

# Sludge Application Rate Advisor for Sustainable Agricultural Use of Municipal Wastewater Sludge

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WISA

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WATER  
RESEARCH  
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# Sustainability

- Linear economy

Natural resources  
and resources  
industries

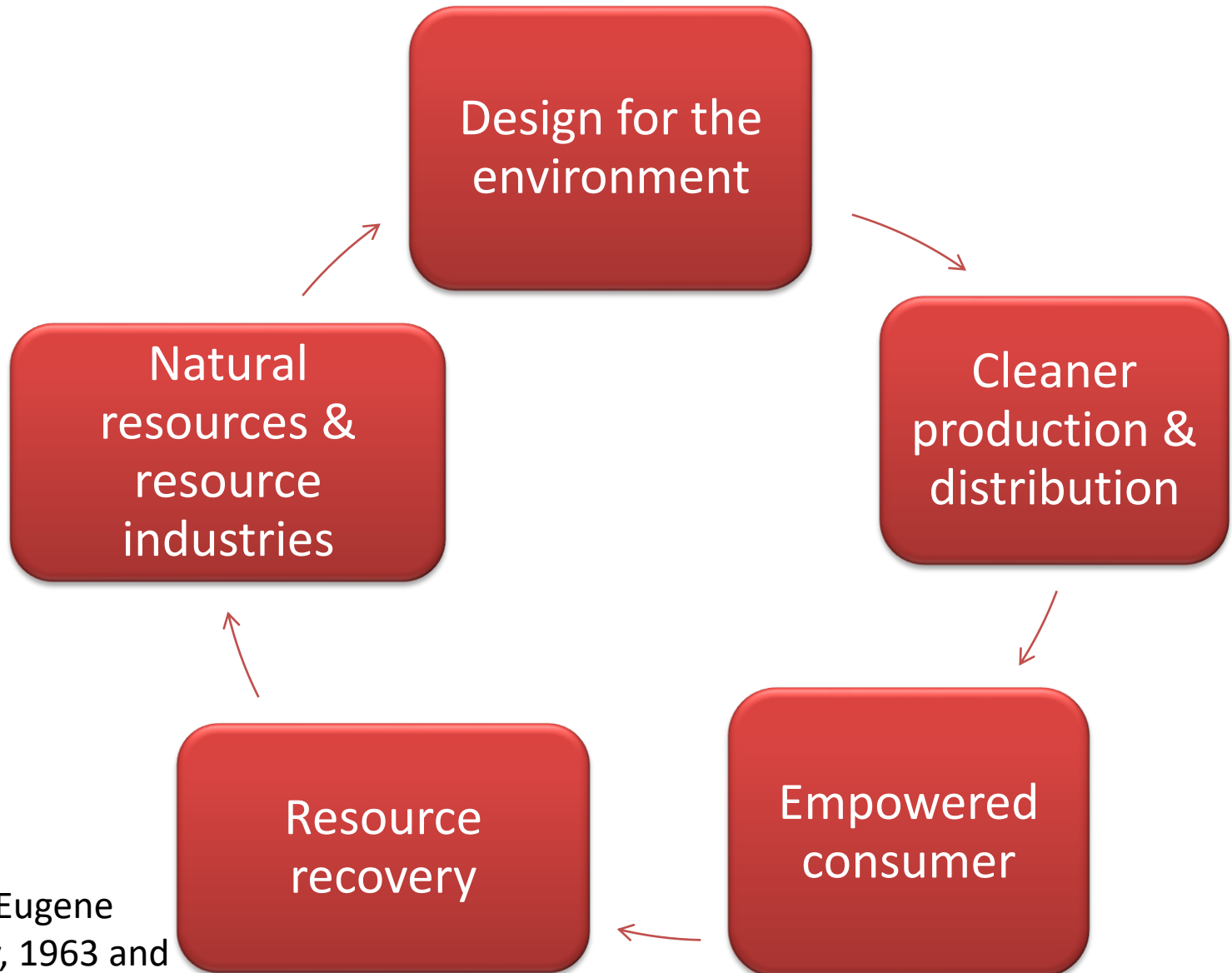
- Air
- Water Land and minerals
- Energy
- biological

Industrial  
processes,  
distribution and  
product use

Waste and  
pollution

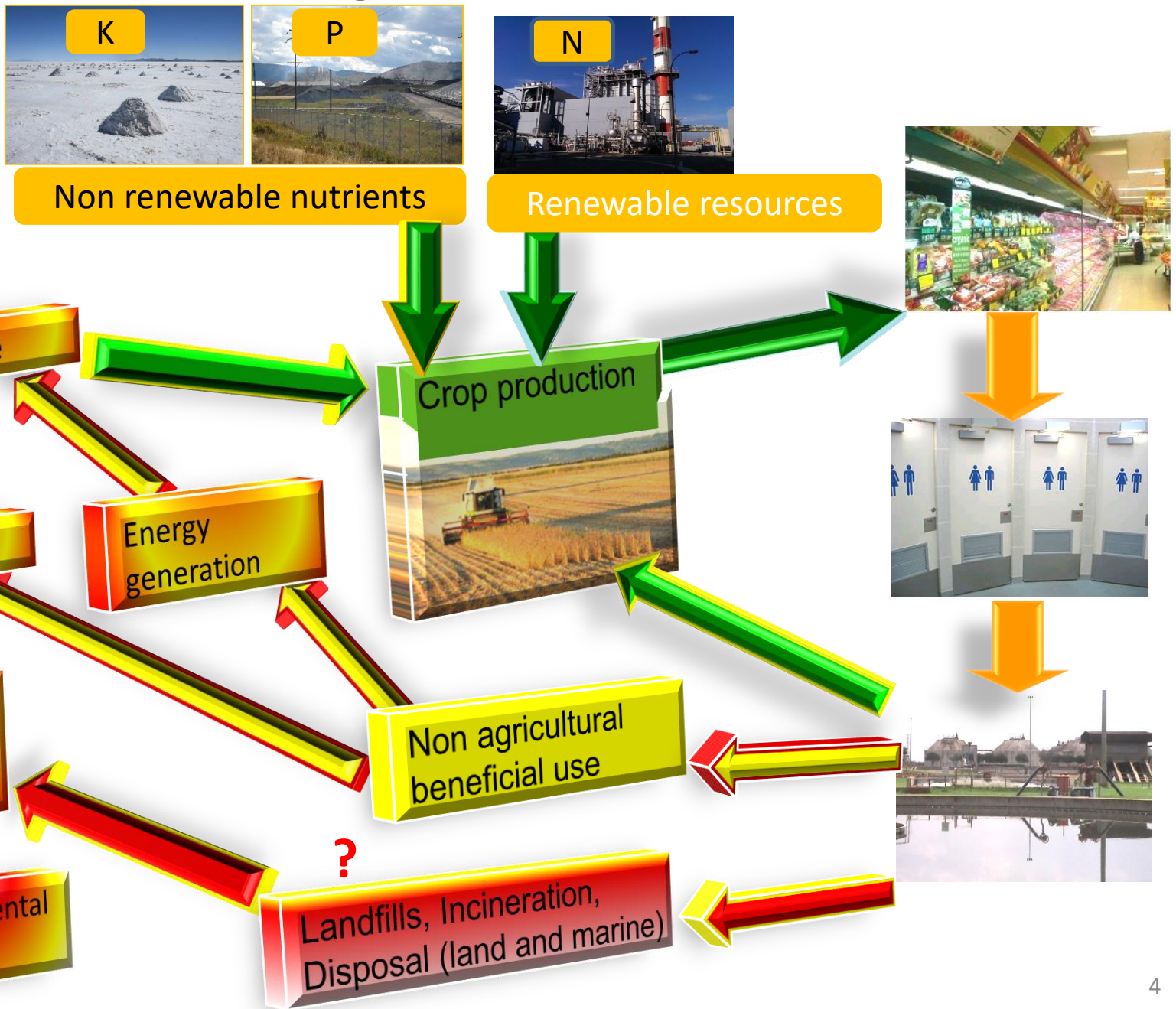
From Eugene Odum, *Ecology*, 1963  
and [www.Ecocycle.org](http://www.Ecocycle.org), 2008

# Circular economy

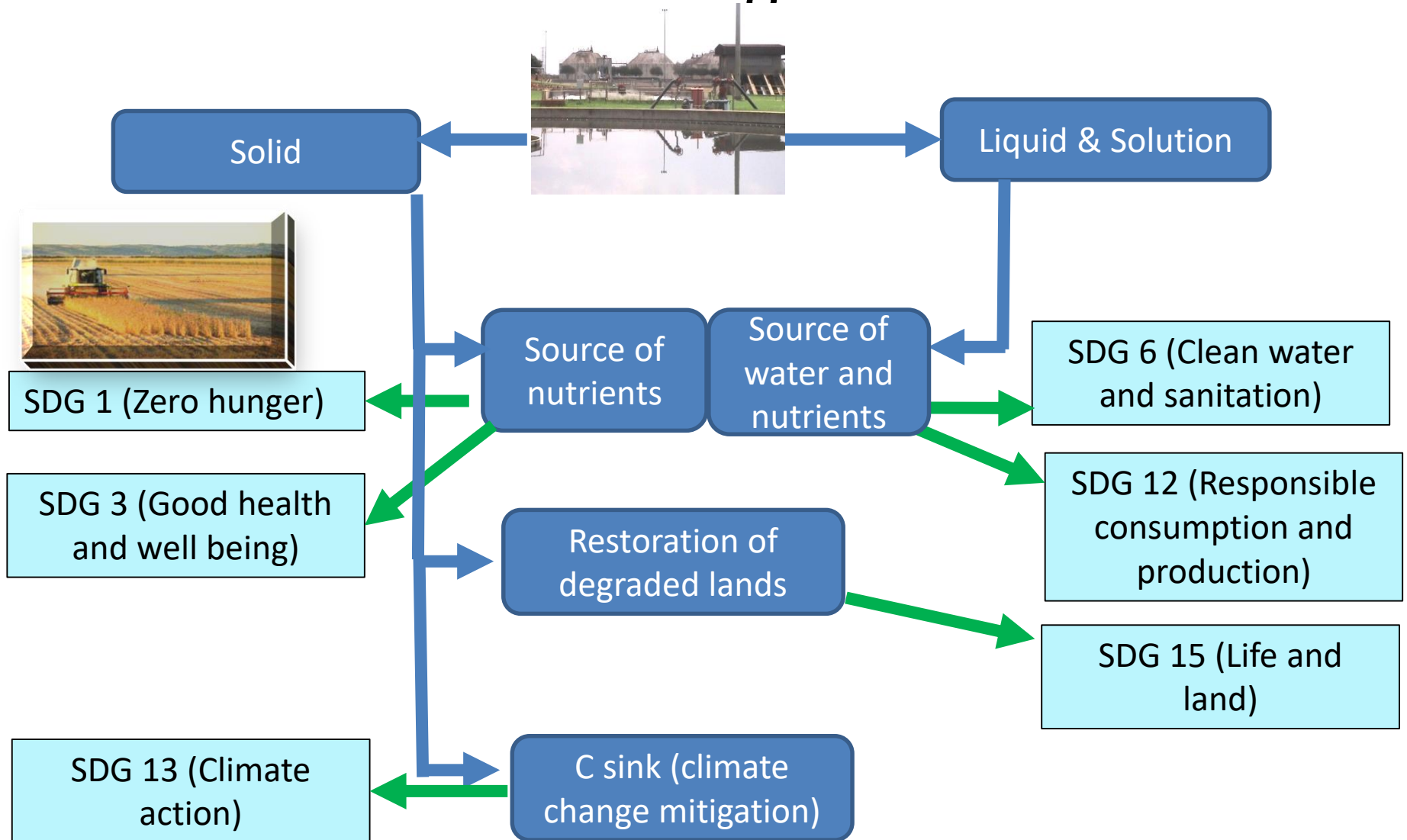


Adapted from Eugene Odum, Ecology, 1963 and [www.Ecocycle.org](http://www.Ecocycle.org). 2008

# Sludge as a resource



# The role of recycling sludge in agricultural lands in fulfilling the UN SDG



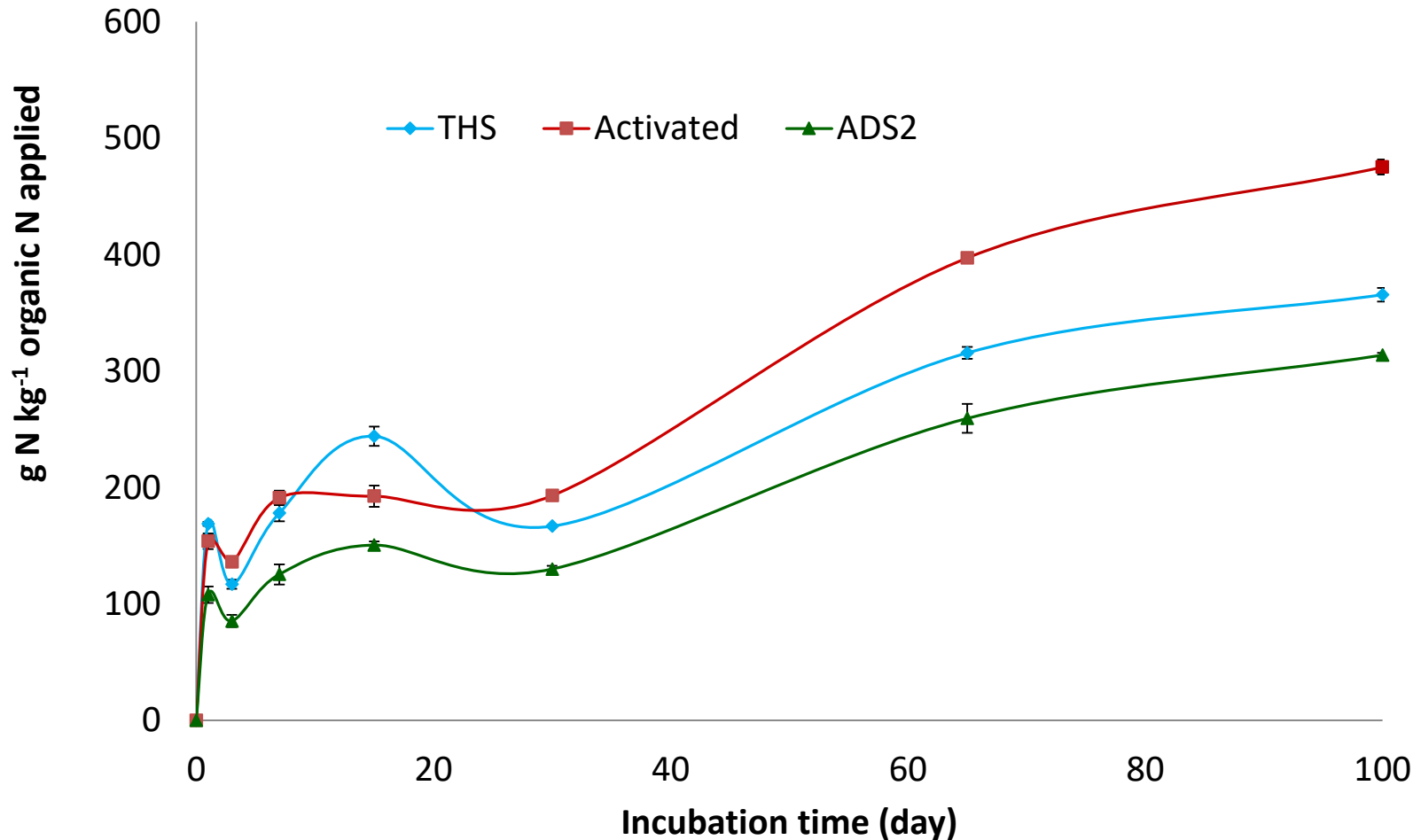
# Beneficial agricultural use of wastewater sludge in South Africa

- According to the South African sludge guideline,
  - Sludge may be used in agricultural lands if the:
    - Microbial content,
    - Stability, and
    - Pollutant concentration fell within acceptable ranges.
- Sludge which qualify for agricultural use:
  - Should be applied according to crop nutrient requirement
    - Maximum application rate set at  $10 \text{ t ha}^{-1} \text{ yr}^{-1}$ .

# Can we use constant application rates regardless of the source of sludge?

- Sludge nutrient release rate varies:
  - Among wastewater treatment processes, and
  - agro-ecological zones.
- Hence sludge application rates should be adjusted accordingly.

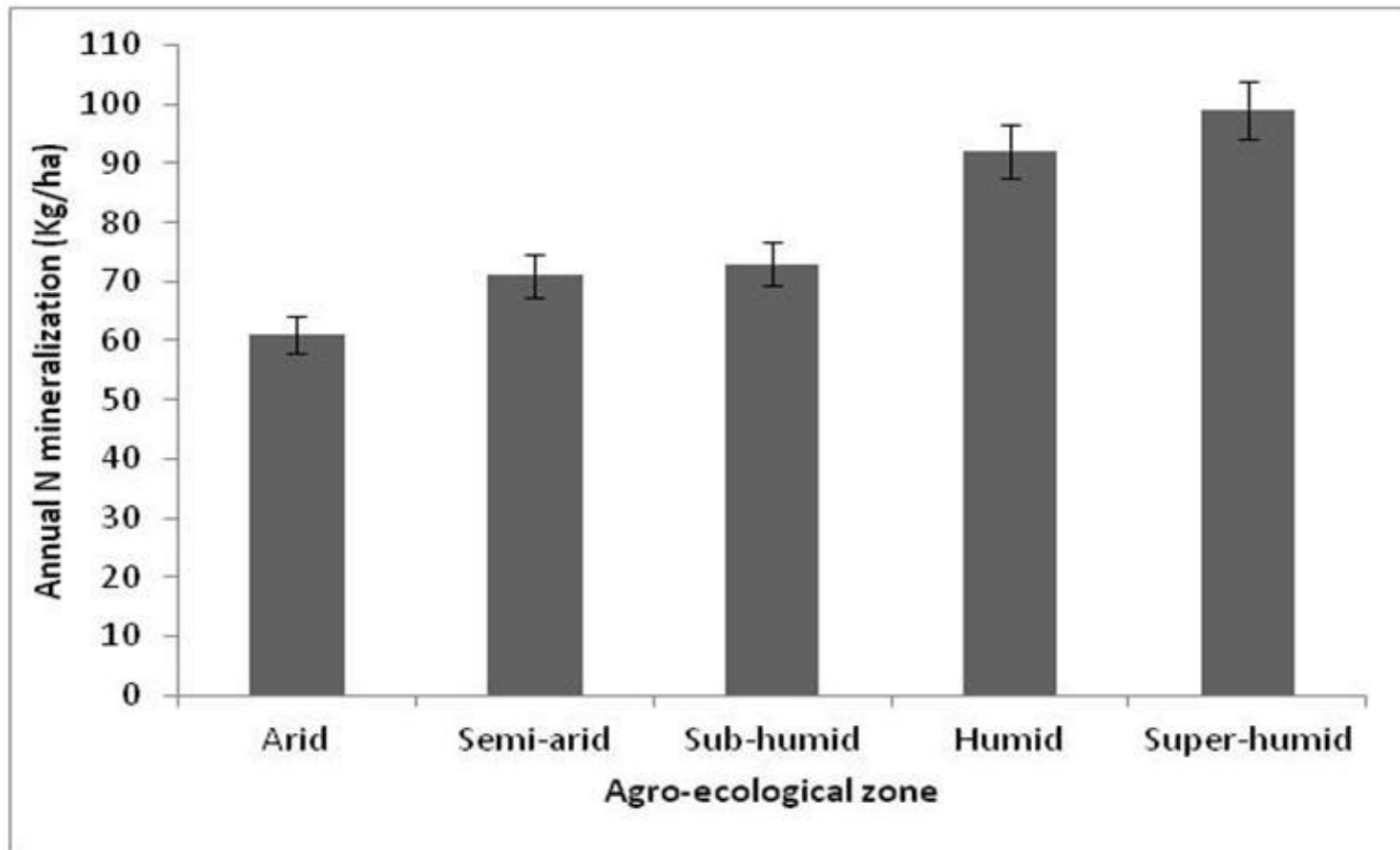
# Sludge N release rate varies between wastewater treatment methods





# Sludge N release rate varies between agro-ecological zones

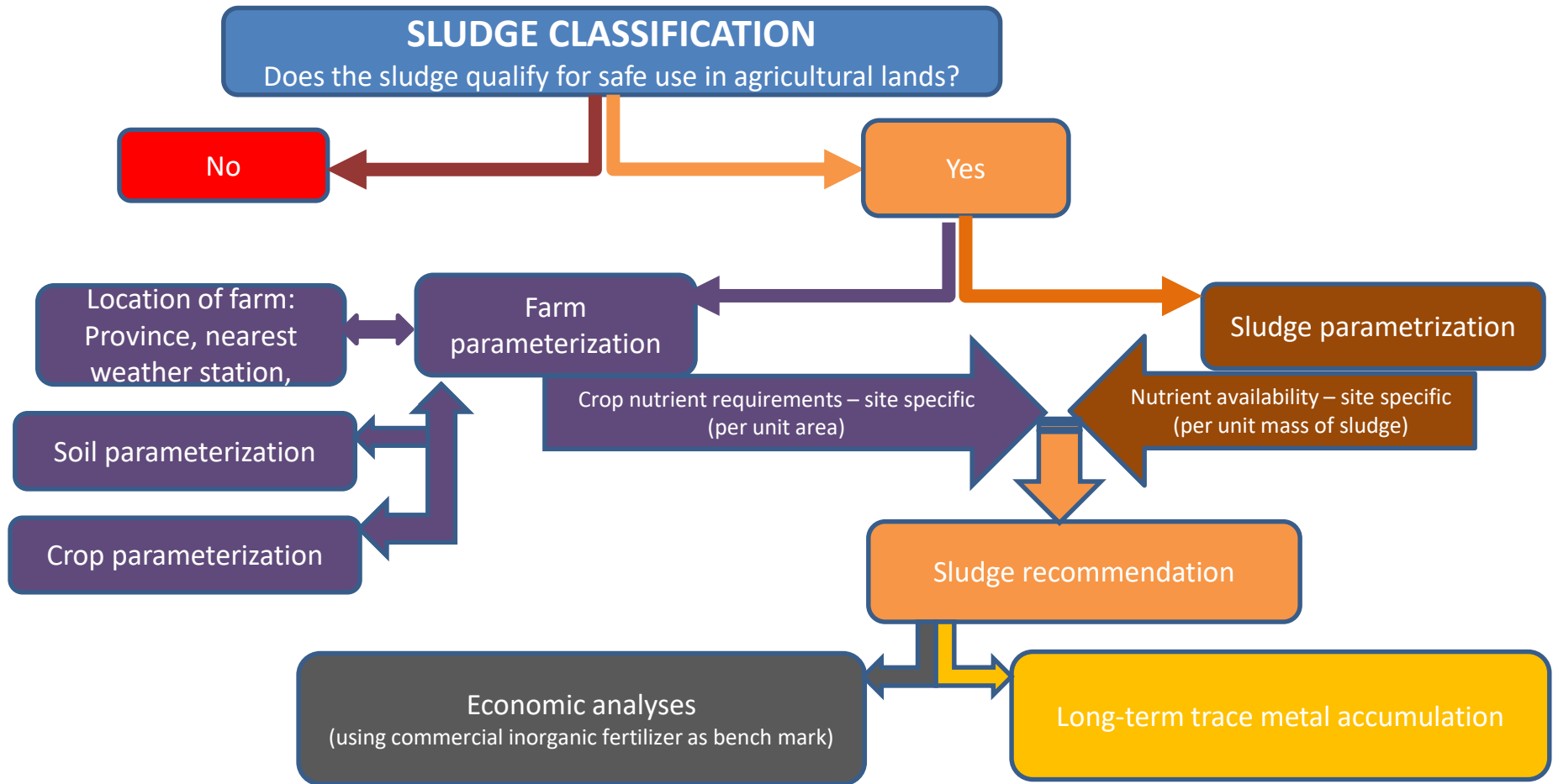
- N mineralization varies significantly across agro-ecological zones (sludge application rate  $10 \text{ t ha}^{-1}$ )



# SARA model development

- SARA model was developed to assist the implementation of site and crop specific sludge recommendation:
  - Across SA agro-ecological zones,
  - Cropping systems,
  - Soil types, and
  - Sludge types.

# SARA model – flow diagram



# **Sludge Classification Interface**

**SARA MODEL**

# SARA Model – sludge classification interface

The screenshot displays the SARA Model sludge classification interface, which is divided into three panels. Each panel shows the same set of input fields for Microbial class, Pollutant class, and Stability class, but with different values entered. The resulting Sludge class is displayed at the bottom of each panel.

**Panel 1 (Left):** Faecal coliforms: 100, Helminth ova: 0.2, As: 35, Cd: 35. Result: **A1a** (No limitations at)

**Panel 2 (Middle):** Faecal coliforms: 100, Helminth ova: 0.2, As: 500, Cr: 1000, Pb: 250, Ni: 400, Cd: 35, Cu: 1400, Hg: 10, Zn: 2500. Result: **A1b**

**Panel 3 (Right):** Faecal coliforms: 100, Helminth ova: 0.2, As: 500, Cr: 1000, Pb: 250, Ni: 400, Cd: 35, Cu: 1400, Hg: 10, Zn: 2500. Result: **A1c** (The sludge metal content is too high for agricultural use. Source control should be implemented)

The interface includes a 'Microbial class' section with input fields for 'Faecal coliforms' and 'Helminth ova'. A 'Pollutant class' section contains input fields for various metals: As, Cr, Pb, Ni, Cd, Cu, Hg, and Zn. A 'Stability class' section offers three options (1, 2, 3) with corresponding descriptions and a list of 10 remediation options. A 'Sludge class' section displays the final classification (A1a, A1b, or A1c) and any associated warnings or limitations. The interface also features a 'Welcome' message, a 'SARA' logo, and several images: a microscopic view of sludge, a biohazard symbol, and a fly.

**Site, Crop And Soil Parameterization**

**SARA MODEL**

# SARA model – Site, Crop And Soil Parameterization

The image shows a software interface for the SARA model, specifically the 'Edit' dialog box for soil parameterization. The dialog box is titled 'Edit' and has two tabs: 'Farm' and 'Soil'. The 'Soil' tab is selected. The parameters are as follows:

Parameter	Value
Soil textural class	Sandy loam
Soil bulk density (kg/m <sup>3</sup> )	1557.00
Clay (%)	10.0
Soil Nitrate & Ammonium (mg/kg)	6.00
Ammonium acetate extractable potassium (mg/kg)	8.00
Soil plant available Phosphorus (mg/kg)	25.00
Analytical method	P-Bray

At the bottom of the dialog box, there are two buttons: 'Update' (with a green checkmark icon) and 'Cancel' (with a red X icon). Below the dialog box, there is a navigation bar with buttons for 'Prev', 'Next', and 'Cancel', along with left and right arrow icons.

# **Sludge Parameterization**

## **SARA MODEL**



# SARA model – sludge parameterization

Sludge Application Rate Adviser (SARA): Updated 25 April 2018

SARA About Adviser expert: Field

**Weld** Edit

Farm-id  Field-id

Application year (yyyy)

Type

Moisture content (%)

Total Nitrogen content (%)

Nitrate content (mg/kg)

Ammonium content (mg/kg)

Phosphorus content (%)

Potassium content (%)

# **Sludge Recommendation**

**SARA MODEL**

# SARA model – Sludge recommendation rate

Adviser expert: Field

## Recommendation interface

Farm-id	Field-id	Farm name	Appl year	Sludge (t/ha)	Potassium (kg/ha)	Sludge (ton)	Potassium (kg)
1	1	John	2014	6.49	37.00	6.5	37.0

Sludge (t) 6.5 Potassium (kg) 37.0

Prev Next Cancel

Sludge recommendation per field

Potassium recommendation (for optimal crop growth)

Total sludge recommendation for the farm

# **Cost Benefit Analyzer**

## **SARA MODEL**

# SARA model – Cost benefit analyser

Sludge Adviser expert: Field

SARA


W

**Input**

Farm distance from wastewater treatment plant (km)  Spreading cost per ton

Rate per km

Truck capacity in tons




**Commercial inorganic fertilizer price information**

Nitrogen price per kg (R)

Phosphorus price per kg (R)

Potassium price per kg (R)


Distance from commercial fertilizer source to farm (km)



Total cost of commercial fertilizer (fertilizer + transport costs) (R)

Net municipal sludge cost (R)

Net margin (R)



Prev Next Cancel

Cost benefit analyses using commercial fertilizer as bench mark

# **Trace Metal Accumulation**

## **SARA MODEL**

# SARA model – Trace metal accumulation

Sludge Ap Adviser expert: Field

SARA | Abc

## Long term trace metal accumulation

	Sludge (mg/kg)	Soil (mg/kg)	
Cu	<input type="text" value="336.37"/>	<input type="text" value="0.103"/>	Application method <input type="text" value="Incorporated"/>
Zn	<input type="text" value="2451"/>	<input type="text" value="1.006"/>	Plough depth (m) <input type="text" value="0.5"/>
Hg	<input type="text" value="0.85"/>	<input type="text" value="0.154"/>	
Pb	<input type="text" value="66.76"/>	<input type="text" value="0.015"/>	
Cd	<input type="text" value="8.96"/>	<input type="text" value="0.029"/>	
Ni	<input type="text" value="81.11"/>	<input type="text" value="0.743"/>	
Cr	<input type="text" value="237.81"/>	<input type="text" value="0.012"/>	
As	<input type="text" value="6.21"/>	<input type="text" value="0.004"/>	

### Duration to reach environmental threshold level

Farm-id	Field-id	Farm name	Appl year	Sludge (t/ha)	1st Element to reach threshold	Yrs to reach threshold	Note
▶ 1	1	John	2014	6.49	Zn	9.7	

Prev Next Cancel

Years to reach threshold level



# THANK YOU ACKNOWLEDGMENTS



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