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ЕВРОПЕЙСКОЕ РЕГИОНАЛЬНОЕ БЮРО

Drinking-Water Supply in Arid Areas

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WASTEWATER REUSE FOR AGRICULTURAL IRRIGATION AND GROUNDWATER RECHARGE

Report on a visit to Spain

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CONTENTS

	<u>Page</u>
1. Purpose of the visit	1
2. Background	1
2.1 Wastewater reuse for agricultural and landscape irrigation	1
2.2 Wastewater reuse for groundwater recharge	2
3. Findings	2
3.1 Assessment of agricultural irrigation and groundwater pollution	2
3.2 Assessment of groundwater recharge to prevent seawater intrusion	3
3.3 Technology transfer and training of national staff	4
4. Recommendations	5
5. Acknowledgements	5
Annex 1 Programme of the visit	7
Annex 2 Summary of recommendations	9

INDEX: WATER
EURODOC: 1210

1. Purpose of the visit

- To assess problems related to the reuse of wastewater for agricultural purposes;
- to assess problems related to the protection of groundwater sources;
- to assess problems of seawater intrusion in groundwater in the coastal areas;
- to assess problems of increased nitrate concentration in water sources;
- to provide technical assistance in planning future WHO/EURO programmes for the Autonomous Government of Valencia;
- to advise on the planning of WHO/EURO fellowships to train national staff for activities related to the International Drinking Water Supply and Sanitation Decade (IDWSSD).

For the programme of the visit, see Annex 1.

2. Background

The degree of wastewater treatment and the operational reliability required depend on the planned reuse applications. For municipal wastewater reuse, these include the following (listed in the descending order of anticipated volume of reuse): (1) agricultural and landscape irrigation; (2) industrial process and cooling; (3) impoundment of recreational facilities; (4) stream flow augmentation; (5) groundwater recharge, and (6) direct potable use.

A number of factors affect implementation of municipal wastewater reclamation and reuse projects; the impetus for water reuse is generally:

- availability of high quality effluents
- increasing cost of freshwater development
- desirability of establishing comprehensive water resources planning including water conservation and wastewater reuse
- avoidance of more stringent water pollution control requirements such as advanced wastewater treatment facilities.

In addition, the general factors affecting wastewater reuse decisions include: (1) local and regional water supply conditions; (2) water quality requirements for intended water reuse applications; (3) existing or proposed wastewater treatment facilities and requirement for degree of treatment process reliability; (4) potential health risks mitigation and public acceptance; and (5) financing water reuse facilities, including sale of reclaimed wastewater.

2.1 Wastewater reuse for agricultural and landscape irrigation

Wastewater reuse for irrigation is one of the oldest forms of water reclamation and it has always been most important from a quantitative point of view. The benefits of reuse and conservation are most apparent in arid and water-short areas, where water for agricultural use may not be available otherwise, the small amounts of fresh water being used for high priority needs. Even in more humid areas, the trend is to use wastewater for irrigation as a conservation measure (1,2).

In regions that are rapidly becoming industrialized (including tourism), the demands for a good reliable water supply can severely tax the available sources, making substitution by reclaimed wastewater attractive from a water resources planning standpoint.

Historically, the quality of irrigation water has been determined by the concentration of certain dissolved salts. The principal chemical water quality of concerns are total dissolved solids (TDS), sodium as expressed by the sodium adsorption ratio (SAR), bicarbonate, and boron or other phytotoxic substances. These substances are the primary concern in determining the suitability of water for irrigation, but problems connected with the removal of infectious agents (bacteria, viruses and other parasites) in reclaimed wastewater have not disappeared. The microbiological quality of reclaimed wastewater is usually controlled where food crops or landscape areas (parks, golf courses, etc.) are to be irrigated or where aerosol generation by sprinkler irrigation is anticipated. Generally, public health agencies define the quality of reclaimed wastewater that can be used for irrigation (3).

2.2 Wastewater reuse for groundwater recharge

Groundwater recharge with reclaimed municipal wastewater allows planned augmentation of groundwater supplies (4,5). The purposes of artificial recharge of groundwater have been: (1) to reduce, stop or even reverse declines of groundwater levels, (2) to protect underground freshwater in coastal aquifers against saltwater intrusion, and (3) to store surface water, including storm or other surplus water such as treated effluents, for future use.

There are several advantages in storing water underground. The cost may be less than that of equivalent surface reservoirs; the aquifer serves as an eventual distribution system and eliminates the need for surface pipelines or canals; water stored in surface reservoirs is subject to evaporation and pollution, which may be avoided by underground storage. Even more important, inclusion of groundwater recharge in any water reuse scheme provides psychological and aesthetic benefits. The loss of identity which groundwater recharge seems to provide for the reclaimed water is due to time-in-storage and separation-in-space. The infiltration and percolation of reclaimed water through the soil and the groundwater zone adds additional treatment reliability to the overall wastewater treatment system. This aspect of groundwater recharge is an important public health consideration.

3. Findings

Since many parts of Spain are semi-arid, planned reuse of treated municipal wastewater has been seriously considered. In this respect, much effort has been focused on the market assessment or actual marketing of reclaimed water, since primary benefits of reuse are in the area of water supply. The following are more specific findings and recommendations:

3.1 Assessment of agricultural irrigation and groundwater pollution

The need for direct and planned reuse of municipal wastewater is increasing in many parts of Spain. Reuse of treated effluents provides a valuable source of water for agricultural and landscape irrigation. Wastewater reclamation and reuse can not only supplement freshwater supplies, but also alleviate water pollution, particularly in the coastal regions.

Many of the problems encountered in the provinces of Valencia and Alicante appear to be related to the overdraft of groundwater for agricultural irrigation. Because of excessive pumping of groundwater, seawater intrusion from the Mediterranean has occurred, deteriorating the groundwater quality. Agricultural production, particularly citrus, has been affected by the high dissolved solids levels of groundwater. The salinity and sodicity problems are managed by over-irrigation with high fertilizer applications. High nitrate concentrations found in some of the wells in the region are the result of the irrigation practices.

To alleviate pollution of groundwater and seawater intrusion, groundwater overdraft must be controlled. Most of the problems, however, seem to be in legal and institutional aspects of water resources allocation, where interagency and interregional cooperation are essential:

- insufficient treatment and uncontrolled use of municipal wastewater for agricultural irrigation should be discouraged;
- in consultation with the Health Department and with its approval, reclaimed water may be used for surface or spray irrigation of fodder, fibre, seed crops, landscape irrigation and certain food crops. Secondary wastewater treatment followed by chlorination is assumed in tourist areas;
- use of reclaimed municipal wastewater for irrigation requires more reliable treatment plant operation than ocean disposal. Seasonal storage of reclaimed water and/or ocean disposal facilities are necessary to resolve problems of excess water, water quality and irrigation system breakdowns;
- interagency and interdisciplinary cooperation are essential for successful implementation of agricultural irrigation projects with reclaimed municipal wastewater. Agronomists may be required to define irrigation water quality, civil and sanitary engineers to design and construct wastewater treatment facilities, and public health engineers to safeguard health and enforce regulations concerning use.

3.2 Assessment of groundwater recharge to prevent seawater intrusion

Artificial recharge of groundwater is an effective way of managing both surface and groundwaters. The consultant feels, however, the difficulty in implementing groundwater recharge in such locations as Denia and Castellon de la Plana is lack of coherent water resources policies and management. Since groundwater recharge could be costly and time-consuming, some direct mechanism must be established whereby beneficiaries, such as farmers, cover the water agency's costs. In other words, a "cause - effect" relationship must be defined in these circumstances so that the affected watershed or groundwater basins can be managed.

The importation of surface water is by itself no panacea for uncontrolled groundwater overdraft. Even in severely depleted basins, groundwater pumping may be much less expensive than the purchase of imported water. Consequently, without proper watershed and/or groundwater basin management, water users are unwilling or unable to purchase imported water if groundwater sources are accessible to them.

- Interagency and interdisciplinary management of both surface- and groundwater resources must be established for efficient use of available water resources.
- The role of Health Department is rather limited in water resources management. Active cooperation with the Public Works Department and other water resources agencies is essential to solve groundwater overdraft problems.
- Coherent water resources policies and management strategies must be established so that the mechanisms for payment by the beneficiaries form part of the groundwater recharge and water resources management plans.
- To finance water resources management programmes, other funding sources possibly available in conjunction with the WHO funding should be sought.

3.3 Technology transfer and training of national staff

The consultant would like to propose the following technology and training programmes for the national staff:

3.3.1 Training of national staff

Two Spanish professionals should visit California in September 1986 to study agricultural irrigation with reclaimed wastewater and groundwater recharge. The consultant would be pleased to arrange for them to visit the California Government (Department of Health Services, Department of Water Resources, and State Water Resources Control Board) and the Federal Government (U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The Spanish professionals should also visit San Diego, Los Angeles and San Francisco to discuss public works projects.

The consultant would like to recommend Ing. Enrique de Quesada, Direccion General de Salud, Valencia and one engineer from Public Works Department to be in the visiting team. Professor Rafael Mujeriego of Universitat Politecnica de Barcelona could join them in California as a consultant; he will be visiting the University of California at Berkeley during 1986 and could be available to the visiting team.

A tentative schedule and cost estimate is as follows:

6 September 1986	Travel from Madrid to San Francisco.
8-9 September	San Francisco and Berkeley. Department of Health Services, US Environmental Protection Agency, Region 9, University of California at Berkeley.
10-13 September	Sacramento. Department of Water Resources, State Water Resources Control Board, U.S. Army Corps of Engineers, University of California at Davis.
14-17 September	San Diego and Los Angeles area. County Sanitation Districts of Los Angeles, Orange County Water Factory 21, San Diego Aquaculture Project.
18-19 September	Agricultural irrigation in Bakersfield.
20 September	Los Angeles - Madrid.

Cost estimate

Ing. Quesada and one engineer from Public Works Department from Spain, joined by Professor Mujeriego in California as a consultant.

Air fare: \$1000 x 2 = \$2000

Per diem: \$100 x 14 days x 2 = \$2800

Consultant (Professor Mujeriego): \$200/day including per diem for 10 days = \$2000.

Estimated total cost: \$6800

3.3.2 Demonstration projects

To promote interagency and interdisciplinary communication, the following two demonstration projects, under the auspices of WHO, are proposed. The consultant believes the demonstration projects serve best to stimulate interagency cooperation and to bring together many talents from universities and industries. The demonstration projects should be guided by technical advisory committees consisting of university researchers, consulting engineers, industrial engineers, soil scientists, public health specialists and government and municipal staff.

Agricultural irrigation demonstration project

Public safety, institutional arrangements
treatment process reliability and use area control
agronomical investigation
cost and liability
public health criteria
water resources alternatives.

Groundwater recharge demonstration project

Water resources planning
conjunctive use of surface and groundwaters
economic and institutional arrangement
public health and liability
recharge method and monitoring
engineering evaluation of hydrogeology and fluid mechanics
fate of micropollutants in groundwater.

4. Recommendations

The consultant's recommendations are summarized in Annex 2. The recommendations are based on the consultants findings and were discussed with Dr J.F. Martinez Navarro and Ing. Enrique de Quesada on 4 October 1985.

5. Acknowledgements

The consultant was helped by all the Government officials with whom he was associated with both in Madrid and Valencia. The consultant is particularly indebted to Dr Antonio Abad Martinez, Ing. Enrique de Quesada, Dr J.F. Martinez Navarro and Professor Juan Marco Segura.

REFERENCES

1. Health Aspects of Treated Sewage Reuse. Reports and Studies No. 42, Copenhagen, WHO Regional Office for Europe, 1981.
2. Middlebrooks, E.J. (Ed.) (1982) Water Reuse. Ann Arbor Science, Ann Arbor, Michigan.
3. Pettygrove, G.S. & Asano T. (Ed.) (1985) Irrigation with reclaimed municipal wastewater - a guidance manual, Lewis Publishers, Inc., Chelsea, Michigan.
4. Asano, T. (Ed.) (1985) Artificial Recharge of Groundwater, Butterworth Publishers, Stoneham Massachusetts.
5. Water Pollution Control Federation (1983) Water reuse, manual of practice SM-3, Washington, D.C.

Annex 1

PROGRAMME OF THE VISIT

- Day 1
a.m. Visit to Dr Antonio Abad Martinez, Ministerio de Sanidad y Consumo, Madrid, to discuss general topics of water reuse and environmental health.
- p.m. Visit to Canal de Isabel II, Madrid, for discussions on water supply for the Madrid metropolitan area, watershed protection, eutrophication problems, and groundwater recharge with Ing. Benito Diaz y Diaz de la Cebosa, Director of Production, Dr Manuel Mateos, Ing. de Caminos, consulting engineer.
- Day 2
Travel from Madrid to Valencia
Met at Valencia Airport by Ing. Enrique de Quesada, Direccion General de Salud.
- Day 3
Meeting with Dr J.F. Martinez Navarro, Director and Ing. Enrique de Quesada, Direccion General de Salud.
- Visit to Denia, Province of Alicante, with Ing. Quesada
- p.m. Discussion on water quality problems with city officials
- Day 4
The consultant discussed (illustrated with slides) the planning aspects of wastewater reclamation and reuse with Ing. Quesada. In the afternoon, the consultant visited the Department of Civil Engineering, Polytechnic University of Valencia. Professor Juan Marco Segura took the consultant to the research site of the "Groundwater Management Project" at Castellon de la Plana, Province of Castellon.
- A summary session was held on the fifth and final day at the Direccion General de Salud with Dr Martinez Navarro and Ing. Quesada. The consultant outlined his findings and recommendations.

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Annex 2

SUMMARY OF RECOMMENDATIONS

Drinking-Water Supply in Arid Areas

INDEX: WATER

EURODOC: 1210

Spain - Asano - Sept./Oct. 1985

WASTEWATER REUSE FOR AGRICULTURAL IRRIGATION AND GROUNDWATER RECHARGE

Recommendation	Action by
1. There are possibilities for planned reuse of treated municipal wastewater for agricultural irrigation and groundwater recharge. Planning of facilities must be conducted and approved by regulatory agencies.	Government and local agencies
2. Insufficient treatment and uncontrolled use of municipal wastewater for agricultural irrigation should be discouraged. Need to establish wastewater reuse criteria.	Government and local health department
3. Promote interagency and interdisciplinary communication on wastewater reclamation and reuse. Coordinate water resources planning and wastewater reuse and water conservation.	Government, water agencies, and universities
4. Increased agricultural irrigation, tourism, groundwater overdraft, groundwater pollution, seawater intrusion are all related. Establish priority system in water resources management and pollution control.	Government, public works department, municipalities, water agencies and public health department
5. Lack of coherent water resources policies and enforcement has resulted in groundwater overdraft, pollution and seawater intrusion. Mechanisms are needed for beneficiaries to pay the associated cost.	Government, public works department, municipalities, water agencies and public health department
6. To promote exchange of information and technology transfer, training of national staff is recommended. Two Spanish professionals should visit the California government for two weeks in September 1986, a Spanish professor visiting the University of California at the time acting as consultant.	Government and EURO
7. To promote interagency and interdisciplinary communication, two demonstration projects in agricultural irrigation and groundwater recharge are recommended (under the auspices of WHO/EURO).	Government, EURO, universities and local agencies