Integrated Water Cycle Demonstration Pilot Project Using MELiSSA Space Technology

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(*) also @ Albavalor – University of Valencia Science Park
Spain

Highly interdisciplinary team

- University of Valencia
  - Faculty of Physics
    - Ernesto Lopez-Baeza
    - Erika Albero-Peralta, Domingo J. Catalán, Carlos Rivero-Moro (Doctorate Students)
  - Higher Technical School of Engineering
    - Alberto Bouzas Blanco
  - IRTIC / LISITT - Institute of Robotics and Information Technology and Communications / Integrated Laboratory of Intelligent Systems and Technologies of Traffic Information
    - Juan J. Martinez Dura, Antonio García-Celda, David Garcia-Rodríguez
  - Faculty of Biology
    - Pedro Carrasco
    - Marta Perez-Rodrigo (Doctorate Students)
  - Faculty of Pharmacy
    - Rafael Boluda
- Albavalor – University of Valencia Science Park
  - Ernesto Lopez-Baeza, Ana Perez-Hoyos, Rafael Catany
- Valencian Institute of Agricultural Research
  - Victor Asensi-Ortega (Doctorate Student)

Working areas

Earth Observation

- satellite remote sensing and drone operation
- ground-based: soil moisture, chlorophyll content, N_2 concentration

Water Treatment

- biological processes
- microalgae
- optional for emergent removal and disinfection:
  - advanced oxidation processes + UV
  - ultrafiltration or nanofibers + UV
- Know discharge water at the Science Campus and the University Scientific Park, particularly Mathematics and Cafeteria
- Know estimated budget (summary) to adapt all downspouts (Mathematics & Cafeteria) to differenciate water types entering MELiSSA

Composting and Waste Management

- impact of different water treatments in ad hoc designed smallholdings

Environment and Sustainability

- complementary activities related to collecting and reusing rainfall water, SUDS, ...

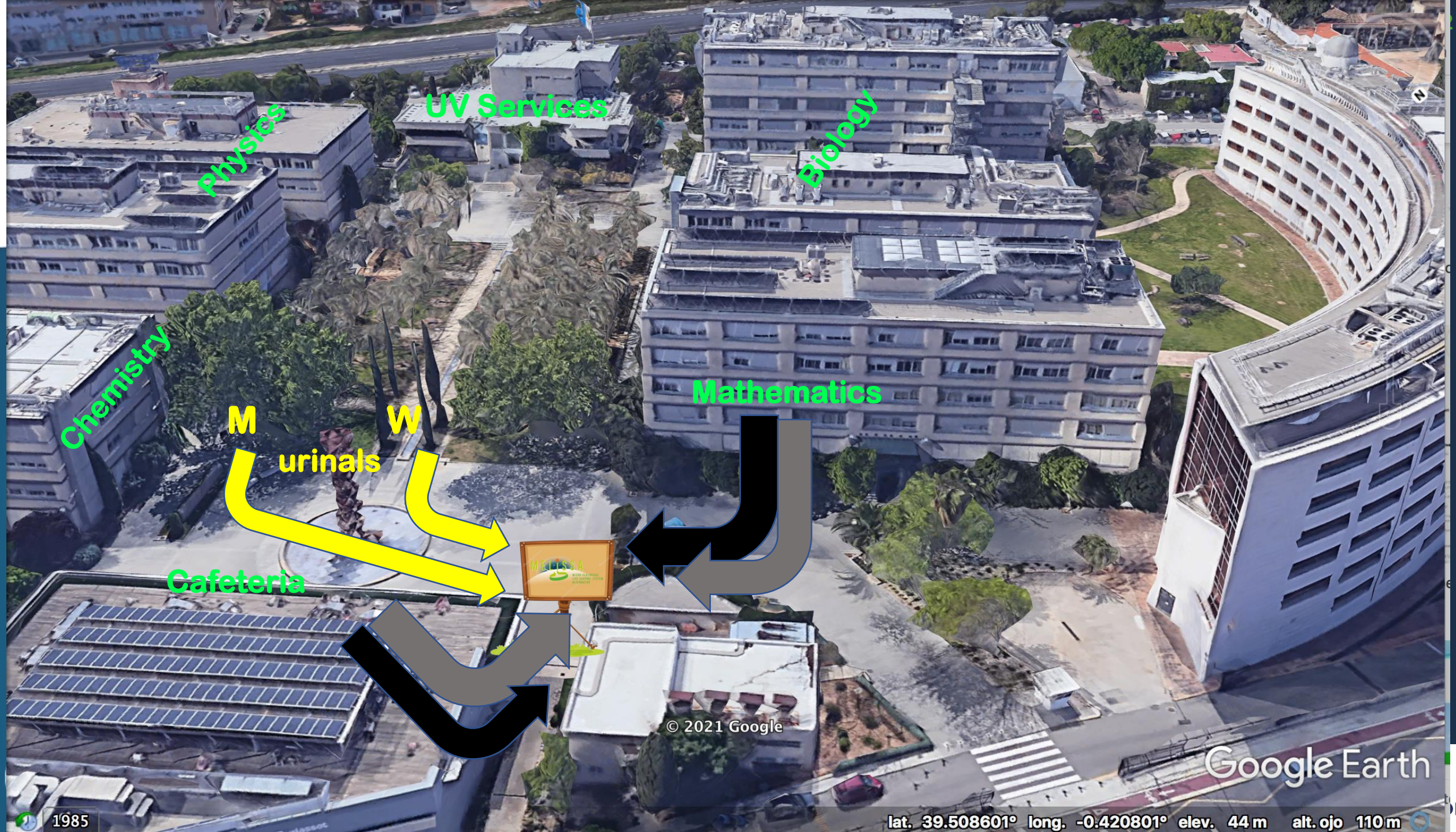
Renewable Energy

Artificial Intelligence & Data Semantics

Objectives

- To consider MELiSSA recycling technologies for a Demonstration Pilot Project at the Valencia University Science Campus
  - Possibility of future potential
    - of using MELiSSA at UVEG itself
    - or with other eventual third-party possibilities
- Focus on a sustainable integral water cycle
  - a "*cradle-to-grave*" showcase
- Scientific collaboration with MELiSSA partners
  - demonstration pilot project → UVEG
  - possibility of developing new research ideas → MELiSSA

University of Valencia Science Campus


Physics
UV Services
Biology
Chemistry
Mathematics
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© 2021 Google
Google Earth
1985
lat. 39.508601° long. -0.420801° elev. 44 m alt. ojo 110 m


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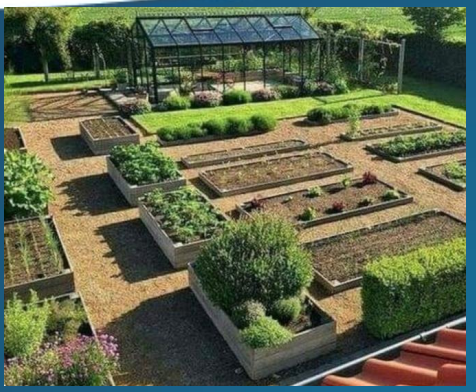
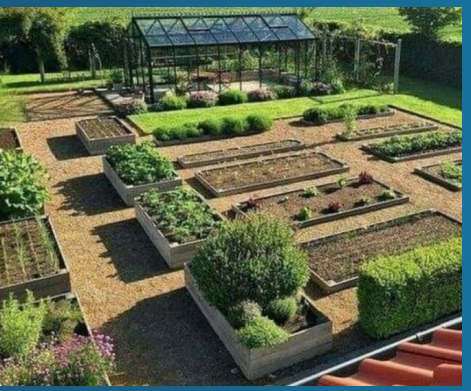
1985
lat. 39.508601° long. -0.420801° elev. 44 m alt. ojo 110 m

Valorisation of Fertilisation (in Campus smallholdings)



tap water & conventional fertilisation

reclaimed water & conventional fertilisation



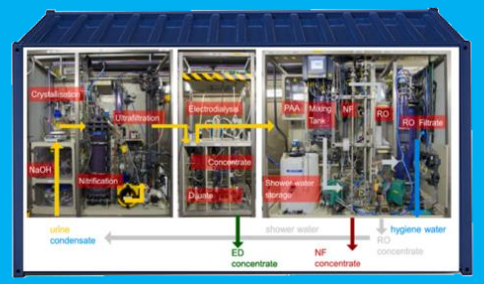
tap water & MELiSSA fertilisation

reclaimed water and MELiSSA fertilisation

tap water & composting fertilisation

Main requirements

- Start with grey and yellow water
- Adding value to reclaimed water irrigation and N_2 fertilisation



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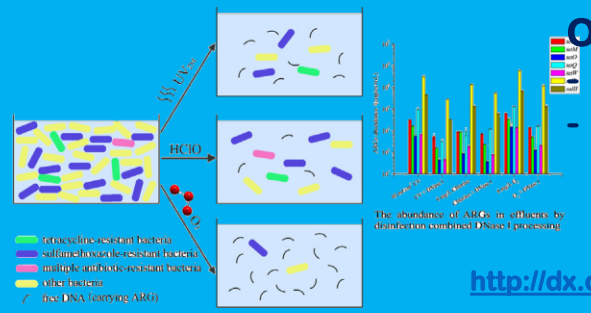
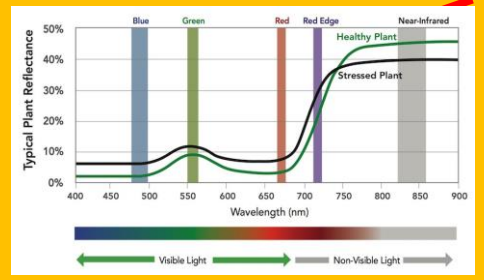


Optional emergent removal and disinfection:
- **Ultrafiltration or Nanofibers + UV**
- **Advanced Ox. Processes + UV**

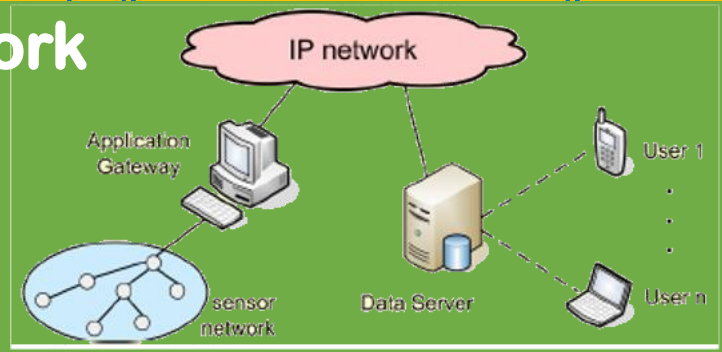
http://dx.doi.org/10.1016/j.cej.2017.02.076

- **Using drone technoloy**



https://gisnote.com/2019/04/15/l11-rededge/

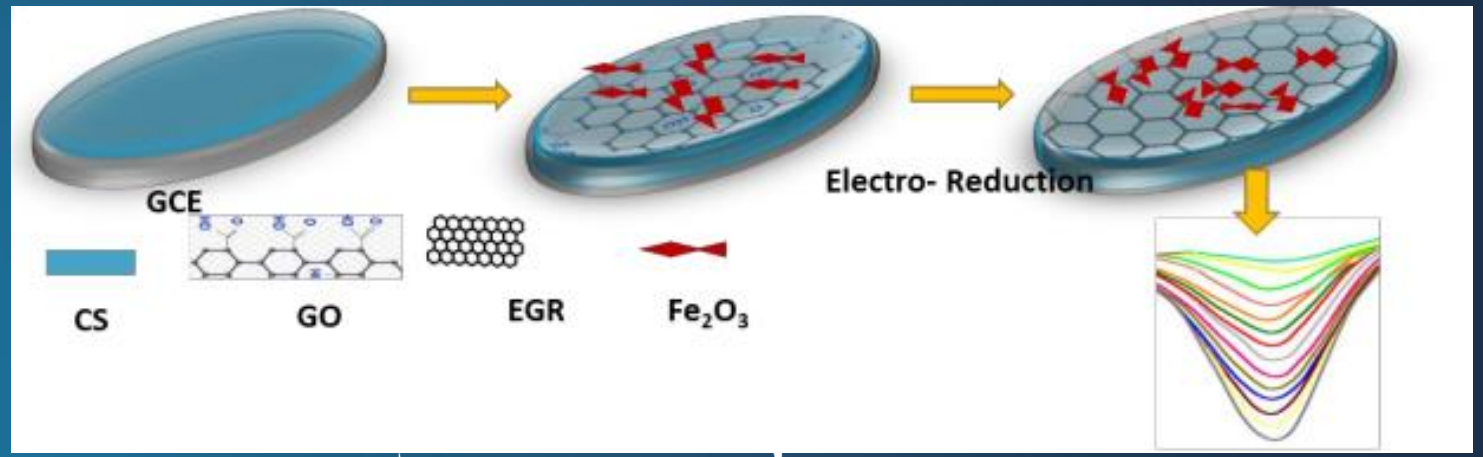
- **Soil moisture monitoring LoRaWAN - Raspberry Pi network**
- **In situ chlorophyll and N_2 concentration content**



- Composting and organic waste management
  - In-Campus smallholdings → with/without N_2 fertilisation
- Secondary aims
  - (Rainwater collecting and Sustainable Urban Draning System – SUDS)

Electrochemical Nanosensor

- Emergent contaminants are of increasing interest as they fit in the broad categories:
  - New industrial products (such as Bisphenol A)
  - Known chemicals being considered as contaminants now (such as pharmaceuticals)
  - Known contaminants whose prolonged toxicity is considered now (such as hormones)

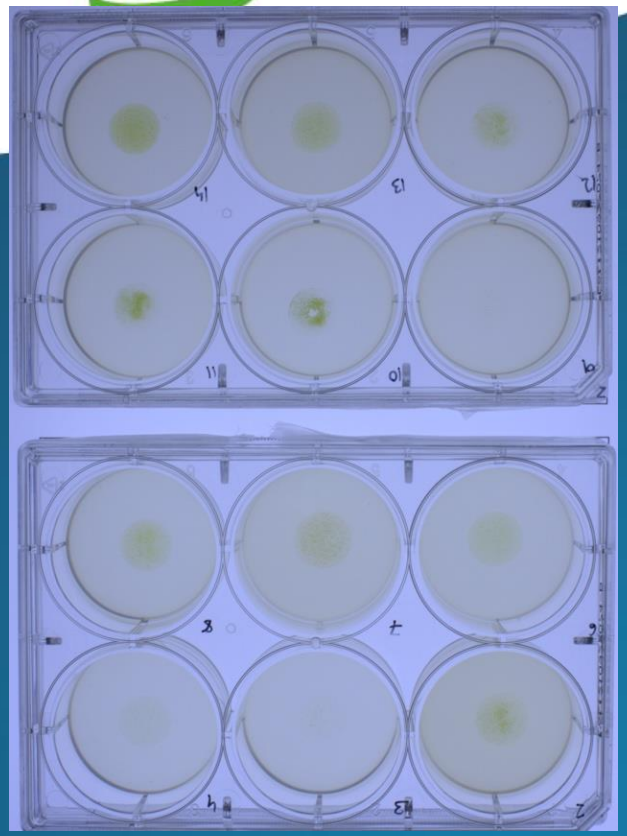


Example of an electrocheminal carbon-based nanosensor for detection of an EC (Kanoun 2021)

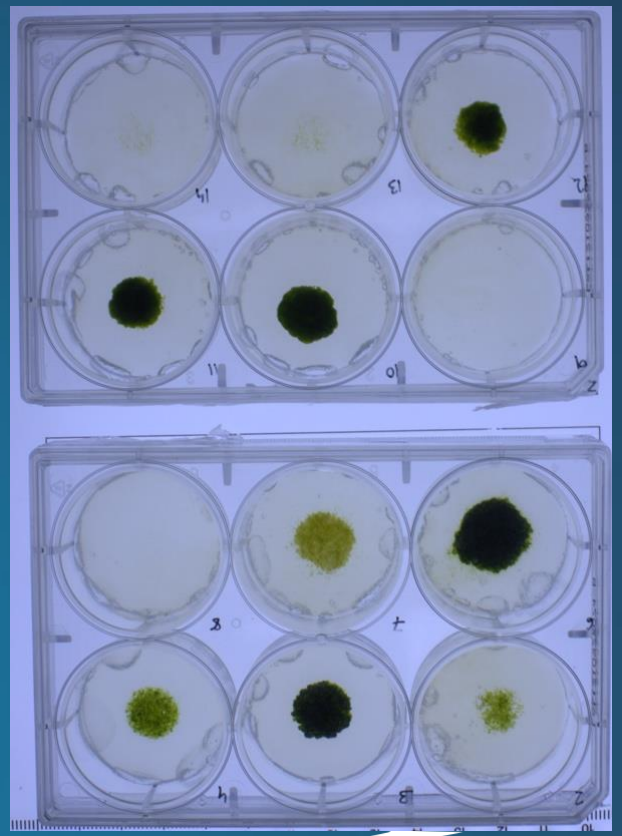
Both emergent contaminants and "classical" contaminants can be sensed through electrochemical nanosesors:

- Economic (money and time)
- Continuous monitoring
- Foreseeable tight regulations

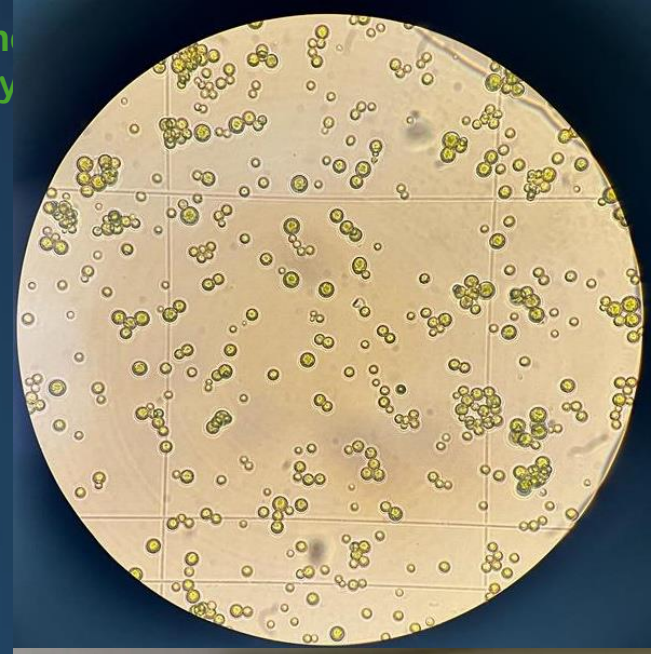
Use of microalgae for wastewater treatment



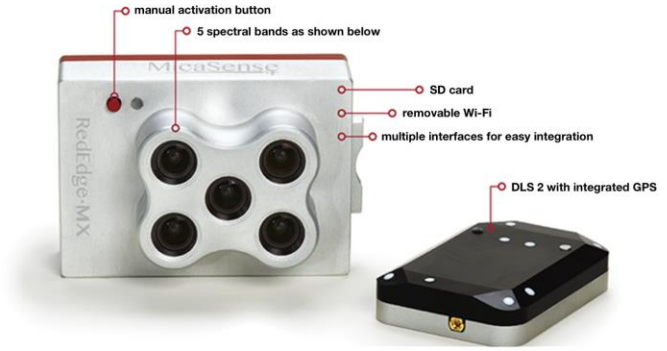
DAY 1

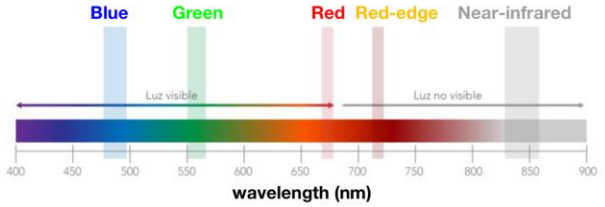


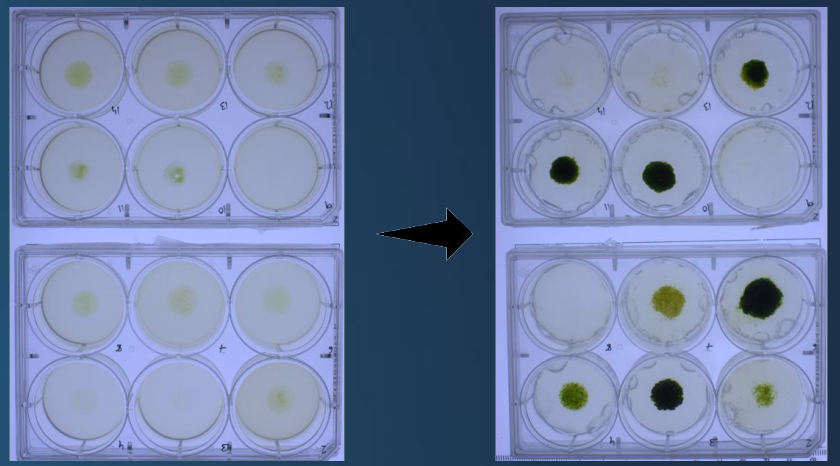
DAY 21

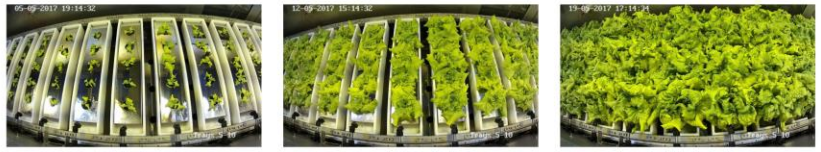


Screening of different species of microalgae of the Trebouxiaceae family (*Asterochloris, Myrmecia, Symbiochloris, Trebouxia, Vulcanochloris,* and *Watanabea*) integrated into The Collection of Symbiotic Algae of the University of Valencia (ASUV).

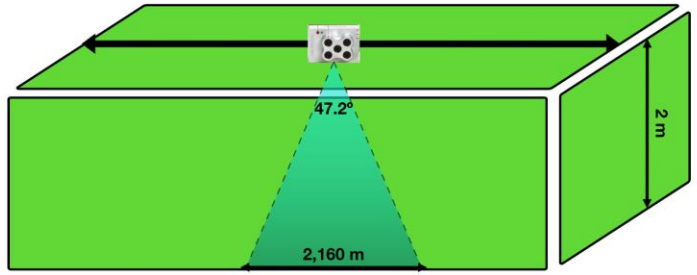








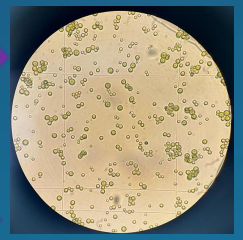
Lettuce culture in the higher plants chamber at the MELiSSA Pilot Plant
<https://www.melissafoundation.org/page/melissa-pilot-plant>

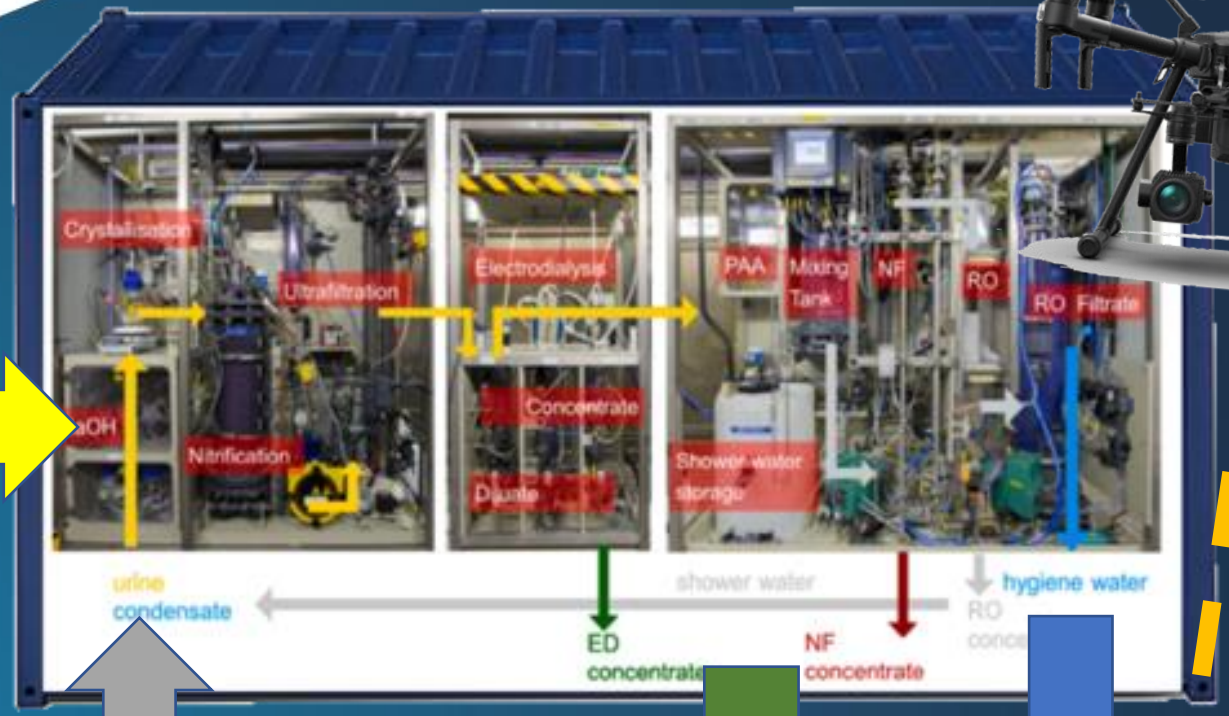


MELiSSA Space Technology

Albavalor

MELiSSA





solid waste

N_2

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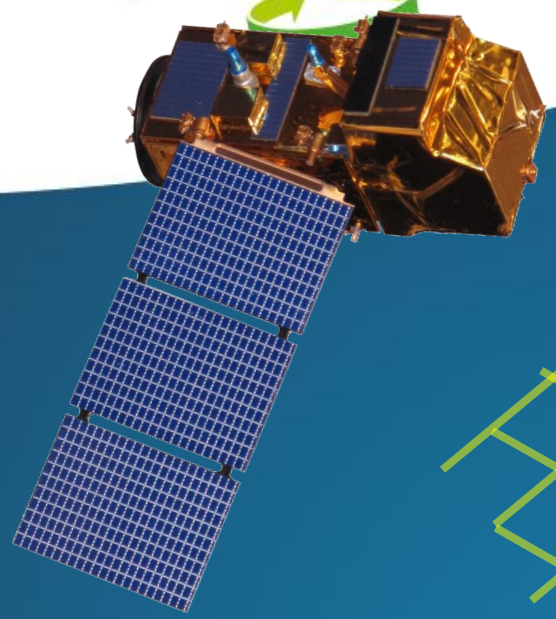
valor

2022 MELiSSA Conference,
Current and Future Ways to

Water reuse at the Burjassot Science Campus



Smart agriculture

- smallholdings
- irrigation optimisation
- N_2 fertilisation

Integrated

Ground Instrumentation

Delta-T Theta Probe Soil Moisture Sensor ML2x

Apogee MC-100 Chlorophyll Concentration Meter

Dualex Sensor NBI® Nitrogen Balanced Index

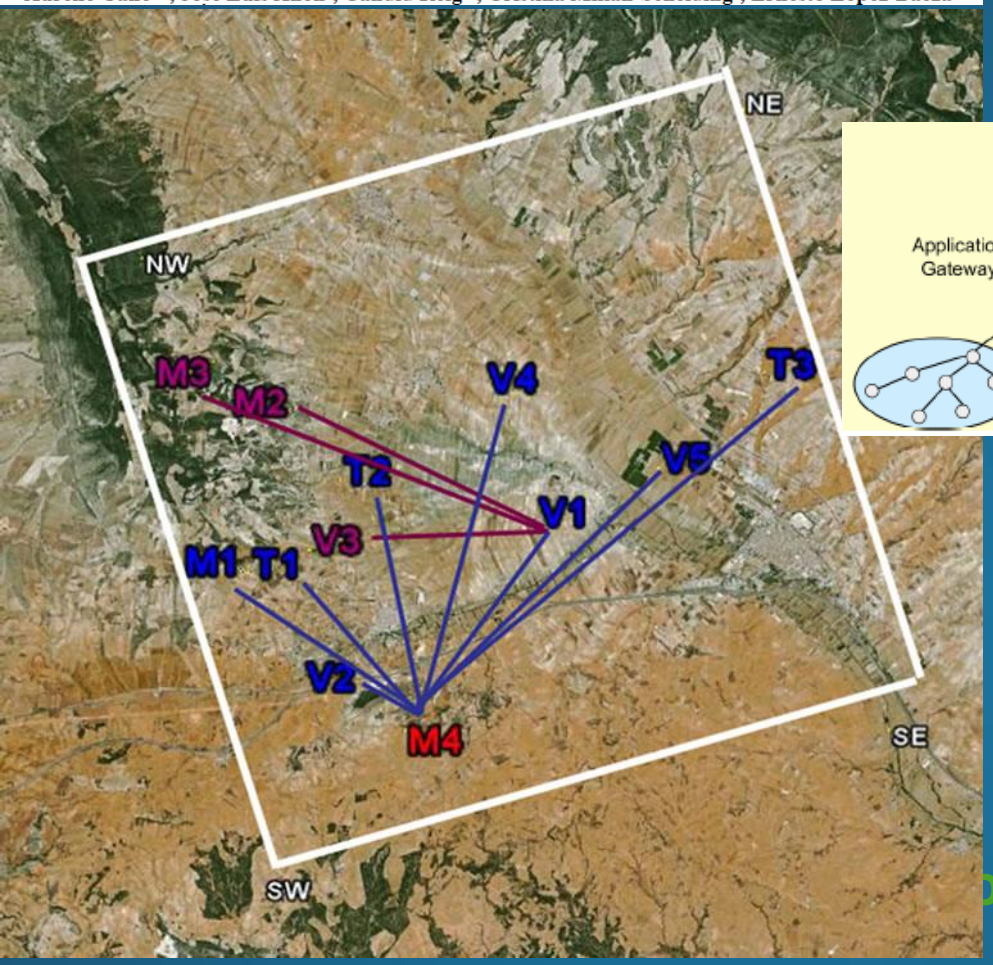
Ground Instrumentation (SM Network)

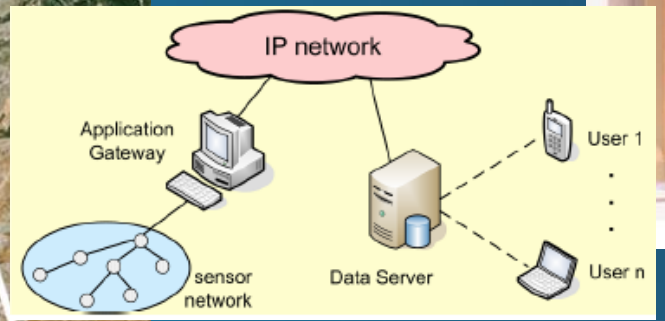
Wireless Sensor Network, 2012, 4, 202-209
http://dx.doi.org/10.4236/wsn.2012.48030 Published Online August 2012 (http://www.SciRP.org/journal/wsn)

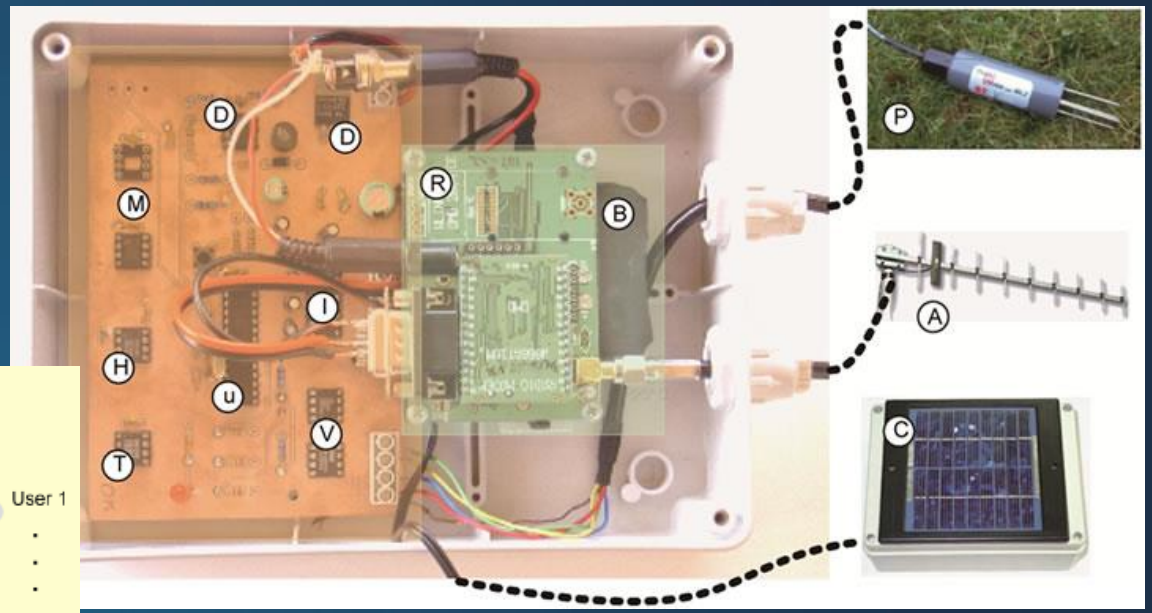
Scientific Research

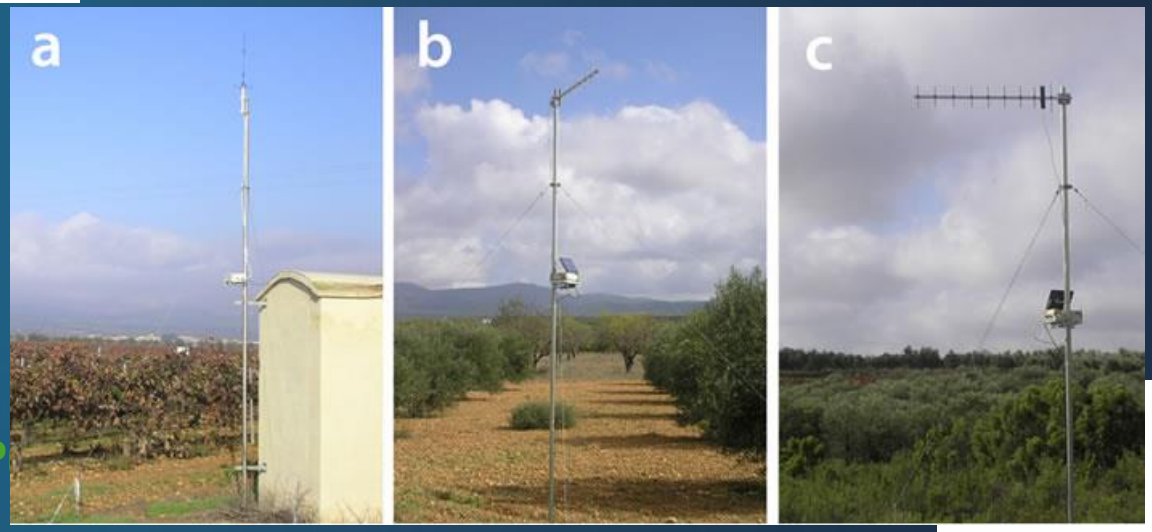
Automated Soil Moisture Monitoring Wireless Sensor Network for Long-Term Cal/Val Applications

Aurelio Cano[1,2], José Luís Añón[1], Candid Reig[1*], Cristina Millán-Scheiding[3], Ernesto López-Baeza[2]



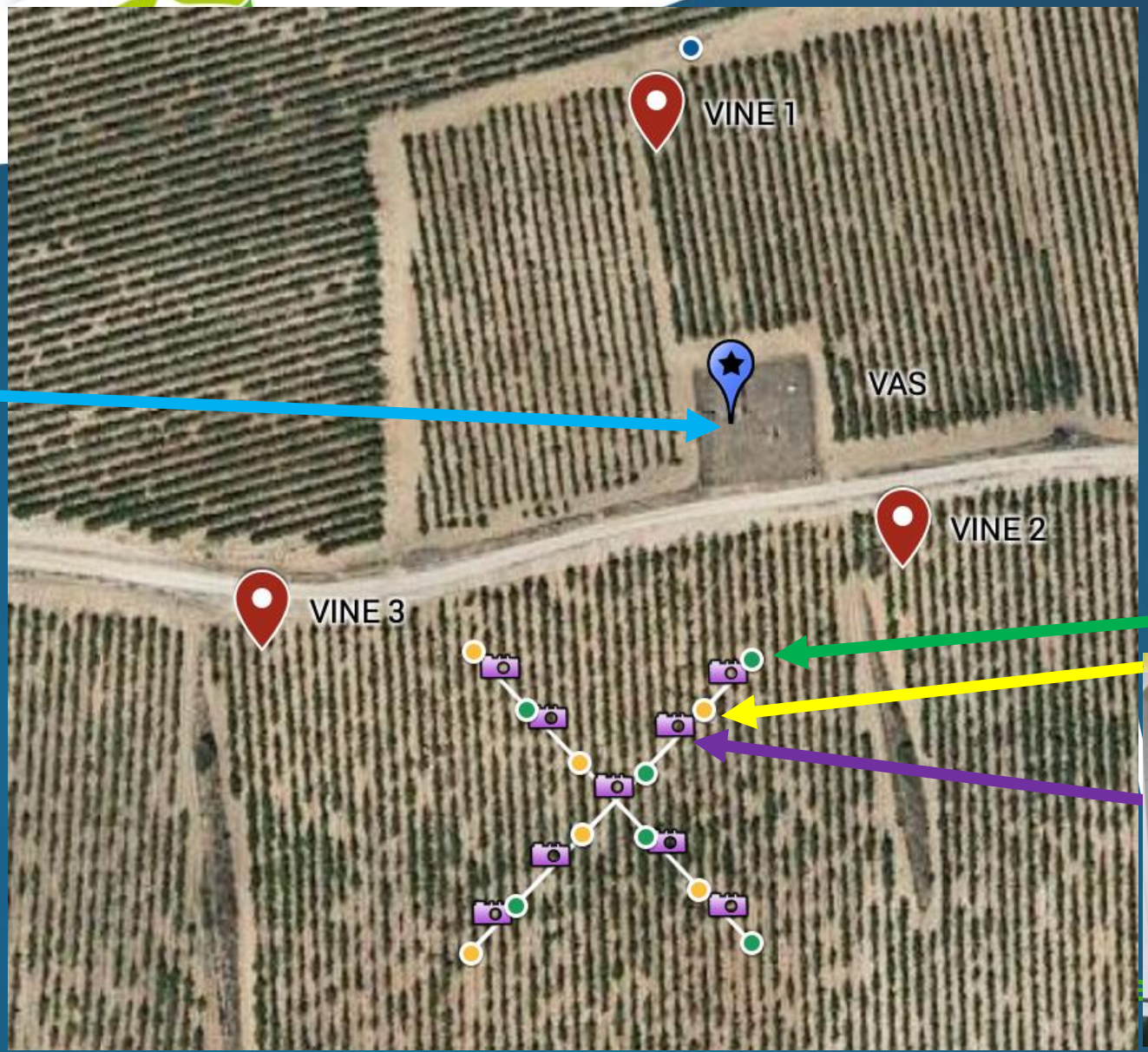




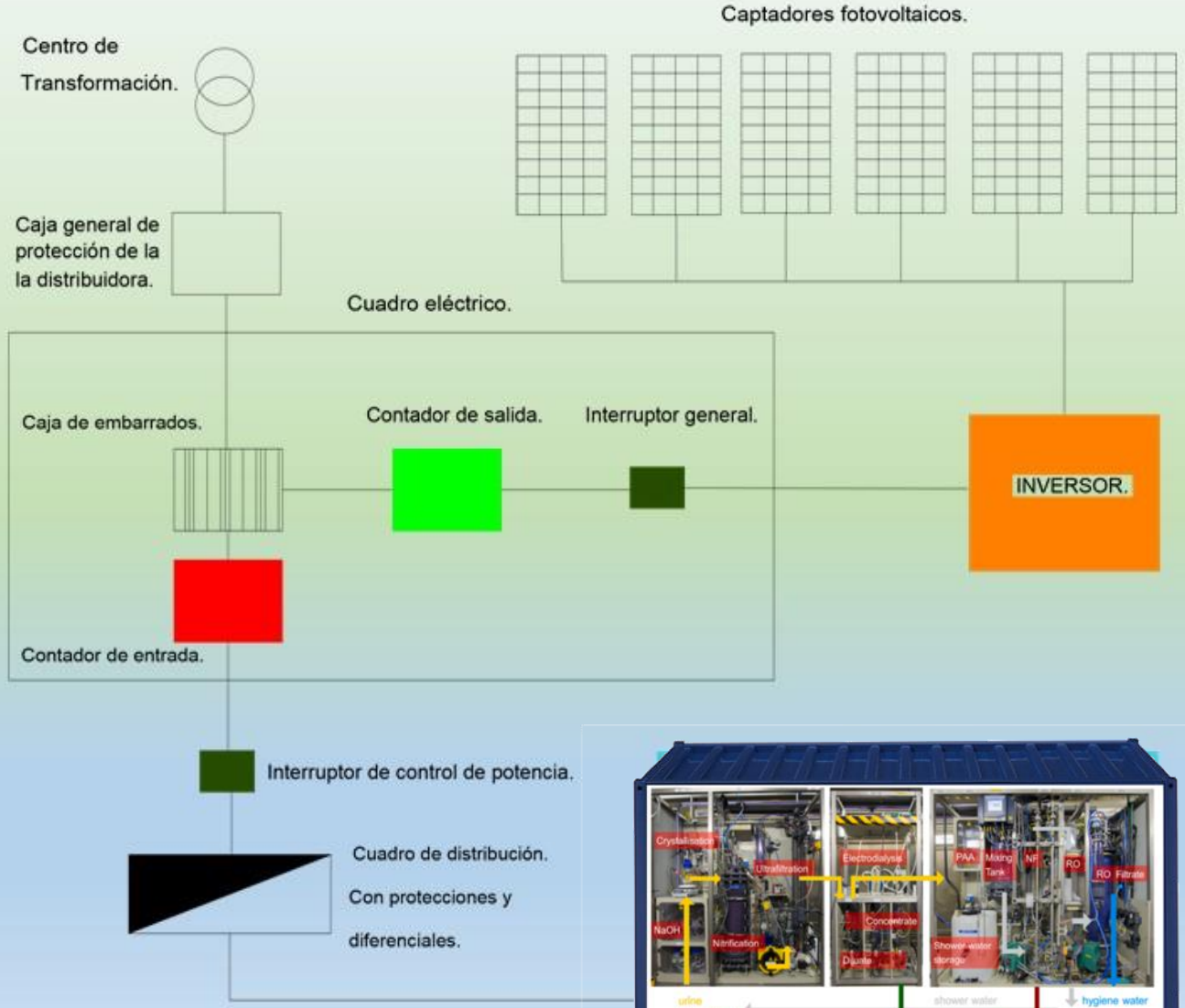


Demonstration Pilot P

Ground Instrumentation (Networks)



ESQUEMA ELÉCTRICO GENÉRICO DE ABASTECIMIENTO ENERGÉTICO MEDIANTE GENERADORES FOTOVOLTAICOS A LA ESTACIÓN DEPURADORA MELISSA.



El esquema genérico presenta la composición y distribución eléctrica de los elementos básicos y equipos para abastecer energéticamente mediante paneles fotovoltaicos y apoyo de fluido eléctrico convencional, en el caso puntual de necesidad de tal forma que la planta sea el mayor tiempo energéticamente independiente de la distribuidora y a su vez vuelque el exceso de corriente eléctrica en los momentos de energía sobrante, obteniéndose un beneficio económico.

Se planteará la vertiente del apoyo mediante acumuladores tras estudio de amortización económico y rendimiento energético.

Power supply

- scalable modul system
- renewable energy
- conventional electrical network support
- surplus retuns (ex. holidays)

Albavalor

reclaimed water reuse

irrigation and fertilisation of the Campus green areas

detecting water needs and N_2 status

- digitisation of the application area
- automatic irrigation based on plant water needs and optimising times and periods
- monitoring water and plant parameters

- remote sensing (UAV + S2) (+ hyperspectral data -tbc)
- soil moisture wireless network
- ground chlorophyll and N_2 measurements

- mapping optimum N crop uptake <doi:10.1017/S2040470017000231>
- crop N monitoring: recent progress and principal developments in the context of imaging spectroscopy missions <https://doi.org/10.1016/j.rse.2020.111758>
- monitoring crop N status by using red edge-based índices <doi:10.1017/S2040470017000243>
- chlorophyll – N_2 content correlations

Red edge-based N_2 indices

Table 1 *Definitions of the Red-Edge vegetation indices applied. The table includes some indications about their use.*

Vegetation Index	Formula	Use	Reference
Red Edge Position	$R_{700} + 40 \times \frac{\left[\frac{R_{670}+R_{780}}{2} - R_{700}\right]}{R_{740}-R_{700}}$	Sensitive in variations of Clorophyll and N.	Guyot *et al.* (1988)
Normalized difference red edge index (NDRE)	$(R_{790}-R_{720})/(R_{790}+R_{720})$	Sensitive in variations of Clorophyll and N.	Fitzgerald *et al.* (2010)
Red edge chlorophyll index ($CI_{red\ edge}$)	$\frac{R_{750}}{R_{720}}-1$	Estimation of N plant uptake at different bandwidths.	Gitelson *et al.* (2005)
MERIS terrestrial chlorophyll index (MTCI)	$(R_{750}-R_{710})/(R_{710}-R_{680})$	N plant concentration after heading. N uptake before heading.	Dash and Curran (2004)
Canopy chlorophyll content index (CCCI)	$(NDRE-NDRE_{MIN})/(NDRE_{MAX}-NDRE_{MIN})$	N plant concentration after heading. N uptake across growth stages.	Fitzgerald *et al.* (2010)
Angular Insensitivity Vegetation Index (AIVI)	$\frac{R_{445}\cdot(R_{720}+R_{735})-R_{573}\cdot(R_{720}-R_{735})}{R_{720}\cdot(R_{573}+R_{445})}$	Stability estimating N at different view zenith angles.	He *et al.* (2016)

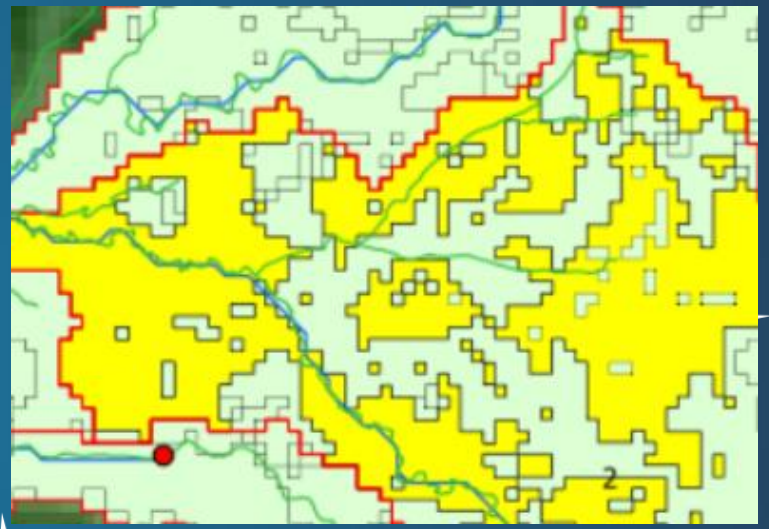
Gonzalez-Piqueras et al. (2017) <doi:10.1017/S2040470017000243>

Secondary objective: Capturing Rainwater and Sustainable Drainage Urban Systems (SDUS)

Rainwater reuse

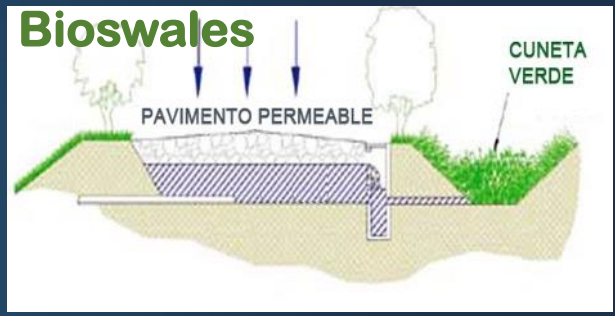
Imperviousness and slope analysis

Urban rainoff model

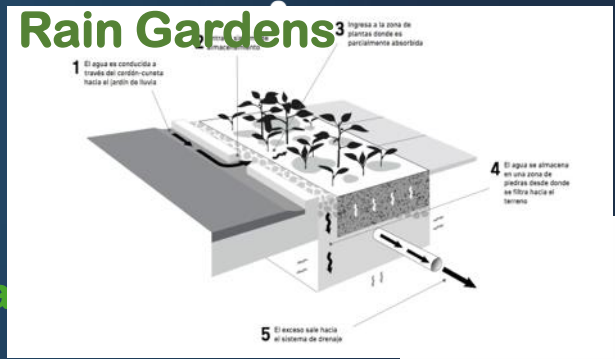


Sustainable Drainage Urban System (SDUS)

Bioswales



Rain Gardens



Interdisciplinarity Academic Faculty Implication

At local –University of Valencia- level

- Faculty of Physics + IRTIC/LISITT + ALBAVALOR
  - Environmental Remote Sensing Group (Climatology from Satellites)
    - MELiSSA
    - Remote Sensing
    - Artificial Intelligence + Data Semantics
    - Smart Agriculture
      - Drone
      - Automatic Irrigation System
    - Rainfall Water and SUDS
- Higher Technical School of Engineering
  - Chemical Engineering
    - Water Treatment, water quality, …
- Faculty of Biological Sciences & Faculty of Pharmacy
  - Environmental Sciences
    - Agriculture and Smallholdings
- ESA
- UAB/MELiSSA Pilot Plant
- Aeroespacial SENER
- SEMiLLA
- UGent

at European level

Marie Skłodowska Curie Actions under Horizon Europe

Doctoral Networks

European Industrial Doctorate

UVEG – MELiSSA Consortium

Integrated Water Cycle Demonstration Pilot Project Using MELiSSA Space Technology

Acknowledgment

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- Christophe Lasseur & Sandra Ortega Ujalde
- MELiSSA Foundation

UVEG
- Maria Victoria Mestre – University of Valencia's Chancellor
- Governing Board
- University's Technical Service & Technical Unit
- Science Campus Technical Unit
- M. Amparo Gilabert – N_2 estimation assessment

- Guido Schmidt -Fresh Thoughts Consulting GmbH https://www.fresh-thoughts.eu/

- BIOAZUL – Water. Energy. Environment https://www.bioazul.com/en/ (TBC)
- IVACE - Valencian Institute of Business Competitiveness - Regional Government
  https://www.ivace.es/index.php/es