Case Study

NBS for pig manure treatment in San Rocco di Piegara

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I. Basic Information

Application ID				
Application Name	**Nature-based solutions for climate change adaptation and water pollution in agricultural regions. Lot 2: TSM in a continental environment**			
Application Location	Country:	Italy	Country 2:	
	NUTS2 Code			
	River Basin District Code			
	WFD Water Body Code			
	Description		The project is located in San Rocco di Piegara, in the hearth of the Lessinia region (Veneto Region)	
Application Site Coordinates *(in ETRS89 or WGS84 the coordinate system)*	Latitude:		Longitude:	
Target Sector(s)	Primary:	Pig breeding farm		
	Secondary:			
Implemented NWRM(s)	Measure #1:	FBA constructed wetland		
	Measure #2:			
	Measure #3:			
	Measure #4:			
Application short description	Until 2013, the farm was equipped with a conventional technological solution for the treatment of the liquid fraction of pig manure, an activated sludge followed by a membrane stage, designed to discharge to surface waters according to Italian law. During the renewal of the authorisation to discharge the regional Environmental Authority (ARPAV) requested to change the authorisation terms, requiring more stringent water quality standards to discharge on soil. After a successful pilot test and thanks to local funding (Rural Development plan, PSR as per the Italian terminology), the farm owner decided to install a "Nature Based" treatment system which, thanks to lower operational and maintenance costs, was expected to make the re-opening of the farm financially sustainable. Due to limited available space, the chosen solution was a "hybrid" solution (NB and technological): an aerated constructed wetland (CW) plus a reverse osmosis (RO) final polishing stage. The new system was sized to treat the liquid fraction of the manure produced by half of the farm capability, i.e. 3000 pigs, maintaining the possibility of an upgrade to 6000 pigs just installing a new treatment stage, while the RO and the primary treatment (a centrifuge for solid/liquid separation) was designed for the full capacity of the farm, i.e. 6000 pigs.			

II. Policy context and design targets

Brief description of the problem to be tackled	Treatment of the liquid fraction of the manure produced by 3000 pigs, maintaining the possibility of an upgrade to 6000 pigs, to respect the strict Italian water quality standards to discharge on soil		
What were the primary & secondary targets when designing this application?	Primary target #1:	Treat pig manure to reduce the pollutant load and allow the discharge on ground	
	Secondary target #1:	Reduce water pollution	
	Secondary target #2:	Reduce OPEX costs	
	Remarks		
Which specific types of pressures did you aim at mitigating?	Pressure #1:	Water pollution from pig manure	Nitrogen/Phosphorous
	Pressure #2:	High OPEX costs of the previous MBR system	
	Remarks		
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	Water pollution from pig manure	Nitrogen/Phosphorous
	Impact #2:	High OPEX costs of the previous MBR system	
	Impact #3:		
	Impact #4:		
	Remarks		
Which EU requirements and EU Directives were aimed at being addressed?	Requirement #1:		
	Requirement #2:		
	Requirement #3:		
	Remarks		

Which national and/or regional policy challenges and/or requirements aimed to be addressed?	The regional Environmental Authority (ARPAV) requested to change the authorisation to discharge on soil terms, requiring more stringent water quality standards

III. Site characteristics

Dominant Land Use type(s)	Dominant land use	Agricultural use
	Secondary land use	Tourism
	Other important land use	
	Remarks	
Climate zone	temperate sub-continental	
Soil type		
Average Slope		
Mean Annual Rainfall	600 - 1100 mm	
Mean Annual Runoff		
Average Runoff coefficient (or % imperviousness on site)		
	Remarks	
Characterization of water quality status (prior to the implementation of the NWRMs)	There is no detailed information available about the water quality status prior to the implementation of the NWRM.	
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way:*	
	Negative way:	

IV. Design & implementation parameters

Project scale	Full-scale	*Small scale project involving a farm, for a total surface of 0.224 hectares.*
Time frame	Date of installation/construction	Design year: 2016 Start-up year: 2017
	Expected average lifespan (life expectancy) of the application in years	The lifespan of the NBS is expected to be in the range of decades (around 30 years)
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1. SASA srl	Intensive pig breeding company where the NBS is operating
	2. Municipality of Roverè Veronese	Municipality representing the local community
	3. Local farmers and Veneto Farmers Association	Beneficiary in terms of the environmental effects generated Potential interest in the use of same technologies

The application was initiated and financed by	The NBS was financed by the Sasa Snc company thanks to local funding (Rural Development plan, PSR as per the Italian terminology). In 2013 the company was closed for two years, due to too high OPEX for swine wastewater treatment using MBR technological solution, Therefore, the choice for NBS technology was driven by financial reasons.	
What were specific principles that were followed in the design of this application?	Achieving suine wastewater purification to discharge on soil, and to lower operational and maintenance costs. The full-scale CW WWTP was designed with a high level of flexibility in terms of possible functioning to enhance the denitrification.	
Area (ha)	Effective area of the NBS:	0.045 ha (the CW WWTP is composed of 5 beds, each one of 448 m^2)
Design capacity	up to 38 $m^3 d^{-1}$	
Reference to existing engineering standards, guidelines and manuals that have been used during the design phase	*Reference*	*URL*
	1. Masi et al. (2017)	https://doi.org/10.2166/wst.2017.180
	2.	
	3.	
	4.	
	5.	
Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?	The design of the NWRMs was chosen in order to meet the necessities of decreasing the load of nitrogen and phosphorous to be discharged on soil. Due to limited available space, the chosen solution was a "hybrid" solution: an aerated constructed wetland (CW) plus a reverse osmosis (RO) final polishing stage.	

V. Biophysical impacts

Impact category (short name) Select from the **drop-down menu** below: ⇩	**Impact description** (Text, approx. 200 words)	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Water quality Improvements	The aerated constructed wetlands and remove nutrients and contaminants thanks to physical (adsorption and sedimentation) and several biological processes. The CW WWTP showed high mass removal efficiencies on average.	TSS (%) COD (%) N-NH_4^+ (%) TKN (%) TN (%) TP (%)	87 88 90 87 73 80

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	The environmental benefits of NWRMs are: the improved water quality (removal of pollutants from agricultural source); the simple management and consequent low O&M costs; the environmental benefits (climate change mitigation, lower energy consumption). The social benefits are represented by: better performance with nuisance, visual impact, and noise mitigation.		
Financial costs		*Soil discharge scenario*	*Surface water discharge scenario*
	Total:		
	Capital:	€ 2,715,200	€ 2,554,200
	Land acquisition and value:		
	Operational:	€/year 88,700	€/year 87,100
	Maintenance:		
	Other: Discounted Costs (T= 20 y; i= 5%)	€ 3,111,398	€ 3,639,659
Were financial	*Yes*		

compensations required? What amount?	*Total amount of money paid (in €):*	
	Compensation schema:[2]	
	Comments / Remarks:	
Economic costs	*Actual income loss:*	
	Additional costs:	
	Other opportunity costs:	
	Comments / Remarks:	
Which link can be made to the ecosystem services approach?	An estimation of the monetization of the ecosystem services have been made with value transfer method for the NWRMs within the two investigated basins obtaining a value ranging from 1,572,485 €/y to 2,741,362 €/y.	

VII. Monitoring & maintenance requirements

Monitoring requirements	The material flow analysis is based on **monitored data** gathered during two sampling campaigns, one at the start-up of the WWTP (from 10 October 2017 to 8 February 2018 - Rizzo et al., 2018) and a second after 1 year of functioning (from January 2019 to January 2020)
Maintenance requirements	N/A
What are the administrative costs?	N/A

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	The material flow analysis is based on monitored data and is also complemented by literature data in terms of effluent wastewater quantity estimation, which will be assessed on the basis of both methods for evapotranspiration proposed by literature (Kadlec and Wallace, 2009) and flow meter available at RO treatment. Literature data are also used to test the proper functioning of NBS in terms of oxygen transfer rate (Nivala et al., 2013).
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	Costs: Reverse engineering Benefits and Cost-effectiveness: Value transfer method
How cost-effective are NWRM's compared to "traditional / structural" measures?	N/A
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	N/A
What is the standard time delay for measuring the effects of the measures?	N/A

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	Lack of space, therefore “intensification” with appropriate technologies (aeration, stripping) was implemented.

What were the main enabling and success factors?	The choice for NBS technology was driven by financial reasons. A non-repayable loan provided by the Regional Rural Development Plan covered more than 40% of the investment costs, however the company would have faced the risk of the full investment costs, to be able to reopen the Piegara pig farm.
Financing	40% of the investment costs were provided by the Regional Rural Development Plan, the company paid the remaining costs.
Flexibility & Adaptability	N/A
Transferability	A pig farm may only be interested in setting up a treatment system when fields to spread the pig manure are not available nearby: in this case the high cost of transporting manure over a long distance makes the solid/liquid separation and the construction of a treatment plant for the liquid fraction interesting for the company. NBS would highly benefit from a public financial support, at least for the first 10-15 years, until they get an established position in the market.

X. Lessons learned

Key lessons	The NBS shows to be effective in removing the most important pollutants of a pig farm, and, among possible treatment systems, NBS solutions appear convenient, compared to technological solutions with comparable removal effectiveness such as Membrane Bio Reactors (MBR), both in terms of construction (CAPEX) and maintenance and operation (OPEX) costs. Considering the environmental side benefits of the NBS, only large passive wetlands would provide interesting effects in terms of ecosystem services. It also must be considered that a legislative framework aimed at promoting the circular economy should somehow encourage treatment solutions that allow the production of fertilizers.

XI. References

Source Type	*Project Report*		
Source Author(s)	*IRIDRA srl*		
Source Title	Nature-based solutions for climate change adaptation and water pollution in agricultural regions. Lot 2: TSM in a continental environment - Feasibility Study		
Year of publication	2021		
Editor/Publisher	Joint Research Centre - JRC		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.	*Fabio Masi*	*masi@iridra.com*

Source Type	*Journal article*		
Source Author(s)	Masi, F., Rizzo, A., Martinuzzi, N., Wallace, S.D., Van Oirschot, D., Salazzari, P., Meers, E. and Bresciani, R.		
Source Title	*Up-flow anaerobic sludge blanket and aerated constructed wetlands for swine wastewater treatment: a pilot study.*		
Year of publication	2017		
Editor/Publisher	Water Science and Technology		
Source Weblink	https://doi.org/10.2166/wst.2017.180		
Key People		*Name / affiliation*	*Contact details*
	1.	*Fabio Masi*	*masi@iridra.com*

Source Type	*Conference proceedings papers*		
Source Author(s)	Rizzo A., Masi F., Dion Van Oirschot, Scott D. Wallace, Bresciani R.		
Source Title	Aerated constructed wetlands for swine wastewater treatment: experiences from the start-up of a full scale system in Italy		
Year of publication	2018		
Editor/Publisher	16th IWA International Conference on Wetland Systems for Water Pollution Control, ICWS 2018		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.	*Anacleto Rizzo*	*rizzo@iridra.com*

Source Type	*Book*		
Source Author(s)	Kadlec, R.H. and Wallace, S.		
Source Title	Treatment wetlands		
Year of publication	2009		
Editor/Publisher	CRC press		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.		

Source Type	*Journal article*
Source Author(s)	Nivala, J., Wallace, S., Headley, T., Kassa, K., Brix, H., van Afferden, M. and Müller, R.
Source Title	Oxygen transfer and consumption in subsurface flow treatment wetlands.

Year of publication	2013		
Editor/Publisher	Ecological Engineering		
Source Weblink	https://doi.org/10.1016/j.ecoleng.2012.08.028		
Key People		*Name / affiliation*	*Contact details*
	1.	*Jaime Nivala*	*jaime.nivala@gmail.com*