ZYMATIC INDUSTRY™

Wastewater treatment for unwanted organic compounds

The world's most flexible water treatment technology uses enzymes

Tailor your own treatment step by using the
full power of the zymatic sand platform technology

ZYMATIC INDUSTRY™

Introduction

ZYMATIC **INDUSTRY™** is a customized water treatment solution for removal of industrial process water pollutants. The ZYMATIC technology is based on the activity of enzymes incorporated in a sand-like material (zymatic sand). The enzymes bound to the material are selected to remove specific target pollutants present in industrial process water. The water is treated as the water flows through the zymatic sand (enclosed in a module/container system). Adapting the zymatic sand will result in a highly performing treatment step at low overall operational costs.

100%

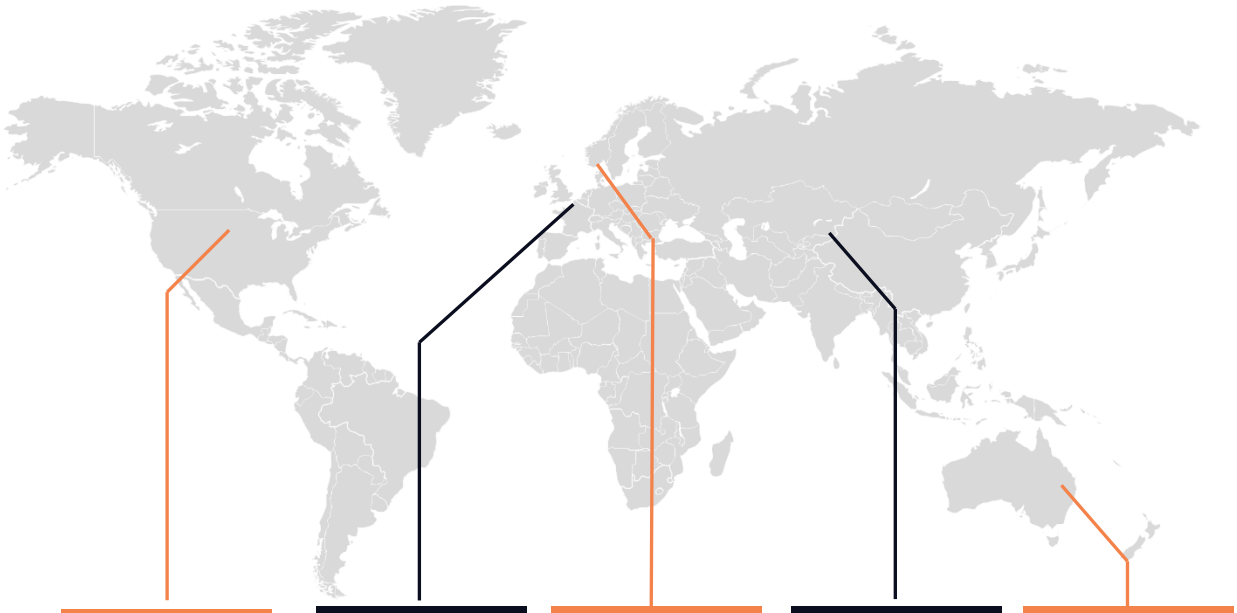
Tailored Treatment

Designed to remove specific organic compounds. The system design can be pre-estimated using standard zymatic sand parameters.

LOW COST

Very Low CapEx and OpEx

Simple treatment design by applying a sand-like material. Installation to lowest possible costs and ease of use minimizes both CapEX and OpEx costs.



Increased focus on PFAS and OMP removal from water resources

High activity in many countries to remove OMP from wastewater

Global focus to implement installations at WWTPs and industry facilities

Ongoing activities to remove OMP from industrial wastewater

Increased focus on PFAS and OMP removal from water resources

About ZYMATIC

With unbeatable low cost for water treatment, we create high efficiency treatment systems using the ZYMATIC enzyme technology. By using a deep-tech knowledge about enzymes, we find simple solutions to your complex water treatment challenges. The use of a sand-like material, for removal of unwanted organic compounds in municipal wastewater, WWTP effluent water and industrial process waters effluents and industrial processes, makes ZYMATIC easy to apply and scale to any water treatment plant. Our goal is to support you as a customer to improve your water treatment by using our flexible water treatment technology.

Degradation Agents

Enzymes are natural catalysts and “Nature´s own degradation agents”. Enzymes are proteins that degrades continuously and can be bound to inorganic materials for increased efficiency.

Zymatic Sand

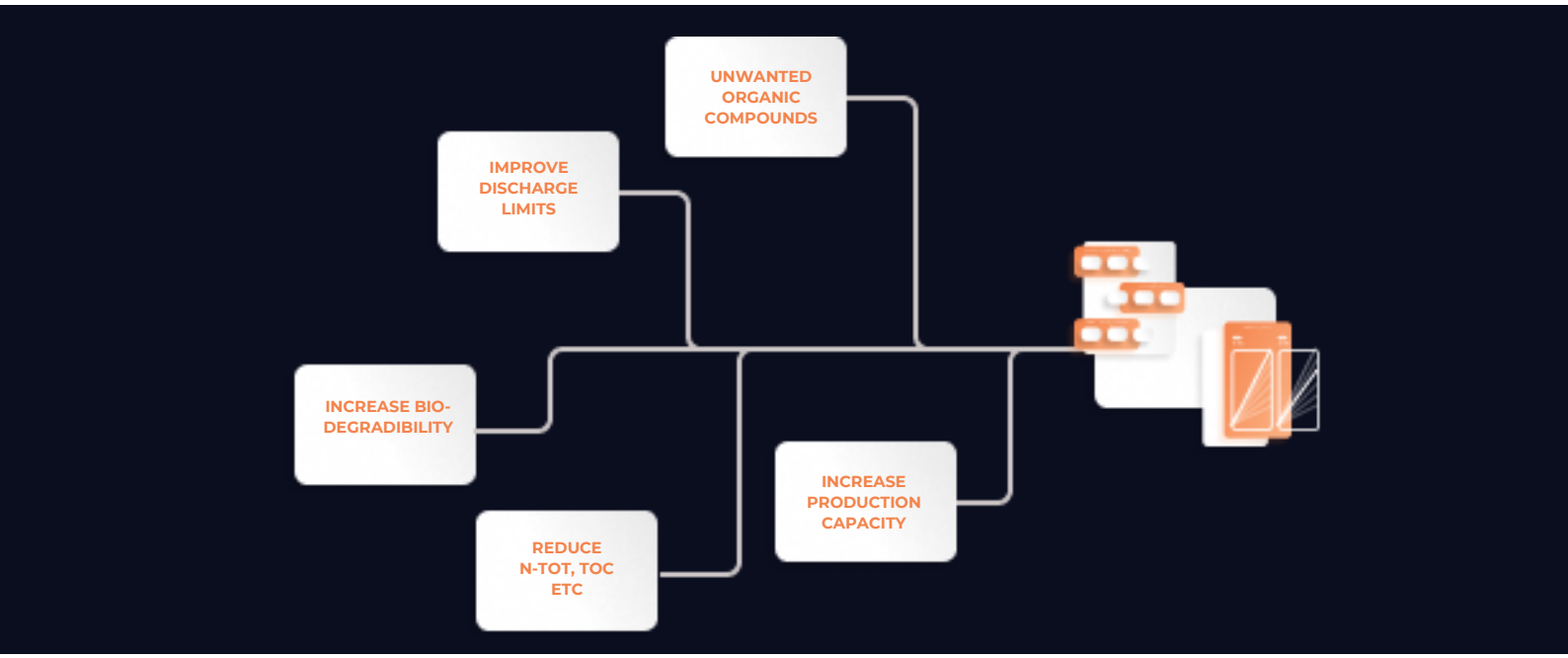
Enzymes bound to a material creates an enhanced (en)zymatic material. The water treatment technology offers continuous upgrades of the zymatic sand and high flexibility for local needs.

How the INDUSTRY™ solution works

The INDUSTRY™ solution is designed to remove organic pollutants present in individual industrial process water streams. INDUSTRY™ normally consists of a module (column and/or container) filled with customized zymatic sand.

The zymatic sand in the INDUSTRY™ solution is tailored to remove customer-specific organic compounds. The adaption process of the zymatic sand is enabled by using the Zymatic platform technology. You can imagine the adaption process as a code in a computer program, where each selected enzyme represents a function returning a treatment step based on a reaction mechanism. The use of various numbers and types of functions (enzymes) in the zymatic sand results in an altered treatment step based on different numbers and types or reaction mechanisms. There are billions of different enzymes, and therefore the mixture of possible treatment mechanisms is large.

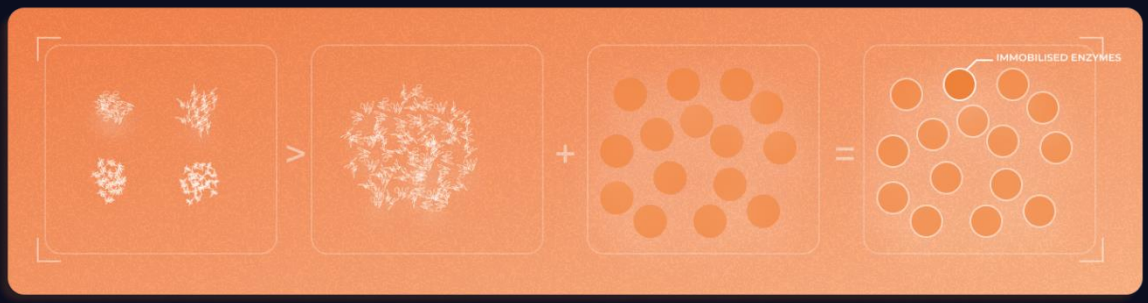
A tailored zymatic sand is developed and prepared according to a standard installation process. The zymatic sand can be applied in batch or flow systems. During flow conditions, the water flow is often designed from bottom-to-top. This creates great movement in the water and improves the contact time between the water and the zymatic sand.



The Zymatic treatment technology can be applied for different purposes and at various industrial process/stream environments. All ingoing cases are evaluated according to the standard installation process.

A Tailored Performance

The INDUSTRY™ system is using customer-specific versions of the zymatic sand. During a standard installation process, the performance of each part of the INDUSTRY™ system is optimised according to a customer requirement and agreement.



Enzyme selection

Based on your specific treatment goals, the enzymes are developed and selected based on the targeted organic compounds and other relevant process and water parameters.

Enzyme immobilization

Using suitable immobilization methods, the enzymes are bound to a sand-like material. The enzyme immobilization methods are strong and results in a prolonged enzyme activity.

Adapted zymatic sand

By combining the selected enzymes, enzyme immobilization methods and material, an adapted version of the zymatic sand is created. This result in a tailored and highly efficient treatment step.

The adapted zymatic sand provides a specific and tailored water treatment step. The enzyme immobilization technique is applied to fixate the enzymes to the sand-like material and makes it possible to reuse the enzymes over time for every new volume of water. This is needed to be able to use enzymes at continuous flow conditions. Successful enzyme immobilization often results in a prolonged life-length of the applied enzymes.

Key Aspects and Benefits

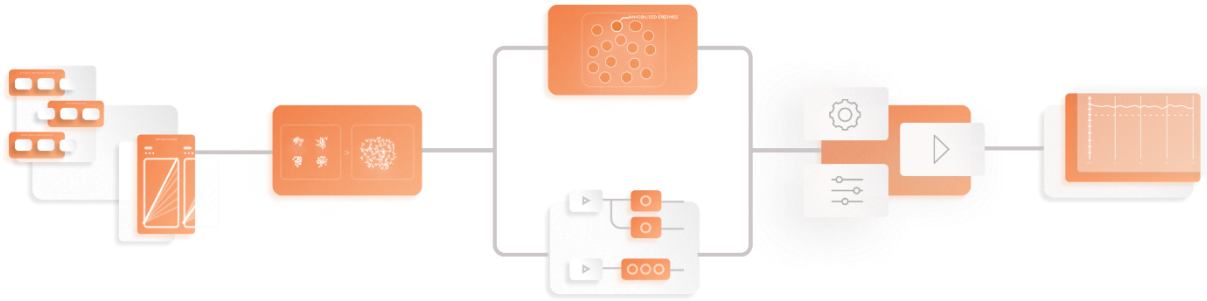
The INDUSTRY™ solution is offered to industrial customers according to a standard installation process (see figure at page 8). During a standard installation process, the zymatic sand is adapted for the removal of customer-specific contaminants from industrial process water streams.

Zymatic sand is an environmentally friendly water treatment technique. No additional chemicals are added to the water. Used zymatic sand are treated as normal sand from WWTPs.

KEY FEATURES	BENEFITS
Organic Micropollutant Removal	• Each system is developed for the specific industrial requirements • Customized systems enable high removal effect towards customer-specific organic contaminants • The contaminants are removed, degraded, deactivated, or transformed according to agreement • The removal effect is depending on the water quality and water residence time
Design and Construction	• Customized solutions are designed • Simple module design enables easy and fast installation • The module sizes are compact to take up minimal space • The modules are made of non-corrosive materials • The ZYMATIC sand is manufactured internally and thus significantly reduces lead times • The modules are easily emptied and refilled • Existing in-house modules can be applied
Cleaning and Maintenance	• A maintenance and service plan are included in the delivery • Water treatment using sand-like materials is considered easy to clean and operate
Environmental Impact	• The solution reduces the amount of organic pollutants released into nature and reaches water resources • The modules are relatively small and has little effect on the local site aesthetics • Used zymatic sand is treated as normal sand from WWTP
Verified Technology	• The zymatic technology and adaptability have been verified by EU Horizon 2020 project 804453

Standard Installation Process

The INDUSTRY™ standard installation process is performed in a project format where the adaption is guided through standardised milestones and deliveries.



TREATMENT PROFILING AND OFFERING

The first step of adapting the zymatic sand towards a certain need is to create and evaluate a treatment profile. A treatment profile maps the targeted treatment and normally includes targeted organic compounds, pH, temperatures, flow etc.

ENZYME SELECTION

Enzymes are selected based on the information gained from the treatment profile. The selected enzymes are evaluated experimentally to remove the target contaminants in both controlled and target process environments.

ZYMATIC SAND OPTIMISATION

The selected enzymes are immobilized to a silica-based material. Using various immobilization techniques, preparations of adapted zymatic sand are further optimised towards the process environment and performance requirement.

TREATMENT STEP DESIGN

The treatment step is designed and scaled to meet the performance parameters. The sand-like material allows for simple designs of column-, bed- or in-tank solutions.

INSTALLATION & PERFORMANCE TUNING

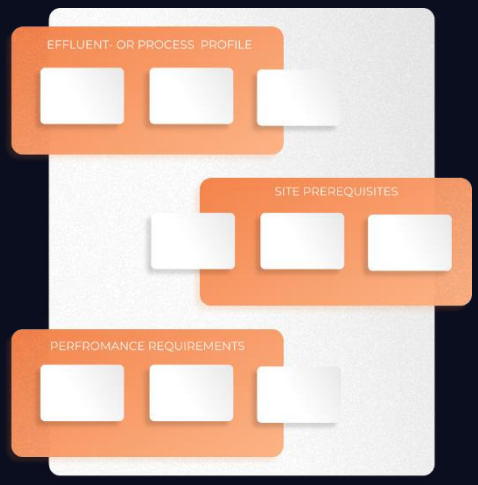
The treatment step is installed and tested at the industrial facility. The performance is fine-tuned to offer the best possible performance and cost levels.

HAND-OVER

The treatment step is fully handed over to the service organisation and operated according to the set maintenance plan. Performance and operations are monitored.

Treatment Profiling and Offering

The Zymatic team has expert knowledge of enzymes and their mechanisms. Based on a process/stream treatment profile, one or several enzymes are selected to obtain the treatment objectives. Enzymes can target organic compounds in various environments (even extreme ones). By combining the expertise of the Zymatic team and the Zymatic technology platform, the treatment step can be optimised in terms of both performance and cost.



WATER/PROCESS CONDITIONS

Relevant process water or water streams parameters are evaluated: Target compounds, concentrations, pH, temperature, flow etc.

FACILITY PREREQUISITE

Opportunities are identified based on the existing infrastructure: Size of installation, flow, recirculating or batch treatment.

PERFORMANCE REQUIREMENTS

Identifying all performance objectives to further adjust strategy in coming enzyme selection.

INITIAL FEASABILITY

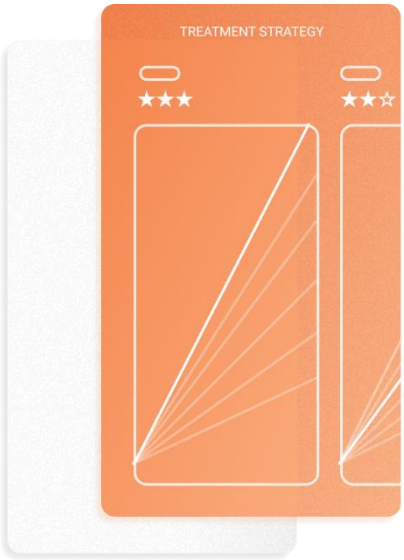
Free of charge, the Zymatic team performs an initial feasibility study based on the treatment profile.

TREATMENT STRATEGY

Based on the deep enzyme knowledge, the Zymatic team pre-selects enzymes and develop strategies to reach initial treatment objectives.

OFFERING

Based on the overall treatment profile and the validated enzyme strategy, a quotation for the adaption and installation process is created.



Enzyme Selection

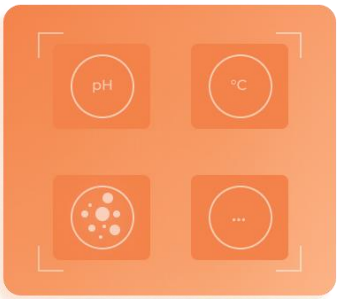
The Zymatic team has expert knowledge of enzymes and their mechanisms. Based on a process/stream treatment profile, one or several enzymes are selected to obtain the treatment objectives. Different types of enzymes can target different organic compounds. The water conditions can vary. Some enzymes are active at extreme or harsh environments.

FEASIBILITY STUDY

Potential enzyme candidates are investigated and reviewed. Based on the treatment profile and the performance objective is the zymatic team selecting the most efficient strategy to create an adapted zymatic sand.

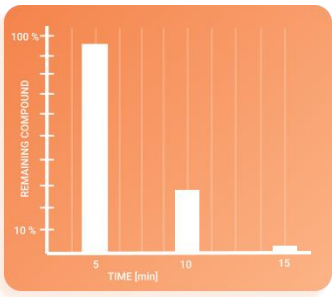
ENZYME OR ENZYME MIXTURE SELECTION

Dependent on the treatment profile and the performance objective, the Zymatic team selects one or several enzymes. It is possible to select both single enzymes and mixtures of enzymes. The number of enzymes selected depends on the complexity of the targeted treatment.



TESTING CONDITIONS

All enzymes and mixture of enzymes are tested in a controlled environment, and if necessary (or ordered by customers), at certain process conditions. The testing conditions are based on the customer-specific process condition parameters, such as compound concentrations, temperature, pH etc.

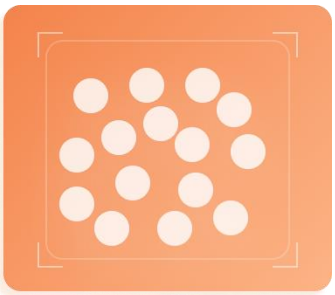


IDENTIFICATION OF ENZYME REMOVAL EFFECT

The removal effect of the selected enzymes or enzyme blends towards the customer-specific compounds are identified. This information will serve as the basis for the next steps in the adaption of the zymatic sand. Already at this stage, a rough estimate of the treatment step, its performance and design can be discussed.

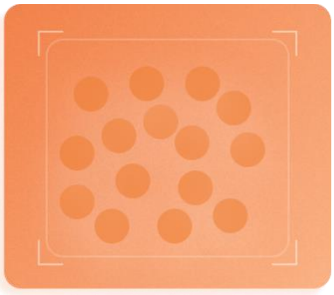
Zymatic Sand Adaption

While the enzyme selection focuses specifically to identify the enzyme removal effect against customer-specific organic compounds, the zymatic sand adaption step aims to determine the performance.



MATERIAL SELECTION

Based on the treatment profile and the selected enzymes, a suitable material is selected. The material physical parameters, such as particle size and surface chemistry, are important to obtain the treatment objectives.

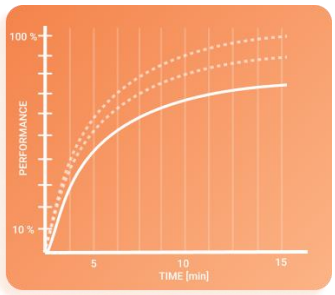


MATERIAL SURFACE MODIFICATION

Enzymes can be immobilized by different techniques and methods. The immobilization of enzymes to materials is depending on the chemistry between the material surface and the enzyme. Depending on the material and enzyme selection, the required material surface modifications are performed according to developed protocols.

ENZYME IMMOBILIZATION – THE ZYMATIC SAND CREATION

Depending on the material surface modification and the selected enzymes, an enzyme immobilization technique is applied to create the zymatic sand. The produced enzymatic sand is now considered to be adapted to customer process.

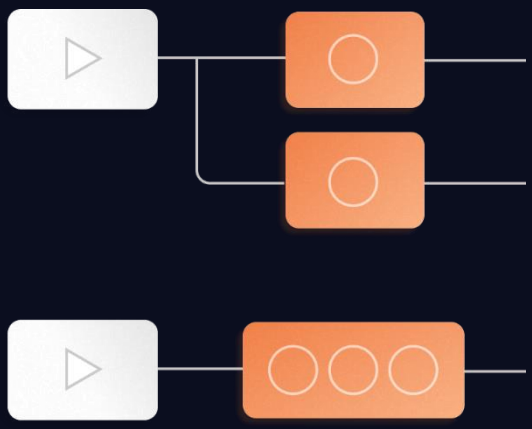


PERFORMANCE EVALUATION

The performance of the created zymatic sand is evaluated in an internal test pilot environment. The performance of the zymatic sand is tested in various setups and residence times to fine-tune the production protocols.

Treatment Step Design

The treatment step is designed in parallel with the zymatic sand adaption process. The initial designs should already have been discussed. The final treatment step is decided based on the conditions of the site and the determined performance of the zymatic sand.



REVIEW TREATMENT PROFILE

Relevant treatment profile parameters are reviewed to design the treatment step.

PLAN INSTALLATION

Dependent on customer needs, the system is either produced for full implementation directly on site or rolled out to test a by-flow of the targeted stream.

MANUFACTURE SYSTEM

The treatment step is manufactured according to design.

FLEXIBILE AND SIMPLE OPERATIONS

An example of a column design holding the zymatic sand is shown to the right. With simple internal adjustments, this design can hold between 20-100 L of zymatic sand. This column was made in stainless steel (other materials are also possible) and prepared with an upwards flow. A possibility for pre-treatment was added.

SCALABLE

Using a column-based system simplifies scalability. At any time, an additional column can be added in parallel or in series.

ACKNOWLEDGED CONTRACTORS

The system (to the right) was produced by acknowledged contractors and was a low-cost production.

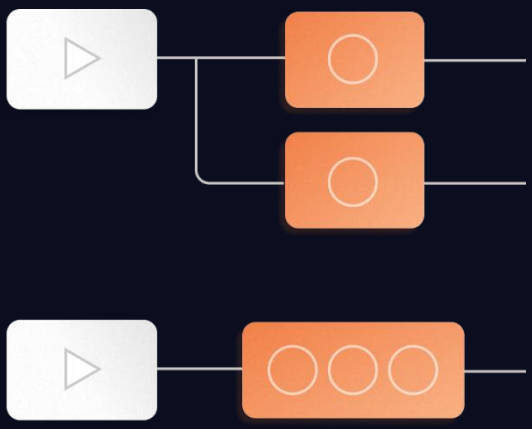
OFFERING

From the overall treatment profile and the validated enzyme strategy, Zymatic creates a quotation for the adaption and installation of the Zymatic treatment step.

Installation and Performance Tuning

The size of the INDUSTRY™ installation is scaled based on the water volume targeted for treatment (m^3/day), the existing treatment profile and the performance requirement. The effect of the treatment step depends on the residence time of the water and the specific performance of the adapted zymatic sand. The system is scaled based on the treatment profile, the performance of the adapted version of the zymatic sand and the water residence time.

To scale for increased performance, a longer residence time can be achieved by designing a treatment step facilitating a larger volume of the zymatic sand.



TREATMENT PROFILE

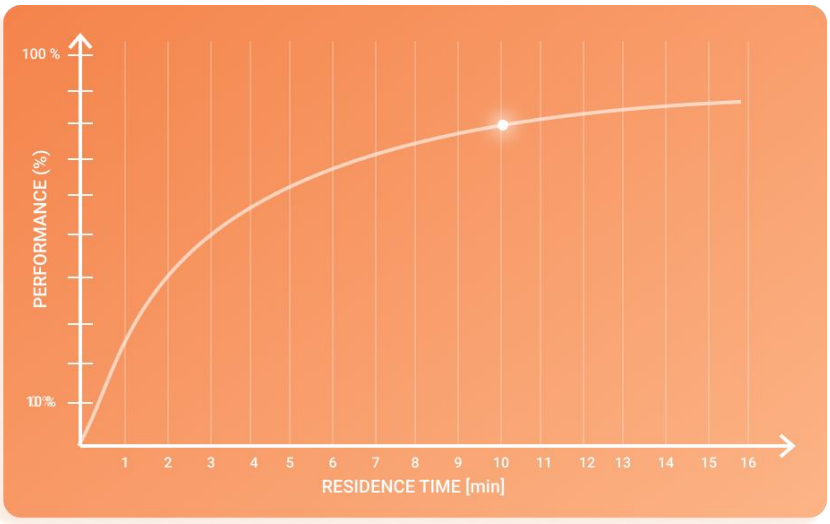
The installation process begins by mapping the customer-specific treatment needs. Based on the type of polluting compounds, enzymes are selected

PERFORMANCE

During the standard installation process, a customized treatment solution of high performance is developed.

INSTALLATION AND TUNING

The tailored solution is installed on site to allow for final adjustments before the official installation.



System performance scaling using residence time based on the effect of the standard version of the zymatic sand. (www.zymatic.com)

Warranty and Life Expectancy

The INDUSTRY™ modules are designed to fit the targeted process/stream. The columns, modules or other system designs that are subject to damage due to incorrect handling or vandalism are exchanged according to an established price range.

Both the treatment step and the zymatic sand are designed and prepared for long-term stability. The life expectancy of the zymatic sand is depending on the water quality. A normal exchange frequency for zymatic sand is after 1 month of use at process conditions, but it is depending on the quality of the targeted process/stream.

1-3 MONTHS

Exchange Frequency

Dependent on the water quality and other important parameters the zymatic sand will be replaced after some use.

STABLE EFFECT

High Durability

The simple system design offers high durability. The long life expectancy of a module is secured by regular quality controls.

LOW RISK

No New Risks

Adding the zymatic sand to an enclosed solution is considered as a low risk operation.

SAFE DESIGN

Safe Treatment

The treatment step is designed with safety in mind, bringing low risks to the local facility.

SIMPLE O&M

Safe & Easy

The O&M of the treatment step is simple and is carried out by the existing organisation.

The (en)zymatic sand

The combination of enzymes, material and enzyme immobilisation techniques have resulted in a highly flexible water treatment material, the zymatic sand. Using a sand-like material allows for easy scalability and flexibility in both design and application.

By applying different enzyme types, different chemical treatment mechanisms can be added directly to the surface of the material. This enables an adaptation of the treatment technology and chemical treatment mechanisms based on the customers' needs. In other words, with the help of the Zymatic platform technology, we can program the mechanisms of water treatment.

The Zymatic solutions provide water treatment solutions based on a mixture of different chemical reaction mechanisms. This feature offers advances over many older and conventional water treatment methods that have only one reaction mechanism. In addition, Zymatic solutions can be adapted or upgraded to future needs without adding installation changes.

Safety and Operations

The plug-and-play design of the INDUSTRY™ treatment steps does not add new Occupational Health and Safety (OH&S) risks, that is not already present on the site. The combination of a sand-like material and the simple construction design enables low-risk operations.

The solution includes a full-service maintenance agreement. Within this framework, Zymatic partner up with local service organizations with many years' knowledge of similar operations. All installations come with a detailed O&M manual and a risk assessment.

Key Dimensions of INDUSTRY™ Models

The INDUSTRY™ solution is presented with two standard columns. The columns enable each site to scale the treatment step for best possible performance at low cost. Any other treatment step design is decided following the standard installation process.

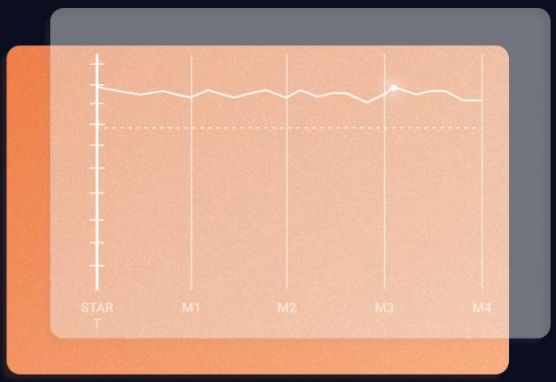
Model no.	Maximum inlet pipe diameter	Approximate product dimensions (external)		Average treatable flow rate*
	[mm]	Diameter [m]	Height [m]	[m^3/h]
ZI-100	200	0.400	0.800	0.18
ZI-1000	200	0.840	1.810	1.8

* Average flow rate is here based on 10 min residence time in a continuous flow design. A treatment step flow must be adjusted according to performance need.

Standard Zymatic Sand

The offered solutions normally use a standardised version of the material. The material is adaptable based on our customer needs.

Version name	Void volume [%]	Average granulate diameter [mm]	Material	Bulk density [kg/m^3]
Standard Zymatic Sand	~30	4.5	Silica-based	200-850



PERFORMANCE MONITORING

The treatment step is continuously monitored for the best possible performance. The performance of the zymatic sand is verified and tested before and after exchange.

WATER FLOW

Existing flow of water through the system is monitored and adjusted according to pre-set flow-specifications.

OTHER PARAMETERS

Parameters such as pH and temperature, or other controls, can be monitored.

Monitoring

The INDUSTRY ™ solution offers different types of system parameter monitoring. The treatment step design do normally not require advanced monitoring, which simplifies both operations and controls. The present system setup is delivered with flow, pH and temperature monitoring. When the zymatic sand is exchanged, performance tests are made before and after exchange to review real-time system parameters. Any additonal monitoring can be added.

Performance Monitoring

The performance of the INDUSTRY™ solution is regularly monitored via standardised protocols.

System Monitoring

The customer decides which types of monitoring devices that is required on their system.

Maintenance Monitoring

The INDUSTRY™ solution comes with a defined cleaning, service, and maintenance plan.

Service, Cleaning and Maintenance

All installations are accompanied with an established maintenance plan. The design of the INDUSTRY™ modules ensure easy and safe cleaning and maintenance.

Industry Standards and Commitment

Our commitment is to continuously improve and upgrade our products and services based on customer requirements, environmental requirements, and regulations. The platform technology is verified via several existing programs using third parties. All operations aim to comply with industry and international standards such as ISO 9001, ISO 14001, ISO 14034, ISO 45001 and ISO 17025. Performance testing and analysis are verified using accredited third parties.

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