IMPETUS

Water-borne pathogen outbreaks and extreme weather events

Modeling microbiological risks in Barcelona's coastal bathing waters under different heat scenarios

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climate-impetus.eu

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IMPETUS project view

Title:

DYNAMIC INFORMATION MANAGEMENT APPROACH FOR THE IMPLEMENTATION OF CLIMATE RESILIENT ADAPTATION PACKAGES IN EUROPEAN REGIONS: Towards Climate Adaptation & Mitigation




IMPETUS in facts

93% of Europeans consider climate change a serious problem

32 IMPETUS partner organisations from 9 countries

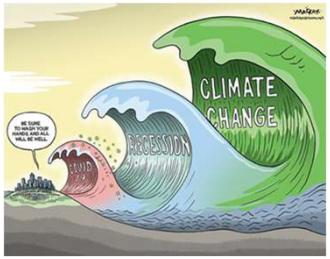
15 technical and nature-based solutions being tested

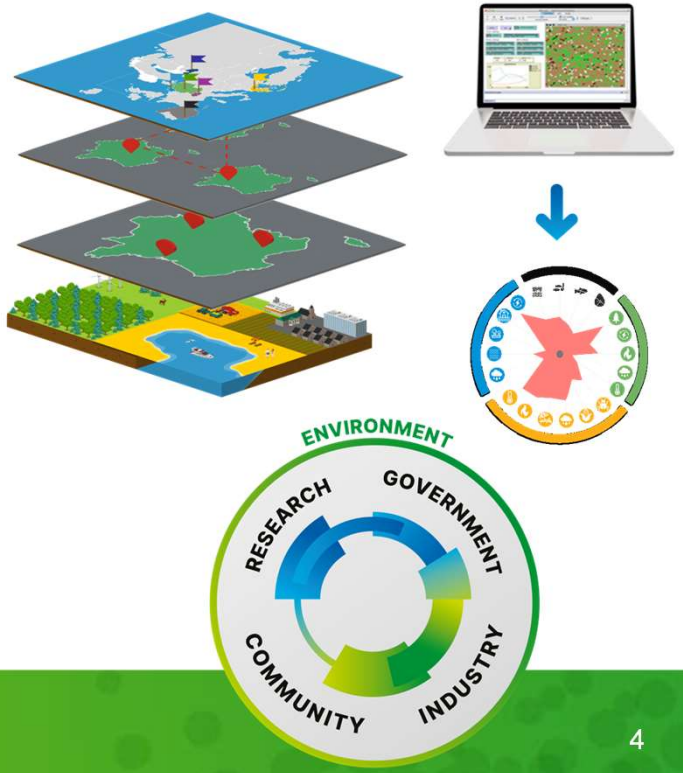
7 demonstrator sites in different European biogeographical regions

14.8M € project budget, funded by the European Union

IMPETUS project view

- Immediate actuations are required to forefront climate change impacts
- Action to protect communities and the planet from climate change:
  - Specific solutions and innovations co-created with local communities in 7 demonstration sites in every climate region of Europe
- Better informed decision-making delivering a targeted climate response:
  - Amplifying and enhancing data sets and digital modelling using cutting edge technologies
- Supporting vulnerable sectors and businesses to be more resilient





IMPETUS project view: objectives

- Technological objectives:
  - Identify, collect and upscale existing real-time territorial data, knowledge and innovations necessary for robust adaptation and resilience planning.
  - Increase knowledge-sharing and awareness on climate change through the combination of modelling tools, advanced data analytics and high visualization
- Operational objectives:
  - Development of IMPETUS Innovation Packages in 7 demo-sites covering the European bio-geographical regions.
  - Present IMPETUS innovation packages ready to be transferred to other areas and socio-ecological systems
- Social objectives:
  - Boost alliance and coalitions with relevant stakeholders to co-create and co-design innovations and adaptation pathways.

Arctic (**Troms & Finmark-NO**)

Atlantic (**Zeeland-NL**)

Boreal (**Semgale-LV**)

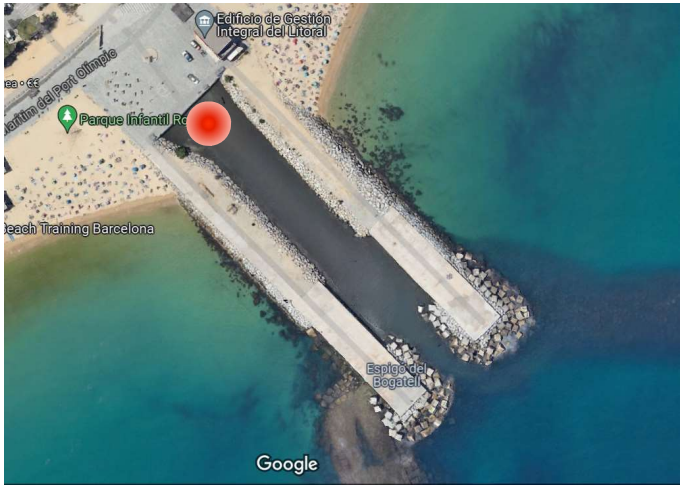
Coastal (**Catalonia Coast ES**)

Continental (**Berlin-Branderburg-DE**)

Mediterranean (**Attica-GR**)

Mountainous (**Valle del Laghi-IT**)

Problem description



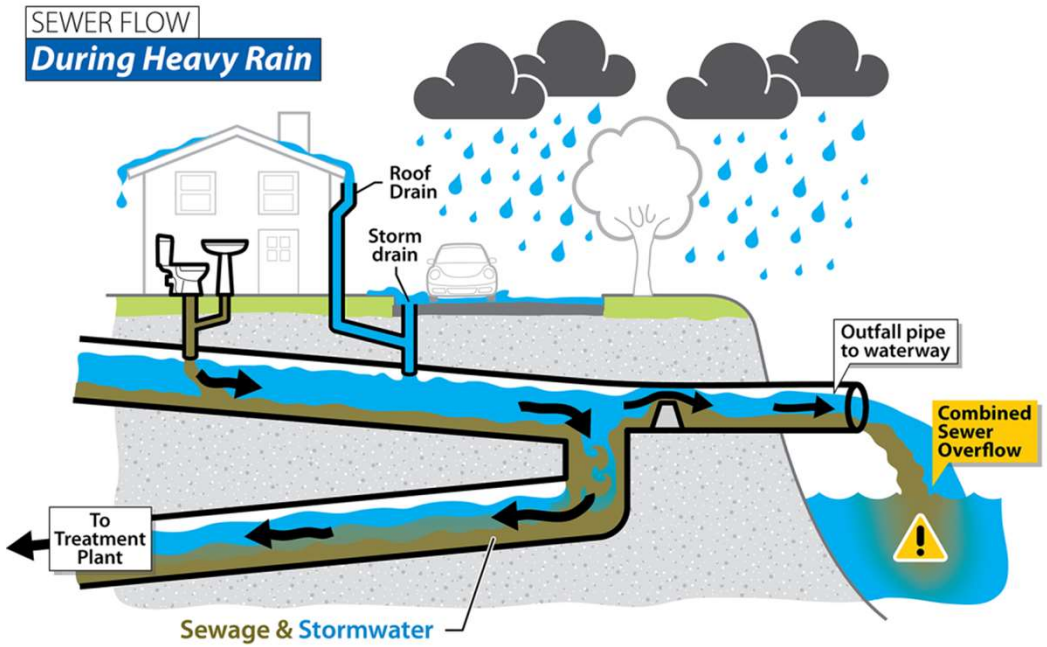
➢ Climate risk addressed and R&I solution

Climate risk addressed	R&I Solution
Sea level rise	**[COASTAL]** Below sea-level multifunctional wetland **[ARTIC]** Climate-proofing of the city centre and of its urban water infrastructure against sea level rise
Flooding risk	**[ATLANTIC, BOREAL]** Digital twins and advanced tools for climate adaptation
Water scarcity	**[COASTAL, MEDITERRANEAN]** Decentralized circular-economy inspired water/energy/materials reuse innovations **[MEDITERRANEAN]** Controlled environmental agriculture (CEA) solutions **[MEDITERRANEAN]** Digital twins and advanced tools for climate adaptation **[MEDITERRANEAN]** Water-energy master plan and business plan for autonomous climate proof regions **[CONTINENTAL]** Decision Theatre (DTh) for regional integrated water resource management **[CONTINENTAL, MOUNTAIN MEDITERRANEAN]** Advanced tools for regional water management
Marine storms	**[COASTAL]** Sand dunes restoration techniques and monitoring **[COASTAL]** Sediment transportation through irrigation networks
Fires	**[MEDITERRANEAN]** Forest fires and restoration
Biodiversity loss	**[MEDITERRANEAN]** Supporting reforestation and biodiversity **[COASTAL]** Changes in the spatial distribution of species
Health diseases	**[COASTAL]** Improving bathing water quality after extreme storm events. **[COASTAL]** Increasing resilience of water plants to water-borne pathogens **[ATLANTIC]** Heat awareness system
Temperature increase	**[ARCTIC]** Digital twin to co-design a Marine Spatial Planning framework **[MOUNTAIN]** Implemented bio-district to address altitudinal shifts of crops
Avalanche increase	**[ARCTIC]** Early-warning and evacuation system for geological and avalanche risk sites
Extreme storms	**[COASTAL]** Assessment of economic impacts of extreme storms in infrastructures
All	**[COASTAL]** Creation of Alliance for a resilient Coast **[COASTAL]** Behavioural change for climate resilient tourism **[MOUNTAIN]** Innovative insurance products for agriculture, forestry and hydropower energy production **[MOUNTAIN]** Activating Cultural heritage to enhance climate resilience **[ATLANTIC]** Decision Support Tool to support the decarbonisation of industrial clusters **[BOREAL]** Climate change adaptation governing plan **[ALL]** Assessment of economic impacts of physical climate risk across demo cases

- **Case study**: Bogatell beach in Barcelona
- Population: 1.6 million
- Area: 100 km^2
- Mediterranean Climate with intense rain events
- Combined Sewer System: scenarios of **Combined Sewer Overflow**

Problem description: CSO

- What are CSOs? overflow of untreated sewage into water bodies during heavy rainfall.
- Climate Change Impact: more intense storms → increased CSO frequency & volume.
- Water Contamination: pathogens (E. coli, enterococci, norovirus), chemicals & microplastics.
- Health Risks: gastrointestinal, respiratory, and skin infections—higher risk for vulnerable groups.
- Economic & Social Impact: beach closures, tourism losses, higher public health costs.
- Solutions: improved infrastructure, real-time monitoring, stricter regulations.



Problem description: Global warming effect on CSO

- Increased Atmospheric Moisture:
  - 7% more moisture capacity per °C increase.
  - More intense rainfall events. (NASA GPM)
- Increase in Extreme Rainfall:
  - 12% rise in record-breaking events (1981-2010) compared to estable climate scenario. (Research VU)
- Climate Projections:
  - With the contimous increase of global temperature, more intense and frequent heavy rainfall is expected.
    - ESD: Intensified water cycle: more available humidity for precipitation.
    - IPCC: Global warning is likely to lead to more extreme weather events, including heavy rainfall.

Increase in frequency and intensity of extreme events with global warming

Name of event	Climate in 1850–1900	1 °C warming	1.5 °C warming	2 °C warming	4 °C warming
1 in 10 years heatwave	Normal	2.8 times more often, 1.2 °C hotter	4.1 times more often, 1.9 °C hotter	5.6 times more often, 2.6 °C hotter	9.4 times more often, 5.1 °C hotter
1 in 50 years heatwave	Normal	4.8 times more often, 1.2 °C hotter	8.6 times more often, 2.0 °C hotter	13.9 times more often, 2.7 °C hotter	39.2 times more often, 5.3 °C hotter
1 in 10 years heavy precipitation event	Normal	1.3 times more often, 6.7% wetter	1.5 times more often, 10.5% wetter	1.7 times more often, 14.0% wetter	2.7 times more often, 30.2% wetter
1 in 10 years drought	Normal	1.7 times more often, 0.3 sd drier	2.0 times more often, 0.5 sd drier	2.4 times more often, 0.6 sd drier	4.1 times more often, 1.0 sd drier

https://gpm.nasa.gov/resources/faq/

https://research.vu.nl/en/publications/

https://esd.copernicus.org/articles/10/73/2019/?

https://www.ipcc.ch/report/ar6/syr/

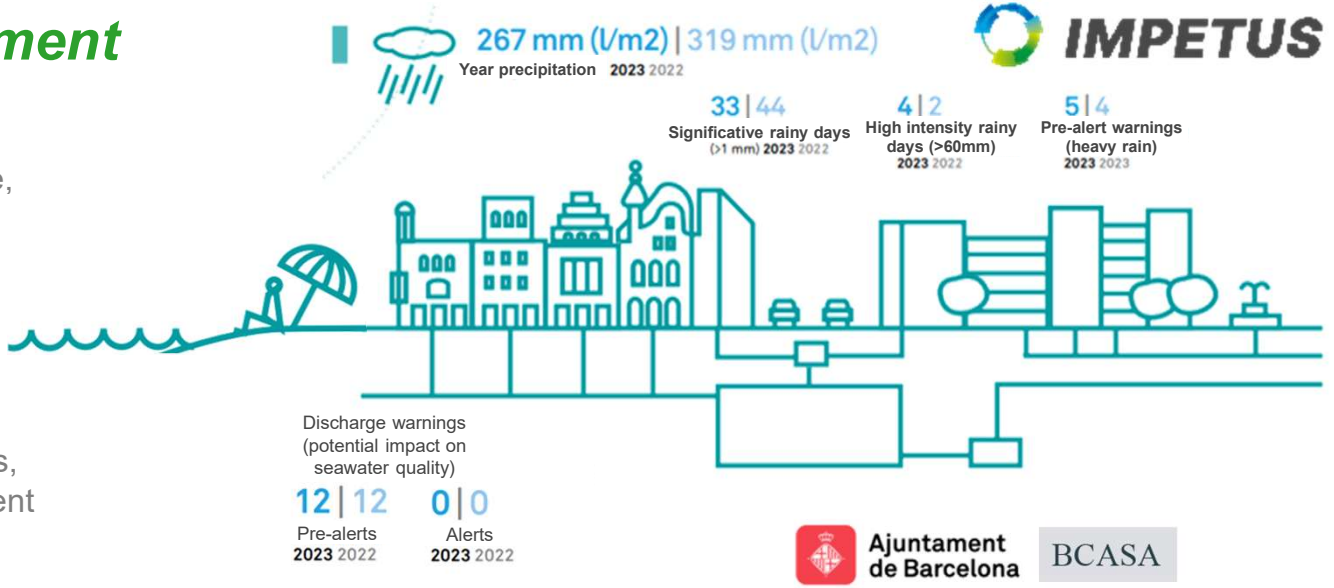
Current authorities' management

- Upgrading Infrastructure → expand wastewater treatment, maintenance activities & storage capacity.
- Nature-Based Solutions → green roofs, wetlands, and permeable surfaces to absorb excess water.
- Early Warning Systems → **real-time monitoring** & **predictive models for heavy rain and CSO events**.
- Policy & Regulation → stricter water management policies and stormwater separation.
- Public Awareness → educating communities on risks & preventive actions.
- Emergency Response Plans → rapid containment and mitigation strategies for contamination events.
- Cross-Sector Collaboration → coordinated efforts between governments, utilities, and scientists.

Current authorities' management

Water Cycle Control Center – BCASA

- Centralized Water Management → controls sewage, groundwater use, irrigation, fountains, and beach monitoring.
- Real-Time Monitoring → telemanagement system enables immediate response to issues, improving efficiency.
- Drainage System Supervision → tracks water levels, quality, and pump station status to optimize rain event response.
- Flood Prevention → adjusts hydraulic flow to distribute peak loads, minimizing overflows and flooding.
- Rain Event Management → alerts activated based on rainfall intensity; protocols coordinated by Civil Protection.
- Rainfall DataBase → significant rain days, high-alert events, and tons of suspended matter retained from reaching the sea.
- Beach Information System → provides real-time beach conditions via municipal websites, panels, and mobile apps.

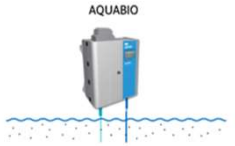


https://www.adasasystems.com/en/technology/aquabio-measuring-water-quality.html

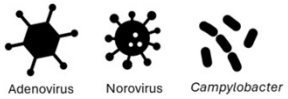
QMRA model: objectives

- Quantitative Microbiological Risk Assessment (QMRA) model to determine the risk of the presence of pathogens in seawater due to CSO scenarios.
- The objective is to develop and implement tools for risk prediction, monitoring and management of water-borne disease in Barcelona demo-site.
- Upgrade previous QMRA model
- Including following improvements:
  - **Improvement of pathogen/FIB ratios with new sampling campaigns**
  - **Transport and decay model to predict pathogen concentration evolution in the bathing are near the CSO**

Online monitoring through Aquabio (E.coli i Enterococci)



Pathogen concentration estimation through calibrated FIB/pathogen ratios

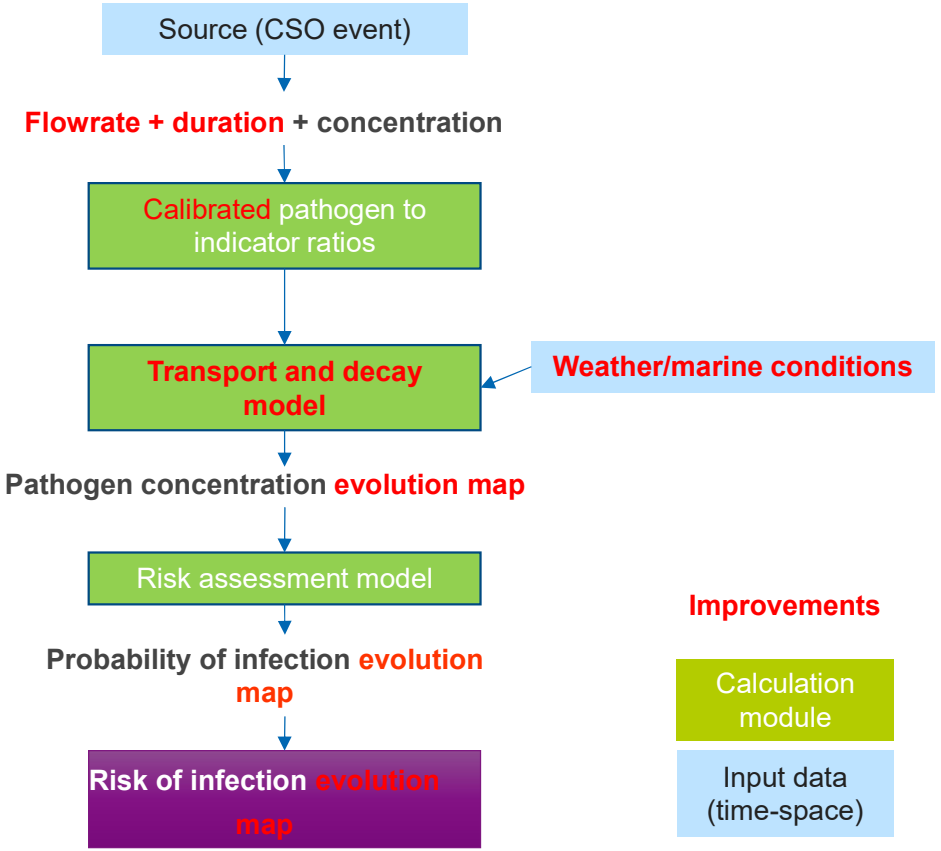


Estimation of infection probability through dose-response model

Estimation of degree of infection risk given the tolerable risk

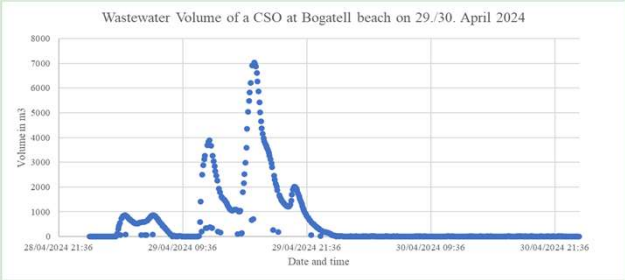
QMRA model: workflow

- Input data:
  - CSO event: duration, flowrate and concentration of FIB to feed boundary conditions (emission point)
  - Weather and marine conditions to feed the transport and decay model
- Development of the 2D transport model (diffusion, advection and degradation in Python) in two domains: breakwater and open sea.
- Average scenarios (seasonal) for environmental input data or potentially real-time weather conditions:
  - sea currents, temperature, salinity, radiation.
- Transport model output: evolution of the heatmap of pathogen concentration in the bathing waters near the CSO → to feed the risk assessment model.
- Risk assessment model output: evolution of heatmap of the level of risk of infection based on the probability of infection (exposure and dose-response analysis).



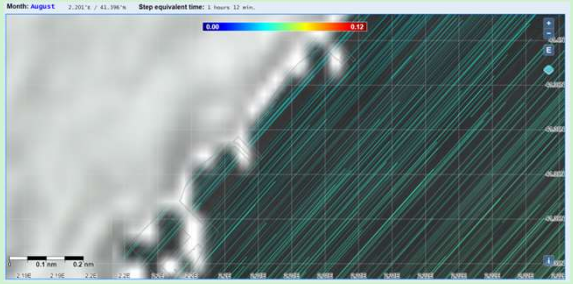
QRMA model: preliminary results

Replicating CSO past event

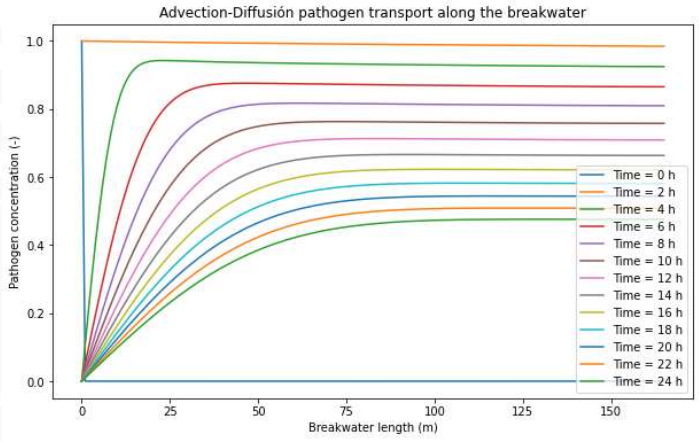


Registered CSO flowrate (source: BCASA)

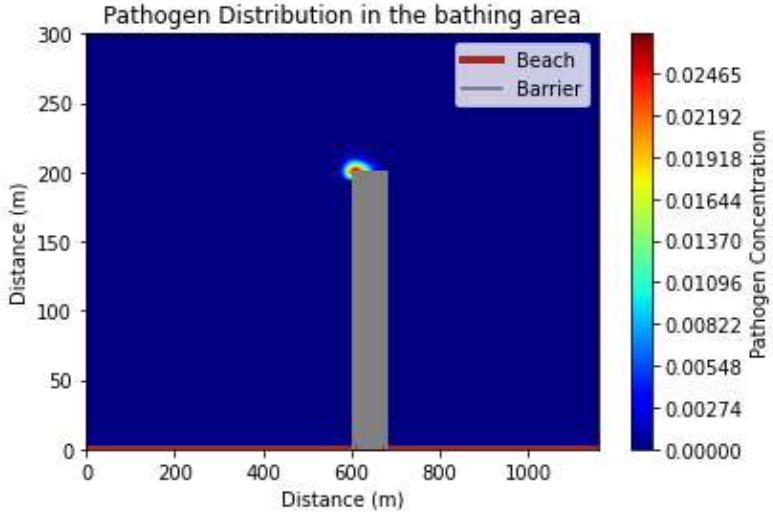
CSO samples for pathogen analysis



Weather and marine conditions (source: COSMO)



Evolution of pathogen concentration along the breakwater channel



Heatmap of the pathogen after 1h

QRMA model: preliminary results

Seasonal study

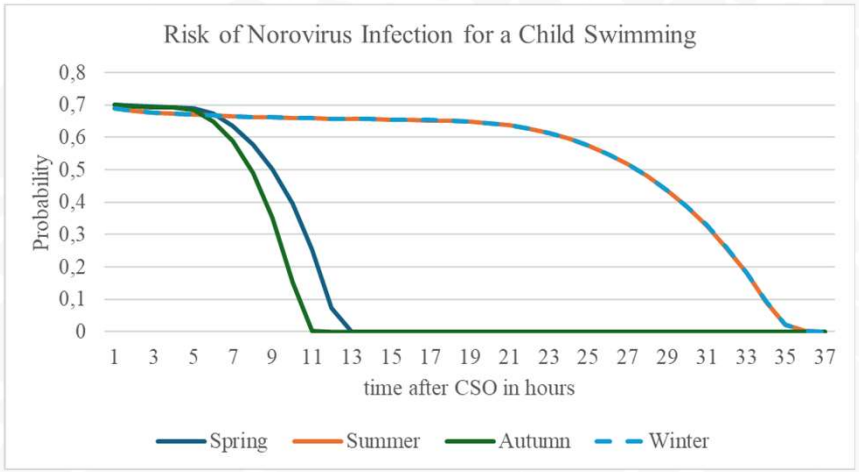
Average pathogen concentration

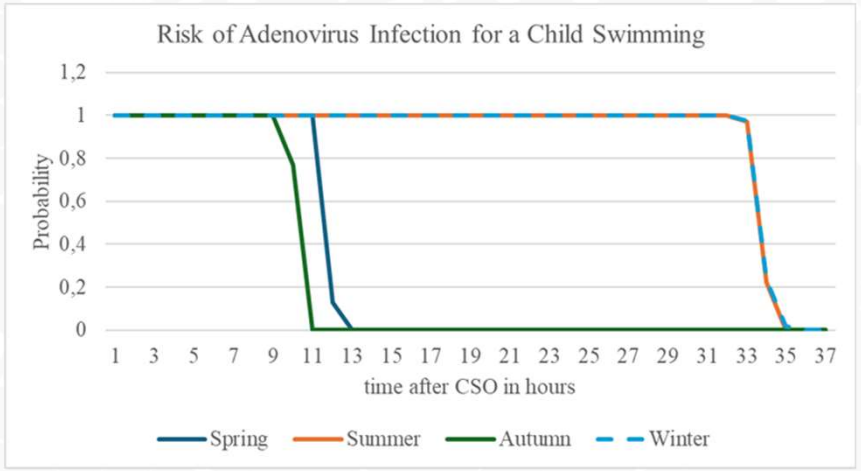
Average CSO flowrate (source: BCASA)

Human Adenovirus (HAdV)	Norovirus Genogroup I (NoV GI)	Norovirus Genogroup II (NoV GII)	E. coli	Intestinal Enterococci
GC/l	GC/l	GC/l	MPN/100 ml	MPN/100ml
4860	3310	178	967	311

Average weather and marine currents (source: LOBELIA)

	Winter	Spring	Summer	Autumn
x-velocity (m/s)	-0,01	0,03	-0,01	-0,04
y-velocity (m/s)	-0,01	0,00	-0,01	0,00





Scenario	Ingestion (ml/h)
Child swimming	37
Adult swimming	16
Activity on water	2

Future work: CSO prediction

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Weather forecast

ECMWF

AEMet Agencia Estatal de Meteorología

CSO predictive model*

QMRA model

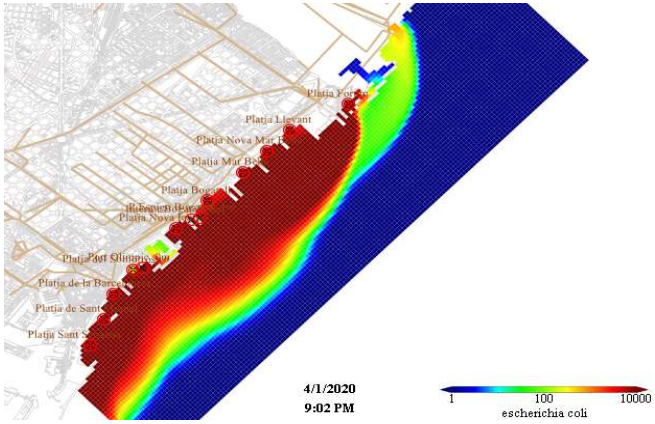
Ajuntament de Barcelona

BCASA

Medi Ambient i Serveis Urbans – Ecologia Urbana

Drainage system indicators

Risk of pathogen infection forecast



***Machine learning-based model fed with historical data on CSO registers and rain intensity/duration**

Future work: CSO prediction

IMPETUS

GFCS GLOBAL FRAMEWORK FOR CLIMATE SERVICES
Climate services

projections

Weather forecast
ECMWF
AEMet Agencia Estatal de Meteorología

CSO predictive model*

QMRA model

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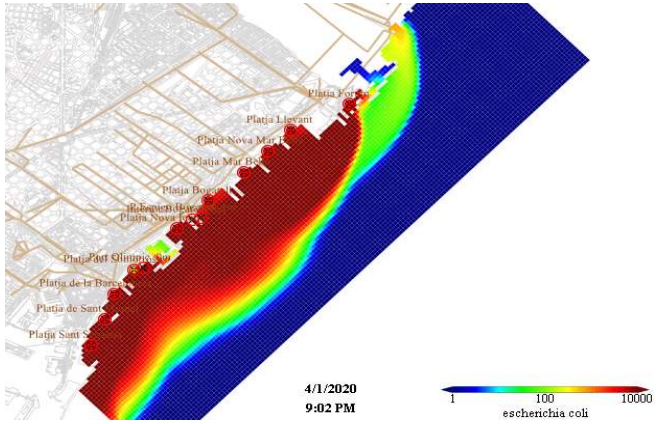

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THANK YOU

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