs	~20,000 €
Costs of introducing of fertilizer on the market: <ul style="list-style-type: none"> • Testing of physical, chemical and biological properties of fertilizers in accredited laboratories mentioned in the directive • Field study of fertilizers conducted by institutions mentioned in the directive 	~7,000 €
Raw materials costs	lower by 38-45%

~4200 Mg of organo-mineral fertilizers based on secondary raw materials are possible to produce annually in the case of technology implementation in the Wastewater Treatment Plant in Żywiec (Malopolska region, Poland).

It allows to recycle

70-78 Mg of N

177-297 Mg of P_2O_5

85-236 Mg of K_2O

319-840 Mg of organic matter
from secondary raw materials.

Table 4. SWOT analysis of technology of waste based fertilizer production

STRENGTHS	WEAKNESSES
<p>In line with a circular economy Zero-waste method Low investment costs Simplicity of technology Based on local and renewable input materials Products with high nutrient content Products are characterized by slow nutrient release Stable, easy for storage, transport and application product Products offer soil enrichment in organic matter</p>	<p>Variable composition of sewage sludge and poultry litter ash Monitoring of input materials quality is needed No possibility for entering on external European fertilizer market (with current regulation) High competition on fertilizer market</p>
OPPORTUNITIES	THREATS
<p>Nutrient recycling Organic matter recycling Reducing of mineral fertilizer consumption Management of sewage sludge and poultry litter ash Reducing of nutrient leakage</p>	<p>Potential presence of pollutants Lack of consumer confidence Lack of mechanisms and incentives Difficulties related to waste status of input materials (sewage sludge, poultry litter ash)</p>

Conclusions

- 1. Fertilizers obtained in the study contain 46-63% of secondary raw materials.*
- 2. Fertilizers are characterized by dedicated composition for rapeseed, flax and sunflower crops.*
- 3. Total nutrient content ($N+P_2O_5+K_2O$) of fertilizers varies from 25.0 to 36.8%.*
- 4. 16-39% of N, 54-100% of P_2O_5 and 16-29% of K_2O in organo-mineral fertilizers are originated from secondary raw materials.*
- 5. Fertilizers fulfill the requirements regarding heavy metal content according to Polish legislation.*
- 6. Field study is needed to verify the efficiency of fertilizers and potential heavy metal accumulation in soil.*



Thank you for attention!

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