

# Wastewater reuse in Italy

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**Abstract** In many parts of Italy, particularly in the South, it has become ever more difficult to meet the water demand. The recent years of drought and the constant increase of water demand for the civil sector have made irrigation supply more problematic. Wastewater reuse could represent a viable solution to meet water demand. The focus of this paper is on the regulation problems, hampering the development of wastewater reuse for irrigation, and on the potentials for reuse, particularly in Southern Italy. Planned exploitation of municipal wastewater could help meeting the irrigation water demand particularly in Southern Italy, where farmers have been practising uncontrolled wastewater reuse for a long time. In Northern and Central Italy, where available water resources generally meet water needs for different purposes, wastewater reuse could play an important role in controlling the pollution of water bodies. Despite the fact that Italian legislation is extremely strict and outdated, for several years in some regions, such as Sicily, wastewater reuse systems have been in operation; furthermore, several projects of wastewater reuse are currently in progress.

**Keywords** Wastewater; reuse; irrigation; legislation; treatment; storage

## Introduction

In many parts of Italy it has become ever more difficult to meet the water demand both in terms of quantity and/or quality. This is mainly due to expanding municipal services and the general rise in living standards, the development of industry and the cultivation of more profitable irrigated crops.

The increase in water demand is accompanied by a decline in the availability of water resources, caused by the deterioration of the quality of surface and groundwater and the imposition of very restrictive quality standards, especially in the case of potable use. The need to guarantee a “minimum ecological flow” in water courses, recently brought forward by Italian legislation, has led to a further reduction in the availability of water resources and added new constraints on construction and management of water supply, storage and distribution works. In Southern regions of Italy (particularly Sicilia, Sardegna and Puglia) the recent periods of drought and the constant increase of water use for civil purposes has made irrigation supply ever more problematic. Serious shortages of irrigation water have occurred both in areas equipped with collective distribution networks and in those previously supplied with groundwater.

The difficulty in satisfying water demand with conventional resources (e.g. flowing and regulated surface water, groundwater) makes the use of unconventional water resources, such as wastewater, indispensable. Municipal wastewater is potentially the most useable, because of its reliability as supply (only slightly influenced by droughts), their allocation (in inland areas they are often available close to agricultural land), their composition (toxic compounds and salt concentrations are generally tolerable in various land and crop conditions) and the diffusion of treatment plants (imposed by the regulations on effluent disposal).

Agriculture is the largest water-consuming sector in Italy. In fact, it has been evaluated that water consumption is about 50 billions m<sup>3</sup>/y, about 50% is used for irrigation purposes, 20% for industry, 20% for drinking purposes and 10% for other uses (IRSA-CNR, 1999).

The planned exploitation of ever greater amounts of municipal wastewater could help to meet irrigation water demand particularly in Southern Italy, where in inland areas farmers have been practising uncontrolled wastewater reuse for a long time.

In Northern and Central Italy, available water resources generally meet in full water demand from all sectors; however, the pollution of water bodies (both surface and groundwater) has raised problems about water quality. In these regions wastewater reuse could play an important role in controlling the pollution of water bodies, particularly in the Po Basin.

Wastewater reuse could easily become a common practice in Southern Italy; however, current legislation is extremely strict and does not take into account the achievements of research activity carried out all over the world and particularly in Mediterranean areas in the field of wastewater reuse.

### Legislation

In Italy the law n.152 issued on 11 May 1999 by Minister of Environment has totally revised the regulations concerning wastewater treatment and disposal and the law n. 319/76 (called the “Merli law”) has been repealed. At the moment reuse of municipal wastewater for irrigation is regulated by Annex 5 of a resolution of the National Interministry Committee for the Protection of Waters from Pollution (CITAI, 1977) (but in the next months the regulatory framework should be fully changed). Wastewater reuse is considered only in the form of discharge on soil for agricultural purposes and is allowed only if wastewater addition can increase crop production. Specific restrictions are imposed on wastewater quality: the upper limit for SAR is set to 15, with a maximum of 10 being recommended. The presence of total coliforms in wastewater for irrigation is accepted at very low levels depending on the use of agricultural products (see Table 1). No limits are set for the concentration of toxic, poisonous or bioaccumable substances, but a specific evaluation is required of the annual volume of wastewater that can be applied depending on soil and crop type.

It is required that environmental impact of the reuse system be assessed. In particular, the qualitative characteristics of wastewater and water bodies as well as the physical–chemical characteristics of soil must be monitored.

The current law require also that the areas irrigated with wastewater be marked with signs warning for health hazards, that access to the irrigated area be restricted and that the irrigated area be surrounded by a buffer strip of at least 80 m with no buildings or roads, regardless of the quality of the wastewater and the irrigation methods. It is evident that Italian legislation is outdated when it is considered that, in many countries throughout the world, treated wastewater is used even for the irrigation of public areas like parks. Moreover, it is difficult to understand why buffer zones exist for irrigation with wastewater but not, for example, for discharge into surface water bodies.

**Table 1** Microbiological standards for irrigation with municipal wastewater: comparison of regional guidelines with national standards (Italian Water Protection Act, Annex 5) and WHO guidelines

	Total Coliforms (MPN/100 ml) <sup>(1)</sup>	Faecal Coliforms (MPN/100 ml)	Faecal Streptococci (MPN/100 ml)	Nematode eggs (number/l)
WHO	not set	1000 <sup>(2)</sup>	not set	1
Italy	2 <sup>(2)</sup> , 20 <sup>(3)</sup>	not set	not set	not set
Sicilia	3000 <sup>(2)</sup>	1000 <sup>(2)</sup>	not set	1
Emilia Romagna	2 <sup>(2)</sup> , 20 <sup>(3)</sup>	not set	not set	not set
Puglia	2 <sup>(2)</sup> , 10 <sup>(3)</sup>	not set	not set	absent

(1) mean value of 7 consecutive sampling days; (2) unrestricted irrigation; (3) restricted irrigation

In Italy current legislation represents one of the major obstacles in the development of irrigation with municipal wastewater. Microbiological restrictions are excessive if compared with guidelines issued by the World Health Organization (WHO, 1989). On the other hand, Italian legislation includes wastewater quality standards which are frequently disregarded in the case of surface water used for agriculture and recreational purposes (Indelicato et al., 1996). The approach is very restrictive if we consider that national water standards for bathing allow 2,000 MPN/100 ml of total coliforms (2 order of magnitude above the limits prescribed for unrestricted wastewater reuse) and 100 MPN/100 ml of faecal coliforms.

To encourage the reuse of municipal wastewater some Regional Authorities (Sicilia, Emilia Romagna and Puglia) have issued regional guidelines for the realisation of reuse systems. In Table 1 regional microbiological standards for irrigation (which are the most discussed and not unanimously accepted) are compared to national and WHO standards; the different approach used by each region is evident: nearly WHO guidelines for Sicilian standards, more strictly linked to national standards for Puglia and Emilia Romagna. Probably Sicilian guidelines are the most articulated and scientifically based; for instance, level of wastewater treatment, type of crops and irrigation methods affect the prescribed limits. However, in this region very few projects have been authorized, even though in inland areas wastewater reuse is a well established practice.

The need for a new, simple and realistic regulation for wastewater reuse is unanimously recognised (Indelicato *et al.*, 1996) and this necessity has been further confirmed by a law issued in 1994 for the reorganisation of water services and more recently by law 152/99. This law has been issued in agreement to the European directive 91/271/EEC concerning wastewater treatment and discharge. Among others in this law, an inter-ministry committee (Ministries of Environment, Health, Agriculture, Industry, Public Works) has been given the task of setting technical norms for wastewater reuse; these norms should be issued before the end of 2001.

There is much controversy about wastewater reuse standards. There are two main points of view. The first one supports the adoption of WHO standard, the second advocates the adoption of very stringent standards. However, feasibility of wastewater reuse, especially in Southern Italy, is strictly linked to the economic aspects, as too restrictive standards would lead to unsustainable treatment costs. For instance, the concentration of trace elements in municipal wastewater is generally very low (Bonomo *et al.*, 1999), so it is not of primary interest to set specific standards for these elements. More attention should be addressed for boron, particularly for irrigation of sensitive crops (i.e. citrus fruits). In fact, several surveys have detected boron concentrations up to 1.5–2 mg/l on urban wastewaters (Mezzanotte, 1995).

Because rumours have been circulating for the past few years that current regulations are about to be updated, officials of control boards, in charge of reuse project evaluation and authorizations, have been rejecting applications to use wastewater (made mostly by farmers' associations). Consequently, in many part of Italy farmers use wastewater without authorization, both as a regular supply source and as a mean to mitigate drought effects. In some cases wastewater discharge into water bodies causes more serious environmental damage than control boards expect from reuse practices.

### Perspectives of wastewater reuse

In spite of the aforementioned problems posed by current legislative constraints, relevant perspectives for the development of irrigation with municipal wastewater exist in Italy, mainly linked to:

- the high amount of water resources used for civil purposes;

- the availability of sewage networks and treatment plants;
- the existence of a gap between irrigation water availability and demand.

The overall amount of useable municipal wastewater is obviously connected to the amount of water used for civil purposes. In Italy, the annual withdrawal of water amounts to 10 billion m<sup>3</sup> (IRSA-CNR, 1999), with only about 7 billion m<sup>3</sup> of it actually being used, assuming average losses around 27%. If these figures are taken as baselines, assuming that 30–40% of delivered water for municipalities can be reused, it should be possible to recover between 150 and 200 million m<sup>3</sup> in Sicilia and Puglia and about 100 million m<sup>3</sup> in Sardegna, being those the regions where the gap between irrigation water demand and water delivery is particularly severe.

The high number of wastewater treatment plants (WWTPs) is another relevant factor for the development of reuse as it ensures, at least potentially, the availability of wastewater suitable for various crop species and irrigation methods. In Table 2 the number of WWTPs in Italy (in operation, not in operation and under construction) and the number of equivalent inhabitants, according to a survey conducted by ISTAT (1996), are reported for each Italian regions. A total of 9806 WWTPs have been built and additional 1412 are under construction. About 13% of the existing WWTPs is not in operation (80% is constituted by plants of less than 5,000 E.I.), due to management problems very frequent in small and average size municipalities.

In Table 3 the number of WWTPs in operation as function of treatment level (primary, secondary and tertiary) is reported according to their geographical distribution: Northern Italy (Piemonte, Valle d'Aosta, Lombardia, Trentino-Alto Adige, Friuli Venezia-Giulia, Veneto, Emilia Romagna, Liguria); Central Italy (Toscana, Umbria, Marche and Lazio); Southern Italy (Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna). More than 55% of the constructed plants run at least a secondary treatment (generally activated sludges or trickling filters).

**Table 2** Distribution of area, population, number of municipal WWTPs and E.I. in Italy (ISTAT, 1996)

Regions	Area (km <sup>2</sup> )	Population (Inhabitants)	Wastewater treatment plants					
			In operation		Not in operation		Under construction	
			Number	E.I.	Number	E.I.	Number	E.I.
Piemonte	25,399	4,306,565	1,677	5,591,315	130	142,153	237	406,405
Valle D'Aosta	3,264	118,239	142	221,844	4	560	9	16,067
Lombardia	23,859	8,901,023	815	7,284,048	72	536,234	68	4,195,373
Trentino-Alto Adige	13,607	903,598	267	1,259,378	16	11,852	56	1,241,016
Veneto	18,364	4,415,309	726	5,409,191	72	71,667	50	450,092
Friuli-Venezia Giulia	7,844	1,193,217	474	1,471,904	46	46,640	49	104,767
Liguria	5,420	1,662,658	392	2,091,332	44	242,143	70	658,850
Emilia-Romagna	22,124	3,924,348	1,146	5,712,838	45	78,000	73	416,931
Toscana	22,993	3,528,225	530	6,262,106	44	94,917	115	705,090
Umbria	8,456	819,172	238	497,175	75	57,652	35	93,715
Marche	9,694	1,438,223	386	1,204,027	47	126,900	61	132,245
Lazio	17,014	5,185,316	341	4,049,293	76	710,456	114	796,213
Abruzzo	10,795	1,262,948	310	896,607	68	188,846	96	141,278
Molise	4,438	331,990	77	189,284	19	29,522	63	83,555
Campania	13,595	5,708,657	204	5,380,499	100	432,271	86	3,166,230
Puglia	19,361	4,065,603	170	5,320,966	11	59,224	11	183,899
Basilicata	9,992	611,155	67	423,482	62	146,386	24	50,124
Calabria	15,080	2,079,588	168	1,569,050	167	413,659	76	177,647
Sicilia	25,707	5,025,280	151	2,093,319	96	514,177	81	1,567,343
Sardegna	24,090	1,657,356	289	1,224,940	42	120,625	38	197,855
Total	301,096	57,138,470	8,570	58,152,598	1,236	4,023,884	1,412	14,784,695

E.I. = Equivalent Inhabitants

Extensive treatment processes such as stabilization ponds are generally not considered among the possible options, despite the fact that these simple and low-cost treatment plants should be particularly attractive to small and medium communities in Southern Italy. In these regions, where the land cost is low (particularly in inland areas) and climatic conditions are very favourable, extensive processes should be implemented as an integrative measure for the largest WWTPS (particularly to achieve more stringent microbiological standards) or alternative measures for small and medium communities, generally affected by management problems. (The law n.152/99 suggests, for less than 2,000 E.I., the treatment of municipal wastewater by lagooning or constructed wetlands.)

In Table 4 the number of WWTPs and their E.I. is reported according to the site of disposal. Presently, most public sewers discharge into surface water courses (79.2% WWTPs and 74.4% E.I.); other recipients are the sea (2.1% WWTPS and 16.7% E.I.), lakes (1.3% WWTPs and 2.1% E.I.) or other bodies (17.4% WWTPS and 6.8% E.I.); the latter figure takes into account also discharges into soil and subsoil and thus reused volumes. Moreover, because of a stream regime with low flows (or no flow at all) which characterise several Italian water courses for most of the year, frequently the "natural" water flow, downstream the discharge point of a treatment plant, is mainly constituted by wastewater (treated or raw).

In Southern Italy (particularly Sicilia, Sardegna and Puglia) a significant amount of the wastewater discharged into water courses is already used by farmers especially during the dry season; in some cases they pump percolated wastewater through wells or they divert wastewater from river beds (where the effluent has undergone a limited dilution and natural depuration) or directly from sewage and treatment plant outlets. This aspect could be carefully evaluated because in some cases wastewaters are already used, and to increase the amount of available water resources those wastewaters produced during autumn-winter period must be stored and more attention should be addressed to the reuse of wastewater produced in coastal areas (Barbagallo *et al.*, 1996; 1997).

The high water demand for irrigation favours the development of municipal wastewater reuse. In Southern regions water resources for irrigation are not sufficient to satisfy water demand, even in years considered "normal" from a hydrological viewpoint. Recent drought periods have caused a significant shifting of water resources from the agricultural to the civil sector (particularly in Sicilia, Sardegna and Puglia). It is estimated that in Southern

**Table 3** WWTPs in operation in Italy in function of treatment level (ISTAT, 1996). PT = primary treatment; ST = secondary treatment; TT = tertiary treatment; NC = not classified

	WWTPs in operation				Total
	PT	ST	TT	NC	
Northern Italy	2,877	2,461	242	60	5,640
Central Italy	488	879	108	20	1,495
Southern Italy	327	985	100	23	1,435
Total Italy	3,692	4,325	450	103	8,570

**Table 4** WWTPs and E.I. according the site of disposal (ISTAT, 1996). WWTPs = Wastewater treatment plants; E.I. = equivalent inhabitants

	River		Sea		Lake		Others	
	WWTPs	E.I.	WWTPs	E.I.	WWTPs	E.I.	WWTPs	E.I.
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Northern Italy	81.5	84.3	0.8	6.3	1.5	1.1	16.2	8.3
Central Italy	77.6	90.6	1.8	6.2	1.0	0.2	19.6	3.0
Southern Italy	74.3	49.3	5.9	38.9	1.0	4.7	18.8	7.1
Total Italy	79.2	74.4	2.1	16.7	1.3	2.1	17.4	6.8

Italy, out of 780,000 hectares equipped with collective distribution networks, no more than 50% are currently irrigated (Leone, 1996); the low value of the ratio between the irrigated area and the irrigable area is indicative of the lack of useable water resources. The deficient and unreliable supply of irrigation water, besides damaging production in most years, has strongly limited irrigation development. The lack of water resources for irrigation is considered one of the main limiting factors in competitiveness of agriculture in Southern Italy.

Wastewater reuse potential is thus high in Southern Italy, where, owing to scarcity of stream flows in the irrigation season, water is mainly supplied from large reservoirs. Wastewater could be used in areas already equipped with collective distribution networks or to irrigate fields near developed areas presently served with conventional waters.

In Northern Italy, due to the presence of perennial watercourses, the agricultural reuse of municipal wastewater can play a major role mainly in controlling pollution of water bodies. Particularly, Emilia Romagna Region has promoted the wastewater reuse of the coastal towns as a mean to control the eutrophication of the Adriatic Sea.

### Wastewater reuse projects

In Italy wastewater reuse is mainly geared toward agricultural irrigation, even if some projects concern industrial reuse and landscape irrigation. In the last years several wastewater reuse systems have been implemented not only in arid and semi-arid regions of Southern Italy, but also in Northern Italy (Emilia Romagna, Valle d' Aosta, Veneto), where available water resources generally meet water demand for different uses.

Since the 1970s water-planning studies have been carried out for various Italian regions including Sicilia, Calabria and Emilia Romagna (Tecneco, 1977; Idroser, 1978; S.I.R.I., 1979). Some of these plans have raised objections because of the relevant works required, the elevated costs of construction and the optimistic forecasts of wastewater availability. Recently according to a survey carried out by CSEI-Catania in 1998 with the support of the Ministry of Agriculture, 16 wastewater reuse systems for irrigation purposes have been selected for a prompt implementation in Sicilia, Puglia and Sardegna.

In Valle d' Aosta the municipal wastewater reuse system of St. Christophe-Aosta-Quart (148,000 E.I.) will be in operation by the end of 2000. The treated wastewater (32,600 m<sup>3</sup>/day) will mainly be used for landscape irrigation and fire-protection.

In the Autonomous Province of Bolzano, even though water resources availability matches water demand, there is an increasing interest in wastewater reuse. Recently, two small reuse systems have been designed: Appiano (1,250 E.I.) and Verano (1,200 E.I.).

In Veneto the wastewater reuse project (wastewater flow rate about 70 l/s) of Rosalina Mare (Province of Rovigo) has been designed for landscape and agricultural irrigation (30% and 70% of available flow, respectively).

In Emilia Romagna, mainly in the coastal areas, there are many cases of the programmed utilisation of the municipal treated wastewater for irrigation and environmental protection purposes. The largest wastewater reuse system (Basso Rubicone treatment plant, 1250 m<sup>3</sup>/day) covers an area of about 400 hectares for orchard irrigation (Angelakis *et al.*, 1998).

In Toscana there are two important examples of wastewater reuse for industrial water supply. In Piombino the municipal treated wastewaters (10,000 m<sup>3</sup>/day) are reused for the cooling in the steel industry. In Prato, in the textile industrial district, about 11,000 m<sup>3</sup>/day of municipal treated wastewater are used for industrial processing (Bonomo *et al.*, 1999).

The regional governments of Abruzzo and Basilicata have recently included norms concerning wastewater reuse in their regional regulations regarding water resources management (Abruzzo) and reclamation water plan (Basilicata); however, no reuse systems have yet been designed.

In the Sarno area (Campania), within a reclamation project of the river basin, 6 new plants will be constructed for treatment of municipal and industrial (agro-food) wastewater. The treated wastewater will be used for irrigation purposes (mainly tomatoes).

In the Salento area (Puglia), where the lack of water resources is coupled with the organic pollution of groundwaters, about 16,000 m<sup>3</sup>/day (about 100,000 E.I.) of treated wastewater (biological treatment plus final filtration) are about to be made available for irrigation.

In Sardegna, as a result of the lack of water resources exacerbated by the droughts of 1990 and 1995, a state of emergency was declared in 1995 and the Italian government drew up a programme for financial provision by the State and local government authorities with the aim of reducing, at least in part, the serious water shortage. Amongst others, wastewater reuse was considered one of the key-actions to face the water supply emergency. Within the framework of a local government programme and EU funded actions, a new wastewater reclamation scheme is actually implemented for using directly the effluent produced by the "Is Arenas" plant which serves the city of Cagliari and its suburbs. The treated wastewater volume is 35 Mm<sup>3</sup> per year, with a short-term forecast of 60 Mm<sup>3</sup>. The reuse scheme includes both direct reuse for agricultural purposes and intermediate storage in reservoirs with further treatment before agricultural irrigation. In Villasimius (province of Cagliari) wastewaters of tertiary treatment plant will be soon available for irrigation of about 200 hectares.

In Sicilia, where the experiences of uncontrolled wastewater reuse are so common, for several years treated wastewater of Grammichele (about 1,500 m<sup>3</sup>/day), a small rural town located in Eastern Sicily (district of Catania), have been used for the irrigation of citrus orchards. Several municipalities (such as Caltagirone, Mineo, S.Michele di Ganzaria, etc.) close to Grammichele have planned to reuse municipal wastewater in order to meet the increasing water demand for agricultural purposes. Recently the Sicilian Government has authorized and financed, with the support of the European Union, the wastewater reuse projects of Palermo (in a first stage about 28,000 m<sup>3</sup>/day of treated wastewater will be soon available) and Gela (where the 2 WWTPs will be integrated with storage reservoirs for a total capacity of 5 million m<sup>3</sup>). In both cases the treated wastewater will be used for agricultural irrigation of several thousand hectares.

## Conclusions

In Italy wastewater reuse for agricultural purposes (and more recently landscape irrigation) is the most attractive option between different reuse applications. However, the controlled reuse of municipal wastewater in agriculture has not been yet developed in most Italian regions. The rationalisation of existing cases of agricultural reuse and the development of irrigation practices require revision of current legislation. More realistic norms should be issued, based on the findings of recent research work and experiences of uncontrolled reuse so common in inland areas of Southern Italy.

In Italy the increasing interest in wastewater reuse is mainly focused on controlling the pollution of water bodies in Northern and Central regions, while in Southern regions wastewater reuse could play an important role to reduce the gap of water supply particularly in agricultural sector. However in Southern Italy (particularly in Sicily, Sardegna and Puglia) the development of irrigation with wastewater is mainly linked to the use of treated municipal wastewater produced by large coastal towns and storage of municipal wastewater produced outside the irrigation season, especially in inland areas.

Experimental tests on wastewater storage so far conducted in Sicily confirmed the presence of positive environmental effects and highlighted the feasibility of the seasonal regulation as a wide-scale practice. In the light of the above considerations, it would seem that

wastewater storage could be a realistic way of increasing water resources for irrigation. Moreover, this practice could be used in the stabilization of wastewater. Thus it would be advisable to encourage, especially in the case of effluents produced in small rural communities, winter storage of wastewater in small reservoirs, as an alternative or integral basic maintenance measure for conventional treatment plants at low cost.

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