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GUIDELINES FOR THE SAFE REUSE OF MUNICIPAL WASTEWATER IN ANDALUSIA (SPAIN)

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ABSTRACT

In Spain, the establishment of basic guidelines concerning reclaimed municipal wastewater reuse is the responsibility of the National Government (Water Act of 1985). Nevertheless, the administrative structuring of the country into Autonomous Communities, many of which are responsible for matters of public health, may produce varying situations due to the existence or introduction of specific sanitary guidelines.

This article describes the situation in the Autonomous Community of Andalusia (Southern Spain), which has an area of 87,277 km^2 and a population of seven million (80 inhabitants per square kilometre). It is an eminently agricultural region (accounting for 80% of total water consumption), with long, dry summers and a significant water deficit. Guidelines (criteria and quality standards) for municipal wastewater reuse were introduced in 1994, after the setting up of an interdisciplinary study.

After performing an analysis of the main guidelines for the sake of comparison, it was decided to adopt a model similar to those applied by the WHO (OMS, 1989) or France (1991). The reuse applications considered are grouped within the following five categories: a) agricultural irrigation, b) urban, c) industrial, d) aquaculture and e) recreational activities. Each of these categories was further sub-divided by particular uses (eleven, in all). A minimum quality standard was established for each use, based on enteric nematode and fecal coliform bacteria concentration. A total of seven different types of quality standards were proposed. As a complement to this legislation, a series of general considerations was addressed, together with others to be applied to specific recycling processes.

Key words: Reclaimed municipal wastewater, reuse, sanitary guidelines, Andalusia (Spain)

RESUMEN

En España, el establecimiento de las condiciones básicas para la reutilización de aguas residuales urbanas es competencia del Gobierno Central (Ley de Aguas de 1985). Sin embargo, la estructuración administrativa de la Nación en Comunidades Autónomas (regiones), con competencias sanitarias transferidas en muchas de ellas, puede introducir situaciones diferenciales, al irse estableciendo normativas (o directrices) sanitarias específicas.

En el presente artículo se expone la situación de la Comunidad Autónoma de Andalucía (Sur de España), que en una extensión de 87.277 km^2 posee una población de 7 millones de habitantes (80 habitantes/km^2). Se trata de una región eminentemente agrícola (80 % del consumo de agua), de estiajes secos y prolongados, y con importantes déficits hídricos. El establecimiento de directrices sanitarias (criterios y estándares de calidad) para la reutilización de aguas residuales se produjo en

1994, a partir del encargo de un estudio interdisciplinar.

Después de efectuar un análisis de las principales directrices y normativas de posible comparación, se optó por adoptar un modelo similar al de la legislación francesa o al de las directrices de la OMS de 1989. Las aplicaciones de reutilización consideradas se clasificaron en las siguientes cinco categorías: a) agrícola y forestal, b) municipal, c) industrial, d) acuicultura y e) turístico-recreativa. En cada una de ellas se hizo la correspondiente subdivisión por usos (once en total). Para cada tipo de uso concreto se estableció un estandar de calidad mínimo, basado en contenido de nematodos intestinales y de coliformes fecales. En total se llegaron a proponer siete tipos de estándares de calidad diferentes. Como complemento de regulación, se contemplaron una serie de consideraciones generales, y otras particulares de aplicación a reutilizaciones específicas.

Palabras clave: Aguas residuales urbanas depuradas, reutilización, directrices sanitarias, Andalucía (España)

INTRODUCTION

In Andalusia, in Southern Spain, the reuse of urban wastewater is common practice. Due to the typically Mediterranean climate, with long, sunny summers and low rainfall, water deficits often exist and these quite frequently affect the supply to urban areas. Levels of water resources are low, and demand tends to be high, mainly from the agricultural sector, which consumes 80% of the water resources. Also significant is the quantity of water consumed by the tourist sector, particularly along the Mediterranean coastal strip. With this situation, a time-honoured custom is the reuse of most urban wastewater, often without treatment of any kind. These circumstances led to the inclusion of wastewater reuse among the objectives of the environmental and public health planning activities (Junta de Andalucía, 1995 and 1993, respectively) of the Andalusian regional government.

From the legal point of view, the Spanish legislation on water (BOE, 1985 and 1986) and also, in part, the EEC guideline on the treatment of municipal wastewater before disposal to water systems (DOCE, 1991a), provide the main references. At present, all activities involving direct wastewater reuse are required to be preceded by a favourable report from the sanitary authorities. From this legal requirement, and from the competence of the Andalusian Autonomous Community in matters of public health, arose the necessity of establishing sanitary guidelines on wastewater reuse in Andalusia, and so the Health Department of the Andalusian regional government draughted these guidelines with the intention of minimizing the sanitary risk that is inherent to water reuse practices.

In 1993, the Health Department officials of the regional government of Andalusia commissioned an interdisciplinary work group of specialists in the field of reuse, originating from such diverse fields as microbiology, parasitology, epidemiology, environmental health, hydrology, water treatment and agricultural chemistry, with the task of establishing sanitary criteria for treated urban wastewater reuse to safeguard public health.

After a process of compilation, study and analysis of the scientific and technical literature available in the data bases of *Pollution Abstract,* MEDLINE (*Index Medicus*), ME66, ACS, AL83 (*National Agricultural Library*) and SCISEARCH (*Science Citation Index*), a paper was published, entitled "*Criterios para la evaluación sanitaria de proyectos de reutilización directa de aguas residuales urbanas depuradas" (Guidelines for the sanitary evaluation of projects for the direct reuse of reclaimed urban wastewater)* (Castillo *et al.,* 1994), which included the catalogue of reuse applications considered viable from the sanitary viewpoint, the recommended quality standards and the corresponding general and particular considerations applicable to each application. These guidelines, which at present are exclusively technical and advisory, are intended, in the near future, to be raised to the level of mandatory sanitary norms.

REUSE APPLICATIONS

From the sanitary aspect, a total of eleven reuse applications were considered viable. These reuse applications were then grouped into five categories, corresponding to: a) agricultural irrigation, b) urban, c) industrial, d) aquaculture and e) recreational activities (table 1). A minimum suggested quality standard and treatment, together with a series of particular considerations were established for each of the applications or uses admitted (given as a footnote to table 1).

Due to the high health risk of certain reuse practices, the prohibition or restriction was recommended for potable reuse, hosing for street cleaning, urban heating and refrigeration, the cleaning of urban premises, and the washing and transport of materials; this is in addition to the use of reclaimed water for human consumption, which the Spanish regulations (BOE, 1985 and 1986), with certain exceptions, expressly forbid. In any case, these uses are very exceptional, with no application in Andalusia; given the high potential sanitary risk, quality standards similar to those for drinking water and strict control programmes would be required. A similar attitude was adopted towards the land application and to the groundwater recharge of municipal wastewater, an activity which is defined within Spanish water legislation (BOE, 1986) as a disposal into the Common Water Domain and subject, therefore, to other legal precepts.

SANITARY GUIDELINES

Up to seven different water quality standards were adopted (table 2) for the various reuse practices that were considered. The quality parameters employed were intestinal nematodes (viable eggs per litre) and fecal coliforms (per 100 ml). No particular frequency was established for analysis; instead, it was recommended that the minimum periodicity should be determined according to the use and the sanitary risk foreseen. For those uses where public access is prohibited, restricted or infrequent (b2, e2, d2 and e4; see table 1), no water quality criteria were established, but a recommendation was made for a minimum level of treatment (pre- and primary treatment), together with a series of particular considerations aimed at protecting the health of the workers involved.

As only municipal wastewater reuse was considered, no standards were included regarding the content of heavy metals or other chemical contaminants. Nevertheless, it was recommended that, where necessary (urban wastewater containing industrial effluent), the limits advised by Le Conseil Superieur d'Hygiène Publique de France (1991) should be observed.

In order to determine the corresponding quality standards for types of reuse applications (table 1), a comparative analysis was made of a series of sanitary norms and guidelines that was considered to be sufficiently representative. Among these, the standards established by the WHO (OMS, 1989 and 1990) were seen as reasonable and balanced, and these provided the main reference base for those eventually adopted. The former provided the inspiration for the similar standards adopted by the French Ministry of Health (Conseil Superieur d'Hygiène Publique, 1991).

When deciding upon the reference guidelines, the socio-economic situation in Andalusia was taken into account. The imposition of strict guidelines, such as exist in the United States of America or Israel (EPA, 1992), would imply unaffordably high treatment and control costs for Andalusia. This decision was also supported by the evidence that, at present, and in some cases as immemorial practice, untreated wastewater has been used in agricultural applications in Andalusia, with virtually no recorded incidences of feco-hydric transmitted disease, except in cases of the consumption of raw vegetables and the contamination of sources of drinking water.

FINAL CONSIDERATIONS

The proposed standards are intended to be exclusively technical recommendations, and are the result of discussions between the team responsible for the study (Castillo *et al*., 1994) and the sanitary officials of the Andalusian Regional Government (represented by the technical managers of the

study). In those cases where the desired concensus could not be reached, the criteria of the health officials prevailed. Among the aspects that caused most debate might be mentioned those corresponding to the desirability or otherwise of disinfection treatments with chlorine, to the statistical criteria to validate the standards (percentiles, geometric or arithmetic means) and to the quality standards to be applied to sports fields and parks.

These guidelines are intended to be legally established in the near future. In any case, the authors strongly recommend that the guidelines finally adopted should be such that compliance, in real-life situations, is practicable. Excessively strict dispositions tend to produce a generalized contempt for the norms and produce, paradoxically, a greater sanitary risk. The WHO itself (OMS, 1990), which is highly experienced in regulatory development in countries with low or moderate levels of development, is in favour of the adoption of guidelines that are relatively simple to observe, depending on the economic level of the country, as an initial step in a gradual process to improve public health protection.

Nevertheless, and despite the fact that the guidelines described in this paper may be categorized as being of practicable compliance, the quality standards proposed, together with the preventive measures suggested as particular considerations, are considered to be more than sufficient to protect public health. Perhaps even more essential than the norms themselves is the real follow-up and control of the recommended guidelines. As in other countries, over time these can be adjusted to suit the standard of living of the population and the scientific knowledge obtained regarding the propagation of diseases of feco-hydric origin.

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TYPES OF REUSE		QUALITY STANDARD (Considerations)	SUGGESTED TREATMENT
AGRICULTURAL IRRIGATION **(a)**	Vegetables to be consumed raw (a1)	Nematodes/l < 1 FC/100 ml < 1.000 (1,2,3,4)	Lagooning or equivalent treatment
	Industrial crops, cereals, dry fodder seeds, forests and conserved or cooked vegetables (a2)	Nematodes/l < 1 (2,3,5,6,7,8,9,10)	Lagooning or equivalent treatment
URBAN **(b)**	Irrigation of sports fields and parks with public access (b1)	Nematodes/l < 1 FC/100 ml < 200 (1,3,11)	Lagooning or equivalent treatment
	Irrigation of green areas where public access is prohibited (b2)	- (3,5,12)	Primary
INDUSTRIAL **(c)**	Refrigeration (c1)	FC/100 ml < 1.000 (*) FC/100 ml < 10.000 (**) (*) Semi-closed circuits (**) Open circuits (13)	Secondary
AQUACULTURE **(d)**	Production of biomass intended for human consumption (d1)	FC/100 ml < 1.000 (14,15,16,17,19)	Lagooning
	Production of biomass not intended for human consumption(d2)	- (5,15,17,18,19)	Pretreatment
RECREATIONAL (d **(e)** **)** **(e)**	As b1 (e1)	As b1	As b1
	As b2 (e2)	As b2	As b2
	Recreational lakes (e3) public access (e3)	Nematodes/l < 1 (14,17,20) (1,14,17,20 FC/100 ml < 2.000 (1,14,17,20)	Lagooning
	" access prohibited (e4) puk	(5,17,19,20) (5,17,19,20)	PretreatmentpREBB BBBBBB

Table 1. The reuse applications of reclaimed municipal wastewater, showing the minimum quality standards, particular considerations and types of treatment recommended for Andalusia (in Castillo et al., 1994)

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- *Reuse applications for which prohibition or exceptionality is recommended, on public health grounds: potable and nonpotable supplies, hosing and cleaning; urban heating and cooling; the cleaning of urban premises; the cleaning and transport of materials.*

- *Other reuse applications not considered, in the context of the impact on public health: land application, groundwater recharge and the washing of saline soils.*

- *For intestinal nematodes (number of viable eggs), 95% of the samples must not exceed the limit value. For fecal coliforms, 90% of the samples must not exceed the limit value.*

(1) *This is a high sanitary risk use, and so analytical control should be even stricter and compliance with the considerations and quality standards for the application in question must be ensured (uses a1, b1=e1, e3).*

(2) *The heterogeneity of the types of crop included in this category, and thus the different sanitary risks involved in their consumption, implies the possibility of a distinct application of the considerations and/or quality standards in general recommended (uses a1, a2).*

(3) *In case of spray irrigation, the following additional considerations must be taken into account: the sprays produced must not, in a continual form, fall on the workers, on asphalted roads or inhabited areas; when such sprays are expected to fall on these areas, then use must be made of sprays with a limited range and/or directed towards the land, together with the placing of obstacles or screens (e.g. hedges). If these measures are not adopted, or if they are considered insufficient, minimum safety distances of 50 m from asphalted roads and 150 m from inhabited areas must be maintained; if there are such roads or inhabited areas within a radius of 500 m, irrigation must always be suspended when there are strong winds. For agricultural irrigation in the immediate proximity of inhabited areas and, particularly, in the case of the irrigation of sports fields and parks, this should preferably be performed at night. In these cases, especially, the use of short-range sprays is recommended, directed towards the ground. Spray irrigation is not recommended for crops under glass or plastic (uses a1, a2, b1=e1, b2=e2).*

(4) *The application of irrigation systems that do not wet the edible part of certain crops, such as drip-irrigation delivery systems may allow, in these cases, the use of waters of lower quality than that normally recommended; under these circumstances, irrigation should be suspended at least two weeks before the harvesting of the crop (use a1).*

(5) *In cases of the absence and/or low microbiological quality of established standards, measures to ensure the hygiene and safety of the workers should be even more stringently enforced, while the necessary action must be taken to avoid the contact of this water with the public (uses a2, b2=e2, d2, e4).*

(6) *With this type of standard, vegetables may not be irrigated by spraying or by inundation. The irrigation of fruit trees with wastewater should be suspended at least two weeks before the crop is harvested, and the fruit should not be collected from the ground. In any case, hygiene measures should be intensified during collection and handling of these products, in order not to contaminate other foodstuffs (a2).*

(7) *Products destined for human consumption are not to be washed with the reclaimed wastewater used for irrigation (use a2).*

(8) *In the case of crops to which two different standards apply, depending on whether they are to be consumed raw or after processing, the stricter standard will be applied when it is not specified whether, or sufficient guarantees are not given that, commercial processing (cooking, peeling, etc.) will be carried out (use a2).*

(9) In the case of cereals, forage and fodder for feed or dry consumption, forest plantations and industrial crops, water of lower quality may be used (minimum treatment: primary sedimentation), provided suitable measures are adopted to protect workers and avoid the water coming into contact with nearby populations (use a2).

(10) For the irrigation of dairy pasture for milk or meat-producing animals, such irrigation must be suspended at least two weeks before the entry of the cattle onto the land.

(11) Under conditions of drought, and in order to preserve recreational green spaces, there may be a positive report, and hence authorisation, from the Regional Water Authority for irrigation with lower-quality water for the following cases: a) localised irrigation (drip-feed, trenches, etc.) of hedges and trees in public parks; b) the irrigation of sports fields where public access is restricted; in both cases, suitable measures to protect the public should be taken (use b1).

(12) There should exist physical barriers to prevent public access to irrigated zones (use b2=e2).

(13) This type of use is prohibited for food-processing and related industries (use c1).

(14) Water samples, to enable the follow-up and analytical control of the established standards, must be taken from the water at the site of exploitation or use. In fact, it has been estimated that the input collectors of the system may present a much higher concentration of fecal coliforms (uses d1, e3).

(15) No references are known to exist of disease caused by this practice; however, the consumption of molluscs and, recently, fish extracted from contaminated open seawater has been related to cholera (uses d1, d2).

(16) Guidelines 91/492 and 493 (DOCE, 1991 b, c) set the sanitary norms applicable to the production and marketing of bivalve molluscs and fish products, respectively, for human consumption (use d1).

(17) Reclaimed wastewater must not emit unpleasant smells nor be a focal point for the proliferation of insects and therefore the aerobic conditions must be favourable (uses d1, d2, e3, e4).

(18) It must be ensured that the commercialization of these products, even when processed, is not directed towards human consumption. The products harvested may not be used, either, as raw foodstuff for milk or meat-producing cattle (use d2).

(19) There must exist physical barriers to prevent the population coming into contact with the water (uses d1, d2, e4).

(20) Actions that could produce spray, such as jets of water, geysers, waterfalls, etc., must be avoided. If such actions are considered within a project, the relevant regulations are those applicable to spray irrigation (uses e3, e4).

TYPES OF STANDARDS	REUSE APPLICATIONS	FC/100 ml	Nematodes/l
1	b1=e1	< 200	< 1
2	a1	< 1.000	< 1
3	c1, d1 (1)	< 1.000	-
4	e3	< 2.000	< 1
5	c1 (2)	< 10.000	-
6	a2 (3)	-	< 1
7	b2=e2, d2, e4	-	-

Table 2. Types of quality standards recommended for the different reuse applications considered for Andalusia (in Castillo et al., 1994)