MARSoluT
Managed Aquifer Recharge ITN

Sant'Anna
Scuola Universitaria Superiore Pisa

Project Presentation

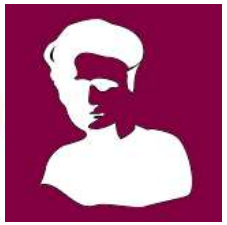
MARSoluT Innovative Training Network

ESR6 - Hydroinformatics and monitoring for investigating groundwater quality changes in Managed Aquifer Recharge

Esteban Rafael Caligaris

MSCA
Marie Skłodowska-Curie Actions

Who am I?



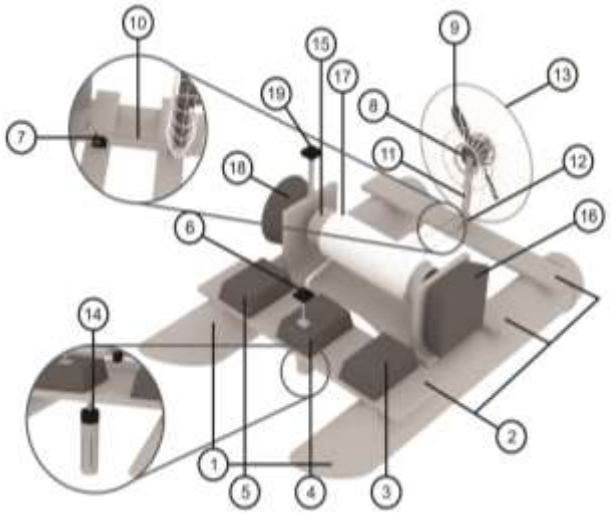
MAR SoluT

- Civil Engineering with Intensification in Sanitation and Water Resources – Faculty of Engineering of the National University of Asunción, Paraguay (2008 – 2016)
- MSc Hydroinformatics and Water Resource Management – EUROAQUAE – Erasmus Mundus Joint MSc Degree – Technical University of Brandenburg, Germany – Newcastle University, U.K. – Warsaw University of Technology, Poland – University of Nice-Sophia Antipolis, France – Technical University of Catalonia, Spain (2017 – 2019)
- Third Semester MSc - Specialization in Groundwater. Hydrogeology. Groundwater Flow and Transport (Theory and Modelling). Groundwater Management and Optimization.
- Object Oriented Programming skills: Python, C, C++ and Java
- Programming for Data Analysis: R and MATLAB.

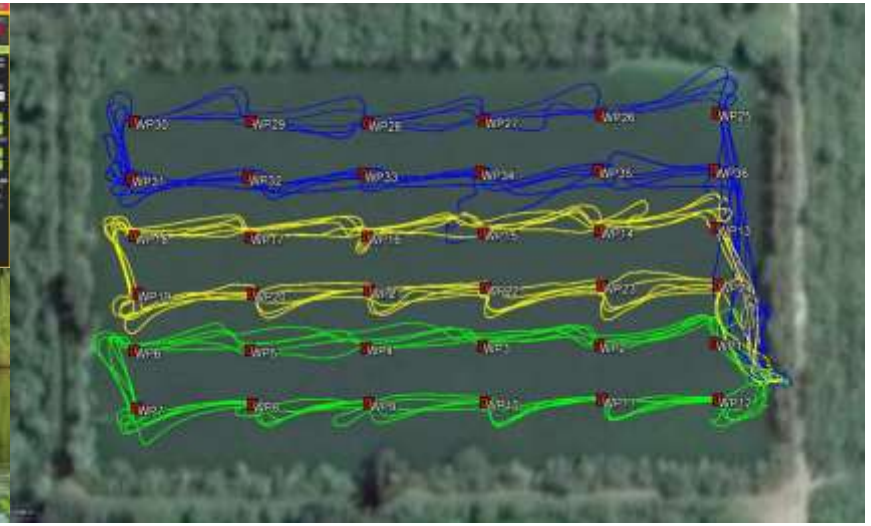
What I did so far?

- Research experience in the German-Paraguayan University (2015-2017)
- Publishing a Technical Paper:

  A. Cuppens, G. Menesse, E. Caligaris, O. Marecos, G. Wyseure; A low-cost, open-source autonomous surface vehicle as a multipurpose waste stabilization pond monitoring platform. Journal of Water, Sanitation and Hygiene for Development 1 March 2019; 9 (1): 172–180. doi: https://doi.org/10.2166/washdev.2018.110



1) Ø 150 mm PVC pipes
2) Plywood
3) Battery
4) Autopilot
5) Telemetry Radio
6) GPS + compass
7) Steering servo
8) Brushless DC motor
9) Propeller
10) Ø 2mm Steel rod
11) Ø 20 mm PVC pipe
12) Furniture caster
13) Safety cage
14) Environmetal sensor
15) Ø 150 mm PVC pipe
16) Window lift motor + Arduino
17) Sensor cable
18) GPS datalogger + Arduino
19) External GPS antenna



- Jr. Consultant. Water Department of the Infrastructure Ministry of Paraguay (2017)

PROJECT TITLE

Hydroinformatics and monitoring for investigating groundwater quality changes in Managed Aquifer Recharge.

MAIN OBJECTIVE

Investigate model-based quantification of groundwater quality changes, understanding hydrochemical reactive processes, during Managed Aquifer Recharge (MAR) operations.

BACKGROUND

Water

[1]

- Essential to life
- Used in human activities
- Increase of water demand
- Over-exploitation of water resources
- Negative impact in water resources systems

Val di Cornia

- Groundwater resource
- Important Agricultural Sector and mass tourism
- Lowering of the groundwater head and seawater intrusion [2]
- Soil rich in Arsenic and Boron [3]
- Engineered water treatment scheme for these elements

[1] UNESCO (2016)

[2] Barazzuoli et al. (1998) **[3]** Pennisi et al. (2006)

BACKGROUND

LIFE REWAT [4]

- Revert situation in Val di Cornia
- Design a MAR scheme [5]
- Operate a MAR scheme pilot [6]
- Goal: 1M m^3 of harvested rainwater
- One of the first schemes of this kind

Unknowns

- Effect of recharged water on the hydrochemistry of the natural system.
- Main processes during the As and B concentration decrease.
- Microbiological changes and their periodicity.
- Effect on crop products and soils of irrigation with As and B.

[4] http://www.liferewat.eu/ ; **[5]** Rossetto et al. (2018) ; **[6]** Rossetto et al. (2019)

RESEARCH QUESTIONS

Which are the main processes involved in the Arsenic and Boron concentration reduction when running Managed Aquifer Recharge operations using surface water?

Are these processes sustainable in the long term?

Is there any microbiological change induced in the soil during recharge? If so, are these transient?

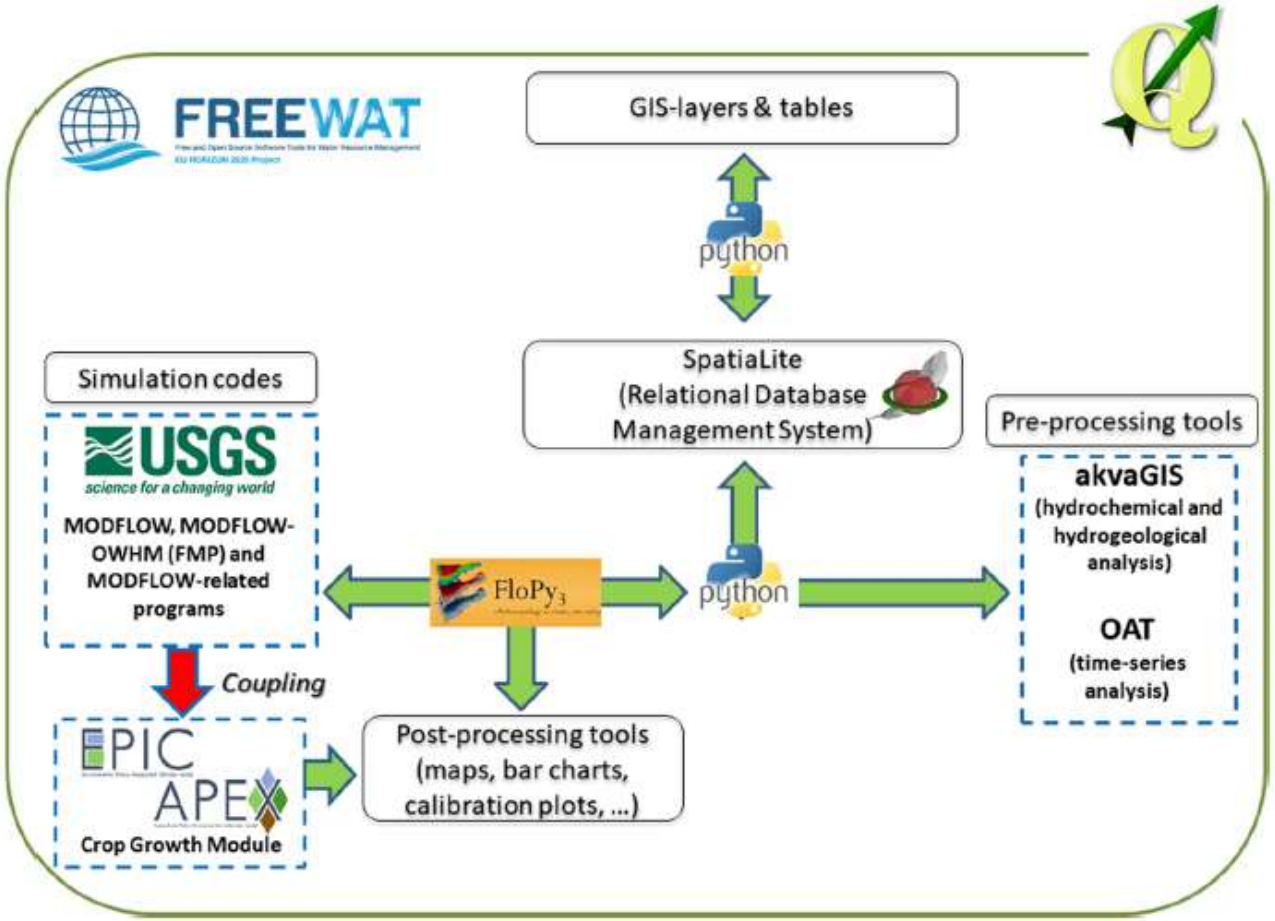
Which is the effect of irrigating crops with this groundwater?

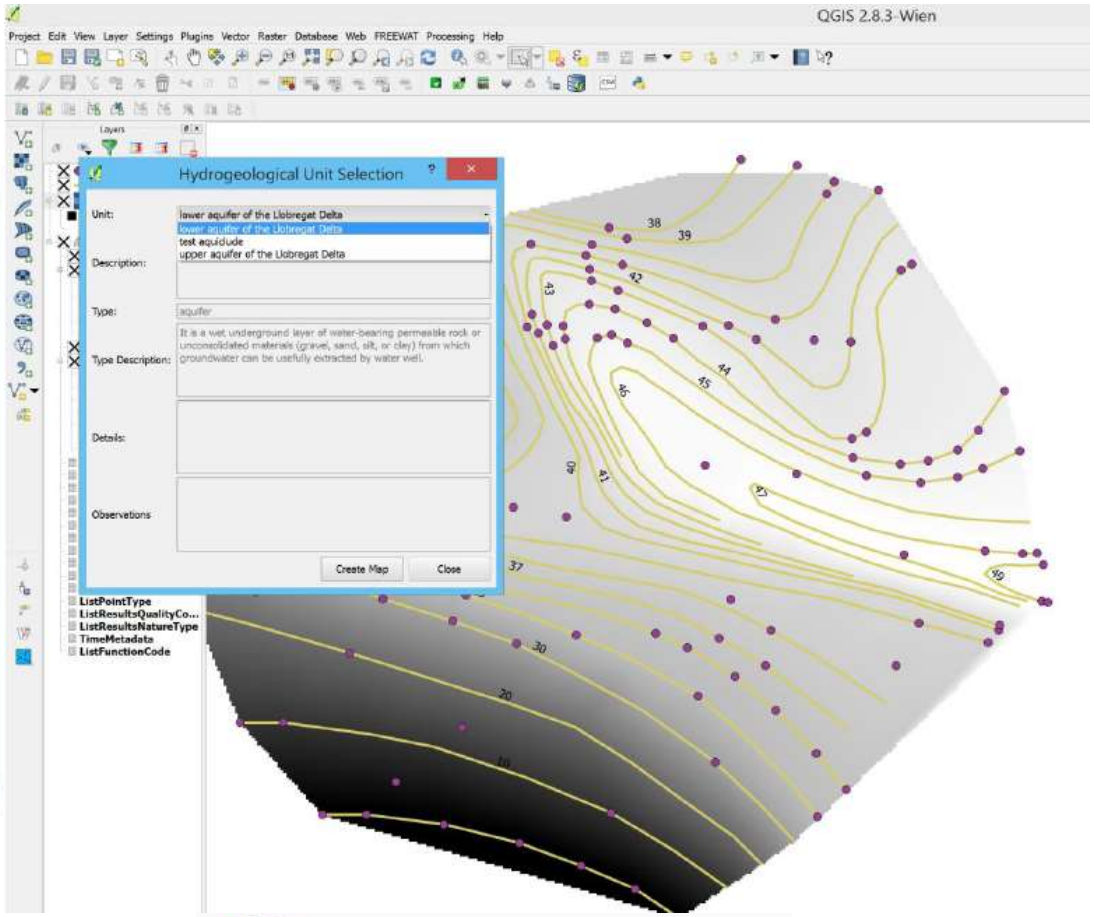
MATERIALS

LIFE REWAT Infiltration Basin

MATERIALS

FREEWAT





[7] Rossetto et al. (2019b)

FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

METHODS

Literature Review

- **Chemistry of Arsenic and Boron in the Water and Crops**
- **MAR Systems**
- **Reactive Transport in Groundwater**
  Models & Chemical Processes

Short and Long Term Experiments

- **Field Data Collection** (LIFE REWAT Infiltration Basin)
- **Lab Analysis** (Water, Soil & Crops)

Data Analysis

- **Statistical Data Analysis**
- **Modelling Analysis**

Assessment of Results

- **Comparison between Statistical and Modelling Results**

Activities	Months																																	
	Year 01												Year 02												Year 03											
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1.Literature Review																																				
-Chemistry of Arsenic and Boron (Interaction with Water and Crops)																																				
-Manage Aquifer Recharge systems																																				
-Reactive transport in Groundwater (Models and Chemical Processes)																																				
2. Experiments (Short and Long Term)																																				
-Field Data Collection																																				
-Lab Analysis of Water Samples																																				
-Lab Analysis of Soil Samples																																				
-Lab Analysis of Crops Samples																																				
3. Statistical Data Analysis																																				
4. Modelling Analysis																																				
-Integration of Reactive transport Model to FREEWAT																																				
-Modelling of Infiltration Processes and reactive processes																																				
5. Comparison between Statistical and Modelling Results																																				
6. Courses																																				
7. Papers preparation												Sm												Sm												Sm
8. Thesis writing																																				

EXPECTED RESULTS

In-depth research on Managed Aquifer Recharge processes (hydrochemistry and hydrology).

Determining the effects of irrigation with Arsenic and Boron on crops on real scale.

Evaluating the benefits of using non conventional water for agricultural purpose.

REFERENCES

1. UNESCO IHP (2016). Water Security. https://unesdoc.unesco.org/ark:/48223/pf0000225103 (accessed 05 Oct 2019).
2. Barazzuoli, P., Bouzelboudjen, M., Cucini, S., Király, L., Menicori, P., & Salleolini, M. (1999). Olocenic alluvial aquifer of the River Cornia coastal plain (southern Tuscany, Italy): database design for groundwater management. Environmental geology, 39(2), 123-143.
3. Pennisi, M., Bianchini, G., Muti, A., Kloppmann, W., & Gonfiantini, R. (2006). Behaviour of boron and strontium isotopes in groundwater–aquifer interactions in the Cornia Plain (Tuscany, Italy). Applied Geochemistry, 21(7), 1169-1183.
4. LIFE REWAT (2019). Progetto Life Rewat. http://www.liferewat.eu/ (accessed 05 Oct 2019).
5. Rossetto, R., De Filippis, G., Piacentini, S. M., Matani, E., Sabbatini, T., Fabbrizzi, A., ... & Menonna, V. (2018, April). Using flood water in Managed Aquifer Recharge schemes as a solution for groundwater management in the Cornia valley (Italy). In EGU General Assembly Conference Abstracts (Vol. 20, p. 12861).
6. Rossetto, R., De Filippis, G., Piacentini, S. M., Matani, E., Sabbatini, T., Fabbrizzi, A., ... & Menonna, V. (2019). Increasing reliability and safety of Managed Aquifer Recharge schemes for tackling water scarcity. In EGU General Assembly Conference Abstracts (Vol. 21, p. 11172).
7. Rossetto, R., De Filippis, G., Triana, F., Ghetta, M., Borsi, I., Schmid, W. (2019b). Software tools for management of conjunctive use of surface- and ground-water in the rural environment: integration of the Farm Process and the Crop Growth Module in the FREEWAT platform. Agricultural Water Management, 223. https://doi.org/10.1016/j.agwat.2019.105717

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Thanks for your attention

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