THE RE-USE OF WASTE WATERS

JUSTIFICATION ACTIVITY

Introduction:

The Water Framework Directive presents a challenge for water management, given that it makes it mandatory to protect and preserve the aquatic ecosystems, promoting the sustainable use of water. This objective is set forth in the agreement of the Member States to achieve a good state of waters before 2015, which is complex in countries like Spain where periods of prolonged drought occur.

The sustainable management of water implies, therefore, not only dealing with the demands of water but also the need to look for alternative sources of water, such as the re-use/recycling of used waters.

For several years, and especially since the passing of Real Decreto 1620/2007 (Spanish Law) on the reuse of waters, consumers, managers and planners have considered regenerated water as an ordinary additional resource that can be counted on given that it offers guarantees of quantity and quality.

In the social sphere the most important benefit derived from the reuse of water is the possibility of reserving the best quality water for the most demanding uses, such as the production of drinking water.

The reuse of urban waste water is a practice that is more and more common in arid or semiarid countries where water resources are scarce. Nowadays, this type of water is considered an alternative water resource, above all in coastal areas where treated water is not returned to the water cycle but run out to sea.

In inland areas, the reuse of waste water does not generate new resources but it can serve to free up conventional resources for priority uses such as the provision of drinking water, which requires a higher quality of water.

The uses to which recycled waste water can be put to are many:

Irrigation: crops, parks and gardens, cemeteries, green belts, golf courses.

Industrial reuse: refrigeration, boiler feed.

Non-drinking urban uses: green zones, fire fighting, toilets, air conditioning, car washes, street cleaning, ornamental fountains…

Others: aquiculture, cleaning of livestock, melting snow, construction, dust elimination…

In Andalusia, the reuse of waste water is being introduced fundamentally in coastal zones, above all in the Mediterranean Hydrographic District [MHD] where most shortage is registered, to attend to the needs of water provision. In total around 50 hm3 of waste water is reused, more than half in the MHD.

The environmental benefits of reusing waste water are especially relevant when the utilization of a determined volume of regenerated water substitutes the utilization of a volume from rivers or aquifers. For example, if an aquifer is at risk of overexploitation, the use of regenerated water can reduce withdrawal from the aquifer so as to recover the balance between recharge and withdrawal.

In conclusion, the reuse of water is a hydrological management and planning measure that brings social and environmental benefits, and resolves some of the frequent problems derived from water shortage in our country.

The development and promotion of regenerated water use is therefore advisable.

Evaluation of the quality of regenerated water

The evaluation of regenerated water quality is performed by means of the application of the conformity criteria and management measures against possible failure to comply, as stated in Annex I.C of the Real Decreto on water reuse.

Conformity criteria of the operating system:

The operating system conforms if it simultaneously fulfils the following:

1. 90% of the samples have results lower than the Maximum Allowable Values (MAV) in all the specified parameters in Annex I.A.

2. The samples that exceed the MAV of Annex I.A. do not exceed the maximum deviation limits (MDL) established in Annex I.C.

3. The Environmental Quality Standards (EQS) for dangerous substances in the supply station of the regenerated water, according to the application of the law.

The MDL referred to in point 2 are the differences between the values measured and the MAV. These limits are fixed in Annex I.C. of the Real Decreto on water reuse and whose resulting values are the following:

PARAMETER	MAXIMUM ALLOWABLE VALUES	MAXIMUM DESVIATION LIMIT
Intestinal nematodes (egg/10 L)	1	2
Escherichia coli (UFC/100 mL)	0	10
	100	1,000
	200	2,000
	1,000	10,000
	10,000	100,000

Legionella spp. (UFC/L)	100	1,000
Taenia saginata (egg/L)	1	2
Taenia solium (egg/L)	1	2
Solids in suspension (mg/L)	5	7.5
	10	15
	20	30
	35	52.5
Turbidity (UNT)	1	2
	2	4
	10	20
	15	30
Nitrates (mg NO_3/L)	25	38
Total Nitrogen (mg N/L)	10	15
Total Phosphorus (mg P/L)	2	3

Table. Maximum deviation limit values per parameter

To summarise, the water conforms to the water-reuse law if it fulfils all of the following:

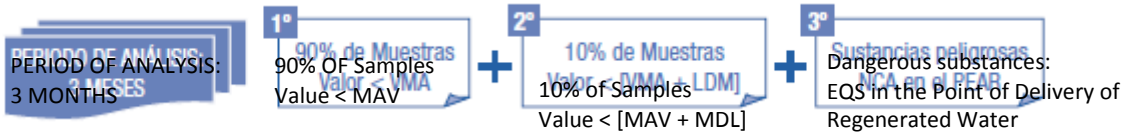


Figure. Conformity criteria of the reuse system with water reuse law (Real Decreto)

EXAMPLE OF EXPERIMENTAL PROCEDURE

Analytical methods for waste water.

(The materials and reactants should be provided by the centre where the activities are carried out; they are common materials and reagents in a school biology laboratory.)

PHYSICOCHEMICAL ANALYSIS

1. DETERMINATION OF CONDUCTIVITY

1.1. Basis

When determining conductivity the capacity of the water to conduct electricity is evaluated. It is an indirect measure of the quantity of ions in solution (fundamentally, chloride, nitrate, sulphate, phosphate, sodium, magnesium, and calcium). Conductivity in bodies of fresh water is primarily determined by the geology of the area through which the water flows (basin). For example, waters that run in granite substrata tend to have less conductivity as this substratum is composed of materials that do not ionize. Discharges of waste water usually increase conductivity due to the increase in the concentration of Cl-, NO3 – y SO4-2, and other ions. It should be remembered that spills of hydrocarbons (oils, petroleum), organic compounds like oils, phenol, alcohol, sugar and other non-ionizables (although pollutants) do not greatly modify the conductivity.

The basic unit for measuring conductivity is the siemens per centimetre.

The conductivity will be determined using an electronic conductivity meter (fig.), which generates a voltage difference between two electrodes submerged in the water. The drop in voltage due to water resistance is used to calculate conductivity per centimetre.

Apparatus

Conductivity meter.

Fig: Conductivity meter, cover (black) and screwdriver to calibrate it.

1.2. Procedure

- If the conductivity of the water sample is very high, it is necessary to dilute it until the measurement comes down to within the scale of the equipment.

- The conductivity cell is introduced into the water sample, waiting a few seconds until the reading can be established. If a digital conductivity meter is used, the sample's conductivity measurement appears directly on the screen.

Equipment with temperature compensation is recommended, otherwise the temperature compensation will have to be effected manually.

2. TOTAL SOLIDS IN SUSPENSION

2.1. Basis

A previously homogenised sample is filtered using a standard glass-fibre filter (Whatman 934-AH; particle retention size 1.5 µm), tared beforehand when dry. The residue retained in the filter is dried to constant weight at 103 – 105º C.

The increase in the weight of the filter represents the total solids in suspension.

Apparatus

Filtering equipment

Pasteur drying oven

Precision scales

Watch glass

Filters (Whatman 934-AH; particle retention size 1.5 µm)

Normal laboratory material

2.2. Procedure

The standard filters needed are individually tared on glass plates and the initial dry weight is noted, determined at 103-105ºC.

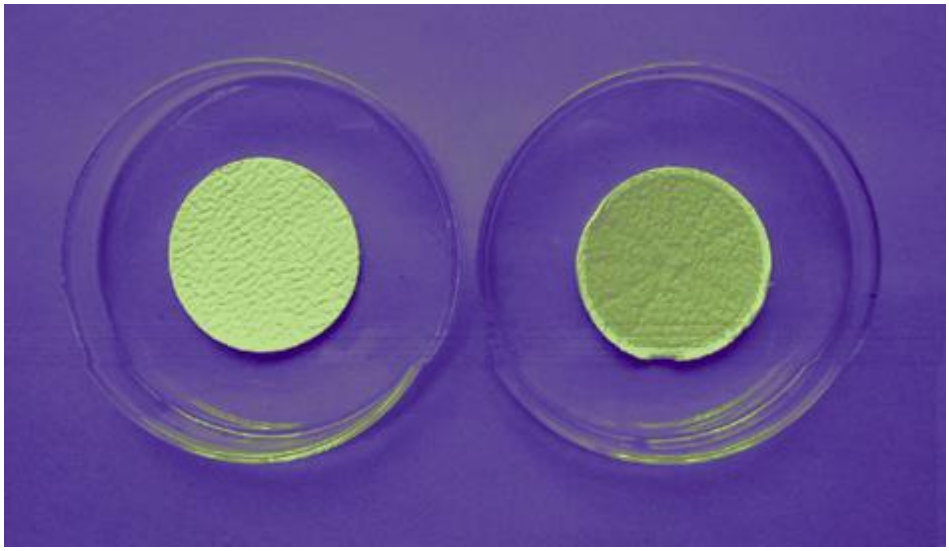
A determined volume of homogenised sample is filtered through a tared filter, with a vacuum pump.

It is oven-dried at 103-105ºC until constant weight.

• Calculations:

Total solids (mg/litre) = [(A-B)*1000]/Sample volume (ml)

A: weight of dry residue + filter (mg); B: filter tare (mg).



3. DETERMINATION OF NITRITES

3.1. Basis.

Sulfanilic acid in hydrochloric medium, in presence of ammonium and phenol ions, forms nitrite (NO_2), a yellow coloured compound, whose colour intensity is proportional to the concentration of nitrites.

3.2 Instruments

Spectrophotometer

50 ml Nessler Tubes

3.3 Reagents

- Distilled water

- Zambelli Reagent

3.4 Procedure

Put 260 ml HCl and 500 ml distilled water in a 1-litre flask. Add 5g of sulfanilic acid and 7.5g of crystallised phenol, heating slowly until dissolution. When cold, fill up to one litre volume with distilled water.

- Pure ammonia. 0.925 density

- Standard nitrite solution. Dissolve 0.345g of sodium nitrite in distilled water up to 1L (1ml = 0.230mg of nitrite). Store in fridge, adding 1ml of chloroform, for one month.

- Daughter nitrite solution. Dissolve the standard nitrite solution to 1/100. (1 ml = 0.023 mg/1 of nitrites)

	BLANK	STANDARD	TEST
Distilled water	50ml	45ml	----
Daughter solution	----	5ml	----
Test water	----	----	50ml
Zambelli Reagent	2ml	2ml	2ml
Ammonia	2ml	2ml	2ml

Mix and let stand for 5 minutes

Read in spectrophotometer at 435 nm.

Concentration of St.= 0.23 mg/l of NO_2.

The concentration of the test sample is determined directly on the calibration curve performed, which is done by interpolation after measuring absorbance.

MICROBIOLOGICAL ANALYSIS

Introduction

The microbiological analysis of the waster water includes, as basic determinations, the total microorganisms, total coliforms and faecal coliforms. There are specific culture mediums on the market for each one of these determinations, such as those provided by Millipore. Below a routine method based on these commercial culture mediums is described.

Basis

It is a question of separating the microorganisms from the water by filtration through specific filter membranes and then depositing the membranes with the residue in Petri dishes that contain a specific culture medium for growing the microorganisms that need to be determined, on a filter paper base. All the material that is utilized must be sterilized so that there is no external contamination. The sterilization of the material is carried out in an autoclave at 121ºC for 20 minutes.

The proposed culture mediums are liquids as these mediums are better at penetrating membrane pores and covering their surface.

Reagents

Culture Mediums

The commercial names of the culture mediums sold by Millipore are here indicated:

- Culture medium for the counting of total microorganisms: TGE (Tryptone Glucose Extract Broth).

- Culture medium for the counting of total coliforms: m-Endo Total Coliform Broth.

- Culture medium for the counting of faecal coliforms: m-FC Broth.

Instruments

Membrane filtration equipment

Millipore filters (filter disc of cellulose esters with 0.45 µm pore diameter)

Millipore membrane

Kitasato vacuum flask

Petri dishes

Procedure

Membrane filtration methodology is followed, utilizing the appropriate culture medium for the counting of different types of organisms. In order to do so, 10ml of waste water is taken initially, it is put into a 100ml flask and filled to volume with sterile water. The dilution to be made of the sample depends on the degree of expected contamination. The stages necessary for the microbiological analysis are as follows:

Preparation of the Petri dishes

- Open the Petri dish, which contains a sterile absorbent base.

- Open a 2ml vial of the appropriate medium and pour onto the absorbent base, distributing it over the whole surface.

Sample filtration

Carried out in a glass vacuum flask (kitasato) onto which a plastic filter holder with a cellulose ester filter disc (0.45 µm pore diameter) is placed.

- The membrane is placed in the filter using sterilized tweezers.

- Take 10ml of the properly diluted sample to the filter holder.

- Connect the vacuum pump to filter the sample. The possible microorganisms will stay trapped in the filter.

- Disconnect the vacuum pump. With the flamed tweezers, take the filter and place in the Petri dish prepared for the microbiological determination.

Incubation and colony count

- The Petri dish containing the filter disc with the residue is taken to the oven, thermostatized to 37ºC, for the determination of total microorganisms and total coliforms; or to 44.5º for faecal coliforms, for a period of 24 hours.

- After the incubation, proceed to counting the colonies formed in each filter disc, expressing the results in millions of microorganisms per litre of water. The colour of the colonies developed in the indicated mediums vary according to the microorganism:

- Total microorganisms: yellowish colour colonies.

- Total coliforms: reddish colonies with metallic green shine.

- Faecal coliforms: bluish colour colonies.