Joint FAO/IAEA Centre
Nuclear Techniques in Food and Agriculture

FAO/IAEA Animal Production and Health Laboratory R&D Initiatives on AMR

Animal Production and Health Laboratory

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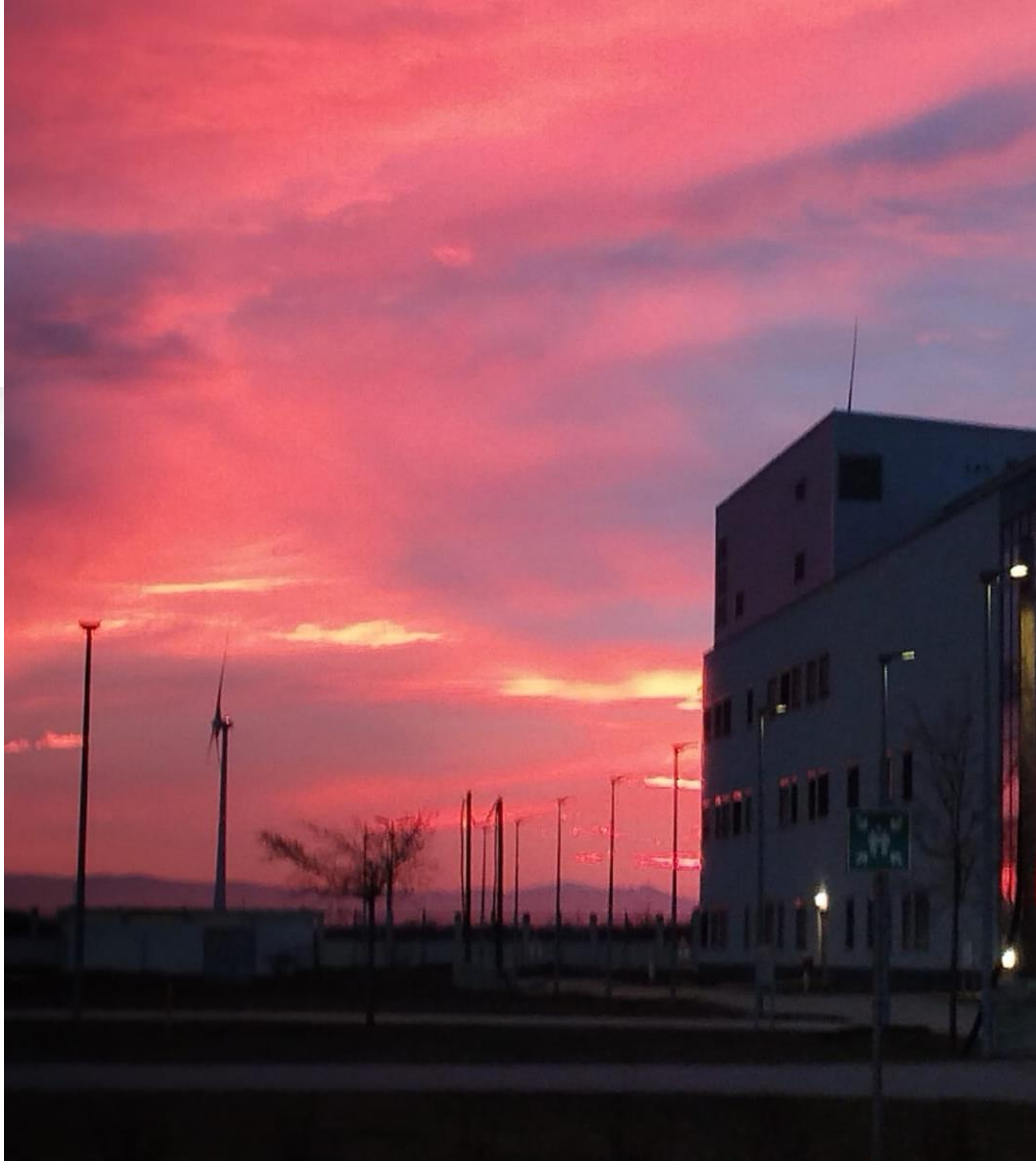
Outline

- An introduction of APHL
- Current Status on environmental sampling in AMR context
- On-going laboratory activities APHL
  - CRP on AMR in Animal Production Environment (D32043)
  - Laboratory research

Animal Production and Health Laboratory

- Located in Seibersdorf, which is 40 km from Vienna, Austria.

- Aims to strengthen food security and livelihoods through improved livestock productivity and control of transboundary animal and zoonotic diseases.



Environmental sampling

- Environmental sampling has become a widely used tool for virus detection and monitoring. It involves collecting samples from various environments—such as water, air, and surfaces—helping detect and monitor the spread of viruses like SARS-CoV-2 and others.

- *A study by Smyth et al. (2022) demonstrated the power of wastewater sequencing in detecting cryptic SARS-CoV-2 variant transmissions up to two weeks earlier than clinical genomic surveillance*[1].

[1] Doe, J., Smith, A. & Johnson, P., 2022. Title of the article. *Nature*, [e-journal] Volume(issue), pp. pages. Available at: https://www.nature.com/articles/s41586-022-05049-6

Environmental sampling in AMR context

- On-going projects like the European One Health Action Plan against Antimicrobial Resistance and WHO's GLASS are starting to include environmental components. Publications are increasingly addressing environmental AMR, highlighting the role of water, soil, and wildlife in spreading resistant genes.
- While AMR surveillance in clinical and veterinary settings is well established, environmental surveillance lags behind, with limited standardization.

Environmental sampling in AMR context

The status of environmental AMR surveillance highlights several ongoing challenges:

- **Limited Environmental Surveillance**: Most existing AMR surveillance systems focus on clinical and veterinary settings, with fewer efforts dedicated to environmental contexts.
- **Methodological Gaps**: The lack of standardized methods for environmental AMR surveillance complicates comparisons across regions and sectors.
- **Technological Limitations**: Advanced methods like whole genome sequencing and metagenomics are costly and require significant technical expertise, limiting their widespread application

CRP on AMR in Animal Production Environment (D32043)

Objective

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Overall Objective

- To enable Member States (MSs) use innovative nuclear and related approaches for enhancing the efficiency and effectiveness of national AMR surveillance programs and promoting good husbandry practices to mitigate AMR in animal production settings.

Specific objectives

- To develop, evaluate and validate farm-level **sampling methods** for detection of AMR in high and low input animal production environments.
- To establish AMR **distribution characteristics** in high and low input animal production environments using nuclear, molecular and microbiological techniques.
- To establish scientific evidence on development and transmission of AMR at animal-human-environment interface.
- To evaluate and optimize phenotyping and genotyping methodologies related to drug **resistance** in animal infections **other than bacteria** (e.g., anthelmintic resistance, acaricide resistance, antifungal resistance, etc.)
- To assess the **efficacy of alternatives to antibiotic growth promoters (AGPs)** as feed additives in animal production settings
- To pilot and recommend good husbandry practices or antimicrobial stewardship that aim to reduce the risk of emergence and occurrence of AMR in farm animal settings

Overall Expected Outcome and Results

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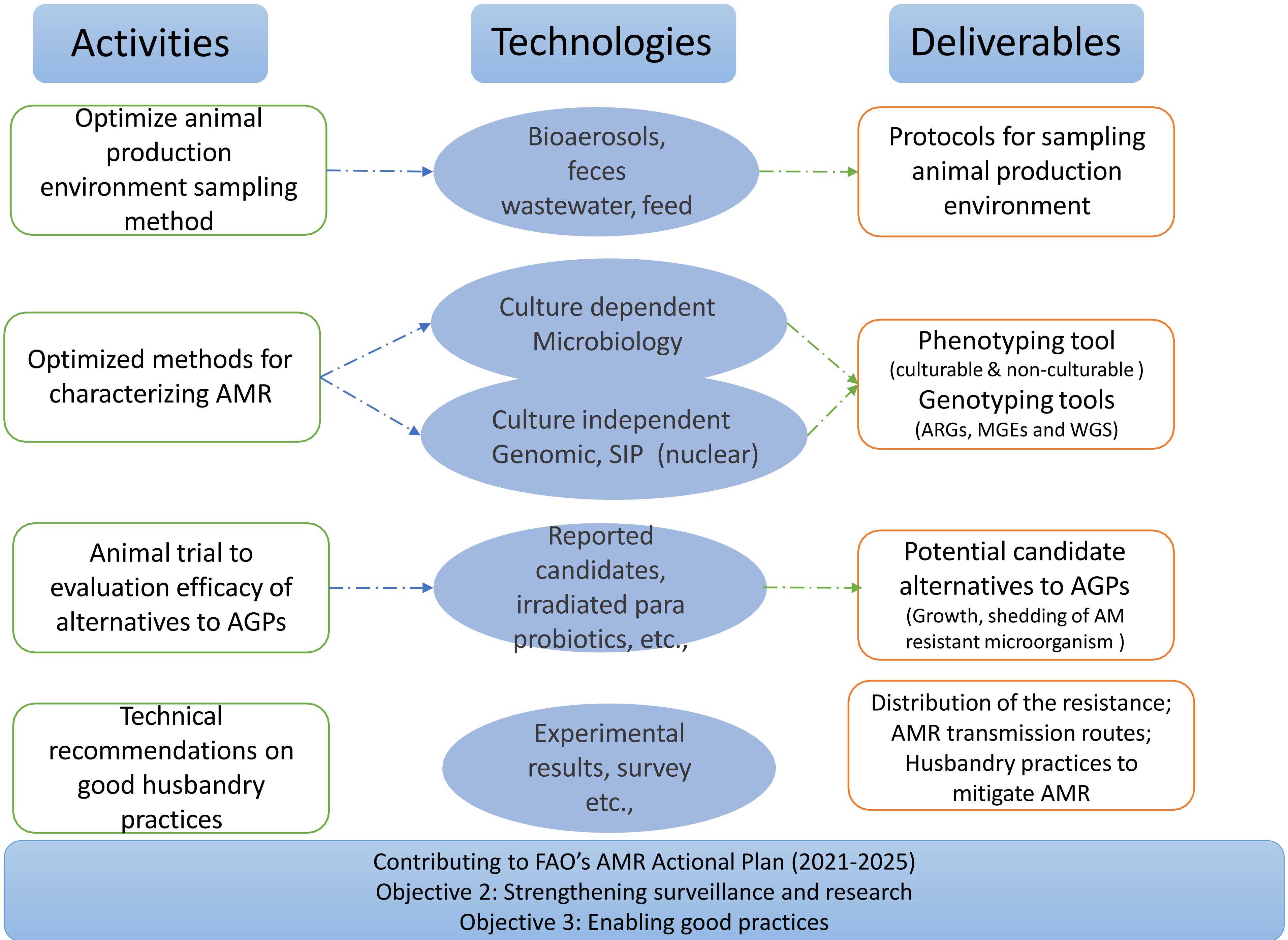
- **Overall Expected Outcome:** Improved understanding on occurrence and transmission of ARGs and mitigation measures to control AMR transmission in animal production environments.
- **Nuclear Component:** Single cell isotope probing and genomic/metagenomic approaches for AMR identification
- **Expected Results:**
  - Optimized methods/protocols for optimal sampling at farm level for detection of AMR in animal and animal production environments
  - Information on prevalence and characteristics of AMR in high and low-input animal production systems
  - Potential alternatives to antibiotic growth promoters (AGPs) as feed additives and their impact on pathogen and ARG shedding
  - Technical recommendations on good husbandry practices that helps reduce the risk of AMR transmission in animal farms


Activities
Technologies
Deliverables
Optimize animal production environment sampling method
Bioaerosols, feces wastewater, feed
Protocols for sampling animal production environment
Optimized methods for characterizing AMR
Culture dependent Microbiology
Culture independent Genomic, SIP (nuclear)
Phenotyping tool
(culturable & non-culturable)
Genotyping tools
(ARGs, MGEs and WGS)
Animal trial to evaluation efficacy of alternatives to AGPs
Reported candidates, irradiated para probiotics, etc.,
Potential candidate alternatives to AGPs
(Growth, shedding of AM resistant microorganism)
Technical recommendations on good husbandry practices
Experimental results, survey etc.,
Distribution of the resistance; AMR transmission routes; Husbandry practices to mitigate AMR
Contributing to FAO's AMR Actional Plan (2021-2025)
Objective 2: Strengthening surveillance and research
Objective 3: Enabling good practices

Our collaborating counterparts

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Surveillance in farm environment

Research agreement:
Technical University of Denmark;
Carleton University

Technical contract:
Oxford University;
Tianjin University

Research contract:
Bangladesh Livestock Research Institute;
Qatar University;
Scientific Veterinary Institute "Novi Sad";
Institut de la recherche vétérinaire de Tunisie

Alternatives to AGP

Research agreement:
Veterinary Research Institute (CZR)

Technical contract:
Indian Council of Agricultural Research-Directorate on Poultry Research

Research contract:
Kenya veterinary science research institute;
National Centre for Veterinary Diagnosis, Vietnam

Resistance in organisms other than bacteria

Research agreement:
The University of Melbourne

Research contract:
University of Peradeniya;
Université Joseph KI-ZERBO (UJKZ)

Sampling scheme

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Sample type	sample number				number of colonies selected per sample [d]	
	farm size [a]	small	medium	large	non-selective	selective
Swab		30-50			[1-5] depend on whether plan to pool	1-5
Boots sample [b]		1	3-5	6-8	10-20	3
Wastewater		1-2			20	3-5
Drinking water		2-5			5-10	3
Feed		1 sample/tonne			5-10 [for comments]	3
Bioaerosol [c]		1	2-3	3-4	10-20	all [no more than 5 per stage]

Current laboratory activity– Bioaerosol sampling

Literature review – Bioaerosol sampling

Air samplers

- **Impactor:**
  These devices draw air through stages with progressively smaller orifices, causing particles to impact onto collection plates. This inertia-based mechanism allows for size-based segregation, enabling a detailed analysis of particle size distribution

Literature review – Bioaerosol sampling

Filter-based Samplers

- By drawing air through various filter materials, such as gelatin, glass, or specialized microfibers, these samplers trap a wide range of airborne particles.

- The choice of filter material is crucial as it directly impacts the downstream analyses.

Photo from: https://www.skcltd.com/products2/impingers.html

Literature review – Bioaerosol sampling

Impinger Samplers:

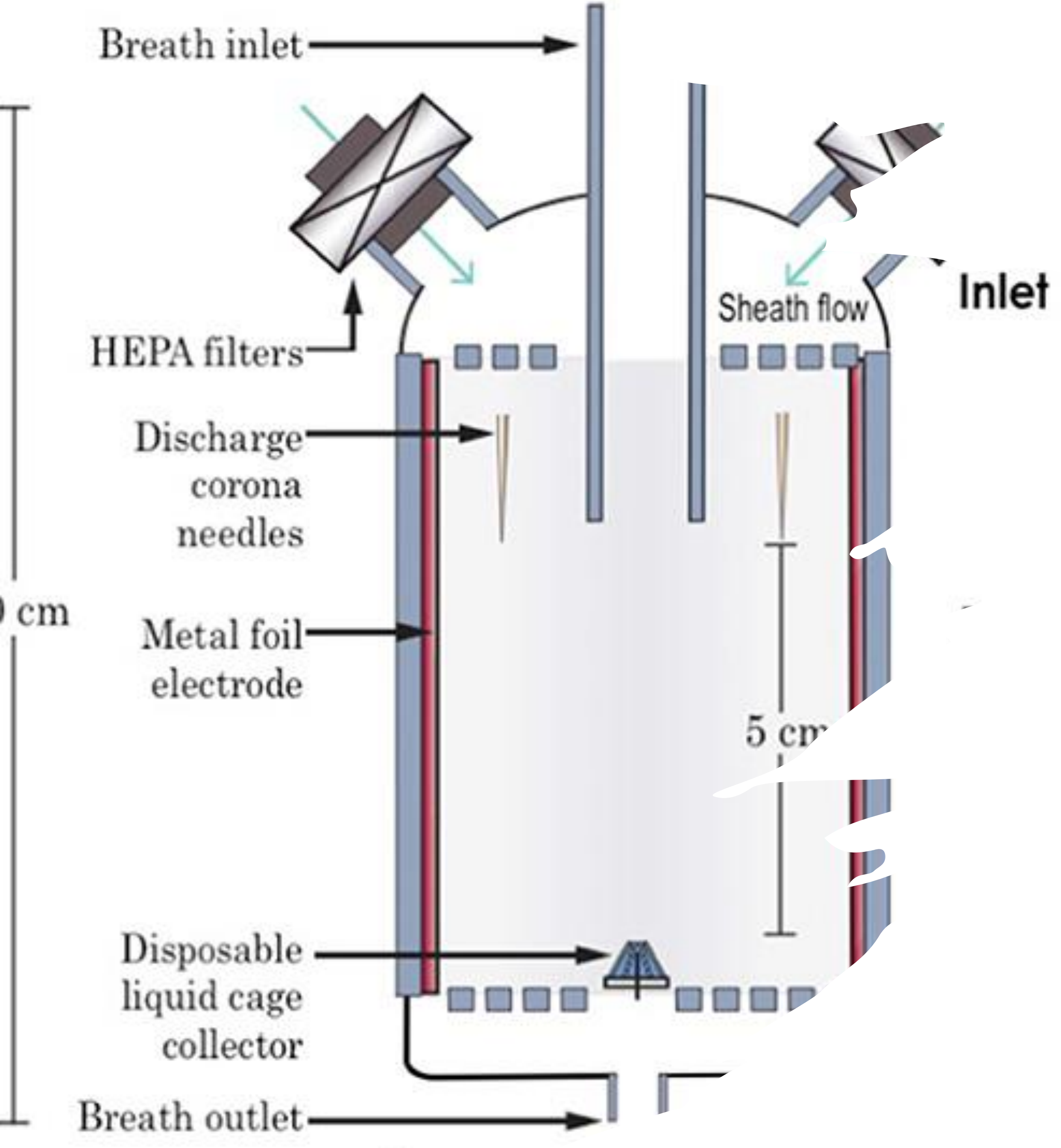
- Impinger samplers operate by drawing air through a liquid medium, where airborne particles are trapped and absorbed.
- The trapping of particles through impaction and inertia within the liquid medium makes these samplers particularly suitable for studies requiring live microbial cultures or DNA extraction.

Literature review – Bioaerosol sampling

Cyclonic Samplers:

- cyclonic samplers use a cyclone or centrifugal force to separate particles from the air based on size and mass, collecting them dryly, usually in a separate container at the bottom of the sampler.
- This ability to operate effectively under various environmental conditions, especially in low-concentration scenarios and targeted analysis.

Photo from Bertin Technologies SAS



Literature review – Bioaerosol sampling

Electrostatic precipitators:

- These samplers operates on the principle of electrostatic attraction, where particles in the air are charged and then attracted to a grounded or oppositely charged surface
- Electrostatic precipitators are particularly effective in collecting a wide range of particle sizes, including very fine particles.

Ladhani, L., Pardon, G., Moons, P., Goossens, H., & van der Wijngaart, W. (2020). Electrostatic Sampling of Patient Breath for Pathogen Detection: A Pilot Study. Frontiers in Mechanical Engineering, 6. https://doi.org/10.3389/fmech.2020.00040

Some key considerations

1. Sampler Efficiency

2. Sampling volume

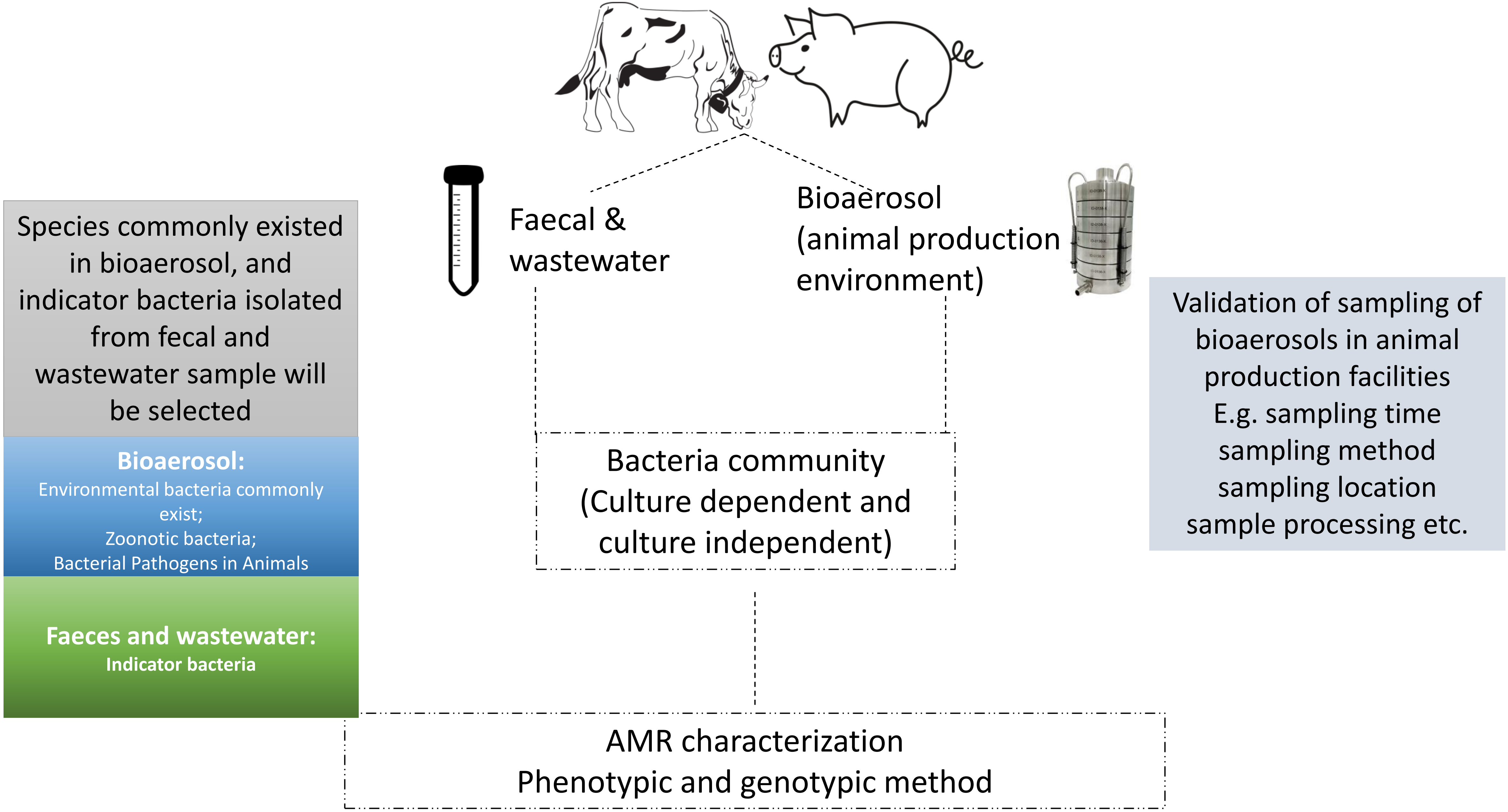
3. Environmental Factors

4. Sample Handling and Processing: a) Culture-based analysis; b) DNA-based analysis

On-going research activities at APHL

- Objective 1: Evaluate the effectiveness of air sampling techniques in assessing AMR dynamics at the human-animal-environment interface, with a goal of understanding transmission pathways and identifying potential intervention points.

- Objective 2:Investigate the patterns of Antimicrobial Resistance (AMR) within animal production settings to gain insights into its distribution, and contributing factors.


Faecal &
wastewater
Bioaerosol
(animal production
environment)
Species commonly existed in bioaerosol, and indicator bacteria isolated from fecal and wastewater sample will be selected
Bioaerosol:
Environmental bacteria commonly exist;
Zoonotic bacteria;
Bacterial Pathogens in Animals
Faeces and wastewater:
Indicator bacteria
Bacteria community
(Culture dependent and
culture independent)
Validation of sampling of bioaerosols in animal production facilities
E.g. sampling time
sampling method
sampling location
sample processing etc.
AMR characterization
Phenotypic and genotypic method

Sample type	Analytical method
Six-stage air sampler	Non-selective and selective culture plus whole genome sequencing
Filter-based air sampler	16s amplicon sequencing and short-gun metagenomic sequencing
Faecal and wastewater sample	Selective culture plus whole genome sequencing and short-gun metagenomic sequencing

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Thank you

For more information about the CRP

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