# Task1: NWRM Case-Study Factsheet

## Status box

**Version**: 1.4 **Date**: 15/04/14
**Authors:** Maggie Kossida (IACO) + Contributors

**Background**:
The Case-Study Factsheets will be filled in with information collated on applications of "particular interest". The CS Factsheets will be an output product able to reflect on a coherent storyline and are mostly targeting, although not being limited to, design practitioners. They are linked of course to the DB via specific queries that extract the information and present it as illustrated in the hereunder document. They contain descriptive info of the specific application (that can of course showcase the implementation of an individual NWRM or o a bundle of them), technical info on the main design parameters and monitoring requirements (to allow the practitioner identify similarities and/or discrepancies as compared to his "candidate" site/environment), quantifiable indicators (especially with regards to the biophysical impacts and economic information, along with possible performance metrics) to help them grasp the range of benefits and costs and the overall performance/effectiveness, lessons learned to highlight the main risks, other outcomes, enabling factors and preconditions.
In the current draft the following elements have been considered:
- Analysis of the design practitioners' user needs
- Feedback on the NWRM DB (WG PoM, DG ENV, EEA, NWRM Consortium)
- Existing factsheets of similar purpose/target

**Main contributions**: (*name of the contributor / commenter*)
- Nick Jarrit (AMEC)
- Martyn Futter (SLU)
- Verena Mattheiss, Pierre Strosser (ACTEON)
- Benoit Fribourg-Blanc, Sonia Siauve (OIEau)
- Alistair McVittie (SRUC)
- Gonzalo Delacamara (IMDEA)
- George Karavokiros, Ayis Iacovides (IACO)

# NWRM Case-Study Factsheet

## 1. Photo Gallery

Pleas provide below 2-3 photos form the case study. Explanatory legend and source are mandatory.


Figure 1: WWTP with RB Kastelir (source: Limnos)

Figure 2: RB (front) with one of the five beds of constructed wetland (back) in Kastelir

## 2. Basic information

<table>
<tr><td>Application ID<br>*(Country_Numeric, e.g.: Greece_01)*</td><td colspan="4">*Croatia*</td></tr>
<tr><td>Application Name<br>*(provide a short name)*</td><td colspan="4">**Sludge Drying Reed Beds in Kastelir**</td></tr>
<tr><td rowspan="5">Application Location</td><td>Country:<br>*(select from list in Annex 1)*</td><td>Croatia</td><td>Country 2:<br>*In case of transboundary applications*</td><td></td></tr>
<tr><td colspan="2">NUTS2 Code *(select from list in Annex 1)*</td><td colspan="2"></td></tr>
<tr><td colspan="2">River Basin District Code *(select from list in Annex 1)*</td><td colspan="2">*MIRNA*</td></tr>
<tr><td colspan="2">WFD Water Body Code *(select from list in Annex 1)*</td><td colspan="2">*For the moment we have only the WFD GWsB in the Annex 1, since the SWBs is a huge list. You can leave out this matching for the moment, just provide the correct coordinates below and we can do all matchings afterwards.*</td></tr>
<tr><td colspan="2">Description<br>*(free text, short description of the location)*</td><td colspan="2">*The WWTP Kastelir is situated in municipality of Kastelir-Labinci, which lies in the karst area of the Istrian peninsula in Croatia.* Area of 34 km$^2$ consists of 15 settlements *and has 1.483 inhabitants (2011). The village Kastelir c is located at an altitude of 220 m.*</td></tr>
<tr><td>Application Site Coordinates<br>*(in ETRS89 or WGS84 the coordinate system)*</td><td colspan="2">Latitude:<br>*- ETRS89 or WGS84? Specify:*<br>13.673172</td><td colspan="2">Longitude:<br>*- ETRS89 or WGS84? Specify:*<br>45.291856</td></tr>
<tr><td rowspan="2">Target Sector(s)<br>*Possibility to select more than 1 sectors (primary vs. secondary)*</td><td>Primary:</td><td colspan="3">Urban</td></tr>
<tr><td>Secondary:</td><td colspan="3">Agriculture</td></tr>
<tr><td rowspan="4">Implemented NWRM(s)<br>*Possibility to select more than 1 NWRM. Link to NWRM catalogue and NWRM Factsheets, Select from list in Annex 1.*</td><td>Measure #1:</td><td colspan="3">Sludge drying reed beds</td></tr>
<tr><td>Measure #2:</td><td colspan="3"></td></tr>
<tr><td>Measure #3:</td><td colspan="3"></td></tr>
<tr><td>Measure #4:</td><td colspan="3"></td></tr>
<tr><td>Application short description</td><td colspan="4">Sludge drying reed beds (RBs) enable sewage sludge dewatering, stabilization, mineralization and hygenization. They are an alternative to mechanical treatment (e.g. belt presses, centrifuges) and enable long-term storage. In the process, sludge is spread on a filter media (substrate) of an open bed after which drainage and evaporation takes place. Planted RBs enable effective dewatering of sewage sludge and produce a mineralized</td></tr>
</table>

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| | product that can be used as a soil amendment in agriculture and other uses. |

## 3. Policy Context and Design Targets

<table>
<tr><td>Brief description of the problem to be tackled</td><td colspan="3">Briefly describe the problem that needs to be tackled in this application<br>With the construction and expansion of municipal infrastructure (sewage and wastewater treatment plants), the amount of sludge produced by the wastewater treatment plants is increasing. Sewage sludge is the main waste by-product of wastewater treatment. The excess sludge presents biomass and microorganisms that contain organic matter, nutrients, and persistent pollutants that originate from wastewater. The project addresses a need to link access to resources from sewage sludge with minimal financial costs and environmental impact.<br><br>RBs were constructed as a cost-effective solution to solve problems of sludge treatment, storage, and disposal in the Municipality of Kastelir-Labinci. Constructed wetland (CW) for wastewater treatment with a capacity of 1.900 P.E. was completed in 2015. Until the sludge drying reed bed was constructed in 2016, the generated sludge was transported to the central WWTP for further treatment and final disposal. Because this was an only temporary solution, they were looking for the alternative, which could solve the problem locally and for many years. Limited disposal options were the key drivers of change in technology.</td></tr>
<tr><td rowspan="5">What were the primary & secondary targets when designing this application?<br>Select from the drop-down menu. The possibility for more than one target is provided. Additional info can be given in the “remark” field to address e.g. other targets not included in the list, and give some details</td><td>Primary target #1:</td><td colspan="2">Choose an item.</td></tr>
<tr><td>Primary target #2:</td><td colspan="2">Choose an item.</td></tr>
<tr><td>Secondary target #1:</td><td colspan="2">Choose an item.</td></tr>
<tr><td>Secondary target #2:</td><td colspan="2">Choose an item.</td></tr>
<tr><td>Remarks</td><td colspan="2">sludge dewatering, stabilization, mineralization and hygenization</td></tr>
<tr><td rowspan="5">Which specific types of pressures did you aim at mitigating?<br>Select the relevant Directive (EU, non-EU) from the drop-down menu and type-in the related pressures. Different types of pressures as identified by EU-Directives (WFD, FD, etc.) are listed in the Annex 2</td><td>Pressure #1:</td><td>WFD identified pressure</td><td>wastewater and sludge</td></tr>
<tr><td>Pressure #2:</td><td>Choose an item.</td><td>Type in the relevant pressure from the EU-Directives’ lists in Annex 2</td></tr>
<tr><td>Pressure #3:</td><td>Choose an item.</td><td>Type in the relevant pressure from the Directives’ lists in Annex 2</td></tr>
<tr><td>Pressure #4:</td><td>Choose an item.</td><td>Type in the relevant pressure from the Directives’ lists in Annex 2</td></tr>
<tr><td>Remarks</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Which specific types of adverse impacts did you aim at mitigating?<br>Select the relevant Directive (EU, non-EU) from the drop-down menu and type-in the related impacts. Different types of adverse impacts as identified by EU-Directives (WFD, FD, etc.) are listed in the Annex 2</td><td>Impact #1:</td><td>WFD identified impact</td><td>chemical and physico-chemical quality elements</td></tr>
<tr><td>Impact #2:</td><td>Choose an item.</td><td>Type in the relevant impact from the Directives’ lists in Annex 2</td></tr>
<tr><td>Impact #3:</td><td>Choose an item.</td><td>Type in the relevant impact from the Directives’ lists in Annex 2</td></tr>
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| | Impact #4: | Choose an item. | *Type in the relevant impact from the Directives' lists in Annex 2* |
| | Remarks | | |
| Which EU requirements and EU Directives were aimed at being addressed?<br>*Select from the drop-down menu the different types of requirements as identified by EU-Directives (WFD, FD, etc.), and provide additional specification.* | Requirement #1: | WFD-mitigation of significant pressure | Sludge from WWTP |
| | Requirement #2: | Choose an item. | *Specify* |
| | Requirement #3: | Choose an item. | *Specify* |
| | Requirement #4: | Choose an item. | *Specify* |
| | Remarks | | |
| Which national and/or regional policy challenges and/or requirements aimed to be addressed? | ▪ Sludge drying reed beds as NBS for cost-efficient sludge treatment;<br>▪ Biosolids use in agriculture and other uses (requires cross-sectoral collaboration on the regional level and environmental and economic assessment of feasible options);<br>▪ Sludge treatment and disposition agenda building with all relevant stakeholders (authorities and engaged sectors). | | |

## 4. Site Characteristics

| | | |
|---|---|---|
| Dominant Land Use type(s)<br>*Select from the drop-down menu with the CORINE LU types and codes. Space of additional comments/remarks is provided* | Dominant land use | *3.1.1.* |
| | Secondary land use | *2.4.2.* |
| | Other important land use | *2.4.3., 2.2.1.* |
| | Based on data from Corine Land Cover data, 65 % of the total area falls under agricultural land. The most intensively cultivated arable land is in the Mirna River valley area. Given that the Municipality is located on fertile land, favorable for the economy, and due to its favorable climate, it boasts numerous olive growers, winemakers, beekeepers, lavender and vegetable producers, fruits and flowers growers. | |
| Climate zone<br>*Select from the drop-down menu* | warm temperate dry | |
| Soil type<br>*Select from the list with the FAO classes in Annex 3* | The greater part of the Municipality of Kastelir-Labinci is formed by dolomites and limestones. The most widespread soil in Istria and in the Municipality is terra rossa on a carbonate base. | |
| Average Slope<br>*Select from the drop-down menu* | nearly level (0-1%) | |
| Mean Annual Rainfall<br>*Select from the drop-down menu. Values are in mm,* | 0 - 300 mm | |
| Mean Annual Runoff<br>*Select from the drop-down menu. Values are in mm.* | Choose an item. | |
| Average Runoff coefficient (or % imperviousness on site)<br>*Select from the drop-down menu. Space of additional comments/remarks is provided* | Choose an item. | Choose an item. |
| | | |
| Characterization of water quality status (prior to the implementation of the NWRMs) | | |

<table>
<tr><td>Please link to the WFD water quality parameters (nutrients N,P; organic pollution; chemical pollution, Cu, Zn; saline pollution; TSS; acidification, elevated temperatures; E.coli, Fecal coliforms, etc.)</td><td></td></tr>
<tr><td rowspan="2">Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way</td><td>Positive way: The efficiency of the system is influenced by climate, which affects the rate of sludge drying.</td></tr>
<tr><td>Negative way: Dry summers can negatively affect the plant growth.</td></tr>
</table>

## 5. Design & Implementation Parameters

<table>
<tr><td>Project scale<br>Select from the drop-down menu the relevant scale and specify.</td><td>Medium (eg. public park, new development district)</td><td>WWTP Kastelir with sludge drying reed beds (1.900 PE)</td></tr>
<tr><td rowspan="2">Time frame<br>NWRM(s) Installation date and lifespan</td><td>Date of installation/construction (MM.YYYY)</td><td>2016</td></tr>
<tr><td>Expected average lifespan (life expectancy) of the application in years</td><td>At least 30 years</td></tr>
<tr><td rowspan="6">Responsible authority and other stakeholders involved<br>List of all + Descriptive Text of roles, responsibilities, etc.</td><td>Name of responsible authority/ stakeholder</td><td>Role, responsibilities</td></tr>
<tr><td>1. Croatian Waters</td><td>Project initiator / project implementation</td></tr>
<tr><td>2. Global Environment Facility</td><td>Provision of funds / donor</td></tr>
<tr><td>4. Municipality of Kastelir-Labinci</td><td>WWTP Owner</td></tr>
<tr><td>5. Public utility</td><td>WWTP Operator</td></tr>
<tr><td></td><td></td></tr>
<tr><td>The application was initiated and financed by</td><td colspan="2">Global Environment Facility and Croatian Waters</td></tr>
<tr><td>What were specific principles that were followed in the design of this application?<br>Examples provided: water-sensitivity, aesthetic benefit, functionality, usability, adaptability, integrative planning, integration of demands, acceptable costs, impact on public perception & acceptability, etc.</td><td colspan="2">Treatment efficiency, long-term biosolids accumulation and storage, potential of biosolids reuse, acceptable operational costs, functionality, usability, aesthetic benefit, impact on public perception & acceptability</td></tr>
<tr><td rowspan="2">Area (ha)</td><td>Number of hectares treated by the NWRM(s).<br>e.g. It could be the upstream drainage area in case of retention ponds</td><td></td></tr>
<tr><td>Text to specify<br>(caution to differentiate between treated or target area vs. the application area occupied by the NWRM). In some cases treated area may not have a meaning (e.g. green walls). In other cases you may have a measure applied in an upstream forest but with the purpose of mitigate an impact in a downstream area</td><td></td></tr>
<tr><td>Design capacity<br>Briefly describe the design capacity(ies) of the implemented NWRM(s), e.g. maximum volume of runoff water that</td><td colspan="2">1.900 PE</td></tr>
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| *can be retained per time step, maximum pollutant removal capacity in mg/l, etc.* | | | |
| Reference to existing engineering standards, guidelines and manuals that have been used during the design phase<br>*References: active links to specific documents or website(s), and if not available online, provided them on the collaborate platform in the library section and URL here* | | *Reference* | *URL* |
| | 1. | | |
| | 2. | | |
| | 3. | | |
| | 4. | | |
| | 5. | | |
| Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?<br>*List and describe specific factors that either guided or constrained the selection and the design (e.g. land use constraints, cooperation issues with land owners, specific legislation, existing funding for specific priorities, private investments, legal obligations - EU requirements, etc.)* | The biggest limitation in the application of reed beds technology is space availability; the technology is land-intensive,. As there was enough space on the property owned by the Municipality, the technology was applied without additional problems (land acquisition or time-consuming administrative processes). | | |

## 6. Biophysical Impacts

| **Impact category** (short name)<br><br>Select from the **drop-down menu** below: | **Impact description** (Text, approx. 200 words) | **Impact quantification** (specifying units) | |
|---|---|---|---|
| | | Parameter value; units<br><br>*and/or* | % change in parameter value as compared to the state prior to the implementation of the NWRM(s) |
| Runoff attenuation / control | / | | |
| Peak flow rate reduction | / | | |
| Impact on groundwater | *The system has no direct impact on groundwater, because the bed is sealed with waterproof membrane.* | | |
| Impact on soil moisture and soil storage capacity | *The system can generate soil amendment (biosolids). It can improve soil characteristics to which biosolids are applied.* | | |
| Restoring hydraulic connection | / | | |
| Water quality Improvements | *In terms of positive affect of WWTP application.* | | |
| WFD Ecological Status and objectives | *In terms of positive affect of WWTP application.* | | |
| Reducing flood risks (Floods Directive) | / | | |
| Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.) | *Both NBS solutions, constructed wetland for wastewater treatment and reed bed for sludge treatment, are built as green space and support habitat/wildlife and reduce emissions.* | | |
| Soil Quality Improvements | *Natural dewatered sludge from RB, can be a source of beneficial nutrients (nitrogen, phosphorous, potassium) and thus used in agriculture in compliance with valid conditions, standards, regulations, and legislation.* | *System produces around 469 tons of biosolids per operating cycle.* | |

## 7. Socio-Economic Information

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| What are the benefits and co-benefits of NWRMs in this application?<br>*Refer to the direct and ancillary benefits (including societal impacts). These are positive outcomes (or welfare gains) closely related to the implementation of the measure, through causal relationship.*<br>*What are the direct benefits of the effective implementation of the measure? Please specify the kind of direct benefits of the effective implementation of the measure.*<br>*What are the additional indirect benefits of the effective implementation of the measure?* | The technology enables long-term and sustainable storage of sludge with low operating and maintenance costs. It can completely replace dehydration which currently represents significant cost on existing wastewater treatment plants or transport of sludge to central WWTP.<br><br>With this technology different types of sewage sludge can be treated. The sludge is stored in the reed beds normally between 8 to 10 years. Due to parallel operation of physical (drying) and biological processes (mineralization) the treatment results in significant (above 90%) sludge volume reduction. |

<table>
<tr><td></td><td colspan="3">The end result of the process is a compost-like soil that can be reused as fertilizer in agriculture, cover layer for landfills or construction material. It can also be used for revitalization of quarries or other degraded areas, sanitation of erosion, on green areas or parks, etc.</td></tr>
<tr><td rowspan="6">Financial costs<br>Value in € (Total + possible breakdown)<br>Suggested categories for the breakdown of costs: capital, land acquisition and value, operational, maintenance</td><td>Total:</td><td></td><td>investment</td></tr>
<tr><td>Capital:</td><td>262.626 €</td><td>Construction</td></tr>
<tr><td>Land acquisition and value:</td><td>0 €</td><td>Land owned by the Municipality.</td></tr>
<tr><td rowspan="2">Operational and Maintenance:</td><td rowspan="2">3.984 EUR/year</td><td></td></tr>
<tr><td>Labor costs<br>Electricity consumption costs<br>Monitoring costs<br>Maintenance costs of mechanical equipment<br>Replacement costs and repairs<br>Sludge disposal – biosolids reuse</td></tr>
<tr><td>Other:</td><td>0 €</td><td></td></tr>
<tr><td rowspan="4">Were financial compensations required? What amount?<br>Describe if financial compensations were required, the compensation scheme (including units, beneficiaries, etc.), the total amount of money paid in €</td><td colspan="3">Was financial compensation required: Yes /No<br>No, it was 100 % grant capital cost.</td></tr>
<tr><td colspan="3">Total amount of money paid (in €): /</td></tr>
<tr><td colspan="3">Compensation schema: /</td></tr>
<tr><td colspan="3">Comments / Remarks: /</td></tr>
<tr><td rowspan="4">Economic costs<br>What is the actual income loss (in some economic sectors) due to the implementation of the measure? Please specify the kind of income loss.<br>What are the additional costs that stem from the implementation of the measure and a result of it? Please specify the kind of additional costs.<br>Are there any specific costs the measure brought about which cannot be assimilated to the above-mentioned categories? Please specify the kind of other opportunity costs.</td><td colspan="3">Actual income loss: /</td></tr>
<tr><td colspan="3">Additional costs:/</td></tr>
<tr><td colspan="3">Other opportunity costs: biosolids selling (not yet initiated)</td></tr>
<tr><td colspan="3">Comments / Remarks: There is no economic cost.</td></tr>
<tr><td>Which link can be made to the ecosystem services approach?<br>Hint: The actual benefits of improving nature's water storage capacity are essentially linked to an improved provision of some of the following ecosystem goods and services:<br>- Freshwater for drinking.<br>- Water provision to deliver water services to the economy both for drinking and non-drinking purposes.<br>- Water security (reliability of supply and resilience to drought).<br>- Health security (control of waterborne diseases).<br>- Flood security and protection.<br>- Storm surge protection.<br>- Biomass production.<br>- Amenities (associated to habitat protection): fish and plants, tourism, recreation, and others.<br>- Benefits of improved coastal water quality and ecological status for a sustainable commercial production of shellfish with human health and welfare values.</td><td colspan="3">- Protection of water resources<br>- Health security (control of waterborne diseases).<br>- Biomass production<br>- Nutrient circulation<br>- Soil formation<br>- Erosion control<br>- Gases regulation<br>- Shelter</td></tr>
</table>

## 8. Monitoring & Maintenance requirements

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| Monitoring requirements<br>*Describe monitoring requirements: which parameters, how often, how many monitoring sites, location of these sites, etc.* | Management of sewage sludge in Croatia is defined by a Rulebook on the management of sludge from wastewater treatment plants when sludge is used in agriculture (Official Gazette of Croatia, No. 38/08).<br><br>It is recommended to analyze sludge once per year.<br><br>For biosolids reuse sludge must comply with national regulations:<br>• Limit values for heavy metal in sludge;<br>• Limit values for soil to which sludge is applied;<br>• Limit values for organic compounds in sludge;<br>• Limit values for pathogens;<br>• Maximum annual load of dry matter in agriculture.<br><br>Sludge analyses include: heavy metals, organic compounds, dry matter, pathogens.<br><br>Soil analysis include: heavy metals (cadmium, copper, nickel, lead, zinc, mercury and chromium). |
| Maintenance requirements<br>*Describe the maintenance scheme: requirements and intensity of, frequency of, responsible authorities, share or tasks, etc.* | Regular maintenance works of RBs consists of:<br>• weekly check of plants;<br>• weekly check if the sludge is drying out;<br>• monthly control of the water level in the filter layer;<br>• monthly check of external parts of drainage pipes and manholes;<br>• cleaning od pipes and manholes as needed;<br>• Service of the pumps as needed. |
| What are the administrative costs?<br>*These are expenses linked to information, monitoring and enforcement.*<br>*What were/are the costs of monitoring the operation of the measure(s) or any other cost incurred by the administration of the measure(s)? Please specify on what the money has/is been spent.* | |

## 9. Performance metrics and Assessment criteria

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| Which assessment methods and practices are used for assessing the biophysical impacts?<br>*Please describe e.g.: comparison to, paired watershed, pre vs. post, etc.* | |
| Which methods are used to assess costs, benefits and cost-effectiveness of measures? | "Unit value transfer method" for assessing direct and indirect benefits of RBs in Kastelir had been used. |
| How cost-effective are NWRM's compared to "traditional / structural" measures? | In this case, alternative to reed bed was pumping and transport of sludge to central WWTP, which didn't want to take sludge from small WWTP Kastelir. Mechanical dewatering as more traditional measure would still not solve the problem of final sludge disposal. The quest for a sustainable solution was imminent.<br><br>The analysis showed that sludge pumping and transport to the central WWTP would be a cheaper option compared to investment costs in sludge drying reed bed. However, operational costs of RBs are in the same range as sludge transport to the central WWTP. |
| How do (if applicable) specific basin characteristics influence the effectiveness of measures?<br>*This field is important and needs a good deal of thought. It seems that the success of NWRM may be very dependent on the biophysical regime in which they are implemented. It would be really helpful for any potential practitioner to have enough information to evaluate whether or not the biophysical preconditions for successful NWRM implementation exist before addressing the much more complex socioeconomic challenges.* | Basin characteristics does not influence the effectiveness of measures. |
| What is the standard time delay for measuring the effects of the measures?<br>*NWRM are multi-purpose and multi benefit measures but like other green infrastructures and on the contrary to grey infrastructure, their effects are not always immediately visible and need a certain time lapse to be fully operational and effective (free text allowed to enter the anticipated delay and the effective deviation from this finally found)* | Efficiency can begin to be measured after the first growing season of plants. |

## 10. Main risks, implications, enabling factors and preconditions

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| What were the main implementation barriers?<br>*Were there delays in the implementation? Please describe the main implementation barriers (e.g. attitude of decision makers, stakeholders, public perception -e.g. NWRM perceived as part pf a problem, existing technical standards, physical constraints, conflicts of interests, legal restrictions, lack of expert knowledge and/or tools, limited financial resources and financing potential, wide dissemination of the project, etc.)* | • RB in Kastelir is the first-ever constructed RB for the treatment of sludge from the Imhoff tank of the constructed wetland (CW) in the Balkan Mediterranean Region. The engineers faced capacity challenges related to technical specifications.<br>• Kastelir is a tourist village characterized by seasonal load. This required special attention focusing on the effect on the RB operation. |

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| What were the main enabling and success factors?<br>*Please describe the main enabling and success factors (e.g. positive attitude of decision makers, willing stakeholders, positive public perception, solid governance and adequate institutional structures, fruitful public consultation, regulatory support, existing expert knowledge and/or tools, availability of financial resources and financing potential, etc.)* | Kastelir was one of the areas to be addressed among the priority pollution hotspot sites, as identified by UNEP-MAP in 2003 and then confirmed by the World Bank study in 2011. Project addressed untreated wastewater discharges, which could seriously affect tourism (industry contributes 28% of GDP in the region), the pillar of the local economy.[1] Thus, investing decisions (initial investment) was made top-down with the initiative from the Ministry, which was looking at whole picture. The project was fully funded through grant agreement by the GEF.<br><br>RB in Kastelir is the first-ever constructed NBS for sludge treatment in Croatia and was very well accepted among all involved stakeholders. Since then, three more RBs were constructed (Čakovec, Mrkopalj, Ravna Gora) and up to ten are in the plan to be built in the next years. In Croatia, RBs are not anymore perceived as novel technology but as an alternative to mechanical dewatering. |
| Financing<br>*What were the main funding sources, and what amount? Where different incentives and financial instruments used? Which ones? Has private investments been encouraged – how?* | Global Environment Facility – 100 % grant |
| Flexibility & Adaptability<br>*Is the current implementation flexible and adaptable to changing baseline conditions? What does the adaptation of these measures requires? What costs could be foreseen?* | *This solution is adjusted depending on the load and the location of the WWTP and still long-term.* |
| Transferability<br>*When and where can a similar application be proposed, assessed and selected? What are the necessary preconditions?* | Reed beds are land intensive technology. Limiting factors usually are RBs land requirements, spatial planning and its administrative risks, land cost and legislation.<br><br>Generally, technology is more likely to be adopted and implemented by smaller settlements and cities where the price of land is low or land is already owned by state or municipality.<br><br>Along the Mediterranean coastline, RBs implementation is limited by the availability and high prices of land. Nevertheless, this case showed that RBs can be implemented in inland regions of coastline where land is cheaper or owned by the Municipality; |

[1] https://www.thegef.org/project/adriatic-sea-environmental-pollution-control-project-i

## 11. Lessons learned

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| Key lessons | • RBs next to the constructed wetland for wastewater treatment can prolong the lifetime of the whole WWTP. They prevent clogging of the constructed wetland due to poor maintenance (irregular sludge pumping from the sedimentation tank);<br>• Implementation can be planned in a series of phases, according to need. In Kastelir, three reed beds were designed, but so far only one was constructed.<br>• RB technology can be transferred and adapted to different climate conditions. RB Kastelir is adapted to the Mediterranean climate;<br>• RBs work well under seasonal variations and are thus appropriate solution for touristic areas;<br>• WWTP Kastelir is an example of integrated wastewater management: (reuse of wastewater and sludge);<br>• A well-prepared project contributed to the widespread acceptance of technology in Croatia. Nowadays RBs are commonly included in WWTP projects;<br>• Emphasized RBs advantages (ease of operation, low maintenance costs and long-term sludge storage) can win the support of key decision-makers;<br>• Biosolids use or final disposal will require coordination on multiple levels of government and cross-sectoral collaboration. |

## 12. References

Note: To enter more references and key people please add rows as necessary

| | |
|---|---|
| Source Type<br>*Select from the drop-down menu* | *Project Report* |
| Source Author(s)<br>*Provide the Name of the author(s)* | Limnos Ltd.:<br>Alenka Mubi Zalaznik<br>Anja Potokar<br>Urša Brodnik<br>Tea Erjavec<br>Gregor Plestenjak<br>Martin Vrhovšek<br>Alenka Fajs<br>Aberon Ltd (Chapter 4):<br>Ivan Kolev<br>Cveta Dimitrova<br>Aarhus University:<br>Carlos A. Arias (Review)<br>Pedro Carvalho (Micropollutants) |

| | | | |
|---|---|---|---|
| Source Title<br>*Provide the Tile of the reference* | TREATMENT OF WASTEWATER SLUDGE OR MANURE FROM LIVESTOCK (TSM) IN A MEDITERRANEAN ENVIRONMENT | | |
| Year of publication<br>*Provide the year in the format (YYYY)* | May 2020 | | |
| Editor/Publisher<br>*e.g. Journal/Volume/Issue* | The Joint Research Centre | | |
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| Key People<br>*List names, affiliation and contact details of key people who have communicated important information presented in this factsheet* | | *Name / affiliation* | *Contact details* |
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| Source Type<br>*Select from the drop-down menu* | *Interview* | | |
| Source Author(s)<br>*Provide the Name of the author(s)* | *Limnos Ltd.*<br>*Anja Potokar*<br>*Martin Vrhovešk* | | |
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| Year of publication<br>*Provide the year in the format (YYYY)* | | | |
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