» Material flow balances and a reduction of the production-integrated water and substance flows (wastewater mapping) are always required before developing a ZLD solution.

» Recirculation may be energetically advantageous when high temperature levels are to be maintained. ZLD usually leads to an increased energy consumption, but it can be energy-efficient if dissipation of the waste heat in the receiving water is not possible.

» For the conceptualization, an analysis of the energy balance is mandatory. How can a production-integrated approach be substantiated with concrete objectives and/or target values?

» Benchmarks are mostly economic parameters on the production side that compete with additional targets such as water demand (m³/kg product), residue volume (waste volume/kg product), maximum concentrations, energy demand (kWh/kg product).

» The additional targets which are frequently motivated by ecological/sustainability considerations, too, compete with each other.

» In industrial applications, defining a target is therefore complex, but necessary.

Process Requirements

» Educts, (intermediate) products and the use of chemicals (type, quantities and concentrations) should be optimized in the water management and the loads that are to be fed to a production-integrated water treatment and/or a ZLD unit, should be minimized.

» Future extensions of the production facilities or new product lines must be considered for the conceptualization.

» Production-integrated approaches and/or ZLD require a close coordination between the production and water treatment processes.

The following questions need to be answered:

» Which different quality requirements exist or can be accepted for the process/cooling water?

» Does the infrastructure in place allow for a supply of different qualities? Which constructional measures need to be taken into account?

» Is a discharge of treated waste waters after implementation of the water efficiency measures possible?

In this context, aspects like the following need to be taken into account: What will change with a view to the operation permits? What are the effects of lower volumes and higher concentrations? Does this lead to an inhibition of biological processes? Do individual waste water streams represent a problem, e.g. lacking carbon source for denitrification?

» Does this lead to the formation of recoverable partial streams? Is it possible to utilize waste streams with high organic loads, for example by methanation?

IMPRINT

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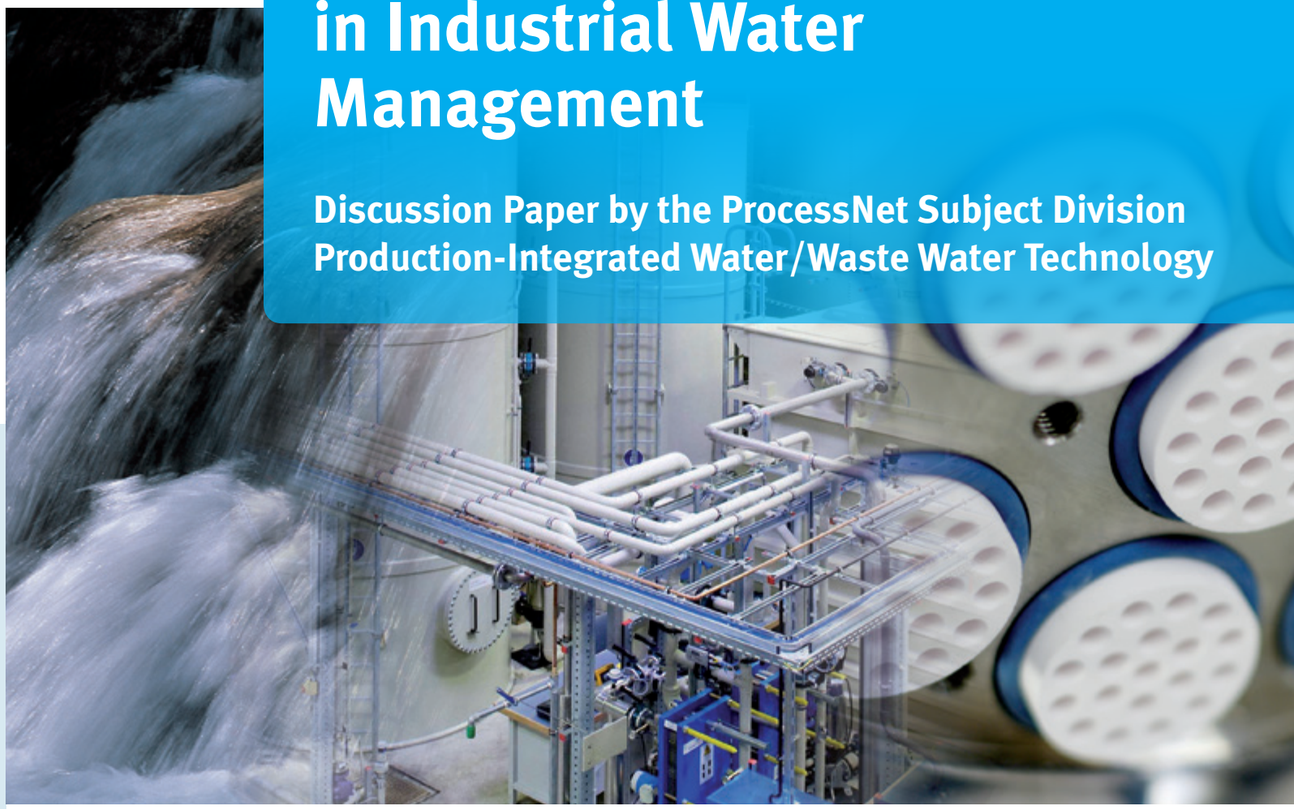
DECHEMA

VDI

Potential of Zero Liquid Discharge (ZLD) in Industrial Water Management

Discussion Paper by the ProcessNet Subject Division Production-Integrated Water/Waste Water Technology



PROCESSNET
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DME

1 MOTIVATION

In its position paper on “Trends and Perspectives in Industrial Water Treatment”, the ProcessNet Subject Division PIWA (Production-Integrated Water/Waste Water Technology) discusses different waste water treatment technologies in terms of their ability to play a role in future water availability requirements. Based on this paper actual topics are addressed and technologies in focus are to be assessed with regard to their viability and economic efficiency under present and future framework conditions.

In this paper, the ProcessNet Subject Division, upon coordination with the DGMT-DME Ausschuss Wasser Zukunft, AWZ (Committee Water Future), puts the potential of **Z**ero **L**iquid **D**ischarge (ZLD) into perspective.

2 INTRODUCTION

The treatment of industrial process fluids without draining or discharge of aqueous flows is currently widely discussed among international experts. In this context, the concept referred to as “ZLD” (Zero Liquid Discharge) takes the center stage as it is allegedly the most comprehensive, technologically most mature and ecologically most valuable waste water treatment solution.

However, there is no clear delimitation with regard to other processes that also re-use water. Moreover, it depends on a vast number of factors whether or not, in a specific case, ZLD represents the very best solution available.

3 ZLD DEFINITIONS

Strict Conditions

Complete reduction of the water volume. Water leaves the system only in the form of steam. Solids are recycled or separated in dry form.

Restricted Conditions

No waste water leaves the system, but sludge, brine, aerosols or water by leaching.

4 REALIZATION

Reasonable conditions

+	If the required infrastructure is not available, insufficient or unreliable (water supply, waste water treatment plant capacity)
+	If no receiving water body is available
+	To become independent from local conditions
+	If waste heat sources are available
+	If the waste water contains a high volume of recyclables or energy
+	In areas with a high level of water stress
+	+n case of administrative requirements
+	In case of ecological requirements
+	In case of a hazard for the ground water body due to seepage

Precondition: The waste stream management does not allow for a more resource-saving solution and production-integrated measures have been fully exhausted.

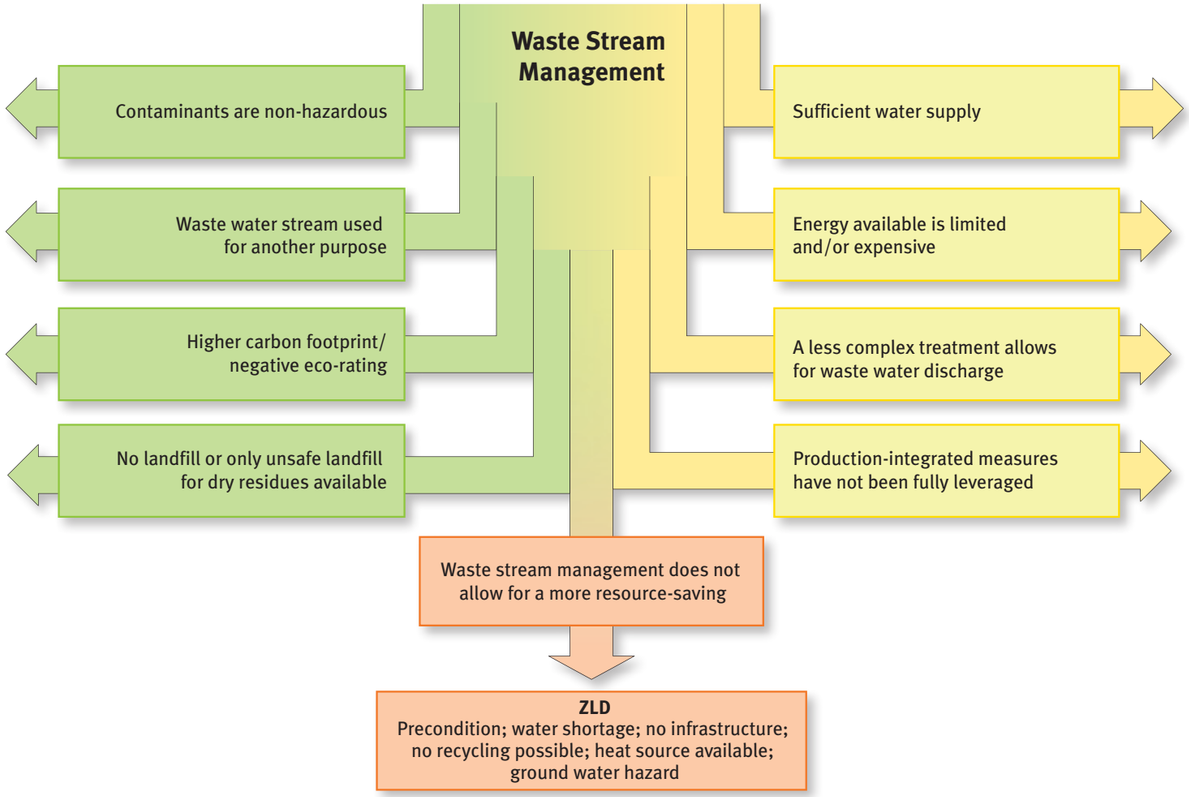
Unreasonable conditions

–	In case of sufficient water supply
–	If the energy sources available are limited and/or expensive
–	If a less complex treatment facilitates a discharge of the effluent
–	If production-integrated measures have not been fully leveraged
–	In case of unobjectionable contaminants (ubiquitous salts in small amounts)
–	If the waste water flow can be used elsewhere (e.g. to balance the pH, as H donor for denitrification)
–	If a high carbon footprint results in a negative eco-rating
–	If no landfill or only unsafe landfill for the dry residues from the ZLD technology is available
–	If the treated water cannot be used for ethical reasons

Note: Business reasons are highlighted in yellow, macro-economic and environmental reasons in green.

5 DECISION PATHS

The decision paths depicted in the diagram below illustrate that ZLD is only reasonable if a substantial number of conditions are met and the waste stream management options have been fully exhausted. For the decision paths, the above distinction between business reasons (yellow) and macro-economic and environmental reasons (green) will be continued.



6 CONSIDERATIONS FOR PRACTICE

Environment

The ecologic benefit, also in applications where only part of the water volume is reduced, is often relatively limited if the sole purpose is to reduce the water volume and if, as a consequence, waste streams that are difficult and expensive to separate are directed to inadequate disposal channels.

» In this case, the complete system must be analyzed and the value chains considered. Also the effects on indirect discharge must be examined and the handling of concentrates must be taken into account.

Economy

For the development of the concept, aspects like potential future cost increases in water supply and waste water disposal, residue disposal and/or the value added potential as well as the energy supply must be taken into account.

» The concept must duly consider the selection of relevant substance groups and interfering contaminants.

» Production-integrated water management approaches are more complex than ZLD, but offer a higher efficiency/savings potential.