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PILOT-SCALE CONSTRUCTED WETLANDS (HORIZONTAL SUBSURFACE FLOW AND FREE WATER SYSTEM) FOR TERTIARY TREATMENT IN A TEXTILE WASTEWATER TREATMENT PLANT

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INTRODUCTION

Prato district (Italy) is an important textile area, its industries are mostly small and medium size. Wastewater discharges are treated by a wastewater treatment plant (WWTP) managed by GIDA spa. GIDA, a company with private and public participation, manages five wastewater treatment plants. Among them, the largest is the Baciacavallo WWTP.

In addition, this company operates in wastewater reuse. The industrial aqueduct owners are also the private partners of the centralized wastewater plant managing company. This aqueduct is funded by mechanisms that provide incentives for the users: all the industries take part in funding by an increase on the ww treatment fare, which produces compensation to the sustained bigger depuration costs. Recycled water from WWTP allows a saving in a valuable even though limited resource for potable use. In fact, textile industries do not need potable water quality; worse quality water can be used without consequences. The treated wastewater has industrial and domestic origins, and the most important pollutants are: anionic and not ionic surfactants, colour and suspended solids.

These organic substances are recalcitrant with traditional oxidation technique, so the WWTP is supplied with an ozonation stage.

To test the constructed wetland (CW) system’s refinement efficiency for the Baciacavallo WWTP outlet and to compare this natural method with other traditional treatments, a CW pilot project has been implemented since year 2001. CWs have been mostly tested for municipal wastewater, but there are few experience on this particular kind of industrial wastewater. This report could give significant informations about the application of CWs as a polishing stage for industrial reuse, as tertiary treatment for the advanced removal of persistent dyers before discharging in freshwaters, for preventing and minimizing the rivers pollution.

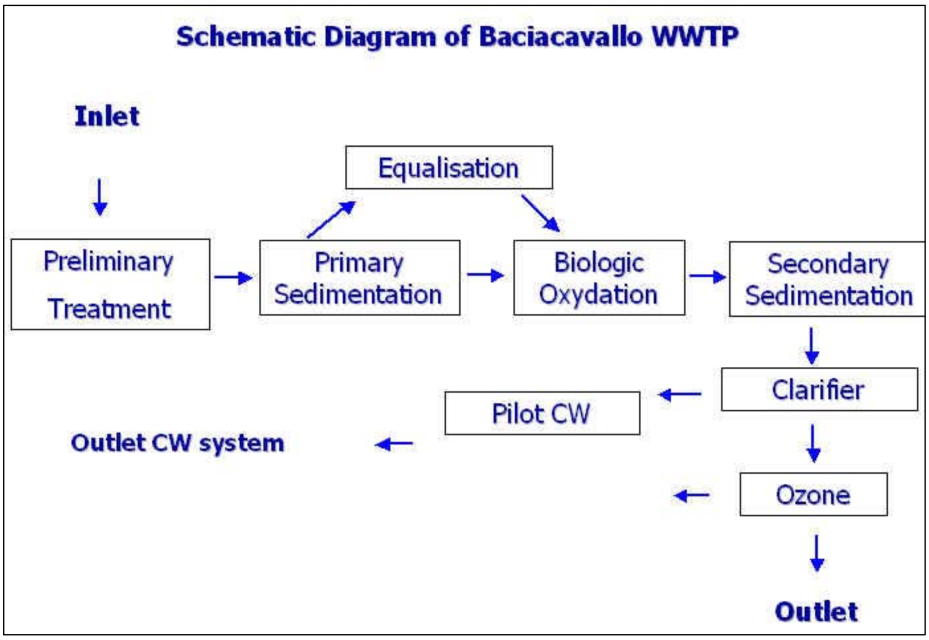
A serious problem in treating the large amount of wastewater produced in Prato by CW is the need for large areas: Prato's district is a very urbanized area, so that at the moment no available location has been found for a "large-size" wetland.

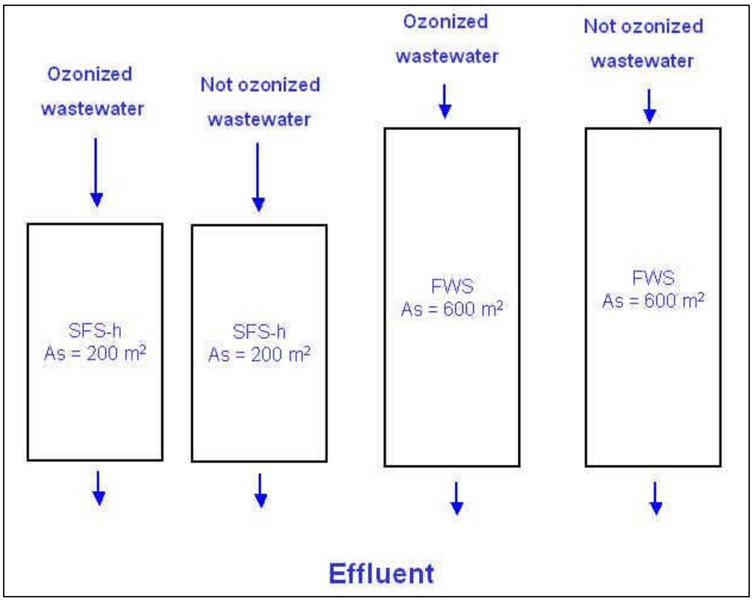
EXPERIMENTAL

The Baciacavallo Wastewater Treatment Plant receives about 30,000 m^3/d from the municipal sewer system and about 100,000 m^3/d of industrial wastewater produced by the local textile pole.

The water treatment process consists in a preliminary treatment (grids, sand remover) followed by a primary sedimentation, helped by an equalisation tank for levelling the daily peaks, a secondary stage by activated sludge and the subsequent sedimentation and clarification. The frequent presence of noticeable quantities of dyers in the outlet has been partially solved upgrading the process with an ozonation system at the end of the cycle. Owing to the high treatment cost that results from this application, a pilot plant for testing the performances of both SFS-h and FWS systems was implemented in 2001.

The CW pilot system consists of four separate plots, two SFS-h and two FWS; an amount of the clarifier effluent is pumped in parallel in one SFS-h and one FWS, while the other two beds are fed, always in parallel, with the ozonation stage effluent. In this way the polishing performances are compared to evaluate which system is the more effective and economically convenient, considering construction and operational costs, and to verify the feasibility for dismissing the ozonation stage.





The two SFS-h have each one the following design details: 0.8 m depth, As = 200 m^2, filled with gravel (size 5–10 mm), planted with *Phragmites australis* and *Typha* spp.

The two FWS have each one the following design details: 1.5–2.5 m depth, As = 600 m^2, including internal gravel filled sections and planted with *Phragmites australis* and *Typha* spp.

The four units, designed based on the project elaborated by the Prato Provincial department of the Regional Environmental Protection Agency of Tuscany (ARPAT), have been operating since May 2001.

The following series of tests have been performed on the pilot site:
year 2001: SFS-h with HRT = 3 days; FWS with HRT = 6 days;
year 2002: SFS-h with HRT = 1 day; FWS with HRT = 3 days;
year 2003 and 2004: SFS-h with HRT = 3 days; FWS with HRT = 3 days.

Monitored parameters: pH, TSS, COD, NH_4^+, NO_3^-, NO_2^- and Colour, Anionic and Non-ionic Surfactants.

Standard analysis methods IRSA/CNR were used for chemical measurements in all cases (IRSA/CNR – Water Research Institute of National Research Centre – is the Governmental Research Institute that provide the analytical standards for Italy: standards methods are almost the same provided by APHA 1992).

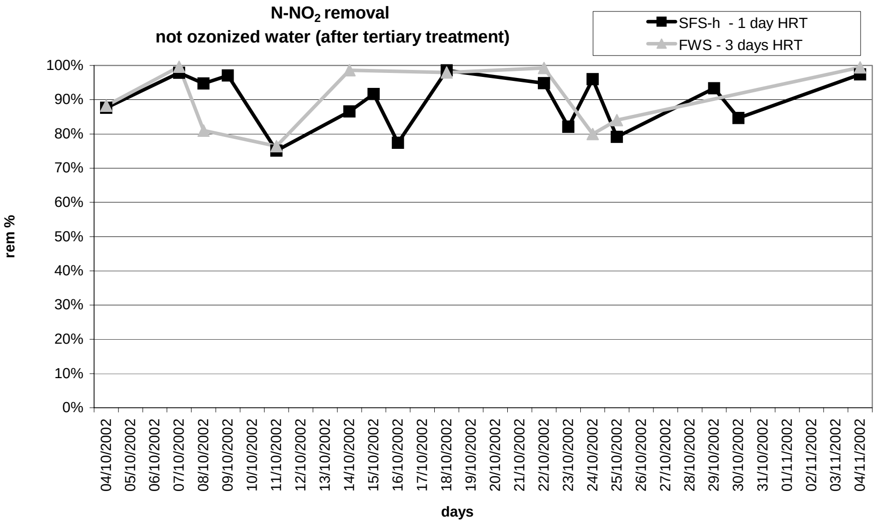
RESULTS

As first result, all the pilot plant has shown an increase in performances during the operational years, and the best removals have been reached in the years 2003 and 2004.

The obtained performances, partially shown in the following tables and graphics, clearly demonstrate the better behaviour of the gravel-based beds (SFS-h), especially for the residual colour removal, applying a 3 days HRT (colour removal percentage = 30–40%).

About the residual COD, results show a removal efficiency up to 30–40% for SFS-h, both for 1 and 3 days HRTs.

Interesting results have been obtained also for nitrite removal by SFS-h and FWS systems and applying both 1 and 3 days HRTs.



Also surfactant removals are remarkable, even with just 1 day HRT a 30% removal is safely obtainable.

Removals of the order of 20–30% have been observed also for the nitrogen compounds and in the range of 40–60% for total suspended solids.

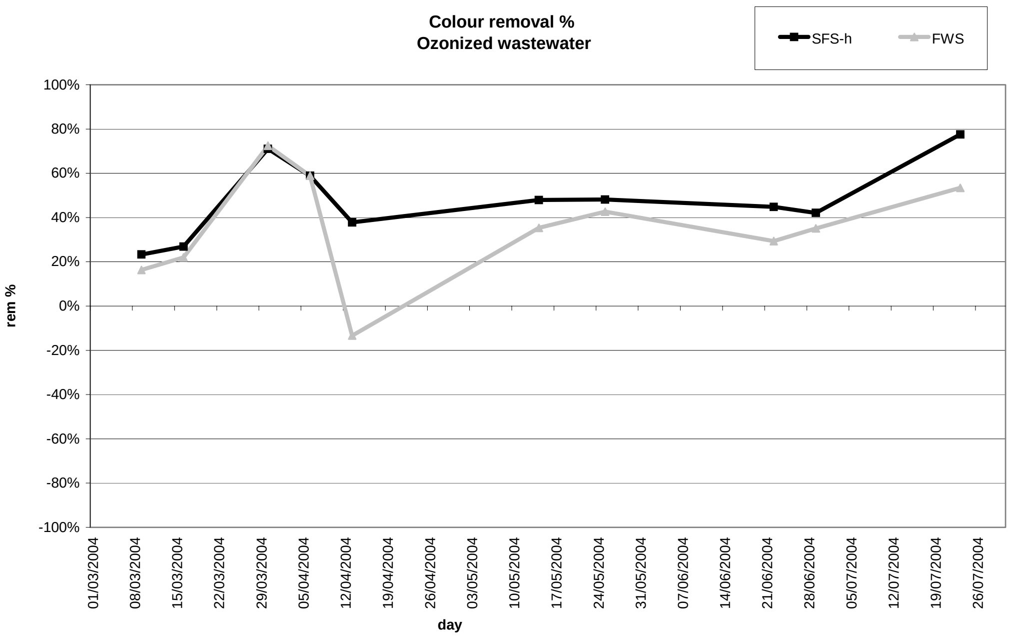
GENERAL STATISTICS OZONATION EFFLUENT

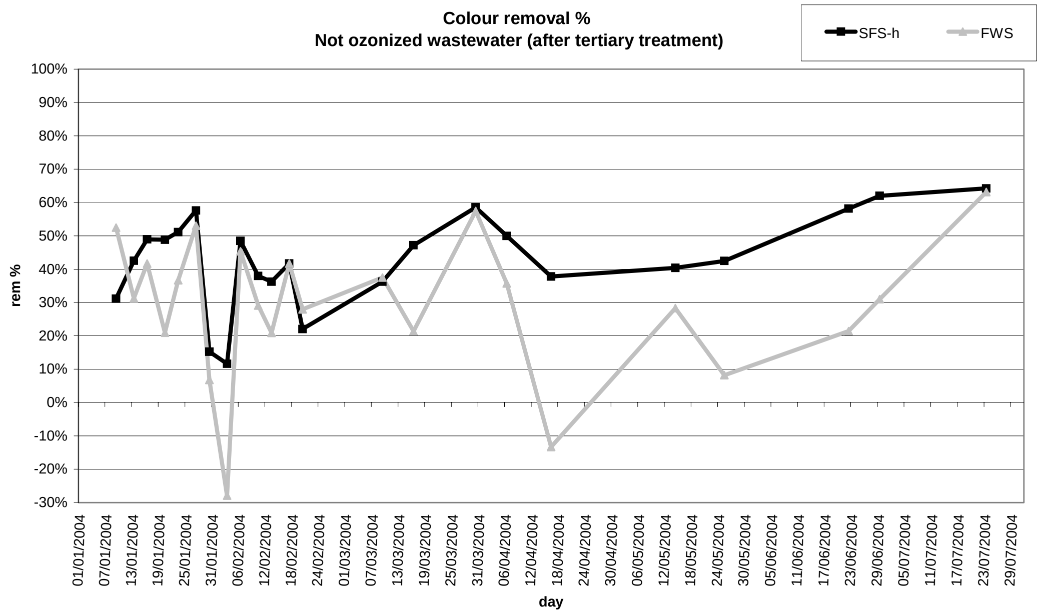
	COD mg/l	N-NH4 mg/l	N-NO3 mg/l	N-NO2 mg/l	pH	TSS	Anionic Surf.	Non Ionic Surf.	Colour ABS 420 nm
INLET									
mean	73.05	7.07	2.72	0.36	7.74	17.27	0.28	0.78	0.050
max	103	20.7	11	2.19	8.13	44	0.6	1.46	0.084
min	25	0.6	0.1	0.035	7.22	1	0.14	0.25	0.014
st. dev	12.29	2.49	1.63	0.39	0.09	7.15	0.06	0.22	0.011
SFS-h outlet									
mean	47.35	5.15	1.81	0.05	7.53	6.90	0.22	0.38	0.033
max	73.8	11.8	6.5	0.454	8.15	26	0.49	0.98	0.054
min	14	0.36	0	0	7.17	1	0.022	0.13	0.013
st. dev	8.82	1.82	1.13	0.05	0.15	4.37	0.05	0.15	0.006
% rem	35%	27%	33%	85%	3%	60%	21%	52%	34%
Pond outlet									
mean	56.13	5.59	2.09	0.06	7.56	8.50	0.25	0.44	0.053
max	97.3	16.7	5.6	0.28	8.27	40	0.56	1.12	0.172
min	24	0.36	0	0.0015	7.2	1	0.034	0.15	0.019
st. dev	7.72	1.98	1.04	0.04	0.16	4.22	0.08	0.21	0.010
% rem	23%	21%	23%	82%	2%	51%	11%	43%	-8%

GENERAL STATISTICS TERTIARY TREATMENT EFFLUENT

	COD mg/l	N-NH4 mg/l	N-NO3 mg/l	N-NO2 mg/l	pH	TSS	Anionic Surf.	Non Ionic Surf.	Colour ABS 420 nm
INLET									
mean	75.55	6.65	2.85	0.39	7.68	17.14	0.42	0.82	0.088
max	118	27.8	18.6	5	8.48	46	0.7	2.24	0.146
min	24	0.2	0	0.046	7.21	1	0.15	0.44	0.025
st. dev	15.40	2.72	1.88	0.52	0.13	6.40	0.10	0.17	0.022
SFS-h outlet									
mean	51.72	5.49	1.72	0.04	7.49	8.27	0.29	0.52	0.051
max	76	11.8	5.9	0.305	8.21	36	0.71	1.17	0.104
min	20	0.12	0.1	0	7.21	1	0.11	0.19	0.028
st. dev	7.73	1.72	1.00	0.03	0.11	6.20	0.06	0.15	0.008
% rem	32%	18%	40%	90%	2%	52%	32%	36%	42%
Pond outlet									
mean	60.04	5.86	2.45	0.08	7.54	10.50	0.33	0.53	0.068
max	83.8	14.8	12.2	0.28	8.16	42	0.91	1.2	0.103
min	24.7	0.444	0	0.003	7.18	1	0.13	0.22	0.029
st. dev	7.52	1.90	1.64	0.05	0.11	5.52	0.07	0.19	0.013
% rem	21%	12%	14%	79%	2%	39%	21%	36%	22%

The most interesting finding in our tests has been the good capacity of the SFS-h in decolouring the effluents from both the sources, with and without ozonation.

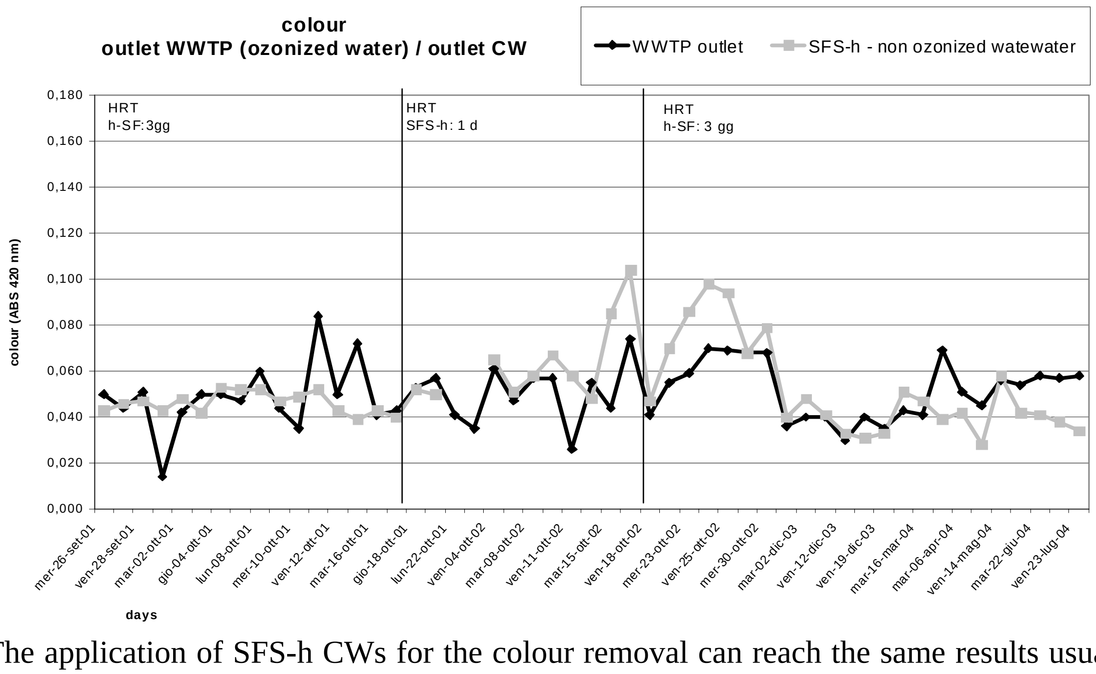




DISCUSSION

The experimental results reported above show that a CW system can improve the outlet quality of the Baciacavallo WWTP.

In addition, we compared colour removal between ozone treatment and SFS-h fed with non-ozonized water, the results for which are shown in the following figure.



The application of SFS-h CWs for the colour removal can reach the same results usually obtained with the ozonation stage (about 40% removal), minimising the risk of harmful by-products formation during the ozonation stage.

Since Prato district is a very urbanized area, the huge area needed for treating about 130.000 m^3/d of wastewater has been until now a strong limiting factor for CW applicability, despite the good results of this research.

CONCLUSIONS

The results of this study can be summarized as follows:

- This experience pointed up interesting textile residual colour and surfactant removal by CWs.
- The highest removal can be obtained with SFS-h, at least 3 days HRT.
- CWs could be applied instead of the ozonation process, if there is enough land available for their realisation (so it is always a convenient choice for small- to medium-sized industrial WWTPs).

SFS-h CWs have assured more stable results and 10–15% higher than the ponds; the ponds, from another point of view, need less superficial area and are cheaper (no filling media) and more compatible with multi-usage confined flooding areas, if these "flooding protection" tools are located far from the settlements; that could represent a valid solution for Baciacavallo, due to a huge area for controlled flooding will be realised in a close future inside the river Arno flooding protection plan, just in proximity of the final discharge point of the Prato's WWTP.

Nowadays GIDA is monitoring other parameters such as harmful substances (nonylphenols, PAHs) into the CW pilot plant. Moreover, a comparative research is running making use of pilot CWs together with other technologies such as MBR and MBBR.

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APPLICATION OF HYBRID REED BED SYSTEM TO TREAT DAIRY WASTEWATER IN COLD CLIMATE IN EASTERN HOKKAIDO, JAPAN

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INTRODUCTION

Dairy milking parlor wastewater is not purified and has been a big problem polluting rivers and underground water in Hokkaido, northern Japan. So, it is very urgent that low cost technology is applied to purify dairy wastewater. A hybrid reed bed system composed of vertical and horizontal subsurface flow constructed wetland to treat milking parlor wastewater was built for the cold climate in eastern Hokkaido, in November 2005. This plant was the first real-scale field experiment of a hybrid wetland system in Japan. We describe the design and early performance of the system in this article.