Final results of the IMPEL Project
“Integrated Water Approach & Water Reuse”

Genève Farabegoli - *Italian National Institute for Environmental Protection and Research*

The IWA&WR Project

Water reuse management in the industry sector in EU (https://www.impel.eu/projects/integrated-water-approach/)

YEAR 1 (2017)

Guidelines on industrial water reuse management best practices in EU were developed:

Report 'Integrated Water Approach: Industrial Water Management guidelines – A guidance for IED permit writers'

YEAR 2 (2018)

Addendum & Report document on the use and best practice of treated wastewaters for irrigation

Addendum: Integrated Water Approach – A practical guide for IED permit writers – November 2018

Urban Water Reuse – Final report 2018

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YEAR 2018 - Working Group 1 (WG1)

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YEAR 2018 - Working Group 2 (WG2)

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YEAR 2018 - IWA&UWR Project meetings

WG1 in Malta in May 2018 meeting & site visit to a wastewater treatment and polishing plant

WG2 in Portugal in June 2018 meeting & site visit to Oil refinery in Porto and a Pulp & paper factory in Coimbra

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IWA&UWR WG1 Results

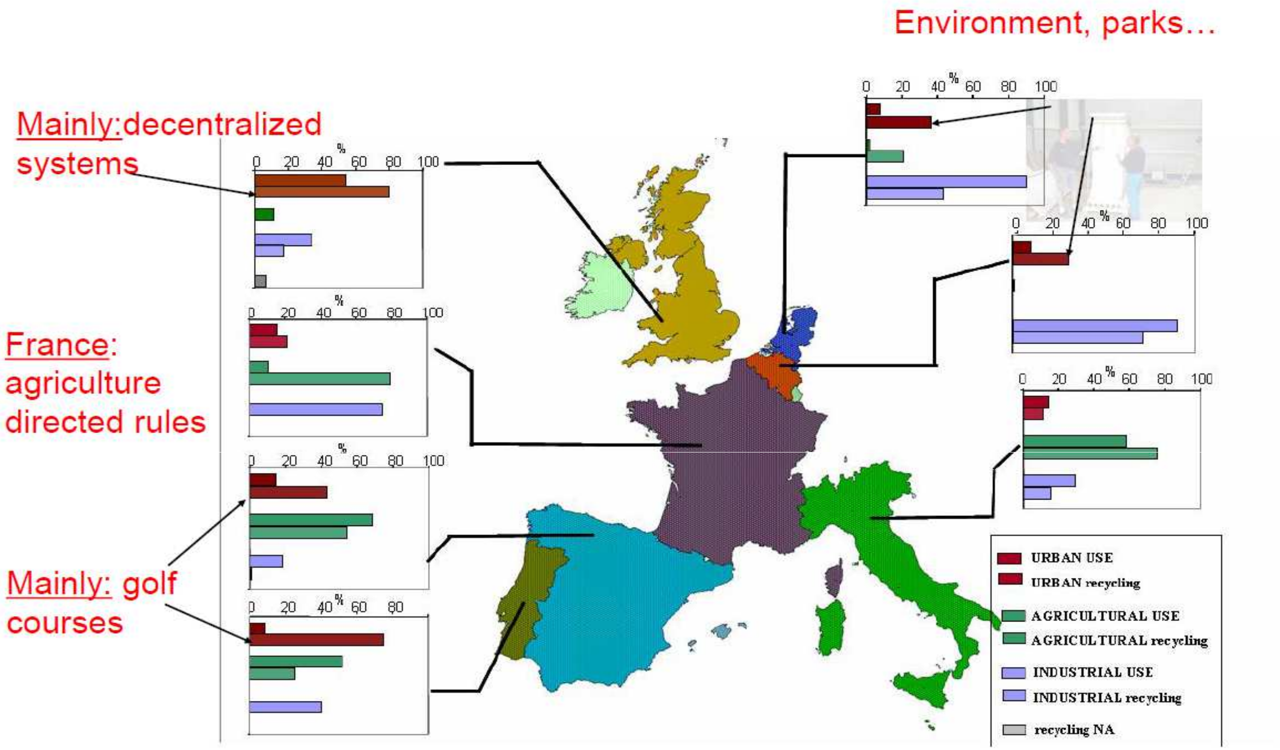
WG1 Subgroup: focus on the urban wastewaters reuse

Aim: exchange current best practices with respect to water reuse of treated urban wastewaters for agriculture irrigation purposes.

Current water reuse practice in Europe
Current technologies/BATs
Expected water reuse practice in Member States/barriers against water reuse

Current quality requirements for irrigation vs JRC (European Requirements)
Risk assessment (key issues for environment)
Monitoring
Benchmarking good practice
Final Remarks

Current water reuse practice in Europe



Reclaimed water is primarily used for agricultural and urban irrigation

In 2013 in Cyprus 89% of the treated wastewater was reused of which 75% for agricultural irrigation

Current Technologies/BATs

Water Reclamation Plant (WRP) is an additional process in the WWTP to remove **pathogens** and **chemical contaminants**

Water Reuse Safety Plans from the WRP to the point of use (storage and distribution systems)

Water Reuse Scheme and a **Decision Support System** (DSS)

Intensive technologies	Extensive technologies
Physical-chemical systems (coagulation-flocculation, sand filters)	Waste stabilisation ponds (maturation ponds, stabilisation reservoirs,...)
Membrane technologies (ultrafiltration, reverse osmosis, membrane bioreactor, ...)	Constructed wetlands (vertical-flow, horizontal-flow,..)
Rotating biological contactors	Infiltration-percolation systems
Disinfection technologies (ultraviolet radiation, chlorine dioxide, ozone, peracetic acid, ...)	

- ✓ Processes that consume **less energy and/or enhance energy recovery**
- ✓ Efficient and reliable **antibiotics and micro-contaminants removal technologies**
- ✓ Very Stable inlet quality from WWTP to WRP

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Barriers against water reuse in EU

- ✓ Inconsistent or inadequate **water reuse regulations/guidelines**
- ✓ Inconsistent and unreliable methods for identifying and optimizing appropriate **wastewater treatment technologies for reuse applications**
- ✓ **Low price of freshwater** compared to reused water
- ✓ **Distance** between wastewater treatment plants and water use sites
- ✓ Difficulties in specifying and selecting **effective monitoring techniques and technologies** for the whole system
- ✓ Significant challenges in reliably **assessing the environmental and public health risk/benefit** of water reuse across a range of geographical scales
- ✓ Inadequate or **complex permitting process** that needs to ensure safety for public and environment, from the producing to the distribution and application of reclaimed water
- ✓ **Low levels of public and government enthusiasm** for water reuse
- ✓ **Limited institutional capacity** to formulate and institutionalize recycling and reuse measures
- ✓ **Lack of financial incentives** for reuse schemes

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Current quality requirements for irrigation vs JRC (European Requirements)

Comparison between:

- ✓ water reuse standards of individual Member States
- ✓ standards proposed in the JRC report
- ✓ requirements for irrigation water quality to address microbial risk for fresh produce proposed by the EU Commission

Parameters	Cyprus	France	Greece	Italy	Portugal	Spain	EU Com. (2017)*	JRC Report (2017)
E. coli (cfu/100 mL) *E. coli* (logs)	$5\text{-}10^3$ -	$250\text{-}10^5$ -	5 – 200 -	10 -	- -	$0 - 10^4$ -	$100 - 10^4$ -	$10 - 10^4$ >5
Fecal coliforms (cfu/100 mL)	-	-	-	-	$100 - 10^4$	-	-	-
Enterococci (logs)	-	≥2 - ≥4	-	-	-	-	-	-
Anaerobic sulf. red. spores (logs)	-	≥2 - ≥4	-	-	-	-	-	-
Clostridium perf. spores (logs)	-	-	-	-	-	-	-	>5
Bacteriophages (logs)	-	≥2 - ≥4	-	-	-	-	-	-
F-spec. coliphages (logs)	-	-	-	-	-	-	-	>6
TSS (mg/L)	10 – 30	15	2 – 35	10	60	5 – 35	-	10 – 35
Turbidity (NTU)	-	-	2 – no limit	-	-	1 – 15	-	5
BOD_5 (mg/L)	10 – 70	-	10 – 25	20	-	-	-	10 – 25
COD (mg/L)	70	60	-	100	-	-	-	-
Total nitrogen (mg/L)	15	-	30	15	-	10	-	-

Note: *'*Guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene' (EU Commission, 2017)*

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Risk Management Framework

A flexible Risk Management Framework should be a systematic tool to develop a management and safety plan achieve the fit-for-purpose solution combined with safety for both human and environmental health.

Four requirements:

1. **Responsible use of reclaimed water**: engagement of authorities with expertise in water supply, wastewater management and protection of public health (contamination pathways scenarios of direct/indirect contact)
2. **Regulatory and formal requirements**: Identification of all relevant regulations, guidelines, and local requirements
3. **Partnerships and engagement of stakeholders**: Identification of all authorities with responsibilities and all stakeholders influencing water reuse activities
4. **Reclaimed water policy**: Development of a reclaimed water policy, permits and specific contracts with end users

Monitoring Programs

- ✓ At least two types of monitoring programs: operational monitoring and compliance or verification monitoring.
- ✓ Operational monitoring protocol should be applied to the whole water reuse system to detect variations in performance.
- ✓ The compliance or verification monitoring are specifically linked with the need of protection of human health and environment.
- ✓ These programs are usually defined by national authorities and ideally included in the permits applied to the water reuse projects.
- ✓ A validation monitoring program is previewed in the new European Regulation proposal for projects that requires a high level of quality. This program aims to guarantee that the treatment performance meets all its design requirements.

Benchmarking Good Practice

The assessment of the current practices in the member states does not allow to promote a benchmarking.

- ✓ Some countries, as Malta and Cyprus, promoted a fit-for-all solution and others, such as Portugal or Turkey, promote different solutions according the intended uses.
- ✓ No current project seems to be developed by a risk assessment and a cost-benefit analysis.
- ✓ Nevertheless the existence of good practices already in place in several countries, the simple adoption of it by other countries may not represent the best option.

Final Remarks

- ✓ Focus on the BAT leads to the promotion of fit-for-all solutions that may not be economically feasible
- ✓ Fit-for-all solution: applicable for similar basins with parallel characteristics and when a single major end-use is present

- ✓ Fit-for-purpose solution: when several end-uses with different quality requirements co-exist

- ✓ Suitable technological solutions with additional risk minimization measures will allow the development of a feasible and reliable water reuse project, to produce safe water at a lower price meeting the circular economy principles

IWA&UWR WG2 Results

WG2 Subgroup: focus on the industrial reuse of wastewaters

Development of a check-list to help permit writers for wastewater discharges, that allows to verify the needs of going beyond Best Available Technologies (BAT) to not put at risk the receiving water bodies status.

Case study: Pulp mill for the production of bleached kraft located near a river bank

Context: water body status less than good, in 2017 a severe drought decreased significantly the water flow in the river and the effects of the treated wastewater discharges negatively affected the receiving water body quality.

Case study description

The pulp mill is an **IED installation** and the respective environmental permit had attached a wastewater discharge permit with Emission Limit Values (ELV) supported exclusively on the BAT reference documents, namely on the emission levels associated with the use of BAT (BAT-AEL).

Wastewater treatment plant: a conventional biological treatment without additional nutrients removal.

Parameter	ELV
pH	6-9
TSS	1,05 kg/ADt
COD	14,5 kg/ADt
BOD_5	2,5 kg/ADt
TN	0,175 kg/ADt
TP	0,02 kg/ADt

The compliance of these values was accessed as *yearly average*, according the respective BREF.

ADt - Air Dry tonnes (of pulp) expressed as 90 % dryness.

Application of Check-List

A. Wastewater discharge assessment:	
1. Is the water status of the receiving water body less than good?	Yes
2. Define which are the critical parameters for water body status achievement	Dissolved oxygen
3. Do the wastewaters of the installation contribute to the enrichment of the content of this (these) critical parameter(s)?	Yes
4. Was (were) defined a BAT–associated emission levels (BAT-AEL) for this (these) parameters on the respective BREF document?	Yes
4.a Is(are) this(these) value(s) sufficient to contribute for the achievement of the good status?	No
6. Can an appropriate Emission Limit Value(s) (ELV) adjusted to the local conditions be defined, according the need of achievement/maintaining the water good status?	Yes
7. Is the appropriate ELV, adjusted to the local conditions, achievable and/or affordable?	Yes
7.b Is a mixing zone advisable?	Yes
7.a Can a mixing zone be applied ?	Yes
8. Was a monitoring program, upstream and downstream (outside the exterior limit of the mixing zone, when applicable) defined? (This program will allow to see that the discharge is not contributing to the deterioration of the quality of the water body).	Yes

Application of Check-List

B. Freshwater consumption assessment:	
12. Regarding the freshwater consumption, is its abstraction contributing for endanger of ecological flows (surface water) or the quantitative status (groundwater)?	Yes (surface water)
12.a Define additional measures are needed to reduce water consumption	Several measures, including internal reuse of specific wastewater streams, are already in place to reduce water consumption per ton of dry pulp produced
5. Is the reducing of the water consumption and/or promotion of water reuse an obstacle for the ELV (or BAT-AEL) compliance?	Yes (Return to question 6)

Result:
Deliver wastewater discharge permit and assess water body quality evolution through the monitoring results.

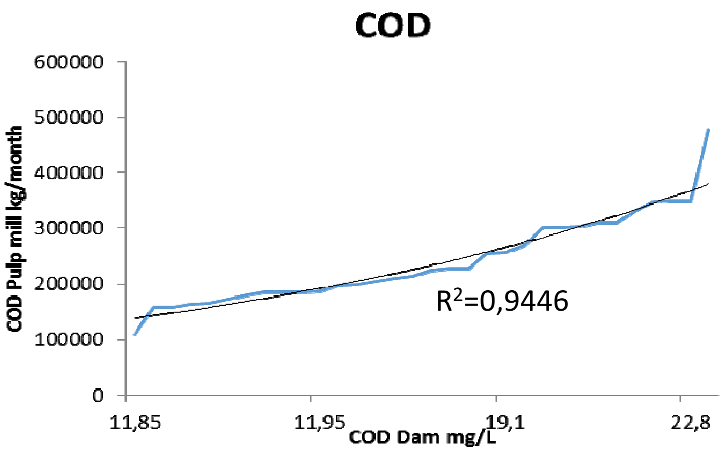
Application of the check-list → need of the definition of adjusted ELV.
A **new permit** was delivered with appropriate ELV.
WWTP upgraded from a conventional biological treatment to a membrane bioreactor (MBR) system with ultra-filtration.

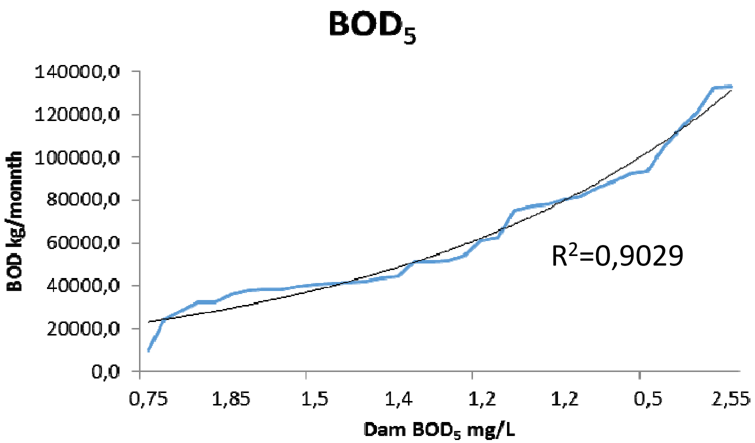
Methodology

Time period evaluated: from 2012 to 2017

Data: Self-monitoring data from the installation + data from the water body (monitoring plan at the dam)

Model: Non-linear regression model. For the parameters COD, BOD_5, Nt and Pt a strong correlation (correlation coefficient, R superior to 0,70) was found, when data from discharges and from the water body was ordered by its magnitude





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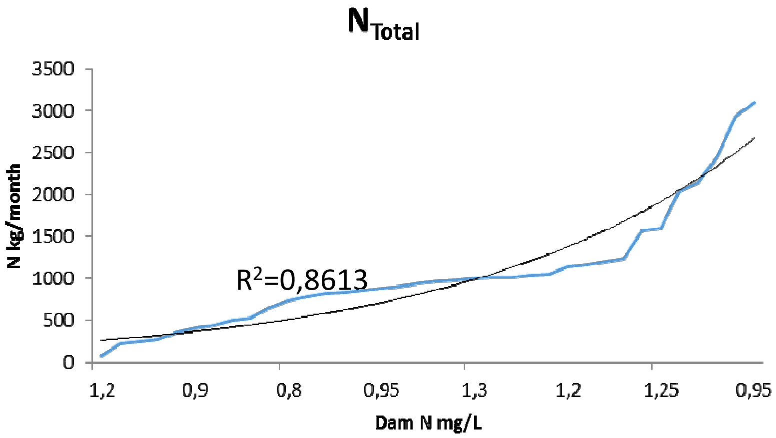
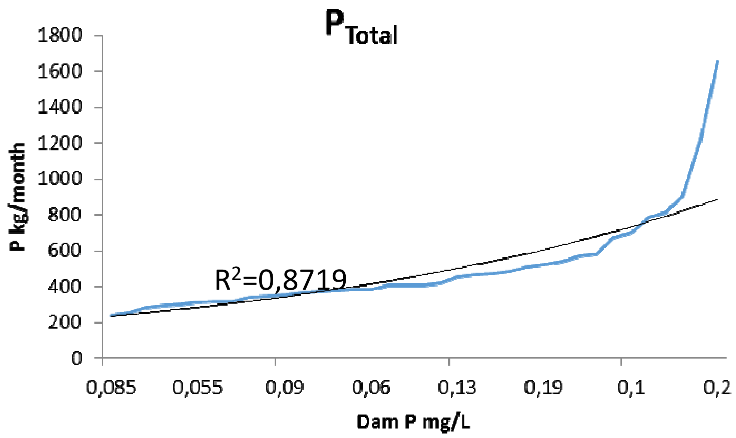
Methodology





Final ELV were derived by the direct use of the mathematical expression of the respective regression model and refined according results from a surface water quality modelling exercise using the **model QUAL2.**

New appropriate ELV

TYPES OF ELV AND COMPLIANCE RULES – CASE STUDY: PULP MILL

3 levels of ELV were defined:

- Wet season (from 1st of October to 30th of April)
- Dry season (from 1st of May to 30th of September)
- Unusual conditions (e.g., severe droughts, low level of dissolved oxygen in the surface water…)

For each period, 3 ELV with specific goals were also defined:

Type of ELV	Goal	Compliance Rule
Punctual concentrations in mg L^{-1}	Protection against acute effects over the water body (e.g. quick depletion of oxygen)	No grab sample can exceed this ELV
Daily mass loads in kg/d	Protection against chronic effects (increasing of nutrients in water body)	In 52 composite samples/year is allowed a maximum of five above this ELV, but not in samples collected during the same season
Yearly averages in kg/ADt	Compliance of BAT-AEL	Yearly average cannot exceed this ELV

Final Remarks

Conclusions: This case study allows to validate the importance of definition of discharge permits that are simultaneously WFD and IED proof.

Wastewater streams intra and inter installation should be properly assessed to find matching uses that not compromise the quality of the discharged waters. This could present an **opportunity to a better closure of the loop of the water use.**

A comprehensive understand how water use can be integrated and managed inside and outside industries, taking into account several descriptors, such as reduction of water consumption, energy balance, CO2 emissions, quality of discharged treated wastewaters and quality and status of the present water bodies, i.e., surface and ground waters, will support a **better transition to the circular economy**.