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LIFE CYCLE ENVIRONMENTAL IMPACTS OF VITICULTURE AND WINE INDUSTRY

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INTRODUCTION

- Wine was, and continues to be, one of the most important, influential, and popular alcoholic beverages in the world.
- The accounted consumption of wine is about 10% of the total alcoholic beverage consumption throughout the world, preceded only by spirits and beer.
- The history of wine is intimately connected to the history of humanity. The earliest traces discovered so far occurred in 6000 before Christ (BC) in Georgia and 5000 BC in Iran.

INTRODUCTION

- Wine is made from fermented grapes or other fermented fruits.
- Grapes can ferment without the addition of acids, sugars, enzymes, water, or other nutrients because of their natural chemistry, as well as natural yeast inoculation.
- Under the action of yeast, the sugars are converted into alcohols (primarily ethanol) and carbon dioxide, thereby making wine.

Introduction to winemaking

- Winemaking begins with **proper** selection and **cultivation** of appropriate grapes and ends with bottling of the finished wine.

- For **red-wine production**, red grapes are harvested, de-stemmed, and crushed; all berry parts including skins, pulps, and seeds are fermented.
- During fermentation, high levels of antioxidants (e.g., tannins and anthocyanins) are extracted, therefore, red wine is less susceptible to oxidation.

Introduction to winemaking

- **White wine** is only fermented by yeast and then chilled and stabilized.
- Only the juice or “must”, which is pressed from the pulps of white grapes, is fermented.
- The whole process is quite quick and, therefore, can produce wines with dry, crisp, and aromatic palates vis-à-vis red-wine profiles.

IMPACT ON THE ENVIRONMENT

- Every agricultural activity has its particular impact on the environment, contributing to climate change and global warming.
- The use of fertilizers, pesticides, soil, land, water, and energy in various agriculture sectors is responsible for approximately 20% of all greenhouse gas emissions.
- The process of growing grapes and transforming it into wine, contributes to environment issues as well.
- In general, viticulture and wine industry have a mix of positive and negative impacts in the world, such as the **social**, **health** and **economic** impacts.

IMPACT ON THE ENVIRONMENT

- While the wine may seem to be one of the most natural alcoholic beverages, **it is not free from carbon dioxide emissions**, which contribute to climate change or to alter the microclimate of the vineyard.
- **Agriculture, as well as viticulture and wine industry:**

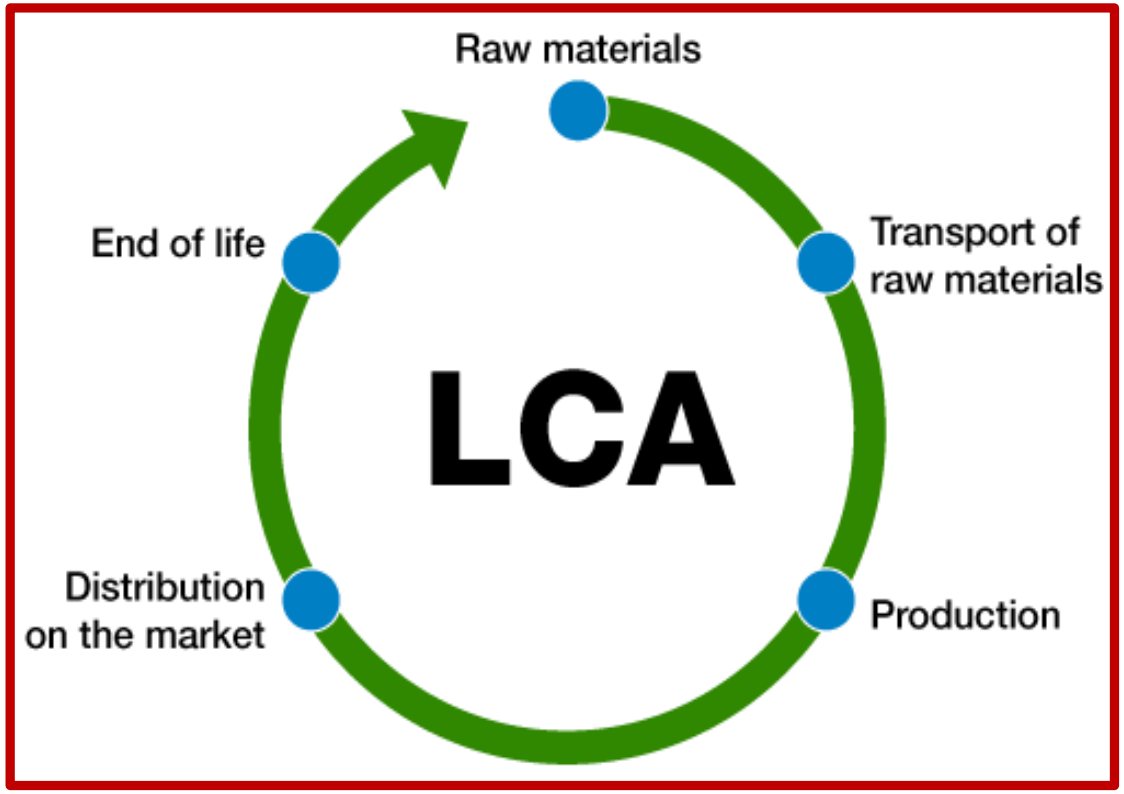
  - benefit from public goods such as natural resources, ecosystems, clean water

  - produce externalized costs that are transferred to the society, such as carbon dioxide, chemical residues and other waste

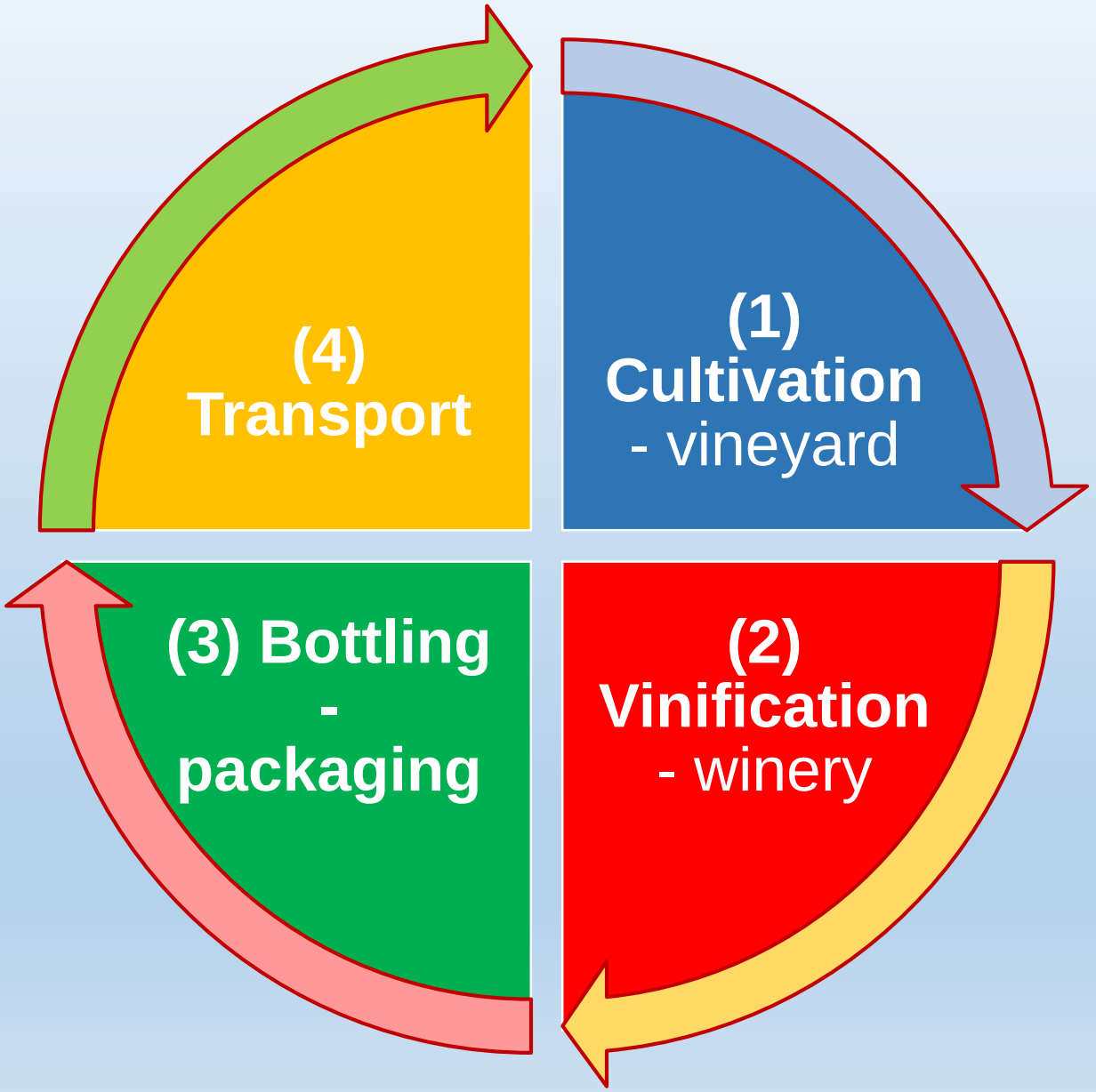
LIFE-SYCLE ASSESMENT (LCA)

- Today the consumer is aware that the consumption of food has an influence on his health and an impact on the environment.
- In contemporary society, consumers are demanding more **environmentally friendly products**, including food and drinks, such as **wine**.
- Companies are changing production processes, as well as entire supply chains, to achieve these ends.
- Implementing sustainability initiatives must make **economic sense**. Toward that end, **life-cycle assessment** is a way of quantifying and understanding business operations.

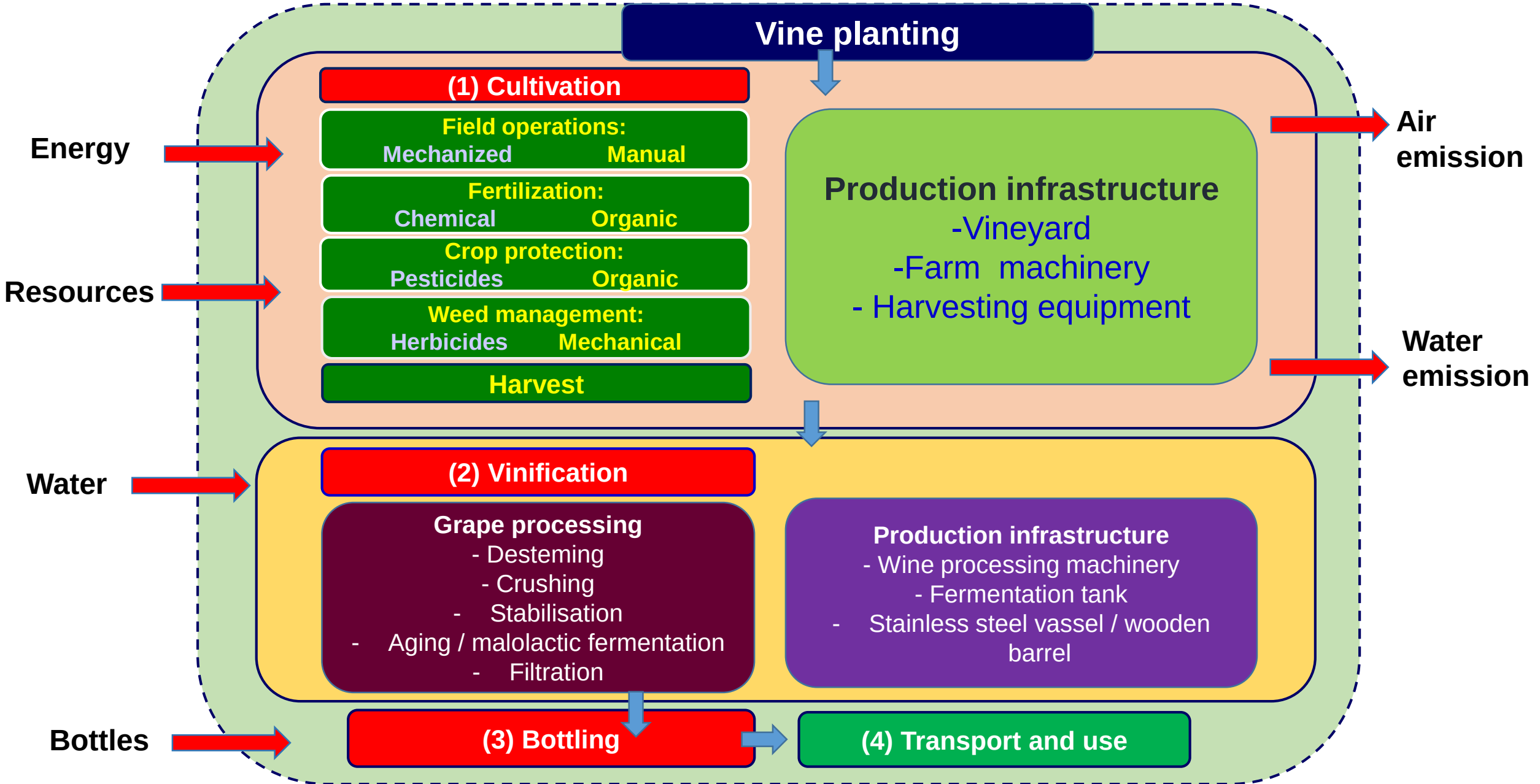
- **Life-cycle assessment (LCA)** is accounting of all environmental burdens associated with a product, a service, or a process, from raw material to waste/end-of-life.



LIFE CYCLE ASSESSMENT OF WINE PRODUCTION



The detailed process of **grape cultivation** and **winemaking** together with the **environmental indicators**



IMAPACTS OF VINICULTURE AND WINE INDUSTRY ON ENVIRONMENT

- The global wine industry:
  - **Uses large amounts of chemical fertilizers and organic substances**,
  - **Uses pesticides to prevent the vineyard of possible crop diseases and to improve grape quality and yield**,
  - **generates a large quantities of waste**.
- Pesticide application in the vineyard contribute the majority of toxicity-related emissions
- The use of nitrogen and phosphorous fertilizers contribute to eutrophication and acidification impact categories.
- Many winegrowers use chemicals too often and without consideration of the environment.
- Grapes have one of the highest levels of pesticide residues, together with apples, peaches, strawberries, and nectarines.

IMAPACTS OF VINICULTURE AND WINE INDUSTRY ON ENVIRONMENT

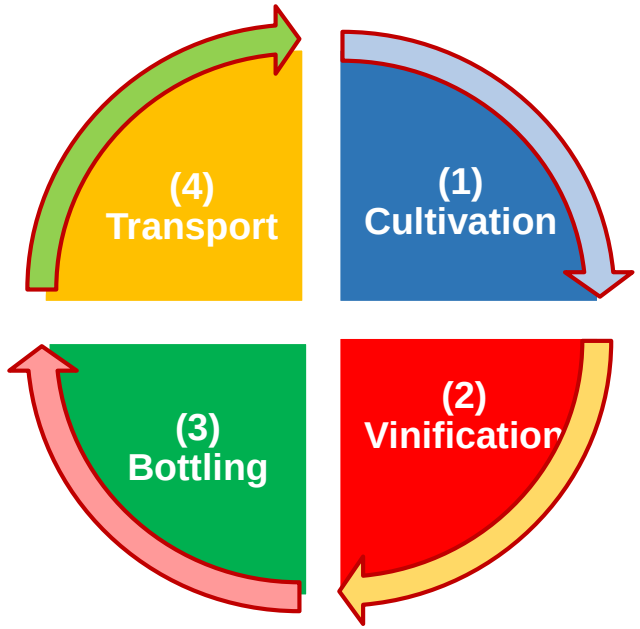
- **The conventional system is supposed to have the highest negative impact on the environment** - mainly due to the use of mineral fertilizers and herbicides, as well as the more repeated use of pesticides.
- In *organic* system, mineral fertilization and herbicides uses are **forbidden**, while plant protection products usage is very **limited**.
- More frequent use of tractors in organic production results in higher greenhouse gas emission and higher energy consumption.

LIFE-SYCLE ASSESMENT (LCA) in wine production

- **Energy** and **water consumption** within the system are input impacts, while **greenhouse gas** emissions and **solid waste** disposal are output impacts.

Input impacts

- ✓ **Energy consumption:** Bottle manufacturing and the wine making (vinification) (approximately 35% and 31%, respectively).
- ✓ **Water consumption:** Wine making - the greatest impact (approximately 91%), due to water used for fermentation, cleaning, etc.



LIFE-SYCLE ASSESMENT (LCA) in wine production

Output impacts

- ✓ **Greenhouse gas** emissions**:** Vine planting (cultivation) and bottle manufacturing (approximately 38% and 25%, respectively).
- ✓ **Solid waste** disposal: Bottle manufacturing and wine making (vinification) (approximately 32% and 59%, respectively).

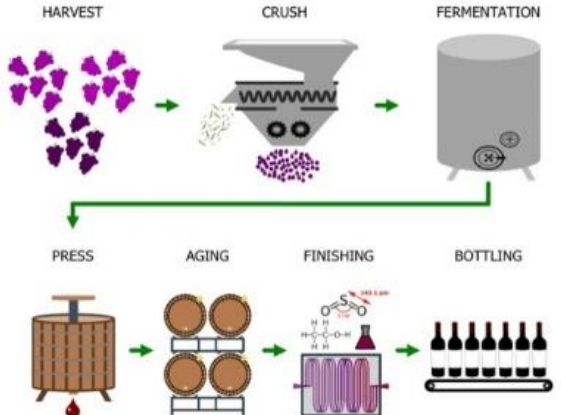
Influence of environment pollution on elements composition of wine

- The knowledge of the mineral composition and content in wine is an important factor influencing its quality and nutritional value.
- Determination of the elemental composition of wines is very important from the:
  - **toxicological** point of view – since it could contain harmful elements, such as **Pb**, **As** and **Cd**
  - **nutritional** point of view – since wine contains essential elements for the human organism, such as **Ca**, **Cr**, **Co**, **K**, **Se** and **Zn.**

- The element composition of wines may be influenced by many factors: **elemental levels in the soil**, **fertilization practices**, **processing conditions**, **environmental contamination of the vineyards**, **agricultural practices**, **climate changes**, **vine variety**, etc.
- Pesticides could influence the level of some elements in wines, such as Cd, Cu, Pb, and Zn.

Element composition of wine

- During vinification, element content changes as a result of wine making processes.
- The concentration of some elements – such as Al, Cd, Co, Cr, Cu Fe, Mn, Pb, V, and Zn:
  - **decreases** during the fermentation, stabilization, and fining of wines as a result of precipitation or coprecipitation with organic complexing agents, such as polyphenols and tannins,
- the content of **rare earth** elements:
  - **increase** from young to finished wines due to the use of bentonite.



Determination of heavy metals (Pb and Cd) in wines

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Determination of Pb and Cd in Macedonian Wines by Electrothermal Atomic Absorption Spectrometry (ETAAS)

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Determination of heavy metals (Pb and Cd) in wines

- All wines presented **low** concentration of Pb and Cd:

< 200 µg/L for Pb and <100 µg/L for Cd, the maximal allowed concentrations

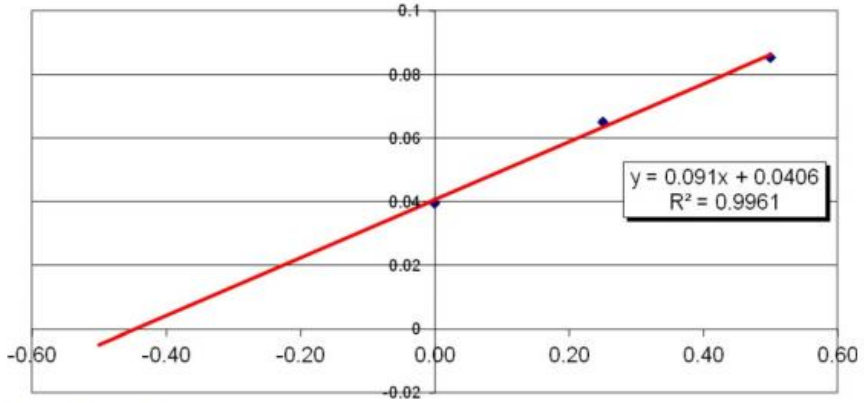

Fig. 1 Results for intercept, slope and R^2 of the calibration curve. Ivanova-Petropulos, Jakabová, Nedelkovski, Pavlík, Balážová, Hegedűs

and 1800 °C for lead and cadmium, respectively; HNO_3 (1 %) as a floated solution; modifiers H_3PO_4 (0.1 %) for Cd analysis and palladium modifier with Mg solution for

Table 2 Results for Pb and Cd content in the analyzed wines

Wine	Wine region	Pb [µg/L]	Cd [µg/L]
Smederevka-1	Tikveš	28.5	0.71
Smederevka-2	Tikveš	9.08	1.07
Riesling-1	Tikveš	24.7	1.43
Riesling-2	Tikveš	2.01	0.40
Chardonnay-1	Tikveš	18.6a	1.50b
Chardonnay	Skopje	18.6a	1.46b
Sauvignon Blanc	Skopje	n.d.	5.69

n.d. not detected, *1* Negotino, *2* Disan

Same letters (a and b) in the columnsindicate the values that are not significantly different ($p>0.05$), determined with one-way ANOVA, Student–Newman Keuls test

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Original scientific paper

MULTIELEMENT ANALYSIS OF MACEDONIAN WINES BY INDUCTIVELY COUPLED PLASMA–MASS SPECTROMETRY (ICP-MS) AND INDUCTIVELY COUPLED PLASMA–OPTICAL EMISSION SPECTROMETRY (ICP-OES) FOR THEIR CLASSIFICATION

Violeta Ivanova-Petropulos[1], Helmar Wiltsche[2], Trajče Stafilov[3], Marina Stefova[3], Herber Motter[2], Ernst Lankmayr[2]

Multielement analysis of Macedonian wines by ICP-MS and ICP-OES

- **42 elements** (Ag, Al, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Ho, La, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Pr, S, Sm, Tb, Ti, Tl, Tm, U, V, Yb, Zn, Zr) in 25 Macedonian **white**, **rose**, and **red** wines from **different wine regions**.

- All studied Macedonian wines **did not contain** hazardous heavy metals.
- Their **nutritional** value was **confirmed**, showing **high levels of macroelements such as P, Na, and Ba**.
- The content of rare earth elements (REE) was very low (total content ranged from 2.5 to 11.6 μg/L).

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Rapid Determination of Trace Elements in Macedonian Grape Brandies for Their Characterization and Safety Evaluation

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Trace elements in Macedonian grape brandies

- GF-AAS was used for determination of trace elements (Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) in “rakija” samples (a grape brandy traditionally produced in Macedonia by distillation of grape pomace or wine).

- Two homemade brandies showed Cu, Fe, and Zn concentrations higher than industrial distillates and thus were found to be not safe for consumption.

- For the industrially produced brandies, **Mn** was identified to be a suitable marker related to aging with oak chips, while **Cu** a marker for the influence of oak chip type.

CONSLUSION

Negative impacts on environment should be reduced by:

- reducing water and energy use
- minimizing pesticide use
- building healthy soil
- protecting air and water quality
- recycling natural resources
- maintaining surrounding wildlife habitat
- providing employee education
- communicating with neighbors, retailers and consumers about vineyard and winery operations

To improve the wine's life cycle impact, to achieve a sustainable development of the viticulture and wine sector and to avoid unnecessary environmental emissions, **the materials and energy resources for wine production and consumption must be used efficiently.**

THANK YOU FOR YOUR KIND ATTENTION!