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Hazardous agricultural waste in Greece: Current status and future perspectives

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INTRODUCTION

Waste originating from agricultural activities have been identified worldwide as among the most hazardous and inevitable human activities producing waste:

- due to their pollutant content
- due to their spatial distribution over the cultivating areas of each region

✓ Agricultural waste may reach up to 40% of the total country waste (e.g. Poland, Latvia, Cyprus)

- Greece: 4.7 mil tn/year
- EU(28): 57.7 mil tn/year
  - Hazardous: 780.000 tn/year (2%)

Major (potentially) hazardous agricultural waste types

02				WASTES FROM AGRICULTURE, HORTICULTURE, AQUACULTURE, FORESTRY, HUNTING AND FISHING, FOOD PREPARATION AND PROCESSING
02	01			wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing
02	01	01		sludges from washing and cleaning
02	01	02		animal-tissue waste
02	01	03		plant-tissue waste
02	01	04		waste plastics (except packaging)
02	01	06		animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site
02	01	07		wastes from forestry
02	01	08	*	agrochemical waste containing dangerous substances
02	01	09		agrochemical waste other than those mentioned in 02 01 08
02	01	10		waste metal
02	01	11	*	hazardous animal tissue
02	01	12	*	hazardous plant tissue
02	01	13		soil from horticulture
02	01	14	*	other hazardous wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing
02	01	15		of specification seeds
02	01	99		wastes not otherwise specified

*hazardous waste

European Waste Catalogue (EWC) 2000/532/EC

Current legislation status

- SUD Directive 2009/128/EC: Handling and storage of pesticides and treatment of their packaging and remnants

"MS shall adopt the necessary measures to ensure that the following operations by professional users and where applicable by distributors do not endanger human health or the environment"

- (a) storage, handling, dilution and mixing of pesticides before application;
- (b) handling of packaging and remnants of pesticides;
- (c) disposal of tank mixtures remaining after application;
- (d) cleaning of the equipment used after application;
- (e) recovery or disposal of pesticide remnants and their packaging in accordance with Community legislation on waste.

Empty pesticides and fertilizers packaging

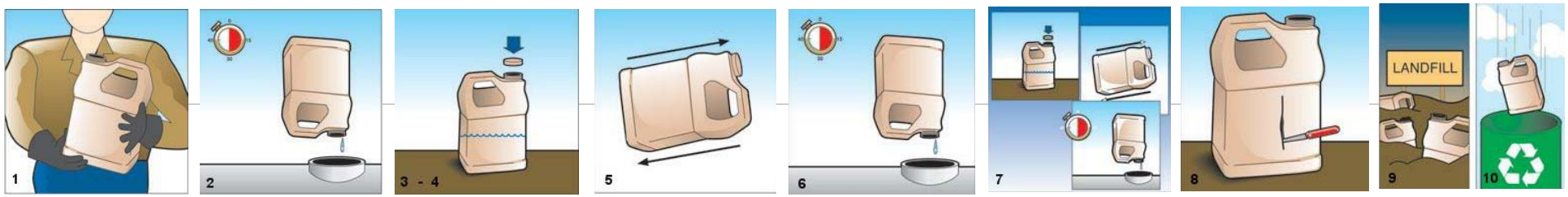
- The containers used for pesticides may still have residues of the included formulation after use
  - 2-5 % of the total amount
- Common practices up to day include:
  - Disposal in the field, dumpsites or with MSW
  - Disposal near irrigation ditches or in wells
  - Uncontrolled burning or burying
  - Collection for reselling
    - Mainly for larger containers/barrels/tanks
  - Collection for re-use (storage of water etc.)
    - Mainly for barrels and larger tanks
- At the same rationale, fertilizers packaging is commonly disposed in the field/dumpsites, with MSW, near irrigation ditches, burned or re-used, e.g. for collecting and transferring seeds and harvested crops
  - Residues are still present as dust or granules

HAZARD FOR THE ENVIRONMENT, ORGANISMS AND HUMAN HEALTH

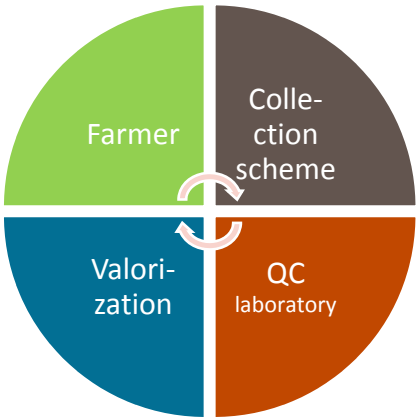
Empty pesticides containers

- In recent years, following the principles of circular economy and environmental protection significant efforts were made from governments, research institutes, pesticides companies and their national and EU associations, and local communities to initiate management schemes
  - via EU funded research projects (LIFE+, INTERREG, INTERREG-MED): AUA, BPI
  - Potential for recycling as well as for energy recovery

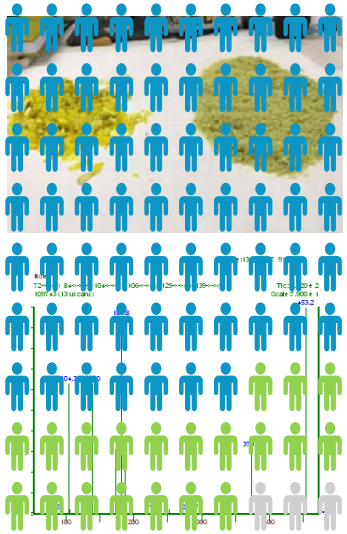
- Problem: Unknown composition (mixed bottles of different active substances PPPs) and pollutant concentration/variable plastic types/no established collection system
- Solution: triple rinsing (FAO 2008)/pressure rinsing/integrated pressure rinsing and physical damage: >99% cleaning efficiency
  - ✓analysis of each batch before valorization and classification to end uses according to the "product" quality/thermal treatment before valorization/farmers training



Empty pesticides containers II



- The Laboratory of Chemical Control of Pesticides (Benaki Phytopathological Institute-BPI) is the designated national laboratory for the control of all PPP and biocides formulation, residues in soil and other matrices as well as the pesticides containers:
  - Collaborates with national and international organizations and companies for this scope
- From the analysis of extended series of empty containers between 2012-2017, from random samplings throughout Greece as well as other countries of the EU it was shown:
  - >97% of farmers rinse the empty containers to clean it
  - 8/10 PPPs users performed successful triple rinsing, thus the container was suitable for further valorization



Agro-plastic materials

Affecting factors for recycling

- Quality vs recyclability:
- Inert contaminants (soil, sand etc),
- Thickness,
- Co-mingled plastics (contamination of the material with other types of plastics),
- Additives-pigments (not recyclable/low resell value),
- Ageing,
- **pesticides residues,**
- organic matter contamination.

Affecting factors for energy recovery as ASF

- Cl and S content,
- Heavy metals,
- Volatiles,
- Moisture,
- Physical properties,
- Calorific value,
- Quantity of ashes

Agro-plastic materials: What/how much?

>80% of agro-plastics:

- HDPE, HDPE-PA, HDPE-EVOH, HDPE PE-PA, LDPE
- PP, COEX, PET, EVA, PVC

✓ High resell value if they meet the requirements of industry

Annual agro-plastic waste production in ES, IT, GR, FR:

- Fertilizer sacks: >40000 tn/yr
- Greenhouse films: 60000 tn/yr
- Small tunnel films: 41000 tn/yr
- Mulching films: 90000 tn/yr
- Direct covers: 5500 tn/yr
- Irrigation pipes: >130000 tn/yr
- Silage films: 50000 tn/yr
- Bale wraps: >11000 tn/yr
- PP strings: 35000 tn/yr
- Vineyard nets: >11000 tn/yr
- Agrochemical containers: 16000 tn/yr (18500 tn/yr, if considering also CY, UK and FI)

All of them potentially hazardous

Data from Briassoulis et al. 2013

Expired, illegal or inappropriate PPP

- When a product's approval has been withdrawn or amended (for commercial, safety or other reasons), or if the product batch has been considered as inappropriate for market or the product's expiration date is passed it shall be dealt as 'hazardous waste'.
  - The pesticide shall be handled as hazardous material
  - Its container may be recycled after the necessary cleaning


Spray tank mix remnants/Triple rinsing leftovers

Spray tank mix remnants

- Contain significant amounts of the active substance
  - Shall not be discarded in water recipients or with WW
  - 54.9% of farmers re-spray the treated field area until the spraying tank is empty
  - 30.2% apply the leftover spray solutions to another crop
  - 4.3% mentioned that they often release the leftover spray solutions near or into irrigation canals and streams

Triple rinsing procedure leftovers

- Normally returned to spray tank mix
  - 45.7% of farmers reported that they release the rinsates over a non-cropped area
  - 40.7% drop the rinsates near or into irrigation canals and streams
- Acceptable procedures:
  - Application of leftovers in the cultivated field or nearby uncultivated land (max. application rate must not be exceed)
  - Collection and management as hazardous waste by licensed contractor
  - On site treatment systems (MBR/natural)

Olive Mill Waste (OMW)

Several technologies have been presented for this waste treatment, each with the respective pros/cons:

- Evaporation (with or without pretreatment using $Ca(OH)_2$ and/or zeolite)
- Direct application on soil
- Physicochemical treatments
- Microbiological treatment
- Composting (with MSW or other agrowaste)
- Membrane treatment (Microfiltration, Ultrafiltration, nanofiltration, reverse osmosis, osmotic distillation, vacuum membrane distillation etc.)
- Co-treatment with other waste streams
- Solar treatment
- High and low value chemicals extraction (antioxidants, antimicrobials, phenols)
- Use in organic fertilizers
- Energy recovery
- Anaerobic digestion-> biogas production

No actual BAT does exist, as it highly depends on specific region parameters, thus requires an *ad-hoc* approach

Waste from other crop processing streams

- Tomato processing waste
- Fruit processing waste (e.g. canning)
- Wine industry waste
- Fruit packaging waste (post-harvest PPP application)

Pesticide residues???

Common approaches?

- Dumped near production sites
- Landfilled
- Released to streams-rivers
- Spread to nearby fields

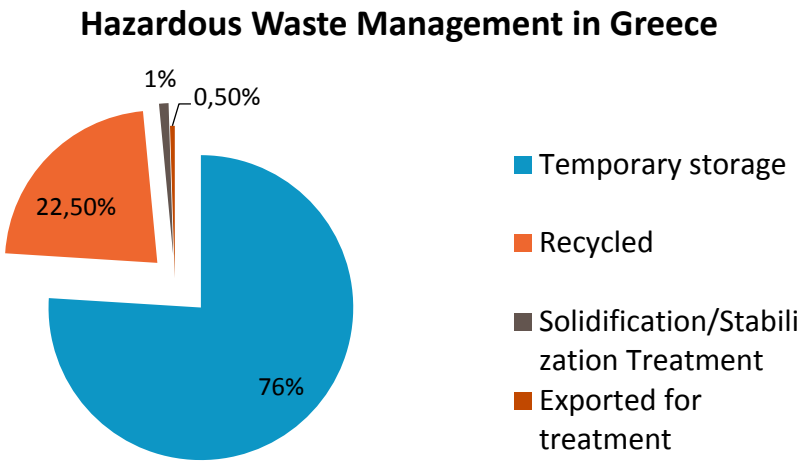
- Acidic, high protein, phenols and fat content, high pollutant level
- Anaerobic treatment/co-digestion not always possible or economically feasible → HWM from external contractors
  - ✓ In-situ case by case treatment: biobeds, SBR, MBR, (photo-)chemical
  - ✓ Removal of possible valuable substances (e.g. antioxidants, phenols)

End of life cycle equipment

- Spraying equipment
  - Plastic pieces shall be cleaned thoroughly and thereafter may be considered as utilizable (recycling or ASF)
    - Potential for sorbed pesticides residues due to extended use for years → further studies required on this specific case
  - Metallic pieces can be recycled as metal scrap after cleaning as any residues will be destroyed during melting

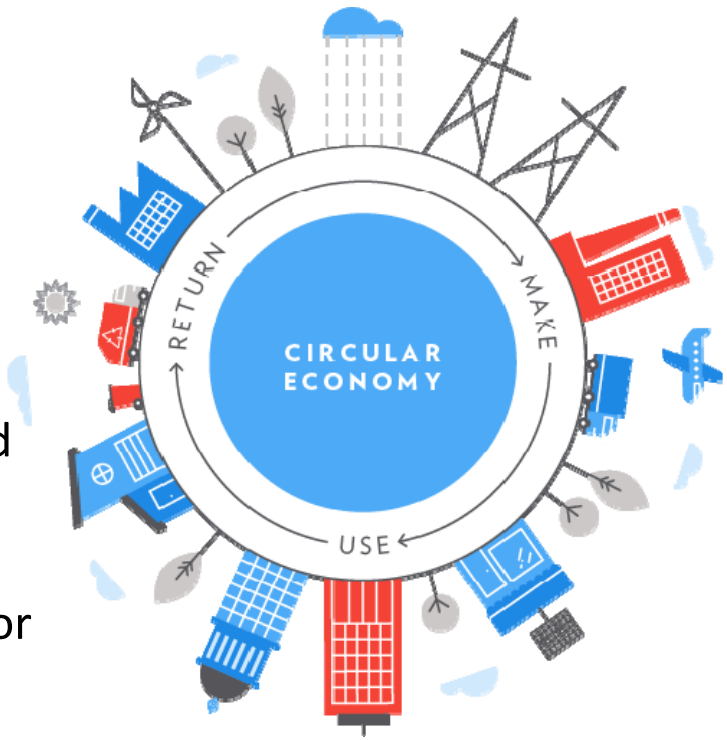
- Mechanized Agricultural Equipment
- Used oils
- Batteries

Current status in Greece



Conclusion and future perspectives

- Agricultural (potentially) hazardous waste exhibit perspective for valorization
  - Production of secondary products from plastic
  - Extraction of high value substances from plant origin waste
  - Valorization of sludges from WW in concrete, road production and brick industry together
  - Use for the production of alternative fuels (ASF) for industry as well as for energy recovery



Does it worth it?

- Only requires training and engagement of stakeholders
- Production temporal in a year but almost stable between years
- Raw material independent from the prices of fossil fuels
- Follows the principles of circular economy, sustainable development & protection of the environment
- Eliminates the cost for Hazardous Waste Management

Agroplastics valorisation potential

- Agricultural drainage piping
- Curb stops
- Treated lumber substitutes
- Highway guard rail posts
- Railroad ties
- Truck sub-floor components
- Liners for highway salting trucks
- Fence posts
- Electric conduit and boxes (buried in walls, floors etc.)
- Plastic lumber
- Watermeter boxes
- Car battery casing
- Hospital trash Bags
- Motor oil containers
- Incineration barrels
- Brooms
- Caps for agricultural chemical containers
- Motor oil containers
- Road speed bumps
- Parking cones
- Highway signposts
- Electrical pylon plastic cross-piece insulators
- Concrete saver
- Stakes
- Marine pilings
- Lighting posts
- Industrial pallets
- Construction nailing strips
- Drainage/sewerage pipes and fittings
- Roof tiles
- New agrochemical containers
- Fuel substitutes

Challenges

- Establishment of a collection and management network
- Cooperation with local authorities and central administration for waste management & agriculture
- Establishment of strategic partners for marketing of the agro-waste (market specification)

- Production in remote areas requires extended networks
- Lack of staff, equipment and financial system dedicated to this very specific stream
- Resources & Training required
- Requirement for clean, defined and repeatable quality material

Understanding of the necessity for environmental protection together with high crop yields agricultural production

Quality Control of the Management System and feedback

Provision of benefits to farmers (payback system)

Better Design-More Information-More Actions-Stronger Incentives





THANK YOU FOR YOUR ATTENTION