Pergamon

Wat. Sci. Tech. Vol. 40, No. 4–5, pp. 21–28, 1999

0273–1223/99 $20.00 + 0.00

PII: S0273-1223(99)00481-3

ADVANCED WASTEWATER TREATMENT AND REUSE: RELATED PROBLEMS AND PERSPECTIVES IN ITALY

L. Bonomo*, C. Nurizzo* and E. Rolle**

** Politecnico di Milano, D.I.I.A.R., piazza Leonardo da Vinci 32, 20133 Milano, Italy*
*** Università degli Studi di Roma "La Sapienza", via Eudossiana 18, 00184 Roma, Italy*

ABSTRACT

An overview of water availability and distribution, water consumption, wastewater treatment trends, with particular reference to advanced ones, is briefly presented. Data about the current situation of municipal wastewater treatment and advanced treatment options are presented and regional trends about wastewater reclamation (agricultural and industrial reuse) are summarised. Some considerations about present and possible future standards, both for disposal into surface waters and for wastewater reclamation in agriculture are discussed. A short list of examples in the field of advanced wastewater treatment and reclamation in various Italian regions is presented and some information about environmental crisis areas in Italy is given.

KEYWORDS

Wastewater treatment; advanced treatment; wastewater reclamation; quality standards.

WATER RESOURCES OUTLINE

Natural water inputs in Italy are evaluated to be, as an average, around 300 billions m^3/y, 46-48% of which is considered to be naturally lost (evaporation, evapotranspiration, etc.); the theoretical amount of water resources (natural inputs - natural losses) is therefore about 155 billions m^3/y. Water effectively available for use is therefore estimated to be about 85 billions m^3/y, with a pretty unbalanced geographical distribution (Rusconi, 1994). Consumption slightly exceeds 50 billions m^3/y: 63% of this figure is evaluated to be required for agriculture, 25% for industry and 12% for drinking water purposes. Precipitation distribution is also quite uneven, both on a territorial and seasonal basis, due to the peculiar Italian geographical situation: climate in Northern Italy appears to be quite similar to the Central European one, while Southern Italy has a typical Mediterranean climate. Therefore precipitations and available water supply change dramatically from northern regions to southern ones; rainfall (and snow) brings some 980 mm/y as a national average, but in some southern areas precipitation can be less than 500 mm/y and the yearly distribution can be quite irregular (for instance July monthly averages can drop below 5 mm in Cagliari, Napoli, Palermo).

This distribution of water resources leads to quite different regional problems: in Northern Italy water resources are abundant and problems are mainly related with water quality. Therefore advanced wastewater treatment is usually not aimed to reclaim water to avoid a quantity gap, but to control pollution, specially when high treated wastewater flows cause low-dilution problems. On the contrary Southern regions have a long tradition of water shortage, especially during summer months, even for drinking purposes. Recent estimations show that in these regions nearly half of the population has to cope with insufficient drinking water flows during summer months (Ministero dell'Ambiente, 1997). This appears to be particularly relevant if compared with the average per capita water flow (278 L/EI x d).

Considering now water demand for agriculture, only 18% of the total national arable area is provided with irrigation networks; this figure reaches 32% in Northern regions and is as low as 8% in the rest of Italy where on the contrary the precipitation cycle would require larger amounts of water (see Table 1).

Table 1. Territorial distribution of surface water resources and amount of irrigable land on the total arable area (ISTAT, 1991/96)

Geographical Area	Resources Distribution* [%]	A = Arable Land [km^2]	I = Irrigable Land [km^2]	I/A [%]
Northern Italy	71.3	51,100	16,500	32
Central Italy	7.2	35,000	2,800	8
Southern Italy	15.7	33,100	4,800	14
Insular Italy	5,8	28,000	2,800	10
ITALY	100	147,200	26,900	18

* This figures consider the total available amount of surface waters, including impoundments.

WASTEWATER TREATMENT SITUATION

Two recent surveys (ProAqua, 1996; ISTAT, 1996), undertaken to evaluate the number of public wastewater treatment plants (WWTPs) in operation in Italy and their characteristics, led to a number of about 8,000 WWTPs, with some uncertainty for the smaller ones, due to different regional survey techniques: data are therefore consistent for WWTPs larger than 2,000 EI. The total number of WWTPs of this size in operation is 2,146 (see Table 2), with a gross purification capability (biological treatment) of about 64 millions EI. The 228 WWTPs having a size larger than 50,000 EI account for about 75% of the whole purifying capability.

Table 2. Biological WWTPs larger than 2,000 EI operating in Italy in 1993, by size classes (ISTAT, 1996)

Size Class (x 1,000 EI)	2-10	10-50	50-250	> 250	Total
Number of WWTPs	1,403	515	178	50	2,146
Design Population (millions EI)	5.74	10.70	17.01	30.41	63.91
Distribution by Size Class (%)	8.98	16.74	26.61	47.58	100

The overall Italian sewer-connectable population (residents, industrial contribution after pre-treatment, fluctuating population, tourists) is evaluated to be in the order of 111 millions EI and the existing works can therefore allow biological treatment for less than 60 % of the whole equivalent population. These figures refer to design estimates, but the number of people really connected to the WWTPs is generally lower. Referring to plants having a size larger than 50,000 EI, the treated/design population ratio is about 77% and extending this figure to all the Italian WWTPs only about 45% of the total population would be really connected to a biological treatment plant; it must be in any case considered that 17% of sewers (as EI) are estimated to dispose of their wastewater into the sea and in this case biological treatment is not always required. The majority of biological WWTPs are activated sludge plants, while the use of traditional fixed films plants (trickling filters and RBCs) is pretty low. With reference to the use of aerobic submerged filters, only one section (420,000 EI) of the Roma-Sud plant is operated in this way (a second section of the same size is under construction). Some other plants of this kind (roughly 200,000 EI) are presently being built in recreational areas or where land availability is low.

Tertiary treatment is focused on nutrients control even if sensitive areas, according to EEC Directive, have not yet been defined. Phosphorus removal is currently implemented when wastewater is to be disposed of within 10 km from lake shorelines, but is frequently practised also for the entire catchment basins upstream of the lakes. In this case the standard is 0.5 mg P/L and post-precipitation is often used. Phosphorus removal is also required in some coastal areas of the northern Adriatic, where over-fertilisation evidence was ascertained, but with a looser standard and on a seasonal basis. Nitrogen removal began to be applied from the early '90s: the 1976 Water Protection Act stated all over Italy the same standards for industrial effluents discharged into streams (20 mg NO_3-N/L and 15 mg NH^+_4/L) and the same limits were adopted in many regions also for municipal WWTPs effluents. When wastewater flow per capita is very large, these limits can be obtained without a specific control; nitrification-denitrification is often needed (usually by a low efficiency pre-denitrification). More stringent standards are enforced in lake districts (10 mg N/L) where few denitrification units with external C sources were put into operation.

Final filtration, mainly used for Phosphorus removal or in some cases of agricultural reclamation, is now being utilised in some highly valuable areas also (for instance the northern catchment basin of the Adige river, N-E Italy) for better control of the main pollution indexes. This practice can also be required as an extra safety item or when some indication for possible industrial or agricultural wastewater reclamation is given (Torino, Trieste, Cagliari, Bari, textile district in the Como region, Prato, etc.) and higher microbiological standards are required. Other kinds of post-treatment (ozonation, carbon adsorption, etc.) are sometimes used when surfactants or colour control is needed. This is for instance the case of the areas where strong or peculiar industrial loads are mixed with municipal wastewater (Prato, Biella, Fino M., Como).

In a recent survey (ProAqua, 1996), 353 WWTPs larger than 2,000 EI and equipped with tertiary treatment were listed. In the case of WWTPs larger than 50,000 EI, P removal is carried out in 32% of them, while 40% of them are equipped with denitrification; P and N removal accounts respectively for 23.5% and 32% of the biological treatment capability of WWTPs of this size. On a national basis, EI connected to tertiary treatment equipped WWTPs can be estimated to be about 10 % for P removal and 14% for denitrification (see Table 3).

Table 3. Amount of WWTPs equipped with nutrients control units (as %) and related capability (% of biological treatment capability). The last column gives an estimate of the Italian equivalent population (%) nowadays connected to nutrients removal equipped WWTPs

Unit operation	WWTPs > 50,000 EI		Italy
	% WWTPs	% EI connected	% EI connected
P removal	32	23.5	10.3
N removal	40	32	14

WASTEWATER RECLAMATION

The interest in wastewater reuse in Italy began to grow during the '80s when sufficient flows of treated wastewater from WWTPs became available and reclamation programmes for agricultural and/or industrial purposes began to be taken into account. The situation can be summarised as follows:

- Northern and Central Italy: the main interest is focused on industrial water reuse, with only some local opportunities for agriculture. Increasing prices of water supply and higher wastewater treatment costs induced a strong effort to get a more rational organisation of industrial water uses: internal recycles were implemented and some interest began to arise also for wastewater reclamation.

- Southern Italy and main islands: the interest for wastewater reuse appears to be specially addressed to agriculture (mainly orchards), having in mind to spare good quality natural water resources for drinking purposes, reducing thus the struggle among resident population, tourists, agriculture and industrial activities.

Industrial reuse

Water consumption for industrial purposes is currently decreasing in the main Italian industrial districts, as a direct consequence of the transformation of the industrial structure: some heavy, high water consuming productions (steel, rubber, chemical industries, etc.) were dismantled or displaced. An example of this trend is given by the recent evolution of some industrial areas in Milan and its neighbours (see Table 4).

Table 4. Recent evolution of water supplies (Mm^3/year) in some industrial districts in Milan and its neighbours (Rosti *et al.*, 1997)

	Sesto S. G. (Steel)	Arese (Automotive)	Rodano (Chemistry)	Bicocca (Rubber)	Rho (Oil refinery)	TOTAL
1990	16.0	8.0	40.8	8.2	7.8	80.8
1996	1.3	4.9	27.8	3.3	2.7	40.0

In any case, also for industries that continued to work in the same areas, more rational water uses, the growth of cleaner technologies and internal recycles led to water consumption reduction. This trend is clearly uneven: for instance, since 1990, specific water consumption per unit production dropped from 40 m^3/t to 6 m^3/t in the recycled paper industry, but only by 20% in tanneries.

The reduction of industrial water supplies and the contemporary abatement of civil ones - civil water supply dropped in the Milan area from 381 Mm^3/year (1990) to 331 Mm^3/year (1996) - led to a strong reduction of the amount of groundwater extracted from the aquifers. With reference to the city of Milan, its suburbs and the surrounding municipalities, the amount of water yearly spared is currently evaluated to be around 150 Mm^3/year. This is probably the main reason for the fast rise of the phreatic aquifer level that recently took place in this area (up to more than 10 m growth, North of Milan, and more than 4 m as a general figure).

The interest in wastewater reclamation in Northern Italy usually comes from economic estimates about the costs for wastewater purification and water supply. In fact many industrial districts did not grow close to important rivers and therefore water/wastewater dilution ratios can be very low in receiving streams; when surface waters are heavily used similar cases can arise also when the final receptor is an important river. This is the case of the Torino WWTP (Po-Sangone): the plant yearly average discharge figure is about 6 m^3/s, while the Po river[1] average natural flow is around 100 m^3/s, but an important water uptake just upstream of the discharge section makes the river flow frequently drop below 20 m^3/s, inducing a very critical situation for wastewater dilution. New trends begin to ask for more stringent and specific discharge standards, related to both quality and flow conditions in receiving streams. The New Lombardy Water Restoration Plan (currently under approval) provides a pollutants mass balance approach; discharge compliance will continue to be related to effluent concentrations during the first years of application, but using standards that, for medium-large size plants, will be more stringent than the previous undifferentiated ones (see Table 5). An example of the interest in industrial reuse induced by more stringent limits is given by the situation of a textile industry district close to Como. Present standards for surfactants and colour, forced the Fino M. plant to build, with a cost increase of 75%, two further purification steps after single-sludge denitrification: clari-flocculation and ozonation. A future biofiltration step, designed to remove organic micropollutants to promote reuse, will add an extra 25%. Total treatment cost will thus double with reference to standard treatment, but the water quality will be high enough to reclaim polished wastewater for the Como's industrial water supply network. The cost itself will be quite similar to the water supply cost for industry in the same area, using the good quality water extracted from the lake.

[1] Po, the largest Italian river, is in Torino quite close to its sources.

Table 5. Standards in Lombardy (mg/L) for plants > 100,000 EI discharging into streams

Standards	BOD_5	COD	N_{tot}	TKN	P_{tot}	TSS	Colour [(b)]
Present	40	160	[(a)]	-	10	80	1:20
Proposed (New Plan)	25	125	15	10	2	30	1:5

[(a)] 15 mg NH^+_4/L and 20 mg NO_3-N/L. [(b)] Not detectable after the indicated dilution ratios.

Industrial reclamation projects of WWTP effluents are generally aimed at producing water having a quality good enough to be used directly for widespread industrial purposes; the attainment of a better quality level will be left to any single user, even if this solution can give place to some inter-industrial struggles from the economic and organizative point of view (average cost of base reclaimed water related to different post-purification costs, different water fees for different consumption levels, etc).

In Table 6 two examples of reclaimed water quality required for future industrial utilisation are given.

Table 6. Some examples of water quality for foreseen industrial reclamation in Italy (all parameters in mg/L, except pH)

	pH	TDS	TSS	BOD_5	COD	NH_3-N	Cl	SO_4	P_{tot}
Trieste (steel industry)	7.0-8.5	500	10	20	100	10	150	30	1
Fino M. (textile industry)	7.0-8.0	-	10	-	30	5	500	500	1

Agricultural reuse

Wastewater reclamation in agriculture appears to be a key topic, especially in Southern regions. In recent years, due to some hygiene problems coming from improper wastewater reuse practices, a growing interest was focused on safe wastewater reclamation, with a higher control level. In addition, the critical situation of water resources, mainly in summer months, became worse in many areas. For instance, in Sardinia, the amount of rainwater since 1975 fell by about 30% with respect to the previous average figures (750 mm/y in the 1925-1975 period). The change was even stronger on surface water flows: in the same period the average yearly flows were 45-65% of the previous ones (1925-1975 average), depending on drainage basins.

The use of wastewater for irrigation in Italy is regulated in the frame of the 1976 Water Protection Act, being considered an extensive treatment process. The approach is very stringent from a hygiene point of view, especially if we consider that Italian surface waters generally used for irrigation display a consistently worse microbiological quality (often in the 10^4-10^5 range for T. Coli) and that recreational waters standards allow 2,000 MPN/100 mL (T. Coli) and 100 MPN/100 mL (F. Coli). Some other Regional Governments (e.g.: Apulia[2] and Sicily), using the powers given by the 1976 Water Protection Act, prepared and issued regional standards. In Table 7 those standards are summarised and compared with the national ones; as it can be easily recognised, quite different approaches were used.

It would be advisable for a new national regulation in this field would consider a more general approach to taking into account some multipurpose parameters to ensure a basic quality level and giving to local Governments the task to state other control parameters or different standards, with reference to the local situation.

In this pathway a more precise definition of quality classes could be of some interest: in fact the reuse of post-treated wastewater for irrigation has different impacts depending on irrigation systems and different crops. Similar approaches were discussed and an example of this trend is a proposal (Nurizzo *et al.*, 1994) based on 3 quality classes: in each class microbiological parameters, control or aesthetic parameters and

[2] The framework has recently changed; the case will be briefly discussed later (see following page).

irrigation related aspects were taken into account. This choice would certainly allow a more precise and reasoned classification of reclaimed water uses, based on water spreading facilities (spray, drip, surface irrigation) and on main crops (raw-eaten vegetables, fruits to be peeled, vegetables to be processed, etc.), but the risk of inappropriate uses of reclaimed water can be high.

Table 7. Reclaimed wastewater to be used for irrigation: examples of regional guidelines (excerpt) compared with national standards (Water Protection Act, Annex 5)

Parameters	Italy	Apulia	Sicily
PH	-	6.5-8.5	6.5-8.5
TSS [mg/L]	(a)	10	30
TDS [mg/L]	-	-	1000
BOD_5 [mg/L]	-	15	40
COD [mg/L]	-	40	160
SAR	< 15	15	10
Residual Chlorine [mg/L]	-	0,2	-
Persistent organic compounds [μg/L]	not detectable	-	-
T. Coli [MPN/100 mL] [(b)]	2 [(c)]-20	2 [(c)]-10	3,000

(a) mean value of 7 consecutive days samples (b) low enough to avoid soil clogging (c) unrestricted irrigation

Different ideas continue to be proposed ranging from very stringent figures (rumours about the future national standards seem to indicate a trend for a "nearly-drinking water option" with a large number of parameters, taking as reference the standards recently adopted in the Salento area, see Table 8), to quite loose ones. It is obvious that the better is the quality, the safer is the reclaimed water utilisation, but, in the authors' opinion, to really implement wastewater reuse in agriculture, especially in Southern Italy, economic aspects must also be taken into account: extremely stringent quality standards would lead to unjustified high costs of reclaimed water; for instance, it does not seem of primary interest to implement specific standards for trace elements, their concentrations in treated effluents being usually very low. This is not the case for Boron, some of the most important crops in Southern Italy being B-sensitive[3]. Boron concentrations in treated effluent are usually not checked, but a recent survey on 10 plants (Mezzanotte *et al.*, 1995) gave the following results: on a one year basis the average concentration was 0.76 mg B/L, but in many samples concentrations as high as 1.5 mg B/L were found.

CRISIS AREAS AND EXAMPLES OF WASTEWATER RECLAMATION

The high concentration of industries in restricted areas, the related high population density or some peculiar situation causing and continuing to cause local pollution problems: these are the so-called "environmental crisis areas" and some of them have a strong territorial impact; hereafter some cases are summarised.

- Venetian lagoon - This area, a very valuable and sensitive one, is environmentally stressed (the effluents of more than one million EI are discharged into the lagoon, together with the runoff of a quite large agricultural area and the wastewater of the Porto Marghera petrochemical site, one of the largest in Italy). Recent surveys led to finding in the lagoon sediments near to the industrial area a very high contamination for PAH, Dioxins, Hg and Cd. A centralised WWTP is provided in Fusina, on the border of the lagoon, for urban effluents and industrial pre-treated ones. Part of the treated effluent will be filtered and polished to be used for cooling purposes (50,000 m^3/d); the rest, including pre-stored stormwater, will be discharged into the open sea.

[3] Lemon is a very B-sensitive crop (B < 0.5 mg/L), while orange and grapes are classified as sensitive (B < 1 mg/L) ones (Westcot & Ayers, 1986).

- Salento area - The lack of streams in some areas of Apulia[4] leads to frequent wastewater spreading on the ground (the risk to pollute the aquifer is very strong, considering high soil permeability); in some places an even worse situation is encountered due to the lack of a sewer network totally connected to WWTPs. In the Salento area 13 WWTPs (more than 450,000 EI and more than 75,000 m^3/d, biologically treated and disinfected) are being built; two of them (100.000 EI, 16,000 m^3/d) were provided with final filtration and all of them have to be completed by summer 1999. By the end of 1997 a rather critical public health situation was recognised and an emergency plan was put into operation, co-ordinated by a commissioner of the Italian Government. The emergency plan, the need for water in agriculture being strong in the area, aims to implement wastewater reclamation for irrigation (possible mixing with groundwater must be taken into account) avoiding the risks related to soil permeability. Therefore a very stringent and complete set of quality standards was provided (see Table 8), taken into account 52 parameters, including trace metals and organic micropollutants. This will require a deep revision of the original layouts; post-treatment plants will be equipped with polishing units not yet defined.

Table 8. Standards for wastewater reclamation in agriculture, also by storage, recently set in Apulia to face the local environmental emergency (Piano Puglia 2)[5]

#	Parameter	Unit	Standard (MAC)	Notes
1	pH		6-8.5	
2	Coarse solids		absent	
3	TSS	mg/L	10	
4	BOD_5	mg/L	10	
5	SAR		< 10	
6	ECw	dS/cm	2	
7	COD	mg/L	50	
12	Boron	mg/L	2	
13	Cadmium	mg/L	0.01	
30	Sulphates	mg/L	500	
31	Chlorides	mg/L	200	
33	Total Phosphorus	mg/L	10	2 mg/L in case of storage
34	Total Nitrogen	mg/L	35	15 mg/L in case of storage
35	Vegetal and animal oils	mg/L	10	
39	Aldehydes	mg/L	0.5	
47	Surfactants	mg/L	0.5	
48	Chlorinated biocides	mg/L	0.01	
50	F. Coli	CFU/100 mL	2	
51	Salmonellae		absent	
52	Helminths		absent	viable eggs

Note: also Al, As, Ba, Be, Cr_{VI}, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, St, Th, V, Zn (beyond B and Cd) are taken into account (parameters 8-27); other considered parameters are THM, CN, SO_3, Benzene, Benzo(a)pyrene, etc.

These standards were clearly stated to face an emergency situation, but in the authors opinion there is a strong doubt about the real effectiveness and the possible management of all those parameters. Moreover some of the considered standards appear quite difficult to be obtained with a reasonable technology.

[4] One of the most important wastewater reclamation plan in Italy was set by Regione Puglia (Apulia): about 20 polishing plants (total gross flow ~ 265,000 m^3/d, roughly 1/3 of the total regional wastewater flow) were planned. One of these plants is Bari-Est: the 1st polishing section (filtration, GAC adsorption and UV disinfection on a 0.2 m^3/s flow) is nearly completed.

[5] These standards are to be considered provisional being set to face local emergency.

- Sicily - Two wastewater reclamation plants for agriculture reuse have been recently approved and financed at Palermo and Gela, operating on the effluents of the biological treatment plants. The work on the first section (320 L/s) of the Palermo reclamation plant are expected to begin this year and the plant will be completed by the end of 1999 to be linked with the existing water distribution system (to be completed). The polishing train is: clari-flocculation, filtration, UV disinfection, Cl_2O final disinfection. The Gela water reclamation plant will polish the treated wastewater of 2 WWTPs and serve an irrigation area of 2,000 ha using also a 5,000,000 m^3 storage basin. The need for water is extremely high in this area: drinking water is produced by seawater desalination.
- Sarno area - A great part of the Italian tomato processing industry is located in this area, where the Sarno river displays an extremely low summer flow (< 3 m^3/s); in the same period wastewater coming from tomato processing industries and reaching the river have an average flow of about 6 m^3/s. To solve the problem a water restoration plan is in progress: the project is based on a rationalisation of industrial water uses (from the present 15 Mm^3, during the 40 days production cycle, to 9 Mm^3/cycle), on 6 new WWTPs for urban and industrial wastewater and on the reclamation for irrigation.
- Prato - The Prato plant, the first example in Italy of an integrated industrial reclamation programme, is the result of a quite peculiar situation based on the presence of a great deal of industries working in the same productive sector (textile), on the existence of new industrial areas equipped with all the basic facilities and, obviously, on a lack of water resources. The reclamation plant that began to operate in 1990 was recently upgraded (the present reclamation train is based on ozonation, contact filtration and biological carbon adsorption) and, beginning from the summer 1998, Prato's industries (in the new industrial areas and in the town itself) will be able to get a 7.7 Mm^3/y flow, half coming from the reclaimed municipal wastewater and half from the Bisenzio river. An equal flow of treated and disinfected wastewater from the Baciacavallo WWTP will be diverted to the river to maintain water balance in the Bisenzio river.
- Other Regions - Some other reclamation activities and programmes are current. For instance the Sardinian Regional Plan provides, mainly for irrigation, thirteen reclamation plants: one of them is finished and four others were granted. Some wastewater reclamation in agriculture is done in Emilia-Romagna: an example can be the Basso Rubicone plant where part of the effluent is reclaimed (biological treatment followed by filtration and NaClO disinfection) for orchards irrigation (400 ha). At Piombino (Tuscany) 10,000 m^3/d of the municipal WWTP effluent is reused in the steel industry after flotation, filtration and disinfection.

ACKNOWLEDGEMENTS

Authors wish to thank gratefully, among others, Dr. A. Lopez (CNR-IRSA, Bari) and Dr. S. Pazienza (Regione Sicilia).

REFERENCES

ISTAT (1996). Statistiche ambientali. Supplemento all'Annuario Statistico Italiano, *Istituto Centrale di Statistica*, Roma.

Liberti, L. and Lopez, A. (1991). Strategy for agriculture wastewater reuse in Southern Italy, *Desalination*, **83**, 173-182.

Ministero dell'Ambiente (1997). Relazione sullo stato dell'ambiente, *Istituto Poligrafico e Zecca dello Stato*, Roma.

Mezzanotte, V. (1995). Analisi di fosforo e boro in alcuni impianti di depurazione urbani. *Inquinamento*, **37**(7), 40-45.

Nurizzo, C., Vismara, R., Mezzanotte, V. and Butelli, P. (1989). Trattamenti per il reimpiego irriguo di liquami depurati. *Quaderni di Ingegneria Ambientale*, n. 10, Milano.

Nurizzo, C. and Mezzanotte, V. (1994). Legislative, economical and technical aspects of irrigation with reclaimed wastewater in Italy. *Resources, Conservation and Recycling*, **10**, 301-316.

Nurizzo, C., Butelli, P. and Mezzanotte, V. (1995). Low-dose polishing of treated wastewater: pilot plant results. *Proceedings of the 2nd IAWQ International Symposium on Water Reuse*, Iraklio (Greece).

Proaqua (1996). L'impatto sul servizio idrico della Direttiva CEE 91/271, concernente il trattamento delle acque reflue urbane, *Proaqua*, Roma.

Rosti, G., Raffaelli, L. and Raimondi, P. (1997). Finanziamento di interventi prevedibili per affrontare i problemi connessi al sollevamento della falda a Milano. *IGEA* **9**, 61-68.

Rusconi, A. (1994). Acqua: conoscenza su risorsa e utilizzo. Editoriale Verde Ambiente, Roma.

Westcot, D. W. and Ayers, R. S. (1986). Irrigation water quality criteria. In: *Irrigation with reclaimed municipal wastewater: a guidance manual*, Pettygrove G. S. and Asano, T. (eds). Lewis Publishers Inc.