One Life

TACKLING ANTIMICROBIAL RESISTANCE IN FOOD PRODUCING ENVIRONMENTS

Summary

Antimicrobial resistance (AMR) is major public health threat globally. The role of natural and food-producing environments in the emergence, selection, dissemination and ultimately transmission of AMR has received much less attention than the direct selection and transmission within and between humans and animals. However, the need to tackle the AMR problem within the One Health approach has been internationally acknowledged and is included in the EU AMR Action plans. Future changes in food production to comply with the EU Green Deal/Farm to Fork Strategy, climate change and other socioeconomic factors will have an impact on the role played by the food-producing environments on the emergence and transmission of AMR. There are large data gaps in the magnitude and direction of these effects. In this session, we aim to discuss the potential consequences that those changes could have on the emergence and spread of AMR through food-producing environments and how this could be considered for future AMR risk management. This will be achieved by: (1) providing a general overview on current AMR issues of public health relevance linked to the food-producing environment and how the EU Health-related agencies are supporting European efforts; (2) exploring how new agricultural practices and climate change may influence AMR linked to environmental sources in different food producing systems; (3) identifying areas/gaps needed to be addressed for better preparedness; (4) discussing possibilities to improve the sharing of data and expertise, breaking regulatory silos to ensure a more holistic One Health approach; and (5) making recommendations for future action.

Vision

Future changes in food production in response to the European Commission's Farm to Fork strategy, climate change and/or other socioeconomic factors will have an impact on the role played by food-producing environments on the emergence and transmission of antimicrobial resistance (AMR). However, there are several data gaps concerning the magnitude and impact (improving or worsening) of these effects on AMR. Considering that the environment is one of the pillars of 'One Health' AMR risk assessments, early identification of future challenges and possible solutions will contribute to the success of the European Green Deal.

Organiser Co-organisers

efsa European Food Safety Authority
ecdc European Centre for Disease Prevention and Control
ECHA European Chemicals Agency
European Environment Agency
European Medicines Agency Science Medicines Health
European Commission Joint Research Centre

Background – Challenges and opportunities

AMR is currently a major global health threat as recognised by international organisations such as World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE) [1], with hundreds of thousands of human deaths estimated annually worldwide, including around 33,000 annual fatalities in the EU alone [2]. Policy makers across the globe are taking action against AMR. In 2011, the European Commission (EC) published its first Action Plan [3], which covers the period 2011-2016, targeting the increasing threat from AMR [4]. It identified seven priority areas for action. One of these priority actions is to contain and limit the possible spread of AMR via the wider environment. The evaluation of the 2011 EC action plan [5] highlighted the need to improve scientific understanding of the role played by the environment in the emergence and transmission of resistance through animal, human and manufacturing waste in water and soil, and to explore necessary actions to reduce the spread of AMR. In 2017, the EC launched its second European One Health Action Plan against AMR [6] covering the period 2017–2022. This plan included specific actions to promote the EU as a 'best practice region' and included addressing the role of the environment and closing knowledge gaps on the spread of AMR in the environment. Both EC action plans integrated 'One Health' (human, animal and environment) considerations to address the threat of AMR in a holistic and transdisciplinary manner.

In general, the role of natural and food-producing environments in the emergence, selection, dissemination and ultimately transmission of AMR has received much less attention than selection and transmission of AMR within and between human and animal populations, with most reports and policy documents focussing on the clinical perspective. Human and animal waste can introduce antimicrobial resistant bacteria (ARB) and antimicrobials into the environment, and more specifically into the food-producing environment, where selection for AMR may occur with some evidence of onward transmission to humans, animals and the wider environment. One of the main drivers of AMR is the use of antimicrobials (AMU) in humans and in animals (EMA and EFSA, 2017). The prevalence and diversity of AMR in livestock-associated bacteria are a function of the nature and magnitude of AMU in food-producing animals and of husbandry/biosecurity practices. The selection pressure of AMU in the food-producing environments depends on the concentrations of antimicrobials in faecal waste, the fate of antimicrobials in the environment and/or process components from environmental sources entering food production systems (e.g., water contaminated with antimicrobials). Manure or organic wastes of human or animal origin via surface water, and potentially wastewater used for irrigation, are

also sources of AMR. Antimicrobials also have the potential to disseminate antimicrobial residues and ARB to the environment and contaminate food (vegetables, fish, meat). Climate change and its associated environmental effects such as flooding will accelerate the spread of AMR in difficult to control scenarios. The European Green Deal [7]/Farm to Fork Strategy [8] highlight risks associated with AMR, and it is clear that there is a need for greater consideration of antimicrobial resistance (AMR) in a 'One Health' and 'Farm to Fork' context. The effect on AMR linked to food-producing environments, future changes in production linked to changes in the use of antimicrobials and heavy metal used for food animals, climate change, expansion of production and food/feed exports from third countries, ongoing agricultural intensification, use of more environmentally "friendly" agriculture practices (biopesticides, biofertilisers, reclaimed water for irrigation, etc.), increasingly widespread consumption of meat-free alternative foods, etc. are unknown. It is a complex challenge with multiple interrelated drivers, data gaps, and targeted surveillance studies are needed to close current data gaps regarding the control of AMR spread. Opportunities are linked to the correct implementation of regulations. EFSA has worked in close collaboration with EMA, EEA and ECDC, on a BIOHAZ Panel self-task on "the role of the food-producing environment in the emergence and transfer of AMR" (EFSA BIOHAZ Panel, 2021[9]), where the sources and transmission pathways, the bacteria and AMR genes of public health relevance and mitigation measures for different food-production sectors have been reviewed. Several data gaps and "hot topics" that need further research as well as recommendations to fulfil these gaps have been identified and will serve as a basis for the AMR Session

Scope and objectives

The aim of the session is to provide a platform to discuss from the public health perspective the potential consequences that changes triggered by the Green Deal/Farm to Fork targets, climate change, etc. could have on the emergence and spread of AMR through food-producing environments, as well as how this should be considered in future EU AMR risk assessments and One Health Action Plans against AMR.

The specific objectives are:

- To provide a general overview of current AMR issues of public health relevance that could be linked to the food-producing environment and explore how the EU's health-related Agencies are addressing/supporting the European efforts.

- To explore how new agricultural practices and climate change may influence AMR linked to environmental sources in different food producing systems including plant-based agriculture, terrestrial animals/food producing animals, and aquaculture (e.g., reclaimed water, fertilizers, sustainable aquaculture, reduction of antimicrobials, water pollution, feed).
- To identify areas/gaps needed to be improved/addressed for better preparedness. This includes discussion on the suitability of the current regulatory context and scientific developments to detect/prevent emerging AMR issues (e.g., new data requirements/uniform principles for biopesticides, use of new technologies for AMR assessments, the need for specific target surveillance).
- To discuss possibilities to improve the sharing of data and expertise across different regulatory areas relevant to the food producing environment to ensure a more holistic One Health approach.
- To make recommendations for future actions and their implementation in the next generation of AMR risk assessments.

[1] http://www.who.int/foodsafety/areas_work/antimicrobial-resistance/tripartite/en
[2] https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(18)30605-4/fulltext
[3] http://ec.europa.eu/health/amr/sites/amr/files/amr_final-report_2016_rand.pdf
[4] http://ec.europa.eu/health/amr/sites/amr/files/communication_amr_2011_748_en.pdf
[5] http://ec.europa.eu/health/amr/sites/amr/files/amr_final-report_2016_rand.pdf
[6] https://ec.europa.eu/health/amr/sites/amr/files/amr_action_plan_2017_en.pdf
[7] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[8] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_en
[9] https://www.efsa.europa.eu/en/efsajournal/pub/6651

People behind the session

Session Coordinator: Beatriz Guerra (EFSA)
Chairpersons: Ernesto Liébana Criado, European Food Safety Authority (EFSA); Dominique Monnet, European Centre for Disease Prevention and Control (ECDC);; Barbara Freischem, European Medicines Agency (EMA); Caroline Whalley, European Environment Agency (EEA); Lieve Herman, Institute for Agricultural, Fisheries and

Food Research (ILVO); Beatriz Guerra Roman, European Food Safety Authority (EFSA)
Rapporteurs: Matteo Lorenzo Innocenti, European Food Safety Authority (EFSA); Zoltan Kunsagi, European Medicines Agency (EMA); Renata Leuschner, European Food Safety Authority (EFSA); John Threlfall, Retired

ONE Life – Session affiliate profiles

TACKLING ANTIMICROBIAL RESISTANCE IN FOOD PRODUCING ENVIRONMENTS

Matteo Lorenzo Innocenti, European Food Safety Authority (EFSA)

Rapporteur

Matteo Innocenti is a EFSA's scientific officer in the new EFSA Unit FEEDCO. Matteo studied Animal Science in the Faculty of Veterinary Medicine of the University of Milan, where he obtained his PhD in Animal Nutrition and Food Safety. His research was focused on animal nutrition, with a specific attention on ruminants. During the PhD he joined as fellow student the Animal Science laboratory of the University of Arizona. After the PhD he worked as a postdoc in the University of Milan, leading research projects on development of innovative nutrition strategies for several animal species. Matteo joined EFSA in 2008. Since then, he was the scientific officer responsible for several Working Groups of the FEEDAP Panel, dealing with the assessment of the safety and the efficacy of different categories of feed additives. He was also contributing to the development of the FEEDA Panel guidance documents. Matteo was also collaborating with other EFSA's Units and Panels on matters related to animal dietary exposure.

Renata Leuschner, European Food Safety Authority (EFSA)

Rapporteur

Renata Leuschner works as scientific officer in EFSA's PLANT Unit, where she performs pesticide residue risk assessments in support of maximum residue level (MRL) setting and the pesticide peer review process. She has been working at EFSA for over 12 years performing microbiological, chemical, animal welfare and consumer risk assessments. She previously worked at the European Commission Joint Research Centre in the European Union Reference Laboratory for Feed Additives in Belgium and at the Unilever Research Centre in Colworth, UK. She was awarded a EU Marie Curie Fellowship and started her career as a post-doctoral scientist at the National Food Biotechnology Centre of the University College Cork in Ireland. She has contributed to a large number of presentations at conferences and workshops. She graduated from Hohenheim University in Germany where she obtained a degree in food science and technology and a PhD in food microbiology.

Recently, she completed a M.Sc. in toxicology at the Medical University of Vienna and she is a Registered European Toxicologist (ERT).

Beatriz Guerra Roman, European Food Safety Authority (EFSA)

Chair/Co-chair

Beatriz Guerra is EFSA's Lead Expert on Molecular Epidemiology and Senior Scientific Officer at the new EFSA Unit BIOHAW. She is a molecular biologist, working in the areas of antimicrobial resistance and molecular epidemiology of foodborne microorganisms for more than 20 years. She is also involved on activities related to the use of OMICs for risk assessment. She studied Biology at the University of Oviedo, Spain, where she also carried out her PhD. She worked as a postdoc at this University, and combined this period with some stages in German Institutions. In 2001, she moved to Germany and joint the Federal Institute for Risk Assessment (BfR, Berlin) where she worked over 14 years, first at the National Reference Laboratory for Salmonella (NRL-Salm), and then at the NRL for Antimicrobial Resistance (NRL-AR), where she was in charge of the Mol. Bio. Group. She joint EFSA in 2015, where she has been in charge of the development of several scientific opinions and reports related to antimicrobial resistance. She has published more than 200 scientific publications and participated at several conferences as invited speaker. She is the coordinator of the AMR in the food-producing environments session.

Caroline Whalley, European Environment Agency (EEA)

Chair/Co-chair

Caroline works at the European Environment Agency on chemicals in water, focusing particularly on the EU Urban Waste Water Treatment Directive and on chemicals under the Water Framework Directive. She's very interested in the importance, responsibilities and opportunities of treating our sewage to protect human health and the environment. Prior to working at the EEA, Caroline worked in water and marine policy at the Department of Environment, Food and Rural Affairs (Defra), leading in policy areas such as Priority Substances, water efficiency, climate change risk and adaptation. Her interest in AMR came out of research undertaken by the UK water industry as part of its efforts towards meeting water quality standards downstream of urban waste-water treatment plants. She studied Environmental Science at Plymouth (UK), before working at the Water Research Centre and then doing her PhD in Environmental Chemistry at the University of East Anglia. She began her post-doctoral career as a marine chemist at CEFAS in the UK.

Domenico Deserio, European Commission

Speaker

Domenico Deserio is a Policy Officer in the Directorate General for Health and Food Safety of the European Commission (DG SANTE). He is responsible for policies related to micro-organisms used as active substances in plant protection products. Within the EU Biopesticide Working Group, he has worked on the amendment of Regulations concerning data requirements and uniform principles for the assessment of microbiological active substances and plant protection products. He has worked as a Scientific Officer at the European Food Safety Authority (EFSA) in the area of biological hazard, by performing investigations on foodborne outbreaks and zoonoses caused by several pathogenic microorganisms (e.g. Salmonella, Listeria). He holds a Master of Biotechnology from the University of Bari (Italy), and completed his thesis on food microbiology. Moreover, he achieved an advanced post graduate Master by Research of Agricultural Science at the University of Adelaide (Australia), carrying out his research on plant genomics and plant pathology.

Title of talk: Regulation- AMR EC Requirements for micro-organisms used as active substances in Plant protection products

Abstract of talk:

The European Commission (EC) 'Farm to Fork Strategy' aims at reducing dependency on and use of chemical plant protection products, including through facilitating the placing on the market of biological active substances, especially micro-organisms that can also be used in organic farming. As of today, more than 65 micro-organisms are approved in the EU for use in biological plant protection products, and statistics show that this trend is increasing.

The current EU regulations concerning data requirements and principles for assessment of micro-organisms entered into force in 2011 and 2013. Since then, scientific and technical knowledge has evolved significantly on how to perform risk assessments on micro-organisms, especially on new threats which have worsened in the last years, such as the capacity of micro-organisms to transfer antimicrobial resistance (AMR) genes.

Taking into consideration the need to facilitate access to the biological substance market, it was deemed necessary to amend the current EU regulations, taking into account the most up-to-date scientific and technical knowledge which has evolved significantly.

Since 2019, the EC and the experts of the EU Biopesticide Working Group have been

working on the amendment of the existing regulations, in order to make the new regulations more fit-for-purpose, with the biological and ecological properties of the micro-organisms considered as a cornerstone of the assessment. This amendment was complemented by the development of guidance documents (i.e. SANCO/2020/12258 and SANTE/2020/12260) supporting the provision and the assessment of data concerning AMR.
On the one hand, this approach is reducing the burden of data-generation for bringing biological pesticides to the market (e.g. by reducing the need for animal studies); on the other hand, it introduces clear requirements and assessment principles on the capacity of micro-organisms to transfer AMR genes. In particular, micro-organisms carrying known, functional and transferrable genes encoding for resistance to relevant antimicrobial agents would not be approved for this use.
The relevant Commission regulations, amending Regulation (EU) No 283/2013, Regulation (EU) No 284/2013, Regulation (EU) No 546/2011, and Annex II to Regulation (EC) No 1107/2009, have been endorsed by the Member States on 8 February 2022. After the European Parliament and the Council have concluded their scrutiny, they are planned to enter into force in November 2022.

Dominique Monnet, European Centre for Disease Prevention and Control (ECDC)
Chair/Co-chair

Dominique L. Monnet joined ECDC in October 2007 to lead ECDC's Disease Programme on Antimicrobial Resistance and Healthcare-Associated Infections. He is also representing ECDC in the EU-US Transatlantic Task Force on Antimicrobial Resistance (TATFAR). Before joining ECDC, he worked in French hospitals, at the US Centers for Disease Control and Prevention (1993-1995) and at the Danish Statens Serum Institut (1997-2007) where he was coordinating surveillance of antimicrobial resistance and antimicrobial consumption in humans in Denmark. His research interests include surveillance of antimicrobial resistance and antimicrobial consumption, the relationship between consumption of antimicrobials and resistance, and the factors that affect antimicrobial usage, both in hospitals and in primary care.

Barbara Freischem, European Medicines Agency (EMA)
Chair/Co-chair

Barbara Freischem is the Head of the Department 'Surveillance and Regulatory Support' in the Veterinary Division of the European Medicines Agency. Her responsibilities include regulatory support to the Division, pharmacovigilance

activities for veterinary medicines, and, a key point in the context of this conference, the monitoring of sales data for veterinary antimicrobials and the implementation of use data reporting for antimicrobials used in animals.
Her focus during the past two years, apart from ensuring the continuity of core business for veterinary medicines, has been the implementation of the legal requirements of Regulation (EU) 2019/6, which entered into application on 28 January 2022, with a focus on the strengthened requirements for use of antimicrobials in animals, and the Union Product Database.
Before rejoining the EMA in 2019, Barbara worked in different roles linked to regulation of mostly veterinary medicines at national, European and international level, both on the side of regulatory agencies and on the side of industry.
Barbara has a degree in Veterinary Medicine from the Free University of Berlin.

Lieve Herman, Institute for Agricultural, Fisheries and Food Research (ILVO)
Chair/Co-chair

Lieve Herman is head of the Unit Technology and Food Science at Flanders Research Institute for Agriculture, Fisheries and Food (ILVO). Lieve has a PhD (University of Ghent) in molecular plant genetics. She has postdoc experience in molecular food microbiology, especially concerning microbiological food safety including antimicrobial resistance and the molecular mechanisms behind, genetically modified microorganism used in the agri-food chain and risk assessment in food safety. She carries also the responsibility for the development of the Food Pilot program, a living lab to support the co-creative process with stakeholders in the agri-food column to support food innovation. She is member of the European Food Safety Agency (EFSA) BIOHAZ panel, chair of the working group on the Qualified Assumption of Safety (QPS) of microorganisms and of several working groups of EFSA dealing with molecular microbiological safety assessment. She is president of the Scientific Committee of the Belgian Food Safety Agency.

Luisa Peixe, University of Porto
Speaker

Luisa Peixe graduated from the University of Porto, Portugal, in Pharmaceutical Sciences and obtained a doctorate in Microbiology. During her career as a Professor of Bacteriology at the Faculty of Pharmacy of the University of Porto (FFUP) (1987-present) her research has focused on antimicrobial resistance in different clinically relevant bacteria. She has worked under the One Health approach to understand its ecology, drivers, evolution, as well as contributing to improving its detection and

control. With the effectiveness of standard antimicrobial treatments for urinary tract infections vastly diminished, the role of the urinary microbiome in urinary tract health and diseases is a recent additional topic investigated by her research team. Currently, she is Director of Department of Biological Sciences of FFUP and has published more than 200 publications in international peer-reviewed journals. She holds several positions in national and international institutions related to her expertise in clinical bacteriology and antimicrobial resistance, including the European Food Safety Authority's (EFSA) Biological Hazards Panel, EFSA's Qualitative Presumption of Safety working group and the Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) scientific board.

Title of talk: AMR in food-producing environments

Abstract of talk:

In the last years, increasing attention has been given to the role of the environment as a source of antimicrobial-resistant bacteria (ARB)/genes (ARG) for both humans and animals, and to the need to tackle antimicrobial resistance (AMR) from a One Health perspective. The need to improve scientific understanding of the role of food-producing environments in the emergence and transmission of resistance and to explore actions that may be required to reduce associated risks for public health has been highlighted in the EC AMR actions plans. In this session, information gathered in a recently published EFSA Scientific opinion on the role of food-producing environments in the emergence and spread of AMR in EU plant-based food production, terrestrial animals and aquaculture will be presented. Scientific evidence available on the ARB/ARG environmental sources leading to the contamination of food and the routes through which they can be transmitted throughout the food chain were explored. Among those, fertilisers of faecal origin, irrigation and surface water were identified as major sources and transmission routes of contamination for plant-based food. For terrestrial animals, limited evidence points to feed and, to a lesser extent, humans, as important sources/transmission routes. For aquaculture, water is the main transmission route. The ARB and ARG considered to be of highest public health priority were identified and their occurrence in different environmental sources was described. Moreover, general (e.g. antimicrobial use) and specific factors inherent to those bacteria (e.g. biofilm formation) contributing to their occurrence and persistence were assessed. Additionally, the strategies and options to mitigate ARB/ARG (generic and AMR specific interventions) threats were explored. Overall, a large number of data gaps in relation to the ARB/ARGs sources, transmission routes and diversity, as well as effectiveness of many mitigation measures were identified. Recommendations for further research include the need

for One Health-based integrated studies and harmonised environmental AMR monitoring/surveillance strategies. Validating the efficacy of practical mitigation methods was also recommended. These studies should be linked to an assessment of the effect of future policy developments (e.g. within the EU Green Deal) namely affecting food-producing environments, future changes in agri-food systems and climate change impacts.

Robert Skov, Statens Serum Institut
Speaker

Robert is a medical doctor from University of Copenhagen (1987) and a specialist in clinical microbiology (2003). He has been working on antimicrobial resistance throughout his career and has more than 20 years' experience as a Public Health microbiologist. He has served as Danish AMR focal point at ECDC, member of the EUCAST and the CAESAR steering committees, member of the ad hoc EMA Expert Groups (AMEG), for Updated opinion on the use of colistin products in animals within the European Union and Advice on the designation of antimicrobials or groups of antimicrobials reserved for treatment of certain infections in humans. He further served as member of Danish and international expert groups on AMR including on One Health cross sectorial committees. His research interest has mainly focused on S. aureus inclusive MRSA epidemiology and antimicrobial resistance especially phenotypic susceptibility testing. Since 2019 he is the scientific lead of the International Centre for Antimicrobial resistance Solutions (ICARS). ICARS works on developing context-specific and cost-effective AMR solutions in low and middle income countries across the One health spectrum.

Title of talk: One-health AMR issues from a public health perspective

Abstract of talk:
The most comprehensive study of the global burden of antimicrobial resistance (AMR) in humans recently estimated that, in 2019, a median 1.3 million [95% CI: 0.9–1.7 million] deaths were directly attributable to AMR for 88 pathogen-drug combinations, affecting all continents (Murray CJL, et al. The Lancet, 2022). Antimicrobial-resistant bacteria can originate in animals, plants or the environment from where they are transmitted to humans; just as antimicrobial-resistant bacteria originating in humans can transmit the other way to animals. Furthermore, as humans, animals, crops and foodstuffs are transported across the globe, AMR respects no borders or sectors, and needs to be viewed and handled in a one-health perspective. In its 2021 report on the spread of AMR through food-producing

environments, the EFSA Panel on Biological Hazards (BIOHAZ) confirmed that several of the most critical AMR genes found in bacteria causing infections with severe public health consequences, were also present in food-producing environments and could spread across the sectors, both directly and via food and water. These included carbapenemase and ESBL genes, as well as fluoroquinolone and methicillin resistance genes.
Although AMR originates as part of natural processes, use of antimicrobials as well as of other substances causing co-selection, is the major factor that drives the occurrence and persistence of AMR. There are, however, considerable knowledge gaps on the relative contribution of each individual driver, and this is often used as an excuse for not taking sufficient action. Prudent use of antimicrobials – in all sectors – is fundamental to slowing the emergence and selection of AMR. Each sector should take part in this effort. Limiting the spread of antimicrobial-resistant microorganisms is also key to mitigate AMR and includes general measures such as good hygienic and biosecurity practices. This is especially important in settings where antimicrobials are frequently used, including hospitals and large animal production facilities. However, the lack of understanding of the contribution of individual factors seriously hinders prioritisation of actions and there is an urgent need to better understand the cross-sector components and drivers of AMR to combat AMR most effectively.

Junxia Song, Food and Agriculture Organization of the United Nations (FAO)
Speaker

Ms. Junxia Song has extensive experience preventing and controlling zoonotic diseases, transboundary animal diseases (TADs), and antimicrobial resistance (AMR). Currently, she works at the Joint FAO/WHO center (zoonotic disease and AMR). She is FAO AMR focal point and unit head, leading the development and implementation of FAO action plan on AMR, coordinating AMR activities with internal and external partners, significantly contributing to AMR tripartite and UNEP collaboration. She also coordinates the endemic zoonotic disease (Rabies, brucellosis, and Zoonotic TB) in the center. Ms. Junxia Song, a national from China, got Ph.D. in veterinary medicine from China Agricultural University. She used to work in the Ministry of Agriculture and Rural Affairs, P.R.China, for 22 years. From January to August 2018, Ms. Song was the team leader of the transboundary animal disease program in the FAO China office. In September 2018, Ms. Song joined FAO RAP as the Great Mekong Sub-region (GMS) partnership coordinator, coordinating TADs control in GMS. She joined FAO HQ in January 2020.

Title of talk: Future changes on agri-food systems and AMR

Abstract of talk:
Antimicrobial resistance (AMR) is a global crisis that threatens the livelihood and health of humans, animals, plants and the environment. Misuse and overuse of antimicrobials are among the main drivers for the development of antimicrobial resistance (AMR), further threatening disease treatments for humans, animals and crops. Studies have estimated that more than 70% of all antimicrobials sold are used in animals raised for food.

Agrifood systems are facing an all times challenge as the global demand for food is rapidly rising, estimated to increase more than 70% by 2050 (FAO, 2009). To adapt to the various complex ecological, economic, social and environmental challenges, agri-food systems will need to constantly adjust and improve in terms of production system, management methods, and sales practices. One of the main subjects related to these challenges and changes are the control of emerging health threats, including emerging diseases, parasites, plant pests and AMR.

As a direct consequence, intensification of animal and crop production is going up, thereby driving an overall increase in the use of antimicrobials. However, AMR prevention and control in agri-food systems is complex, involving a wide variety of terrestrial and aquatic animal species, different plant/crop types of production, diverse production environments, and the need to cover the whole food chain from primary production to consumption.

It is essential to apply good agriculture production practices and management, antimicrobial stewardship, vaccination programmes, and alternatives to antimicrobials to reduce the need for their use in agri-food systems, while strengthening surveillance, awareness raising and governance.

Werner Ruppitsch, Austrian Agency for Health and Food Safety (AGES)
Speaker

Dr. W. Ruppitsch received his PhD at the Free University Berlin. His work contributed to the identification of defective genes in the hereditary disease Fanconi anemia. As a scientist at AGES, he developed and established diverse methods for the identification, characterization and surveillance of diverse pathogens to support outbreak investigation and public health actions. In 2014, he received the venia

docendi from the University of Natural Resources and Life Sciences, Vienna. He has mentored several diploma and PhD students, PostDocs of the Austrian OEAD program and fellows in the ECDC Public health microbiology fellowship program. His students have been awarded with prizes from diverse Austrian societies and ESCMID. He has implemented and established whole genome sequencing (WGS) at AGES and developed the first whole genome sequence-based typing scheme for Listeria monocytogenes that is in use by many institutions world-wide. Since 2019 he has been in charge of all whole genome sequencing activities at AGES. Dr. W. Ruppitsch is author and coauthor of more than 100 articles in peer-reviewed journals. He is currently leader of the H2020 OHEJP project FED-AMR and the ECDC HERA-WGS project. He is an invited expert of the German MiGenomSurv project of the Robert-Koch-Institute (RKI) and the Federal Institute of Risk Assessment (BfR), with the aim to establish a German-Austrian WGS-database for surveillance of diverse pathogens.

Title of talk: FED-AMR: The role of free extracellular DNA in dissemination of antimicrobial resistance over ecosystem boundaries along the food/feed chain (One Health EJP)

Abstract of talk:
In the past decades antimicrobial resistance (AMR) has emerged as a major health threat. The FED-AMR project ('The role of free extracellular DNA in dissemination of antimicrobial resistance over ecosystem boundaries along the food/feed chain') as part of the One Health European Joint Programme (OHEJP) investigates the relevance of free extracellular (ex)DNA as a source of antimicrobial resistance (AMR) via bacterial transformation in agricultural soils and along the food/feed chain by investigating microbial communities, clinically relevant bacteria, contaminants and antimicrobial resistance genes (ARGs) in diverse interconnected ecological compartments across European countries. Results of FED-AMR will contribute to improve preparedness, to develop strategies and a faster response to AMR threats. Five-hundred and eleven samples were collected over a one year crop growing season from 11 different ecological compartments (pig faeces and manure, fertiliser, soil, crops, feed, surface water, waste water, wildlife, farmers) in Open Air Laboratories (OALs) and other agricultural areas, and exDNA extracted. Samples were analysed for microbial diversity using 16S rRNA amplicon sequencing, for ARGs using a gene-enrichment sequencing approach, for the presence of clinically relevant resistant bacteria, including C. difficile, and for the presence of contaminants that might drive AMR, i.e. antibiotics, pesticides and heavy metals. Environmental conditions modulating transformation frequencies in soil microcosms and an in vitro

porcine gut model are being studied. Preliminary results show a high ARG variability between different countries, different farms and between different compartments. The lowest number of ARG were detected in river water and crops and the highest numbers in wildlife, wastewater sludge and animal feeds. Final analysis of all collected samples by country, compartment and collection date (to account for seasonal variations) will provide new and detailed information about the role of exDNA as an AMR source, about antimicrobial, microbial- and ARG diversity, and about interactions and factors influencing emergence and spread of AMR and resistant microorganisms in an agricultural environment. The findings will be analysed and critically scrutinised in the light of a systematic evidence map and mechanistic models currently conducted to identify critical control points for intervention and reduction of AMR spread and public health risks.

Despo Fatta-Kassinos, University of Cyprus

Speaker and panellist

Dr. Despo Fatta-Kassinos is a Professor in the Department of Civil and Environmental Engineering of the University of Cyprus. Her research expertise includes water and wastewater treatment and reuse; contaminants of emerging concern; advanced chemical oxidation processes; advanced biological treatment; identification of microcontaminants in environmental matrices; assessment of the biological potency of microcontaminants and wastewater flows through the application of bioassays; antibiotic resistance in the aquatic environment; uptake of microcontaminants by crops during wastewater reuse. She is a Highly Cited Researcher since 2018 (Web of Science, Clarivate Analytics). She was the founding leader of the WG5 'Wastewater reuse' of NORMAN Association (2013-2019) and a founding member of the International Ph.D. School on Advanced Oxidation Processes and member of its Scientific and Management Committee. She was the Chair of the Scientific and Technological Advisory Board of the European JPI 'Water Challenges for a Changing World' for the years 2015-2019, the Chair of the COST Action NEREUS ES1403 (2014-2018) and the Coordinator of the H2020-MSCA-ITN-2015/675530/ANSWER project (2015-2019). She is Chair of the Advisory Board of the African Center of Excellence in Water and Environment Research in Nigeria. She is a member of the core group of the Global Panel on Chemical Pollution of the Environment (GPCPE), an initiative of the French National Water Academy.

Title of talk: The need for reclaimed water reuse for irrigation: Current challenges & ongoing developments

Abstract of talk:
Climate change has been widely recognised during recent decades, and water availability and management issues are of particular importance around the world. Agriculture is likely to come under serious threat due to water scarcity, as it is a major consumer of water. To address this challenge, reclaimed water reuse is a strategy that is gaining wide acceptance and is growing rapidly.
In this framework, there is a need to look beyond conventional contaminants when assessing the potential risks of wastewater discharge and reclaimed water reuse with respect to ecosystems and human health. This is now recognised as an important issue in all policy areas at EU level and beyond. The possible implications of contaminants of emerging concern (CECs) such as pharmaceuticals, as well as their transformation products, during reuse need to be understood. The mechanisms associated with the uptake of CECs by crops has been the focus of various studies in recent years. The extent of the uptake is mainly determined by both biotic (e.g., plants' genotype/physiology, soil fauna) and abiotic factors such as temperature, wind speed, UV radiation, salinity, drought, and environmental pollution. The physicochemical properties of CECs and soil composition constitute the main abiotic factors that influence the potential for uptake. Most studies have been conducted in controlled laboratory or greenhouse conditions, or under field or simulated conditions, and used mainly vegetables, cereals and fodder crops. The results of experiments carried out revealed that the potential for CEC uptake decreases in the order of leafy vegetables, root vegetables, cereals and fodder crops and fruit vegetables. However, the uptake of CECs by important crop plants such as fruit trees has not yet been evaluated.
To summarise, there are several knowledge gaps related to the potential reuse practice regarding CECs. It has become clear that new strategies consistent with the precautionary principle and the 'One Health' approach are needed to assess the overall quality of wastewater intended for reuse. Knowledge about the risks of low-dose exposure of CECs to non-target organisms, the additive/synergistic behaviour of various CECs in mixtures, crop uptake and antibiotic resistance is only now starting to emerge.

John Threlfall, Retired
Rapporteur

John Threlfall is an independent consultant microbiologist, having formally retired from the Health Protection Agency (HPA) (now UK Health Security Agency) in 2010 after almost 42 years of service in the HPA and its predecessor, the Public Health Laboratory Service (PHLS). He served as Director of the Laboratory of Enteric

Pathogens (LEP), HPA, from 2003 to 2010. From 2008 to 2010, he was Head of Research and Development in the Gastrointestinal Infections Division, HPA. From 2004 to 2008, he was Director of the EU-funded Network of Excellence, Med-Vet-Net. From 2003 to 2008, he also served as Director (Microbiology) of Enter-Net (European Network for Salmonella, VTEC and Campylobacter. He was a member of EFSA's Biological Hazards (BIOHAZ) Panel from 2009 to 2018 (including as Chair of 5 working groups focussed on various issues related to antimicrobial resistance). Since 2012, he has been a member of the EU-funded joint ECDC/EFSA/EMA Antimicrobial Resistance Expert Advisory Group (AMEG). Since 2019, he has also been a member of the Joint WHO/FAO Expert Advisory Group on Antimicrobial Drug Resistance in the Food Chain. He is an Honorary Consultant on AMR for the UK Food Standards Agency (FSA) and a member of the AMR subgroup of the UK's ACMSF. John is an author/co-author of over 350 peer-reviewed publications and over 30 book chapters on all aspects of gastrointestinal infections and AMR. He has given over 300 presentations in more than 30 countries world-wide.

Title of talk: The need for reclaimed water reuse for irrigation: Current challenges & ongoing developments

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In this framework, there is a need to look beyond conventional contaminants when assessing the potential risks of wastewater discharge and reclaimed water reuse with respect to ecosystems and human health. This is now recognised as an important issue in all policy areas at EU level and beyond. The possible implications of contaminants of emerging concern (CECs) such as pharmaceuticals, as well as their transformation products, during reuse need to be understood. The mechanisms associated with the uptake of CECs by crops has been the focus of various studies in recent years. The extent of the uptake is mainly determined by both biotic (e.g., plants' genotype/physiology, soil fauna) and abiotic factors such as temperature, wind speed, UV radiation, salinity, drought, and environmental pollution. The physicochemical properties of CECs and soil composition constitute the main abiotic factors that influence the potential for uptake. Most studies have been conducted in controlled laboratory or greenhouse conditions, or under field or simulated conditions, and used mainly vegetables, cereals and fodder crops. The

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Stineke Van Houte, University of Exeter

Speaker

Stineke van Houte obtained her PhD from Wageningen University in 2014, and is currently a Lister fellow and Associate Professor in Microbiology at the University of Exeter's Cornwall Campus. After obtaining a permanent position in 2018, she now heads a team of 10 people who study evolutionary and molecular aspects of interactions between bacteria and mobile genetic elements, such as bacteriophages and plasmids, in which they address fundamental research questions and aim to apply this knowledge to solve real-world problems. An important line of research is the development of new approaches to remove antibiotic resistance genes, based on the genome editing tool CRISPR-Cas9. Her group specifically aims to apply these approaches in ecologically relevant settings, such as the gut microbiome. Her publications (n=31; H=20) have consistently been published in top journals. She has obtained >3.5M GBP in grant funding as PI since 2018, including an ERC starting grant (2022) and is regularly invited to speak at large international conferences.

Title of talk: CRISPR-Cas as a tool to fight AMR: challenges and future prospects

Abstract of talk:
Antibiotic resistance presents one of the most pressing problems of our time, jeopardising healthcare procedures such as surgery and cancer treatments. As the pipeline of new antibiotic development is drying up, finding novel ways to eradicate antibiotic resistance is of major global importance. A highly promising strategy to combat antibiotic resistance is to remove resistance genes using CRISPR-Cas9, a genome editing tool that in its native context acts as a bacterial immune system. The great advantage of CRISPR-Cas9 based tools is that they are completely

programmable to target any gene of choice, are highly versatile and can be used in a wide range of organisms. However, to take advantage of this exciting new approach and implement it as part of the One Health approach, important challenges need to be addressed. This talk will first discuss how CRISPR-Cas9 can act as an antimicrobial tool and why these systems have such great potential. Subsequently the different modes in which CRISPR-Cas9 based tools can be used within the One Health framework will be discussed. Particular emphasis will be put on reducing the spread of antibiotic resistance from faecal microbial contamination in food producing environments, including the possibility to develop CRISPR-Cas9 based probiotics that can be added to animal feeds, or CRISPR-Cas9 based clean-up strategies of antibiotic resistance-contaminated wastewater. The talk will then address what the main challenges are that currently prevent this tool from being implemented. These include challenges around how CRISPR-Cas9 can be delivered to the target site of choice (e.g. gut microbiomes), effectiveness in antibiotic resistance removal in situ (e.g. evolution of resistance to CRISPR-Cas9 targeting). Legislative and ethical challenges around responsible governance of these new antimicrobial technologies will also be addressed. The talk will conclude by providing an outlook on the future of CRISPR-Cas based technologies in addressing the antibiotic resistance problem in the One Health Approach.

Amy Pruden , Virginia Tech
Speaker

Amy Pruden is a University Distinguished Professor at Virginia Tech, Blacksburg, USA, serving in the Department of Civil & Environmental Engineering. She received her B.S. in Biological Sciences in 1997 and her PhD in Environmental Science in 2002 from the University of Cincinnati. Dr. Pruden's research focuses on advancing means of monitoring and mitigating the spread of pathogens and antimicrobial resistance in the environment, including water, wastewater, and agricultural systems. Most recently, her team has focused on the development and standardization of methodologies for tracking antimicrobial resistance in the environment, especially next-generation DNA sequencing based metagenomic techniques. Dr. Pruden has published over 175 research articles on related topics and currently serves as a Senior Editor of the International Society for Microbial Ecology Journal. She is the recipient of the Presidential Early Career Award in Science and Engineering, the Paul L. Busch Award for Innovation in Water Research, the ReciPharm International Environmental Award, and is a fellow of the International Water Association.

Title of talk: AMR and climate change

Abstract of talk:
Antimicrobial resistance (AMR) and climate change present analogous and interrelated great challenges that humanity must tackle together on a global scale. Both have dire consequences if allowed to run their course without mitigation. The consequences of climate change have been broadly studied and communicated, including disruptions to marine, terrestrial and urban ecosystems that will directly affect human health and well-being. Likewise, human and animal health, as well as agricultural productivity, will gravely suffer if the world runs out of antibiotics to effectively treat and prevent infections. The science around AMR is coalescing, shedding light in particular on the importance of the environmental dimension, in addition to the human and animal aspects that contribute to the development and spread of resistance, locally and globally. For example, it has been confirmed that some antibiotic resistance genes (ARGs) which confer resistance to antibiotics used against clinical infections have their evolutionary origin in environmental bacteria. Increased temperatures increase the rates of microbial metabolism, leading to questions about whether this could also accelerate the rate of horizontal gene transfer and other evolutionary processes by which bacteria acquire resistance traits. Furthermore, increased intensity and frequency of storms will lead to increased flooding, which has also been identified as a mechanism of AMR dissemination. Such opportunities for dissemination via flooding or other environmental disasters are magnified in peri-urban areas with poor sanitation conditions, which could increase with higher population density caused by migration due to rising sea levels. Thus, locations that suffer the brunt of climate change could also create circumstances that increase the risk of AMR evolution and spread. There is therefore now an important need to establish understanding of the interrelatedness of AMR and climate change in order to inform effective policies for addressing both these great challenges. First and foremost, we need to identify strategies for reducing AMR spread that are broadly feasible and do not have unintended consequences, such as contributing to greenhouse gas emissions or additional harm to the environment. Here, we will discuss the interrelatedness of AMR and climate change and consider in particular what can be learned from climate change in developing effective policies for mitigating AMR spread.

Rene S. Hendriksen, Technical University of Denmark, National Food Institute (DTU)
Speaker

Dr. Rene S. Hendriksen is a professor at the Technical University of Denmark, National Food Institute, and leads the Research Group of Global Capacity Building.

He acts as director and co-director of the reference centres; World Health Organization (WHO) Collaborating Centre, Food and Agriculture Organization (FAO) Reference Center, and European Union Reference Laboratory for Antimicrobial Resistance (AMR) and Genomics, respectively.
He provides advisory service to the European Commission, European Food Safety Authority, European Centre for Disease Prevention and Control (ECDC), Fleming Fund, WHO GLASS and FAO in the area of surveillance and capacity building. In his early days, the focus was on conventional and molecular microbiology. Since 2010, he has embraced the new era of genomics with a strong focus in implementing research building global capacity for surveillance and outbreak detection. In addition, his research also focuses on global epidemiology of mainly food and waterborne pathogens. He has authored over 130 peer-reviewed published and accepted articles in international refereed journals conducted in collaboration with more than 500 scientists in over 100 countries.

Title of talk: Surveillance of AMR in food producing environments

Abstract of talk:
Humans and animals are being exposed more than ever to the emerging threat of antimicrobial resistant (AMR) bacterial pathogens. The spread and transmission of AMR has been discussed intensively and pathways and routes have been mapped showing the complexity and dynamics of the One-Health approach – now including the environment as well. The WHO, FAO, UNEP, EFSA and the EC have all emphasised the importance of addressing the risks of AMR transmission in the environment and of integrating this area in future monitoring programmes.
In the current EU legislation on the monitoring and reporting of antimicrobial resistance in zoonotic and commensal bacteria, the environmental component is not included; it focuses solely on isolates collected primarily from meat and the caecal content of food-producing animals. Similarly, also the monitoring of AMR among humans does not include the environmental compartment.
Complementary baseline surveys on AMR have been proposed by EFSA to supplement EU monitoring, integrating the AMR testing of bacteria carried out in the framework of the EU bathing water directive with an EU baseline survey on domestic shellfish products to assess environmental exposure from, for example, wastewater, testing potentially extended spectrum beta-lactamases- (ESBL) producing Escherichia coli (E. coli).
Despite intentions to include the environment in official harmonised monitoring of AMR, this has only been piloted by the tripartite study 'Tricycle' led by the WHO, FAO and OIE, which focuses on monitoring one indicator: single isolates of ESBL

producing E. coli across the human, animal and environmental sectors. The Tricycle study collects, inter alia, samples of sewage waste water of which a subset of the collected isolates from all sectors are analysed using comparative genomics by whole genome sequencing to detect AMR determinants and clonal relatedness.
The matrix of sewage waste water has also been used in other AMR surveillance attempts, using a metagenomic approach. This has also shown promising results in detecting all AMR determinants in the complex samples, and will likely be the genomic approach for the future.
To boost integration of the environment into AMR surveillance, UNEP recently joined the tripartite study to strengthen the Tricycle project. In parallel, EFSA published the role of environment in the emergence and spread of AMR through the food chain, both setting priorities and recommendations for One Health-based integrated environmental AMR surveillance strategies.

Zoltan Kunsagi, European Medicines Agency (EMA)

Speaker

Zoltan Kunsagi is Scientific Specialist in Antimicrobials Resistance at the European Medicines Agency (EMA).
Zoltan graduated as a veterinarian from the University of Veterinary Medicine of Budapest, Hungary in 1999 and holds additional master's degrees as specialist in toxicology (2003) and analytical chemist specialised in chromatography techniques (2009). Between 1999 and 2014 he worked as a laboratory analyst, a researcher and a consultant in Hungary (Central Agricultural Office), Belgium (European Commission, DG Joint Research Centre) and Saudi Arabia (Saudi Food and Drug Authority). In 2014 Zoltan joined EMA and he is now the leader of the antimicrobial resistance team in the Veterinary Medicines Division. He provides support to the Agency's CVMP Antimicrobials Working Party (AWP), the Antimicrobial Advice ad hoc Expert Group (AMEG) and is the main contributor from EMA to the Joint Interagency Antimicrobial Consumption and Resistance Analysis (JIACRA). In the last two years Zoltan's main task was related to the implementation of the Regulation (EU) 2019/6 (veterinary medicines regulation).