Task Force on Techno-Economic Issues

Guidance document on the interactions between emissions of methane and ammonia, and other nitrogen compounds, and the potential for their co-mitigation from agricultural sources

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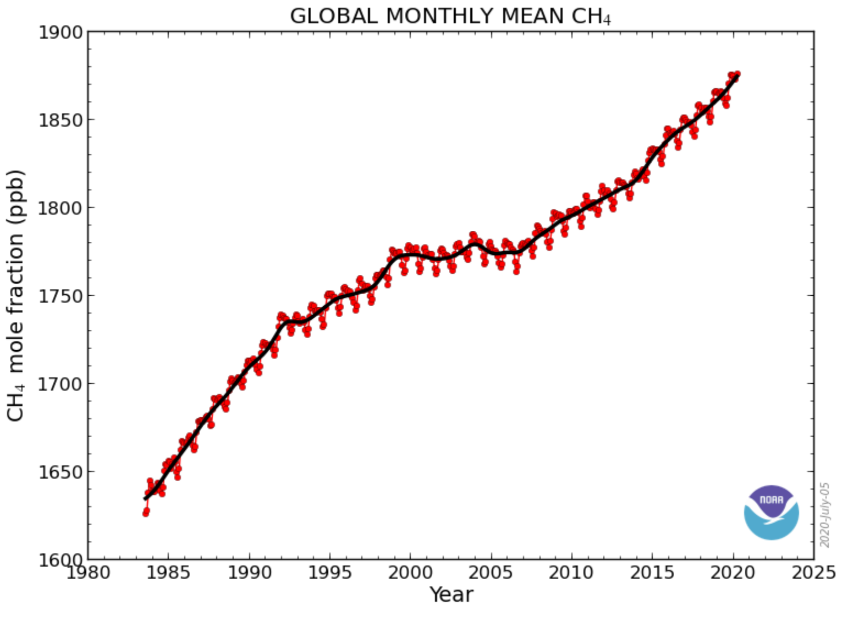
Why methane is a problem?

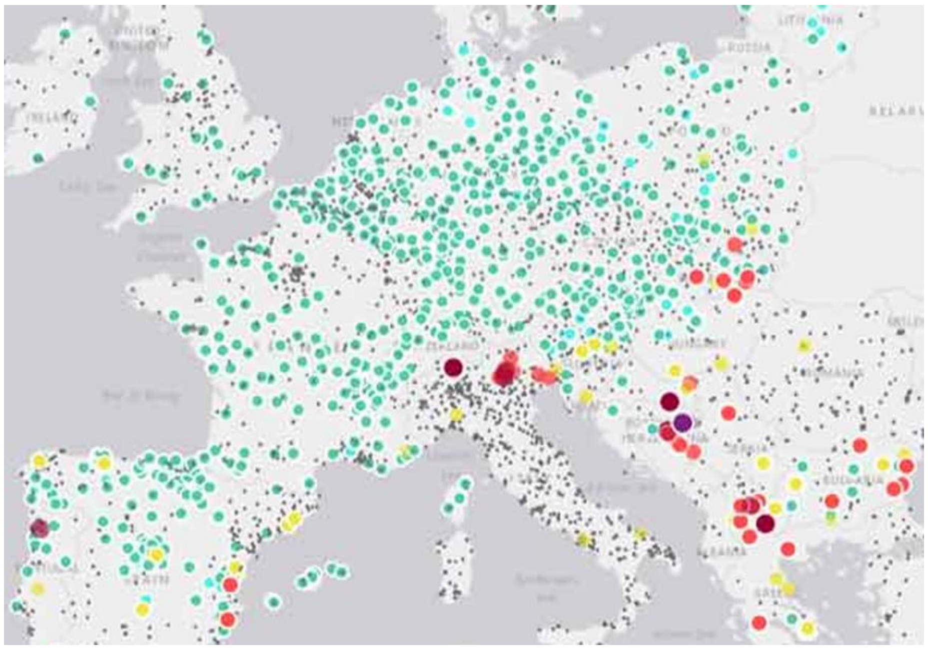
Agriculture sustains humanity and provides livelihoods for over 800 million people (27% of the global workforce) (FAO, 2020) and emit a substantial amount of greenhouse gases, including large amounts of **methane (CH_4)**, which is the main precursor of tropospheric ozone and air pollutant.



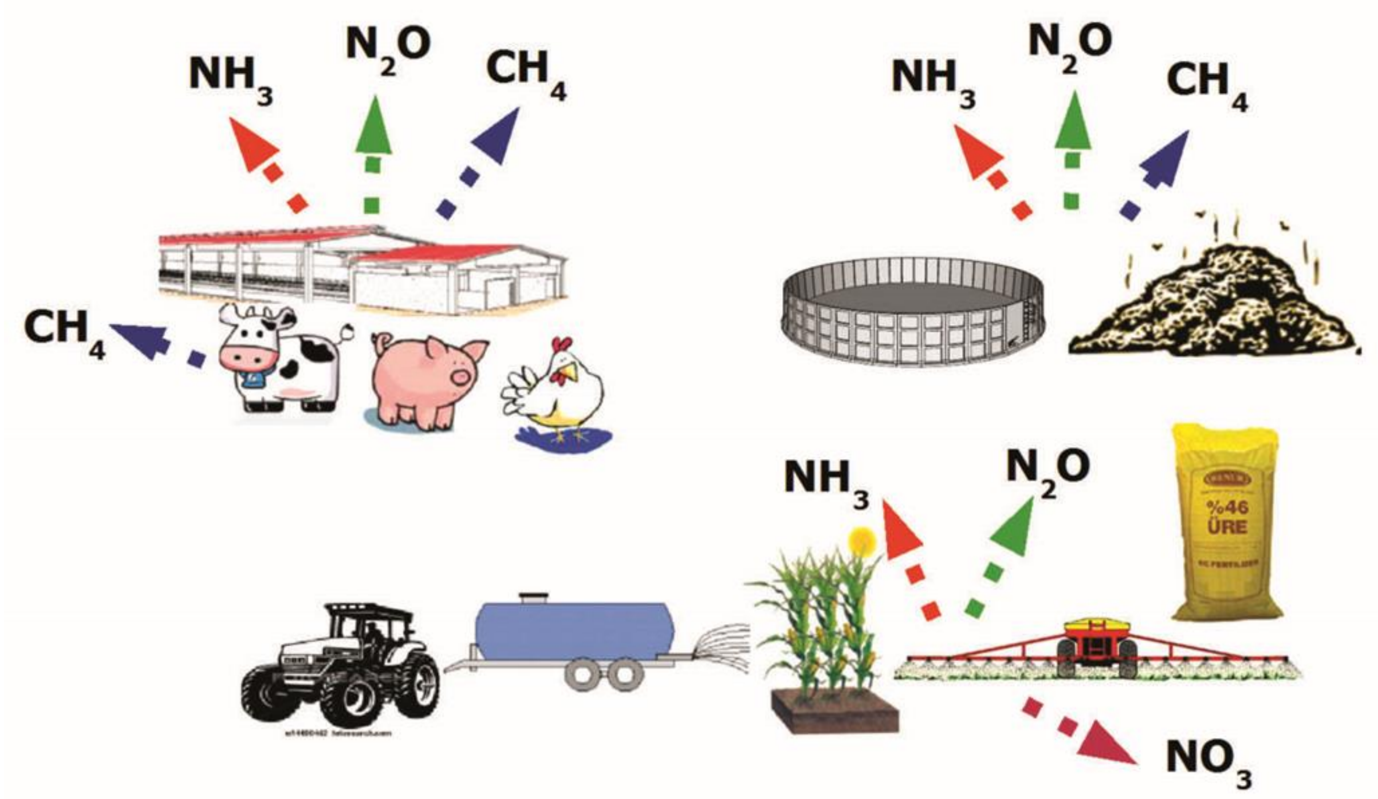
The main sources identified by the study were:

- **30% from enteric fermentation and manure management**
- 22% from oil and gas production and use
- 18% from handling solid and liquid wastes
- 19% from coal extraction and rice cultivation
- 8% from biomass and biofuel burning
- The rest is transport and industry.

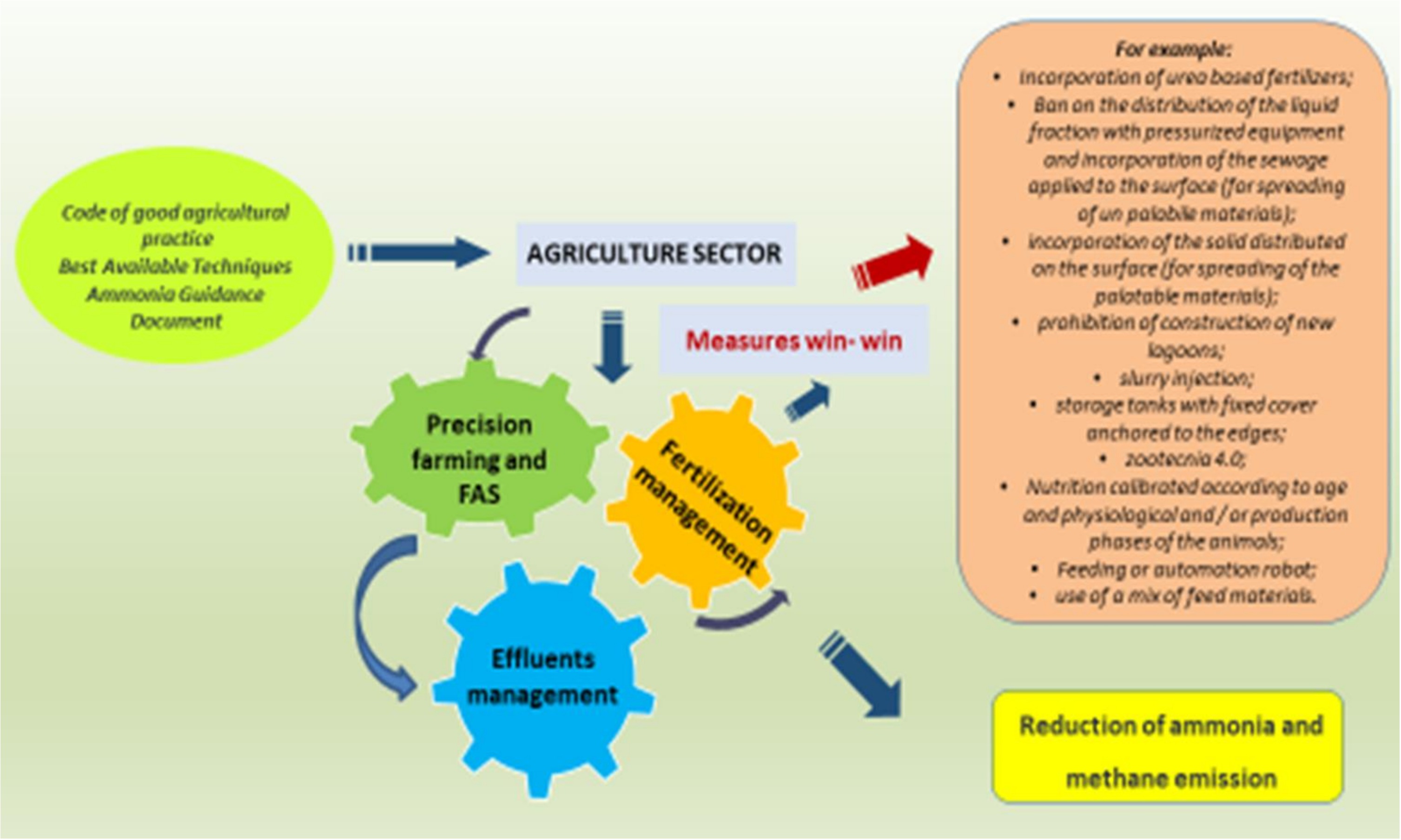
Why ammonia is a problem?



Emissions sources from agriculture

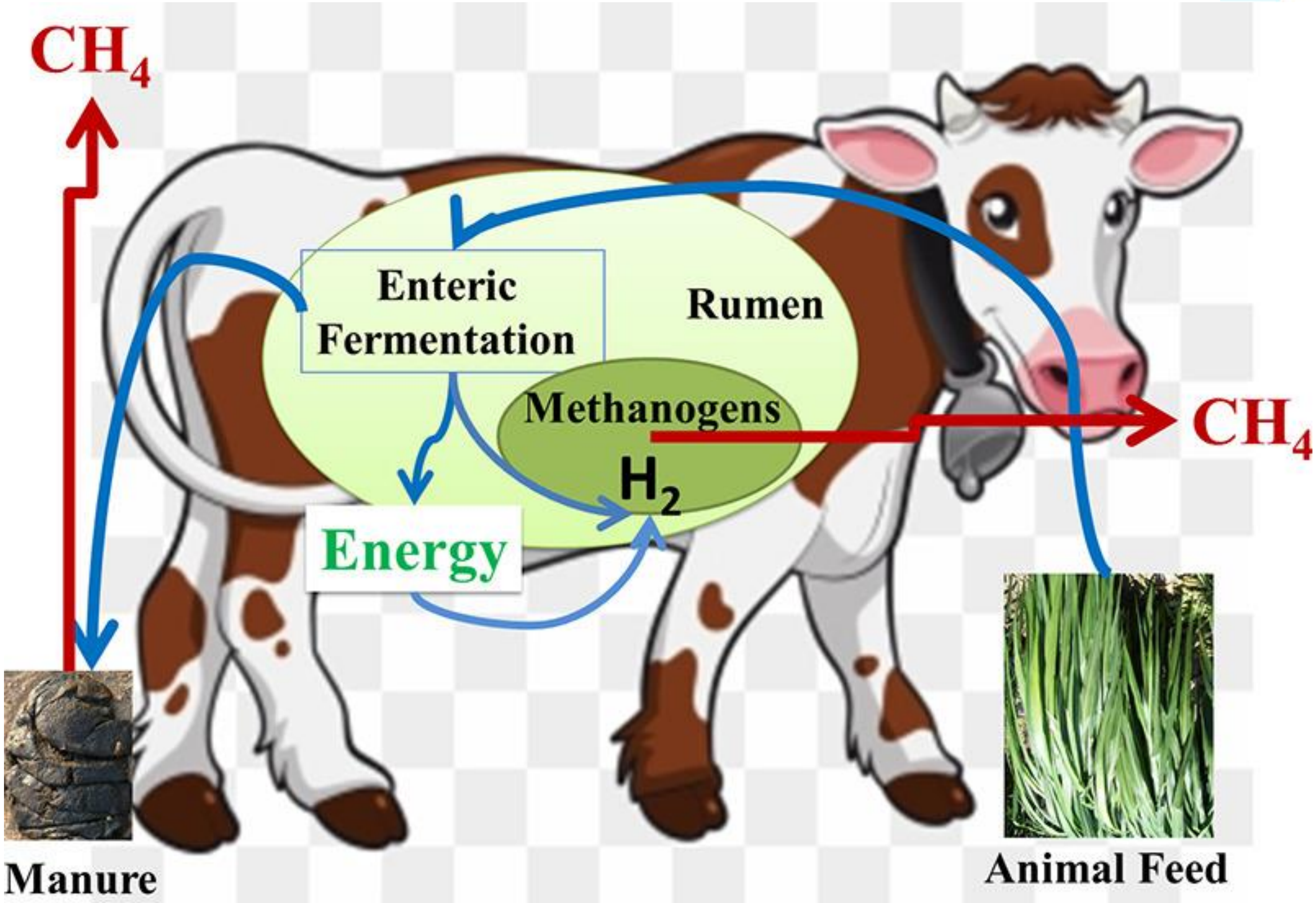


Guidance document on technical measures for reduction of methane emissions from agricultural and livestock activities

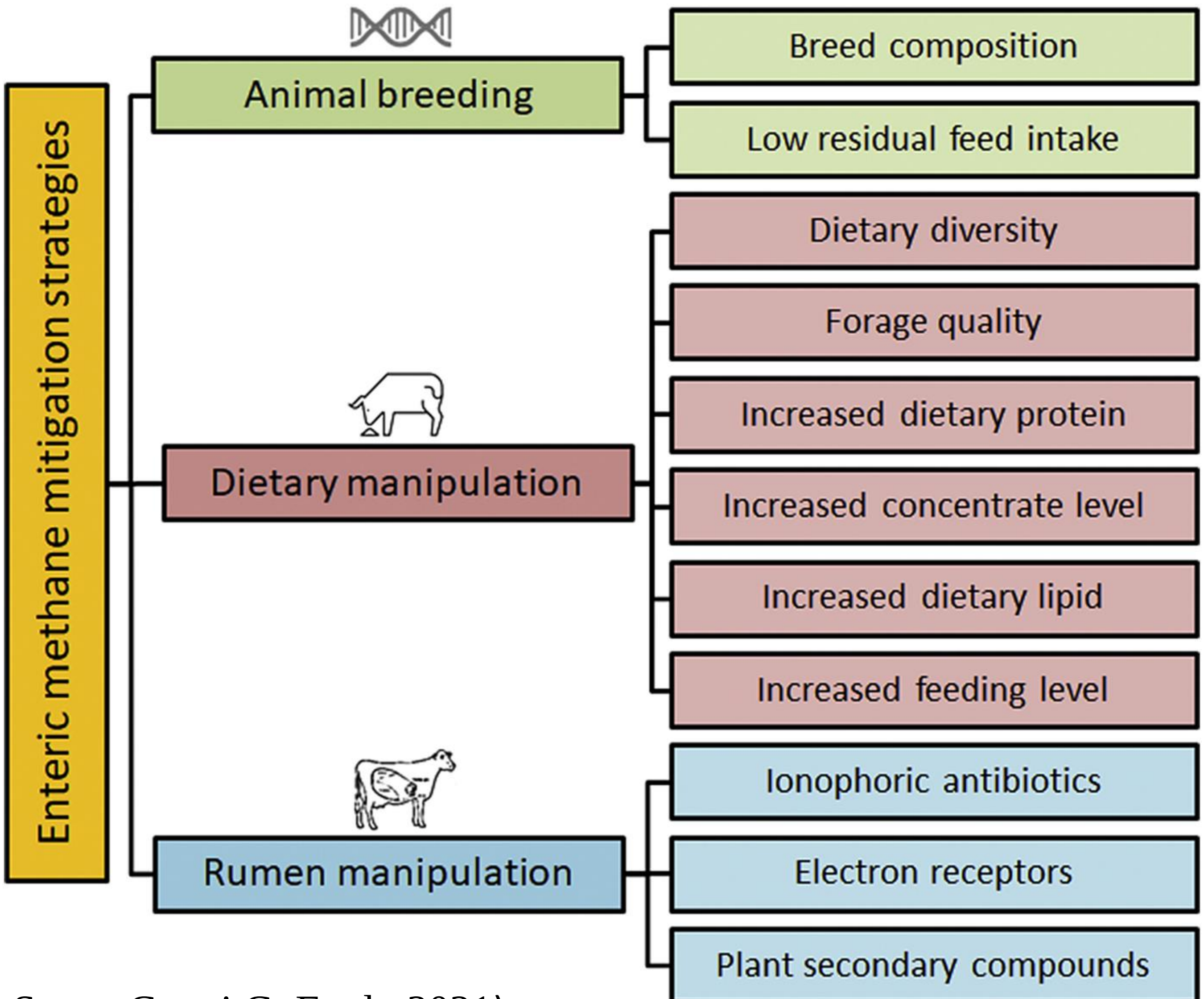


Methane production

Ruminant animals



Mitigation strategy to reduce enteric CH_4 emissions



(de Souza Congi G. Et al., 2021)

Mitigation strategy to reduce CH_4 emissions from manure

Mitigation strategies:

- **Temperature**: to reduce the temperature below 20°C to inhibit the growth rate of different type of methanogenic bacteria and consequently of CH_4 production;
- **Covered lagoons:** by placing a different types of manure storage covers (natural crusts, straw, wood chips, oil layers, expanded clay, wood, semi-permeable and sealed plastic covers)
- **Anaerobic digester**;
- **Enhancing manure storage and handling** where biogas systems are not available through aeration of manure stocks reduces CH_4 emissions by inhibiting methanogens.

Ammonia production and volatilization

Animals

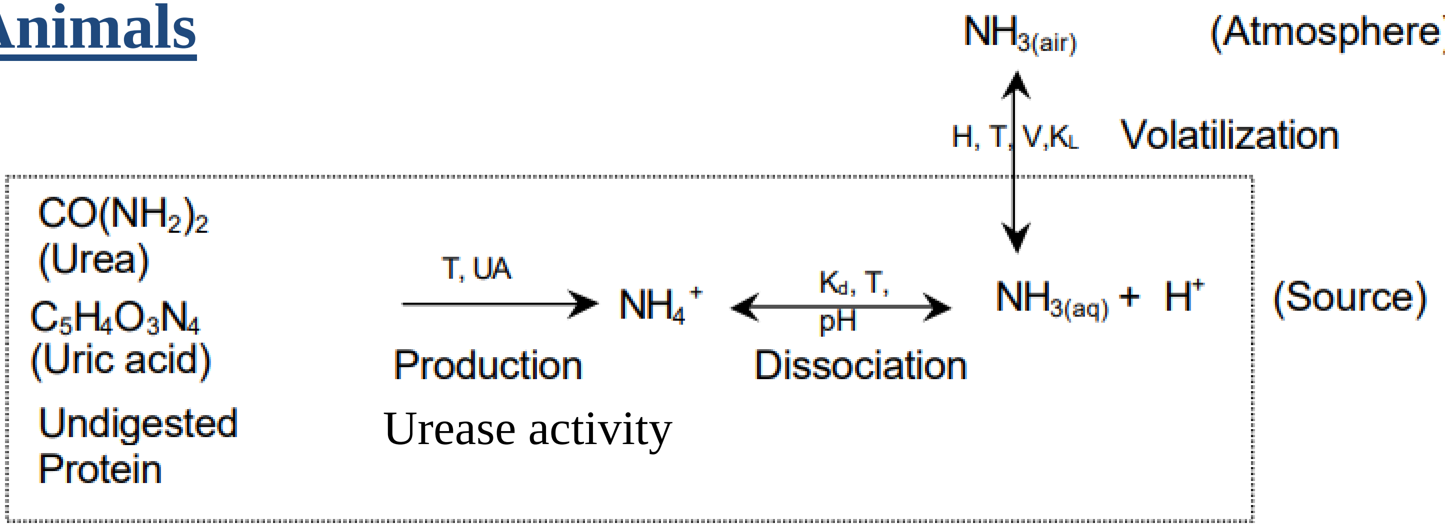


Figure 1. Ammonia Production and Volatilization Equilibria (H - Henry's Law constant, K_d - dissociation constant, K_L – mass transfer coefficient, pH, T - Temperature, UA - Urease activity, V- wind speed).

(Arogo et al., 2002)

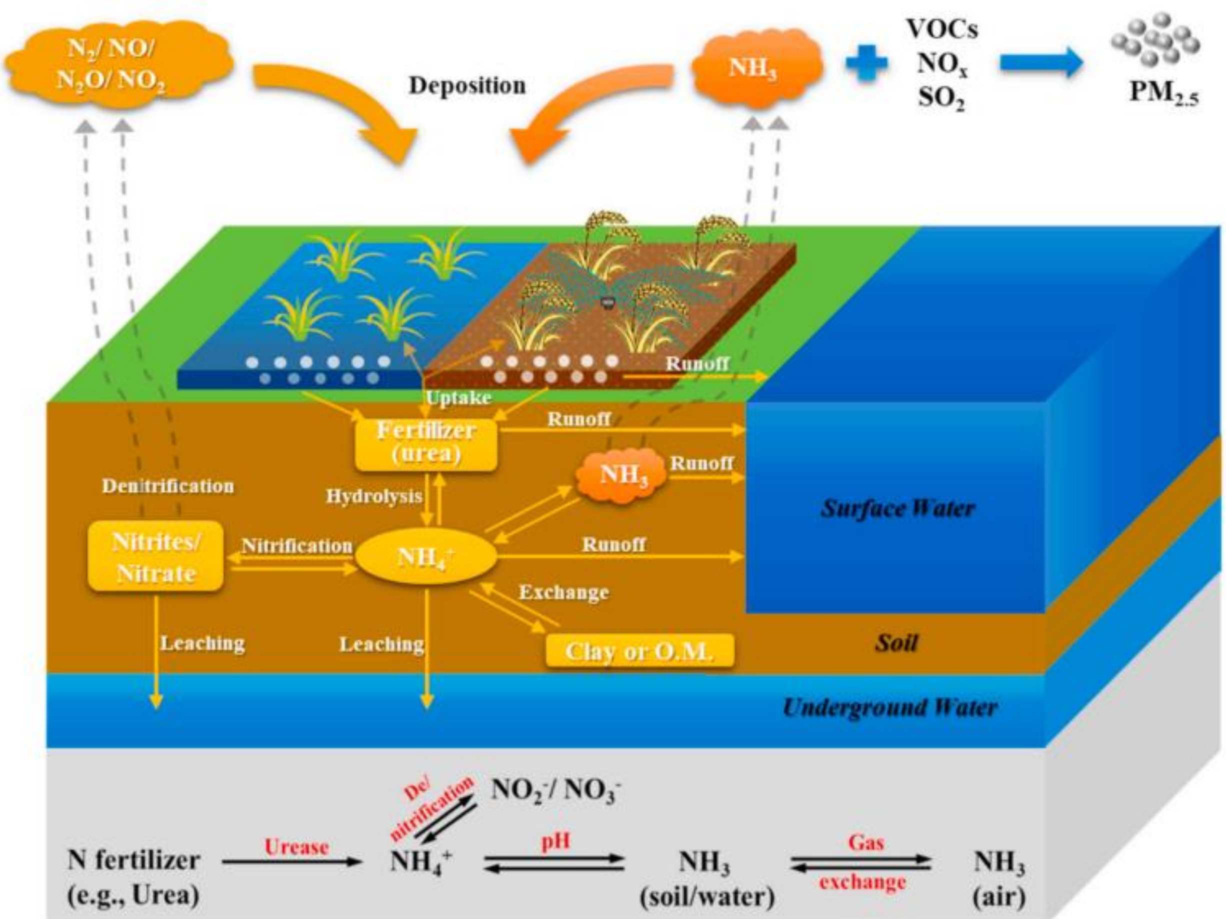
Factors affecting NH_3 volatilizzazion:

- ✓ TAN concentration
- ✓ pH
- ✓ temperature
- ✓ wind speed
- ✓ chemical and microbiological activity

High urease activity, warm temperature, large emissions surface area, high pH and high air velocity enhance NH_3 volatilization.

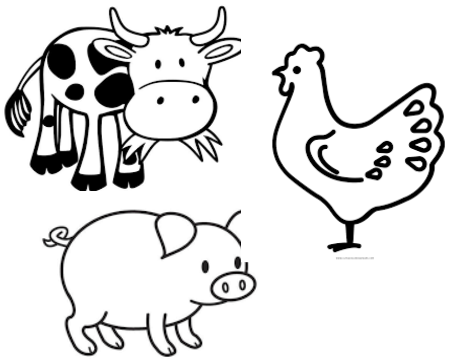
Ammonia volatilization

Farmland



The nitrogen cycle and ammonia volatilization in the agriculture system. (Li et al., 2022)

Mitigation strategy to reduce NH_3 volatilization



Animal: reduction of the excretion of N by feeding reduced protein diet or by matching more accurately the diet to specific requirements of different growth and production stages; supplementing the diet with zeolite, use of antibiotics and probiotics to increase feed efficiency; vegetable oil, plant extract rich in tannins and saponins and exogenus enzyme.

Building design:
Dairy barn: reduce of emitting area surface, use sloped concrete floors, combine scraping and spraying the floor with water
Pig barn: reduce of emitting surfac are using different floor system, ventilation.

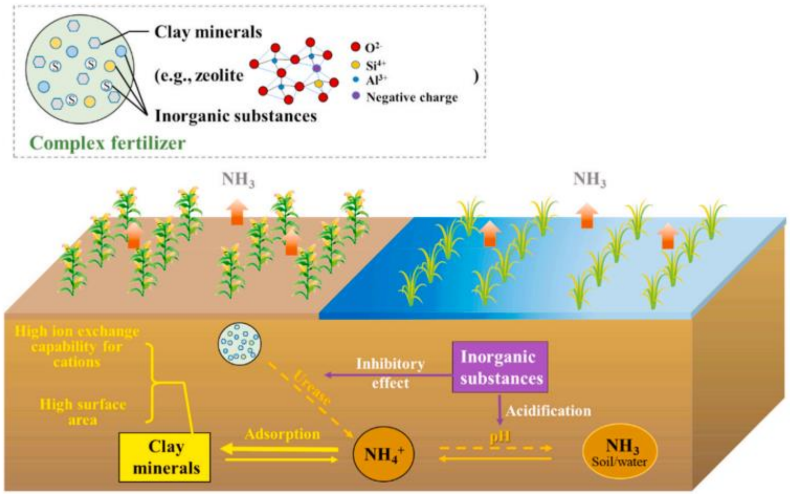
Manure storage: covers for slurry tanks and manure store, drying manure (poultry litter), v), Maintaining the temperature of the heap below 50°C or increasing the C:N ratio to > 25, composting of solid manure, additives to absorb NH_3,reduce manure pH, increase microbial N immobilization, inhibit microbial growth.

Land application: injection

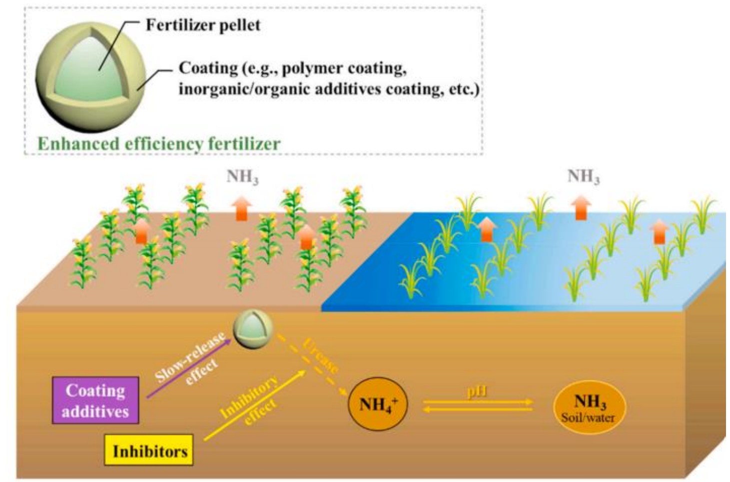
Manure treatment: acidification and manure diluition

Mitigation strategy to reduce NH_3 volatilization

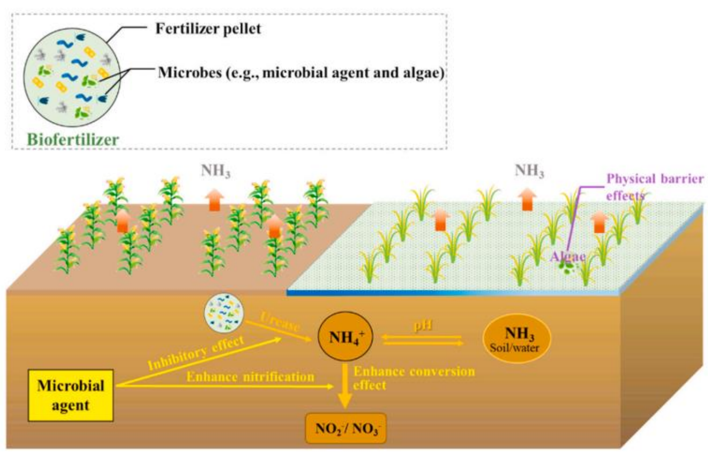
Fertilizers amendment



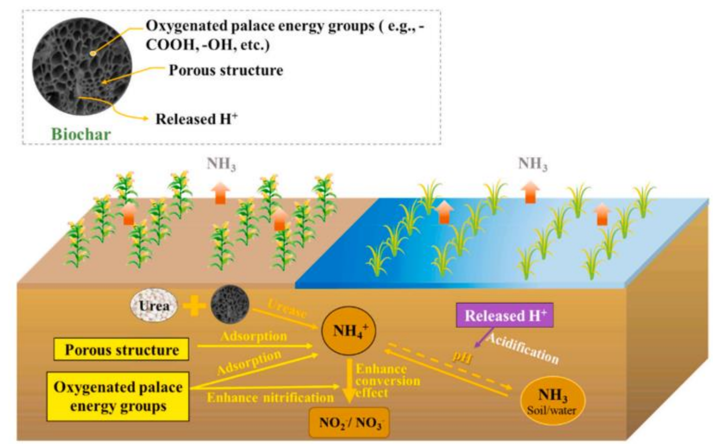
Complex fertilizers



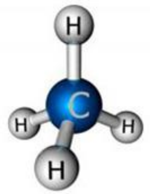
Coating and inhibition based fertilizers



Biofertilizer



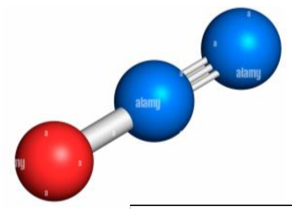
Biochar



Interactions between CH_4 with other emissions

Mitigation strategy	Effectiveness	Interactions with other categories of emissions
Feed supplements		
Dietary lipids	Medium	Reduction of feed digestibility and this increases CH_4 from stored manure. If source is from oil seeds (e.g. cotton), then it can increase N content of feed, and thus of excreta. Not recommended if base feed has high protein content.
Tannins	Low	A potential for reducing enteric CH_4, decrease in urine-N and potential lower emission of N_2O.
Feeds and feeding management		
Concetrate	Low to medium	Decrease enteric CH_4 but higher starch in the diet may potentially have a destblizing effect on ruminal fermentation, pH, rumen health and disgetibility.
Improving forage quality and grazing management	Low to medium	If CP content of diet exceeds protein requirement of animal, N_2O emissions may increase. Increased digestibility can reduce CH_4 from stored manure. Can increase overall intake and thus increase enteric CH_4 emissions in grazing systems. Legume introduction in pasture can reduce emissions related to fertilizer use.
Feed processing (grains)	Low	May have mitigation effect on N_2O emissions from manure application, and on CH_4 emissions from stored manure.
Precision feeding	Low	Contributes to the reduction of manure CH_4 and N_2O emissions.

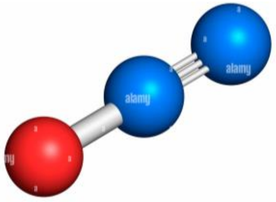
***Low** 5 < 10% mitigating effect; **medium** 5 10 to 30% mitigating effect; **high** 5 > 30% mitigating effect (Hristov et al.,2013) (Gerber et al., 2013)



Interactions between manure CH_4 and N_2O with other emissions

Mitigation strategy	Effectiveness	Interactions with other categories of emissions
Dietary manipulation		
Balanced dietary CP	Medium	Reduce NH_3 emissions from manure through a reduction of urinary urea excretion
Tannins	Low	A potential for reducing enteric CH_4, decrease in urine-N and potential lower emission of N_2O.
Housing		Straw-bedded system creates an aerobic environment favorable for N_2 emissions but not for CH_4. The opposite is with liquid-manure systems, that tend to increase CH_4 emissions and reduce those of N_2O and NH_3
Manure storage		
Natural or induced crust	High	Covering manure with semi-permeable covers can provide conditions for nitrification, denitrification and release of N_2O emissions. Impermeable covers can be an effective mitigation practice if CH_4 caputured under the cover is burned using a flare system or engine-generator to produce
Manure acidification	Low	This strategy is an effective mitigation option for NH_3 emissions but the effect on N_2O is not well studied.
Composting	High	It reduces CH_4 emissions compared with storage of manure under anaerobic conditions. However, NH_3 losses can be particularly high, reaching up to 50% of the total manure N.
Anaerobic digestion	High	May increase NH_3 during storage and application of liquor and is a source of renewably energy in the form of biogas which is 60% to 80% CH_4 depending on the substrate and operation conditions.

Low 5 < 10% mitigating effect; **medium** 5 10 to 30% mitigating effect; **high** 5 > 30% mitigating effect (Hristov et al.,2013) (Gerber et al., 2013)



Interactions between manure CH_4 and N_2O with other emissions

Mitigation strategy	Effectiveness	Interactions with other categories of emissions
Manure application		
Manure incorporation in soil	Low	Reduces indirect N_2O emissions from NH_3 losses but may cause increase in direct N_2O and CH_4 emissions.
Time of application	Low (CH_4) to High (N_2O)	May result in increase in NH_3 losses. May reduce N-fertilizer consumption (and related emissions) through better use of manure .
Nitrification inhibitors	High	Can result in higher NH_3 emissions, depending on storage conditions and time prior to application. Can increase pasture productivity and/or displace N fertilizer.
Urease inhibitors applied at time of excretion/urination	Medium	Reduces indirect N_2O emissions from NH_3 losses but may increase direct N_2O and CH_4 emissions.

Low 5 < 10% mitigating effect; **medium** 5 10 to 30% mitigating effect; **high** 5 > 30% mitigating effect (Hristov et al.,2013) (Gerber et al., 2013)

Interactions and links with productivity

Feed, enteric CH_4, manure content and productivity

Dietary lipids:

reduce enteric CH_4 but can increase methane emissions in manure because they reduce ration digestibility or increased N content (if lipids are oil cake rich in CP).

Dietary manipulation:

increase feed digestibility, reduce CH_4 emissions from animal and manure storage because less fermentable organic matter will be excreted by faeces. Furthermore, increasing nutrient digestibility may give a surplus of N to the animal resulting in a higher N_2O emissions from manure.

Manure storage, processing and application

Storage time: reducing storage time reduce CH_4 emissions, however the more frequent need for soil application may increase N_2O emissions.

Manure application: the incorporation reduce NH_3 emissions and N losses and reduce CH4 emissions, but the increase of organic matter accelerates soil metabolism and denitrification process and N2O emissions.

Anaerobic digestion: reduce CH_4, but the inhibition of nitrification under anaerobic conditions can lead to greater ammonium N in digested manure which can lead an increase of NH_3 .

Conclusions

- Many technical options exist for the mitigation of direct emissions from livestock production.
- Diet manipulation, feed additives and capturing the biogas emitted under anaerobic conditions have been identified as main strategies to reduce enteric CH_4 production and manure CH_4 emissions.
- N_2O emissions are much more difficult to prevent once N is excreted, because the effective mitigation of N losses in one form (es. NH_3) is offset by N losses in other forms (es. N_2O or NO_3).
- Different intercations were highlighted between mitigation techniques for CH_4 and N_2O emissions from manure and must be considered when recommending GHG and NH_3 mitigation practices.
- More research work is needed:
  - ✓ to develop practical and economically viable techniques that can be widely put into practice
  - ✓ To quantify the impact of mitigation practices may have on other environmental objectives on broad development goals, such as poverty reduction and food security.

TFTEI

Thank you very much!!

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