

# CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT IN CENTRAL ITALY

G. Conte\*, N. Martinuzzi\*, L. Giovannelli\*\*, F. Masi\* and B. Pucci\*

\* IRIDRA S.r.l. - Via Lorenzo il Magnifico 70 - 50129 - Florence (Italy)

\*\* A.R.P.A.T. (Regional Environmental Protection Agency) - Dept. of Prato – Via Vittorio Veneto 9 – Prato (Italy)

## ABSTRACT

The performance of 4 constructed wetlands designed by IRIDRA Srl and operating in Tuscany (central Italy) has been monitored during the last few years. The 4 treatment systems have different size and characteristics: one single stage secondary treatment; two secondary treatment plants with effluent reuse: one small (60 p.e) and the other bigger (350 p.e.); a tertiary treatment of effluents from an activated sludge plant with high hydraulic load fluctuation (5-500 p.e.). All the systems show interesting results, especially the ones with higher inflow COD concentrations.

## KEYWORDS

Constructed wetlands; reed beds; horizontal subsurface flow; macrophytes; secondary treatment; wastewater reuse

## INTRODUCTION

Tuscany Region, is one of the first areas in Italy where constructed wetlands have been used for wastewater treatment. In fact, human settlements in Tuscany still preserve a diffuse pattern originated several centuries ago. Thus a significant part of the population lives in many small isolated areas (ranging from below 100 to one or two thousand p.e.). Some of the original rural settlements have been converted in tourist facilities, hosting up to a few hundred p.e., especially in spring and summer period. In this situation constructed wetlands appear to be the best technology for wastewater treatment.

The company IRIDRA S.r.l., based in Florence, has designed most of the constructed wetlands for wastewater treatment operating in Tuscany. The performance of four different constructed wetlands designed by IRIDRA have been monitored during the last three years by IRIDRA and ARPAT (Agenzia Regionale per la Protezione dell'Ambiente, the regional public authority responsible for environmental monitoring). The four treatment facilities are:

- 1) Moscheta (Firenze): a small village of summer residents with a big restaurant working all year round using a SFS-h reed bed;
- 2) Gorgona Island (Livorno): penitentiary wastewater treatment and reuse using SFS-h reed bed series followed by a wet meadow;
- 3) Spannocchia (Siena): lodging site with wastewater treatment and reuse using a SFS-h reed bed followed by a collecting pond;

4) Pentolina (Siena): tourist village with a high hydraulic loading fluctuation, tertiary treatment of effluents from a total oxidation activated sludge plant by a SFS-h reed bed.

## METHODS AND MATERIALS

The dimensioning tools utilised for the design of the four systems was based on published criteria from the following publications: E.P.A. (1993), Cooper P.F. (1990, 1993), Reed et al. (1995), Kadlec & Knight (1995). The superficial area and basin dimensions were based on desired effluent characteristics, the daily average hydraulic loading, organic load, fill depth and gravel size and the basin slope. Table 1 summarises the main features of the four plants. The larger in terms of surface is the Gorgona Island plant, but the tertiary system of Pentolina treats a larger population.

Table 1 – Main features of treatment facilities and number of monitoring samples

	<i>Moscheta</i>	<i>Gorgona</i>	<i>Spannocchia</i>	<i>Pentolina</i>
Load (p.e.)	1150	450	60	500
Area SFS-h (m <sup>2</sup> )	375	900	160	550
Area SFS-h/p.e. (m <sup>2</sup> )	2,5	2	2,6	1,1
Area third stage - Pond, wet meadow (m <sup>2</sup> )	-	450	20	-
Water use (l/p/day)	120	125	150	250
Flow (mc/d)	18	56	9	125
Primary treatment	Imhoff + Degreaser	Grid + Imhoff	Imhoff + Degreaser	Act. Sludge Plant
Operating since	1999	1997	1997	1998
N° of samples	3	11	8	8

At the time the systems were designed the outlet standards were established in the Italian National Law n° 319/76, but, with the enforcement of a new law (D.Lgs. n.152 of 1999), which implements EC Directive 91/271 concerning municipal wastewater treatment, more stringent standards have been adopted (Table 2).

Table 2 - Outlet criteria

Parameters	Max effluent concentration acceptable	
	Law 319 (1976)	Law 152 (1999)
B.O.D. <sub>5</sub>	40 mg/l O <sub>2</sub>	25 mg/l O <sub>2</sub>
C.O.D.	160 mg/l O <sub>2</sub>	125 mg/l O <sub>2</sub>
SS	80 mg/l	35 mg/l
N-NH <sub>4</sub> <sup>+</sup>	15 mg/l	15 mg/l
P-total	10 mg/l P	10 mg/l P
N-total	35 mg/l N	35 mg/l N

The treatment facilities have been monitored four times a year, in different seasons, since their construction. Standard analysis methods were used for both chemical and microbiological measurements in all cases, as specified in table 3. Unfortunately microbiological data was not available for Gorgona, therefore only the remaining three

systems could be compared in terms of microbiological performance.

Table 3 - Parameters analysed and methods

<i>Parameters</i>	<i>Analytical methods</i>
COD	Standard Methods
Suspended Solids	IRSA/CNR 2050
NH <sub>4</sub> <sup>+</sup>	IRSA/CNR 4010/A
NO <sub>3</sub> <sup>-</sup>	IRSA Notiziario 1/12
P Tot.	IRSA/CNR 4090/2
MBAS	IRSA/CNR 5150
Total Coliforms	IRSA/CNR 7010/B
Faecal Coliforms	IRSA/CNR 7020/B
Faecal Streptococci	IRSA/CNR 7040/B

## RESULTS AND DISCUSSION

The average concentrations of parameters monitored at the input and at the output of the reed bed (SFS-h) of the four treatments facilities are summarised in table 4. The performances, in percentage of pollutant removal, are indicated in the following picture.

Table 4 - Concentration of inputs and outputs of the four treatment facilities

		<i>Moscheta</i>		<i>Gorgona</i>		<i>Pentolina</i>		<i>Spannocchia</i>	
		in	out	in	out	in	out	in	Out
TSS	mg/L	428,0	5,0	138,8	72,7	31,5	18,2	114,2	14,5
COD	mg/L O <sub>2</sub>	449,0	18,5	251,5	94,8	199,7	50,5	599,9	78,3
Ammonium	mg/L NH <sub>4</sub> <sup>+</sup>	48,3	5,2	33,8	19,7	49,2	13,8	74,6	40,8
Nitrates	mg/L N-NO <sub>3</sub> <sup>+</sup>	1,0	0,7	4,0	0,8	5,8	4,1	1,5	3,7
Phosphates	mg/L P-PO <sub>4</sub> <sup>---</sup>	6,5	5,1	11,7	5,6	2,4	2,0	3,4	2,2
MBAS	mg/L	15,8	2,0	3,2	1,2	16,0	8,3	15,4	2,5
Total Coli	Mpn/100ml	7 725 000	61 075	-	-	21 255	1 120	2088000	300 200
Faec. Coli	Mpn/100ml	6 072 500	50 875	-	-	1 500	525	126000	74 700
Fae. Strept.	Mpn/100ml	40 225	200	-	-	2 250	137	261600	80 660
Esch. Coli	Mpn/100ml	2 503 500	30 450	-	-	100	10	73000	4 667

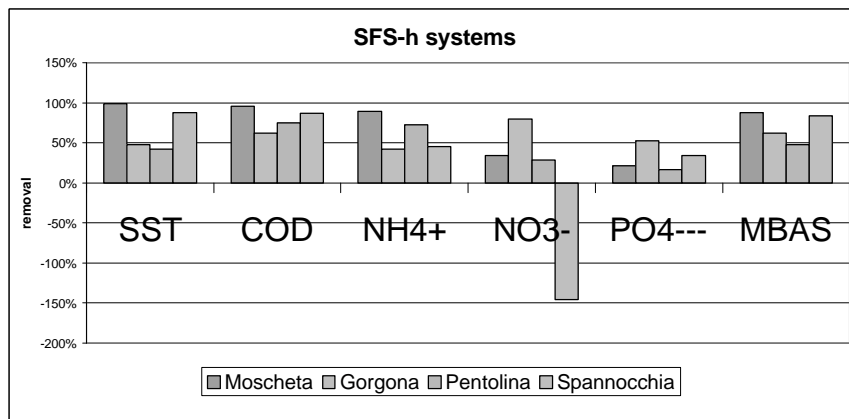


Fig. 1 – Mean chemical pollutants removal percentages

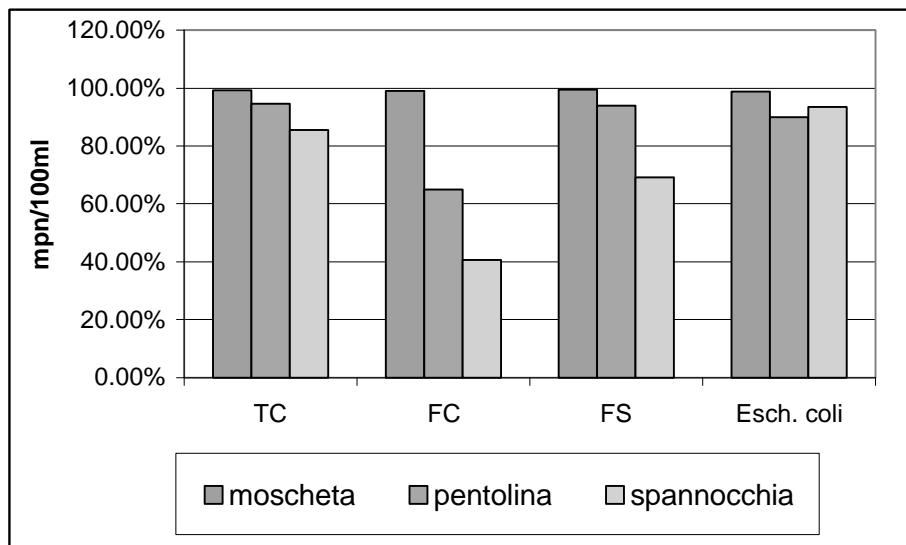


Fig. 2 – Mean hygienic parameters removal percentages in three SFS-h systems

The results show that the effluents of the two reed beds that discharge directly into the environment (Moscheta and Pentolina) are always well within the Italian quality standards regarding discharge of wastewater in the environment, even considering the more stringent standards set by Law 152/99 that were yet to be enforced when the facilities were designed. The outflows of the other two reed beds (Gorgona and Spannocchia, that have a third stage before discharging into the environment), show higher concentrations: Gorgona for SS and  $\text{NH}_4^+$  and Spannocchia for  $\text{NH}_4^+$  only. The third stage treatment occurring in the wet meadow of Gorgona facility allows a substantial reduction of SS and  $\text{NH}_4^+$  in its final effluent, while the small third stage pond of Spannocchia system not always is able to guarantee good water quality, specially when weather condition prevent a good water oxygenation in the pond.

In terms of removal efficiency the performance of Moscheta system appears to be the best of the four, with reference to SS, COD,  $\text{NH}_4^+$ , MBAS, but the Spannocchia system also shows very interesting results for COD and  $\text{NH}_4^+$ . The high removal rate appears to be due to the high input concentration, that, in presence of good oxygenation, allows better conditions for bacterial activity.

## REFERENCES

- Cooper P. F., Ed. (1990). European design and operations guidelines for reed bed treatment systems. WRc Report UI 17, presented to the *Conf. Constructed Wetlands in Water Pollution Control*. Cambridge, U.K., September 1990.
- Cooper P. F. (1993). The use of reed bed systems to treat domestic sewage: the European design and operations guidelines for reed bed treatment systems. In: *Constructed Wetlands for Water Quality Improvement*. G. A. Moshiri Ed., Lewis, Boca Raton, pp. 203-217.
- Kadlec R. H., Knight R. L. (1996). *Treatment Wetlands*. CRC Press/Lewis Publishers, Boca Raton, Florida.
- Reed S. C., Crites R. W. and Middlebrooks E. J. (1995). *Natural Systems for Waste Management and Treatment* - 2<sup>nd</sup> ed. McGraw Hill, New York, pp. 173-284.
- U.S.E.P.A. (1993). *Subsurface flow constructed wetlands for wastewater treatment*. EPA 832-R-93-001, U.S.E.P.A. Office of Water (WH547).