Groundwater contamination from nitrates in the intensively irrigated California Central Valley

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Introduction

- Nitrate contamination of groundwater is a major problem worldwide including the United States.
- Agriculture constitutes the primary contributor to groundwater nitrate contamination.
- Excess nitrogen, on average, accounts for 40% of the nitrogen applied to vegetables, representing a substantial risk of nitrate loading into groundwater.
- Regulations such as the ILRP requires BMPs to mitigate the release of nitrate from agricultural lands into water bodies.
- Robust continuous monitoring methods are required to evaluate the effectiveness of irrigation and nitrogen BMPs on mitigating nitrate leaching from agriculture into groundwater.

Objective

To estimate nitrate leaching in an irrigated processing tomato-cucumber rotation field using a three-tiered approach based on:

1. Field mass balance assessments
2. Shallow and deep vadose-zone monitoring
3. Intensive shallow groundwater monitoring

References

- Raij-Hoffman, I., Miller, K., Paul, G., Yimam, Y., Mehan, S., Dickey, J., Harter, T., & Kisekka, I. (2022). Modeling water and nitrogen dynamics from processing tomatoes under different management scenarios in the San Joaquin Valley of California. Journal of Hydrology: Regional Studies, 43.
- Harter, T., Dzurella, K., Kourakos, G., Hollander, A., Bell, A., Santos, N., ... & Tomich, T. (2017). Nitrogen fertilizer loading to groundwater in the Central Valley. Final report to the Fertilizer Research Education Program, Project 11-0301.
- California State Water Resources Control Board. (2023). Irrigated Lands Regulatory Program. Retrieved from https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/

Methods

Nitrate mass balance

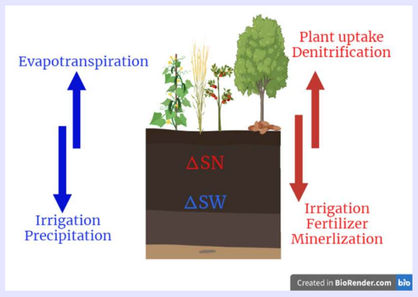

Figure 1. Field Mass Balance based assessment of nitrate leaching

Vadose zone monitoring

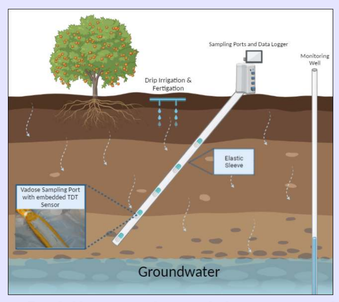

Figure 2. Nitrate leaching monitoring using the Vadose Zone Monitoring System (VMS).

Groundwater monitoring

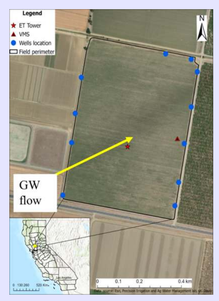

Figure 3. Nitrate leaching monitoring using a network of groundwater observation wells.

- Bi-weekly sampling of the VMS
- Groundwater monitoring every six weeks
- Field scale water mass balance
  - **Drainage =** I+P-ET±dS
- Field scale N mass balance approach
  - **N Leached** = N_{Irr} + N_{Min} + F - N_{Upt} - N_{Denit} ± dSN

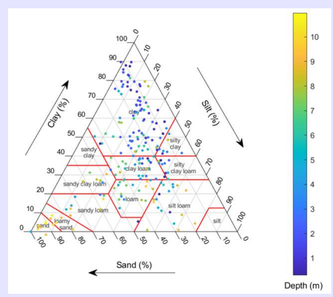

Figure 4. Soil texture variations from surface to groundwater in the processing tomato field Field

Results

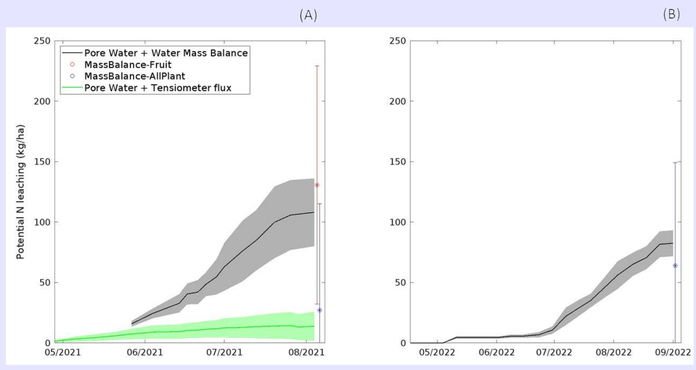

Figure 5. Field mass balance comparison for 2021 & 2022 (A) Tomato, (B) Cucumber growing seasons.

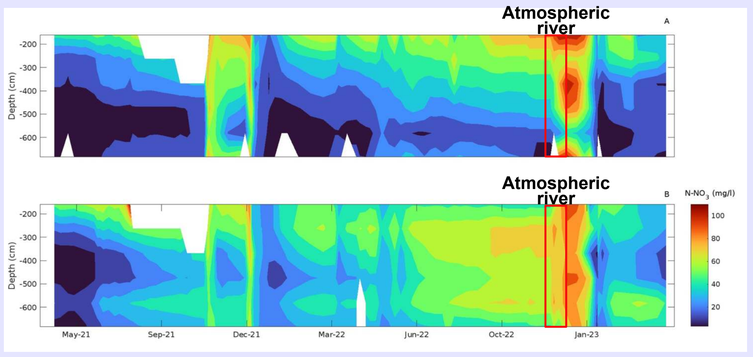

Figure 6. Spatial distribution of Nitrate concentrations in the deep vadose zone.

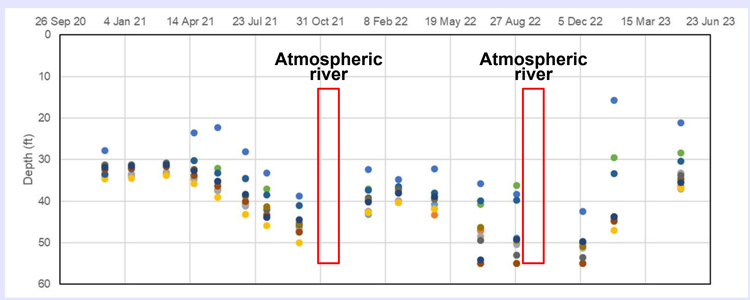

Figure 7. Temporal changes in groundwater levels during irrigation seasons

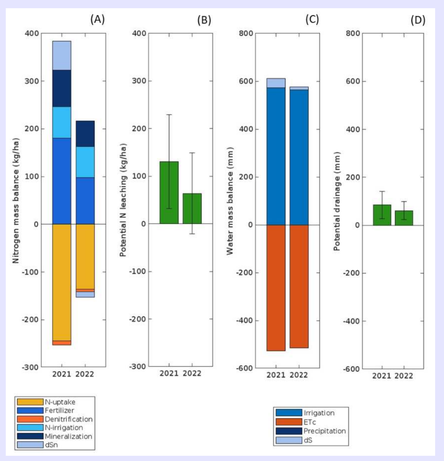

Figure 8. Nitrogen (A, B) and water (C, D) mass balances for both Tomato and Cucumber growing seasons.

Acknowledgment

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Conclusion

Nitrate leaching to groundwater occurs during heavy rainfall in the winter following dry periods. It is critical to end the season with minimal residual soil nitrate.