The Director General

Maisons-Alfort, 2 February 2015

OPINION
of the French Agency for Food, Environmental and Occupational Health & Safety

regarding the "Assessment of the health risks associated with the reuse of greywater for domestic use"

ANSES undertakes independent and pluralistic scientific expert assessments.
ANSES primarily ensures environmental, occupational and food safety as well as assessing the potential health risks they may entail.
It also contributes to the protection of the health and welfare of animals, the protection of plant health and the evaluation of the nutritional characteristics of food.

It provides the competent authorities with all necessary information concerning these risks as well as the requisite expertise and scientific and technical support for drafting legislative and statutory provisions and implementing risk management strategies (Article L.1313-1 of the French Public Health Code).

Its opinions are made public.
This opinion is a translation of the original French version. In the event of any discrepancy or ambiguity the French language text dated 2 February 2015 shall prevail.

On 21 April 2011, ANSES received a request from the Directorate General for Health (DGS) to undertake the following expert appraisal: "Assessment of the health risks associated with the reuse of greywater for domestic use".

1 BACKGROUND AND PURPOSE OF THE REQUEST

In the context of sustainable development aiming to save water in particular, the reuse of greywater (GW), treated wastewater and/or rainwater is often mentioned. In the last few years, there has been growing interest in this practice and some countries such as Australia, the United States, Israel and Japan have been turning to these additional resources in situations of freshwater shortages.

The use of treated greywater (TGW) consists in harvesting and collecting water from showers, bathtubs, washbasins, washing machines and sometimes kitchen sinks, and using it after treatment. GW has microbiological and physico-chemical contamination.

The use of TGW for domestic purposes is not authorised in France. That said, some facilities have been authorised by prefectural orders on an experimental basis and/or as a derogation. Moreover, the use of TGW is increasing, primarily for the construction of buildings meeting the requirements of high environmental quality (HQE).

The French High Council for Public Health (CSHPF 2006) defined the notion of "domestic water use" as follows:
" - use for food: beverages, food preparation, dish-washing,
- use related to personal hygiene: washbasin, shower, bathtub, laundry,
- use in the home (excreta disposal, washing floors, etc.) and related activities (watering green spaces, watering vegetable gardens, washing the ground and vehicles, etc.)"

The DGS asked ANSES to undertake a scientific and technical expert appraisal in order to:

1. "*characterise the quality of untreated greywater by its origin and the quality of treated greywater by the treatment method used*;
2. *assess the health risks related to the reuse of greywater for domestic use with the exception of use for food;*
3. *formulate management recommendations, whether in terms of outcome obligations (i.e. water quality limits different from those defined for drinking water) or in terms of obligations of means (i.e. treatment effectiveness and types of maintenance and monitoring to be used). Management recommendations may be modulated according to the type of building in question (individual home, collective housing, establishment open to the public, etc.)".*

The expert appraisal aims to offer quality targets for TGW based on possible domestic uses and preventive measures to be taken.

The expert appraisal does not cover:

- the effectiveness and relevance of the various treatment processes,
- economic aspects and in particular cost/benefit evaluations of uses with regards to health risks,
- devices for the direct reuse of GW, with no treatment or networks, such as toilets with a hand-wash tank built into the flushing mechanism and washing machines with an internal system for recycling rinsing water.

2 ORGANISATION OF THE EXPERT APPRAISAL

This expert appraisal was carried out in accordance with the French standard NF X 50-110 "Quality in Expertise – General Requirements of Competence for Expert Appraisals (May 2003)".

The issues being appraised lie within the scope of the Expert Committee (CES) on Water. ANSES entrusted examination of this request to the Working Group (WG) on the Reuse of greywater created on 10 February 2012, reporting to the CES on Water. This appraisal was conducted by groups of experts with complementary skills.

ANSES analyses interests declared by experts before they are appointed and throughout their work in order to prevent risks of conflicts of interest in relation to the points addressed in expert appraisals.

The experts' declarations of interests are made public via the ANSES website (www.anses.fr).

The methodological and scientific aspects of the WG's expert appraisal work, prepared in the form of a report[1], were submitted to the CES on Water at the meetings of 8 January and 2 July 2013 and of 4 February, 1 April, 3 June and 1 July 2014. The report prepared by the WG takes into account the observations and additional information received from the members of the CES on Water and was adopted by the CES on Water, unanimously minus one abstaining expert, at its meeting of 1 July 2014.

The expert appraisal was undertaken on the basis of:

- documents submitted or mentioned by the DGS in the request:
  - French Scientific and Technical Centre for Building (CSTB), Panorama international sur le recyclage des eaux grises, June 2010;
  - World Health Organization (WHO), Guidelines for the safe use of wastewater, excreta and greywater, 2006;
  - US-Environmental Protection Agency (US-EPA), Guidelines for water reuse, 2004;
- a literature search undertaken on the PubMed, ScienceDirect and Scopus sites up to January 2014 dealing primarily with:
  - the characteristics of GW and TGW,
  - practices and feedback in France and other countries,
  - the identification of chemical and microbiological hazards,
  - epidemiological aspects related to the reuse of TGW;
- a search for information on the management of this practice abroad, calling on:
  - competent authorities in foreign countries,
  - scientific teams specialising in GW,
  - members of the European ENDWARE[2] network (an informal group responsible for drafting regulations on DW for EU Member States);
- hearings with representatives from the Professional Federation of Water Companies (FP2E) and industrial companies selling GW treatment processes.

3 ANALYSIS AND CONCLUSIONS OF THE CES AND WG

3.1 Definitions and primary characteristics of greywater

3.1.1 Definition

GW (or household water) is water from showers, bathtubs, washbasins, washing machines, sinks and dishwashers. It is collected by a network and usually directed to a sanitation system.

TGW is GW that has undergone a treatment aiming to reduce levels of particulate and organic matter and/or limit levels of pathogenic or opportunistic micro-organisms.

Industrial uses of TGW have not been examined in this report.

3.1.2 Water flows

The priority source of water supply for homes is drinking water (DW) from the public distribution system. Given the wide variety of possible situations, the use of supply sources other than DW has not been taken into account in this expert appraisal. Figure 1 below shows the paths taken by GW and TGW in the framework of the expert appraisal.

[1] ANSES, 2014, "Assessment of the health risks associated with the reuse of greywater for domestic use" - Collective expert appraisal report. (www.anses.fr)
[2] ENDWARE: European Network of Drinking Water Regulators

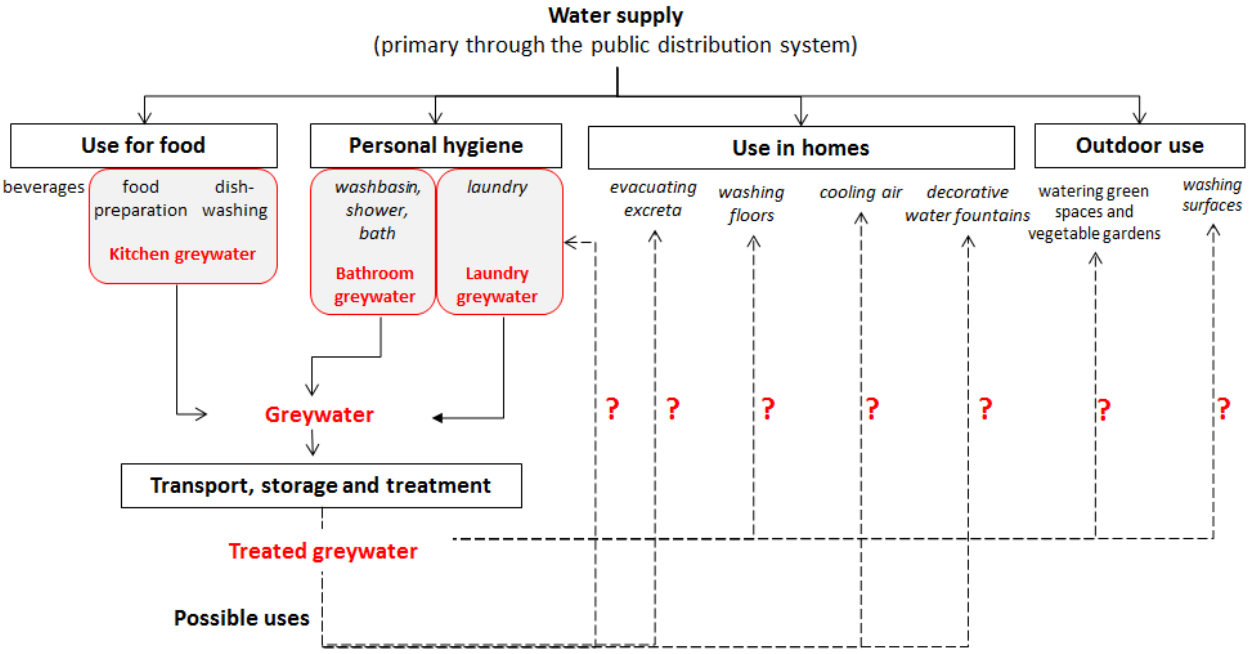

Figure 1: Schematic diagram of flows of greywater and treated greywater and the potential uses analysed in the request.

3.1.3 GW characteristics

The characteristics of GW depend on the following in particular:

- the quality of the water used for the initial supply;
- the uses that generate GW, which can depend on the type of home, the number and health status of its occupants and the source of the water collected (bathroom, kitchen or washing machine);
- the system for the collection and distribution of GW (design, materials, maintenance, etc.);
- the volumes of water collected;
- the treatments used where applicable;
- water storage conditions.

These factors can vary by country in light of differences in climate, demographics, user behaviour, etc.

In light of the published data, there is very little documentation on the microbiological quality of GW, which overall is not different from that of domestic wastewater in terms of the diversity and concentration of micro-organisms.

The physico-chemical characteristics of GW are such that it can promote microbial survival and growth. GW therefore has some biodegradability.

3.1.4 Treatment

GW cannot be used as is for domestic purposes. In order to be used, it has to be suitably treated, and dedicated collection and distribution systems have to be created.
The processes developed to treat GW have primarily been inspired by those used for the treatment of wastewater. Four categories of treatment systems can be identified, based on the primary treatment process:

- two-stage systems, including a macrofiltration stage (sand filtration, reed bed filtration) and/or a lagoon stage, sometimes supplemented by disinfection;

- biological treatment systems: biological filters, activated sludge;
- membrane filtration: microfiltration, ultrafiltration or nanofiltration, possibly preceded by pre-treatment;
- hybrid processes, combining biological and membrane processes (membrane bioreactor, aerated biofilter followed by a membrane, etc.).

Depending on the type of primary treatment, a coarse filtration stage may be offered upstream, together with an end-of-treatment disinfection stage.

It has been established that treatments offered for individual homes are less advanced than those offered in communal buildings.

3.2 French and foreign practices and experience

The reuse of GW for domestic use has developed primarily in countries and regions of the world facing situations of water stress (Australia, California, etc.). In this context, measures are taken to control this practice. These may be regulations (local, national, federal), standards, guidelines and/or recommendations depending on the country.

These measures vary depending on the climate context and local practices. As a result, authorised uses, required quality criteria by use, and control measures taken are relatively different.

The domestic uses of TGW accepted by these countries are as follows:

- mainly flushing toilets, watering green spaces and washing outdoor surfaces (cars, furniture, terraces).
- and also doing laundry, washing floors inside buildings, cooling air and supplying decorative water fountains.

"Personal hygiene" is not mentioned in the regulations, guidelines or standards. It was cited for only one very specific situation during the hearings: a research station in Antarctica with reverse osmosis treatment and rigorous monitoring combined in particular with analytical surveillance of the facility.

In all countries regulating the reuse of treated wastewater or GW, quality criteria are identified for the water reused (treated wastewater and/or greywater).
From a microbiological standpoint, quality standards imply the use of disinfecting treatment, which is not always explicitly recommended. The following parameters are tested: turbidity, suspended solids, 5-day biochemical oxygen demand (BOD_5), pH, residual chlorine, *E. coli*, sometimes thermotolerant coliforms and intestinal enterococci, and more rarely *Legionella pneumophila*, *Pseudomonas aeruginosa*, nematode eggs and *Salmonella* spp.

Procedures for the certification and/or accreditation of treatment facilities and systems have been introduced in some countries.

In most cases, the recommended risk control measures aim to protect DW distribution systems from connection errors, limit storage times, and maintain and monitor facilities.

3.3 Identification of hazards

The possible sources of TGW contamination come from:

- the uses that generate the GW (personal hygiene, cleaning toilets, washing surfaces and doing laundry),
- the treatment, transport and storage system (disinfection by-products, biofilms, release of materials, bacterial proliferation, etc.).

The occurrence of microbiological and chemical hazards in GW and TGW varies, in particular because chemical and microbiological properties depend on human behaviour and matter discharged into GW.

- **Chemical hazards**

Chemical contaminants in GW can come from personal hygiene products or cosmetics, medicinal products, house-cleaning products, pet-care products, gardening, DIY and leisure products, or the treatment, transport and storage system.
It is considered that when reusing GW after conventional water use, the hazards associated with chemical contaminants can be considered as not having a decisive impact for the assessment of the health risks associated with the reuse of GW. However, unpredictable misuse (intensive cleaning, DIY product spillage, etc.) may lead to significant concentrations of chemical contaminants in GW, which may be associated with a health risk, depending on the nature and concentrations of contaminants involved.

- **Microbiological hazards**

There is little information in the scientific literature regarding levels of microbiological contamination in GW and TGW. Given their origins, it is considered that the nature of contamination is not significantly different from that of domestic wastewater. Several types of hazards are likely to be found in GW: bacteria, viruses, protists, yeasts and moulds.

3.4 Exposure

The populations that may come into contact with reused TGW and thus be exposed to the contaminants it contains are as follows:

- residents and/or occupants of buildings (homes, offices, workshops, etc.) where there is reuse;
- occasional users who may be in contact over a shorter period of time, when visiting or staying at a place where there is reuse (hotel, holiday residence, etc.);
- professionals cleaning or maintaining GW reuse facilities.

The potential health risks depend, on the one hand, on certain parameters related to the mode and nature of exposure (duration, frequency, route, intensity, etc.), and on the other hand, on the occurrence and levels of contaminants (microbiological and/or chemical and their properties). The potential health effects induced are also closely related to the health status of the people exposed.

In the population, there are subjects who have particular reactions to exposure and develop a particular health effect. These people make up a fraction of the population and are referred to as "vulnerable populations". In France, as part of public health policy, it is customary to consider young children, pregnant women, immunocompromised individuals[1] and elderly people as vulnerable populations *stricto sensu*.
In the context of TGW use, the experts draw particular attention to the situation of infants, elderly people, immunocompromised individuals and people with contact allergies to personal hygiene and cleaning products.

[1] According to a methodology of the InVS and the National Nosocomial Infection Alert, Investigation and Surveillance Network (RAISIN), immunocompromised individuals are individuals with an advanced disease (blood disorder, metastatic cancer, HIV infection with CD4 < 500/mm^3) or a disease whose treatment reduces resistance to infection (immunosuppressant, chemotherapy, radiotherapy, corticotherapy ≥ 30 days, recent corticotherapy at high doses, i.e. above 5 mg/kg of Prednisolone for more than five days) (InVS and RAISIN, 2012).

There are still uncertainties regarding the biological characteristics (genetic, metabolic, etc.) of vulnerable populations and the nature and levels of GW contamination; therefore, it is not possible to undertake a risk assessment for these categories of vulnerable populations.
Vulnerability is a characteristic that takes into account not only an individual's sensitivity and susceptibility but also social and cultural factors, in particular socio-economic status. A person's "vulnerable" nature is likely to change over time, and depending on types and levels of exposure.
Sensitivity is defined as an increased health risk due to susceptibility and exposure differences.

The possible routes of exposure for domestic use taken into account are mucocutaneous, respiratory and oral.

3.5 Analysis of the risks associated with the use of treated greywater

The data required to undertake a health risk assessment (HRA) are inadequate or lacking. Moreover, several parameters have high variability over space and time: these include the quality of GW to be treated, the health status of occupants, behaviours, treatment facilities, building management modes, etc. It is difficult to rigorously and accurately identify all hazards and assess exposure. That is why a robust HRA related to this practice, applicable to all situations, cannot be undertaken.
Every project for the reuse of GW is a specific situation calling for a regulatory framework at national level relying on a systematic risk assessment process. The assessment should rely on a survey of critical points for every domestic use and for the reuse system.

The reuse of GW in buildings requires the construction of an additional system for distributing TGW to points of use. This can generate risks related either to its implementation, operation and maintenance or to the quality of the transported water. Feedback shows that the complete separation of systems is not possible over the long term and/or on a large scale whenever there is a dual system. Health risks related to a connection between DW and TGW systems represent a critical point that is difficult to control.

Thus, the use of TGW requires that water systems and distribution points be very clearly identified. The risk of confusion from having two distribution points (TGW and DW) in the same area is high, and the control of this critical point cannot be guaranteed.

Regarding dual indoor systems, the scientific and grey literature identifies the risk of DW system contamination from interconnections as high and provides for measures such as:

- prohibition of interconnections with the DW system (for example in Germany, the United Kingdom, Australia and the United States),
- differentiated identification of systems (for example in Portugal, Germany, Australia and the United States),
- limitation of storage times (for example in Australia and the United States).

To avoid confusion and interconnections, the clear identification of systems (colours, symbols, etc.) should be understood by all populations, including visually impaired people and people[1] who cannot read or who have a poor grasp of French.

To supplement the identification of critical points for each use and those related to the flow of greywater before treatment and then the use of treated greywater, a risk classification method related to the reuse of TGW for domestic use was used, relying on the Failure Mode, Effects and Criticality Analysis (FMECA) approach. This approach made it possible to establish a level of

[1] These are in particular young children under the age of six, foreigners not fluent in French, and illiterate or uneducated people

criticality for each use and each route of exposure taken into account. The criticality calculation helped classify risks related to each use and each exposure route.
The approach was applied to the microbiological risk for the general population and did not take into account the effectiveness of the various treatments that can be used. It was not possible to undertake a chemical risk assessment, which was excluded given the conclusions set out in section 3.3.
Criticality is the product of the impact (or effect or severity) and the probability of an event occurring (occurrence index, exposure to a micro-organism here). The higher the criticality, the greater the risk related to the event's occurrence. Table I gives maximum criticality indices estimated by use and exposure route.

Table I: Risk criticality indices related to the domestic use of treated greywater determined according to expert opinion

Use	Maximum criticality index by exposure route		
	Ingestion	Inhalation	Mucocutaneous
Flushing toilets	20	40	30
Doing laundry and rinsing with TGW	24	16	48
Doing laundry and rinsing with DW	8	16	24
Washing floors inside buildings	16	16	36
Washing outdoor surfaces with a pressure washer	12	48	45
Washing outdoor surfaces without a pressure washer	12	12	27
Cooling air	10	60	15
Decorative water fountains	**30**	**60**	**30**
Personal hygiene	30	40	75

In bold: decorative water fountain index used as a threshold for each exposure route
Shaded cells: maximum index below that of decorative water fountains for exposure by inhalation and ingestion (respectively <30 and <60) and a maximum index less than or equal to that of decorative water fountains for the mucocutaneous route (≤ 30).

There is documentation on epidemics caused by exposure from the ingestion and/or inhalation of contaminated water from decorative water fountains using DW. ***The experts therefore chose the maximum indices for fountains as the limits not to exceed for the respiratory and oral exposure routes.***
However, no epidemics related to mucocutaneous exposure have been documented to date: the experts therefore decided not to strictly use the maximum fountain index for mucocutaneous exposure. They have proposed an adaptation: for the mucocutaneous route, the maximum index for a use should be less than or equal to that of decorative water fountains by the mucocutaneous route; moreover, the value of 30 corresponds to the most penalising index.
Maximum criticality indices for the "decorative water fountain" use are 30 for exposure by ingestion, 60 for the respiratory route and 30 for the mucocutaneous route.
Thus, despite the approach's limitations, it is considered that uses with a zero to low risk level (see Table II) are those meeting the following criteria:

- a maximum index less than that of decorative water fountains for the respiratory and oral exposure routes, i.e. respectively <30 and <60,
- and a maximum index less than or equal to that of decorative water fountains for the mucocutaneous route, i.e. ≤ 30.

In Table I, the cells meeting these criteria are shaded.

Table II: Risk levels related to the use of treated greywater.

Criticality index by exposure route			Criticality level	Risk level
Ingestion	Inhalation	Mucocutaneous		
1	1	1	zero criticality	zero risk
]1; 30[	]1; 60[	]1; 30]	low criticality	low risk
[30; 100]	[60; 100]	]30; 100]	very high criticality	very high risk

The uses meeting the two criteria listed above for the three exposure routes are as follows:

- flushing toilets,
- doing laundry and rinsing with DW,
- washing outdoor surfaces without a pressure washer.

The classification approach results in zero to low risk related to the reuse of TGW for doing laundry and rinsing with DW. However, this implies having two water dispensing taps, distributing two different qualities of water in the same room, which can cause confusion and generate risk. In the current state of knowledge and given the available data, it is considered that TGW cannot be used for laundry even with a cycle including rinsing with DW.

TGW cannot be used for washing floors inside buildings because this use:

- requires the installation of an outlet in the home, which could generate health risks;
- cannot preclude the presence and formation of chemical contaminants after adding a cleaning product;
- frequently exposes young children playing at floor level.

Cooling systems rely on complex technical systems requiring water storage in particular, with high quality levels and high constraints[1] incompatible with the characteristics of TGW. The health risk is deemed too high for TGW to be used for air cooling systems.

The use of a pressure washer generating a large amount of aerosols increases health risks and is not compatible with the use of TGW for domestic use.

3.6 Conclusion and recommendations

Given its characteristics, GW cannot in any circumstances be reused, irrespective of the use, without prior treatment in view of reducing levels of chemical and microbiological contamination. The aim of this treatment should be to ensure a zero to low level of health risk. It involves the use of appropriate means and/or technologies requiring know-how for its design and management. Furthermore, user ownership and public information are also essential conditions to ensure the safety in health terms of the operation.
A "risk/benefit" assessment and a technical and economic feasibility study should be undertaken before making any decision to reuse GW, to ensure that the overall health and environmental impact of the operation remains positive or neutral. Moreover, decision-makers (private individuals, co-owners, elected officials, etc.) should be informed about the health, environmental and economic impacts of the operation for the reuse of GW before making a decision.

Considering its impacts, the practice of reusing TGW should also be regulated. To that end, the WG on Greywater and the CES on Water are proposing recommendations. They underline that

[1] Ministerial Order of 14 December 2013 relating to general requirements applicable to installations subject to a prior declaration under section 2921 of the nomenclature of classified installations for the protection of the environment

these are valid only for TGW with no occasional or chronic pollution related to the abnormally high collection of chemicals (e.g. soda, DIY and gardening products).

3.6.1 Origins and identification of reusable greywater

In the current state of knowledge, only GW from showers, bathtubs, washbasins and washing machines has characteristics compatible with use after treatment.
GW from kitchens, which has a high quantity of organic and particulate matter (greases in particular), should not be reused. Moreover, some industrialists, and most of the conclusions of scientific publications, do not consider it, so as to avoid a specific treatment, which would be too cumbersome.

3.6.2 Building stock concerned

The reuse of GW can be considered in residential buildings (collective or individual), establishments open to the public, and commercial buildings.
Regarding healthcare facilities and social and medical-social facilities, and homes for elderly people; medical practices, dental practices, medical biology testing laboratories and blood transfusion facilities; day-care centres, preschools and primary schools; considering that:

- as a precautionary measure, vulnerable populations (infants, elderly people, immunocompromised people, people with contact allergies to personal hygiene and cleaning products, etc.) should avoid use leading to contact with TGW;
- the use of rainwater is prohibited inside these facilities (Ministerial Order of 21 August 2008 on the recovery of rainwater and its use inside and outside of buildings);
- GW is more contaminated than rainwater;

the reuse of GW should not be allowed in these facilities.

3.6.3 Domestic use of reused treated greywater

In the current state of knowledge, it is considered that, subject to the implementation of appropriate treatment and management measures, TGW can be suitable for three uses:

- flushing toilets,
- watering green spaces,
- washing outdoor surfaces with no generation of aerosols (and therefore without the use of a pressure washer); the addition of cleaning products is discouraged.

The experts propose that the following uses should not be allowed:

- personal hygiene,

because it exposes the population to a health risk such that it warrants the use of DW;

- washing outdoor surfaces with a pressure washer,
- supplying decorative water fountains,
- cooling air,

because they expose users and/or the population to a health risk related to the production of aerosols, which may be contaminated;

- washing floors inside buildings,

because it exposes users and/or the population to frequent and prolonged skin contact and to transformation products by reaction with cleaning products;

- doing laundry,

because it requires having two dispensing taps in the same room with a high risk of confusion during use.

3.6.4 Quality limits for treated greywater

The highly diverse nature and level of microbiological contamination of GW are such that none of the uses described above can be considered without prior disinfection. In order for this to be effective, the water has to have suitable physico-chemical characteristics (turbidity, TOC, etc.). These can be specific to the disinfection process.

Possible uses can be divided into two categories of requirements:

- flushing toilets and washing outdoor surfaces for which quality limits have to be defined,
- watering green spaces for which health quality levels have to be the same as those defined in the Ministerial Order of 2 August 2010, as amended on 25 June 2014, on the "*use of water resulting from the purification treatment of urban wastewater for irrigation of crops or green spaces*".

For the first category, quality limits are presented in Table III below. A quality surveillance system has to be implemented:

- Microbiological parameters: *E. coli* and intestinal enterococci taken into account to assess the effectiveness of bacterial disinfection. Their occurrence in disinfected TGW means there may also be pathogens with equal or greater resistance to the applied disinfectant. Note that intestinal enterococci have greater resistance to UV rays (Medema *et al.* 2003) and chlorine (WHO 2004). That is why the proposed quality target is the non-detection of *E. coli* and intestinal enterococci in 100 mL. If levels are detected, corrective measures have to be taken.
- Physico-chemical parameters: turbidity, suspended solids, BOD_5 and TOC as indicators of treatment effectiveness, the microbiological quality control of disinfected water, and the aesthetic appearance of water produced. The TOC value was established, according to expert opinion, by analogy with swimming pool water that contains organic matter and has to be disinfected (AFSSET 2010). When there is disinfection with chlorinated products, a free chlorine residual is required in order to ensure effective disinfection.
- The experts recommend taking a sample of water at one of the TGW distribution points in order to analyse all of these parameters, at a frequency defined in section 3.6.5.4 below.

Table III: TGW quality criteria recommended for certain domestic uses (flushing toilets, washing outdoor surfaces without a pressure washer, etc.)

Domestic use	Parameter	Recommended TGW quality at the point of use
Flushing toilets And Washing outdoor surfaces without a pressure washer	*Escherichia coli*	not detected/100 mL
	Intestinal enterococci	not detected/100 mL
	Turbidity	2 FNU at the point of use and <0.5 FNU entering a UV reactor where applicable[1]
	Suspended solids	< 10 mg/L
	BOD_5	< 10 mg/L
	TOC	< 5 mg/L
	Free chlorine residual	between 0.1 and 0.5 mg/L in the event of chlorination
Watering green spaces	Consistent with Class A of the Annex to the amended Order of 2 August 2010 relating to the use of water resulting from the purification treatment of urban wastewater for irrigation of crops or green spaces	

When there are multiple uses, including the watering of green spaces, the quality criteria established for the most stringent use apply to all of the uses.

3.6.5 Technical procedures for implementation

These procedures cover the design and maintenance of facilities for the collection, treatment, storage and distribution of TGW.
These facilities should be designed so as to meet quality criteria for treated water required according to the intended end use while guaranteeing the protection of indoor DW systems. Among other things, they should also prevent the proliferation of insects and unpleasant odours.
Moreover, TGW should not be used as part of a closed-loop system due to the cumulative contamination likely to be generated.

3.6.5.1 Treatment

The reuse of GW requires the establishment of a treatment system made up of several stages. There is a wide variety of available technologies and possible combinations. Their implementation and operation require know-how going beyond the skills of private individuals.
As a reminder, the definition of suitable treatments by use does not fall within the scope of the expert appraisal.
Under no circumstances should a treatment lower the quality of water, for example by forming a large quantity of disinfection by-products harmful to health and the environment.

3.6.5.2 Collection and distribution systems

Pipes for the collection and distribution of GW and TGW should be separated and manufactured so as to prevent any risk of contamination caused by the backflow of water into the DW system. Visible disconnection from the DW system should be provided for using an overflow system. To that end, compliance with the requirements of the NF EN 1717 standard is called for.

[1] See Ministerial Order of 9 October 2012 on conditions for placing on the market and implementation of membrane filtration modules used for the treatment of water intended for human consumption pursuant to Article R. 1321-1350 (I and II) of the French Public Health Code.

In order to avoid any risk of confusion for users and professionals, the TGW system, including ancillary elements, should be clearly marked with appropriate signage separate from that of the DW system (coloured, marked pipes; warnings such as "non-potable water" or "'do not drink") also tailored to the visually impaired and people[1] who cannot read or who have a poor grasp of French.

All TGW outlets should be prohibited inside buildings to avoid misuse, including directly at the flush water inlet (shower heads, taps, etc.). Taps distributing TGW used for watering or for outdoor washing should be fitted with removable handles (safety valves) and not be located near a DW tap. A bypass valve should be installed to be able to divert TGW to sewers if there is a treatment system failure.

3.6.5.3 Storage of treated greywater

The reuse of GW requires two storage areas: one for GW and one for TGW.
The experts underline that as for domestic wastewater, experience shows that the period between GW production and treatment should not exceed 90 minutes in order to avoid fermentation.
Treated water should not be stored for more than 48 hours. If the system has been left unused for a long period of time (work leave, long absence of over 48 hours), the experts recommend draining it before returning it to service. This recommendation is also valid for the flush tank of toilets in the event that the water stored inside it is not replaced on reoccupation of the premises.

3.6.5.4 Maintenance and monitoring of reuse facilities

On the basis of the hearings, the experts recommend inspecting and servicing the facility (distribution and treatment system) at least twice a year to maintain it and ensure its reliability, and to verify compliance with the quality objectives by undertaking analyses on the parameters set out in section 3.6.4. Maintenance operations require know-how and the intervention of trained professionals with protective equipment. The experts recommend having a mandatory maintenance and servicing contract. The frequency of these operations should be tailored to the size and characteristics of the facility.
Furthermore, weekly self-monitoring of the treatment facility should be undertaken (e.g. measuring turbidity and residual chlorine where applicable, verifying the UV radiation lamp) by a person with suitable training. This frequency was proposed by manufacturers and operators during their hearing. A logbook should be kept for the facility.
The experts recommend making a good practice guide, supplied by the manufacturer, available to users and all people servicing the facility for cleaning, maintenance and monitoring.

To avoid risks of interconnections, the compliance of the building's internal distribution systems should be verified by an independent organisation (marking, signage, etc.) before commissioning and then at a frequency that could be five-yearly, with mandatory checks when there is a change of ownership.

3.6.5.5 Certification of the treatment system

In order to ensure the proper operation of the treatment system, the experts recommend having an independent organisation assess treatment effectiveness in order to verify in particular compliance with the quality criteria set out in section 3.6.4. The performance certification protocol should be drawn up by the competent entities.

3.6.6 Information for exposed populations

The three categories of exposed populations defined above (residents, occasional users, professionals) should be informed that there is a TGW reuse system and about the potential health risks.

[1] These are in particular young children under the age of six, foreigners not fluent in French, and illiterate or uneducated people

An as-built drawing of the facility (distribution, treatment, etc.) should be established and kept available for the people in charge of cleaning, maintenance and monitoring.
For apartment buildings, there should be a charter and property regulations where co-owners and tenants undertake to avoid misusing the system for the collection (inappropriate use, etc.), treatment and reuse of TGW. Signs in the communal areas and regular meetings organised by the management company should supplement the personal information campaign.
When the building is used for professional purposes (offices, workshops), its users should be informed, in particular to avoid spilling effluent into washbasins that could compromise the reuse of GW.

3.6.7 Professional populations

For professionals cleaning or maintaining GW reuse facilities, the following preventive measures should be reiterated:

- **Collective prevention:**
  - Do not use pressure washers
  - Inform professionals of the potential health risks related to the reuse of GW and preventive measures to be taken (including basic hygiene practices);
  - Provide specific training on hygiene and in particular on hand-washing (risk of hand contamination of the mouth and facial mucosa);
  - Provide workers who do not have access to sanitary facilities with containers of drinking water and soap or waterless cleaning methods (foam, liquid gel or antiseptic wipes) that dry quickly;
  - Provide a first-aid kit and all necessary means to clean, disinfect and protect skin wounds.
- **Personal prevention:**
  - Recommend wearing waterproof gloves;
  - Recommend systematically wearing personal protective equipment for eyes if there is a risk of splashing into the face (when cleaning, repairing or handling the GW reuse system): glasses with rigid side protection or a splashproof face shield.
  - Immediately clean and disinfect any wound and cover it with a waterproof dressing;
  - Cover any wound on bare skin with a waterproof dressing, before starting work.

3.6.8 Limitations of reuse

With permanent or temporary collective housing, the attention of the residents and the designers of the GW reuse facility should be particularly drawn to two points:

- If a resident has an infectious disease that can be transmitted through water, the GW collected from his/her apartment should be directly released into the wastewater system.
- A vulnerable person should be able to avoid contact with TGW, in his/her apartment, in the communal areas and also outdoors.

These two points refer to the notions of free will, confidentiality and individual and collective responsibility when designing and managing this type of facility.

3.6.9 Risk management plan

For residential and professional buildings, a plan for the management of risks and malfunctions should be established and include at least the following information:

- characteristics of the facility,
- definition of critical points,
- corrective measures,
- procedures to follow in the event of a failure,

- cleaning procedure,
- logbook for the facility,
- informational documents for the people concerned.

3.6.10 Improving knowledge

Few qualitative and in particular qualitative data have been published on TGW and the related risks.

It is therefore essential for the competent authorities to develop a strategy to improve knowledge in view of adapting these recommendations. This strategy should aim to survey existing facilities and undertake a measurement campaign covering them. It should also aim to support research work with the goal of better characterising:

- Levels of chemical and microbiological contamination in GW and TGW in particular involving potentially pathogenic species (bacteria, viruses, protists, yeasts and moulds, etc.),
- Chemical contaminants transferred to linen during machine-washing,
- Useful parameters for characterising exposure (frequency of exposure, skin transfer, etc.).

Lastly, three important points are worth noting that do not fall within the scope of the expert appraisal and have no responses available in the literature:

- The effectiveness of treatment systems, particularly in real-life situations,
- The production of disinfection by-products related to these treatments,
- Biomass changes and the proliferation of some potentially pathogenic micro-organisms within these systems.

The experts recommend epidemiological monitoring of exposed populations and of professionals in particular.

4 AGENCY CONCLUSIONS AND RECOMMENDATIONS

The French Agency for Food, Environmental and Occupational Health & Safety adopts and agrees with the report, conclusions and recommendations of the collective expert appraisal undertaken by the dedicated working group and approved by the CES on Water.

Moreover, the Agency underlines the following points.

Having a non-potable water system inside a home is the main issue associated with the reuse of GW. The main risk is an interconnection between the DW distribution system and the system transporting GW, which could result in the generalised contamination of DW. Adding an extra system of this type can generate health risks for the users and/or occupants of buildings, whether related to the installation, operation and maintenance of the system or to the quality of the transported water. Human error cannot be ruled out, whether during the design and use of the non-potable water system in the home, during work or servicing on the indoor system, or due to a loss of information during a property sale. That is why traceability is essential to ensure health and safety over time and prevent misuse.

There is a specific standard (NF EN 1717) that must be complied with. Moreover, to avoid confusion and interconnections, the clear identification of systems (colours, symbols, etc.) should be understood by all populations, including visually impaired people and people who cannot read or who have a poor grasp of French.

The implementation of GW reuse should take into account differences between individual homes and residential or professional buildings: number of people and types of populations, informed choices of users, characteristics of treatment systems, ability to manage operations.

An ageing population and an increase in the frequency of hospital care and follow-up care at home after short-term hospitalisation are some of the arguments in favour of imposing a bypass valve in collective housing to avoid using the greywater reuse system if necessary.

In terms of greywater treatments in light of the proposed quality criteria, there is a wide variety of available technologies and combinations, but not all of them appear to ensure compliance with the recommended quality levels at points of use for TGW.

Therefore, ANSES considers that the reuse of greywater should be considered only for strictly limited uses in geographic regions with repeated and long-lasting water shortages. The population should be informed and trained regarding conditions of use required to minimise risks related to having a non-potable water system in a building. Lastly, the rational use of water should be promoted in all circumstances to save this resource.

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KEYWORDS

Greywater, water reuse, risk assessment