



PROJECT

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1) Project title

Plant Uptake and Biotransformation of Central Nervous System-Acting Drugs: Implications for Edible Plants, Phytoremediation, and Aquatic Toxicity

2) Abstract (max 500 words)

Drugs designed to act on the central nervous system (CNS-acting agents) are now recognized as an emerging class of environmental contaminants. After human use, these compounds enter urban wastewater systems, where conventional treatment technologies often remove them only partially. As a result, residual concentrations of neuroactive drugs are increasingly detected in treated effluents and surface waters, raising concern due to their bioactivity and potential effects on non-target organisms. Surveys in Europe show that certain CNS-active drugs can persist through wastewater treatment and reach aquatic environments in trace yet biologically relevant amounts, where they may alter metabolic or behavioral pathways in exposed species. Beyond rivers and lakes, CNS-acting agents may also reach agricultural environments. Treated wastewater is being promoted globally as an alternative irrigation resource to address water scarcity, and international guidance recognizes its potential role in agricultural production. However, such water can contain micropollutants, including pharmaceuticals, that may enter the soil–plant system during irrigation. Similarly, sewage sludge, a nutrient-rich byproduct of wastewater treatment, is widely considered a valuable soil amendment. Institutional and scientific reviews highlight its agronomic benefits but also emphasize the presence of contaminants, including therapeutic agents, whose environmental behavior and long-term impacts remain insufficiently understood.

A key knowledge gap concerns the uptake and metabolism of neuroactive pharmaceuticals by plants. While some classes of pharmaceuticals are known to be taken up and transformed by crops, for various CNS-acting agents no data are available, leaving open the possibility that such compounds could accumulate in edible plant tissues and/or potentially generate plant-derived toxic metabolites. This raises questions about potential implications for food safety and environmental exposure through the food chain. At the same time, plant-based systems offer promising opportunities: several plant species have demonstrated the capacity to remove or degrade pollutants, suggesting that phytoremediation could become a sustainable tool for mitigating pharmaceutical contamination in water and soil.

This PhD project aims to investigate the uptake and biotransformation of selected CNS-acting pharmaceuticals in plants, using both edible model species and non-edible plants with potential for

phytoremediation. The selected drugs have been identified based on their recurrent detection in environmental waters and their ecological relevance. The project will characterize their accumulation patterns in roots and aerial parts, and will aim to identify potential plant-derived transformation products. In addition, the project will assess whether exposure to the selected pharmaceuticals influences plant health, including growth and key physiological parameters (e.g., photosynthetic pigments content). Controlled exposure studies will be carried out under hydroponic conditions, complemented by mechanistic experiments using subcellular fractions prepared from plant tissues. Detection of parent compounds and identification of their metabolites will rely on advanced liquid chromatography–mass spectrometry techniques. In parallel, and in collaboration with Prof. G. Paolone (Department of Diagnostics and Public Health, University of Verona), the project will evaluate the ecotoxicity of environmentally relevant concentrations of the selected drugs and their main human-derived metabolites through zebrafish-based assays, integrating plant and aquatic toxicology.