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NON-CONVENTIONAL WATER USE IN THE CONSORZIO DI BONIFICA OF CAPITANATA (APULIA – ITALY): WASTEWATER AND BRACKISH WATER

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INTRODUCTION

Wastewater flow in the drainage network of Capitanata area (northern Apulia) is a quite recent phenomenon. Until the 70's and the 80's, when drinking water was made available to the inhabitants of Capitanata province on regular basis, the amount of wastewater discharged into watercourses was extremely low.

Until 1974, drinking water to the province of Foggia was almost exclusively supplied through the water system of Sele river and few wells. Some municipalities of the Sub-Appennine area still receive water from the supply water system of Molise region. Later, the drinking water systems of Fortore and Gargano replaced the Sele water system.

The water flow diverted from Sele river in Upper Irpinia could only supply low daily water volumes, on a discontinuous basis and for few hours a day. People had to queue at the public drinking fountains to have their vessels filled with water.

In the 70's, the drinking water supply system was completed, but sewage networks were not. Numerous quarters of towns and villages were not equipped with adequate sewage system and unregulated waste flows reached natural uncontrolled stream beds.

Later, the former Southern Italy Development Fund financed the pollution abatement project of the gulf of Manfredonia through regional government funds, and additional works of drinking and sewage system works were constructed to equip the built areas with collective sewage systems and this resulted in increasing and sometimes really huge amount of wastewaters being discharged into watercourses.

HYDROGRAPHIC NETWORK – ESTIMATE OF WASTE WATERS VOLUMES

The Apulian Drinking Water Supply Authority – *AQP – Aquedotto Pugliese* – withdraws more than 60 million cubic meters of water from the hydraulic node of Capitanata. After potabilization the water is delivered to the towns of Capitanata area.

Wastewater flow to the sewage network is estimated to be equal to 80%. Wastewaters discharged to the water streams are estimated to amount to about 48 million cubic meters, 42 million of which flow in the plain water courses, of the Consorzio di Bonifica Scheme, and the remaining 6 million m^3 difference falls within the hydrographic network of Gargano.

All municipalities are equipped with treatment plants that abate pollution in a percentage varying from 30 to 40%. Very few municipalities started being equipped with wastewater treatment plants having adequate characteristics for re-use and complying with the parameters set out in the laws in force.

WASTEWATER AMOUNTS

At present, in the province of Foggia, municipal wastewaters from treatment plants are almost totally released in the sewage network managed by the *Consorzio*.

Considering only large towns, the amounts of waste water discharged into the sewage network, and thus the amount of water that could be recycled, are summarized as follows.

Table 1. Discharged wastewater into the sewage network

City	Amount (m^3/year)
Large towns	
Foggia	15,000,000
San Severo – Torremaggiore	4,500,000
Lucera	2,500,000
Cerignola	3,500,000
Manfredonia	3,500,000
Total	29,000,000
Medium-size municipalities	
Apricena	800,000
S.Ferdinando di Puglia	1,100,000
S.Marco in Lamis	800,000
San Giovanni Rotondo	1,500,000
Ortanova – Stornarella	1,500,000
Trinitapoli	1,000,000
Total	6,700,000

The amounts released from small towns are globally equal to 7,000,000 m^3/year

Such waters generally have constant discharge, with fluctuations solely related to winter-summer seasonal consumption.

USE OF WASTEWATERS

A distinction of treated wastewaters is made in terms of purpose and period of use:

a) Agriculture
    1. Irrigation period (April-November): if waters are adequate for use, they can be delivered injecting them directly into the network;
    2. Off-irrigation period (December-March): stored in basins or tanks, or directly discharged into the watercourses.

b) Industry
    1. Directly and continuously injected into the network and delivered to the users throughout the year.
    2. Partially stored in basins or tanks for being used in the irrigation periods or directly discharged into the watercourses.

TYPES OF TREATMENT PLANTS

At present, the most widely spread technique is the physical-chemical treatment whereby suspended and non-sedimentable particles are eliminated through physical-chemical processes and subsequent sedimentation, filtration, sludge disposal, disposal into canals and water streams.

A natural treatment technique based on natural biological processes, referred to as lagooning, is being established. This method doesn't need any special technology but simply a basin where water accumulates for a given period of time in the presence of adequate plant species.

PIPED NETWORK, RECOVERY AND USE

All the plain sites of the Consortium scheme where treatment plants are located or are going to, fall within the areas equipped with irrigation systems or in neighbouring areas. Therefore, the problem of capture, storage and distribution networks of treated waters can be solved through inexpensive connections or works: basins, conveyance pipes, lifting stations.

To date, plants for the reuse of treated wastewater (secondary treatment) have been implemented at almost all the large towns (Cerignola, Foggia, San Severo and Lucera) as well as at a medium-size municipality (Trinitapoli). In the short run, other plants could be implemented at the remaining large town (Manfredonia) and other medium-size municipalities (S.Giovanni Rotondo, and Ortanova-Stornarella).

No lagooning treatment plant is presently available.

TREATED WASTEWATER FOR IRRIGATION

Based on the state of the art on the use of treated wastewaters, reasonable forecasts for the short or medium term use of these waters for the following plants are possible.

Foggia

The treatment plant has a capacity to treat about 15,000,000 m^3 per year; treated wastewater will be used for agriculture and industry; the following works are required:

- adaptation of the lifting plant;
- conveyance pipe from the treatment plant to the distribution plant;
- waters could possibly be stored in the dam reservoir on Celone stream.

Lucera

The built-up area of Lucera is equipped with 2 treatment plants:

- Lucera 1: it discharges into a small right affluent of Salsola stream;
- Lucera 2: it discharges directly into Salsola stream.

A sound use of the treated water forecasts the following works:

- a pipe for conveying waste waters of the plant of Lucera 1 to the plant of Lucera 2;
- basin to store treated waste waters of the two double-purpose plants;
- supply network to district 5A- Fortore;
- storage of waters, through the existing conveyance pipe, in dam reservoir on Celone stream, where the quality characteristics of waters are compatible.

San Giovanni Rotondo

The treatment plant of the municipality of S.Giovanni Rotondo discharges into Vallone Asinara and subsequently in Candelaro stream. A sound use foresees the implementation of the following works:

- intake work situated in Vallone dell'Asinara;
- conveyance pipe at Monte Aquilone;
- storage basin;
- connection with the irrigation network.

Treated water could be used in agriculture and industry. The required budget, for implementing such works, is estimated to be equal to € 6.000.000, the scheduled execution time is 18 months.

San Severo

The treatment plant discharges in Venolo canal. A sound use foresees the implementation of the following works:

- a lifting plant;
- corresponding conveyance pipes to the irrigation network.

The treated water will be used in agriculture.

Manfredonia

The purification plant is situated at Palude Frattarolo and it discharges into Candelabro stream. A sound use foresees the implementation of the following works:

- intake work situated in Candelabro stream;
- conveyance pipe at Monte Aquilone;
- storage basin.

Treated water could be used in agriculture and industry.

Trinitapoli

The treatment plant situated at Castello, in a municipal area close to salt-pans of Margherita di Savoia, will allow treating the municipal waste waters that otherwise would flow to the mouth Carmosina. The works required for its use consist in implementing:

- a storage basin;
- a conveyance pipe to the irrigation network;
- a lifting plant;
- an irrigation sub-scheme.

Treated waters could be used in agriculture in areas that are not yet served by the collective irrigation system and whose works are still ongoing. For such system, in the years 2004-2005 experimental studies have been done on old equipped areas and results are encouraging.

Cerignola

The treatment plant is located in the northern periphery of the town, downstream the purification plant whose treated waste waters are discharged into Fosso Pila canal. The plant for the use of wastewaters is composed of:

- lifting plant starting from since the delivery of treated waters;
- storage basin;
- irrigation network.

The volumes that are not used in winter months should be stored in the basin of Trinitapoli plant.

OPERATIONAL ORGANIZATION

Treatment plants include operations of management and maintenance for;

- hydraulic parts;
- electromechanical components;
- buildings;
- analysis of inflow and outflow waste waters of the plant;
- disposal of solid residues and sludge.

As for the first three activities, at present, the Consortium has both knowledge and operational organization to manage such types of plants, be them technological or engineering or natural lagooning. As for the analysis and monitoring, having a minor economic importance, they imply consulting an analyst or, alternatively, agreements could be signed with specialized laboratories.

STORAGE

The treated waste waters are known to have a constant seasonal hydrological regime, varying in discharge only between winter and summer.

During the irrigation period April-October, wastewaters, if adequate, could be immediately injected into the network, whereas in winter period, November-March, waters have to be stored. The distribution of the plants on the territory is such that wastewaters could be stored in already existing plants. Should it not be possible, storage could be made at appropriate sites with costs estimated to be of few tens of million euros.

OBJECTIVE OF THE EXPERIMENTATION

The objectives of the wastewaters experimentation can be summarized by the assessment of the following parameters:

- risk and degree of contamination related to the irrigation method used;
- sanitation risks on agricultural produce related to the operation of the irrigation systems;
- sanitation risks related to natural decay of faecal pathogens on agricultural products;
- short-term effects on the physical-chemical characteristics of the soil through monitoring a number of parameters (boron, Ph, electrical conductivity, calcium, magnesium, sodium, chlorides, heavy metals, etc.) in the soil saturated extract and after the irrigation season;
- possible supply of nutrients to the soil.

EXPERIMENTATION

The Decree no. 191/02 of the delegate Commissioner for environmental emergency in Apulia and the decree of the Ministry for Environment no. 185/03, set out the technical regulations and the threshold values of acceptability of the chemical-physical and microbiological parameters for treated waste waters to be reused for irrigation.

In the irrigation season 2004, in the light of the new regulation on this matter the Consortium has implemented the experimentation in irrigation district no. 17 of the Scheme Sinistra Ofanto, to assess the possibility of using in irrigation the municipal waste waters usually treated through the purification plant of the Municipality of Trinitapoli, without additional treatment processes.

Close to the treatment plant, the Consortium has installed a lifting plant equipped with a reinforced concrete stilling basin of a capacity of about 1,200 m^3 and a pumping station with 5 horizontal-axis electrical pumps, one of which as standby, of an average single discharge of 50 l/s and a total manometric head of approximately 45 m .

The territory subject to experimentation, of 480 ha, is located in the area of Trinitapoli between the Foggia - Bari railway line and the basins of the stated-owned salt-pans. Irrigation parameters taken as a basis for designing the main pipe and the distribution network are equal to those used for the remaining part of the Scheme and summarized in the following:

- net water supply to the Agricultural Area: 2 000 m^3/ha
- peak continuous discharge on the A.A.: 0.20 l/sec.ha
- peak discharge 16/24 hours on A.A.: 0.30 l/sec.ha
- basic module: 5.00 l/sec

The irrigation district is subdivided into 5 Sectors that represent the territorial units served by the distribution network. The following table gives the cropping pattern during the irrigation campaign 2004.

Table 2. Cropping pattern during the irrigation campaign 2004

Crop type	Surface (ha)	% incidence on total area
Sown land	211	44
Vineyard	116	24.2
Olive orchards	94	19.6
Artichokes	31	6.5
Peach orchard	14	2.9
Almond orchard	2	0.4
Tomato	2	0.4
Vegetables	10	2.1

Total area is equal to 480 ha with n° 101 users.

Analysing the crop distribution in each single sector, it is found that vineyard, olive orchards and sown lands are more present.

The table below reports the surfaces effectively irrigated with wastewaters in the course of the experimentation 2004.

Table 3. Areas irrigated with treated wastewater

Crops	Surface of sectors in ha					Total
	1	2	3	4	5	Ha
Olive orchard	18	5	0	6	7	36
Vineyard	24	21	3	8	6	62
Artichokes	1	0	12.5	0	0.5	14
Peach orchard	1	1	0	0	0	2
Almond orchard	0	0	0	0	0	0
Vegetables	0	0	0	0	0	0
Tomato	0	0	0	0	0	0
Total	44	27	15.5	14	13.5	114

From the table, it is inferred that olive trees, vineyard, peach trees and artichokes are the crops that received at least one irrigation with unconventional waters. The total volume supplied during the 53 days of effective distribution of water was equal to 67.5 m^3 as illustrated in the following table for each single sector.

Table 4. Irrigated areas with wastewater and supplied water

Sectors	1		2		3		4		5	
	Area (ha)	TWW volume (m^3)	Area (ha)	TWW volume (m^3)	Area (ha)	TWW volume (m^3)	Area (ha)	TWW volume (m^3)	Area (ha)	TWW volume (m^3)
Olive orchard	18	11	5	3	0	0	6	5	7	8.5
Vineyard	24	9	21	10	3	1.5	8	6	6	4
Artichoke	1	0.5	0	0	12.5	6.5	0	0	0.5	1
Peach orchard	1	0.5	1	1	0	0	0	0	0	0
Almond trees	0	0	0	0	0	0	0	0	0	0
Vegetables	0	0	0	0	0	0	0	0	0	0
Tomato	0	0	0	0	0	0	0	0	0	0
Total	44	21	27	14	15.5	8	14	11	13.5	13.5

Out of 67.5 cubic meters distributed, 41% and 45% were supplied to olive trees and vineyard respectively, the remaining part, equal to 14%, to artichoke and some peach orchards.

RESULTS

From the analysis of the data obtained in the experimentation on the reuse of treated waste waters for irrigation, using the effluent of the purification plant of municipal waste waters of the Municipality of Trinitapoli and based on the chemical-physical parameters, the following was found:

- The investigated effluent showed to have better characteristics than underground waters; it caused no pollution or degradation neither of the soil nor of groundwater; and it didn't exhibit any dangerous pollutant, like pesticides, solvents and heavy metals.
- The B.O.D and C.O.D values were up to the standard according to the parameters set out in the MD. 185/03

As for the microbiological parameters it was observed:

- The presence of bacteria, as expected, in groundwater, in soils and even sporadically on the fruit surface; although, in the latter case, it was found that their presence was not due to the use of treated water, but certainly to external agents that conveyed the polluting microbial flora.

It was also observed that:

- For the continuity of the process, it is extremely important for the inflowing wastewaters to the treatment plant to be exclusively those coming from sewage, since rainfall waters, when conveyed together with the waste waters towards the treatment plant – as in the case of the drainage network of the municipality of Trinitapoli - interrupt the purification process that, once restarted, requires no less than 2 days to keep again the contamination parameters within the limits set out by law to supply the scheme irrigation systems after the end of the rainfall event.
- If a single pipe conveys wastewaters and rainfall waters towards the treatment plant, and in order to prevent the risk of injecting raw wastewaters, a device is required to promptly prevent untreated waters from entering the network. In fact, because of excessive flows to the treatment plant, waters are conveyed untreated into the irrigation network which engender completely skipping the purification step. In our case, in the compensation basin at the upstream end of the treatment plant of Trinitapoli, an electrical float connected to a switch of boosting pumps at the head of the scheme distribution network was installed in order to stop the pumps when the level of liquid in the said basin is close to the level at which the by-pass is situated.

CONCLUSIONS

The effluent from the treatment plant of the municipality of Trinitapoli was adequate for being used in irrigation. Nevertheless, it was observed that for making management easier, it is recommended to slightly elevate the threshold of some parameters as specified below:

- The B.O.D.5 threshold should be raised to 40 mgO_2/l;
- The threshold of suspended solids concentration should be raised from 10 to 20 mg/l ;
- The threshold of admissible active chlorine concentration at the outlet of the recovery plant should be raised to 0.4 mg Cl/l.