DEMOCRATIA-AQUA-TECHNICA

DEMOCRATIA

Democratia-Aqua-Technica

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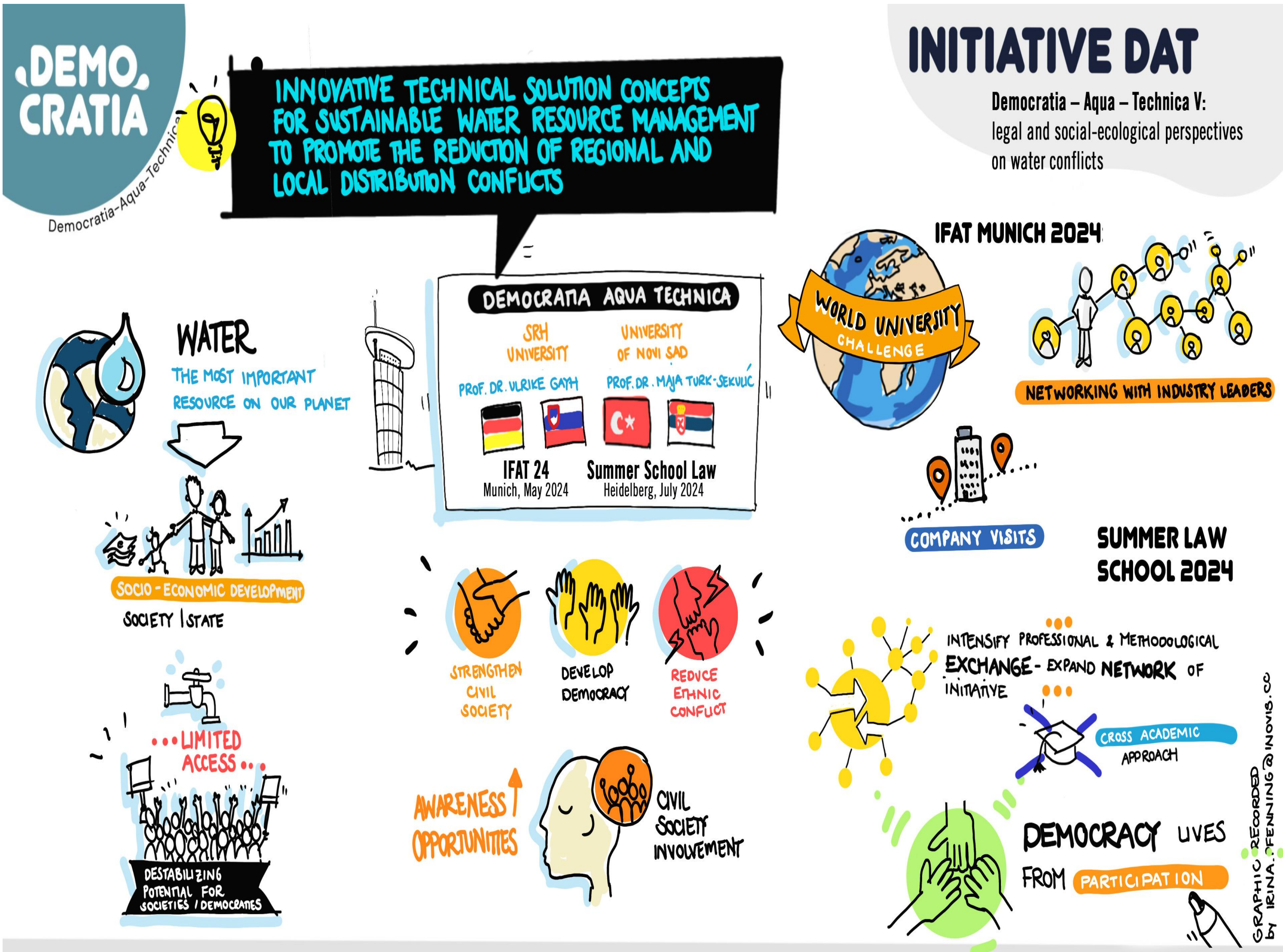

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FOREWORD

The idea of the initiative Democratia-Aqua-Technica is about transforming local and regional water conflicts into pathways to peace and democracy, incorporating innovative science and technology approaches.

The DAAD programme „Hochschuldialog mit den Ländern des westlichen Balkans“ funded the project “Democratia - Aqua – Technica : focus on water conflicts related to water pollution” in 2024.

Four events were planned in 2024 under the umbrella of the Democratia – Aqua -Technica network, which intensified the technical and methodological exchange between the partner universities. The joint project work on socio-political issues also offered an ideal framework for intercultural dialogue at eye level, which in particular provided an exchange of personal experience with civil society engagement.

During the study visit in Germany, a group of Master’s students, PhD-students and professors visited from the University of Novi Sad and SRH University Heidelberg visited together the World’s leading trade fair for environmental technologies, the IFAT in Munich. Next to company visits, a focus had been on digitalization in the German water sector. During the young scientist research week at the University of Novi Sad, water samples were taken and analyzed in the laboratories. Furthermore, field visits, e.g. to the water works, were carried out.

After two years of changing the project into a digital format, it was great that we had been able to carry it out as it was planned. This E-book provides an overview about the different projects and the different contributions to our annual Democratia-Aqua-Technica conference. Thanks to all participants and partners who made the projects and conference that exciting to everybody.
In 2024 we will continue focusing on agricultural water conflicts. The next Democratia-Aqua-Technica conference will be held in September 2025.

Prof. Dr. Ulrike Gayh
Prof. Dr. Maja Turk Seculic

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PROF. DR. ULRIKE GAYH

Ulrike Gayh is Professor for Environmental and Process engineering and is the Dean of the Master´s program in Water Technology (M.Eng.) at the School of Engineering and Architecture of the SRH University Heidelberg. She conducts international research activities in the field of water technology solutions for the prevention and reduction of local and regional water conflicts. Together with colleagues from the Serbian partner university, the University of Novi Sad, she established the Democratia-Aqua-Technica initiative which deals with the question of innovative technical concepts for sustainable water resource management. She has further research interests in the fields of biogas, wastewater management and water protection. The focus being mainly alternative sanitation systems as well and the removal of micropollutants using alternative adsorbents.

PROF. DR. MAJA TURK-SEKULIĆ

Maja Turk-Sekulić is a Professor of Environmental Engineering at the Department of Environmental Engineering and Occupational Safety and Health, Faculty of Technical Sciences, University of Novi Sad. She is a Chair of Master´s academic studies program Water Treatment and Safety Engineering, and Vice President of the Serbian Chemical Society (Section for Environmental Chemistry). Her main activities and responsibilities are teaching, research and leadership in national and international scientific projects. Her main areas of specialization are green technologies for wastewater treatment, wastewater management, monitoring and low-cost decontamination and remediation; The partitioning, dispersal and retention of organic pollutants in Biotic and Abiotic Systems; Analysis, environmental processes, and the fate of POPs in the environment, biotic and abiotic transformations. Other fields of specialization are air pollution, gas/particle partitioning, and the partitioning of polychlorinated biphenyls.

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Democratia-Aqua-Technica

Democratia -Aqua -Technica V:

⇒focus on legal and social-ecological perspectives on water conflicts

⇒IFAT in Munich, May 2024

Company visits

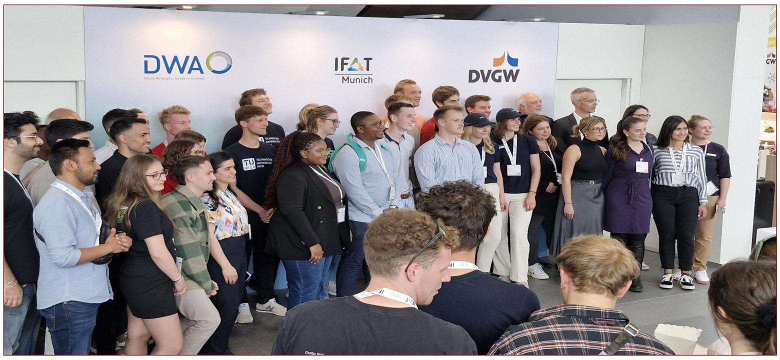
Networking

World University Challenge

⇒Study Visit in Heidelberg, July 2024

Summer School Law

IFAT in Munich



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Study Visit in Heidelberg

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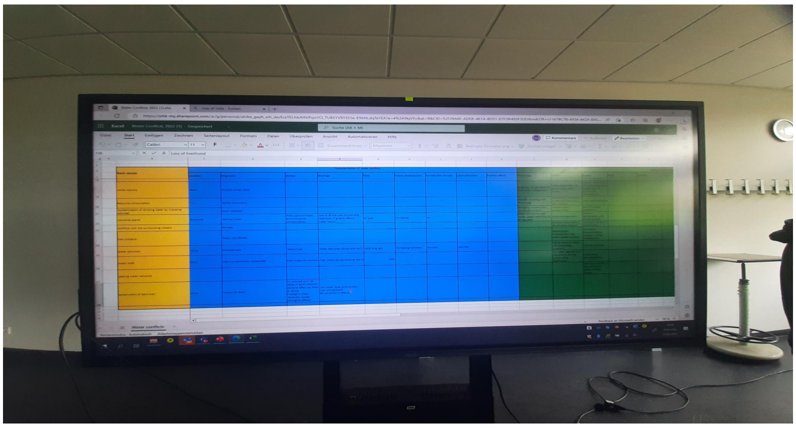
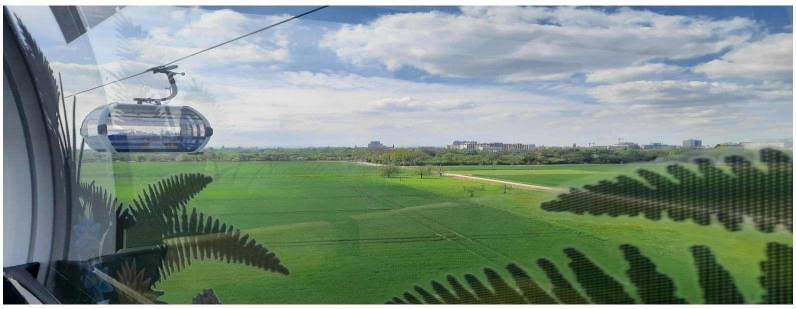
Democratia-Aqua-Technica

The project 2023

Initiative Democratia-Aqua-Technica

Practical in Heidelberg





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Democratia Aqua - Workshop - Heidelberg - Aftermovie - YouTube

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The project 2022

Initiative Democratia-Aqua-Technica

<u>Practical in Novi Sad</u>

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PROGRAM DAY 1

Time (CEST)	Title	Speaker
09:30 – 10:00 a.m.	Welcome from project leaders Democratia-Aqua-Technica	Prof. Dr. Ulrike Gayh (SRH University Heidelberg, Germany), Prof. Dr. Jelena Radonic (University of Novi Sad, Serbia)
10:00 – 10:30 a.m.	Bathroom savings: Combining IoT-sensors, data and behavioral changes	Anders Barkholt (Aguardio, Denmark)
10:30 – 11:00 a.m.	Challenges and limitations in the application of machine learning for water quality assessment	Dr. Jelena Antović and Ivana Mihajlović, (University of Priština)
11:00 – 11:30 a.m.	Evaluation of the Performance of a Nanofiltration Membrane Filter Doped with Magnetic Zeolite for the Removal of Heavy Metals from Water	Koffi Sossou (University of Andhra, India)
11:30 – 12:00 p.m.	Poster presentations	
12:00 – 01:30 p.m.	Lunchbreak	
01:30-02:00 p.m.	Biohydrogen Production from Wheat Straw and Chicken Manure.	Prof. Dr. Yasemin Dilsad Yilmazel, Idilay Konar (Middle East Technical University, Turkey)
02:00-02:30 p.m.	Agricultural Water Management Policies and Challenges: Initiative for Blue Peace in the Middle East	Prof. Dr. Oner Cetin (Dicle University, Turkey)
02:30-03.00 p.m.	Optimization of an Electrocoagulation system for the Primary Harvesting of microalgae biomass for Biofuel Production	Amma Konadu Adjei (KNUST, Ghana)
03.00-03.30 p.m.	Poster presentations	
04:30 – 06:00 p.m.	Digital city rallies Heidelberg and Novi Sad - water and architectural highlights of the cities	

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PROGRAM DAY 2

Time (CEST)	Title	Speaker
9:30 – 10:00 a.m.	Welcome + Coffee	Prof. Dr. Jelena Radonic (University of Novi Sad, Serbia) / Prof Dr. Ulrike Gayh (SRH University Heidelberg, Germany)
10.00-10.30 a.m.	Life Cycle Assessment of Wastewater Treatment Operation - A Case Study of the Kumasi Wastewater Treatment Plant.	Bridget Quansah (SRH University Heidelberg, Germany / KNUST, Ghana)
10.30-11.00 a.m.	PM2.5 air pollution during heating and non-heating seasons in ambient air of Novi Sad, Serbia	Prof. Dr. Jelena Radonić, Sonja Dmitrašinović (University of Novi Sad, Serbia)
11.00-11.30 p.m.	The STREAM project - The Sounds of the Danube: Towards an Interdisciplinary Environmental Education	Vilmaurora Castillo, Dr. Fernando Palacios, Prof. Dr. Ulrike Gayh (SRH University Heidelberg, Germany)
11.30-12:00 p.m.	Poster presentations	
12:00 – 01:30 p.m.	Lunchbreak	
01:30 – 02:00 p.m.	A review on methods of water treatment and reusing, saving and preservation	Prof. Dr. Mohammad Ghomi (SRH University Heidelberg, Germany)
02:00 – 02:30 p.m.	Study and characterization of runoff coefficients for the Department of Cauca: Implementation guide focused on water security	Felipe Agredo (Hydraulic Engineering Department, School of Civil Engineering, Columbia)
02:30 – 03:00 p.m.	SRH Humanitarian Engineering Project. Appropriate Technology Development Process.	Prof. Dr. Livier de Regil + students MWT (SRH University Heidelberg, Germany)
03:00 – 03:30 p.m.	Poster presentations	
03:30 – 04:00 p.m.	Closure and Outlook Democratia-Aqua-Technica Initiative	Prof. Dr. Jelena Radonic (University of Novi Sad, Serbia) / Prof Dr. Ulrike Gayh (SRH University Heidelberg, Germany)

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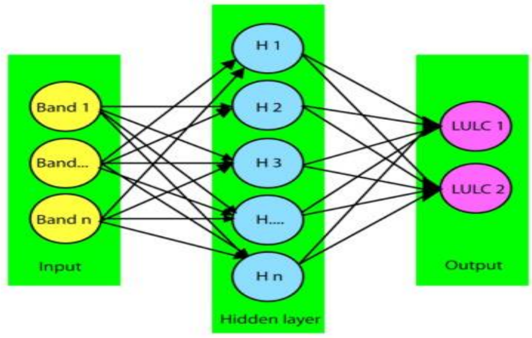
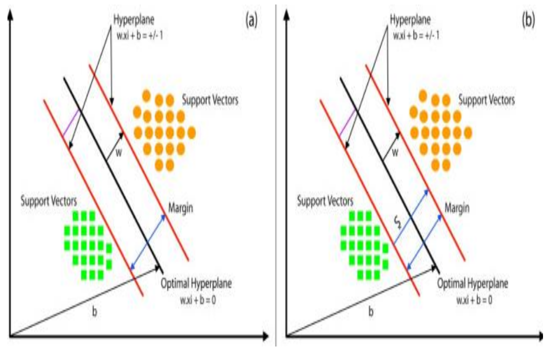
CHALLENGES AND LIMITATIONS IN THE APPLICATION OF MACHINE LEARNING FOR WATER QUALITY ASSESSMENT

Dr. Jelena Antović, Ivana Mihajlović

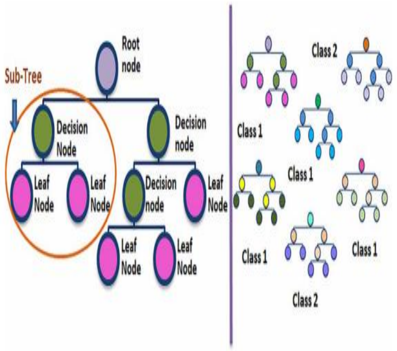


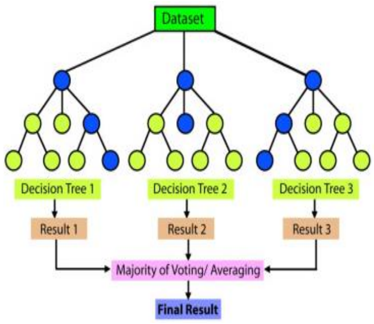
This presentation provides a comprehensive analysis of the challenges and limitations associated with the application of machine learning in water quality assessment. It focuses on exploring various algorithms, their advantages and disadvantages, as well as opportunities for improvement and future development.

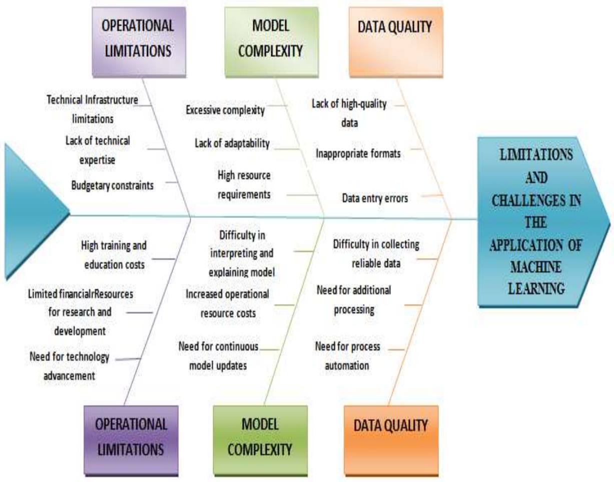
• Machine Learning (ML) is a branch of Artificial Intelligence (AI) that enables computers to learn from data and make decisions without explicit programming.



• In the context of water resource management, ML is used for analysis, prediction, and monitoring of water quality, offering advanced methods to tackle complex problems that surpass traditional approaches.







Algorithm	Advantages	Disadvantages	Specific Applications
Regression Models	- Simple to implement - High interpretability	- Sensitive to anomalous data	- Analysis of trends in water quality
Artificial Neural Networks (ANN)	-Capable of modeling complex nonlinear relationships	- Significant computational resource demands	- Modeling intricate patterns
Support Vector Machines (SVM)	- Effective in high-dimensional spaces - Suitable for smaller datasets	- Poor scalability with very large datasets - Requires meticulous parameter tuning	- Water quality classification - Anomaly detection
Random Forest (RF)	- High accuracy - Robust against overfitting - Manages a large number of variables effectively	- Elevated resource requirements - Limited interpretability	- Feature importance evaluation - Pollution prediction
Deep Learning	- Models complex patterns effectively - High accuracy for large datasets	- High computational resource requirements - Difficult to interpret results	- Complex time series analysis - Pattern recognition in extensive datasets

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MODERNIZATION AND WATER PRODUCTIVITY IN AGRICULTURAL WATER USE: INNOVATIVE APPROACHES

Dr.Oner CETIN

Population → Pollution → Poverty

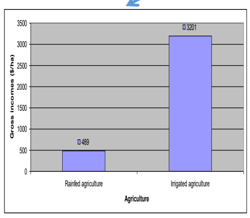
More food demand
More use of resources
Environmental issues

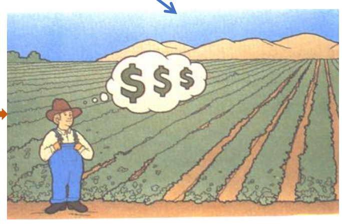
The Water-Energy-Food-Ecosystem Nexus (WEFE Nexus) approach highlights the interdependence of water, energy and food security and ecosystems

The WEFE Nexus approach uses context-specific solutions based on different levels of interventions to achieve long-term economic, environmental, and social goals..

IRRIGATION

INCREASING YIELD
1-5 Folds

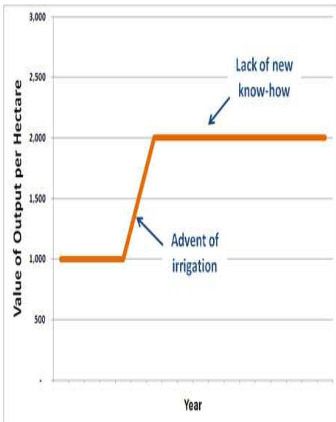




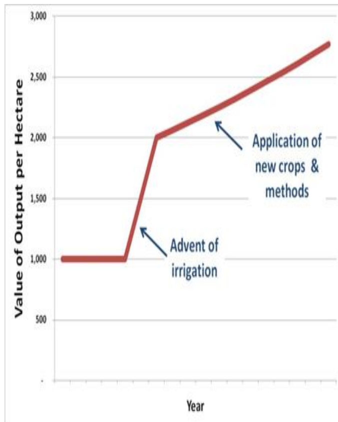
Misuse, Mismanagement
Climate Change
Population growth
Economic growth
Land use change

→ WATER SCARCITY

Climate Change
↓
Reduced water availability
Increased drought



The effects of irrigation



The expected effects of irrigation

PRESSURIZED IRRIGATION SYSTEMS

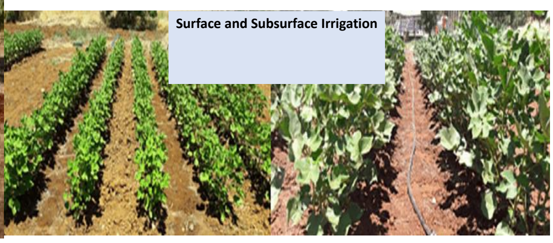
Sprinkler

Center-pivot

Big gun

Mini sprinkler

Surface and Subsurface Irrigation



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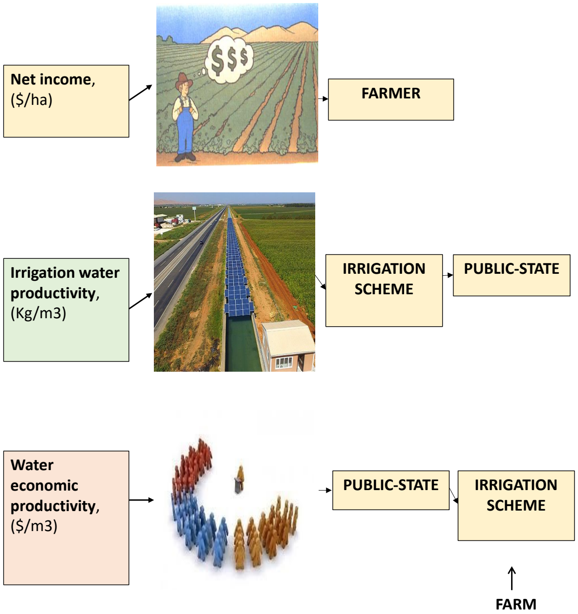
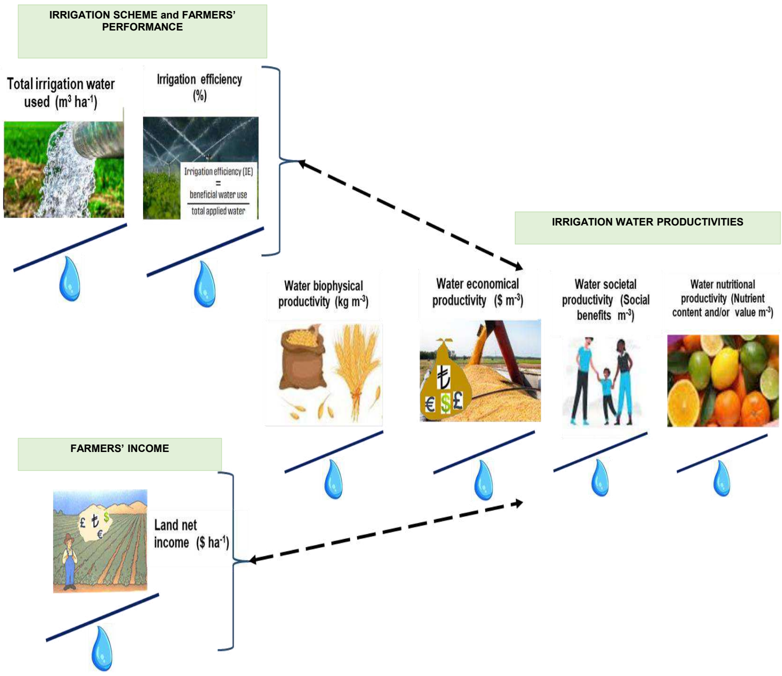
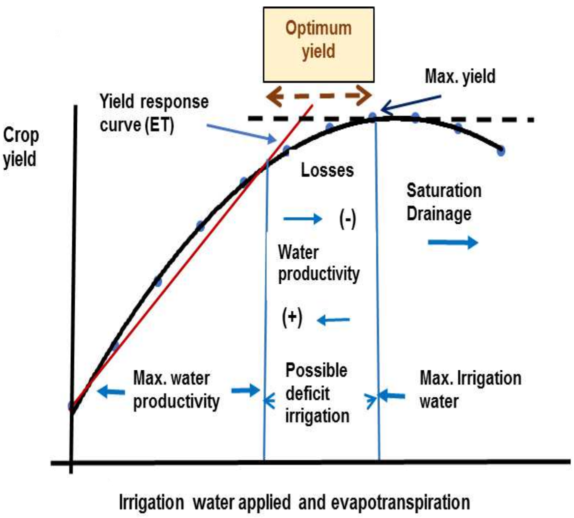
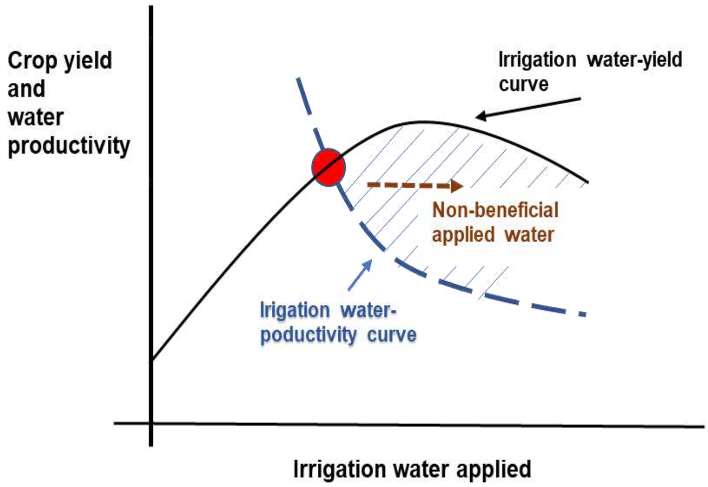
Sulama sistemlerinin geliştirilmesi → Modern sulama sistemlerinin kullanımı







Optimum (economical) yield ≤ Max. yield



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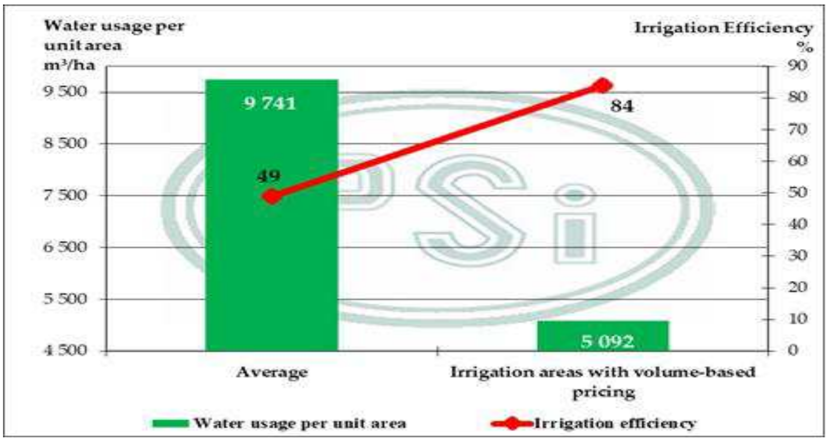

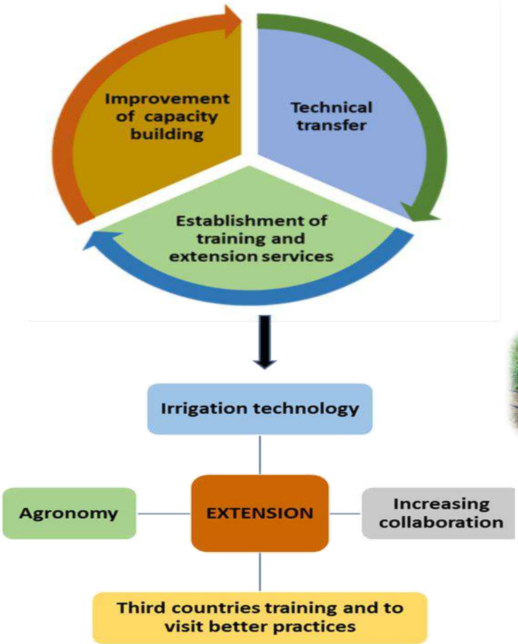

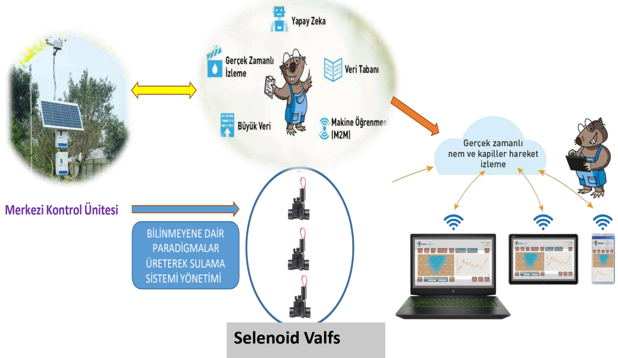

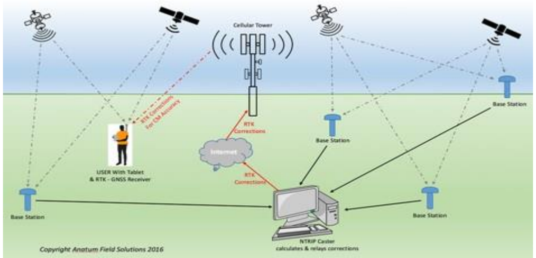

The use of technology is crucial to save time, inputs and water and to increase water productivity.

However;

1. **Suitable infrastructure of agricultural lands (land leveling, consolidation, land roads etc.)**

2. **Users need to adopt and adapt to the modern technologies**

3. **For sustainable use, a trained and experienced users and/or farmers**

4. **The use of modern technology such as smart systems and artificial intelligence is not always the only unique solution or panacea. Because socio-cultural and economic conditions directly affect this situation.**

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OPTIMIZATION OF AN ELECTROCOAGULATION SYSTEM FOR THE HARVESTING OF MICROALGAE BIOMASS FOR BIOFUEL PRODUCTION

AMMA KONADU ADJEI

Democratia-Aqua-Technica

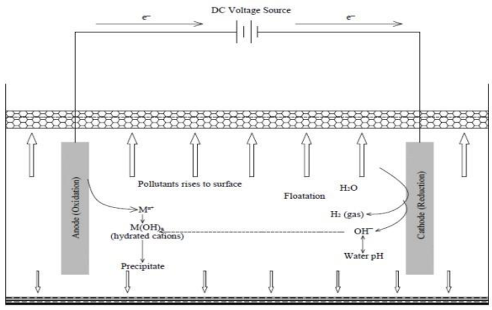

Fig: Diagram of a basic Electrocoagulation (EC) cell (Bharath, Krishna and Manoj Kumar, 2018).

STAGES OF AN EC PROCESS

Formation of coagulants by electrolytic oxidation of the sacrificial electrode.

Destabilization of the particulate suspension.

Aggregation of the destabilized particles to form flocs.

MICROALGAE CULTIVATION

- Species: Green algae freshwater strain *Chlorella sp.* – CSIR-WRI, Accra.
- Growth medium – Bold's Basal (BBM)
- Growth conditions – Light intensity 1000 lux, temperature 25 – 28 °C, pH 7-9, 16-20:4-8 h dark: light cycle, air mixing by air pump.
- Growth monitoring – optical density (OD) via UV-Vis + Calibration curves.

ELECTRO-COAGULATION EXPERIMENTS

EC SETUP	EC CONSTANTS	EC VARIABLES
• EC cell • Al plate electrodes • DC power source • Magnetic stirrer	• 25°C • 1 cm electrode distance • 150 rpm • 100.8 cm2 active Al	• Voltage • pH • Time • NaCl conc.

RESPONSE SURFACE METHODOLOGY MODELLING

MINITAB® 20

- Design of experiments (DOE) and optimization
- Full Central Composite Design (CCD) with 4 variables
- Total 30 experiments
- 3 responses – Recovery efficiency, Metal and Energy consumption.

ARTIFICIAL NEURAL NETWORK MODELLING

MATLAB R2021a

- Experimental data from RSM
- A multilayer feedforward neural network (MLP)
- Levenberg-Marquardt backpropagation algorithm
- 4-5-1 neuron architecture (for each response)

Table : Summary table for performance of ANN models.

Output	No. of hidden neurons	MSE training set	MSE validation set	R^2 of training set	R^2 of validation set	R^2 of overall data set
Recovery Efficiency	5	0.00032	0.00057	0.99	0.97	**0.99**
Aluminium Dissolution	5	0.00014	0.00021	0.93	0.91	**0.93**
Energy Consumption	5	0.0019	0.0154	0.99	0.93	**0.95**

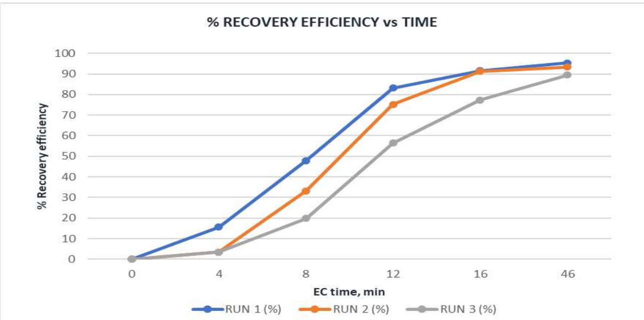

Fig : Recovery efficiency (%) of *Chlorella sp.* as a function of Electrocoagulation (EC) process time.

Table : Minitab® 20 Response Optimizer conditions for maximum algae recovery at minimum energy and metal requirements.

	pH	NaCl	Time	Voltage
Solution	5	4	15	6.08
Experimented	5	4	16	5.5

Table : Experimental results for EC runs at Optimizer conditions

	Energy Fit	Al Dissolution Fit	Recovery Fit
Solution	1	0.084	92.080
Experimented	0.953 ± 0.068	0.04 ± 0.01	92.76 ± 3.05
Deviation	-4.67	-51.76	-0.18

ASSUMPTION

Cost requirements are based on experimental data and parameters obtained from the EC experiments run at optimum conditions.

OVERALL OPERATIONAL COST OF EC PROCESS

OPEX was **$ 0.19/m3** calculated from:

$$OPEX\left(\frac{\$}{m^3}\right) = (E \times C_E) + (M \times C_M) + (C \times C_C) \quad \ldots\ldots\ldots (Eqn. 4)$$

where E, M and C are energy (kWh/m^3), metal (g/m^3) and chemical consumption (g/m^3), and C_E, C_M and C_C are the unit prices of electricity, metal and chemicals (Abdulhadi et al., 2021).

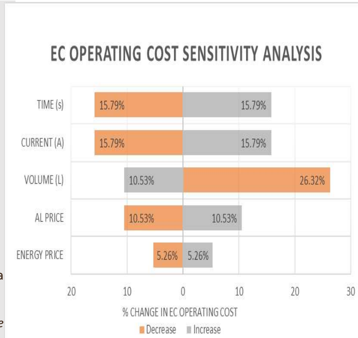

Fig 14: Sensitivity analysis of selected parameters on the overall cost of the EC process at optimum conditions.

- Electrocoagulation (EC) can efficiently harvest microalgae from its culture medium.
- Modelling results showed that the recovery efficiency and Al dissolution depends on all independent factors, while the energy consumption seems to depend only on the process time and voltage.
- **By using low currents and process times**, EC can achieve high recovery while minimizing energy and metal requirements.

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A REVIEW ON METHODS OF WATER TREATMENT AND REUSING, SAVING AND PRESERVATION

Dr. Mohammad R. Ghomi

Democratia-Aqua-Technica

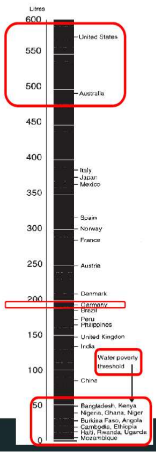
WATER SHORTAGE KEY FACTS:

- Half of the world's population (about 4 billion people) experience severe water scarcity for at least one month each year.
- World population, which is steadily increasing by roughly 85 million per year. Thus, the availability of freshwater per capita is decreasing rapidly.
- Globally, 2 billion people have no access to clean drinking water now (UN, 2022).
- Every day, 2 million tons of human waste are disposed of in water resources.

Water consumption per capita (and consumption pattern)

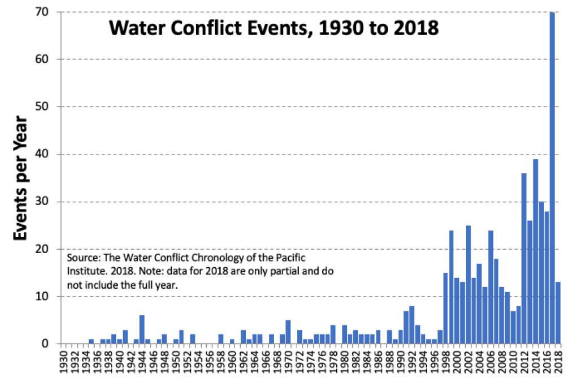
- **Germany** uses nearly 160 billion cubic meters of water a year:
- 73% of which goes to **agriculture**
- 23% to **industry**
- about 4% to **domestic use**.

- The UK has one of the **lowest per capita water usage rates** in the developed world, with the USA and Australia topping the consumption rates at 580 and 495 l/ca/d, respectively.

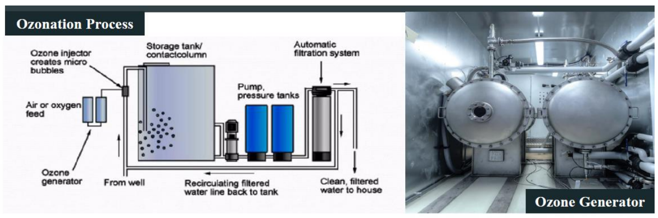


The Water Conflict Chronology

- Attacks on civilian water systems in Middle Eastern conflicts, especially in Yemen, Syria, and Iraq, are notable new cases.
- As extreme drought worsens, farmers in Africa are fighting over scarce water resources.



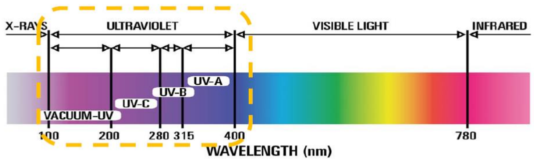
Methods of water treatment and reusing, saving and preservation (development of studies, knowledge, techniques, monitoring, …)



- Ozone water treatment is the process of using ozone to purify water that is mainly removing microorganisms that can make you sick from drinking water.
- This process has been used in drinking water plants since 1903 where the first industrial ozonation plant was built.

Results of ozone application on some protozoa

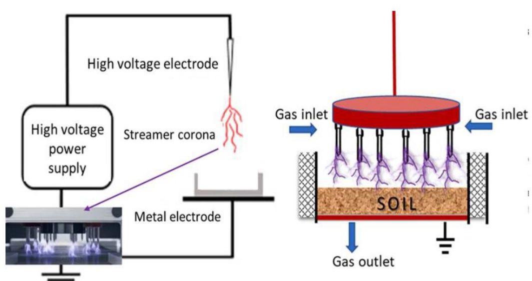
Organisms	Dose O_3 (mg/L)	Time (min)	Temperature °C 5	10	15	20	25	pH	log	Reduction (%)	References
Giardia lamblia	5-10	0.94- 5	---	----	----	----	----	7	1.0	99	[1]
Giardia lamblia	10	----	0.32	0.23	0.16	0.12	0.08	----	0.5	99.9	
			0.63	0.48	0.32	0.24	0.16		1.0		[7]
			0.95	0.72	0.48	0.36	0.24		1.5		[16]
			1.3	0.95	0.63	0.48	0.32		2.0		
			1.6	1.2	0.79	0.60	0.40		2.5		
			1.9	1.4	0.95	0.72	0.48		3.0		
Giardia muris	----	2.8-12.9	----	----	----	----	----	7	----	----	[1]
Cryptosporidium	50/50	----	----	----	----	----	----	7	----	99	[23]
parvum	100/0										[24]
Poliphaga sp.	----	4	----	----	----	----	----	----	----	95	[23]



Electromagnetic Spectrum

- For disinfection, UVC radiation in the range from 240 to 280 nm is used.

Plasma mechanism



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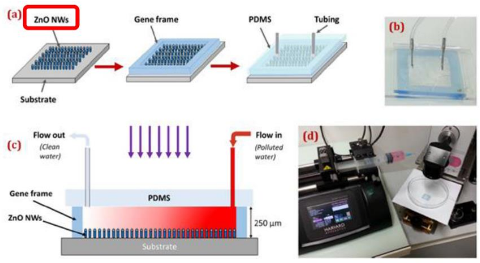
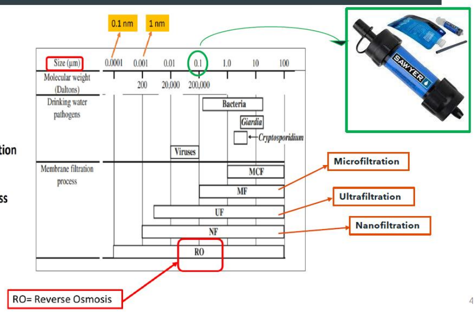
2.1.4 PHOTOCATALYST

Combination of nanomaterials e.g. ZnO/TIO$_2$ and UV



2.1.5 MEMBRANES

Comparison of membrane filtration applications in drinking water treatment process

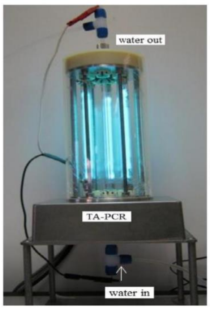


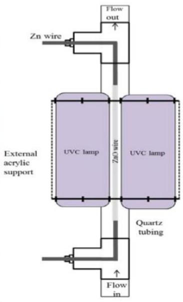
.2024

4

srh

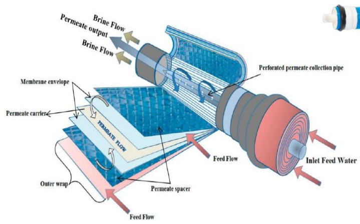
Tubular batch photocatalytic reactor





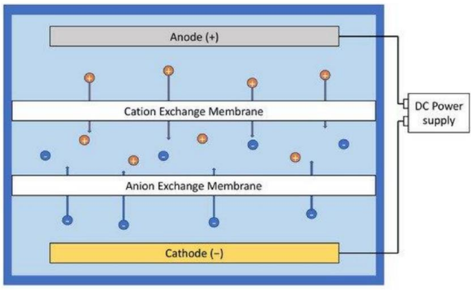
srh

Reverse Osmosis (RO):
Mainly in water treatment and desalination



2.1.6 ELECTRODIALYSIS

Separation of ions based on charged membranes



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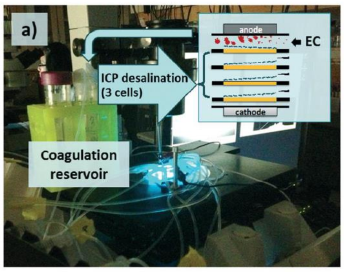
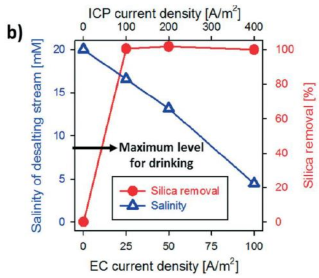
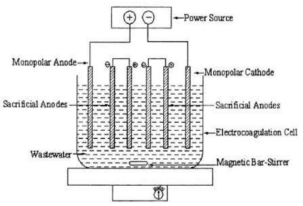




2.1.8 ELECTROCOAGULATION

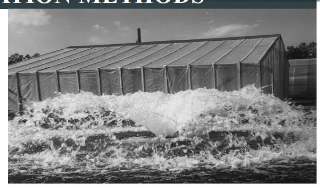


Using mainly in settling down the impurities of wastewater based on electrical charges

2.1.9 AERATION METHODS

To increase amount of water oxygen (for wastewater treatment)

1. Vertical pumps
2. Pump sprayers
3. Propeller-aspirator-pumps
4. Paddle wheels
5. Venturi pumps
6. Air blowers

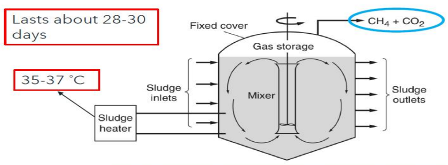


A vertical pump aerator

2.2.1 ANAEROBIC DIGESTION

Lasts about 28-30 days

35-37 °C



Mannheim wastewater plant's biogas towers

- Anaerobic digestion involves the decomposition of organic matter and reduction of inorganic matter in the absence of molecular of oxygen.
- Large fraction of digested organic matter (85-95%) is converted to biogas.

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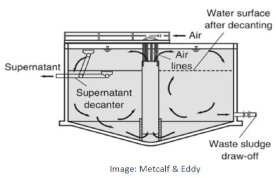
2.2.2 AEROBIC DIGESTION



Aerobic digestion may be used to treat:

waste activated sludge/ primary sludge (when we have extra amount of sludge)

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STUDY AND CHARACTERIZATION OF RUNOFF COEFFICIENTS FOR DEPARTMENT OF CAUCA: IMPLEMENTATION GUIDE FOCUSED ON WATER SECURITY

Felipe Agredo

Democratia-Aqua-Technica

Correlate runoff coefficients (C) and curve numbers (CN) in 41 watersheds in the department of Cauca.

Due to the difficulty of access and social conflicts, the installation of hydrometric stations is limited,

making the integration of GIS methods very necessary for watershed characterization (Digital elevation

models, geological and land cover maps were used to classify hydrological soil groups and slopes - SCS).

Code.py the characterization. The implementation criteria were validated using a watershed characterized

by LiDAR, yielding values that differed by 16%.

With temporal monitoring, an indicator of the evolution of land cover and water supply (quantitative and

qualitative estimates), particularly in high mountain watersheds, will be obtained.

We made the quality water monitoring using bioindicators (aquatic macroinvertebrates) in the Puracé

National Park in the last 5 years (except 2020).

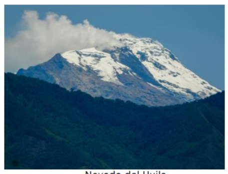
ABOUT THE CLIMATE

It is determined by its relief and geographical position, resulting in the presence of all thermal floors, from the super-humid warm climate found on the Pacific coast of Cauca to the perpetual snows of Nevado del Huila.


Gorgona Island


Patia Valley


PNN Puracé
by Kelvin Girón


Nevado del Huila
by SGC

OBJECTIVES

Assess water security (quantity and quality) through the temporal monitoring of runoff coefficients in watersheds.

Characterize land cover, soils, and slopes for the 41 watersheds in the study and estimate runoff coefficients.

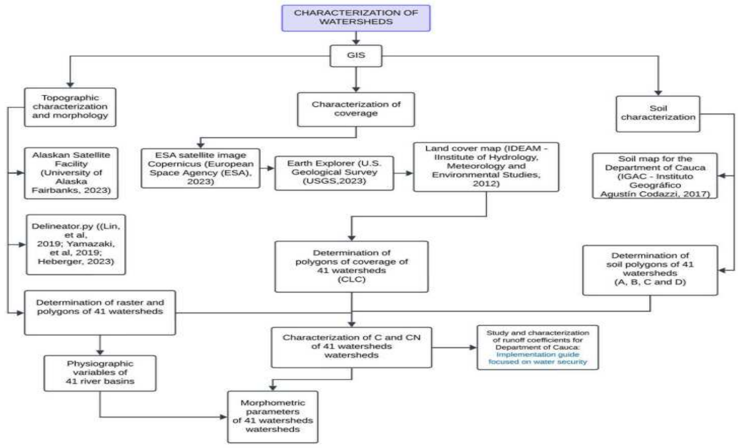
Create an implementation guide for the coefficients that can be extended to any watershed within the study polygon, considering the specific conditions of the region.

Validate the results obtained against radar characterization.

Assess and project water supply, considering hydrological models, time series analysis, and field measurements.

Assess water quality using bioindicators in a National park of the Colombian massif.

METHODOLOGY



METHODOLOGY

Information Analysis.

Soils have been classified into four different groups according to the drainage manual for roads by INVIAS (INVIAS, 2009). The four classifications are:

- **A** **(Low runoff potential).** Soils that have a high infiltration rate even when very wet. They consist of deep sands or gravels, well to excessively drained. These soils have a high water transmission rate.
- **B** **(Moderately low runoff potential).** Soils with a moderate infiltration rate when very wet. Moderately deep to deep soils, moderately well-drained to well-drained soils, with moderately fine to moderately coarse textures, and moderately slow to moderately fast permeability. These soils
- **C** **(Moderately high runoff potential).** Soils with slow infiltration when very wet. They consist of soils with a layer that impedes downward water movement; soils with moderately fine to fine textures; soils with slow infiltration due to salts or alkalinity, or soils with moderate groundwater levels. These soils may be poorly drained or well to moderately well-drained, with layers of slow to very slow permeability at shallow depths (50-100 cm).
- **D** **(High runoff potential).** Soils with very slow infiltration when very wet. They consist of clay soils with high expansion potential; soils with a high permanent groundwater level; soils with a shallow clay layer; soils with very slow infiltration due to salts or alkalinity, and shallow soils over nearly impermeable material. These soils have a very slow water transmission rate.

METHODOLOGY

Information Analysis.

- Trimming of vector files containing **land cover** and soil information to obtain only the data relevant to the study area.
- A "dissolve" function is applied to each of the trimmed polygons, merging areas with the same characteristics into a single polygon.
- Soil classification into four different groups according to the INVIAS Highway Drainage guide.

Example of soil type classification according to the researchers.

UCS	Characteristic	Type	Justification.
MKB	Deep to very deep, well drained, moderately coarse and coarse textures, extremely to strongly acidic, high aluminum saturation, light to moderate erosion and low fertility.	A	Despite having moderately coarse textures, great depth, high drainage capacity and low fertility are characteristics of type A soils.

METHODOLOGY

Information Analysis.

- The information on **soil texture** was analyzed. It affects many land uses and cannot be changed unless significant costs and efforts are incurred. Texture influences many physical, chemical, and biological processes, as well as properties such as water retention capacity, water movement through the soil, soil strength, natural fertility, and the ease with which contaminants can leach into groundwater.
- Coarse texture: Soils where sand predominates. Fine texture: Soils where clay predominates. Medium texture (loam): Soils where sand, clay, and silt are in balance (Polanco, 2009).

Property	Coarse	Medium	Fine
Water storage	Low	Medium	High
Water movement	Low	Medium	High
Force required for tillage	Low	Medium	High
Wind to water erosion (ease of separating particles)	High	Medium	Low
Wind to water erosion (ease of transporting particles)	Low	Medium	High
Nutrient storage for plants	Low	Medium	High
Contaminant movement	High	Medium	Low

Hydrological characteristics of soil textures.

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RESULTS

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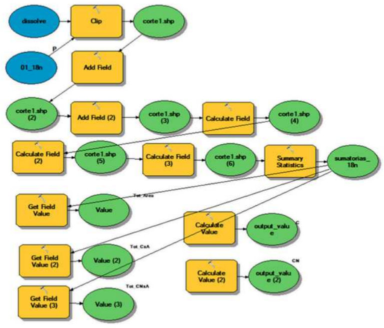
- A code was developed to calculate C and CN for any polygon that falls within the working area.
- The following script was generated, where the only input is the polygon for which C and CN are to be calculated, called C and CN Calculator.

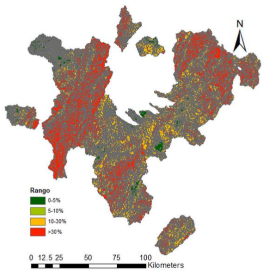


Flowchart for calculating C and CN for any polygon within the study area.

RESULTS

DEMOCRATIA

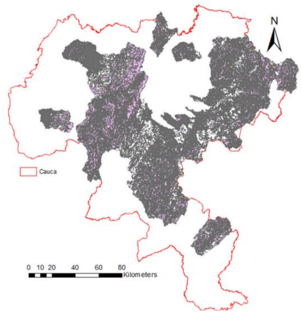
- Processing of digital elevation models to characterize land slopes.
- These slopes were reclassified into four classes, according to the guidelines of the drainage manual for roads by INVIAS
- Four slope polygons were obtained: flat, rolling, mountainous, and steep.
- Geospatial operations were conducted to obtain the intersection of the coverage, soil, and slope maps, in order to estimate the weighted runoff coefficient (C) for each watershed.



RESULTS

DEMOCRATIA

- Six soil polygons were obtained: A, B, C, D, ZU, and CA.
- Thirty-three land cover polygons were obtained according to the CLC methodology.
- Information on land cover and soils was cross-referenced to estimate the weighted curve number (CN) for each watershed..
- After the information was cross-referenced, through union and dissolution, 496 polygons were obtained to characterize C and CN



RESULTS

DEMOCRATIA

- A value of C was assigned to each obtained polygon, considering the information from the runoff coefficient tables (Monsalve S., 1999).
- For the assignment of the CN value to each obtained polygon, the information from the curve number tables was considered (ASCE/EWRI Curve Number Hydrology Task Committee, Richard H. Hawkins, Environmental and Water Resources Institute (U.S.), 2009).

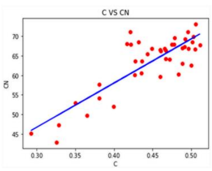
Example of classification of C and CN coefficients according to the researchers

Legend	C (1 for bodies of water, and the same value of clay for urban areas and soils A: sandy loam, soils B and C: clayey silt loam and soils D: clayey)	CN (100 for bodies of water, and the same value of D for urban areas and mostly regular hydrological condition*)
1.1.1. Continuous urban fabric	Multi-family houses connected 0.75	Permeable areas formed (according to hydrological classification) 76, 87, 91 or 94
2.3.1. Clean pastures	Pastures (depending on slope) 0.1, 0.16, 0.22 o 0.3, 0.36, 0.42 O 0.4, 0.55, 0.6	Continuous meadows, protected from grazing, and generally mowed for hay, 30, 58, 71 and 78

RESULTS

DEMOCRATIA

STATISTICAL ANALYSIS



Scatter plot for C and CN point series.

- The data for the analyzed variables do not follow a normal distribution, thus justifying the use of non-parametric tests.
- A strong and significant correlation was found between the runoff coefficient and the curve number, with a Spearman correlation coefficient of 0.627.
- The coefficient of determination indicated that 70.8% of the variability in (CN) can be explained by (C); this high percentage allows the runoff coefficient to be used as a significant predictor of the curve number.

RESULTS

DEMOCRATIA

QUALITY WATER MONITORING IN PURACÉ NATIONAL PARK

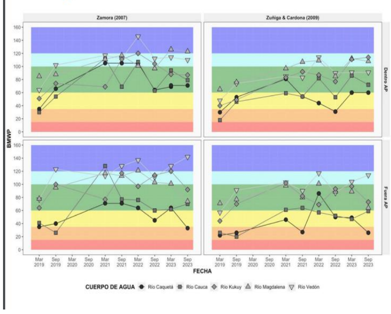
Management Objective:
Maintain water quality to an acceptable level, at least up to the park's boundary.

Frequency:
Semiannually, during the dry season and the rainy season.

RESULTS

DEMOCRATIA

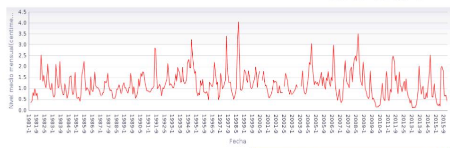
QUALITY WATER MONITORING IN PURACÉ NATIONAL PARK



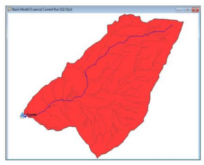
RESULTS

DEMOCRATIA

QUANTITY WATER??



$$Q_{2.33} = -55.2597 + 0.3364A - 7.1408I_{as} + 1.1059Pmáx_{24}$$
$$Q_{25} = 22.3445 + 0.5733A - 93.5653I_c + 2.2402Pmáx_{24}$$
$$Q_{50} = 14.571 + 0.6277A - 107.3706I_c + 2.8583Pmáx_{24}$$
$$Q_{100} = 3.0872 + 0.679A - 121.5349I_c + 3.5812Pmáx_{24}$$
$$Q_{200} = -255.0102 + 0.7036A + 4.8163Pmáx_{24}$$
$$Q_{500} = -319.2288 + 0.7601A + 6.2004Pmáx_{24}$$



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STREAM PROJECT THE SOUNDS OF THE DANUBE: TOWARDS AN INTERDISCIPLINARY ENVIRONMENTAL EDUCATION

Vilmaurora Castillo, Dr. Fernando Palacios, Prof. Dr. Ulrike Gayh

STREAM is a transdisciplinary project SRH University of Applied Sciences Heidelberg in cooperation with the University of Novi Sad (UNS, Serbia), the University of Pécs (UoP, Hungary) and the Music and Arts University of Vienna (MUK, Austria).

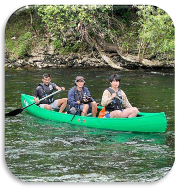
The multinational project focuses on the Danube River as it flows from Germany through Austria and Hungary to Serbia. Its main aim is to promote a conscientious approach to water protection, with an emphasis on environmental and cultural sensitivity.

- The project employs the integration of audio files and sound recordings with comprehensive water quality analysis to establish a dynamic comparative framework.
- It aims to evoke a deeper emotional and intellectual response to environmental issues by contrasting the sensory experience of soundscapes with scientific data on water conditions. Therefore, we engage the public on a more profound level, enhancing awareness of the relationship between ecological health and human perception.
- *Expected outputs*

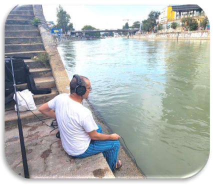
- A digital knowledge platform that will provide free access to recorded sounds and the results of water analyses conducted along the Danube.
- Teaching and learning materials for environmental education about the Danube will be made available online.
- A capacity-building workshop will be held at SRH University Heidelberg to share the results and present the website.

- The fieldwork has been completed, with audio files and water samples successfully collected.
- We are now in the process of analyzing and processing the data obtained.

Donaueschingen, Germany


Viena, Austria

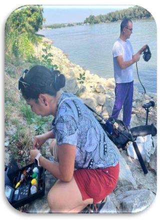


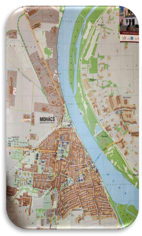


Novi Sad, Serbia




Pécs/Mohács, Hungary

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LIFE CYCLE ASSESSMENT OF WASTEWATER TREATMENT OPERATION - A CASE STUDY OF THE KUMASI WASTEWATER TREATMENT PLANT.

Bridget Quansah

- Wastewater treatment process basically consists of three phases, primary, secondary and tertiary which involves physical, chemical or biological treatment throughout the process stages to remove various contaminants depending on its constituents (Naidoo & Olaniran, 2013).
- Life cycle assessment (LCA) has been recognized as an approach to evaluate the overall impacts of a process and related by-products through its life cycle from an environmental viewpoint.
- LCA is a quantitative methodology used to assess the potential environmental impacts of systems including products, processes or services.
- Full LCA includes all stages of the lifecycle from raw material extraction, material processing, manufacture, transport, use, repair and maintenance, recycling and end-of-life (Cradle-to-grave)(Laitala et al., 2018).

PROBLEM STATEMENT

Emissions from wastewater treatment processes present a significant environmental challenge, contributing to air, water, and soil pollution with adverse effects on human health and ecosystems. Despite advancements in wastewater treatment technologies, the release of greenhouse gases (GHGs) and other persisting pollutants, poses a threat to environmental sustainability.

Addressing this multifaceted problem demands a comprehensive understanding of emission sources, pathways, tools and mitigation measures tailored to the specific characteristics of wastewater treatment processes.

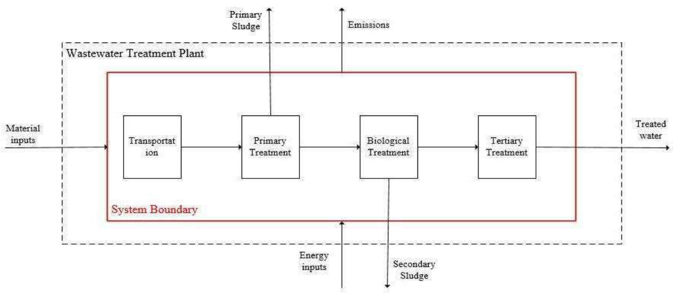
AIM AND OBJECTIVES

The main aim of this study was to assess and compare the overall environmental impacts associated with the provision of treated water from wastewater treatment in Ghana using the Life Cycle Assessment (LCA) methodology.

The research focused on the following specific objectives;

- Compile raw materials, energy consumption data and environmental releases from the various stages of the wastewater treatment process.
- Determine the total environmental burden associated with the treatment of a defined quantity of wastewater.
- Provide recommendations on the improvement of the overall environmental sustainability of wastewater treatment plants in Ghana based on results obtained.

SYSTEM BOUNDARY

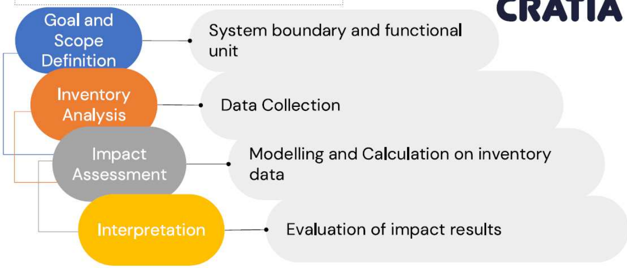


CONCLUSION

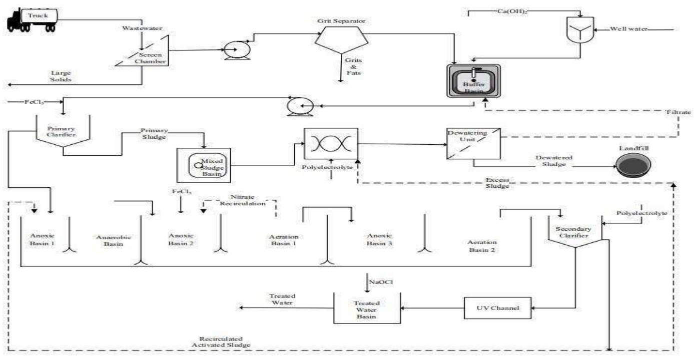
This study highlighted the trade-offs between three scenarios where the primary and tertiary stages of the treatment plant was modified and compared to conventional treatment pathway. Overall, Scenario 3 was considered a superior option regarding the environmental impact assessment of the of all the three scenarios

It is recommended that decision-makers take into account elements including choice of treatment materials, type and cost of energy and treatment efficiency during the operation of a wastewater treatment plant.
Future research should focus on optimizing wastewater treatment plant designs and operation to minimize environmental impacts. This can be achieved by improving LCA methodologies and addressing data gaps for wastewater treatment.

METHODOLOGY



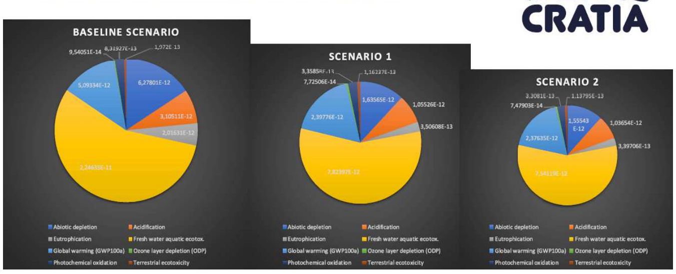
PROCESS DESCRIPTION



RESULTS AND DISCUSSION

- The impact result was based on the CML IA baseline environmental impact assessment protocol.
- The relative contribution of each impact category was adjusted to a scale of 100% during the characterization stage.
- Sensitivity analysis was carried out by modelling and comparing three different scenarios; Baseline Scenario, Scenario 1 and Scenario 2

NORMALIZED IMPACTS



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PM2.5 AIR POLLUTION DURING HEATING AND NON-HEATING SEASONS IN AMBIENT AIR OF NOVI SAD, SERBIA

Jelena Radonić, Sonja Dmitrašinović

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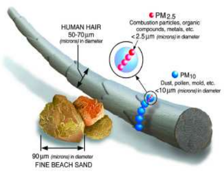
Particulate matter (PM)

- Solid compounds suspended in air
- **Categorised** based on particle size:
  - Total suspended particulates (TSPs, with aerodynamic diameters smaller than 100 µm)
  - Inhalable coarse particles (PM10, with aerodynamic diameters between 2.5 µm and 10 µm)
  - Fine particles (PM2.5, with aerodynamic diameters smaller than 2.5 µm)



Size comparisons for PM particles (https://www.epa.gov/pm-pollution/particulate-matter-pm-basics)

MATERIAL AND METHODS

Study area

- Novi Sad, Serbia - the **second largest city** after the capital, Belgrade
- **Urban-industrial agglomeration** divided by the Danube River into two distinct regions
- **Area** of 702.7 km2
- Experiences **four distinct seasons**
- **Elevation** of approximately 80 m above sea level
- According to the latest publicly available **population census data** from 2022, the city has 367,121 Inhabitants
- Urban air quality - **influenced** by several factors:
- Residential **heating** using wood, coal, or natural gas
- Intensive **traffic** in urban areas
- **Low energy efficiency** of plants in the energy sector and industry
- Diffuse pollution from **agriculture** and others

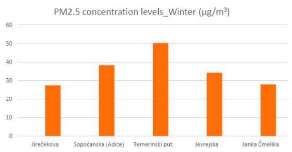
PM2.5 - measured by two **networks**:

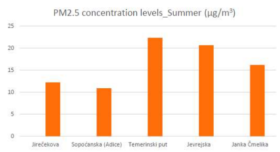
- **National** network running under the **Serbian Environmental Protection Agency** (SEPA) (one measuring site, urban)
- **Local** network established by the **City Administration for Environmental Protection** (two measuring sites, urban and industrial)
- PM2.5 - measured at **21 locations**
- The study area and sampling sites - categorized into urban zone (**URB**), industrial zone (**IND**), border of urban and industrial zone (**URB/IND**) and background zone (**BCG**)

RESULTS

Estimated seasonal PM2.5 concentration levels

Location	PM2.5 µg/m³ (WINTER)	PM2.5 µg/m³ (SUMMER)
Jirečekova	**27.39**	12.22
Sopoćanska (Adice)	38.19	**10.85**
Temerinska street	**50.21**	**22.31**
Jevrejska	34.16	20.62
Janka Čmelika	27.92	16.15



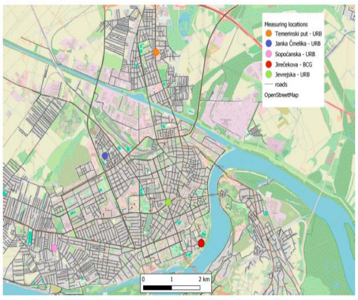


CONCLUSIONS

- The values of the concentrations of the estimated **seasonal** PM2.5 particles in the period of both seasons **differed slightly** in most locations
- By analyzing the spatial and temporal variations of the estimated seasonal concentrations of PM2.5 at the city level, **higher concentrations were found in the winter** period
- The ranges of values were from **27.39 - 50.21 µg/m3** for **winter** and from **10.85 - 22.31 µg/m3** for **summer season**

MATERIAL AND METHODS

Air sampling



Temerinski put	URB/traffic site/IH area	26 January–5 February 2021 6 July–16 July 2021
Janka Čmelika	URB/traffic site, low traffic/DH area	15 February–25 February 2020 24 July–3 August 2020
Sopoćanska (Adice)	URB/resident area, low traffic/IH area	26 February–7 March 2020 4 August–14 August 2020
Jirečekova	BCG/vicinity of the river, no traffic/DH area	26 August–5 September 2020 8 December–18 December 2020
Jevrejska	URB/high traffic site, vicinity of intersection/DH area	26 August–5 September 2020 11 January–21 January 2021

DH - district heating by thermal power plants (TPP); IH - individual heating

MATERIAL AND METHODS

Toxicological risk assessment

- To assess the **exposure** of the adult residents, two parameters were calculated:
  - **Lifetime average daily dose** (LADD; µg/kg-h)
  - **Toxicological risk** (RQ)
- **LADD** - the amount of PM2.5 suspected of having adverse health effects that a person is exposed to over a long period

$$\mathbf{LADD} = \frac{c_{air} \times IR \times ED_{1/2} \times EF}{BW \times AT} \qquad \mathbf{RQ} = \frac{LADD}{RfD} \qquad \mathbf{RfD} = \frac{RfC \times IR}{BW}$$

- c_{air} – the concentration of the pollutant in the air (µg/m³) during a given sampling period
- *IR* - the individual's inhalation rate (m³/h)
- *ED* - the duration of exposure (years) for that activity
- *EF* - the exposure frequency (365 days/years)
- *BW* - the individual's body weight (kg)
- *AT* - the total averaging lifetime (days)
- RfD - reference dose
- RfC - PM2.5 reference concentration (15 µg/m³)

RESULTS

PM2.5 concentration levels (µg/m³) – WINTER

Location (winter)	corrected 48 - 1	corrected 48 - 2	corrected 48 - 3	corrected 48 - 4	corrected 48 - 5
Jirečekova	31.96	26.98	27.94	27.00	23.09
Sopoćanska (Adice)	43.06	41.26	38.39	40.79	27.43
Temerinska street	33.53	51.39	**67.48**	38.40	60.24
Jevrejska	34.48	33.84	34.86	31.02	36.61
Janka Čmelika	**19.44**	34.12	32.47	29.98	23.61

RESULTS

PM2.5 concentration levels (µg/m³) – SUMMER

Location (summer)	corrected 1	corrected 2	corrected 3	corrected 4	corrected 5
Jirečekova	10.96	15.03	13.04	11.55	10.53
Sopoćanska (Adice)	11.72	**9.46**	10.58	11.19	11.31
Temerinska street	16.76	25.89	22.78	25.28	20.82
Jevrejska	18.82	**30.62**	20.97	15.34	17.35
Janka Čmelika	N/A	12.95	17.68	14.91	19.08

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EVALUATION OF THE PERFORMANCE OF NANOFILTRATION MEMBRANE FILTER DOPED WITH MAGNETIC ZEOLITE FOR THE REMOVAL OF HEAVY METALS FROM WATER

Koffi SOSSOU

This work aims to assess the removal of heavy metal (Cu, Zn, Pb, Cd) from water using nanomenbrane filter doped with magnetic zeolite and evaluate its efficiency

Preparation of Nanomembrane filter

A nano membrane filter was prepared using low-cost materials (quartz, clay, calcium carbonate, and wood powder). Each raw material was selected for its unique functional properties.

1-To design, develop, and evaluate the adsorption capacities of the nanofiltration membrane filter,

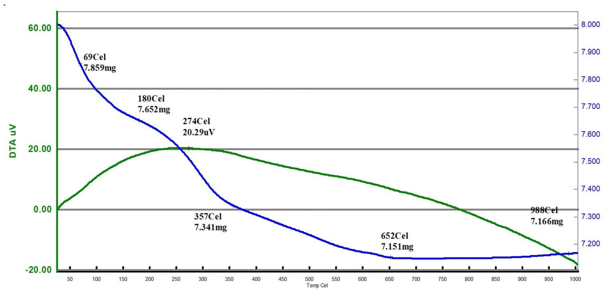
2-To determine the nanomaterials physiochemical characteristics, including structural, magnetic, and surface properties, as well as morphology that contribute to the adsorptive attribute.

3-Analyze the effectiveness of the developed membrane filter in removing specific heavy metals (Cr, Cu, Pb, Zn) from water samples under different concentrations, times, and pH

4-Assess the long-term stability and durability of the filter by conducting regeneration studies, evaluating fouling mechanisms, and proposing effective cleaning

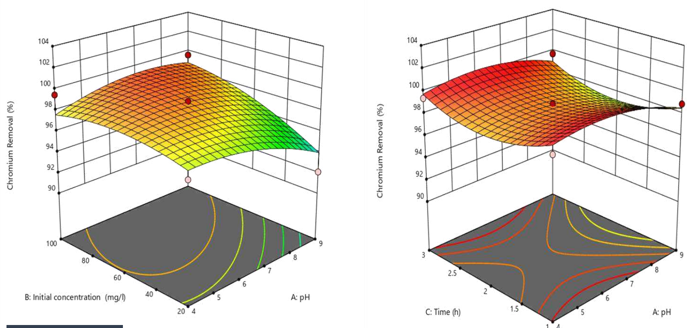
Preparation of Nanomembrane filter

TGA / DTA

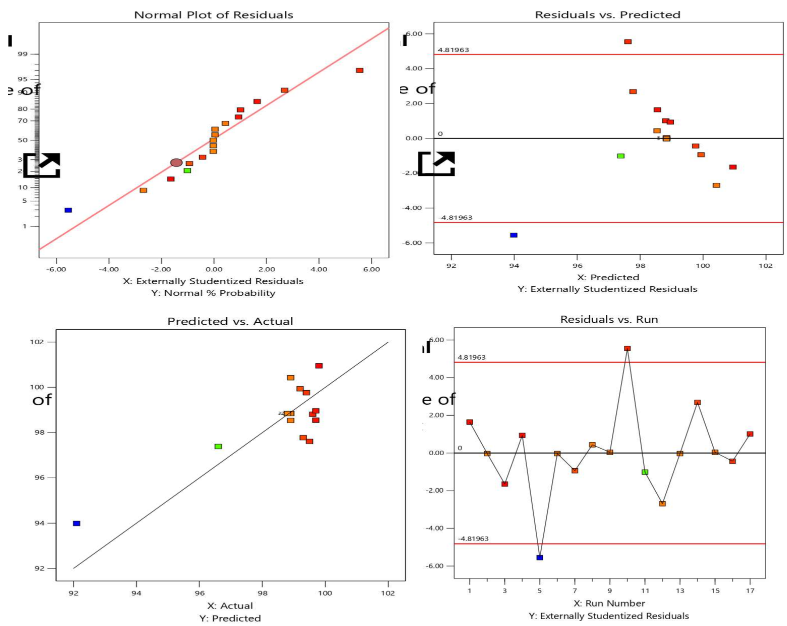


Filter	Quartz %	Clay %	CaCO3 %	Wood powder %	Sintering temperature °C
F40 - 950	40	30	25	5	950

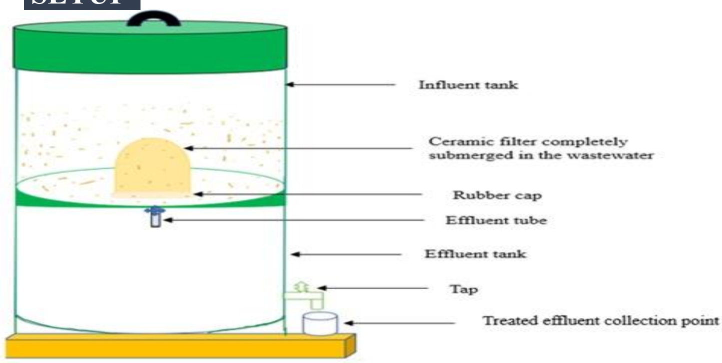
Single-response optimization for chromium



Diagnostic plots for chromium response: (a) normal % probability vs. residuals; (b) residuals vs. predicted; (c) predicted vs. actual, (d) residuals vs. run order



SETUP



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BATHROOM SAVINGS: COMBINING IOT-SENSORS, DATA AND BEHAVIOURAL CHANGES SCIENTIFIC INSIGHTS ON HOW TECHNOLOGY CAN BE COUPLED WITH HUMAN BEHAVIOUR AND NUDGING

Anders Barkholt (Aguardio, Denmark)

Scientifically based solution to instantly reduce water & energy consumption and increase customer satisfaction in the shower

The bathroom industry does not operate on correct facts!

- Do women or men shower the longest?
- Are young people more “green” in their behaviour?
- Hard water (high mineral content) showering effects?
- Can “low flow” showers be a solution?
- Nobody knows how many toilets are leaking!
- Is a toilet a trash bin?

Instead of ASKING people let data from sensors MEASURE facts!

Shower Sensor data by Aguardio

The technology & data

Placed on wall with tape

Interactive nudging:

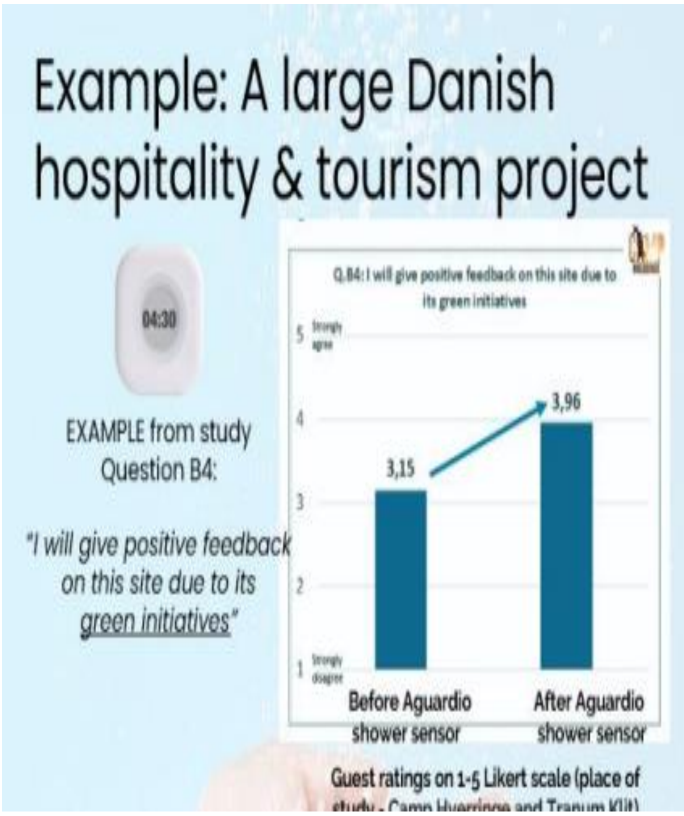
- Displays time while showering
- Time pauses when water is paused (e.g. when shampooing)

How: Movement (PIR) + Water sounds + Humidity

Data:

- Shower stats: Times + When + Number of
- Statistics on pausing water (save 20%)
- Humidity + Temperatures

- Women: Use less water! And seemingly more receptive to shortening time!
- Hard water = shorter shower duration → Negative effect of softening water !?
- Comfort feeling = longer showers
- Younger people shower much longer
- Interactive nudging a positive sustainability experience!



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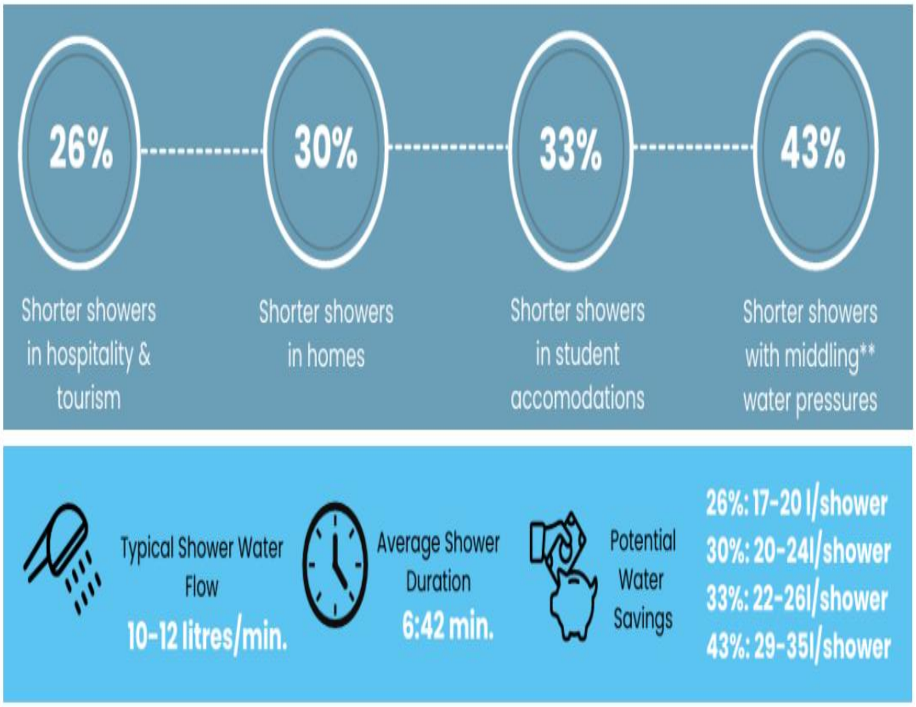
Shower Sensor result



Business case? Payback 4-10 months, e.g.: verbraucherzentrale Nordrhein-Westfalen

Digitalizing the toilet

Placed with a plastic tie on the water inlet pipe

Data & insights:

- Leak state of the toilet (e.g. constant leak, e.g. "on/off" leak)
- Option: "Beep" alert at leaks
- Number of flushes

CASE domea.dk

DOMEA is a large Danish housing organisation

With ShowerSensor + Toilet sensor:

Bathroom consumption reduced 1 / 3 !

33% reduction in shower duration*

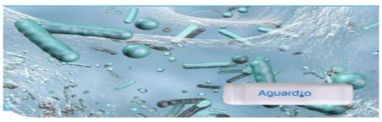
17,3% toilets found to be leaking

1-3% of bathrooms expected to be saved from mould-related renovations, each costing €800-2000, per year

Nominated as Finalist for Vejle Climate Prize

Leaks of 275 litres per day cannot be seen or heard

- All toilets start leaking (minerals, rubber sealings, mechanics etc.)
- How many leak? >20% ?
- And who acts?
- Is "digital metering" the answer to identify also leaking toilets?
- Flushing as water waste:
- Toilets as "trash bin"
- HILTON hotels → 4-5 flushes when cleaning a room



AGUARDIO **HYGIENE SENSOR**

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OPTIMIZATION AND MODELING OF A HYBRID SYSTEM FOR EFFICIENT WASTEWATER TREATMENT WITH A FOCUS ON WETLAND PERFORMANCE ENHANCEMENT

Camila Valencia, SRH Hochschule Heidelberg
Dra. Sandra Pascoe Ortiz, UNIVA Campus Guadalajara

This project focuses on optimizing an existing design and simulating a Subsurface Horizontal Flow Constructed Wetland, integrated into a hybrid treatment system, to enhance wastewater treatment efficiency while optimizing land use. The goal is to improve pollutant removal, including nitrogen and phosphorus, using innovative media like Red Tezontle.

Background

Global pig production has risen significantly due to population growth and demand, leading to environmental challenges. At García Farm, in Mexico, daily cleaning of pig stables generates approximately 1,000 liters of slurry, prompting the integration of a geomembrane tubular biodigester for anaerobic digestion, producing leachate known as biol. [1]

In response, the Universidad del Valle de Atemajac (UNIVA) proposed a hybrid treatment system to purify this as shown below. While efficient, the hybrid system requires excessive space at full scale, necessitating design optimization to reduce its footprint.

Filtration	Activated Sludge	Constructed Wetland	Filtration	Maturation Pond
Gravel, tezontle, fine sand, and activated carbon	1. Aeration 2. Settler Biologically degrade organic matter and nutrients	Subsurface Horizontal Flow throw Tezontle and Gravel.	Volcanic tezontle: removes suspended solids, nutrients, organic compounds.	Polishes effluent

Figure 1. Hybrid System for Biological Treatment for Liquid Waste Generated in Livestock Processes.[1] Own Elaboration.

Objectives

1. To optimize and simulate a subsurface flow wetland for leachate treatment, enhancing efficiency and reducing land use using SubWet 2.0.
2. To scale up the design, ensuring consistent pollutant removal efficiency from lab to field application.

Methodology

01 Literature Review → 02 Identify Software Options → 03 Data Collection → 04 Wetland Design → 05 Simulation SubWet 2.0 → 06 Optimization Process → 07 Simulation vs. Real Data → 08 Anaylisis and Discussion

Wetland Design

Table 1. Wetland Parameters Design and Dimensions. Own Elaboration.

Parameter	Influent (mg/L) [1]	(1)	(2)	(3)	(4)	Q	d	Cin	Cout	k	A
BOD	3546,2	5% [5]	75% [2]	17%	97%	0,9 [1]	0,6 [11]	709,2	106,4	0,3 [5]	9,49
COD	8015,0	5% [6]	65% [6]	18%	88%	0,9 [1]	0,6 [11]	2404,5	961,8	0,2 [5]	6,87
Grease and Oil	14,4	20% [2]	45% [5]	20%	85%	0,9 [1]	0,6 [11]	5,0	2,2	0,07 [12]	18,16
Total N	807	10% [5]	40% [7]	23%	73%	0,9 [1]	0,6 [11]	403,5	217,9	0,08 [13]	11,55
Total P	11,41	5% [6]	20% [2]	30%	55%	0,9 [1]	0,6 [11]	8,6	5,1	0,055 [13]	13,93
S. Solids	320	10% [7]	15% [5]	15%	40%	0,9 [1]	0,6 [11]	240,0	192,0	0,15 [12]	2,23
							Stimated Area Wetland (m2) =				18

(1): % Removal Filter
(2): % Removal Activated Sludge Unit
(3): % Removal Constructed Wetland
(4): % of total target removal
A = Wetland area (m²)
Q = Flow rate (m³/day)
Cin = Influent concentration (mg/L)
Cout = Target effluent concentration (mg/L)
k = First-order areal rate constant (m/day)
d = Effective depth of the wetland (m)
n = Porosity of the wetland media (Red Tezontle ranges from 0.45 to 0.55)

$$A = \frac{Q \cdot \ln(C_{in}/C_{out})}{k \cdot d}$$ [9]

2:1 L/W Ratio (EPA) [12]		
Width	3	m
Length	6	m

$$HRT = \frac{n \cdot A \cdot d}{Q}$$ [9]

n =	0,55 [14]	
d =	0,6 [11]	m
Q =	0,9 [1]	m³/day
HRT =	7	days

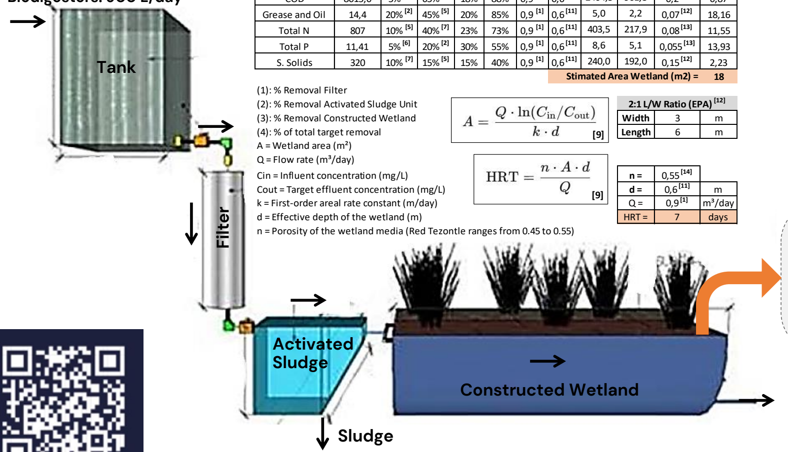

Figure 2. Optimized Hybrid Wastewater Treatment System for Livestock Processes [15]

Red tezontle, a volcanic rock common in Mexico, serves as an effective filter media in constructed wetlands due to its high porosity. [14]

Simulation with SubWet 2.0 and Results

1. **Input Data:** Width, Length, Precipitation Factor[17], Slope[9], Hydraulic Coductivity[18], Flow
2. **Forcing Functions:** Vol, Porosity[19], Oxygen, DBO, Total N, Total P, Organic Matter [1]
3. **Initial Values** BOD[1], Nitrates, Ammonia, Organic Nitrogen, Total P [1]
4. **Descomposition and Saturation Rates** (Nitrification and Dinitrification) [2, 3, 9]

Nitrate:	5% Total N
Ammonium:	45% Total N
Organic Nitrogen:	50% Total N

[2]

Table 2. Removal Efficiencies SubWet 2.0

Data Sheet for Simulation

Day	eff. BOD5 re	eff. nit. rem	eff. amm rem	eff. P. rem	eff. o.n. rem	eff. t.n. rem
1	0,03	3,89	1E-8	1E-8	1E-8	1E-8
2	24,81	64,68	1E-8	1E-8	45,18	29,89
3	42,13	78,93	38,56	1E-8	70,24	60,93
4	55,88	86,91	65,72	1E-8	83,85	78,4
5	67,24	91,68	81,07	1E-8	91,23	88,09
6	76,92	94,57	89,58	1E-8	95,24	93,43
7	85,33	96,38	94,26	1E-8	97,42	96,37

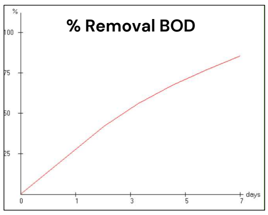

Table 3. Comparison % Removal Hybrid System UNIVA, Calculated Design and Simulation. Own Elaboration

Parameter	% Removal		
	UNIVA[1]	Calculated	SUBWET 2.0
BOD	96,6%	97,0%	85,3%
Total N	73,5%	73,0%	96,4%
Total P	Increased	55,0%	0,0%

Discussion

A subsurface flow constructed wetland was designed to improve the efficiency of a hybrid pig farm wastewater treatment system by consolidating two units into one and eliminating the maturation pond. Based on literature, **an 18 m² wetland with a 7-day retention time was proposed** to meet removal targets for BOD, COD, grease, oils, solids, nitrogen, and phosphorus..

SubWet 2.0 was used to validate the design, confirming a BOD removal efficiency of 85.3% and higher-than-expected total nitrogen removal, 96,4%. However, the wetland was insufficient in removing phosphorus, indicating the need for additional treatment.

While the program offers valuable insights, **limitations** such as the inability to input decimal values reduce precision. Testing different scenarios or obtaining field data is recommended for better system configuration.

By consolidating the wetlands into one and removing the maturation pond, the design optimized space and reduced costs while maintaining high pollutant removal efficiency. Despite the software's limitations, it remains useful for predicting system responses to variable wastewater volumes and optimizing treatment systems.

Red tezontle proved highly effective for BOD and nitrogen removal in the constructed wetland, with its porous structure enhancing filtration and adsorption.

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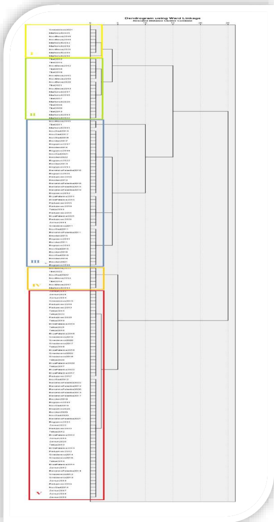
ENHANCING RIVER POLLUTION DETECTION WITH A NOVEL MODULAR WATER QUALITY MONITORING SYSTEM

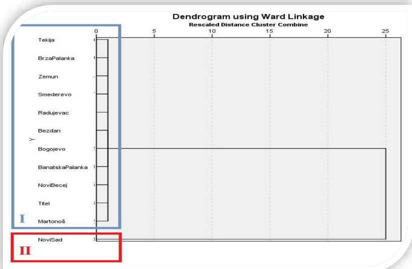
Maja Brborić , Sonja Dmitrašinović , Jelena Radonić, Sanja Čojbašić , Maja Turk Sekulić

University of Novi Sad, Faculty of Technical Sciences, Department of Environmental Engineering and Occupational Safety and Health, Novi Sad, Serbia

This research, under the REWARDING project, addresses the limitations of Serbia's current water quality monitoring system, particularly in pollution "hot spots" along the Danube basen in Serbia. The study proposes the installation of a modular sensor network to monitor these areas in real time, focusing on regions near Belgrade and Novi Sad. Site selection is based on hydrological and pollution data, alongside a novel methodology for identifying critical hot spots.



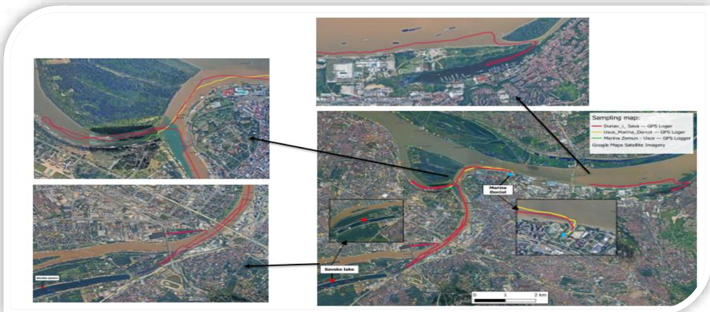
Using data from 2011 to 2022, six major pollution sites were identified through hierarchical cluster analysis. The dataset was then expanded to include six additional locations, enhancing the scope of analysis. Factors such as industrial discharges, agricultural activities, and natural events (floods, droughts) were found to heavily influence water quality.



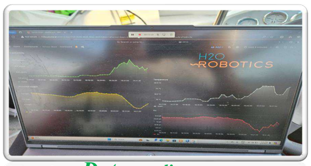
Hierarchical cluster analysis for all 12 sites period 2011-2022

A more frequent and prominent appearance of the Zemun locality was observed, indicating the most frequent and significant contamination in this area. Additionally, through this analysis, new and expanded lists of localities were compared by observing the overall pollution for the examined period. In this broader analysis, the Novi Sad locality emerged as the most significant, indicating a pronounced influence of fecal/industrial wastewater discharged into the Danube without any treatment.

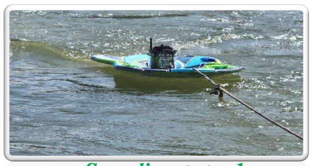
In April 2024, a sensor system was deployed to gather real-time data from key locations on the Danube and Sava rivers. Over 20,000 measurements were collected for parameters like water temperature, pH, dissolved oxygen, and conductivity, revealing significant fluctuations.



Measurement path on Danube and Sava Rivers



Data reading



Sampling device 1

Sampling device 2

Sampling path

The results showed substantial spatial and temporal variations, particularly in conductivity and oxygen levels, likely due to pollution from untreated wastewater. This demonstrates the effectiveness of the sensor system in capturing rapid changes in water quality.

09/04/2024	Min	Max	Mean	Median
Tw (°C)	15.7	25.3	17.0	16.5
pH	8.7	10.5	9.7	9.8
O_2 (mg/l)	1.8	4.2	2.9	2.8
Conductivity (µS/cm)	223.5	1080.0	659.5	671.4

Significant fluctuations in water temperature, pH, dissolved oxygen, and conductivity measured in the Danube near Belgrade on April 9, 2024, were attributed to both natural and human-induced factors. Diurnal cycles, seasonal changes, and biological activity, such as algal photosynthesis, caused variations in temperature and oxygen levels. Pollution sources like untreated wastewater and industrial discharges further influenced pH and conductivity. Additionally, turbulence from boat movement and site-specific pollution levels contributed to the observed variability in the recorded measurements.

The project underscores the importance of adaptive, real-time water quality monitoring to manage pollution and safeguard water resources. Enhanced data collection will improve environmental strategies and support sustainable river management. Additionally, the integration of artificial intelligence is planned to optimize data analysis, enabling predictive modeling and more effective identification of pollution trends, further advancing the scope of the monitoring system.

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Acknowledgements

This research was supported by the Science Fund of the Republic of Serbia, grant number 6707, REmote WAter quality monitoRing anD IntelliGence – REWARDING and by the Ministry of Science, European Union's Horizon Europe Marie Sklodowska-Curie Actions (MSCA) under grant agreement project number 101086387 – REMARKABLE and Technological Development and Innovation through project no. 451-03-47/2024-01/200156 'Innovative scientific and artistic research from the FTS (activity) domain'.

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FAST-TRACK BTX DETECTION IN WATERWAYS: PORTABLE MIMS FOR ON-SITE ENVIRONMENTAL MONITORING

Daria Ilić[1], Boris Brkić[1], Maja Turk Sekulić[2]

[1]BioSense Institute, University of Novi Sad, Serbia
[2]Faculty of Technical Sciences, University of Novi Sad, Serbia

DEMOCRATIA

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The detection of Benzene, Toluene, and Xylenes (BTX) in water is critical for assessing pollution in aquatic environments, as these compounds pose significant environmental and public health risks. Traditional methods for BTX monitoring often require lab-based analysis, causing delays in obtaining actionable data. This study introduces an innovative use of portable Membrane Inlet Mass Spectrometry (MIMS) for the rapid, on-site detection of BTX. It provides a swift, efficient, and dependable method for real-time monitoring of environmental contaminants in waterways.

Introduction

In a world facing increasing environmental challenges due to both natural disasters and human-induced activities, pollution has become a significant global issue. The contamination of water, air, and soil by harmful substances poses a threat to all living organisms and disrupts ecosystems. Rapid detection and intervention are crucial to prevent further damage, particularly in the wake of disasters and industrial accidents. Portable environmental monitoring tools, such as membrane inlet mass spectrometry (MIMS), offer significant advantages in this regard. MIMS technology allows for real-time, in-field analysis of volatile organic compounds (VOCs) and other pollutants, without the need for extensive sample preparation.

Since its introduction in the 1960s, MIMS has proven to be highly effective for monitoring environmental pollutants in water, soil, and air, providing a reliable and portable solution for environmental monitoring. Its application can significantly improve our response to environmental threats, offering high sensitivity, rapid results, and the ability to detect contaminants at the site of an incident.

Experimental section

Table 1 List of the BTX compounds used for validation of the MIMS method.

Compound	CAS number	Molecular weight (g/mol^{-1})	Target Ion (m/z)	MRL (I, II class of water) μg L^{-1}	MRL (drinking water) μg L^{-1}
Benzene	71-43-2	78.11	78, 77	500	2
Toluene	108-88-3	92.14	91, 92	500	700
Xylene	1330-20-7	106.168	105, 106	50	50

The details of the compounds of interest are presented in Table 1, including their molecular weights, target ions, and maximum residue levels (MRLs) allowed in drinking and irrigation water. The MRL limits are expressed in micrograms per litre of water (mgL^{-1}) as determined by the regulations of the Republic of Serbia where class I and II can be used for irrigation.

Our testing, calibration, and validation of the MIMS portable analytical system for water-quality monitoring were carried out in accordance with the relevant guidance documents. Following the guidelines for the validation and verification of quantitative and qualitative test methods and the analytical quality control requirements, we clearly demonstrate that BTX from water can be successfully quantified with a high level of confidence in the results.

Experimental set up

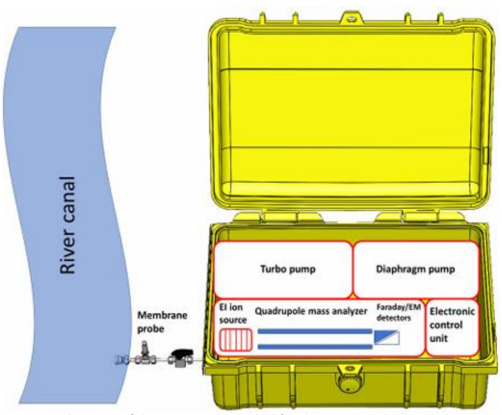

Fig. 1 Schematic of the MIMS system used for the river canal water monitoring.

The experimental setup utilized MIMS system (Fig. 1) designed for real-time monitoring of organic contaminants in water. The system employed a polydimethylsiloxane (PDMS) membrane inlet, which selectively allowed organic compounds to pass through while blocking water.

This facilitated the separation and detection of analytes using a quadrupole mass spectrometer with a mass range of 1–300 amu. The vacuum system consisted of a diaphragm pump and a turbomolecular pump, Ionization was achieved through an open electron impact (EI) ion source with yttriated iridium filaments. The MIMS system was compact, with dimensions of 25 cm x 50 cm x 60 cm and a weight of 25 kg, making it suitable for field applications. The instrument provided unit mass resolution and a rapid response time of less than 0.5 seconds, ensuring near real-time analysis of water samples.

Sample analysis

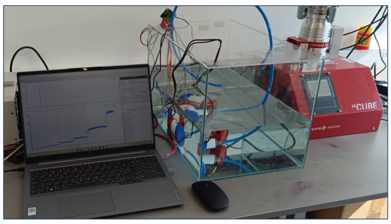

Fig. 2. Temperature-controlled aquarium with continuous mixing used for sample preparation.

A water analysis method was developed based on oil-in-water monitoring technique. During field tests on river canal water, a membrane sample probe was connected to the water flow system via a PA hose. The method was compared with a lab technique for quantifying benzene, toluene, and xylene (BTX) residues in water. Validation used DI water and DTD canal water, spiked with BTX standards at concentrations from 10 to 250 mg/L. Samples were prepared in a temperature-controlled aquarium with continuous mixing, and the membrane probe was inserted directly for analysis (Fig 2.). All measurements were taken at ambient temperature. The sample was introduced directly into the vacuum system.

Results and discussion

The analysis of BTX in water and the total time needed for the on-site analysis was ~10 min. During the validation study, all the tests were performed in the analytical range from 10–250 mgL^{-1} to confirm the linearity, specificity, selectivity, accuracy, and precision of the method, and to determine the detection and quantification limits.

Selectivity of the method - Fig. 3 shows that the developed analytical method was able to distinguish the analyte(s) of interest from endogenous components in the matrix or other components in the sample, without interference. Fig. 2a displays the selectivity of the method when using DI water, while Fig. 2b illustrates the influence of the matrix on the selectivity of the method. After recording and enriching the canal water, it was observed that the selectivity of the method was at the same level as the DI water.

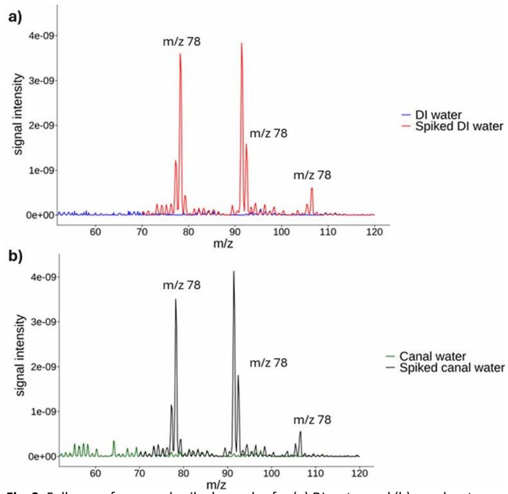

Fig. 3. Full scan of pure and spiked samples for (a) DI water and (b) canal water using the portable MIMS.

Limit of detection (LOD) and limit of quantification (LOQ) – for target compounds, using the MIMS, analytical standard of 10 mgL^{-1} was used, which was added to the water sample at a defined concentrate on range. Our results show (Table 2) that the LOQ values were significantly lower than the MRL values for irrigation water and slightly above the MRL values for drinking water.

Table 2. Results for the LOQ and LOD values obtained using the MIMS.

Analyte	MIMS (LOD), μg L^{-1}	MIMS (LOQ), μg L^{-1}
Benzene	4.88	16.27
Toluene	7.43	24.77
Xylene	7.46	24.85

In this study, we employed a portable MIMS device to create and validate a method for the fast quantitative analysis of BTX in river and irrigation canal water, covering a specific analytical range. The system's portability, rapid response, and accuracy make it a valuable instrument for environmental monitoring and the on-site detection of water contaminants.

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Acknowledgments: This work is supported through ANTARES project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement SGA-CSA. No. 739570 under FPA No. 664387 (https://doi.org/10.3030/739570). The authors acknowledge financial support from the Ministry of Education, Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03 66/2024-03/ 200358)

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MET TECHNOLOGY: INNOVATIVE MICROWAVE-INDUCED SEPARATION FOR OIL-WATER MIXTURES IN THE WASTE DISPOSAL SECTOR

DEMOCRATIA
Democratia-Aqua-Technica

SRH Team: Prof. Dr. Ulrike Gayh & M.Sc. Vilmaurora Castillo-Moie
GiveTech Team: Dr. T. Seyrich & A. Blätte

INTRODUCTION

Oily wastewater originates from metalworking processes [1] and crude oil extraction, transportation, and processing [2]. Its treatment is crucial to prevent environmental damage, as untreated wastewater increases organic load, reduces sunlight in water bodies, and disrupts aquatic ecosystems.

Chemical methods for emulsion splitting are widely used for quick separation and effective emulsifier matching. However, they have drawbacks such as producing by-products, causing secondary pollution, and incurring high costs[3]. In recent years, there has been a notable increase in the utilization of microwave technology, largely due to its efficacy in accelerating chemical reactions[4]. In 2008, the European Patent Office designated a Patent to the MET (Microwave Induced Emulsion Separation) technology, also known as the MET device. The results of various studies provided valuable initial findings, including a separation rate of up to 90% of the oil in the water. The project's objective is to assess the separation performance and energy efficiency of the MET process through comparative tests on a small-scale experiment.

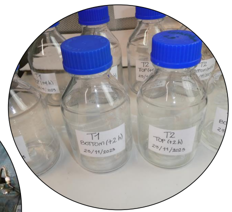
EXPERIMENTAL SETUP

The emulsion material utilized in this study was procured from a waste disposal company in Mannheim. The research involved an examination of emulsions containing approximately 5% mineral oil and emulsions containing a greater than 50% mineral oil concentration. Two 200-liter stainless steel tanks were filled to a volume of 80% of their total capacity, which corresponds to 160 liters.

Subsequently, a heating element was introduced into each tank. Each heating unit was connected to the temperature controller to maintain the emulsion at a temperature of 60°C. Each sample was comprised of 2 bottles, taken from the upper and lower sections of the tank. Two MET treatments were conducted in Tank 1 at a designated time throughout the course of each experiment. The physico-chemical analysis, including measurements of pH, temperature, conductivity, salinity, and total dissolved solids (TDS), was conducted using a Voltcraft multimeter (modelKBM 700) with a range of electrodes.

A series of statistical tests were employed to ascertain the impact of the MET treatment. Specifically, the Mann-Whitney U-tests were employed, as these do not assume a normal distribution of the samples (excluded according to the Kolmogorov-Smirnov test with a significance level of $p < 0.05$).

The heating, stirring, and MET devices were connected to an energy meter to measure the energy consumption.



MET Technology

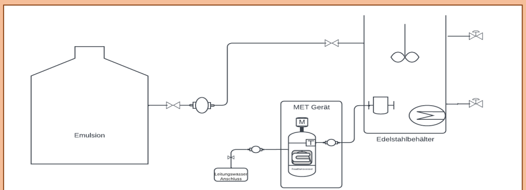


Figure 1. Flow chart of the emulsion treatment with the MET device.

Figure 1 depicts the general MET treatment process. However, the process within the MET device occurs as follows: When the MET device is activated, the internal glass container is filled with water. The generation of microwaves by the magnetron is triggered by the sensors as soon as a sufficient water level is detected, resulting in a heating reaction within the glass container. During the thermal reaction in the glass container, the treated water vapor ascends and flows through a metal lance that has been inserted into the container with the emulsion to be treated.

RESULTS AND DISCUSSION

In all four experiments, the parameters reflected typical emulsion phase separation, with oil droplets coalescing into a distinct phase. The salt content remained mostly in the aqueous phase due to its high solubility in water, resulting in lower conductivity in the oil phase compared to the aqueous phase. Regarding the water content, significant statistical differences were identified in 3 of the 4 tests with 95% certainty between the tank treated with the MET device and the control tank. *Figure 2* illustrates the behavior of the top samples from the experimental trial #1.

The calculation of the energy requirement for a single MET treatment resulted in a value of 9.44 kWh. In comparison, various emulsion treatment devices from other suppliers indicate an average energy consumption of approximately 50 kWh/m³. However, it should be noted that the costs of a MET treatment are lower compared to the other emulsion splitting processes due to the non-use of chemicals.

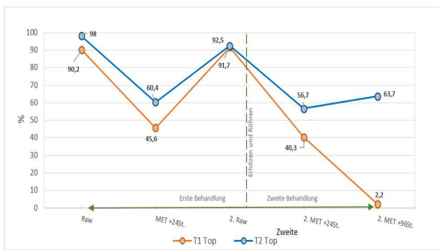


Figure 2: Water content of the upper samples from experimental trial #1

CONCLUSIONS AND RECOMMENDATIONS

The MET treatments showed a significant improvement in emulsion separation, proving it to be an effective addition to existing technologies. MET technology offers an economical and sustainable option for emulsion separation. Further optimization is recommended, including acquiring specialized equipment, improving heating methods, increasing sample size, using duplicate determinations, and extending experiment duration.

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IFAT MUNICH 2024:
WATER TECHNOLOGY STUDETNS PARTICIPATING IN THE WORLD UNIVERSITY CHALLENGE, EXPLORING INNOVATION, AND NETWORKING

Camila Valencia. Student M.Eng. Water Technology, SRH Heidelberg.

Democratia-Aqua-Technica

During IFAT 2024, the largest international trade fair for environmental technologies, students from the Water Technology program had the unique opportunity to engage with cutting-edge innovations and participate in high-profile events, including the prestigious World University Challenge. Here's a snapshot of our key activities at IFAT:

1. World University Challenge: Competing on the Global Stage

1 — Integrated Water Resources Management (IWRM)

Create an Integrated Water Resources Management (IWRM) concept for a chosen region with the DWA environment cards as planning tools.

2 — Measurement, control and regulation of water flows

Using Adiro's EduKit PA advanced for Festo Didactic, interpret piping and instrument flow diagrams and implement them in practice.

3 — Numerical simulation of waste water systems

Use SIMBA #classroom to create a digital wastewater treatment plant, optimize processes and flows and showcase your system understanding!

2. Networking with Industry Leaders

- Learning about emerging trends and career opportunities.
- Built relationships with students from other institutions, strengthening our global network
- Shaping Future Collaborations

3. Exploring Groundbreaking Technologies

- Live demonstrations of Inventive technologies.
- Explore the newest innovations for water treatment, and sustainable solutions

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DEVELOPMENT OF A COMPOST BIN AS AN APPROPRIATE TECHNOLOGY WITHIN THE FRAMEWORK OF A HUMANITARIAN ENGINEERING PROJECT

Tafaghoditag, Ghazal; Sun, Borui; Huang, Haitao, Amin, Siar; Valencia, Camila; Guo, Zheng;.
Prof. Livier De Regil.

In this project by using appropriate technology development process, a compost bin was designed and built for the Wormser Erlebnisgarten, in Wroms, Germany. The main goal of this project was, finding the best way to manage resources in order to achieve a more sustainable technology in the garden.

❖ Problem Statement

The old compost bin not functioning the way it is supposed to, due to broken structure.

Rats damaging the compost area

After realizing and learning about the problems, resource and time management, and finding the best design, it can be assured that a more sustainable compost area will be achieved.

Figure 1– Compost Bin Area

❖ Main Question

How to build a new compost bin with less expencess using appropriate technology?

❖ Objectives

I. Environmental Benefits
II. Cost Management
III. Children Engagement
IV. Keeping the Animals away

Compost bins are an environmentally responsible method of managing organic waste. In this project almost 80% of the material were either recycled or donated. As Humanitarian Engineers, the main goal was to find the most certain and affordable way for solving the problems in the garden.

❖ Theory

- Appropriate Technology Criteria [1]
- Humanitarian Engineering Process [2]
- Appropriate Technology Development [3]
- Frugal Innovation [4]
- Impact Evaluation [5]

❖ Method

- **Identifying the Problems**
- **Gathering Ideas**
- **Preparing a Plan**
- **Preparing all the materials**
  - ✓ Wooden Pallets
  - ✓ Wire Mesh
  - ✓ Hinges
  - ✓ Nails and Screws
- **Assembly**
- **Evaluation of the Project**

Figure 2 – Building the Bin

Figure 3 – Painted, Finished Bin

❖ Discussion

The path of development is often faced with resource constraints, such as insufficient funds, materials, and equipment. Within these constraints, learning how to innovate and solve the problems, finding creative, low-cost solutions, might be challenging. The project needs evaluation in order to reassure that the installed technologies are working properly and also to check if the compost area has odor issues or not.

	Criteria for identifying appropriate technologies (Haba Prieto, S. 2014).	Yes	No
1	It solves a specific need of a specific social group.	X	
2	Adapt the original design to the local condition.		X
3	Flexible design to respond to environmental changes.	X	
4	Low costs for execution, operation and maintenance	X	
5	According to the management capabilities of the locality	X	
6	Environmentally sustainable	X	
7	Promotes training by involving beneficiaries	X	
8	Facilitates social and cultural appropriation	X	
9	Promotes the participation of men and women equally	X	

Figure 4 – AT Criteria analysis

❖ Conclusion

Constructing a compost bin out of recycled materials has encouraged environmental responsibility and sustainability. By developing a closed-loop organic matter system, the project improves soil health and minimizes waste. It works also as a teaching tool, spreading awareness about recycling and composting to promote sustainable living, specially for children visiting the garden.

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DEVELOPMENT OF A RAINWATER HARVESTING SYSTEM AS AN APPROPRIATE TECHNOLOGY WITHIN THE FRAMEWORK OF A HUMANITARIAN ENGINEERING PROJECT

Amin, Siar; Valencia, Camila; Guo, Zheng; Tafaghoditag, Ghazal; Sun, Borui; Huang, Haitao.
Prof. Livier De Regil.

This project used the appropriate technology development process to build a **Rainwater Harvesting System** at **Wormser Erlebnisgarten**, an environmental education center located in Worms, Germany. By showcasing sustainable water management, the project supports the center's mission of fostering environmental awareness and hands-on learning for all ages.

1. Problem Statement

The area faces significant challenges due to limited access to water and inadequate maintenance of existing water infrastructure. These issues result in unreliable water availability and frequent system failures, which severely impact the daily lives and activities of the local population. Addressing these problems is critical to ensuring a consistent and sustainable water supply for the community of the garden.

2. Main Question

How to increase access to water using easier mainte-nance appropriate technology?

3. Objectives

To increase access to water by implementing easier-maintenance appropriate technology that can collect and store up to 100 liters of rainwater per installation, with a focus on cost-effective and eco-friendly design tailored to local environmental conditions.

- 3.1 Install a wooden gutter system to collect at least 30 liters with a Rain Water Harvesting System.
- 3.2 Use locally available materials and basic tools for construction.
- 3.3 Complete the project in 4 days with daily miles-tones.

4. Theory

Humanitarian Engineering Process	Appropriate Tech. Development	Appropriate Technology Criteria
Service-Learning approach (Engineers Without Border Australia).	According Product Development Process (Steven D. Eppinger, Karl Ulrich)	Criteria for Identifying Appropriate technology (Haba Prieto, 2014).

FRUGAL Innovation	Impact Evaluation
Do more, with less, for more (Navi Radjou & Jaideep Prabhu)	Social & Environmental Impact Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. J. (2016).

5. Method

Fuzzy Front End (FFE)

- 01 **Problem identification**: Initial Research, local needs & resources
- 02 **Idea Generation**: 365 Technique, Brainstorming
- 03 **Concept Selection**: Sketches, Design Sketching, Criteria for Selection
- 04 **Proof of Concept**: Interview community members, Feasibility.
- 05 **Specifications**: Modules/Components/Parts. Materials, Dimensions
- 06 **Work Plan (Timeline)**: Milestones: material sourcing, construction, testing.
- 07 **Construction**: Material Sourcing and Prepa-ration, Modular Assembly
- 08 **Testing and Validation**: System Testing, Validation of Appropriate Technology (AT)

6. Discussion

This initiative exemplifies appropriate technology, showing that effective solutions can be developed with limited resources. It highlights the power of community efforts and proves that similar systems can be replicated in resource-constrained areas to address water scarcity. This rainwater harvesting system showcases environmentally sustainable design using local materials. V-shaped gutters and recycled plastic bottles ensure efficient, low-cost water collection. Testing confirmed minimal leakage and reliable performance, offering a scalable solution for water-scarce communities

	Criteria for identifying appropriate technologies (Haba Prieto, S. 2014).	Yes	No
1	It solves a specific need of a specific social group.	X	
2	Adapt the original design to the local condition.	X	
3	Flexible design to respond to environmental changes.	X	
4	Low costs for execution, operation and maintenance	X	
5	According to the management capabilities of the locality	X	
6	Environmentally sustainable	X	
7	Promotes training by involving beneficiaries	X	
8	Facilitates social and cultural appropriation	X	
9	Promotes the participation of men and women equally	X	

7. Conclusions

*The rainwater harvesting system demonstrates that integrating humanitarian engineering principles with advanced water technology can produce sustainable, scalable solutions that effectively meet the water needs of underserved communities.
*This project enhanced community resilience by establishing a sustainable water source and empowering local residents through educational initiatives.
*This interdisciplinary approach enhances the design's effectiveness by ensuring that diverse perspectives are taken into account when addressing community needs.

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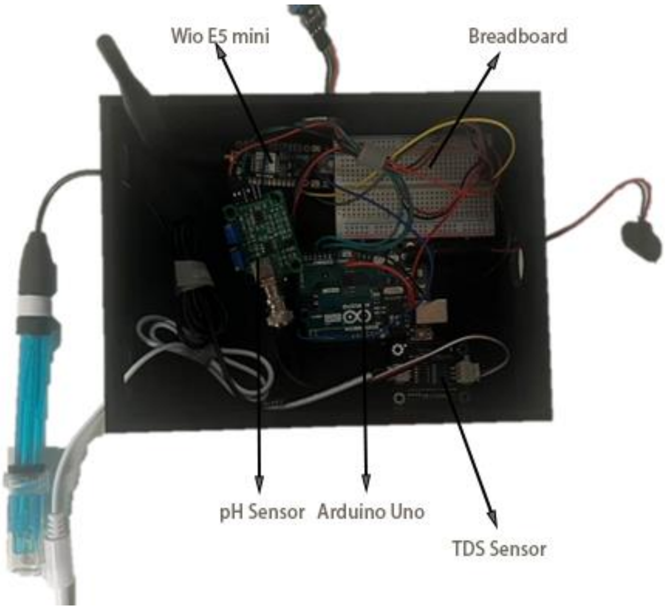
DEVELOPMENT OF WATER SENSORS FOR THE URBAN WEATHER PROJECT

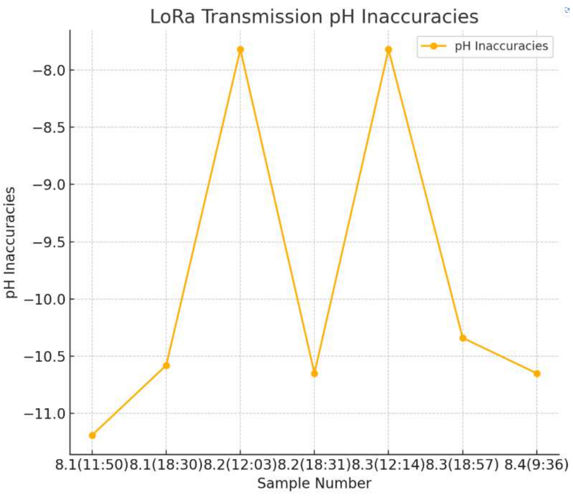
Song Shukai

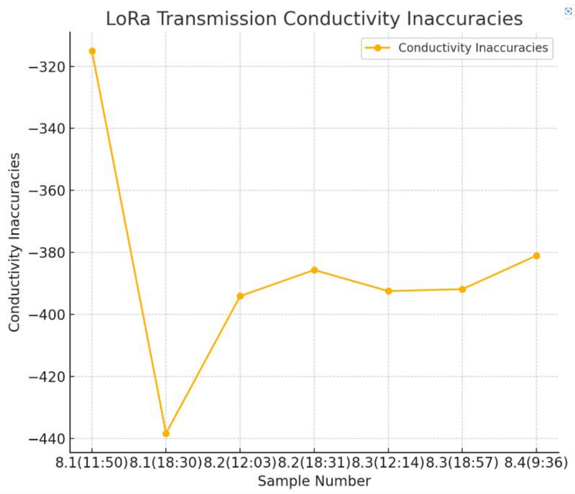
Democratia-Aqua-Technica

Introduction：

Development of a low-cost Arduino Uno based water sensor system for urban weather monitoring. The system integrates pH, temperature and humidity, and conductivity sensors with data transmission via LoRa technology for real-time monitoring of surface water quality and response to extreme weather.







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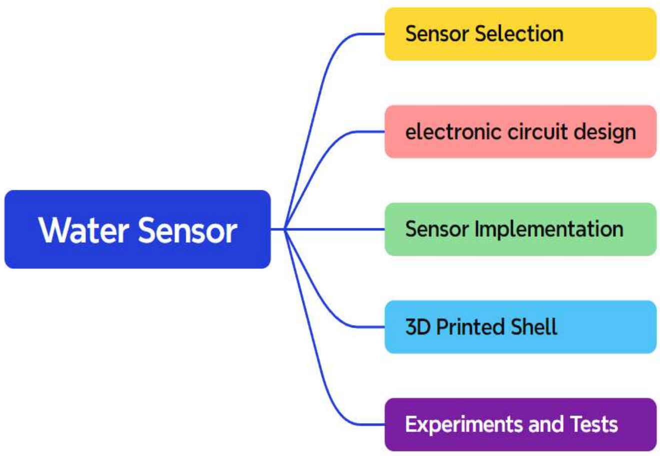

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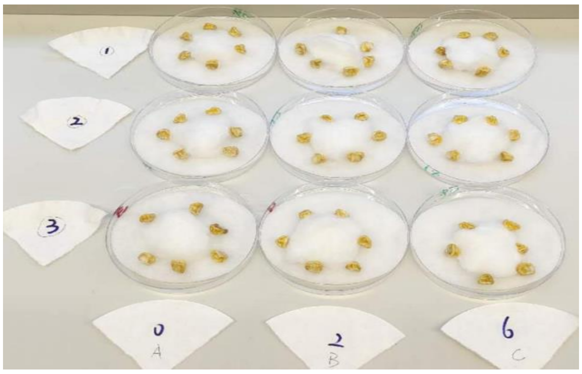
TOXICITY OF CIGARETTE BUTTS

Wang Haonan

In this study, the effect of tobacco water on seed germination and plant growth of corn was analysed experimentally



Experiment 1

In this study, we investigated the toxic effects of cigarette butt water on corn seed germination and plant growth through two experiments. Experiment 1 focused on evaluating the effects of different concentrations of bong water on germination, rooting and early growth of corn seeds, while Experiment 2 further analysed the growth traits of corn plants, including plant height, stem thickness, leaf area, root number and fresh weight, over a period of 20 days.

Experiment 2

In this experiment, Marlboro Gold cigarette butts were selected to produce different concentrations of leachate to study its effect on corn seeds. Corn was chosen as the experimental plant because of its fast germination and easy observation, and the leachate was prepared by soaking 2 and 6 cigarette butts for irrigation analysis in different groups.

Experiment 1: Irrigation of corn seeds by different concentrations of butt water revealed that germination and rooting were significantly inhibited in the high concentration group, while the low concentration group was inhibited but recovered at a later stage.

Experiment 2: Observations extended to 20 days further verified the inhibitory effect of high concentrations of tobacco water on corn growth, particularly affecting plant height, leaf and root development, while the low concentration group showed some degree of promotion.

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COMPARATIVE LIFE CYCLE ASSESSMENT OF VERTICAL AND HORIZONTAL FLOW CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT_CASE STUDY OF NECKAR RIVER, STUTTGART.

Bridget Ama Quansah

DEMO CRATIA Democratia-Aqua-Technica

Introduction

Constructed wetlands are engineered systems designed to mimic natural wetlands to treat wastewater through physical, chemical, and biological processes. These systems are eco-friendly alternatives to conventional wastewater treatment methods, leveraging natural processes to remove contaminants. The two common types of constructed wetlands are vertical flow (VF) constructed wetlands and horizontal flow (HF) constructed wetlands (Kushwaha et al., 2024). Each type has distinct design features and operational characteristics that influence its environmental impact. The aim of the study was to conduct a comparative Life Cycle Assessment (LCA) between vertical flow constructed wetland (VFCW) and horizontal flow constructed wetland (HFCW) with the following objectives.

- Obtain material and energy balance data on vertical flow and horizontal flow constructed wetlands from plant officials and literature
- Model vertical flow and horizontal flow constructed wetland inventory with OpenLCA 2.0
- Analyze and compare environmental impact results for vertical flow and horizontal flow constructed wetlands.

Materials and Methods

Goal and Scope Definition

Inventory Analysis

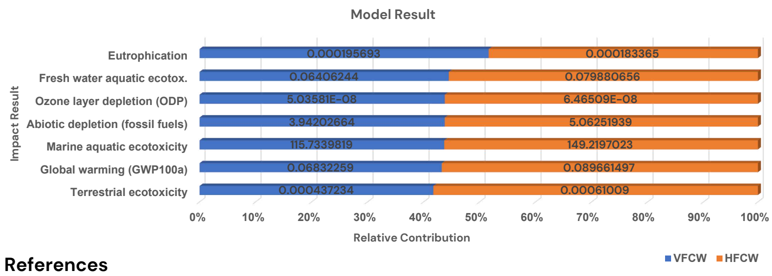
Impact Assessment

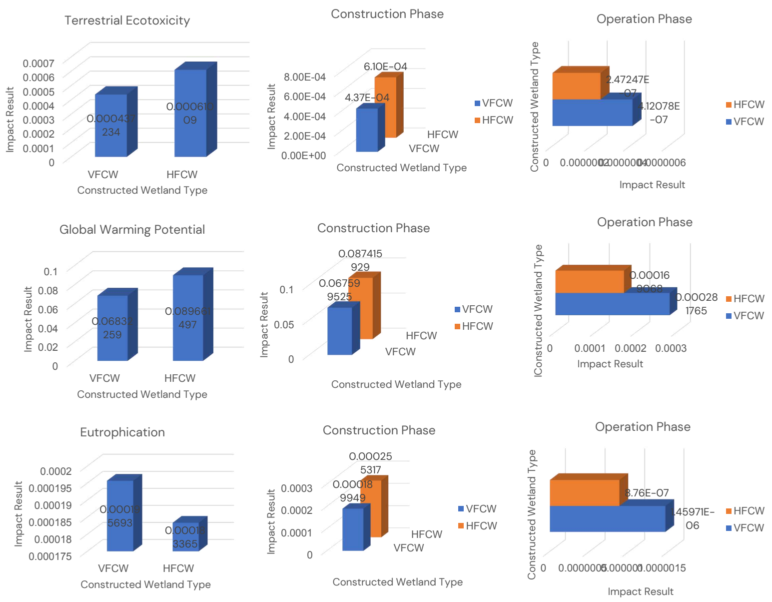
Interpretation

- The scope considered the construction and operation phases of the constructed wetlands with a functional unit aiming at the treatment of 1 L wastewater to ensure comparability.
- Primary data was obtained through interviews and secondary data obtained from literature on material input and output for the construction and operations stages of a constructed wetland.
- OpenLCA 2.0 and Ecoinvent database version 3.8 was used to model obtained data for both VFCW and HFCW and CML IA baseline was selected as the impact assessment method for the analysis.
- Environmental impacts were calculated with Excel and the model results from both wetlands were carefully analyzed and compared.

Results

Impact category	Reference unit	VFCW	HFCW	Total Impact	% VFCW	%HFCW	% Difference
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000437	0.00061	0.001047324	41.75%	58.25%	16.50%
Global warming (GWP)	kg CO2 eq	0.068323	0.089661	0.157984087	43.25%	56.75%	13.51%
Marine aquatic ecotoxicity	kg 1,4-DB eq	115.734	149.2197	264.9536841	43.68%	56.32%	12.64%
Abiotic depletion (fossil fuels)	MJ	3.942027	5.062519	9.004546029	43.78%	56.22%	12.44%
Ozone layer depletion (ODP)	kg CFC-11 eq	5.04E-08	6.47E-08	1.15009E-07	43.79%	56.21%	12.43%
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.064062	0.079881	0.143943096	44.51%	55.49%	10.99%
Eutrophication	kg PO4--- eq	0.000196	0.000183	0.000379058	51.63%	48.37%	-3.25%





Discussion

The results indicated the VFCW had relatively lower emissions in five impact categories which can be primarily attributed to less construction materials, efficient aeration, reduced energy consumption and lower concentrations of residual COD.
However, the VFCW had higher Eutrophication potential which was 3.25% higher than the HFCW. The operation phase accounted for this result and it can be concluded that amount of phosphorus and nitrogen releases in this phase contributes to high Eutrophication potential.

To reduce eutrophication potential from VFCWs, optimizing nitrogen and phosphorus removal through design improvements, operational adjustments, and incorporating hybrid systems is essential. Enhancing denitrification, phosphorus retention, and plant uptake, combined with regular monitoring and maintenance, can significantly lower nutrient emissions and improve the environmental sustainability of VFCWs.

Conclusion and Recommendations

This study highlighted the trade-offs between VFCW and HFCW comparing their environmental burdens. Overall, VFCW was considered a superior option regarding the environmental impact assessment of the construction and operation stages of a constructed wetland.

- It is recommended that decision-makers take into account elements including choice of construction materials, type and cost of energy, treatment efficiency, and phosphorus management when selecting constructed wetland types.
- Future research should focus on optimizing constructed wetland designs and operation to minimize environmental impacts. This can be achieved by improving LCA methodologies and addressing data gaps for constructed wetlands.

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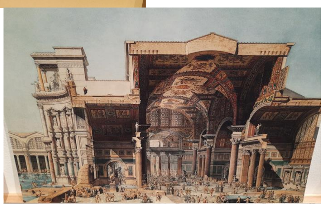
Water Rights are Human Rights!

Purpose of the Conference

Water Sustainability: To promote knowledge sharing on the management and protection of water resources.

Adaptation to Climate Change: To identify the necessary strategies for combating climate change and enhancing water security[1].

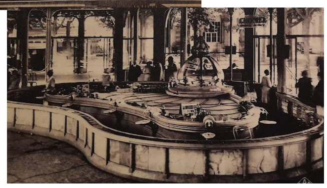


ANCIENT PERIOD

Mesopotamian civilizations, including those led by Hammurabi, developed communal irrigation systems and legal frameworks for water management [2].

MIDDLE AGES

Various laws were established regarding the management and distribution of water channels



19th and 20th CENTURIES

With the industrial revolution, the management of water resources became more complex. Water pollution and scarcity increased the need for legal regulations [3].

MODERN PERIOD DISPUTES

MIDDLE EAST

Euphrates and Tigris rivers

Turkey, Syria, and Iraq [4].

NILE RIVER

Grand Ethiopian Renaissance Dam

Egypt and Sudan [5].

SOUTH EAST ASIA

Ganges and Brahmaputra rivers

India and Bangladesh [6].

INTERNATIONAL SOLUTIONS

1992 Dublin Principle

These emphasize environmental sustainability and human rights in the management of water resources [7].

UN Water Framework Convention

This provides legal frameworks for the management of transboundary water resources

International RecognitionIn 2010, the UN General Assembly declared clean drinking water to be a human right [8].

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SUMMER LAND USE REGRESSION MODEL FOR PREDICTING $PM_{2.5}$ AIR QUALITY CONCENTRATIONS IN NOVI SAD, SERBIA

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The assessment of air quality in urban areas has long been a priority due to significant variability in pollution levels. As a result, a range of air pollution modeling techniques is widely utilized to address this challenge.

- Quality of ambient air in Novi Sad during summer is under influence of pollution emitted from traffic, present in various densities and vehicle structures depending on the road classes (primary, secondary, tertiary or residential).
- Beside this primary emission source, pollution can also be transported through the atmosphere from nearby areas or greater distances.
- Within presented study, seasonal Land Use Regression (LUR) model focused on predicting summer $PM_{2.5}$ levels in Novi Sad, was developed for the first time in Serbia.

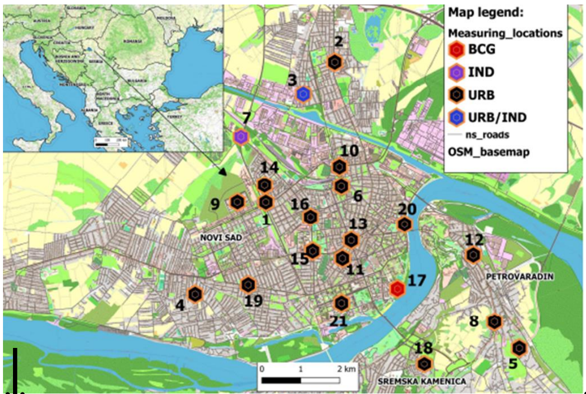
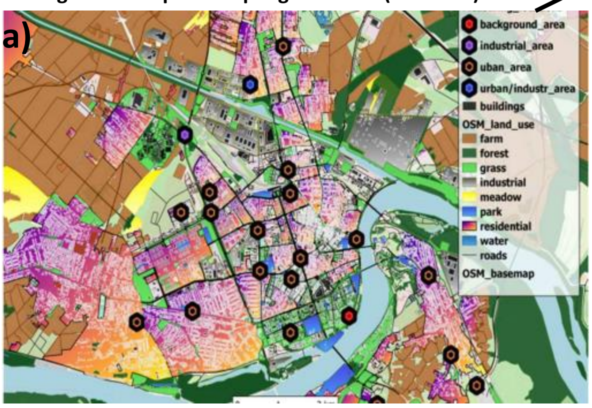
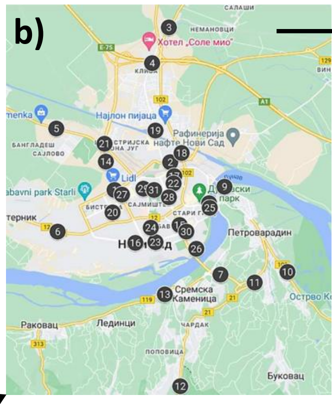


Figure 1. Map of sampling locations (Novi Sad)





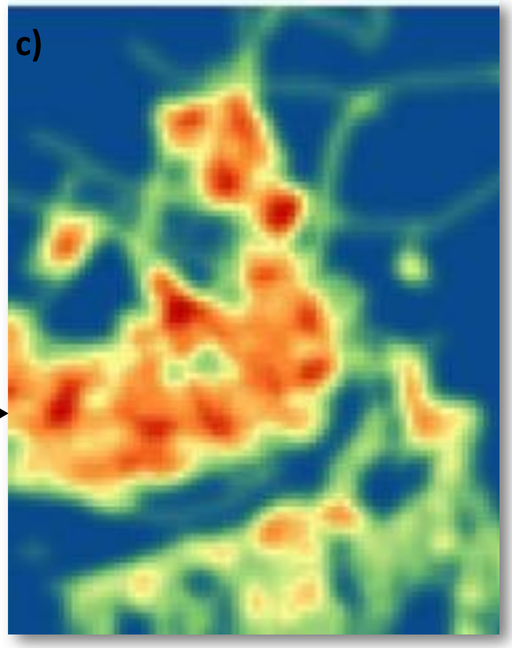


Figure 2. Maps: a) predictors, b) traffic counters, c) $PM_{2.5}$ prediction surface

- *As a final step in the development process, a summer $PM_{2.5}$ prediction surface was created for the City of Novi Sad, reflecting the model's achieved efficiency (Figure 2c).*

- $PM_{2.5}$ data were collected from 21 sites in the City Novi Sad during the summer using reference gravimetric pumps, with microfiber filter replacements every 48 hours.
- The assessed summer $PM_{2.5}$ concentrations ranged from 10.49 to 22.31 μg/m³.
- The developed summer Land Use Regression (LUR) model explained 40.3% of $PM_{2.5}$ variability, using total road length within a 50 m buffer as a proxy for traffic intensity.

$$PM_{2.5}\_LUR_{summer} = 12.43 + road\_length\_50m + 0.020$$

- Evaluation tests confirmed the model's validity, with Cook's distance values below 1 and the White test showing equally distributed residual variance. The residual distribution was treated as approximately normal.
- Leave-One-Out Cross Validation (LOOCV) revealed adjusted R² values between 31.2% and 45.3% and RMSE values from 2.74 to 3.01 μg/m³, with mean absolute errors ranging from 2.36 to 2.68 μg/m³.
- These results further validate the effectiveness of the summer model in predicting $PM_{2.5}$ concentrations.

- *The evaluation tests confirmed the model's robustness and that the data structure was suitable for regression analysis, validating the results of the summer model.*
- *This seasonal model is an effective tool for predicting $PM_{2.5}$ concentrations at unmonitored sites, offering valuable insights into air quality.*

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Acknowledgements

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SUMMER LAW SCHOOL 2024

08.07.2024 - 12.07.2024

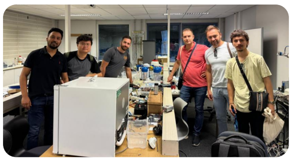
Collaborating Universities

- SRH Hochschule Heidelberg (Host) - Germany
- University of Novi Sad - Serbia
- Dicle University - Turkey

The Summer Law School 2024 brought together participants to explore the intersections of climate protection, water rights, and European Union legislation. This vibrant week was filled with workshops, hands-on learning, and collaborative research, culminating in poster presentations that showcased innovative solutions to pressing environmental and legal challenges.
The following section provides a detailed overview of the activities.

1. Campus Tour and Lab Facilities

- Campus Tour Highlights
- State-of-the-Art Labs
- Climate Research Insights
- Innovative Techniques
- Ideas Exchange



2. Group Research and Poster Creation

- Pressing Global Topics
- Teamwork & Collaboration
- Innovative Solutions
- Poster Creation
- Constructive Feedback

3. EU Climate Legislation

- EU Climate Regulations
- Deforestation Regulation (EUDR)
- ESG Strategies in Action
- Legislative Frameworks
- Corporate Responsibility

4. Innovation Workshop

- Hands-On Workshops
- Out-of-the-Box Thinking
- Lego for Collaboration
- Rich Dialogue & Ideas
- Real-World Solutions
- Innovative Problem-Solving

5. Workshop on Water Rights

- Water Rights Workshop
- Wastewater Recycling
- Legal Frameworks
- Sustainable Practices
- Practical Knowledge
- Resource Management

6. Poster Presentations

- Engaging Poster Presentations
- Global Collaboration
- Innovative Ideas & Solutions
- Interdisciplinary Research
- Commitment to Global Challenges
- Showcasing Creativity

KEY LEARNINGS!

Interdisciplinary Collaboration
Students tackled global challenges by combining legal, environmental, and technical perspectives.

Actionable Knowledge
Participants gained insights into climate legislation, sustainable practices, and innovative solutions for water rights and resource management.

Cultural Exchange
The event strengthened connections between participants from Germany, Serbia, and Turkey, enriching both academic and personal experiences

srh

UNIVERSITAS STUDIORUM NEOPLANTENSIS

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YIP

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JOIN THE FUN AND LEARN ABOUT WATER CONSERVATION!

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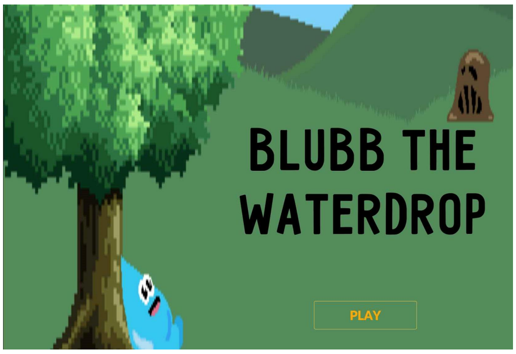
•Apple Store

•Web Version

In 'Blubb the Waterdrop,' you not only embark on an exciting water conservation adventure, but you also have the opportunity to explore various engaging game modes.



<u>*Available other water games:*</u>

•Antique Escape Room

•Slide Puzzle

•Water Quiz

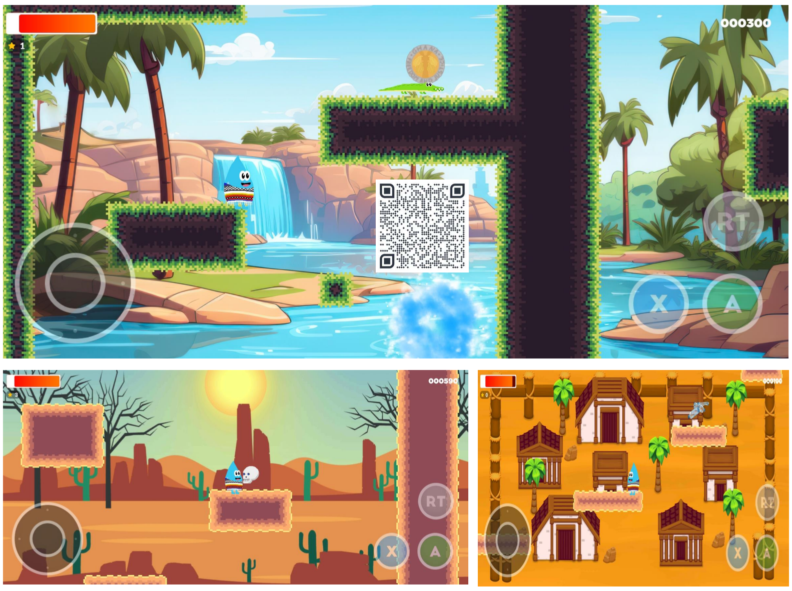
•Sewage Plant Escape Room

•VR + PC Wastewater Treatment Plant Tour

See Blubb the Waterdrop in Action

Curious about how 'Blubb the Waterdrop' looks in action? Watch gameplay videos from different countries and see how players are exploring water conservation challenges

Mexico | Ghana | Germany



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- Main website: https://democratia-aqua.org/

  Project information, E-Books 2020, 2021 and 2022

  Poster sessions

  Digital rallies
- YouTube channel: Democratia Aqua – YouTube
- Instagram: https://www.instagram.com/hshd_water_technology/
- Digital Tools: Escape Rooms, puzzle game, jump‘ n run water droplet game

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