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REUSE OF GREY WATER IN BUILDINGS. A EUROPEAN APPROACH

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1 Introduction

Water has become a resource of the utmost importance.

Demographic growth and, most especially, economic development and today's lifestyles have rendered drinking water scarce.

Climate change has worsened the situation and it is predicted that in certain countries the forecast reduction in rainfall or the alteration of its regime could have a negative effect on situations of crisis in the short to medium term.

So, for reasons of sustainability and rational water use, a growing interest in the reuse and recycling of grey water in buildings is being shown in many countries.

In Portugal, the National Association for Quality in Building Services (ANQIP), a NGO that promotes quality and efficiency in the water cycle in buildings, has recently decided to develop a technical specification in this field.

This paper presents a detailed analysis of this new specification, looking at some technical aspects of the installations, with special attention to the quality requirements of the treated water, according to the possible uses allowed.

2 The principle of the 5R for the water efficiency in buildings

Efficient water use in buildings can be summarized as a principle which is known as the "5R principle":

- *Reduce consumption*
- *Reduce losses and waste*
- *Reuse water*
- *Recycle water*
- *Resort to alternative sources*

} *- WATER EFFICIENCY IN BUILDINGS*

The reuse and recycling of greywater are included in the third and fourth R, and, as mentioned above, ANQIP developed a specific technique for this (Technical Specification ETA 0905).

This Specification defines as grey water the domestic waste water with a lower concentration of pollutants, that can be considered for recycling or reuse.

In residential buildings this water generally comes from the discharges of baths, sinks and showers but, in certain conditions, the discharges from washing machines or even wastewater from kitchens can also be considered.

The grey water treated for reuse purposes, satisfying the quality criteria established for the uses for which it is intended, is called "regenerated water".

3 Health concerns

The water security has been consolidating itself as a global concern to ensure the health of populations.

In this sense, was published by the International Water Association the Bonn Charter for the supply, which describes the institutional and operational conditions to manage the water supply from the source to the consumer, in accordance with WHO guidelines. In this perspective, the management and control systems should be based on a Security Plan, taking into account the resources, the available technology and the reality in each country.

The Portuguese Specification ETA 0905 states that a Safety Plan must be also prepared for the systems of reuse and recycling of grey water in buildings (SPRAC), with an initial version the installer's responsibility, but periodically updated by the user.

This Safety Plan must include, at least, the following chapters:

- Description of the installation;
- Risk analysis;
- Criteria for the evaluation of the conformity of the quality of reclaimed water;
- Procedures in the event of a fault or serious problem (Action Plan).

For technical and public health reasons, the SPRAC must be **certified** under the terms of the Technical Specification ANQIP ETA 0906, which requires the prior examination of the project by ANQIP, inspections to the construction, certification of installers, as well as the Safety Plan also approved by ANQIP.

4 Quantity and quality of grey water

The quantity of grey water produced can vary considerably depending on the sanitary habits and living standards of families.

In the absence of specific studies, in new or rehabilitated buildings where the devices which have been installed are class A (or less) of water efficiency (ANQIP certification and labeling system), the average water consumption can be estimated at about 100 l/(inhab.*day) and the production of grey water is about 70 l/(inhab.*day).

These values are similar to those proposed in Germany by FBR (information sheet H201):

Nature of the water used	Use of water	Wastewater produced	Destination of water
52 litres of water of drinking quality	40 litres for showers, baths and basins	70 litres of grey water	48 litres of regenerated grey water
	12 litres for the kitchen		
48 litres of regenerated water	5 litres for cleaning		22 litres of discharged grey water
	13 litres for the washing machine		
	25 litres for flushing toilets	25 litres of black water	25 litres of discharged black water
	5 litres for watering		Infiltration in the soil

FBR (information sheet H201)

According to this estimate, the potential for reuse is around 48 l/(inhab.* day), of which 25 to 35 l/(inhab.* day) can be used in toilet cleaning.

Information on the water balance in residential buildings presented in Table can be adapted to non-residential buildings, through a case study.

The production of grey water and its pollution levels are essentially determined by the habits of consumers, resulting from personal hygiene products, detergents, body dirt and also clothing dirt. These pollutants are considered as easily biodegradable.

In general, the water from showers and baths is not very polluted. Water from washing machines usually has a higher pollutant level and water from the kitchen (sink and dishwasher) even greater.

Values may vary depending on the quality of the tap water or treatments carried out in the building network (for example, a higher concentration of nitrates in the overall network or the addition of polyphosphates in the water supply installation to prevent the corrosion of the pipes).

Relatively high concentrations of phosphates may result from dishwashing detergents.

A large number of microbiological studies performed in recent years in bath, shower and sink waters showed much lower levels of total and *faecal coliforms (E. coli)* in comparison with total domestic wastewater.

It is worth noting that in the effluent from washing machines, the concentrations of bacteria depend on the washing temperature.

In terms of present knowledge, it is considered that regenerated water can be used in flushing of toilets, washing machines and watering gardens, after appropriate treatment.

The quality is considered adequate if, in yearly analytical checks, no parameter exceed the specific Maximum Admissible Value (MAV), with the tolerance given in next Table and, in the latter case, a confirmatory analysis carried out after inspecting the installation, and within a maximum of 15 days, leads to a new value that complies with the MAV.

The user of the regenerated water is responsible for preventing the deterioration of its quality between the treatment and use locations.

During the start-up phases the grey water cannot be reused in the building.

Parameter	Tolerances pertaining to MAV
Legionella spp.	1 logarithmic unit
Faecal streptococci (*Enterococci*)	1 logarithmic unit
Faecal coliforms (*Escherichia coli*)	100% of the MAV
Pseudomonas aeruginosa	100% of the MAV
Enteric parasites	100% of the MAV
Suspended solids	100% of the MAV
Turbidity	100 % of the MAV

To flush toilets the requirements in next Table should be considered, where the values for total *coliforms* and *faecal coliforms* are defined as in the quality standards for interior bathing waters, under the terms of the national legislation and applicable European directives (Directive No. 2006/7/EC of the European Parliament and the Council).

Additional safety measures may be considered, such as the placement of signs requiring the closing of the toilet lid in the case of the flushing of toilets.

Parameter	MAV	MRV
Total coliforms	-	10^4 UFC /100 ml
Faecal streptococci (*Enterococci*)	400 UFC/100 ml	-
Faecal coliforms (*Escherichia coli*)	10^3 UFC /100 ml	0 UFC/100 ml
Pseudomonas aeruginosa	1 UFC/ml	
Enteric parasites	1 ovo/ 10 l	
Suspended solids	10 mg/l	
Turbidity	2 NTU	

In the Table, MAV and MRV mean, respectively, Maximum Admissible Value and Maximum Recommended Value, as usual.

The requirements indicated in last Table are also applicable to the washing of clothes, which should not be carried out at temperatures less than 55º C.

For the watering of private gardens, the requirements given in next Table must be complied with, without the need for adding chemical products.

In the case of irrigation of products that can be eaten raw, the MAV indicated in the Portuguese Standard NP 4434 (2005) must be considered, and is not recommend the use of grey water from kitchens.

Parameter	MAV	MRV
Legionella spp.(*)	100 UFC/100 ml	-
Total coliforms	-	104 UFC /100 ml
Faecal streptococci (*Enterococci*)	100 UFC/100 ml	-
Faecal coliforms(*Escherichia coli*)	200 UFC/100 ml	0 UFC/100 ml
Salmonellae	Not detectable	-
Enteric parasites	1 egg/ 10 l	Not detectable
Suspended solids	10 mg/l	-
Turbidity	2 UNT	–

In the Table, MAV and MRV mean, respectively, Maximum Admissible Value and Maximum Recommended Value, as usual.

The start-up phase must have a minimum duration of 6 weeks and will only be considered finalized when, for each parameter, conformity in X successive tests is seen (next Table). During start-up period, the tests cannot be done with intervals of less than 7 days and the first test should only be carried out two weeks after the start-up of the installation.

After a prolonged stoppage or the detection of a serious problem in the installation, the restoration of its operation can be done only once verification has been carried out on the compliance with all parameters in Y successive tests (next Table).

Parameter	Start-up period (value X)	After a prolonged stoppage or the detection of a serious problem (value Y)	Current operation
Legionella spp.	3	2	1 (summer sample)
Total coliforms	2	1	1
Faecal streptococci (*Enterococci*)	3	2	1
Faecal coliforms (*Escherichia coli*)	3	2	1
Pseudomonas aeruginosa	3	2	1
Enteric parasites	3	2	1
Suspended solids	3	2	1
Turbidity	3	2	1
Salmonellae	2	1	1

The values indicated in last Table, in the current operation column, correspond to the number of tests to be performed in a period of one year. The tests to be carried out during this period must be included in a installation maintenance contract.

The installer is responsible for the analysis during the start-up phase or that resulting from the stopping of the system caused by problems identified during the guarantee period (minimum 2 years).

The compliance must meet the values in the Tables corresponding to the uses, and without considering the tolerances indicated before.

If the tolerances are exceeded in any of the parameters, a revision of the installation must be carried out and the tests repeated within a maximum of 15 days (confirmation analysis). The procedure must be repeated on this frequency until they obtain compliance in all parameters.

If this is not verified within three successive confirmation tests, a serious problem should be considered and the installation stopped to detect and correct the anomalies.

The Safety Plan may impose more restrictive procedures than those mentioned above.

5 Design of the systems and technical recommendations

In general, the need for reclaimed water in residential buildings is considerably less than the quantity of grey water available, so it is not necessary to treat all of it but only the least polluted effluents, such as those from the shower, bath and sink.

An alternative supply of water to SPRAC should be considered with water from other sources (supply), but with quality appropriate for uses intended. The operation should preferably be automatic and in the last stage of treatment.

If, along with the reduction of organic matter, there is also a microbiological reduction (which can happen with membranes or filters, for example) a particular stage for disinfection may not be necessary.

Several disinfection techniques can be considered, but the use of chlorine should be avoided because it can cause the formation of organic chlorine compounds, with possible adverse effects on the environment and public health.

A common technique is ultra-violet radiation (UV), where, after the separation of solids and a biological treatment, a radiation of 250 J/m2 is usually sufficient to ensure the necessary quality requirements.

The SPRAC installer must provide a plan of the executed system, the Maintenance Plan and analytical reports relating to the tests performed during the start-up period.

Inspections must be carried out according to manufacturer and installer instructions.

There should be a maintenance contract with a certified installer or entity accredited by ANQIP for that purpose, whose presentation will be mandatory for the purposes of ANQIP Certification of the SPRAC.

6. Conclusions

The efficient use of water is an environmental must for every country in the world.

In the context of the 5R principle for efficient water use in buildings, the reuse and the recycling of grey water in buildings is one important measures, with viability in different types of buildings.

This is why ANQIP, a non-profit Portuguese NGO composed by companies and universities decided to draw up a technical specification for Portugal, taking advantage of some of the experiences undertaken in this field in some countries and of some studies carried out recently in Portugal.

Particular attention was placed on public health aspects. The Portuguese specification requires that a safety plan is prepared and that periodical analytical checks are carried out.

For technical and public health reasons, the Technical Specification ETA 0905 also recommends that the systems are certified by ANQIP.

It is felt that, despite the different conditions of the countries, it should be quite easy, and even desirable, to draw up a European (or more international) standard for this domain.

Thank you very much for your attention

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