Low impact remediation: A case study in southern Italy

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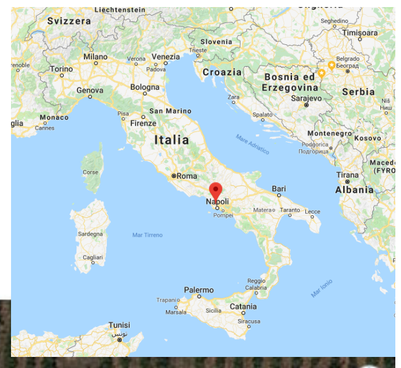
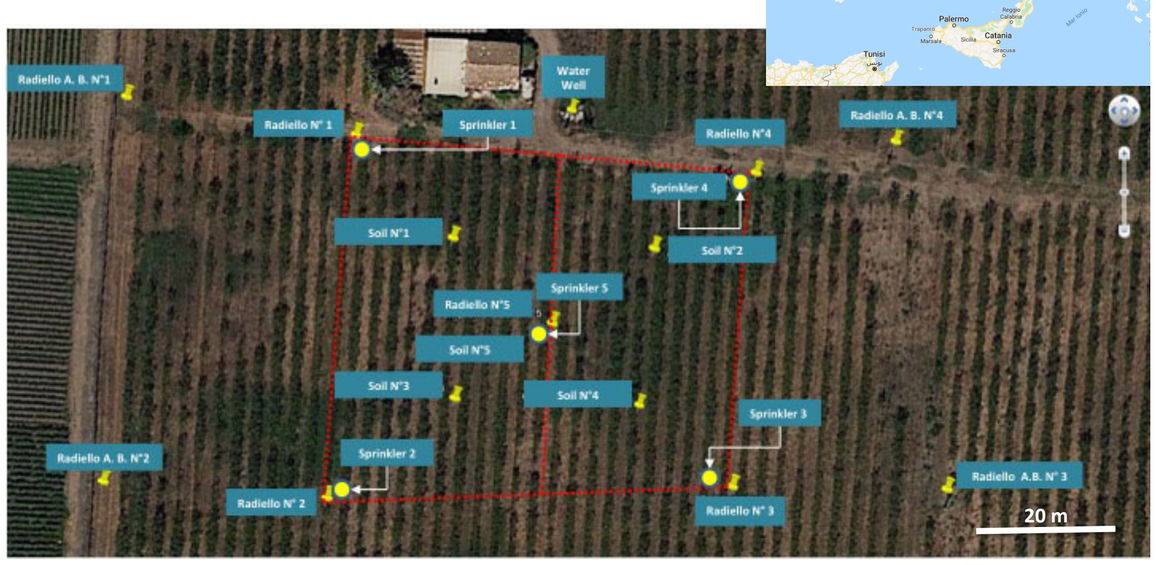


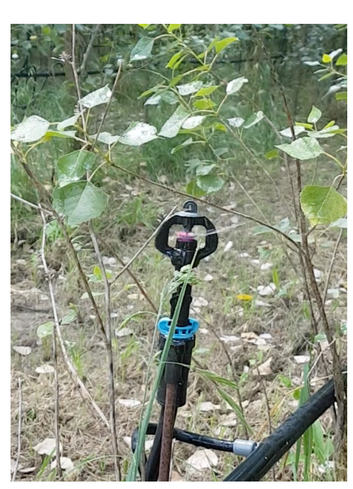
Introduction and context

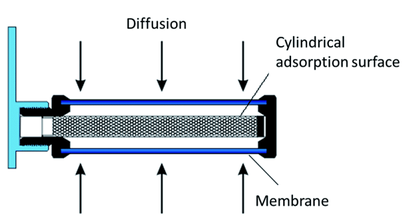
The site of San Giuseppiello (near Naples, Italy) covers an area of 60,000 m^2 and currently hosts several thousands of poplars, planted for the bioremediation of the site according to the LIFE11/ENV/IT/275-ECOREMED Project protocol (www.ecoremed.it). The underlying aquifer is contaminated with relatively low concentrations of Volatile Organic Compounds (VOCs). Usual remediation protocols would employ a pump-and-treat + stripping treatment, but, given relatively low contamination rates, an experiment employing an irrigation system by sprinklers has been tested to verify if a "stripping-like" effect is achieved with the result of water remediation and its reuse for irrigation purposes.



Materials and approaches

Groundwater is pumped into an irrigation system equipped with properly-selected micro-sprinklers (Netafim Supernet^{TM} LR, flow regulated at rate 35 L/h, 3.0 bar pressure) and deployed at the field site (2000 m^2). During the irrigation season (April-September 2018), four sampling campaigns were carried out to evaluate: i) if the VOCs concentration in the water reaching the soil decreases after being "sprinkled"; ii) if the excess VOCs impact other environmental matrices, particularly air (due to VOCs volatilization) and soil (due to VOCs in poured water). Air dispersed VOCs were collected by passive sampling (Radiello®), water samples were collected from the well and from the sprinklers at 5 sampling locations at different times during the day every 2 months. Soil samples were collected before and at the end of the experiment to assess if any VOC enrichment had occurred. Radiello® samples were analysed by GC-MS after solvent extraction; water and soil samples were analysed by Solid Phase Micro-Extraction (SPME) - GC/MS.





Outcomes

The table shows the preliminary results (1st out of three campaigns for selected substances) that are fairly promising. The water samples from the sprinklers show a significant reduction of the VOCs concentration with respect to the supply water (from the well) for all five sampling locations and for the three different pumping times of the campaign. Reduction in the considered compounds varies between about 79% and 100% and the concentration levels decrease below the regulatory thresholds. This situation occurs without any measurable transfer of VOCs to the air of the site: the air samples collected by Radiello® show no significant variations of VOCs concentrations with respect to those of the background level measured at control locations.

The results show that the designed irrigation system is suitable for the remediation of groundwater slightly contaminated by VOCs, resulting in the possibility to reuse it for crop production. Besides, sprinkler irrigation is relatively cheap and shows the potential not only to effectively remove VOCs from contaminated groundwater, but also reuse it eliminating the costly disposal of both remediated water and contaminants.

Substance/samples	Ethene. 1.1-dichloro-	Ethane. 1,1-dichloro-	Trichloro methane	Ethane. 1,1,1-trichloro-	Trichloro ethene	Propane. 1,2-dichloro-	Methane. bromodichloro-	Tetrachloro ethene
Limit values Dlgs. 152/06	*0.05*	*810*	*0.15*	*1*	*1.5*	*0.15*	*0.17*	*1.1*
T1 (well)	**0.050**	0.070	**0.196**	0.027	0.016	0.010	0.008	0.184
T1 (sprinkler 1)	<DL	0.005	0.025	<DL	0.001	<DL	<DL	0.012
T1 (sprinkler 2)	<DL	0.001	0.018	<DL	<DL	<DL	<DL	0.003
T1 (sprinkler 3)	<DL	0.002	0.170	<DL	<DL	<DL	<DL	0.005
T1 (sprinkler 4)	<DL	0.002	0.027	<DL	0.001	<DL	<DL	0.005
T1 (sprinkler 5)	<DL	0.004	0.039	0.003	0.001	<DL	<DL	0.009
mean (sprinkler)	<DL	0.0028	0.0558	0.0006	0.0006	<DL	<DL	0.0068
% reduction (mean)	**100.0**	**96.0**	**71.5**	**97.8**	**96.3**	**100.0**	**100.0**	**96.3**
T2 (well)	0.036	0.067	**0.211**	0.020	0.013	0.013	0.005	0.152
T2 (sprinkler 1)	<DL	0.005	0.039	<DL	0.001	<DL	<DL	0.013
T2 (sprinkler 2)	<DL	<DL	0.032	<DL	<DL	<DL	<DL	0.003
T2 (sprinkler 3)	<DL	0.003	0.080	<DL	<DL	<DL	<DL	0.005
T2 (sprinkler 4)	<DL	0.004	0.024	0.002	0.001	<DL	<DL	0.013
T2 (sprinkler 5)	<DL	0.003	0.032	0.002	<DL	<DL	<DL	0.007
mean (sprinkler)	<DL	0.003	0.0414	0.0008	0.0004	<DL	<DL	0.0085
% reduction (mean)	**100.0**	**95.5**	**80.4**	**96.0**	**96.9**	**100.0**	**100.0**	**94.4**
T3 (well)	**0.065**	0.133	**0.355**	0.039	0.024	0.018	0.010	0.190
T3 (sprinkler 1)	<DL	0.006	0.051	0.002	0.001	<DL	<DL	0.011
T3 (sprinkler 2)	<DL	<DL	0.023	<DL	<DL	<DL	<DL	0.002
T3 (sprinkler 3)	<DL	0.003	0.080	<DL	<DL	<DL	<DL	0.005
T3 (sprinkler 4)	<DL	0.003	0.030	0.002	0.001	<DL	<DL	0.007
T3 (sprinkler 5)	<DL	0.009	0.083	0.003	0.001	<DL	<DL	0.013
mean (sprinkler)	<DL	0.0042	0.0534	0.0014	0.0006	<DL	<DL	0.0062
% reduction (mean)	**100.0**	**96.8**	**85.0**	**96.4**	**97.5**	**100.0**	**100.0**	**96.7**
mean	**100**	**96,1**	**79,0**	**96,7**	**96,9**	**100**	**100**	**95,8**

Concentrations in µg/L; DL = detection limit

Transferability

A USGS nationwide survey (Zogorski et al., 2006) found that total VOCs concentrations were less than 1 µg/L in about 90% of the 867 analysed groundwater samples. The costs to remediate all these aquifers applying usual techniques would impose quite high running costs for very long lasting interventions. The low cost and high impact of the sprinkler irrigation treatment alternative provides a beneficial use for the treated water and is an example of effectiveness and efficiency in remediation intervention. The system can be easily implemented and is economically sustainable in all the cases where a VOCs low level contamination is present in a productive aquifer and can effectively support bio/phytoremediation techniques.

Eco-sustainable best practices and technologies can be derived and transferred to public bodies and companies, also with the aim to improve the current environmental legislation, in particular concerning irrigation waters.

References

Zogorski JS, et al. (2006) Volatile Organic Compounds in the Nation's Ground Water and Drinking-Water Supply Wells. USGS Circular 1292

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