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PathoCERT

D3.3 — Communities of Practice: best practices and key learnings

WP3 — Requirement Analysis, Engagement of Professionals through Communities of Practice & Social Engagement

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ABSTRACT	This report consolidates the key outcomes and learnings of the CoPs that have been conducted in the past two years in the various PathoCERT countries. These key learnings include the needs, expectations and challenges the stakeholders have regarding the technologies that are being developed in the project. In addition to these findings, reflections on the methodological approach taken in the project with the CoPs as multi stakeholder engagement tools are highlighted. Based on the past developments, next steps concerning the CoPs as well as the further exchange with relevant project partners are outlined.		

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS/ACRONYMS

AUTH	Aristotle University of Thessaloniki
CISD	Communication and Information Systems Directorate
DPP	Disaster Protection Plans
DUTH	Democritus University of Thrace
ERP	Emergency Response Plan
EYATH	Thessaloniki Water Supply & Sewerage Co
FR	First responders
CoP	Community of Practice
HRT	Hellenic Rescue Team
KWDCC	Korean Wildlife Disease Control Center
KWR	KWR Water Research Institute
MOIB	the Ministry of Interior of Bulgaria
NDMI	National Disaster Management Research Institute
RIEW	Sofia Regional Inspectorate for Environment and Water
SPEIS	Prevention, Fire Fighting and Rescue Service
SYL	Limassol Water Supply Council
TAST	Civil Defence
UCY	University of Cyprus
WBL	Water Board of Lemesos
WDD	Water Development Department
CET-MD	Crisis Expert Team environment and drinking water

Executive summary

PathoCERT is a project working towards decreasing the risk of first responders (FRs) being exposed to waterborne pathogens during emergency situations, through the development of novel technologies. This deliverable provides an overview of the initial findings derived from the applied multi-stakeholder engagement processes including the descriptions of all project´s technologies, and related pilot cases and scenarios where they will be pilot-tested.

Specifically, it starts with Section 1 providing an overview of the PathoCERT technologies that are currently under development and will be tested and validated in five European countries, namely Spain, the Netherlands, Cyprus, Bulgaria and Greece. Following, an overview of the background situation in each of these pilot cities is presented, looking at their emergency management systems. This overview includes the case of Seoul in South Korea, which although it is not among the pilot cities, it is one of the implementers of the multi-stakeholder engagement activities and directly contributing to the advancement of the technologies.

Section 2 continues by presenting in more detail the PathoCERT multi-stakeholder engagement approach exemplified via the Communities of Practice (CoP) concept. This approach enables to bring together a broad range of stakeholders operating within the pilot cities emergency management systems. Specifically, CoPs have been set up in each of the six PathoCERT cities: Limassol (Cyprus), Seoul (South Korea), Sofia (Bulgaria), Thessaloniki (Greece), Amsterdam (The Netherlands) and Granada (Spain) and tailored-made meetings have been organised in order to establish a common understanding on necessary novel emergency management technologies, procedures and tools and discuss the potential and related challenges to their uptake at the local level.

This applied approach has now generated its first tangible outputs. Accordingly, in Section 3 the content specific learnings of the first two rounds of CoP meetings are described. For each CoP, content-specific outcomes have been generated following key specific aspects, namely challenges, needs, stakeholders' interests and expectations on technologies' usage and practical application.

Together with the insights derived from each CoP meeting, this deliverable also presents partners´ feedback with respect to the application of the multi-stakeholder approach. Specifically, good practices and key learnings have been collected to derive a comprehensive overview underpinning the setting up and running of each CoP.

All the summarised outputs will act as guidelines for the further development and/or refinement of different components of the PathoCERT technologies as well as for the further refinement of the multi-stakeholder engagement processes. The report concludes with an outlook linking the outputs of the CoP with the pilot preparations, showcasing how the methodology will be improved in the upcoming project years as well as outlining the role of the European CoP meetings.

1. Introduction

First responders can be exposed to waterborne pathogens when they are responding to an emergency. The PathoCERT project's goal is to enhance the protection of first responders from these waterborne pathogen contaminations and augment their ability to react to dangers. This is done through developing technologies, services and governance mechanisms that enable the fast and accurate detection of waterborne pathogens as well as improve the communication between different emergency management actors.

This report provides an overview of the gathered knowledge-base stemming from the co-creative and multi-stakeholder engagement approach applied in the project via the setting up of six Communities of Practice in five different European countries and in Seoul, South Korea. It also offers an overview of all technologies under development including interlinked stakeholder´s needs, challenges and interests. It then concludes with a summary of the derived best practices and key learnings in relation to the applied engagement methodology.

1.1 The PathoCERT technologies & Pilot Cities

1.1.1 The PathoCERT technologies

The PathoCERT project aims to develop 12 main technologies, as outlined in **Table 1** and the Annex section. It is important to highlight that this list of technologies is constantly evolving, as a result of the identification of needs and requirements from first responders as well as based on input received from local stakeholders and project partners. Throughout the second and last year of the PathoCERT project (2022 and 2023) the developed technologies will be tested and validated in five pilots across different European countries, more specifically in Spain, the Netherlands, Cyprus, Bulgaria and Greece.

Table 1 Brief description of the PathoCERT technologies

PathoCERT technology	Description
PathoSENSE	A set of mobile sensing solutions for detecting the existence of pathogens and determining their type. It will be complemented by guidelines and smart interfaces to assist FRs in setting up the specialized sensing equipment in as little time as possible while reducing human errors
PathoSENSE-AQUATRACK	An optical early warning system with an automatic sampling function for water systems
PathoSENSE-BACTCONTROL	An automatic quality analyser that detects bacteria in water systems
PathoSENSE-PathoTeSTICK	A portable sensor to allow FRs to rapidly distinguish both if contamination has taken place and between multiple pathogens in a water source
PathoSENSE-Mobile and AR Guidance Tools	Augmented reality guidance and instructions for the use of the PathoSENSE tools
PathoSENSE- IoT GATEWAY	The gateway collects the information from the PathoSENSE tools and relays it to PathoWARE
PathoDRONE	Autonomous path planning to map the affected area. Collects water samples from water bodies that first responders are unable to reach. It supplies PathoSENSE with water samples for evaluation and identification

PathoDRONE-MAP	Navigation, surveillance and mapping of a water area, processed data sent to PathoSENSE IoT Gateway
PathoDRONE-SAMPLE	A drone that has the ability to collect water samples from surface water
PathoVIEW	Allows FRs to see relevant information from (and communicate with) PathoWARE through smart wearable interfaces and augmented reality systems. For example, FRs will be warned if an area poses a high risk to the FRs' health through obstacles and possible hindrances
PathoVIEW-WATCH	Smart watch that alerts first responders to a change in their surroundings
PathoVIEW-Mobile	Mobile app to exchange information relevant to the situation
PathoVIEW-GLASS	Augmented reality glasses that allow first responders to see maps and actions plans in the field
PathoVIEW-VEST	Haptic vest which alerts first responders if they enter a danger zone
PathoINVEST	Provides information to the incident commander on the threat risk (after a contamination has been identified), predicts the evolution of events and foresees possible impacts. This tool starts the epidemiological and criminal investigations of the water pathogen contamination
PathoINVEST- URBAN	Desktop application, can be linked to a virtual city for tabletop exercises For FR and utilities to make decisions and produce maps to give to PathoGIS
PathoINVEST-FLOOD	Desktop application to compute the evolution of a flood event
PathoTHREAT	Provides information on the proper course of action concerning specific pathogen contaminations by utilizing various databases to ensure the safety of the FRs and that of citizens
PathoSAT	Collects data and images from satellites to identify water contaminations and their extent. Analysing satellite images from pilot areas and relaying them to PathoWARE
PathoTWEET	Analyses data and photos from social media to assess the occurrence, severity and extent of water contamination events
PathoCAM	Installing IoT cameras at reservoirs to monitor water quality and detect changes using artificial intelligence
PathoWARE	A platform that collects data from geographical information systems (GIS) as well as from water authorities and integrate it into the data generated by PathoSENSE, PathoDRONE, PathoSAT and PathoTWEET to provide the FRs with a complete picture of the emergency situation. The results are visualized on PathoGIS.
PathoALERT-CITIES	Monitor and produce alerts by combining telemetry and social media data on contaminations in drinking water
PathoALERT- LAKES	Combining satellite camera and SCADA data to produce alerts for contamination events in natural waters.
PathoGIS	A GIS-based intelligent disaster situation decision-making support system centred on pollution area detection and disaster situation risk assessment technology
PathoIMS	Incident Management Software to facilitate the communication between FR's headquarters and the Command-and-Control Centre and the remote FR units.

1.1.2 The Five PathoCERT Pilot Cities

Every PathoCERT pilot city has specific foci, testing different scenarios or sets of technologies. In the following section the individual objectives and pilot scenarios are outlined.

Bulgaria, Sofia

The location of the Bulgarian pilot activities is the capital Sofia, located in the western part of the country with around 1,3 million inhabitants. The most common types of disasters to occur include floods, fires, snowstorms and earthquakes. In Bulgaria the general emergency /disaster management framework is regulated by the Disaster Protection Act, which outlines the measures taken to protect human life and health as well as the environment and property in case of emergencies. The act also accounts for certain types of risks or disaster events pertaining to risks related to earthquakes, floods, fires, nuclear and radiological accidents. [1]

The Disaster Protection Act outlines the requirements for the design and implementation of *Disaster Protection Plans (DPP)* that are carried out at national (i.e., National DPP), regional (i.e., regional DPP) and municipal (i.e., Municipal DPP) levels. These plans indicate what measures are to be taken in regards to the different disaster management stages of prevention, preparedness, response and recovery. It also regulates the insurance of resources and the dissemination and distribution of relief funds. [2] In addition, the Disaster Protection Act is complemented and informed by the *National Disaster Risk Reduction Strategy (NDRRS) (2018 - 2030),* which centres on the identification of the key priority areas for disaster risk reduction and accordingly informs and guides the planning and implementation in the different territorial divisions, as well as from the National Program for Disaster Risk Reduction 2021-2025. It should support the implementation of the NDRRS, taking into account the need for planned activities to be effective, coherent, resource-intensive and cover all sectors and hazards. The national program helps to systematize the approach to reduce existing risks and prevent the emergence of new ones, increase preparedness and response capacity and rapid recovery from disasters, while respecting the principle of *"rebuild but better"*.

In light of these framework conditions the Bulgarian pilot activities will focus on testing the PathoCERT technologies, outlined in **Table** *2*. The pilot revolves around the detection of possible pathogen contaminations, threat assessment and incident management over a flooded area that has been contaminated by warehouses' waste materials. The pilot-testing activities are coordinated by the Ministry of Interior of the Republic of Bulgaria with the aim to improve the safety and response of the first responders, as well as the evacuation of people in a safe and timely manner.

Table 2 PathoCERT technologies for Sofia

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

Cyprus, Limassol

The Cyprus pilot activities are taking place in Limassol. With its 183,658 inhabitants Limassol is the second largest urban area in Cyprus after the capital, Nicosia.

Most common past emergency and disaster events have included fires, floods, earthquakes and droughts. Due to the dispersed nature of the Cypriot emergency management within various ministries, the enactment and implementation of the emergency management lays with national or local authorities. Specifically, the emergency management framework is regulated by the *National Framework on Emergency Response Plan (ERP) "ZENON"*. This plan sets the guidelines and the overarching framework for the government-approved national ERPs for specific risk and disaster events. In total there are 23 ERPs that span a plethora of natural and human-made risks, outlining measures regarding preparedness, mitigation, response and recovery. [3]

Building on this regulatory framework, the Cypriot pilot will focus on testing the PathoCERT technologies in regard to a drinking water contamination with wastewater, due to an earthquake with a magnitude of 7.2 on the Richter scale. In **Table *3*** the technologies that are relevant for the Cypriot pilot are outlined.

Table 3 PathoCERT technologies for Limassol

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

Greece, Thessaloniki

Thessaloniki is located in the northern part of Greece and is the second largest city in the country with 1,1 million inhabitants. Emergency and disasters events in the past include earthquakes, floods, fires and industrial accidents.

In Greece, emergency management is organized in a top-down approach. On a national level the framework conditions are set by the *National Civil Protection Plan "Xenokrates".* The General Secretariat for Civil Protection coordinates the implementation of this plan in the entire country. [4] It outlines the measures taken for prevention, preparedness, response and recovery, also assigning specific organizations which are responsible for operating in each stage. For example, preventive activities include risk assessments as well as communication of these risks and strategies. Preparedness activities revolve around conducting trainings and emergency drills as well as developing the operating procedures. In the response stage, all relevant actors are coordinated and the set plans are implemented. The recovery stage focuses on set of actions aiming at restoring affected sites to the status quo prior to the emergency event. This top-down planning is further complemented by regional and local organizations plans and strategies. [5]

The Greek scenario underpinning the pilot activities is located in Thessaloniki and the implementers are HRT and EYATH with the support of SATWAYS and CERTH. The Greek scenario and pilot activities will focus on the management of contamination incidents, due to severe flooding phenomena that occur in the open flow river channel that transports water to the Thessaloniki Drinking Water Treatment Plan, as well as in the delta of Axios river where Search and Rescue activities must take place. The performance and impact of the developed tools for pathogen monitoring, threat assessment and incident management will be studied. Accordingly, the technologies outlined in **Table *4*** will be tested.

Table 4 PathoCERT technologies for Thessaloniki

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

The Netherlands, Amsterdam

Amsterdam is located in the province of North Holland, one of the 12 provinces in the Netherlands which are in turn subdivided into 431 municipalities. It is the most populous city with a population of 872,80 inhabitants within the city, 1,558,755 in its urban areas and 2,480,394 in the broader metropolitan area. Influenced by the geographical location and characteristics, Amsterdam and the Netherlands are exposed to disaster incidents such as heavy winds, high sea water tides, fires, as well as industrial accidents or infrastructural failures which in turn could affect the city's and/or country's water supply.

The emergency management system in the Netherlands is coordinated and regulated by the country's three governance levels, namely, central/ national, regional, and local level, with the degree of operational details and guidance increasing by each passing level. Nonetheless, the on-the-ground management of disasters is organised bottom-up, meaning the initial responsibility to respond and provide relief is allocated to the actors operating at the local (i.e., municipal) level. Depending on the scope and risk of the disaster as well as on the basis of managing capabilities, further support to manage the disaster is sought and provided by other municipalities and/or the management responsibility shifts to regional actors and central national institutions in cases of high-degree disasters. [6]

It is important to highlight that this approach is followed for emergency events that are categorised as disasters. The Netherlands distinguishes between disasters and crises. If an emergency event is categorised as a crisis, the management responsibility shifts to national level institutions such as Ministries, while regional and local actors provide support and execute actions directed from the central actors.

This emergency management system and related operations in the Netherlands is largely managed by the following guidelines:

- The '*National Manual on Decision Making in Crisis Situations*' that guides the emergency management system and related operations and is complemented by detailed acts like the '*Fire Service Act*'. [7] [8]
- The *'Disasters Act'* that creates the differentiation between three types of plans for disaster management.
- The *'Security Region's Act'* that regulates the regional responsibilities and efficient collaboration. [9]

Against this background, the Dutch pilot scenario focuses on the pilot-testing of technologies linked to the case of a joint epidemiological and criminal threat namely an intentional contamination of the water supply system of the system of the city with biological agents that cause disease among citizens and/or visitors of mass events. The full list of relevant technologies is presented in **Table *5***.

Table 5 PathoCERT technologies for Amsterdam

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

Granada, Spain

The province of Granada is located in the southern part of Spain, home to 914.678 inhabitants, out of which 234.462 live in its capital area. Historically, the most common types of disasters the region and city of Granada have encountered are floods, forest fires, earthquakes and hillside movements that could damage the water distribution and waste water collection network as well as cause a mixture of water types, leading to cases of water contamination.

The emergency and disaster management framework in Spain follows a nation-wide approach and it is then further tailored according to the territorial / administrative divisions, disaster types and degree of risk, with binding guidelines and regulations for the preparation and approval of the different territorial levels of planning to ensure an adequate correspondence between the different plans:

- At the state level, the framework is defined by means of the *'Law of the National Civil Protection System'*; [10]
- At the regional level through the *'Territorial Emergency Plan of Andalucía'*; [11]
- At the local level the planning is regulated on basis of the *'Territorial Emergency Plan of the Municipality of Granada'*. [12]

The level of detail increases from one stage to the other, with the local management frameworks being more detailed due to the scale of the area to be covered, while the national ones provide more general guidelines that ensure the correct interrelationship of subsequent plans.

Furthermore, the Spanish emergency and disaster management framework differentiates and plans according to the specific type of risk or disaster event. Such specific planning is regulated through the national legislation *'Basic Civil Protection Standard'*. Nuclear emergencies, war situations, floods, earthquakes, chemical outbreaks, transport of dangerous good, forest fires, volcanic eruptions are type or risks / hazardous events that are subject to specific planning. The general and specific emergency plans (territorial and topical) in Spain are updated annually, to ensure and account for the most recent developments (i.e., hazards, resources, tools, operational methods, stakeholders). [13]

Specifically, in Granada emergency and disaster management is managed through the city's Emergency Control (Communication) Centre. The latter is connected to the Emergency Control Centre (Emergencias 112-Andalucía) and to the Operational Control Centre of EMASAGRA the water utility company in Granada. This enables to receive and distribute direct and real time warning of risks either through remote devices such as rain gauges, water level control sensors or from citizens themselves. Granada's Emergency Control Centre, besides anticipating potential emergencies, also serves as a coordinating, monitoring and control point for responding to an emergency and its developments, from the departure of response operational actors until their return to base.

Against this background, the focus of the Granada pilot case lies on specific scenarios referring to the detection of possible water pathogen contamination, threat assessment and incident management system following a contamination event caused by the mixture of wastewater and drinking water caused by an earthquake in the city. Accordingly, the PathoCERT technologies of interest are different ones, as outlined in the table below (Table 6).

Table 6 PathoCERT technologies for Granada

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

1.1.3 The Case of Seoul, South Korea

The South Korean case differs slightly from the setting of the other five PathoCERT pilot cities mentioned above since no specific pilot activities were foreseen during the proposal phase. Nevertheless, depending on the project developments and their relevance to the South Korean case, ad-hoc pilot activities might be developed and implemented in Seoul at a later stage in PathoCERT. Within the project, thanks to their long-term experience in the management of emergency situations, South Korean partners are responsible for the development of the PathoGIS software (Decision Support Tools for Water Contamination Management, WP7), and are directly involved in multi-stakeholder engagement activities (WP3). Accordingly, understanding the processes, procedures and components of their emergency management system is also of outmost importance.

The capital of South Korea, Seoul, is located in the north-western corner of the peninsula. Seoul is by far the largest city in South Korea with 9,3 million inhabitants that could be potentially exposed to various emergency events / threats, including waterborne pathogen contaminations. Among other emergencies, South Korea is affected by the East Asian monsoon season causing heavy rainfalls (on average 383 mL) and typhoons between June and September. These events frequently trigger flooding and landslides in the country's mountainous landscape posing a severe risk to its water supply.

The emergency management framework in the country is developed, coordinated by the central government, providing the organisation and planning framework for the sub-levels i.e., national, regional, local and actors operating within. This coordination is achieved through the *Disaster and Safety Management Act*, which prescribes the necessary measures for the prevention, preparation and response to emergencies and disaster events as well as restoration activities and other matters. [14] Building upon this Act, the particularities of the disaster management sector are regulated by means of three types of emergency management manuals:

- The *emergency management standards manuals* written by the central government organisation, specifying the overarching general procedures, roles and responsibilities that need to be accounted for and implemented by the subsequent territorial divisions and organisations operating within.
- These general guidelines are then specified and further detailed by the regional and local operating governmental organisations in their own *working emergency manuals*.
- Complementing the latter are the *on-field action manuals*, which are developed and implemented by operating actors, describing the specific procedures and actions to be undertaken for various emergency events.

These three manual groups enable effective communication and coordination between the relevant actors before, during and after an emergency event.

Given the emergency management system in South Korea and the role that local partners will play in the development of the PathoGIS, the following technologies (Table 7) are of particular interest in their case.

Table 7 PathoCERT technologies for Seoul

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

2 The PathoCERT Multi-Stakeholder Engagement Approach

2.1 The Community of Practice

As described in the previous sections, the emergency management systems vary a lot from one country to the other including different layers of complexity and stakeholders' composition. Accordingly, in order to enable an effective actors' engagement approach within the project to facilitate the development and uptake of novel technologies and processes on the ground, a tailored-made multi-stakeholder engagement approach has been defined and practically applied via the concept of Community of Practice.

The CoP approach aims to create a shared vision and derive joint strategies to address concerns and overcome existing technological, economic, environmental and societal challenges. Unlike more traditional multi-stakeholder engagement formats, Communities of Practice are based on members' interest and desire to learn, develop and share their experiences and expertise. Broadly speaking, a CoP can be defined as *a structure that brings together a group of actors who share a common interest in a topic and who come together to fulfil both individual and group goals*. Therefore, when setting up a CoP one needs to account for the following aspects:

- **Connect actors** who might not otherwise have the opportunity to interact, either as frequently or at all; and enable dialogues between them in order to explore new possibilities, solve challenging problems, and create new, mutually beneficial opportunities.
- **Provide a common ground:** CoP engaged members need to have a shared domain of interest and commitment that distinguishes them from others. This shared domain creates common ground, inspires them to participate, guides their learning, and gives meaning to their actions. This, in turn, provides a forum to identify solutions to common problems and a process to collect and evaluate best practices.
- **Share practices:** CoP members need to be actual practitioners in the domain of interest, and build a shared repertoire of resources and ideas that they take back to their practices. While the domain provides the general area of interest for the community, the practice is the specific focus around which the community develops, shares and maintains its core of collective knowledge.

It is crucial for single actors and/or groups of actors to communicate and share information, stories and expertise and experiences in a way that builds understanding and insights. Accordingly, the design of a CoP differs depending on local purposes and needs. Generally, four basic types of CoPs can be distinguished [15]:

Table 8 Basic types of Communities of Practice

Helping Communities: provide a forum for community members to help each other with everyday needs	**Best Practice Communities:** develop and disseminate best practices, guidelines, and strategies for their members' use
Knowledge Stewarding Communities: organize, manage, and steward a body of knowledge from which community members can draw	**Innovation Communities:** create breakthrough ideas, new knowledge, and new practices

In the PathoCERT project a combination of two types has been used, namely the **Best Practice Communities** and **the Innovation Communities**. This blend of formats and operational settings has enabled the sharing and dissemination of project knowledge and outcomes stemming from focused research; the creation of new knowledge and practices through real-time discussions; and will lead to prototype testing in a holistic format allowing the active engagement of technical and non-technical actors.

2.2 The six PathoCERT Communities of Practice

In the PathoCERT project, a CoP acts as a central knowledge sharing and learning tool on which key stakeholders can capitalize to promote the acquisition and transfer of knowledge. It is tightly linked to their interests, needs, operating principles, and means of collaboration and enables a continuous dialogue in order to define/refine novel technologies, services and governance mechanisms that enhance first responders' capacities and safety during waterborne pathogen contamination situations. In the project, six Communities of Practice have been established, in the five European pilot cities as well as in Seoul, South Korea (Figure 1).

Figure 1 The PathoCERT Communities of Practice

The regular interactions – which are a crucial part of the methodology – are structured as face-to-face, hybrid or online meetings enabling key actors to communicate, connect and conduct activities. Those meetings specifically focus on:

- **Feedback provision and exchange** of information with project stakeholders;
- **System scoping** is conducted to pinpoint which barriers, challenges or opportunities might exist in the different local, regional and national contexts;
- **Sharing of knowledge and experiences** in an interdisciplinary and cross border manner to enhance reciprocal learnings;
- **Testing and experimenting** with the PathoCERT technologies to provide FRs with the opportunity to articulate feedback and test the technologies in simulated scenarios;
- **Dissemination and outreach** of the project results to internal and external stakeholders.

Consequently, each CoP meeting in each of the six pilot regions (as presented in the next section) has been shaped according to a participatory approach enabling identified actors to actively and efficiently work together, share information and knowledge, co- create, test and validate methods and novel solutions.

3 Content-specific learnings from the CoPs

This section focuses on the specific learnings derived from each CoP meeting. Firstly, a summary is introduced in terms of overall rationale and objective underpinning the setting up of the CoP. The following sections then outline the number of meetings, their specific objectives and participating actors. Finally, the key outcomes of all conducted CoP meetings are presented including identified local challenges and needs, expectations on usage and application of the different technologies.

3.1 The Sofia Community of Practice

3.1.1 The starting point

Prior to the creation and implementation of the Community of Practice, an in-depth stakeholder mapping exercise and analysis was conducted to identify the key stakeholders to be involved. In combination with a detailed analysis of the Bulgarian emergency and disaster management a solid basis for the further shaping of the CoPs was put in place. Both these analyses led to the identification of initial local stakeholders to be engaged in the CoP meetings: Sofiyska voda, Fire Safety and Civil Protection Ministry of Interior, Sofia Regional health Inspectorate, Directorate Emergency Aid and Prevention Sofia Municipality, Sofia Regional Environmental and Water Inspectorate.

3.1.2 The first three rounds of CoP meetings in Sofia

Based on the stakeholder analysis and assessment of the emergency management system, three Bulgarian CoP meetings have been conducted from beginning of the project till February 2022. Due to the COVID-19 restrictions these have been held online or in hybrid set-ups. The CoPs were organized by the Communication and Information Systems Directorate (CISD), the Ministry of Interior of Bulgaria (MOIB) and the subcontractor KL Office.

In total 32 stakeholders from various institutions have participated in the meetings. These include public stakeholders, such as representatives from the Ministry of Environment and Water, from the Regional Environmental Inspectorate, from the Emergency Aid and Prevention Directorate from the Sofia Municipality, from the Sofia Regional Health Inspectorate and the EU Emergency Response Coordination Center. Stakeholders from the private sector where also present, such as Eurofins Testing and Sofiyska Voda. First responders from the General Directorate Fire Safety and Civil Protection of the Population have also participated.

The first CoP held in July 2021 introduced the overall project and its technologies and enabled an exchange about the strengths and possible weaknesses of the Bulgaria’s emergency management framework. During this meeting, the pilot exercise - which will be conducted in July/August 2023 – were also presented to the stakeholders to collect their initial feedback.

During the second CoP – which was organised in October 2021 - a closer look was taken at an initial set of technologies, namely: PathoSENSE, PathoTeSTICK, PathoIMS and PathoWARE. Another point of discussion was the usage of these technologies in the Bulgarian pilot case, including possible challenges, barriers and opportunity areas of application.

The third CoP meeting – organised in December 2021 - was a continuation of the second event which accordingly aimed at in-depth discussions to expand the previously initiated knowledge-base on the possible uptake of selected project technologies. The complete list of all presented and discussed PathoCERT technologies is presented in the following **Table *9***.

Table 9 PathoCERT technologies discussed in the Sofia CoP

PathoSENSE	PathoTeSTICK	PathoIMS
PathoWARE	PathoSENSE	PathoDRONE
PathoVIEW	PathoSAT	PathoTWEET
PathoINVEST	PathoTHREAT	

3.1.3 Key Outcomes and Learnings from the Sofia CoP

During the above-mentioned CoP meetings, stakeholders voiced their interest in a specific group of technologies summarized in **Table *10***.

Table 10 Interesting PathoCERT technologies for stakeholders in the Sofia CoP

PathoCERT Technology	Interested stakeholder(s)
PathoIMS	Sofia Regional Health Inspectorate Emergency Aid and Prevention Directorate Sofia Regional Inspectorate for Environment and Water (RIEW) Sofia Water
PathoSENSE	Sofia Regional Health Inspectorate Emergency Aid and Prevention Directorate Sofia RIEW
PathoWARE	Sofia Regional Health Inspectorate Emergency Aid and Prevention Directorate Sofia RIEW Sofia Water

In addition to this, the CoP events also gathered an overview of challenges, needs and expectations of the stakeholders in relation to the technologies and their implementation. This has led to the creation of a list of user requirements which is summarized in Table 11.

Table 11 Challenges, needs and expectations on usage voiced by Sofia stakeholders

PathoCERT Technology	Challenges	Needs	Expectations on usage/application
PathoIMS	Finding financial resources for the maintenance of the necessary mobile devices	These tables should be made available to every actor in emergency management	The technology should be available on mobile devices such as tablets and phones so that it can be use in the field

	Financing of the software and of the platform	Maintenance of the software in case of issues needs to be ensured	The reliability of the collected data and its unification
	All institutions involved in the emergency management have to accept and use the technology	The software should be included in the normative documents and generally accepted for all state institutions that have commitments to take action in emergency situations and accordingly need to have free access to it	The technology should improve the communication in order to ease cross-cutting actions
		Reduces the time for forming specialists among the first responder organizations	
PathoSENSE	Disruption of the mobile cells/communication due to a lack of signal	Better communication and coordination between the different involved units	PathoSENSE should reduce the time required to detect deviations in water quality
	Acceptance and usage of PathoSENSE by all emergency management actors		PathSENSE should reduce the errors caused by human factors
	Financing the technology		Provision of real data about the current state of the flooded area
			Ease identification of bacterial activity in water in reduced time
			The software related to these tools need to be made mobile so they can be used in field work
PathoTeSTICK			Additional information on replacement of the electrodes and on the levels (highest/lowest) of quantitation that can be achieved
			Identification of different pollutants
PathoWARE	Acceptance and usage of PathoWARE by all actors operating in the emergency management system	PathoWARE would improve the communication among the involved stakeholders	A platform that summarizes all available data on incidents, also using GIS maps, to provide information to first responders
	Financing the implementation of the technology	Reliability of the collected and unified data	Accumulation of a sufficient database to prevent subsequent events of this nature

			It should be possible to access the software in the field
PathoDRONE		Additional information on the basket that carries the sample and on the overall drone weight	

3.1.4 Next Steps

The upcoming rounds of CoP meetings will aim at expanding this pool of knowledge and generating additional feedback and insights especially with respect to the users' requirements and field of applications. Concurrently, further exchanges with the technical partners will take place in order to clear up open questions and concerns.

3.2 The Limassol Community of Practice

3.2.1 The starting point

Similar to the other PathoCERT CoPs, a stakeholder mapping and analysis as well as an initial analysis of the Cyprus emergency & disaster management framework, was conducted. This resulted in a preliminary list of local stakeholders that should be involved throughout the project by the CoP meetings. The stakeholders included are the: Water Development Department (WDD), Cyprus Civil Defence, Public Health Service, Sewage Board of Limassol, Sewage Board of Nicosia, District Administration Limassol, District Administration Nicosia, Limassol Municipality, Water Board of Limassol (WBL), Water Board of Nicosia, Ambulance Service Directorate, Electromechanical Service, Cyprus Fire Service, Cyprus Police, State General Laboratory, Department of Labour Inspection, Veterinary Services, Volunteers and Non- Governmental Organizations, Cyprus Red Criss and the Cyprus Scouts Association.

3.2.2 The first two rounds of CoPs in Limassol

Between September 2020 and February 2022 two CoP meetings have taken place in Cyprus, both in person. In total 32 representatives from various institutions have been present at the CoPs, including: Limassol Municipality, Water Development Department, Fire Service, Water Board of Limassol and Larnaca, Limassol and Larnaca Sewerage and Drainage Board, Limassol and Nicosia District Administration, Electromechanical Services, Cyprus Police, General State Laboratory and the Labour Inspection Department.

During the first CoP meeting held in June 2021 the emphasis was placed on introducing the project and the technologies to the stakeholders as well as gathering feedback on the needs, requirements, challenges and opportunities of using the PathoCERT technologies in the Cypriot pilot case as well as at a local level. In order to do this, different scenarios were created that were then discussed with the stakeholders, looking at the interactions between the stakeholders, the information flow, the usage of GIS map data and a case of urban sewage contamination.

The second CoP meeting held in November 2021 then looked more closely at each of the PathoCERT technologies and how they could be used by first responders, utilities and authorities. Priority was also placed on gathering feedback and requirements of the stakeholders regarding the technologies and the refinement of the Cypriot pilot case. The Cyprus CoP focused on presenting all PathoCERT technologies and tools to the participating stakeholders.

The following table outlines the technologies discussed in the Limassol CoP meetings (see **Table *12***).

Table 12 PathoCERT technologies discussed in the Limassol CoP

PathoSENSE	PathoSENSE IoT Gateway	PathoDRONE
PathoSAT	PathoTWEET	PathoCAM
PathoWARE	PathoGIS	PathoVIEW
PathoIMS	PathoTHREAT	PathoINVEST

3.2.3 Key Outcomes and learnings from the Limassol CoP

The first two CoP meetings have kicked off the long-term stakeholder engagement within PathoCERT. In addition to these, valuable information was already collected regarding the interest of the various stakeholders in the PathoCERT technologies. **Table *13*** provides an overview which of the Cyprus stakeholders would be more interested in which of the PathoCERT technologies.

Table 13 Interesting PathoCERT technologies for stakeholders in the Limassol CoP

PathoCERT Technology	Interested stakeholder(s)
PathoTHREAT	Water Development Department Water Boards
PathoSENSE AQUATRACK	Water Development Department Water Board of Limassol (maybe)
PathoSENSE BACTCONTROL	Water Board of Limassol Water Development Department
PathoSENSE PathoTeSTICK	Civil Defence, Fire Service (EMAK) Water Development Department, Water Board Limassol Sewage Board for checking irrigation water
PathoSENSE IOT GATEWAY	Civil Defence (TAST)
PathoDRONE MAP	Civil Defence Water Development Department
PathoDRONE SAMPLE	Civil Defence Water Development Department
PathoVIEW Watch	Civil Defence and Fire Service, mainly for localization and health monitoring
PathoVIEW GLASS	WDD interest to show location to equipment in dams or zones in dams Civil Defence: maps, wind direction
PathoINVEST URBAN	UCY (KIOS) & Water Board Limassol
PathoSAT	Civil Defence Fire Service District Authority WBL/WDD

PatthoSAT Service	Water Development Department
PathoTWEET	Might be relevant to gather/filter information from official sources, e.g., other organisations
PathoIMS	Civil Defence and Fire Service to learn more
PathoCAM	Water Development Department (monitor dams and infrastructure)
PathoGIS	Civil Defence Fire Service District Authority WBL/WDD

Moreover, the stakeholders have also identified specific challenges, needs and expectations on the usage/application regarding some of the PathoCERT technologies. This list can be seen as an indication of what requirements the stakeholders have in relation to the technologies and can be used for further development throughout the project. Table *14* summarizes these. In addition to the specific aspects mentioned in the Table, some general challenges regarding the technologies are:

- The information exchange between the different organizations
- Who has the authority to act first?
- Not all technologies are relevant
- Lack of scientific/technical expertise

Some general needs mentioned by the stakeholders include:

- The need for more scientific and technical training
- Direct, correct and official information

Some general expectations on the usage/application are:

- Low cost
- Easy to use technologies
- Need for integration into existing structures

Table 14 Challenges, needs and expectations on usage voiced by Limassol stakeholders

PathoCERT Technology	Challenges	Needs	Expectations on usage/application
PathoVIEW	Coordination of staff in the office and on the field	Event history needs to be available when new organizations need to get involved	Logging exchanged information between organisation will support the transparency and investigation among the organizations
	Confusion caused by measurements from different parts of the network		

	Higher level information (is necessary but not available)		
PathoTeSTICK		Equip First Responders on the field	PathoTeSTICK will allow for rapid assessment on the field
		Some partners require more information on the function of the tool	
PathoSENSE BACTCONTROL	Isolating contamination sources	Monitoring change in water quality	Water Development and State Chemistry can use it to share information with Water utilities and Health Services
			Organizations, beyond the state chemistry lab can have more immediate information about an event thanks to PathoSENSE BACTCONTROL
SmartWATCH	Safety of the first responders		Enables assessing the vitals of individual first responders
			Allows GPS tracking of FRs
			Can provide physiological live updates on the health of the people on the field
SmartGLASS	FR operation can potentially damage installed equipment near water surfaces (e.g., dams, water sources)	Maps that show where in the dams WWD has installed equipment	
	Difficult to protect FR from harmful substances	Maps that show concentration of potentially harmful materials in the dam	
			Useful in the case of low visibility (fog)
		Map to show where the access locations are on the dam depending on water level	
PathoIMS		Require a presentation from SATWAYS	To possibly be used as a secondary tool to manage the evolution of a water contamination incident

PathoCAM			Helpful for the detection of humans in dams
PathoGIS	Usually, 90% of the decision-making process is done by a single organisation so there is a lack of collaboration	Situational awareness in the coordination centre is necessary	
	Limited permission to edit or view (not all involved parties have these rights)		
PathoTHREAT	Threat/risk assessment in their field when ZENON (Zenon) plan goes from Green to Yellow		Possible to encode the Zenon plan in the PathoTHREAT database
	The designated authority may not be available		

3.2.4 Next Steps

With the first two CoPs, Cyprus has already gathered a substantial amount of input from the stakeholders regarding the PathoCERT technologies as well as the pilot activities. An important next step is to engage more closely with the technical work packages of the project, that are responsible for the development of the technologies. These meetings will have a twofold function. First, they enable the communication of the needs and expectations of the stakeholders regarding the technologies in more detail. Second, they also allow for the technological partners to further explain and elaborate on the functions and usage of the technologies they are developing as well as outline any requirements that are necessary to use the technologies in the field.

3.3 The Thessaloniki Community of Practice

3.3.1 The starting point

The tailored stakeholder mapping exercise that was conducted by the local partners in Greece, allowed for the identification of key stakeholders playing a role in the emergency response system. The analysis of their activities and operational settings against the disaster management framework led to a list of the most relevant ones to compose the core members of the first two rounds of CoP meetings in Thessaloniki.

3.3.2 The first two rounds of CoP meetings in Thessaloniki

A total of two CoP meetings have been organized in Thessaloniki thus far: one in June 2021 and one in January 2022. Due to the increasing number of COVID-19 cases in Greece both meetings were held online to comply with health regulations and ensure the well-being of the participants. The stakeholders engaged in these meetings represented the following organizations: Regional Civil Protection Departments, Public and Municipal Authorities, Research Centers, Universities, First Responders and Water operators.

The key objectives of the first CoP meeting in Thessaloniki were to introduce the PathoCERT project, its objectives and technologies as well as the CoP approach and the related engagement activities to be undertaken. In addition, stakeholders were able to discuss and exchange on the role and responsibility of each organization in the management of the incidents described in two pilot exercise scenarios (exercise-scenario 1 and exercise-scenario 2). In the first exercise-scenario, polluted water from Axios river overflows due to flooding, to the water transportation channel towards the Thessaloniki Water Treatment Plant posing a potential risk to the safety of drinking water. In the second exercise-scenario, also due to a flooding event, two photographers are missing in the area of the Axios river basin and delta (including also the wider sea area). Specifically, the discussion was structured around four key questions:

- *What actions do you take today when an incident occurs per exercise-scenario?*
- *What information is available today when one of these exercise-scenario incidents occurred?*
- *What information is missing today when one of these exercise-scenario incidents occurred?*
- *What technologies and tools do you think are needed to tackle both exercise-scenarios?*

These guiding questions allowed for the collection of stakeholders' requirements and needs regarding the collaboration and coordination procedures when managing an emergency or disaster incident, but also the collection of an initial dataset regarding the relevance and ease of use of the PathoCERT technologies in the exercise-scenarios developed.

Following up on the discussions of the first CoP meeting, the aim of this second online CoP in January 2022 was to look more closely at some of the technologies that will be tested in the Thessaloniki exercise-scenarios and gather the stakeholders' inputs pertaining to the following aspects: advantages and disadvantages of each technology; interest in using the technology; and the applicability of each technology in the different stages of the exercise-scenarios. The technologies that were discussed in detail in Thessaloniki are presented in the table below.

Table 15 PathoCERT technologies discussed in the Thessaloniki CoP

PathoIMS	PathoSAT	PathoDRONE
PathoTWEET	PathoTWEET	

3.3.3 Key outcomes and learnings from the Thessaloniki CoP

During the exchanges in the Thessaloniki CoP, stakeholders were able to identify a first set of technologies highly relevant both for their operational context(s) and also for their exercise-scenarios. **Table *16*** shows the discussed technologies and the stakeholder organizations which indicated their respective interest:

Table 16 Interesting PathoCERT technologies for stakeholders in the Thessaloniki CoP

PathoCERT Technology	Interested stakeholder(s)
PathoDRONE	Hellenic Police, Fire Service, Greek Biotope/Wetland Center, Municipality of Thessaloniki, Management Authority of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control Department- Region Of Central Macedonia, Aristotle University Thessaloniki.

PathoDRONE Map	Hellenic Police, Fire Service, Greek Biotope/Wetland Center, Municipality of Thessaloniki, Management Authority of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control Department- Region of Central Macedonia, Aristotle University Thessaloniki.
PathoDRONE Sample	Hellenic Police, Fire Service, Municipality of Thessaloniki, Management Authority of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control Department- Region of Central Macedonia, Aristotle University Thessaloniki.
PathoSAT	Hellenic Police, Fire Service, Greek Biotope/Wetland Center, Municipality of Thessaloniki, Management Authority of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control Department- Region of Central Macedonia, Aristotle University Thessaloniki.
PathoSAT Service	Hellenic Police, Fire Service, Greek Biotope/Wetland Center, Municipality of Thessaloniki, Management Authority Of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control Department- Region Of Central Macedonia, Aristotle University Thessaloniki.
PathoTWEET	Hellenic Police, Fire Service, Greek Biotope/Wetland Center, Municipality of Thessaloniki, Management Authority Of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control Department- Region Of Central Macedonia,
PathoIMS	Hellenic Police, Fire Service, Greek Biotope/Wetland Center, Municipality of Thessaloniki, Management Authority Of Thermaikos Gulf Protected Areas, Environmental Hygiene & Sanitary Control department- Region Of Central Macedonia, Aristotle University Thessaloniki.

The stakeholders and PathoCERT partners also discussed specific characteristics of different technologies, exploring in details challenges, needs and also expectations on the use and application. An initial set of these findings is presented in (**Table** *17*).

Table 17 Challenges, needs and expectations on usage voiced by Thessaloniki stakeholders

PathoCERT Technology	Challenges	Needs	Expectations on usage/application
PathoDRONE Map	The efficiency of the tool is highly dependent on weather conditions	Familiarity with the tools, training of users for more efficient use	Easy to locate missing persons
	Costly technology (both as a tool and workforce)	Special licensing both for operator(s) and temporal restrictions	Fast and accurate depiction of the flooded regions
	Spatial-temporal restrictions		Contribution to the planning of itineraries and actions to exclude dangerous human interventions on the field
			Easy to use during all the stages of an event to provide real time visual information in short time

			Real-time images can be useful for correlating with water quality parameters
PathoDRONE Sample	Data/ sample collection at extreme weather conditions	Familiarity with the tools, training of users for more efficient use	Sampling from inaccessible areas
	Special licensing both for operator(s) and temporal restrictions		Decrease the sampling time - increase the number of samples
PathoSAT	Discrepancies between the time of generation of satellite images and the actual incident	Higher resolution images (VHR) offer more detail	Clear view on flooded areas close to the time of maximum impact
	In the case of rapid crisis events, satellite images may not be available	Increase frequency of images	Monitoring of much wider areas using fewer resources
	High resolution images cannot be used for large scale phenomena		A continuous data base following the event, for the monitoring (+prevention) of any effects on the aquatic reservoirs and the marine environment
	Inherent technical difficulties of satellite tools		
PathoSAT	Validity of used algorithms	Satellite images to be incorporated into a platform with additional GIS info concerning e.g., mapping of habitats, land use, available anthropogenic pressure	Organization of a rescue operation - Investigation of potential health risks by specific pathogens (cyanotoxins)
PathoSAT Service	Inherent technical difficulties of satellite tools		Monitoring of much wider areas using fewer resources
			A continuous data base following the event, for the monitoring (+prevention) of any effects on the aquatic reservoirs and the marine environment
PathoTWEET	Reliability of the provided information	Real time update	Rapid warning about the incident
	Social platforms may include frisks of misinformation, exaggeration of irrelevant incidents, negative impact on the psychological state of users with possible unnecessary escalation of anxiety-fear during a crisis event	Dashboards that provide comprehensive and validated info	Provision of additional information concerning the occurred incident

		A tool for gathering citizens' views and / or additional information in real time that may not be otherwise available e.g., from field sensors	Connection to rescue teams supporting citizens whom are at risk (e.g., citizens on the roofs of buildings at risk of flooding)
PathoIMS	Lack of sufficient communication among different stakeholders	Definition of communication protocols among engaged stakeholders based on the legislation and according to specific incidents	Creation of a user-friendly platform
	No exact definition of the responsibilities for each action in the pilot exercise considering the legislation and regulatory framework	Reduction of time of response and communication between FRs	Universal and secure access for all involved actors
	Inability for simultaneous update of FRs and operating actors	The Departments of Civil Protection (Regional and Municipal) need to act as connecting links of the Environmental and Health Services with the Fire Brigade and the Police bodies	Clear definition of responsibilities and required actions per type of incident
		Special training(s) to become familiar with the tool	

3.3.4 Next Steps

During the first two rounds of CoPs in Thessaloniki, the organizers have collected a significant amount of feedback with respect to challenges and needs as well as on expectations in terms of usage for the presented and discussed technologies. As a next step, stakeholders and the CoP organisers have identified the need to engage more directly with the respective technology developers in order to specify and clarify technical aspects. These specifications will then allow for a more detailed review of the exercise-scenarios and targeted adjustments to the technologies of interest. Furthermore, since not all the PathoCERT technologies have been fully discussed with local actors, similar exercise will be repeated in the upcoming CoP meeting. Finally, parallel to the technology aspects, the Greek stakeholders will focus on further defining the roles and responsibilities of the various actors involved in the emergency management system in order to define a common and detailed framework of their operational coordination in connection to the PathoCERT technologies.

3.4 The Seoul Community of Practice

3.4.1 The starting point

As for the five pilot cities before setting up the CoP in Seoul, a stakeholder mapping exercise and analysis were conducted to identify local key actors, their roles and responsibilities in the occurrence of an emergency event. In parallel, the emergency and disaster response framework was analysed, providing an overview of the most important policies and procedures. On this basis, key stakeholders were identified, such as the National Disaster Management Research Institute (NDMI) and the Korean Wildlife Disease Control Center.

3.4.2 The first two rounds of CoP meetings in Seoul

Two CoP meetings were organised in Seoul. Due to the COVID-19 pandemic, both took place online, the first in July 2021 and the second at the beginning of January 2022. For both events the number of participating stakeholders was kept to a close circle, mostly from the field of research (e.g., Soonchunhyang University College of Medicine) central and local governmental agencies (e.g., NDMI, KWDCC). This targeted group was chosen due to the particular role of local partners in the project as well as on the basis of emergency management system in place requiring a tailored-made approach.

The first CoP in July 2021 focused on the introduction of the PathoCERT project, relevant technologies and the overall CoP concept. While, in following CoP meeting, targeted discussions took place with respect to the different PathoCERT technologies. **Table *18*** provides the overview of presented and discussed technologies.

Table 18 PathoCERT technologies discussed in the Seoul CoP

PathoSENSE	PathoDRONE	PathoIMS
PathoSAT	PathoTWEET	PathoWARE
PathoTHREAT	PathoINVEST	PathoVIEW wearables

3.4.3 Key Outcomes and learnings from the Seoul CoP

The two CoP meetings resulted in a mapping of stakeholders' interest for a specific number of technologies summarised in Table 19.

Table 19 Interesting PathoCERT technologies for stakeholders in the Seoul CoP

PathoCERT Technology	Interested stakeholder(s)
PathoSENSE	General interest
PathoTeSTICK	Governmental agencies; field researcher
PathoDRONE Map	Governmental agencies
PathoSAT	Governmental agencies
PathoSAT Service	Governmental agencies
PathoTWEET	Governmental agencies; field researcher
PathoGLOVE	General interest

The second CoP meetings has also provided the ground to identify potential challenges, needs and usage requirements towards certain technologies. These aspects are summarised in **Table *20***. It is important to highlight that in addition to the data reported in the table, stakeholders also identified additional opportunity areas. Specifically, they suggested that those PathoCERT technologies displaying gathered data should not only visualize data and generate graphics, but should also facilitate data analyses. Secondly, they highlighted the need for legislative actions to allow for effective data gathering and management, as well as for the further uptake and commercialisation of the developed technologies. Lastly, some participants mentioned the desire to develop for each PathoCERT technology a tailored user manual.

Table 20 Challenges, needs and expectations on usage voiced by Seoul stakeholders

PathoCERT Technology	Challenges	Needs	Expectations on usage/application
PathoSENSE	Accuracy must be tested		
PathoTeSTICK			The technology would be substantial in the water pollution management area.
PathoDRONE		Possibility to track vehicles which carry contaminating/ polluting material	
PathoSAT	Real time production and use of data using satellites is unlikely	Possibility to track vehicles which carry contaminating/ polluting material	
	Real time analysis could not be done with satellites, however it might be possible with the use of super-spectral camera-equipped drones		
PathoTWEET			Contribution to better understanding of the emergency situation from control centre
PathoIMS		Clear definition of facilities or target sites that need to be alerted etc. so enough data can be accumulated and analysed	
PathoWARE		Clear definition of facilities or target sites that need to be alerted etc. so enough data can be accumulated and analysed	A system to manage contaminated facilities
			Specific data must be provided for each target user with tailored visualisation to different types of users
PathoGLOVE	Accuracy must be tested		
PathoINVEST		If automated, PathoINVEST would be	

		helpful for the after-the-fact disaster assessment	

3.4.4 Next Steps

Stakeholders expressed the interest in exploring the possibility to compile clear guidelines for the application of the PathoCERT technologies, especially for the detection of water quality and pathogens, particularly bacteria. Secondly, an overview, containing information on which technologies would be best utilised in specific use case scenarios, will be investigated. Further, a new use case scenario for animal disease outbreaks - such as *Avian Influenza* and *African Swine Fever* with a specific use case highlights potential paths for testing - and related infectious disease disaster situations is currently under discussion and, after an evaluation process, might eventually enter a design phase in collaboration with other PathoCERT project partners. Another potential next step lays in the assessment of the possibilities for technologies´ exchange and commercialisation after the development phase is concluded. Lastly, the enlargement of the pool of engaged stakeholders considering the already unfolded great potential derived from the initial events.

3.5 The Amsterdam Community of Practice

3.5.1 The starting point

The process of developing the CoP in Amsterdam started with the mapping of local key stakeholders and the analysis of their responsibilities, relations and activities. In parallel, the local emergency and disaster response framework was analysed and a more detailed concept for the pilot scenario was outlined. Key stakeholders for the Amsterdam case are the local project partners Waternet and KWR Water Research Institute, the water laboratories, contractors and the inspectorate. It was recognised that both operational experience and expertise from research are needed during these emergencies. In case of a multi-sectoral emergency, the response lead is shifted to municipal or even safety-region level and will include other organisations from the fields of first responders, public authorities and agencies, and governing organisations and networks. An important finding was the unique vertically and horizontally interlinked emergency response structure of multi-stakeholder governing bodies, within which the different stakeholders already operated. This provided the opportunity to test a workflow-integrated approach, with the goal of using the existing networks to gather input for the CoPs, ahead of the establishment of the CoP standard meetings.

3.5.2 A workflow-integrated approach and the first round of CoP meetings

Given the unique local context, it was agreed together with local partners / implementers to test an experimental workflow-integrated format for the first-round of multi-stakeholder meetings which would feed into the setting up of the Dutch CoP. Instead of setting up a determined CoP straight away, the initial stakeholder engagement activities used existing networks that include all Dutch and one Flemish (Belgian) drinking water utilities and their associated laboratories. This took place through coordination meetings of the *Themagroep Biologische Veiligheid* - which is a local multi-stakeholder board to coordinate collective biological safety research – and of the *Platformgroep Bedrijfsvoering (Operational Platform)* – which is an organization responsible for the development of the Standard Operating Procedures (SOP) for the drinking water sector. A similar meeting with the national emergency organisation for the environment and drinking water was delayed due to shifts in that organisation. This meeting will be planned in 2022. Additionally, the project partners informed actors outside these two groups about the project and possibility of taking part in the Dutch CoP as well. This was done in other meetings in the established emergency and disaster response framework.

A first workflow-integrated CoP meeting was organised in June 2021. For the safety of the participants during the COVID-19 pandemic, this meeting was held in an online format. The meeting gathered 16 local stakeholders, including the project partners and participants primarily from the field of research and engineering for water utilities. The aim of the meeting was the presentation of the PathoCERT project, with a particular focus upon work packages 3 and 7, including the PathoCERT technologies PathoTHREAT and PathoINVEST. Further, it was discussed how these technologies could best be tested in the local pilot case and how they could contribute to emergency response at other utilities. Based this exchange and the goal to establish a Dutch CoP, the meeting especially focused upon the technological aspects. Especially methodological and practical questions were raised, regarding the artificial intelligence (AI) features of the PathoTHREAT technology.

A similar workflow-integrated approach was chosen for a meeting with stakeholders from the field of water utility operators (SOP group), to whom the PathoCERT project was also presented with a particular focus on the same work packages and technologies. This was followed by a discussion upon the practical applicability of the technologies in certain pilot case scenarios. The stakeholders were most interested in the potential of PathoCERT technologies and CoP activities to contribute to a more uniform approach of responding to contamination events between the various utilities. Yet, not all participants of this introductory meeting were convinced of the need for further development. One important argument was that each event is unique and adequate response requires personal insights and experience that cannot be captured in technologies. The hosts of the Amsterdam CoP provided a summary of the project outputs and the benefits for the Dutch use cases as a follow-up to the meeting to allow for further discussion on participation in the member organisations.

Both meetings were revisited to raise further interest and clarify any questions regarding the CoP approach. Following both meetings, several members from both groups agreed to participate in the dedicated Dutch CoP. Thus, various utilities that represent different Dutch and Flemish settings will be participating in the upcoming CoP meetings.

3.5.3 Key outcomes and learnings from the Amsterdam CoP

The meetings so far have led to interesting findings for the CoP methodology, as well as for the development of the pilot case and technologies. Among the discussed technologies, the engaged stakeholders showed particular interest in those summarised in Table 21.

Table 21 Interesting PathoCERT technologies for stakeholders in the Amsterdam CoP

PathoCERT Technology	Interested stakeholder(s)	Scenario of application
PathoINVEST		Intentional contamination
		Exposure assessment after contamination

	Water utility operators, first responders	Using sensor signal to identify potential contamination areas
		Mitigation options (contaminant isolation/flushing/disinfection) after contamination
PathoTHREAT	Water utility operators, first responders, researchers	Identify possible causes
		Improving response time and response accuracy
		Threat assessment
		Propose control options

Further, based on the discussions of potential use cases, first assessments of challenges and needs for the application of the PathoCERT technologies were made. **Table** *22* below summarises the most important findings.

Table 22 Challenges, needs and expectations on usage voiced by Amsterdam stakeholders

PathoCERT Technology	Challenges	Needs	Expectations on usage/application
PathoINVEST	Being fast and accurate enough to mitigate a contamination event	Integrating more stakeholders into the process of getting information and designing a quick and accurate detection process	Could be incorporated in the modelling software and SOPs of water utilities
PathoTHREAT	Identifying the relevant people at the crisis organisations	Data required to train the AI aside from news articles	Willingness to apply PathoTHREAT has been expressed by multiple stakeholders
	Scepsis regarding the reliability of applying AI in the use case	Guidelines to integrate PathoTHREAT into the existing procedures	

The identification of the needs and challenges guided the development of the CoP activities in the recent months. To respond to the challenges identified with the PathoTHREAT application, a group of experts has been recruited from the crisis organisations currently being onboarded to facilitate a long-term collaboration for testing the application. Further, the aspect of data collection, bias and accuracy has been discussed and will be considered when testing the first draft of the PathoTHREAT tool.

Further, the approach is currently in the phase of transition to the organisation of multi-stakeholder CoP meeting, which will no longer be bound to specific meetings within the existing research and operational organisations. Instead, all stakeholders from the fields of research, engineering, water utility operators and first responders will come together in a Dutch CoP. This decision has been made to facilitate more focused meetings and to optimise the feedback provision and exchange of knowledge also enabling better engagement opportunities for stakeholders in the periphery of the project partners' immediate work environment. Thus, first responders and third parties will soon be able to provide more feedback in a shared environment, which will also be central to further investigate the potential of PathoINVEST in the Amsterdam pilot scenario.

3.5.4 Next steps

The Amsterdam CoP is currently in a process of transition to soon host multi-stakeholder CoP meetings, integrating several types of stakeholders in shared meetings. For one, the goal is to engage stakeholders of the *Themagroep Biologische Veiligheid,* the *Platform Bedrijfsvoering* and the *Crisis Expert Team environment and drinking water CET-MD*, as well as first responders from the category of field workers such as the laboratories. This process will make use of the learnings derived from the application of the workflow-integrated approach via existing working groups. To start with the organisers of the upcoming Dutch CoP will share upfront detailed information with engaged participants. It has been noticed that the fact stakeholders were already familiar with each other, thanks to the long close collaborations - in formats like the *Themagroep Biologische Veiligheid* – enabled in-depth discussions about challenges of integrating the novel technologies into the operating procedures, despite only running for a short amount of time. Furthermore, as the willingness to test certain technologies has been stated among stakeholders upcoming CoP meetings will place particular emphasis on technological related aspects.

3.6 The Granada Community of Practice

3.6.1 The starting point

The setting up of the Community of Practice (CoP) in Granada, as in the other PathoCERT pilot cities, was preceded by a tailored mapping and analysis of local key stakeholders´ roles and relationships as well as by the analysis of the Spanish emergency and disaster management framework. This resulted in the identification of the first set of key local actors - together with the already engaged PathoCERT local partners - to be engaged in the initial CoP meetings, i.e., the Prevention, Fire Fighting and Rescue Service (SPEIS); Cetaqua; EMASAGRA water-operator; Confederacion Hidrografica del Guadalquivir (River Basin Authority); Public Health Authority of the Andalusian Government; 112-Emergencias Andalucía and Civil Protection Unit of Spanish Government, in representation to the Military Emergency Unit and the National Police and Guardian Civil Units.

3.6.2 The first two rounds of CoP meetings in Granada

Two CoP meetings have been organised in a hybrid format due to the country´s COVID-19 restrictions: the first CoP meeting took place in May 2021 and the second was held in November 2021. The two events gathered a total of 27 local actors representing a vast array of stakeholders, namely: first responders, the Prevention, Fire Fighting and Rescue Service (SPEIS), 112-Emergencias Andalucía and Civil Protection Unit of Spanish Government; water operator (EMASAGRA); technology centre (Cetaqua); and public authorities, namely the Municipality of Granada (Ayuntamiento de Granada), and the Councillor Delegate for Civil Protection (Chief Political Officer in the area of Civil Protection).

The focus and key objectives of these initial CoP meetings, similarly to the others pilot cities, aimed to establish the basis for the long-term engagement and collaboration approach with local key stakeholders. The first meeting enabled the introduction of the PathoCERT project, its key objectives and technologies. Furthermore, it also provided the opportunity to further exchange on the key interlinkages and collaborative approaches necessary among the involved stakeholders and to finalize the framing of the pilot scenarios in Granada. Specifically, evolving from the initially foreseen scenario, two specific ones have been developed.

An earthquake of magnitude 5.5 - with epicentre in the town of Cenes de la Vega - generates a map of concentric isosists from the epicentre with maximum intensity (EMS) of VII with zones VIII in soft soils resulting in:

1. **Scenario 1:** a land slide in the tail of the Canales reservoir (upstream of the city of Granada) occurs. This slide affects the WWTP (Waste Water Treatment Plant) of the town which in turn causes a possible faecal contamination of the water reservoir. In addition, two EDAR operators are missing, the location, search and rescue of the operators are the framework conditions of scenario (search/rescue mission in waters with unknown water quality);
2. **Scenario 2**: a contamination event occurred due to the breakage of a sewage pipe and subsequent mixing with the water supply.

Following the initial productive exchanges, the second CoP meeting focused on finalizing the definition of the suggested scenarios and identifying those technologies that would be of interest for the respective local actors in view of the pilot activities to be conducted against the developed scenarios. Specifically, the technologies in **Table** *23* have been presented and discussed.

Table 23 PathoCERT technologies discussed in the Granada CoP

PathoSENSE	PathoWARE	PathoINVEST
PathoIMS	PathoCAM	PathoVIEW
PathoTHREAT	PathoTWEET	PathoDRONE
PathoGIS		

3.6.3 Key outcomes and learnings from the Granada CoP

The first two rounds of CoP meetings in Granada - in addition to setting the basis for the long-term engagement process with the local stakeholders - have also enabled the gathering of initial data and key learnings for the further development / refinement of the PathoCERT technologies. The engaged local stakeholders (i.e., first responders, water operators, technology centres, public authorities) have identified among all the presented PathoCERT technologies those of higher interest for them in view of the three developed scenarios. **Table** *24* below summarizes this overview:

Table 24 Interesting PathoCERT technologies for stakeholders in the Granada CoP

PathoCERT Technology	Interested stakeholder(s)	Scenario of application
PathoTHREAT	First responders: emergencies 112, Civil protection service of Granada Supply company: Emasagra Basin regulator	Scenario 1 and 2
PathoSENSE AQUATRACK	Supply company: Emasagra	Scenario 2
PathoSENSE PathoTeSTICK	First responder: Civil protection service of Granada	Scenario 2

PathoDRONE	First responders: emergencies 112, Civil protection service of Granada	Scenario 2
PathoDRONE MAP	First responders' emergencies 112, Civil protection service of Granada. Supply company: Emasagra	Scenario 2
PathoVIEW	Supply company: Emasagra First responders: emergencies 112, Civil protection service of Granada	Scenario 1 and 2
PathoVIEW WATCH	Supply company First responders: emergencies 112, Civil protection service of Granada	Scenario 1 and 2
PathoVIEW GLASS	Supply company First responder: emergencies 112, Civil protection service of Granada	Scenario 1 and 2
PathoINVEST	Supply company	Scenario 1
PathoINVEST URBAN	Supply company	Scenario 1
PathoTWEET	First responders: emergencies 112, Civil protection service of Granada	Scenario 1 and 2
PathoWARE	First responders: emergencies 112, Civil protection service of Granada	Scenario 1 and 2
PathoIMS	First responders	Scenario 2
PathoCAM	Basin regulator	Scenario 2
PathoGIS		Scenario 2

Furthermore, the conducted dialogues also contributed to the identification of key challenges, and needs regarding the implementation and usage of the different technologies and consequently to a list of user requirements summarised in **Table *25*** summarizes below.

Table 25 Challenges, needs and expectations on usage voiced by Granada stakeholders

PathoCERT Technology	Challenges	Needs	Expectations on usage/application
PathoTHREAT	Clear and consistent information	Advice(s) about actions in unknown emergency events	Contribute to the design of specific protocols based on the experiences of others in similar incidents
PathoTWEET		Bidirectional capacity: detection of information through what citizens publish, but also enables the sending out of warnings and recommendations	Detection of possible emergencies via social networks in their early stages
		The technology needs to be able to detect any risks	Possibility to use the tool to provide mass warnings to the population (specific self-protection measures, recommendations, etc.)

PathoDRONE	Legislation: there is the need to investigate the flight limitations in the sector where scenario 2 is developed	The drone must be able to integrate different types of sensors (high resolution cameras, thermal, etc...), which will make it versatile in different emergencies,	We need a multi-purpose drone to assist FRs in various emergencies
		Need to know what weight the drone can carry	
PathoTeSTICK		An information type "traffic light" indicating the degree of risk to the FR and clear and simple operational suggestions	Detection of any type of pollutants (chemical, radioactive, etc.)
		Provision of clear and simple information on type of pollutant and related risks Including suggestions on self-protection measures	Provision of information has to be simple and clear
PathoSENSE	Supply company NOT is interested in the use of AquaTRACK at the exit of its treatment station in scenario 2. It would be better at the entrance (raw water) because currently usefulness is not clear to key actors as long as the detection thresholds are not known accurately	Greater sensitivity of the equipment is necessary. It is necessary to guarantee the 0 in microbiology contamination.	Detection of the slightest presence of pathogens
PathoIMS	The implementation aspect with existing platforms within emergency services must be determined with the developers	It must be compatible with existing incident management software(s)	The technology is implemented within a global emergency management system perspective, enabling its use in any type of emergency event
PathoWARE	The implementation aspect with existing platforms within emergency services must be determined with the developers	This technology needs to centralize and manage all the data coming from other sensors	
PathoVIEW	So far it is unclear how the information the command post is transmitted to the first responders	Information should be clear and concise	Provision of a graphical interface which allows clear and concise information transmission to FRs
PathoINVEST		For optimizing the uptake of the PathoINVEST (URBAN), it would be desirable for the graphical interface to be integrated into the existing GIS in the EMASAGRA control centre	Application that enables to detect the possible origin of the pollution as well as its possible evolution, in term of concentrations of it, etc.
PathoGIS	The technology must be integrated into the	More information similar to that provided for	PathoGIS must have a graphical interface with

	existing Emergency Services	PathoWARE and PathoIMS are needed	associated databases relevant to the management of the emergency
		The tool should provide cartographically and georeferenced all variables and outputs from the other PathoCERT technologies and types of sensors or cartographic information already known (rain gauges, river gauges, pressures, hazard and risk maps, distribution networks, etc.); in the form of layers that can be activated/deactivated allowing in a quick and easy way to visualize all relevant information for the management of the emergency	

3.6.4 Next steps

The upcoming rounds of CoP meetings in Granada will aim to continue the work on collecting user requirements and defining technology aspects that provide essential information about the application for end-users. Specifically, as stakeholders raised several technical questions further exchanges will be targeted to address those aspects contributing to the further development / refinement of those PathoCERT technologies, i.e., PathoTHREAT, PathoTWEET, PathoTeSTICK, PathoSENSE, PathoVIEW, PathoINVEST and PathoGIS.

4 The implementation of the CoP approach

4.1 Good practices & Key learnings

These initial rounds of CoP meetings – characterised as mentioned in section 2.1 by so-called *"best practice communities and / or innovation communities"* - have allowed not only to compile an overview of technologies of interests for each stakeholder, their needs, challenges and expectations on usage on those tools, but it also enabled the gathering of insights on on-the ground application of the multi-stakeholder engagement methodology (as described in Section 1.2) by PathoCERT project partners. Hence, it has been possible to infer a list of key learnings pertaining to the applied engagement approach and identify some good practices across the six PathoCERT CoPs. **Table** ***26*** provides an overview of these aspects categorised according to: organisation and running of CoP meetings and communication and exchange with stakeholders.

Table 26 Best practices and key learnings from the PathoCERT CoPs

	Good practices	Key learnings
Organization and running of CoP meetings		
Implementation aspects (format, assignment of roles and responsibilities, etc.)	The use of online tools (e.g., Miro, Mural, …) increase interaction among participants, facilitate discussion and capturing of key outcomes	Clear assignment of roles, e.g., for moderation of session is crucial especially in hybrid and / or online setting
	The use of online interactive tool allows for a better balanced of the overall length of meeting	It is important to keep the exchange on-going: the moderators play a crucial role in ensuring engagement and participation from all stakeholders
		Tailoring the content of each meeting to the needs of the engaged stakeholders is crucial given existing differences between structures, operational procedures, and priorities
Communicating and exchanging with stakeholders		
Communication with stakeholders	Sharing upfront detailed information e.g., on the PathoCERT technologies or local scenario(s) can ease the exchange and enable more in-depth discussions	Supporting engagement of stakeholders between meetings has the potential of strengthening networks and working relationships
Creating extended stakeholder networks	Understanding stakeholders' roles and relationships, mapping possible links existing communication channels and networks, adapting the approach to specific needs contribute to the long-term engagement of key stakeholders	CoP meetings need to account for networking time as not all engaged stakeholders work together and / or have the opportunity to meet outside of the CoP settings
Creating a shared (local) vision	Jointly outline and shape a shared vision for the application and usage of PathoCERT technologies and tools within local/ regional operational emergency management frameworks	CoP organizers need to build bridges between local / regional stakeholders with diverse backgrounds and roles and technical project partners e.g., by directly engaging them in CoP meetings

CoPs in the broader PathoCERT context	Anchoring and integrating the CoP approach in the broader PathoCERT context was a crucial process and key for explaining to the stakeholders the importance of their participation	CoP meetings need to include specific sessions to establish a direct communication channel between the end users and the technology developers. This resulted in a more effective collection of insights in terms of user requirements for the different technologies
	Setting up of internal training webinars and a tailored-made manual has proved to enable an easier setting up and running of CoP meetings, especially for those project partners not familiar with the CoP concept and methodology	Through the familiarization of the stakeholders with the PathoCERT engagement process, the added-value of the CoPs became clearer together with their long-term objectives
	Including a specific session in each of the first CoP meetings - to present in details the PathoCERT CoP approach – has been crucial in order to increase the understanding and engagement level of key local stakeholders	

Reflecting on the aforementioned good practices and key learnings, interesting main findings have been made regarding the CoP methodology. Due to the COVID-19 pandemic, the stakeholders only met remotely, using videoconferencing tools. While these meetings were still very productive, the local partners expressed that in-person meetings would have increased the depth of the discussions and outcomes even more. Accordingly, where possible, upcoming CoP meetings will be organised as physical events. Additionally, despite the small size of some of the conducted meetings, the CoP produced very insightful input for the development process highlighting how the initial mapping and analysis of stakeholders including the countries' emergency management systems as a component of the whole CoP approach are crucial. Indeed, despite the flexibility that the CoP format provides - in terms of topics to be discussed, type of format (physical, hybrid or virtual), and stakeholder groups to be involved - it is also very important that core features of the CoP approach as outlined in Section 1.2 and previous WP3 deliverables (i.e., Milestone 1, Deliverable 2.1 and 2.2) are to be adhered to allow for an effective and uniform engagement approach across the CoPs. The so-far conducted meetings have highlighted the benefit of taking a step out of the ordinary work environment for local stakeholders, since this has proved to have the potential to facilitate targeted discussions. However, it also points out the need for the CoP approach and thus for the meetings to be sensitive to different

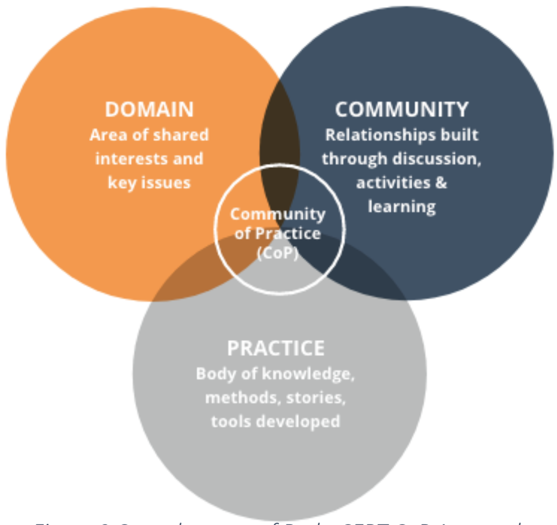

Figure 2 Core elements of PathoCERT CoP Approach

needs enabling diversification of formats and engagement activities depending on local context, though while keeping the core CoP methodology elements outlined in Figure 2.

4.2 Outlook

As we move towards the next rounds of CoP meetings and towards the kicking-off of pilot activities in WP8, in terms of domain, the CoP meetings will focus on the further collection of user requirements for the relevant technologies pertaining to different devoled scenarios.

Currently, in order to progress with the project activities and the pilot exercises, CoP organizers will present to the PathoCERT technology developers all of the gathered feedback on the different technologies, including identified strengths and weaknesses. The direct involvement of technology developers in the CoP meetings - that to some extent was already initiated in the second round of CoPs - will bring more clarity to how the WPs interlink and the extent to which CoP meetings can be used and/or adapted to accommodate testing of technologies. It will also contribute to the better understanding of project developments among local stakeholders. This collaboration will act bi-directionally as the stakeholders will be able to grasp more in-depth the characteristics of each technology, discussing specific functions, thus evaluating how these tools could be effectively uptake in the current management frameworks, but also PathoCERT technology developers will receive direct feedback from end-users.

In addition, the key learnings from this revision exercise will be taken into consideration in the design and planning of the upcoming European CoP meetings, which aim to exploit and replicate the outcomes of the CoP activities at a broader European level, bringing together selected representatives from the various local CoPs and supporting the mainstreaming of knowledge amongst key actors operating in other European countries.

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6 Appendix: Technology Factsheets

The technology factsheets included in this Annex do only include the main PathoCERT technologies together with some of their sub-components. These factsheets have been developed and used for the so-far conducted CoP meetings.

This list should not be considered exhaustive, as additional factsheets will most probably be developed for the missing technologies on the basis of key focus and objectives of the upcoming rounds of CoP meetings.

PathoDrone-SAMPLE

PathoCERT

Aim and scope

The PathoDRONE-SAMPLE technology can be used with any of the aerial vehicles employed in the PathoCERT framework with the proper payload capabilities. Its main scope is to provide autonomous water sampling from remote regions of interest. It is based on a specially designed water sampling mechanism mounted on the UAV and a set of intelligent algorithms that guarantee safe and efficient water sampling. The samples can be delivered to remote stations for further analysis.

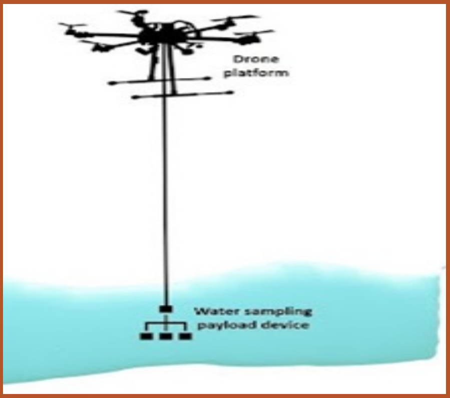
Key characteristics

The main characteristics of the PathoDRONE-SAMPLE technology are:

- Autonomous safe collection and delivery of samples using drones in remote and hazardous locations
- Sampling from multiple different areas
- Autonomous transportation of the sampling mechanism with minimum swing angle to ensure safety during sample transportation
- Robust stabilization control of the UAV against external environmental disturbances (e.g. strong water currents in rivers) to ensure proper water sampling
- Flood simulation software is used to predict water depths and water flow
- Areas of interest (waypoints) are selected exploiting simulation results

The PathoCERT project

PathoCERT project works towards the development of pathogen contamination emergency response technologies, tools and guidelines to help first responders detect pathogens quickly and accurately.



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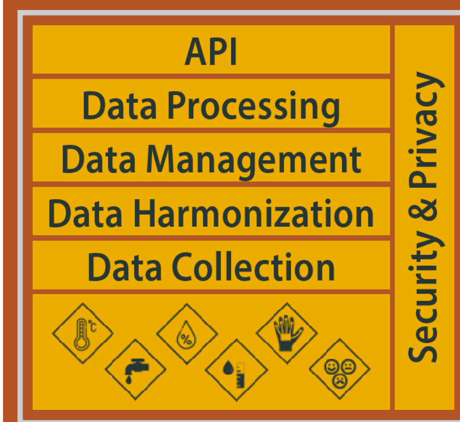
The PathoCERT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 883484.

PathoWARE

PathoCERT

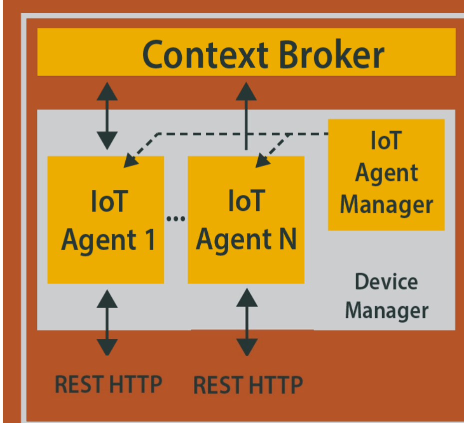
Aim and scope

In the PathoCERT project, all the information exchanged between the different actors (FR on the field, FR in the Command & Control Centre, Crisis Management Headquarter, Water quality Specialist and Water Quality Authorities) through different technologies (PathoGIS, PAthoVIEW, PATHOSENSE, ect...) are cleaned, harmonized according to data models and correlated with each other in order to generate added value for all actors, quickly providing a broad picture of the emergency to be faced.



Key characteristics

In order to better manage all collected data, PathoWARE is composed of several tools organized in different layers. The main components are the Device Manger in the Data Collection Layer, the Data Harmonization in the Data Harmonization Layer, the Context Broker and the Geospatial server in the Data Management Layer and the Security & Privacy component. Using the Device Manager, PathoWARE is able to collect data from devices in different formats (e.g. JSON, Ultralight 2.0- UL2.0, SIGFOX, LWM2M, OPCUA, CayenneLpp, CBOR, custom) and through different protocols (e.g. HTTP, MQTT, OPCUA, LORA, SIGFOX, CoAP). The Data Harmonization component harmonizes all collected data according to data models using NGSI-LD (Next Generation Service Interfaces - Linked Data). NGSI-LD is an information model for querying, publishing and subscribing to context information. It is intended to facilitate the open exchange and easy sharing of structured information between different stakeholders. Information that has been modelled according to the data model is then sent to the Context Broker or Geospatial server. The main functionality of the Context Broker is performed by the publish/subscribe mechanism. The Geospatial server is responsible for sharing geospatial data and implements industry standard OGC protocols such as Web Feature Service (WFS), Web Map Service (WMS), and Web Coverage Service (WCS). All data is then ready to be used by Data Processing Layer components and/or to be made available through APIs to other PathoCERT technologies. Also very important is the Security and Privacy component. This module provides authorization and accounting capabilities.



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PathoSense

PathoCERT

Aim and Scope

PathoSENSE comprises a toolkit of novel technologies, facilitating the collection of data from the emergency response field, the processing of this data for field-relevant knowledge extraction and the inter-communication with the PathoWARE module. It deploys advanced sensing infrastructure, including three different sensors depending on the use case, for in-situ rapid detection of bacteria in water matrices. Data is filtered through a smart gateway at the field, communicating useful information to the higher layers and offering actionable decision making to first responders.

The use of PathoSENSE becomes accessible through a package of protocols, guidance use-cases and tools that instruct first responders on how to deploy the technologies in the field and also guide the verification process and acceptance of the functionality.

Key Characteristics

- Portable and online sensors for microbiological events.
- Advanced sensing infrastructure for water quality.
- IoT gateway to easily communicate data to the decision support tools.
- Protocols, guides and tools to instruct first responders on the use of the different technologies and the whole PathoSENSE toolkit.

The PathoCERT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 883484.

PathoSense

AQUATRACK®

PathoCERT

Aim and Scope

AQUA-Q has developed an optical early warning and automatic smart sampling system for on-line monitoring of drinking water. The system provides **alarm** 24/7 to the operator of a water treatment plant when it detects an increased activity of biological load in water which can be harmful for humans and process.

The system automatically collects smart water samples with time and date during the period of contamination to be analysed at site or at a lab. Samples are stored under clean and cold conditions. The system is EU-ETV verified.

The purpose of the system is to give **early warning 24/7** to the management for possible danger of contamination in water systems and provide **correct water samples** to be analysed. It sends an SMS when contamination is detected. AQUATRACK will be connected to the PathoSENSE IoT gateway.

Key Characteristics

- Real-time, on-line smart sampling with time & date.
- Creates non-contaminated fingerprint and immediate detection of deviation of contaminants.
- Generates alarm when contamination level exceeds fingerprint value.
- Automatically collects samples (500mL sterile bottles) and stores them under cold & clean conditions.
- 220V AC.
- 1 prototype under testing, the goal is to deliver two.

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PathoSense

Bactcontrol

PathoCERT

Aim and Scope

The BACTcontrol is an automatic quality analyser for the rapid detection of bacteria species such as *E.coli*. It is based on an enzymatic reaction to detect its presence. The device is designed to be plug and play. The first responder can collect the sample directly using BACTcontrol or install the instrument in a "forward operation base" in which the sample can be transported to the BACTcontrol.

The BACTcontrol communicates with an Ayyeka wavelet, the transmitted data is picked up by the PathoSENSE IoT gateway.

Key Characteristics

- Measures enzymatic activity of *E. coli* and gives results in about 40 minutes.
- Measurement result is given in pmol/min/volume, but functions well as an indicator if *E.coli* is present. A calibration can be made to display CFU or MPN.
- Can be installed online along the treatment network or be used as a portable device.
- Sample volume 10 mL.
- Little maintenance, depending on water type, or if tubes get polluted/clogged. Easy to clean.
- Plug and play.
- Increased portability due to less parts.
- It is expected to run with batteries, no electric supply will be needed for portable use.
- 2 prototypes available.

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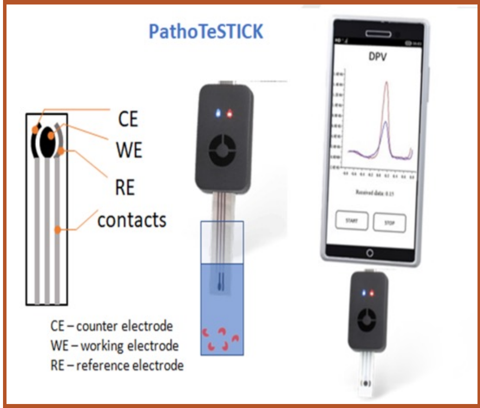
PathoSense

PathoTeSTICK

PathoCERT



Aim and Scope

The PathoTeSTICK was designed to protect first responders, since it is a portable device which can be used when approaching a possible contaminated site for the first time.

The PathoTeSTICK is an ultraportable sensor for the individual detection of bacteria and protozoa, concretely *Escherichia coli* (*E. coli*), *Pseudomonas aeruginosa, Campylobacter species* and *protozoa species*. It is based on electrochemical detection of pathogen species via their markers.

The PathoTeSTICK consists of different use and throw sticks (analytical part) and a commercial potentiostat (to read data), which are connected to a smartphone for operation and data transmission to the IoT gateway.

Key Characteristics

- Detects *E. coli, P. Aeruginosa, Campylobacter sp., protozoa sp*.
- Requires only 1 mL of sample to make a measure.
- It requires a mobile phone for operation and internet for data transmission to the IoT gateway.
- The stick dimensions are 10x70 mm.
- Only 5 minutes to obtain a result.

The PathoCERT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 883484.

PathoSense

IoT Gateway

Aim and Scope

The PathoSENSE IoT Gateway comprises a cyber-physical device that can be deployed in the emergency field as part of the PathoSENSE Toolkit.

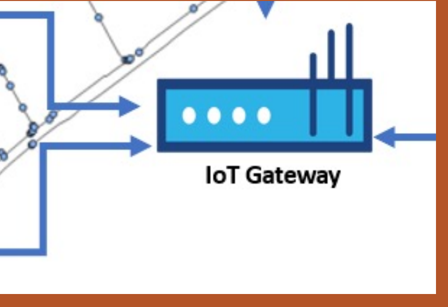
The gateway establishes a two-way communication with the PathoWARE module and integrates software algorithms for the processing of heterogeneous measurements.

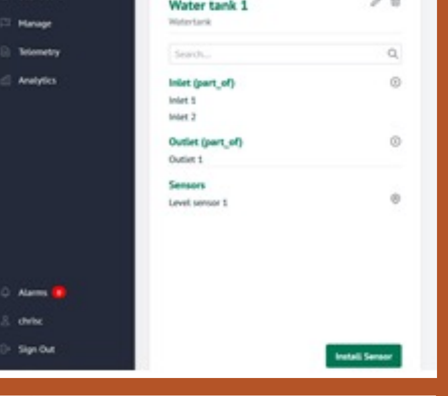
In addition to field data, it can also collect data from the SCADA system of local utilities, including flows, pressures, chlorine concentrations, consumptions, etc.

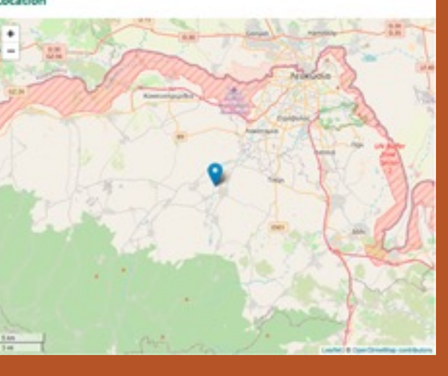
The PathoSENSE IoT Gateway comprises a local analytics tool that extracts useful information from the data

Key Characteristics

- Robustness of the tool, to be used in the emergency field.
- Speaks various communication protocols.
- Collects data and pre-processes it to systematize and add metadata.
- Ability to connect within a SCADA Control Room.
- Ability to connect with traditional databases and cloud services.
- UI to perform configurations and visualize field information.
- Ability to receive messages from the Command-and-Control Centre or the First Responders' vehicles.
- PathoSENSE IoT Gateway is useful for the first responders since: i) it is easy to install, connect to sensors from different vendors and heterogeneous data, and ii) offers direct connection and compatibility with PathoWARE.







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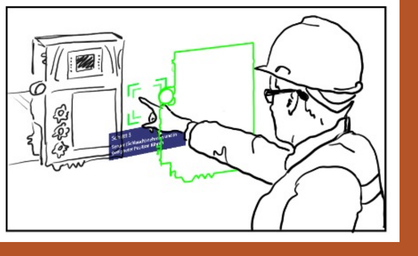
PathoSense

Mobile and AR Guidance tools

PathoCERT

Aim and Scope

The sensors, IoT gateway and the related technologies will be accompanied with operation procedures for proper use and detailed instructions for commissioning and maintenance. The aim of this module is to provide a "Quick Start Guide" for mobile and AR devices that goes through the important steps from beginning to finish. This should enable any user to handle basic steps to get them up and running.



Key Characteristics

- Show step-by-step instructions and 3D overlays on how to setup and use sensors and IoT gateway.
- Provide interaction mechanisms (speech, hand gestures…) to navigate through the information.
- Hands-free interactions while concentrating on actual task.
- Information overlaid on relevant target objects or areas.
- Content as static documents (pdf, images) or interactive animated elements, including 3D overlays, video and audio content where necessary.

The PathoCERT project

PathoCERT project works towards the development of pathogen contamination emergency response technologies, tools and guidelines to help first responders detect pathogens quickly and accurately.

Contact details

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PathoWare

GIS

PathoCERT

Aim and Scope

Development of a GIS-based intelligent disaster situation decision-making support system centered on pollution area detection and disaster situation risk assessment technology by integrating PathoCERT technology to strengthen first responders and central HQ commanders' ability to respond to pollution by waterborne pathogens

-GIS-based disaster situation monitoring technology using location information

- General display of situation on a GIS bulletin, integrating PathoCERT technology

- Utilization of decision-making support system for disaster situations, which includes spatial analysis technology

-Verification of the functionality and usability of the platform through application in pilot areas

Key Characteristics: GIS

- It Informs First Responders and HQ commanders of the exact location of the disaster outbreak through map-based platform, and displays on the system situation reports by field dispatchers.
- It helps HQ commanders recognize disaster situations by displaying Twitter, satellite, risk-assessment and flood and water quality evaluation modelling results on the map.
- It assists First Responders and HQ commanders by providing information collected from IoT sensors mapped in real-time to immediately grasp the time-series changes in water pollution.
- It calculates the scope and degree of damage caused by the diffusion of pollutants through quantitative evaluation utilizing spatial analysis technology
- It provides GIS-based visualization and spatial analysis tools for water resource authorities to make decisions for water quality management in the event of disaster.

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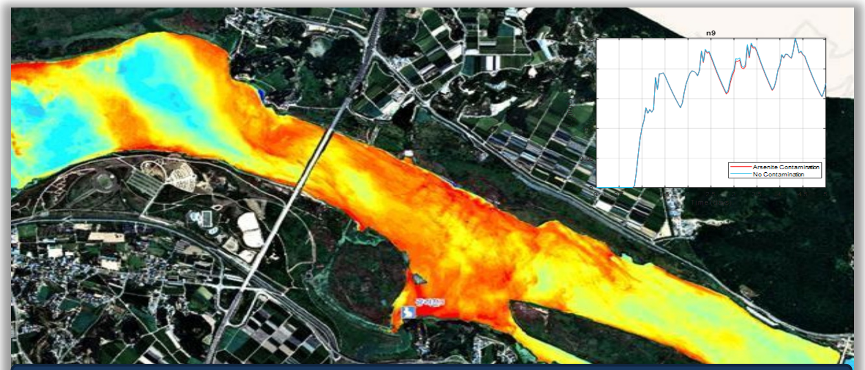
PathoWare

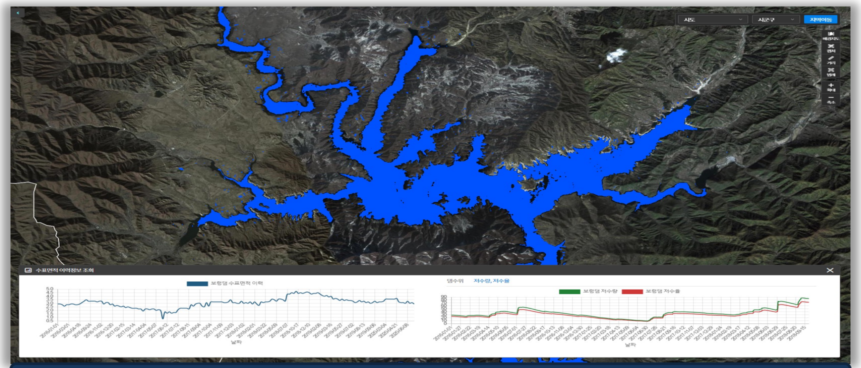
GIS

PathoCERT

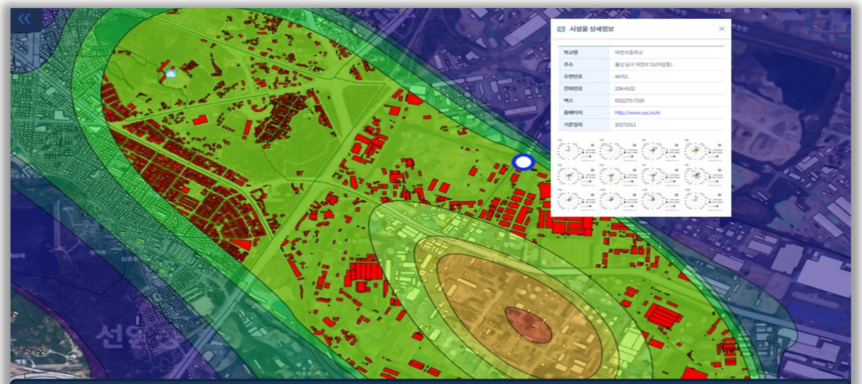
Key Features



Overlaying the analyzed data collected from PathoCERT technologies



Time series data visualization



Extracts the damage in the pollutants spreading area (Spatial querying)

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PathoIMS

Aim and scope

PathoIMS is based on the ENGAGE C2/CAD system, a legacy Command & Control system provided by Satways. It is a multi-agency generic software suite for Integrated Emergency Management in routine or extra-ordinary emergencies. It integrates information from multiple and diverse systems into a single command environment and coordinates emergency response actions based on real-time data.

PathoIMS will provide incident management capabilities to the PathoCERT framework. Commanders will be informed about the situation and will be able to manage the response activities efficiently.

Key characteristics

PathoIMS will be deployed at the Command and Control centers, supporting the management of the event and of the first responders that are involved in the event. Furthermore, the collaboration between the Command and Control center and the Headquarters of the public safety agencies will be improved, enabling the effective exchange of operational information that is useful for the management of the response activities.

In general, PathoIMS is designed for operational use by professional organizations employing mobile resources, such as Police, Fire Departments, Rescue Services, Emergency services, Security Departments etc.

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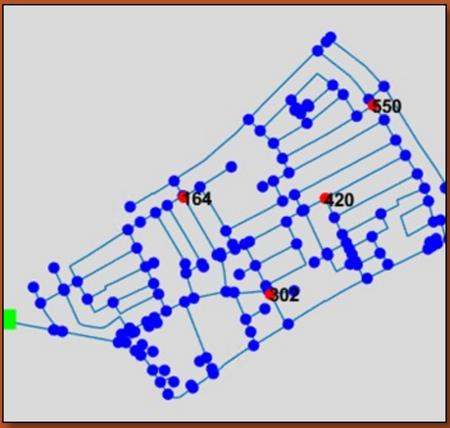
PathoINVEST

PathoCERT

Aim and scope

The aim of PathoINVEST is to provide an innovative and accessible tool designed to model and predict the fate of microbial contaminants within water distribution networks (WDNs), assess health risks and propose control measures. Operators will be able to work on digital twins for more reliable decision-making on the effective management of a contamination event. Realistic pathogen models are utilized, as well as open data for more accurate risk estimation. Synthetic datasets with contamination events will also be generated through the setup of the Virtual City "L-TOWN" benchmark (based on a city in Cyprus) for tabletop exercises.



Key characteristics

- **Pathogen modelling:** Realistic modelling of pathogen contamination and impact estimation in a WDN
- **Digital Twin**: PathoINVEST integrates with telemetry, GIS, EPANET and PathoWARE to create a Digital Twin in real-time, to answer different "what-if" scenarios
- **Actionable insights**: Results emerging from the various analyses and scenarios to be visualized through PathoGIS and used by First Responders..
- **Smart Water Apps**: Using a selection of tools, First responders and water operators can perform activities related to emergency response. This include:
    - Placement of sensors for contamination detection and selection of locations to sample
    - Estimation of hydraulics and quality dynamics
    - Estimation of the possible pathogen contamination impact on the population and the real-time risk
    - Isolate area of contamination, identify possible source area and suggest flushing schedule
    - Propose booster chlorination locations

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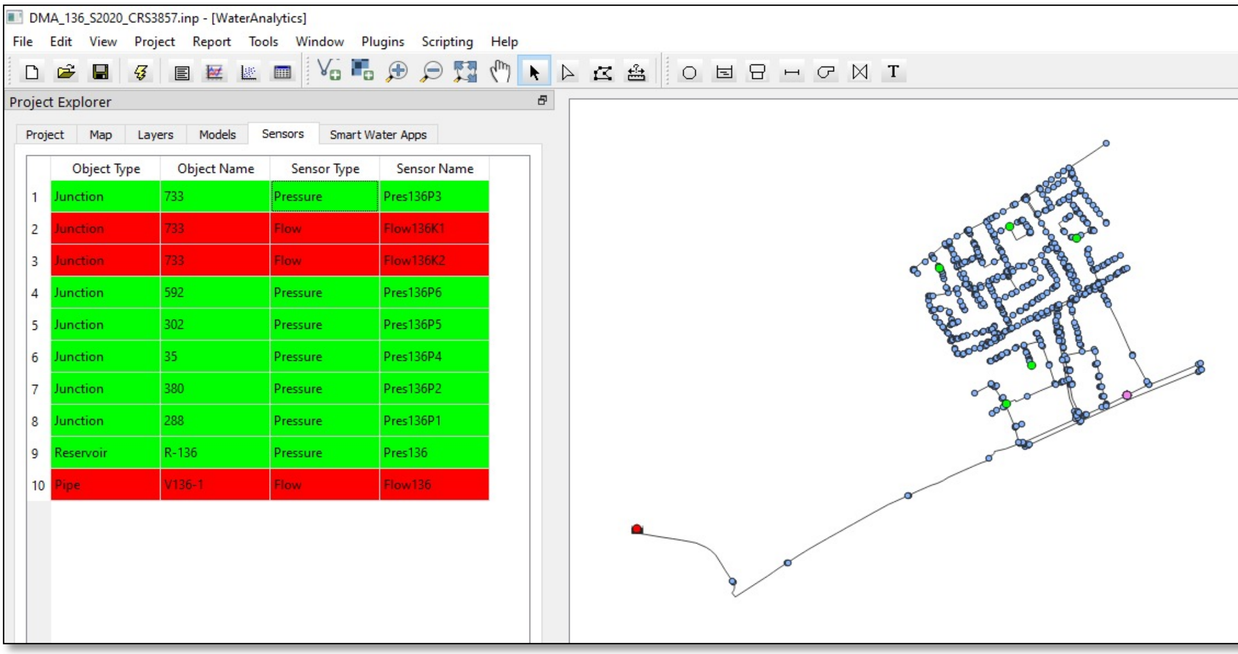
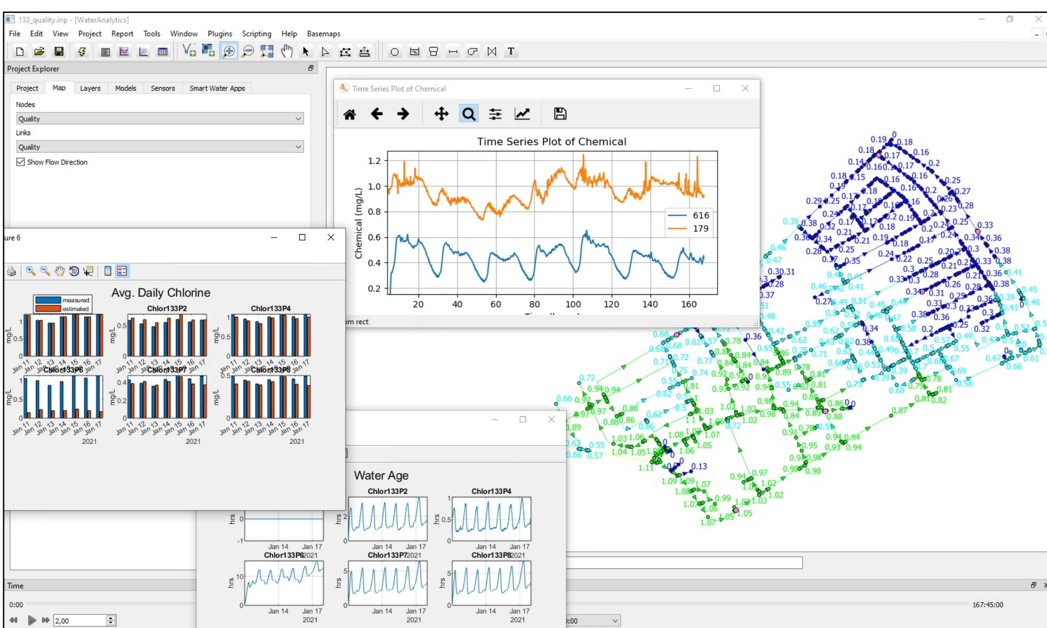
PathoInvest

PathoCERT



WaterAnalytics connects GIS and EPANET models with sensor telemetry from SCADA



WaterAnalytics performs real-time state estimation of water quality dynamics

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PathoSAT

PathoCERT

Aim and scope

PathoSAT monitors the formation of algal blooms on surface water using satellite images. Algal blooms can be poisonous for human and animals via skin contact, or via consumption. Through PathoSAT, the First responders have open access to recent satellite information and thus can obtain the most recent information on the quality of the water and avoid exposure to infected waters. The outcome of PathoSAT is visualised in the dashboard of PathoWARE and on the map of PathoGIS. In the case that an algal bloom event is detected, information is passed to PathoIMS and an alert is triggered via PathoALERT.

Key characteristics

- PathoSAT focuses on monitoring cyanobacteria that can cause harmful blooms, by estimating the levels of cyanotoxins.
- The input considered is satellite data including Sentinel 1, Sentinel 2 and Sentinel 3, which are provided on a free, full and open basis by Copernicus Open Access Hub with a 1-5 days revisit time.
- A series of techniques are investigated for algal bloom detection involving standard remote sensing, machine learning and novel deep learning techniques.
- In the case of machine learning and deep learning techniques, a large satellite image collection of historical events is required in order to train the respective models.
- Generation of timeseries of Chl-a concentration maps
- Visualisation of algal maps in a GIS system, supporting situational awareness

The PathoCERT project

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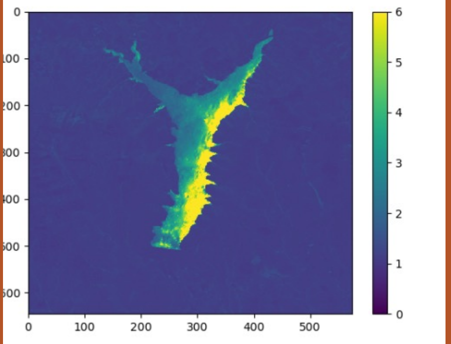
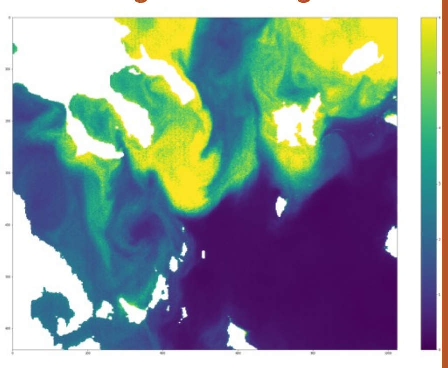
Chl-a in Kouris dam using Sentinel 2



Chl-a in Aegean sea using Sentinel 3



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PathoTHREAT

PathoCERT

Aim and scope

The aim of PathoTHREAT is to help first responders and water utilities manage a pathogen contamination event, utilizing a decision support system (DSS). Users can access information on pathogen characteristics, health risks, and control options from historical contamination events through a friendly user interface (UI). PathoTHREAT will receive information from other PathoCERT technologies such as drone footage or water quality sensors by communicating with the PathoWARE platform and will use this information in the emergency assessment and action plan.

Key characteristics

- **Information extraction:** Using Artificial Intelligence to extract faster high-quality information from scientific publications.
- **Pathogen characteristics database:** Populated with information on pathogen characteristics such as health effects, symptoms, and their association with events.
- **Historical contaminations database:** Populated with information on health risks and control options associated with past drinking water contamination events collected from the scientific literature.
- **Friendly UI reporting:** The user reports basic information such as the cause of contamination, affected infrastructure, magnitude, and associated pathogens.
- **Historical contamination and pathogens similarity:** The PathoTHREAT tool matches the reported information with historical data from the 2 databases.
- **Emergency assessment and action plan:** After the proper curation, the DSS returns information based on similarities and helps the user assess the threat and create an action plan.

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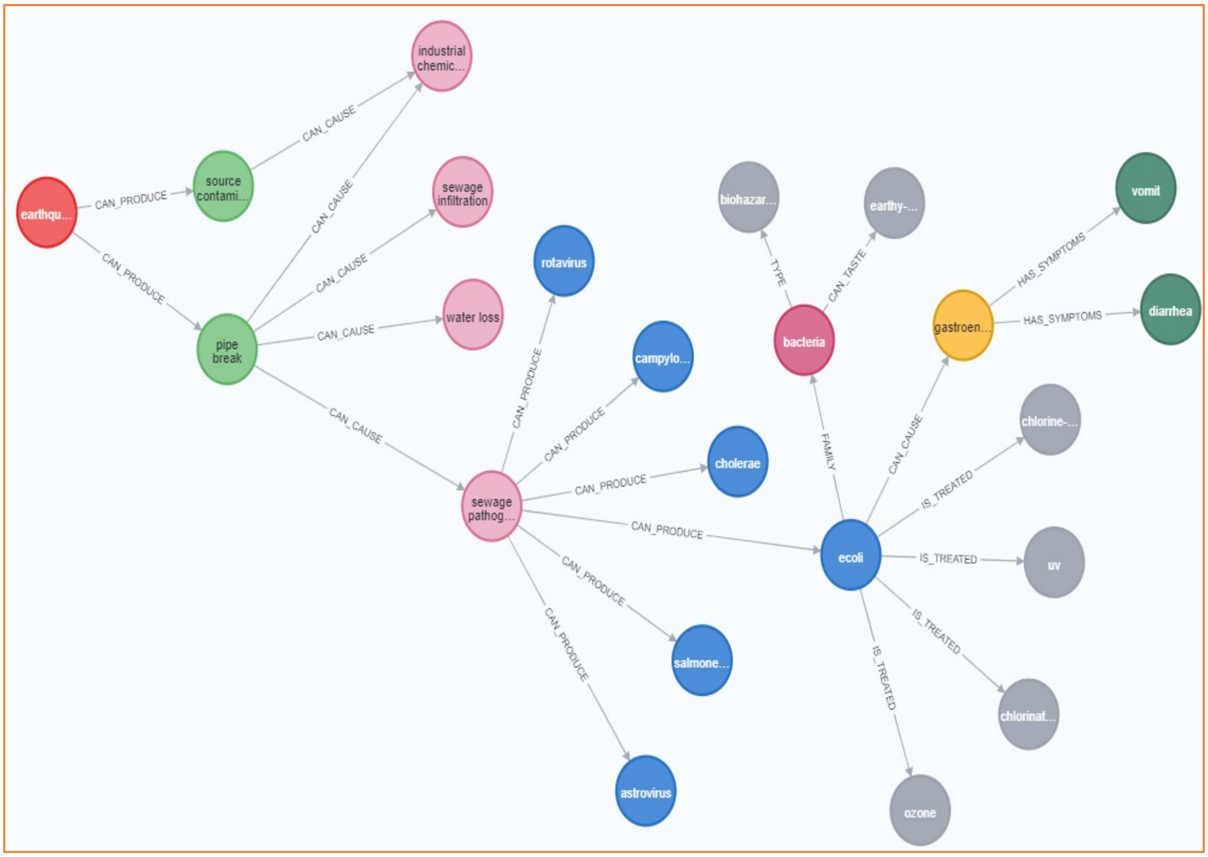
PathoTHREAT

Pathogen Characteristics Database



The figure shows the interconnections of different elements related to the cause of contamination, associated pathogens, symptoms, and various treatment options.

Example: An earthquake **"can produce"** a pipe break, which this **"can cause"** sewage pathogens infiltration, that is associated with pathogen indicator *Escherichia Coli.* This **"can cause"** gastroenteritis and **"has symptoms"** of diarrhoea and vomit.

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PathoThreat

PathoCERT

Emergency reporting process using PathoTHREAT

Impact assesment

Number of people exposed (range): 140-400

Number of people hospitalized (range): 5-100

Number of people died (range): 1-10

Time of contamination to first detection (range): 2-5 days

Time of contamination to response (range): 3-8 days

Associated Pathogens: Campylobacter| Escherichia coli | Salmonella spp | Adenovirus | Rotavirus | Giardia intestinalis | Norovirus |

Associated symptoms: Fever | Abdominal pain | Diarrhea | Abdominal distention | Stomach pain | Nausea | Vomiting | Cramps

Control actions

Investigation:

Start collecting information on number of people connected to the network, list of patients and associated symptoms.

Mitigation options:

- Boil water advisory
- Stop water supply
- Prohibit any use of the water - except for toilet flushing.
- Warn citizens using the police and radio broadcasts.

Restoration:

- Flush the entire distribution system
- Chlorination the distribution system

Emergency details after the threat assessment

Report emergency

1 Reporter info — 2 Event description — 3 Additional feedback

Customer complaints
Specify the complaints

- X Water smells bad
- The colour of water is strange
- X The taste of water is strange

Infrastructure
Specify the complaints

- X Drinking water distribution network broken
- X Sewage network failure
- Flooding

Laboratory Results
Indicate associated pathogens

- X Escherichia Coli
- X Norovirus
- Rotavirus

Additional observations:

Back | Submit | Cancel

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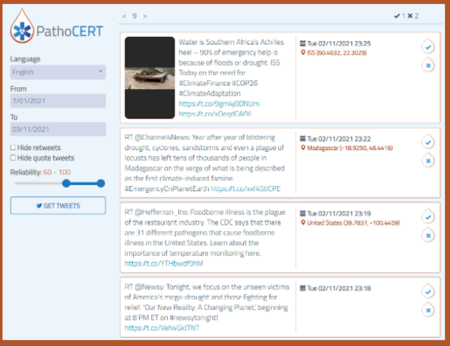
PathoTWEET

PathoCERT

Aim and scope

PathoTWEET enables the automatic collection and analysis of citizen observations and news coverage from social media, in particular Twitter, about water-quality issues. Relevant, geotagged tweets are visualised in the dashboard of PathoWARE and on the map of PathoGIS, providing first responders with an alternative source of information (humans as sensors) for events affecting water quality, complementary to traditional means.



Key characteristics

- Real-time collection of tweets about the quality of water areas near urban regions and the clarity of drinking water, with keyword- and account-based search
- Filtering out posts that match the search criteria but are irrelevant, to decrease incoming noise
- Estimating the reliability of a tweet, to detect fake news
- Automatic geotagging based on mentioned locations in the post text
- Visualisation of filtered & geotagged tweets in a timeline or as pins on a map, supporting situational awareness

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PathoVIEW

Smartphone /Tablet App

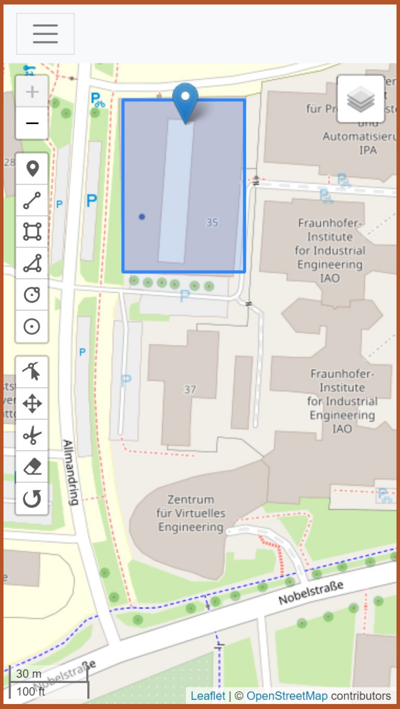
PathoCERT

Aim and scope

PathoVIEW App on smartphones / tablets provides a single system for communicating relevant information collected by PathoWARE. It enables quick and easy access to information for the FR and enhances overall situational awareness. It provides a two-communication system wherein the FR can also send back information to PathoWARE.

Key characteristics

- Shows emergency incident information (incident location and type, units assigned, comments, casualty count, etc.)
- Shows alerts / notifications about changing circumstances
- Shows additional helpful information (action plans, symptoms, and treatment of pathogens)
- Supports navigation/orientation (shows maps)
- Collects, reports, exchanges and shares real-time information, e.g., position
- Sends photos / videos
- Allows to request drone or sampling team to make observations or measurements at a specific position



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PathoVIEW

Smartwatch

PathoCERT

Aim and scope

PathoVIEW Smartwatch is a wearable device that can be used in addition to other PathoVIEW technologies mainly to receive alerts / notifications. Its location on the wrist allows for intrusive free usage especially while wearing personal protective equipment.

Key characteristics

- Shows alerts / notifications about changing circumstances
- Communicates position
- Can be extended in the future for sending some basic information such as confirmation / denial of mission objectives etc.

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PathoVIEW

Smartglass

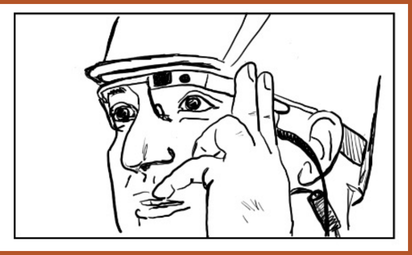
PathoCERT

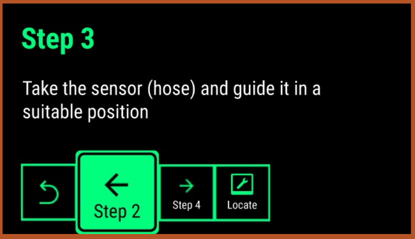
Aim and scope

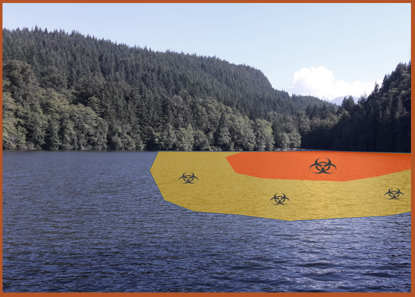
PathoVIEW Smartglass gives the ability to access helpful information, when needed during a task, to increase the situational awareness. The information is presented in front of the eyes on a heads-up display or can be overlaid on relevant target objects or areas with an AR glass. It provides interaction mechanisms (touch, speech, hand gestures...) to navigate through the information. It enables hands-free interactions while concentrating on actual task.

Key characteristics

- Shows alerts / notifications about changing circumstances
- Shows additional helpful information (action plans, maps, images, symptoms, and treatment of pathogens)
- Provides interaction mechanisms (speech, hand gestures...) to navigate through the information
- Shows step-by-step instructions and 3D overlays (Augmented Reality) on how to setup sensors and IoT gateway







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PathoVIEW

Haptic Vest

Aim and scope

PathoVIEW Haptic Vest can be used in addition to other PathoVIEW technologies to use the vibrational feedback as low-threshold information to increase the situational awareness.

Key characteristics

- Alerts if entering danger zone
- Alerts when receiving critical or time-sensitive information
- Navigation / orientation through vibrational feedback

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