

Illinois Rural Water Association Training Session

Digitization and AI for Small- and Mid-sized Water and Wastewater Utilities

3 December 2024
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Discussion Outline

- Trends in AI and Digitization
- Ensaras Case Studies
- Cyber Security Threats
- Agency Recommendations
- Concluding Remarks



AI and Digitization in Water and Wastewater

Digitization

Digitization in water and wastewater is the integration of digital technologies, such as sensors, data analytics, automation, and software solutions to enhance the efficiency, monitoring, and management of water and wastewater systems.

Artificial Intelligence

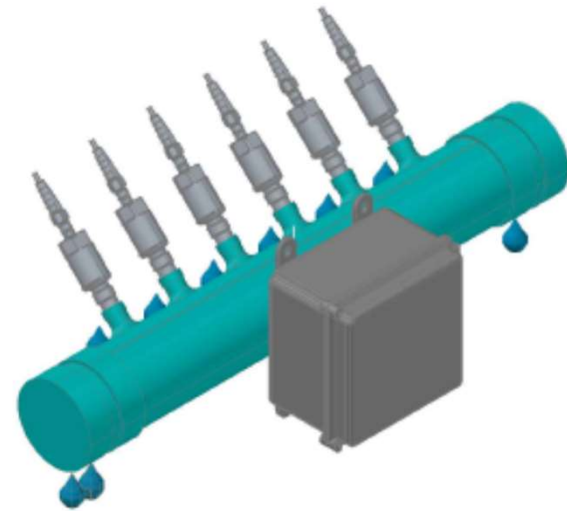
AI in water and wastewater refers to the use of artificial intelligence technologies, such as machine learning, predictive analytics, prescriptive analytics, and generative AI, to optimize the monitoring, treatment, distribution, and management of water resources and wastewater processes. It enables smarter, more efficient, and sustainable operations by analyzing data, predicting outcomes, and supporting proactive interventions.

Digital Trends in Water & Wastewater



Advanced Metering Infrastructure

AMI water meter drivers used for leak detection, operational efficiency, and increased consumer engagement

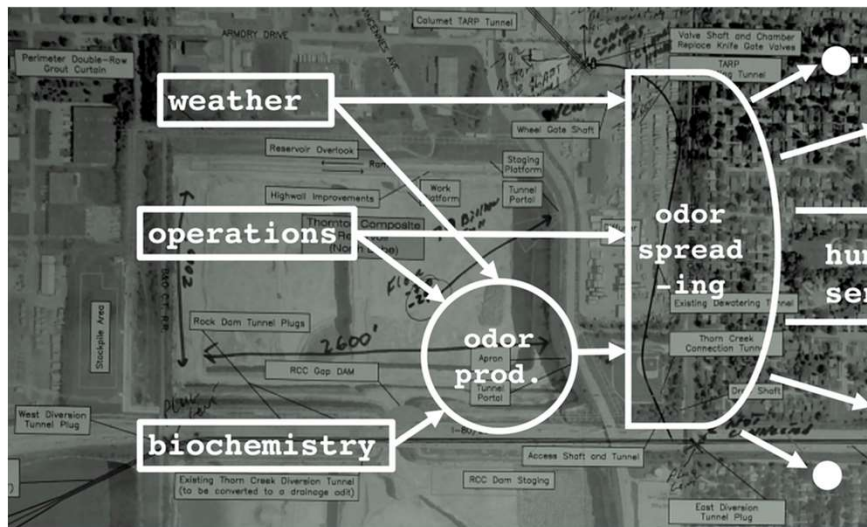


Internet of Things

IOT sensors used for quality monitoring, process control, asset management, and edge computing

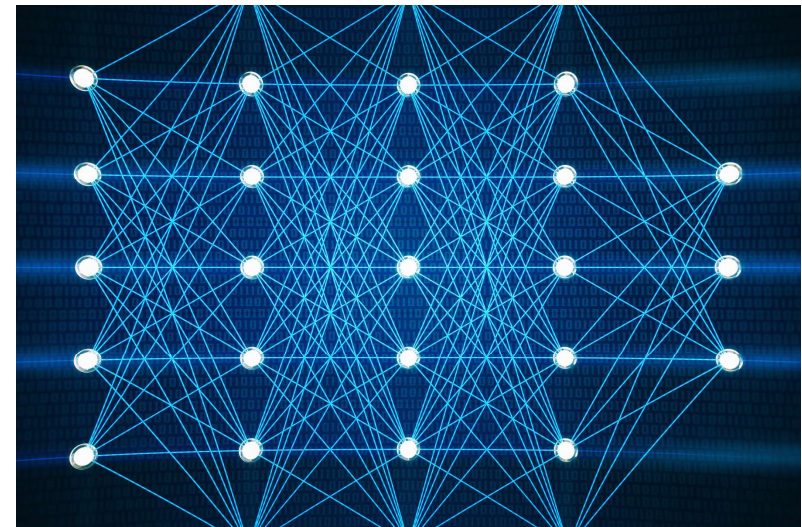


Digital Trends in Water & Wastewater



Advanced Analytics

Data analytics and machine learning to generate descriptive, predictive, and prescriptive insights.



Artificial Intelligence

AI used to generate descriptive, predictive, and prescriptive insights. Growing applications with generative AI



Digital Trends in Water & Wastewater



Remote and Autonomous Systems

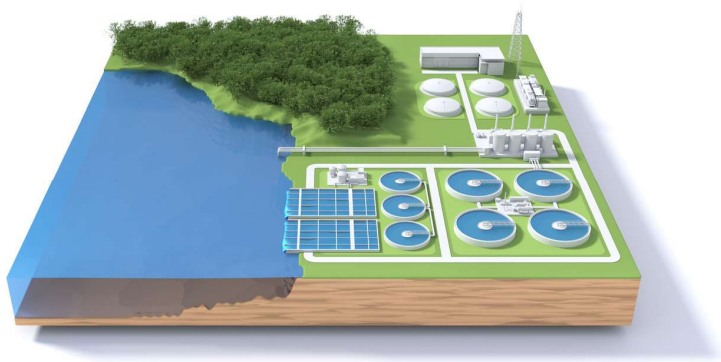
Operational technology provides automation and remote monitoring



Cloud Infrastructure and Computing

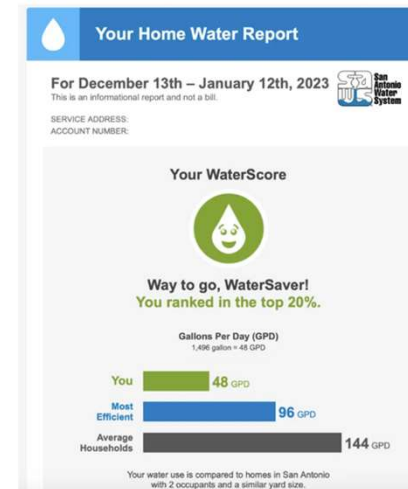
Cloud infrastructure decreases costs, and is used in many SaaS, DaaS, and AlaaS solutions

Digital Trends in Water & Wastewater



Digital Twins

A dynamic digital model of a plant to obtain actionable insights, using a hybrid data-driven and physical models




Customer Engagement Platforms

Used to interact and engage with customers, and provide novel insights like usage patterns or potential leaks



Case Studies

Using complaint data to resolve process and infrastructure problems



Enсарas, Inc. worked with the Metropolitan Water Reclamation District of Greater Chicago to help them alleviate odor complaints at an 8 Billion Gallons Stormwater Reservoir.

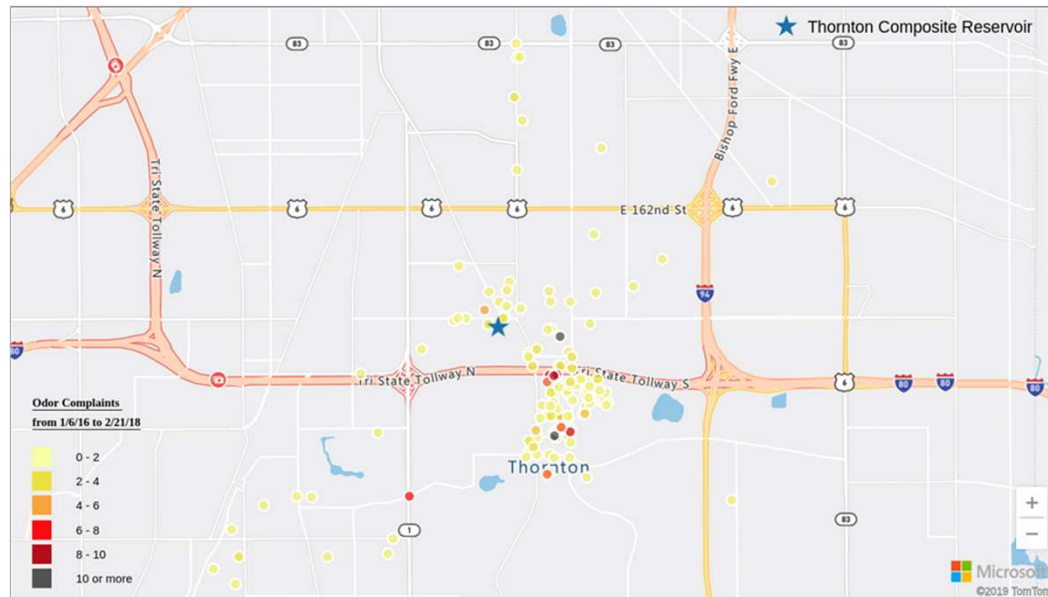
Challenge:

- Odor problems
- Unhappy customers
- A physical model of odor dispersion was not available

Publication:

Mulrow, J., Kshetry, N., Brose, D., Kumar, K., Jain, D., Shah, M., Kunetz, T., Varshney, L. "Prediction of Odor Complaints at a Large Composite Reservoir in a Highly Urbanized Area: A Machine Learning Approach," Water Environment Research: Volume 92, Number 3., March 2020: 418-429.

Using complaint data to resolve process and infrastructure problems



Solution:

The ML model developed by Ensaras provided the following benefits:

- (1) identification of the likely source of odors
- (2) rather than odor mitigation at a larger scale, client could target odor mitigation at the source
- (3) cost-effective odor management solution identified

The project won second place in the WEFTEC LIFT Intelligent Water Systems Challenge.

Publication:

Mulrow, J., Kshetry, N., Brose, D., Kumar, K., Jain, D., Shah, M., Kunetz, T., Varshney, L. "Prediction of Odor Complaints at a Large Composite Reservoir in a Highly Urbanized Area: A Machine Learning Approach," Water Environment Research: Volume 92, Number 3., March 2020: 418-429.

Using Machine Learning to Overcome Challenges in Remote Regions

Enсарas worked on a project for the US Army to develop a method to classify wastewater (safe to discharge, safe to reuse, etc.) using low-cost sensors.

Challenge:

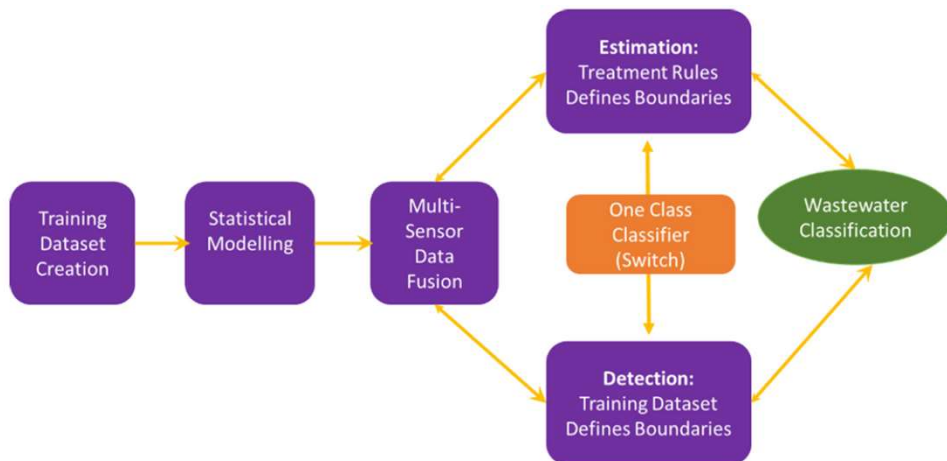
In remote regions of the world, it is difficult to monitor wastewater treatment plants using standard laboratory methods



Publication:

N. Kshetry and L. R. Varshney, "Safety in the Face of Unknown Unknowns: Algorithm Fusion in Data-Driven Engineering Systems," in Proceedings of the 2019 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), Brighton, England, 12-17 May 2019.

Using Machine Learning to Overcome Challenges in Remote Regions



Solution:

Ensaras developed a theoretically optimal model for the accurate wastewater classification using field deployable and low cost sensors, when standard laboratory methods are not available.

With this ML solution, our clients can classify wastewater with high accuracy despite not having access to standard laboratory testing methods.

Publication:

N. Kshetry and L. R. Varshney, "Safety in the Face of Unknown Unknowns: Algorithm Fusion in Data-Driven Engineering Systems," in Proceedings of the 2019 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), Brighton, England, 12-17 May 2019.

Ensaras AI Wastewater Stack Reduces Energy by 30% at MBR Plant



The Ensaras AI Wastewater Stack has been in use at a 2.0 MGD sewage MBR in Pune, India.

Challenge:

- High energy consumption at an MBR compared to conventional STP
- Irreversible fouling of MBR membranes can cause plant to lose its ability to treat at capacity, and cost of replacing membranes is high
- No streamlined data collection and reporting mechanism was in place

Enсарas AI Wastewater Stack Reduces Energy by 30% at MBR Plant

Solution:

With the Enсарas AI Wastewater Stack, the facility achieved the following benefits:

- (1) Reduction in energy intensity by 30%
- (2) Optimized MBR cleaning schedules to keep membrane permeability, flux, and transmembrane pressures stable
- (3) Reduction in hundreds of hours in data collection, visualization, reporting, and management activities each month.

With the energy savings alone the facility achieved a less than 6 months ROI.

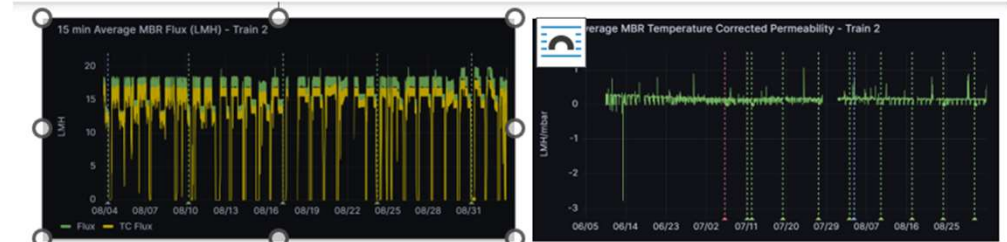


Figure 1. Average Flux and Temperature Corrected Flux with Toggle Lines Indicating Cleaning Type

Figure 2. Average Temperature Corrected Permeability with Toggle Lines Indicating Cleaning Type

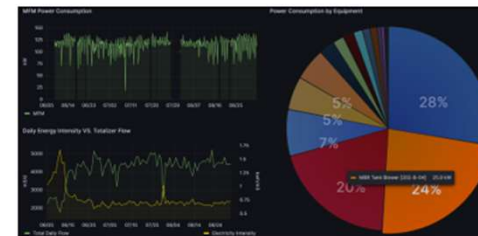


Figure 3. KPIs for Real-time Energy Consumption

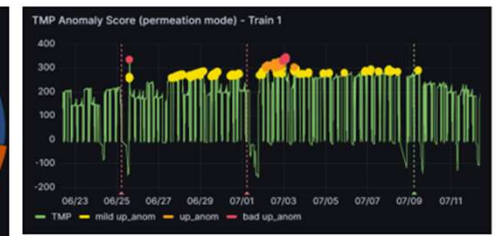


Figure 4. Real-time Anomaly Detection for TMP



Figure 5. Real-time Equipment Health Monitoring

Ensaras AI Wastewater Stack For Small- to Mid- sized Facilities

Challenges	Feature	AI
Manual data collection in form of paper logs or spreadsheets, leads to messy data that takes days or weeks to process	Intelligent Wastewater Web Forms	Web form data is instantaneously validated and KPIs are available in dashboards and email reports, AI powered plant health insights
Aging infrastructure leads to excessive equipment downtime, hampering plant performance and leading to customer complaints	Wastewater Equipment Wizard	Critical equipment health is monitored to generate predictive maintenance routines, and GenAI powered wastewater assistants provide expert guidance.
Increasingly complex treatment schemes for resource recovery, and growing sustainability objectives to achieve net zero carbon, require optimal operations	WWTP Digital Twin	Real-time data collection from SCADA and instruments provides real-time data for advanced AI systems, creating WWTP digital twins for optimizing plant and network operations

Intelligent Web Forms

AT&T LTE 10:17 PM 9%

Create Data

Type of lab test
Volatile Acids

Location
digester 1: 202-P-01

Time of sample collection
May 21, 2024 at 10:16 AM

Time of lab test
May 21, 2024 at 11:17 AM

Sample Type
grab

Sample Storage
refrigerated

Result
200

AA portal.ensaras.com



Move away from paper logs and spreadsheets with intelligent web forms with in-built data validation



Ensaras - Water
Management Solutions

Equipment Wizard

Ensaras AI Assistant

My gas analyzer is not reading correctly - help me diagnose?

Submit

Answer:

Explanation:

When a gas analyzer like the BA-200 is not reading correctly, it could be due to a variety of issues ranging from calibration errors, sensor malfunctions, or even environmental factors affecting the readings. The BA-200 is designed to continuously monitor gas concentrations, and accurate readings are crucial for its effective operation. Incorrect readings can lead to improper data interpretation, potentially compromising safety and efficiency.

Possible Causes:

Calibration Issues: The analyzer may need recalibration if it hasn't been calibrated according to the recommended schedule or if the calibration was not performed correctly.

Sensor Problems: Sensors can degrade over time or become contaminated, affecting their ability to detect gases accurately.

Electronic Component Failures: Faulty wiring or malfunctioning components on the circuit board could impact readings.

Environmental Interferences: External factors such as temperature fluctuations or the presence of other chemicals might interfere with accurate gas detection.

GenAI powered chat bots to help operators quickly access information they need to troubleshoot equipment health, and provide references to documentation.

Real-time Sensor Data

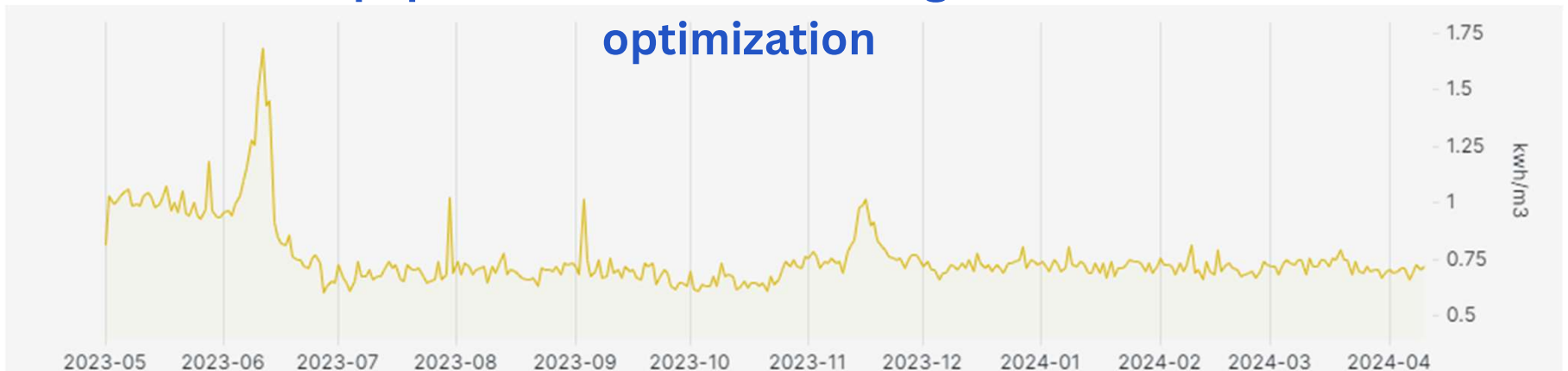


Securely bring in data from SCADA, PLC, and other systems and databases

AI and ML Powered Digital Twins

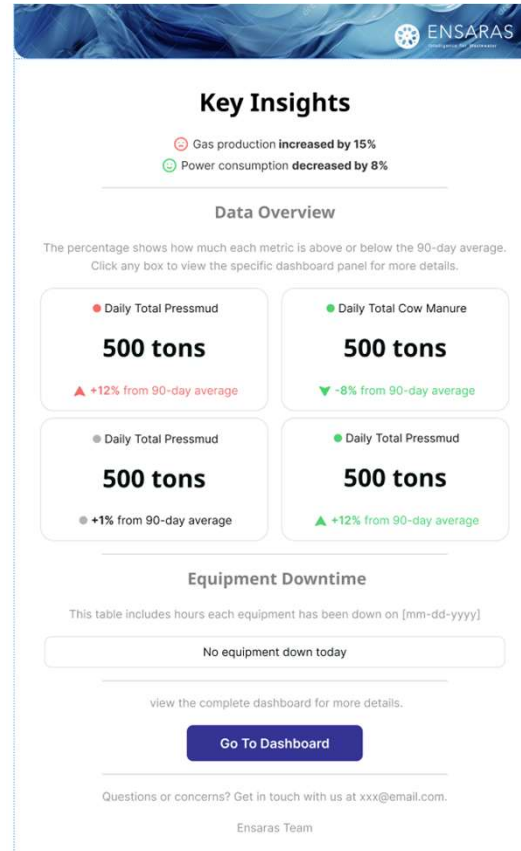


Critical equipment health monitoring and maintenance optimization



Energy monitoring and optimization

Automatic Reporting



Customized AI Driven Daily Email Insights

Cyber Security



Best-in-class security keeps automation systems safe, we receive data through secure read-only channels, and our systems prevent data poisoning and data interception.

Features	Essentials	Standard	Premium
Intelligent Web Forms	✓	✓	✓
Data and KPI Visualization	✓	✓	✓
Automatic Reports	✓	✓	✓
Plant Health AI Insights	✓	✓	✓
SCADA/PLC Integration		✓	✓
AI/ML for Anomaly Detection		✓	✓
AI/ML for Prediction		✓	✓
Equipment Wizard		✓	✓
Digital Twins			✓
Advanced AI/ML Algorithms			✓
Custom Data Integrations			✓

A Plan to Suit Your Needs

No matter where you are in your digital transformation journey

Benefits of AI and Digital Technology



Workforce Decision Support

Empowering the workforce with a data-driven and AI powered decision support platform, to identify anomalies, predict failures, recommend AI supported operational targets and corrective actions, or even build their own GenAI assistant for the local context.

Decarbonisation and Sustainability

Optimizing plant performance to maintain treatment standards, and derive value added products that fuel the circular economy, while reducing the energy and carbon intensity of the treatment processes.

Protecting Public Health and Environment

Prioritizing public health and environmental safety by ensuring treatment plant, and the associated network, are meeting regulatory and performance metrics.

Benefits of AI and Digital Technology

Reduced Customer Complaints

Analyzing problem areas in the network or within the treatment plants, and identify trouble spots that require corrective action, resulting in reduced complaints and happier customers.

Enhanced Oversight

With digital asset control helps monitor and manage infrastructure remotely via laptops or mobile devices, receive automatic email reports with KPIs and AI insights , providing real-time oversight from anywhere. This enhances decision-making, operational efficiency, and maintenance planning.

Improved Infrastructure Health

Much of the wastewater infrastructure is aging, resulting in frequent breakdowns, overflows, and inefficiencies. These systems require substantial investment for rehabilitation and upgrades. These issues are alleviated by enabling better equipment performance monitoring and data-driven predictive maintenance.

Digital Twins

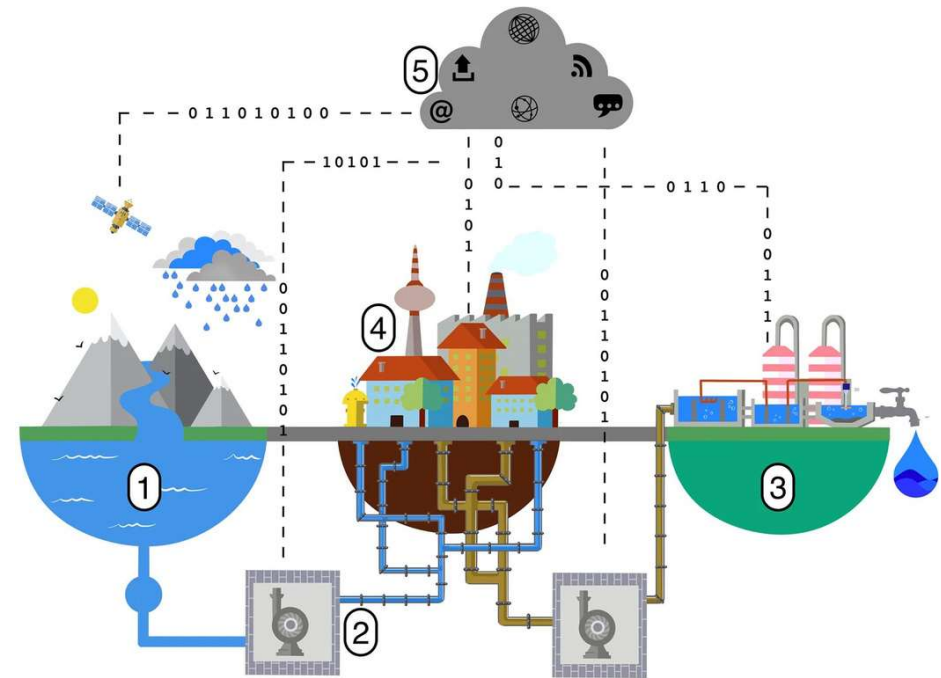
Accurate data on the condition and performance of plants and equipment, by using hybrid process and data models (digital twins), enabling informed decisions for asset management, ensuring long-term quality and reliability of wastewater infrastructure, and achieve optimization.



Growing Cybersecurity Threats

Growing Cyber Security Threats

- **Increasing attack surfaces** with growth of digitization and AI in water and wastewater.
- **Changing adversarial landscape**, growing attacks from cyber criminals and cyber terrorist organizations, in addition to nation states (China, Iran, Russia, North Korea).
- **Changing victim landscape**, attacks on rural utilities equally likely as on urban utilities.



Source: <https://doi.org/10.1038/s41467-019-12490-1>

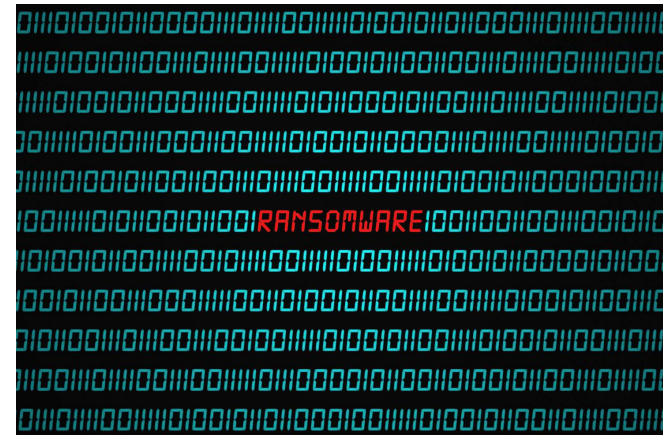


Common Cyber Threats



Operational Technology

Since at least November 22, 2023, IRGC-affiliated cyber actors have compromised multiple Unitronics PLC devices using default credentials.

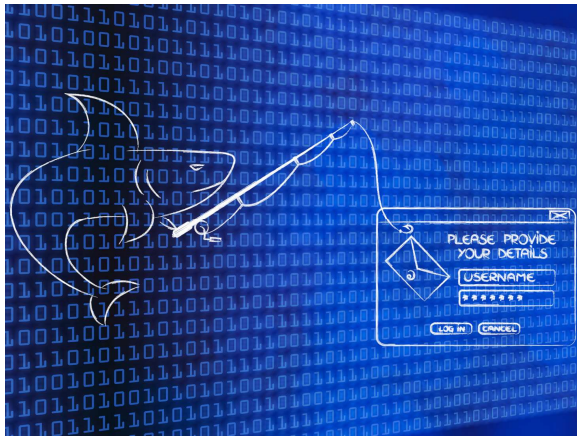


Ransomware

On January 19, 2024 Veolia announced that a ransomware attack affected some of the division's software applications and systems.

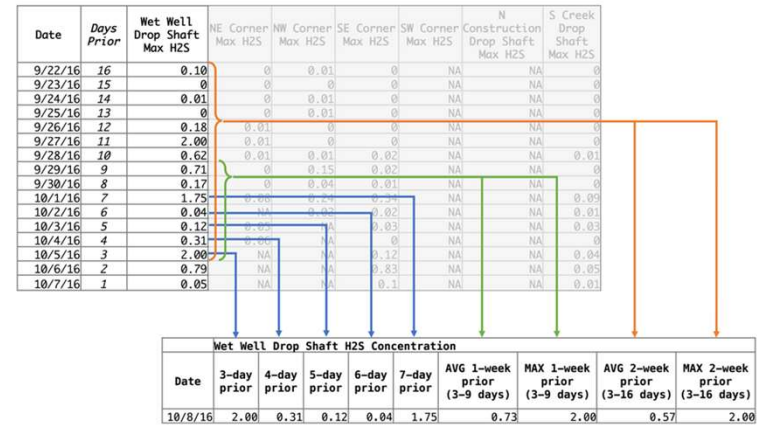


Common Cyber Threats



Phishing

Phishing is one of the top cyber security threats in water and wastewater utilities



Data Poisoning

Data poisoning is the deliberate and malicious contamination of data to compromise the performance of systems or present incorrect outcomes



CISA, EPA, and FBI Release Top Cyber Actions for Securing Water Systems

Top Cyber Actions

- Reduce Exposure to the Public-Facing Internet
- Conduct Regular Cybersecurity Assessments
- Change Default Passwords Immediately
- Implement Multi-Factor Authentication, when possible
- For Remote Access to Networks, Implement a VPN or Firewall

CISA Fact Sheet: <https://www.cisa.gov/sites/default/files/2024-02/fact-sheet-top-cyber-actions-for-securing-water-systems.pdf>

Top Cyber Actions

- Conduct an Inventory of OT/IT Assets
- Develop and Exercise Cybersecurity Incident Response and Recovery Plans
- Backup OT/IT Systems
- Reduce Exposure to Vulnerabilities
- Conduct Cybersecurity Awareness Training

CISA Fact Sheet: <https://www.cisa.gov/sites/default/files/2024-02/fact-sheet-top-cyber-actions-for-securing-water-systems.pdf>



Concluding Remarks

Conclusion

- Benefits of AI and digitization in the water and wastewater sector is great, with new use cases constantly emerging.
- The increasing use of AI and digital tools is creating new attack surfaces, and new AI-enhanced cyber threats.
- However, when AI is implemented using best practices, cyberthreats are minimized. AI can even be used to monitor for cyber attacks.

Cybersecurity Resources

CISA, EPA, FBI Fact Sheet

<https://www.cisa.gov/sites/default/files/2024-02/fact-sheet-top-cyber-actions-for-securing-water-systems.pdf>

EPA Cyber Security for the Water Sector

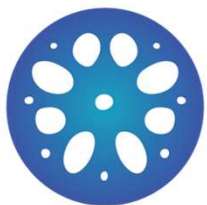
<https://www.epa.gov/waterresilience/epa-cybersecurity-water-sector>

CISA Water and Wastewater Cybersecurity

<https://www.cisa.gov/water>

Thank You

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