GREYWATER AND RAINWATER SYSTEMS: RECOMMENDED UK REQUIREMENTS

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No. of pages: (i) - (ii) of preamble
16 of text
Appendix A1

EXECUTIVE SUMMARY

This report summarises proposed water quality standards and conditions of use for recycled greywater and stored rainwater systems in the UK. The study, on which the conclusions presented here are based, was carried out by BSRIA, during the period October 1996 to February 1997, for the Drinking Water Inspectorate of the Department of the Environment. Full details of the research are contained in BSRIA Final Report 13034/1 dated March 1997, available from BSRIA Publications.

An important constraint on the uptake and use of greywater reuse and stored rainwater systems in the UK is perceived risk to public health. This is particularly so for greywater recycling systems, as there is a possibility that greywater, having been in contact with humans before its reuse, may contain low levels of faecal contaminants. Such concerns have led a number of authorities outside the UK to severely restrict the types of greywater recycling system that are permitted. However, due to recent advances in wastewater treatment technology, experience gained elsewhere, and because public health risks are very application-specific, it is considered unnecessary to impose similarly restrictive regulations on the end-use of recycled water in the UK. Instead, it is proposed that individual systems be tested to an agreed standard, by an accredited test-house, before they can be sold or installed. It is also proposed that water quality criteria appropriate for such systems should be application specific.

Suitable application-specific water quality standards for the UK are proposed in this report, based on relevant standards from the UK and overseas. In addition, the report summarises general requirements for the design, construction, operation and maintenance of UK systems, necessary to protect public health and minimise deleterious effects to plumbing systems and the environment.

The detailed, separate report, referred to above, also provides information on systems currently marketed or under advanced development and includes a comprehensive economic analysis of the application of recycled greywater and stored rainwater systems in five building types, using six generalised system types, two toilet cistern sizes and both new-build and retrofit situations. It also contains details of user acceptability issues, which published reports from overseas and experiences from the limited number of systems already installed in the UK, suggest will not be a problem if systems are designed, installed and operated correctly.

The only factors now limiting the wide-scale use of such products in the UK are perceived lack of economic benefits and water quality assurances. However, the use of greywater and stored rainwater technologies will become increasingly popular as water charges rise; as a recognised system of accreditation, to verify the safety and performance of such systems, is introduced; and, if designers, suppliers, installers and users adhere to the guidelines presented here.

CONTENTS

LIST OF APPENDICES

LIST OF TABLES

1. INTRODUCTION

Rising demand for water, particularly for domestic uses, has led to an increasing strain on water supplies in some areas of the UK. Although rainfall levels are relatively high over much of the UK, and the construction of new reservoirs might therefore be seen as a solution, recent increases in environmental concerns have led to this becoming a more controversial option. Instead, critics point out that the use of existing resources has yet to be optimised, through reduced leakage and effective demand management. Such an approach has recently received backing from the House of Commons Environment Committee [1].

A study recently completed by BSRIA [2] has assessed the implications for the UK of using recycled greywater and stored rainwater as alternatives or supplements to mains water supplies. The potential water savings could be significant; recycled greywater or rainwater consumption could supply the total demand for toilet flushing, which would reduce mains water consumption used in dwellings by up to one third. In a number of other countries, greywater and/or rainwater is already reused on a much wider scale than in the UK. In Germany, for example, a significant number of rainwater supply systems have been installed in buildings, and in Japan the reuse of greywater for toilet flushing is a common practice. One factor that may be limiting the wider uptake and use of such systems in the UK is the lack of water quality assurances. It is intended that the publication and subsequent application in the UK, of the water quality standards and conditions of use detailed in this report, will increase confidence in systems.

1.1 SCOPE

Guidelines and standards for systems that apply in the UK and in selected countries overseas have been reviewed, including those produced by the World Health Organisation (WHO) [3]. Possible deleterious effects that may result when recycled greywater or stored rainwater are used in a range of situations and building types have been considered. Application-specific water quality guidelines and generalised conditions of use are proposed for the UK.

1.2 DEFINITIONS

For the purposes of this study, "Greywater" is defined as all wastewater from domestic (non-process) appliances and fittings with the exception of that from WCs and bidets. It thus includes the discharges of wastewater from kitchen sinks, washroom basins, baths, showers, washing machines and dishwashers.

"Stored rainwater supply systems" are broadly defined as systems which collect and store rainwater from hard surfaces on and around buildings, and distribute it, with or without treatment, to the point(s) of use.

"Greywater reuse systems" are broadly defined as systems which transfer greywater, with or without storage and/or treatment, from the point(s) of production to the point(s) of reuse.

"Combined systems" possess a combination of the above features, being designed to collect both greywater and rainwater for reuse.

2. RECOMMENDED UK REQUIREMENTS

2.1 WATER QUALITY CRITERIA

Table 1: Proposed Water Quality Criteria for Recycled Greywater and Stored Rainwater in the UK[a]

Category of Use	Type of Use		Magnitude of human exposure and/or potential epidemiological risk if water was reused without treatment	Faecal coliform limits (count / 100ml)[b]	Other water quality criteria that apply
	Greywater and Combined Greywater / Rainwater Reuse Systems	Stored Rainwater Supply Systems			
1[c]	Drinking, cooking, bathing, irrigation of crops to be eaten uncooked	Drinking, cooking, bathing	High	None detectable	Standards contained in the UK Water Supply (Water Quality) Regulations 1989, as amended in 1991
2[d]	Toilet flushing (hand-basin toilets excepted), vehicle washing, clothes washing, surface landscape irrigation, irrigation of crops to be eaten cooked, impoundments, use in fire protection systems and commercial air conditioners	Toilet flushing, clothes washing, use in commercial air conditioners	Medium	None detectable	None
3[e]	Sub-surface landscape irrigation, hand-basin toilets[f]	Vehicle washing, surface and sub-surface landscape irrigation, irrigation of crops to be eaten cooked and uncooked, impoundments, use in fire protection systems	Low	Not applicable	None

Notes for Table 1

[a]Criteria proposed by BSRIA

[b]Recommended quality limits apply to the reclaimed water at the point of discharge from the system, prior to reuse, under routine operation of the system. Stored rainwater supply systems are to be tested using rainwater collected at the test site. Greywater and combined greywater/rainwater reuse systems are to be tested using simulated greywater including a known content of an identifiable faecal coliform organism. It is equally acceptable for faecal coliform removal efficiency to be assessed using artificial greywater including a known concentration of an identifiable general coliform organism.

[c]The limit for Category of Use 1 is taken from the UK Water Supply (Water Quality) Regulations

1989 [4] (and as amended in 1991 [5]). Sampling requirements and methods of analysis should be based on those already in use for testing drinking water.

[d]For Category of Use 2, the test procedure must involve the daily collection of a test sample, from Monday to Friday, for a period of eight weeks. Faecal coliforms must not be detected in more than 10% of samples and in no sample should the number of faecal coliforms exceed 14/100ml. Analysis should be conducted using methods and procedures recommended and described in the Standing Committee of Analysts' series of monographs on Methods for the Examination of Waters and Associated Materials [6] published by HMSO, in particular the monograph The Microbiology of Water 1994 Part 1 - Drinking Water [7].

[e]Water quality testing is not required for Category of Use 3.

[f]Hand-basin toilets are placed under Category of Use 3 because although the level of human exposure to reused water may be similar to that which occurs with other recycled water flushing systems, the source of the water is from hand washing alone and this type of toilet has been used in Japan on a wide scale, with no known detrimental effect on public health [8].

2.2 CONDITIONS OF USE

Presented below are requirements that it is proposed should apply to all greywater reuse and stored rainwater supply systems used in the UK. Section 2.2.1 lists requirements that have been designed to protect health and safety, particularly from the stand-point of minimising potential risks from pathogenic micro-organisms. Section 2.2.2 lists additional requirements for the protection of plumbing systems and the environment. Except as otherwise provided for in these requirements, the legal provisions already in place in the UK will apply and suffice (see Appendix A1). Although the majority of requirements apply primarily to designers, manufacturers, suppliers and installers of systems, a number are inevitably the responsibility of system users.

2.2.1 Health and Safety Requirements

- All gross faecally contaminated waste, such as that from WCs and bidets, must pass directly to the sanitary sewer system.

- Greywater or rainwater must not contaminate any domestic potable water supply or be discharged directly into or reach any stormwater drainage system or waterway.

- Regulatory anti backflow devices (as required by the UK Water Byelaws) must be installed on the potable water service to the property and at other critical points on the premises.

- Where potable water is used for back-up supplies to greywater or rainwater storage vessels, a type A air gap must be provided for backflow protection. An overflow to sewer must be incorporated into these vessels to ensure the integrity of the air gap.

- Colour coding and labelling must be used to identify the contents of pipe work, valves and fittings.

- At any point where human contact with reused greywater or rainwater may occur, such as at a tap from which it is supplied, a clear warning sign must be in place. Under circumstances in which this measure may be inadequate to prevent inappropriate use, additional precautions should be taken, such as the application of a coloured dye to the reused water, to avoid confusion with potable supplies, or the placement of locks on supply points, to prevent use by unauthorised individuals.

- Greywater reuse systems must not include laundry water that is likely to contain gross faecal contamination (e.g. from soiled nappies) or any wastewater resulting from the bathing of animals (e.g. family pets).

- Greywater reuse systems should in general not include water from kitchen sinks, dishwashers and waste disposal units.

- Systems must be designed to minimise the potential for the growth of micro-organisms in stored greywater or rainwater. Cool conditions should be maintained, where possible below 20 °C, and the period of storage should be minimised. Untreated greywater should not be stored for longer than 48 hours.

- Systems must be designed in such a manner that inadequately serviced systems will not compromise public health and so that systems have user friendly operation and simple routine service requirements.

- Systems must be supplied with a full and clearly worded set of safety instructions.

- Systems must only be used in applications for which they have been specifically designed and tested.

2.2.2 Additional Requirements Considered Necessary for the Protection of Plumbing Systems and the Environment

To Protect Systems

- Plastic or other corrosion-resistant materials are required in construction. Any metal parts which may be prone to corrosion must be easily accessible in order to allow regular checking, maintenance and replacement.

- All water collected for reuse must be coarsely filtered to remove large debris. Greywater must be filtered more finely to remove hair, large soap particles and other such matter.

- Systems must be constructed, operated and maintained to:

    - prevent the likelihood of blockage, leakage, or overflow;

    - be provided with access points for maintenance and clearing of any blockages;

    - be ventilated to prevent the likelihood of foul air accumulating in the installation and drainage system.

To Protect the Environment

- Where recycled greywater is used for irrigation, adequate care must be taken to avoid the contamination of underlying aquifers and neighbouring watercourses.

- Systems must be designed in such a manner that inadequately serviced systems will not harm the environment.

- It must be ensured that by-products of systems, including chemicals used for water treatment, are disposed of in a manner which is not detrimental to the environment or the sewer system.

- Systems must be constructed, operated and maintained to:

    - prevent the likelihood of air and gases entering buildings or causing nuisance;

    - prevent the likelihood of discharged water causing offensive odours and nuisance.

- Recycled greywater should only be used to irrigate tolerant plant species.

2.3 BACKGROUND TO RECOMMENDATIONS

2.3.1 Water Quality Criteria

There are currently no published water quality criteria in the UK that apply specifically to rainwater and greywater systems. In their absence, it has often been assumed that recycled water should be treated to either potable or bathing water standards (see Appendix A1). This ambiguity has been a matter of concern both to the developers and manufacturers of systems and to those with responsibility for safeguarding public health.

The need for specific water quality standards stems from the fact that greywater, and often also stored rainwater, contains material, in particular microbiological contaminants, which under certain circumstances may present risks to health. Although, by definition, greywater does not contain gross faecal contamination, tests have shown that there are sometimes faecal contaminants present. For example, analysis of greywater from the washers, showers and bathroom sinks of different families in the USA, revealed the presence of micro-organisms of faecal origin. Total and faecal coliforms were found to be more abundant in shower and bath water than in laundry water [9]. Rainwater reuse systems collect water from roofs and other hard surfaces, and as the rainwater does not generally come into contact with humans prior to its use, there is less chance that it will contain human pathogens. However, some degree of contamination can occur, with research showing, for example, that coliform bacteria may be present, probably due to the presence of bird faeces on roofs [10].

The actual epidemiological risk to health posed by the use of recycled greywater and stored rainwater depends not just on the degree to which the water is contaminated, but also on the degree to which humans are exposed to the water. In certain applications, therefore, in which there is little or no human contact with the water, it can be safe to omit treatment.

A number of overseas authorities have set water quality limits specifically for reused water (generally recycled municipal wastewater, however) and these have frequently been based on human exposure levels. The proposed water quality criteria shown as Table 1 of this summary report, have been produced with reference to the most important of the overseas criteria, and to existing UK standards for bathing water and drinking water. These sources are listed below, under the categories of use to which they bear most relevance (see Table 1).

Category of Use 1
Water should be of potable quality, hence the water quality criteria defining wholesome water in the UK's Water Supply (Water Quality) Regulations 1989 [4], and as amended in 1991[5], are relevant.

Category of Use 2
Water quality criteria produced by the US Environmental Protection Agency for "Urban Reuse" [11], by WHO for "Category A" agricultural reuse [3], by the States of California [12] and Florida [13] for uses including toilet flushing, by NSF (National Sanitation Foundation) International for recycle/reuse devices for toilet flushing [14] and by the UK Government for bathing water [15], are relevant.

Category of Use 3
No water quality criteria required, as there is a very low likelihood of human contact with the water and/or negligible epidemiological risks.

As is the case with the WHO guidelines for wastewater use in agriculture [3], the proposed water quality criteria have been formulated from the standpoint of protecting public health and so provide limits for faecal coliform concentrations in reused water. Limits for Categories of Use 1 and 2 have been set at the lowest (i.e. safest) level used in overseas standards (no faecal coliforms detectable). Additionally for Category of Use 1, as there is either the intention, or risk, that the reused water will be consumed, it must fully conform, in terms of quality, to the UK Water Supply (Water Quality) Regulations 1989 [4] (and as amended in 1991 [5]). No water quality requirements are given for Category of Use 3, however, as the degree of human exposure to the reused water is very low and/or the epidemiological risks are negligible.

Due to the high diversity of greywater reuse and stored rainwater supply systems available, and the range of different situations in which these may be employed, parameters such as turbidity, BOD and pH have not been included in the proposed water quality criteria. This is because it is considered that elevated levels of these parameters cause adverse effects only under certain circumstances. For example, in systems which ensure that greywater is reused within a few hours for toilet flushing, a high level of BOD in the reused water will probably be inconsequential, as there is insufficient time for significant organic decomposition to occur that would lead to problems with odour. Also, if disinfection systems are appropriately designed, effective disinfection of water with a relatively high level of turbidity is possible. In place of standards for these parameters, relevant means to protect plumbing systems and the environment and additional mechanisms to ensure health and safety are incorporated into the design and use requirements detailed in Section 2.2 of this report.

It is suggested that the minimal risks involved do not warrant water quality monitoring on every individual greywater reuse or rainwater supply system installed in the UK. Instead, a scheme should be devised by which different system types are comprehensively tested by a recognised test-house before use is permitted. Tests should be devised, similar to those produced by NSF International for wastewater recycle/reuse and water conservation devices [14], that are application specific (i.e. accreditation would be for Category of Use 1, 2 or 3). Once a manufactured system received such accreditation, it could be sold, and installed on premises by a qualified and specially trained plumber, without further testing or water quality monitoring. Certain 'DIY' designs could also receive such accreditation. Such an approach to water quality control is based on the recommendations of WHO [3]. This approach can also be justified in view of the fact that blackwater (i.e. that containing gross faecal contamination) is not being treated by such systems, and thus the potential dangers associated with system malfunction are reduced. The fact that greywater is of domestic (non-process) origin also means that, for Categories of Use 2 and 3, it is unnecessary to set water quality standards for toxic substances such as heavy metals and pesticides. However, instructions should be supplied with greywater recycling systems to ensure that users know that such substances, should they be used in the home, must be disposed of correctly and must not, for example, be discharged into sinks.

2.3.2 Conditions of Use

The health and safety requirements listed in Section 2.2.1 of this report are intended for use in conjunction with the proposed water quality criteria shown in Table 1. The requirements listed in Section 2.2.2 are additional safeguards for plumbing systems and the environment. When formulating the conditions of use a number of overseas guidelines and standards were consulted, in particular the recent Australian guidelines for domestic greywater reuse [16].

The health and safety requirements are principally designed to avoid cross-contamination of potable water supplies with rainwater or greywater and to ensure that non-potable water systems are clearly identified as such. The requirements are also intended to ensure that systems are properly designed, installed and maintained; that they are only used in appropriate applications; and that greywater is obtained from suitable sources.

Requirements relating to plumbing systems are primarily concerned with mitigating or avoiding problems related to the growth of micro-organisms, the corrosion of metals and to scaling, fouling and sedimentation. Possible deleterious effects on other equipment, such as irrigation systems, have also been taken into account when formulating these requirements.

Requirements relating to the environment can be broadly categorised into those designed to protect against potentially harmful direct (e.g. possible damage to sensitive plant species when greywater is used in irrigation) and indirect effects (e.g. problems arising from changes to previous patterns of water usage). It is important to note, however, that in most cases both positive and negative environmental effects can be identified, and that the overall balance is usually positive.

3. OUTLINE OF SYSTEM TYPES

A diverse range of designs are available for greywater reuse and stored rainwater supply systems. Systems can be classified with regard to a number of features, the most important of which are outlined below.

Reused Water Source
The water source may consist of rainwater only, greywater only, or a combination of both. Rainwater may be collected from roofs or from suitable surfaces around buildings. Greywater may be collected from any suitable domestic (non-process) appliance or fitting.

End-Use of the Reused Water
Reused water may be employed for a range of end-uses, the most important of which are shown in Table 1 of this report. The UK application with greatest potential may be toilet flushing, due to the high water savings that can be achieved and the fact that water for flushing does not have to be of potable quality.

Complexity and Size
The simplest form of stored rainwater supply system is the garden water butt, while the least complex greywater reuse system is the 'hand-basin toilet'. The latter consists of a hand-basin, in place of a low-level toilet cistern lid, into which water automatically passes, through a raised pipe, after flushing. This water is used for hand-washing and passes directly into the cistern to be used in the next flush. In size, systems range from those designed for single family dwellings to those used in groups of large buildings, which are usually also the most complex systems (in this report schemes involving public supplies of rainwater or greywater, which may be larger scale, have not been included).

Water Treatment
Systems may incorporate a water treatment process. Brief details are provided in Section 4 of this report.

Water Storage
Almost all systems incorporate some form of water storage. The provision of adequate storage is particularly important for rainwater supply systems, as sufficient rainwater must be retained to cover, at the very least, short periods without rain. Tanks are used as the standard storage mechanism, but novel devices also exist, such as water storage roofs and permeable paving, which have the additional advantage of incorporating collection and storage capabilities. As greywater can be obtained on a more regular and reliable basis than rainwater, only small volumes may need to be stored. This is particularly true when the reused water is to be employed in applications such as toilet flushing, in which the daily demand for water corresponds closely to the daily production of greywater. Also, due to problems associated with micro-biological growth, it is inadvisable to store greywater for extended periods of time.

Method of Manufacture

There are now a number of rainwater and greywater systems available on the UK market which can be purchased as complete, ready-to-install packages including all the necessary features for the collection, storage, treatment and distribution of reused water (contact addresses of manufacturers and suppliers are given in BSRIA Final Report 13034/1 [2]). In some cases components of the system can, if necessary, be modified or replaced to allow customised installation. 'DIY' systems may also be constructed. These can range from small-scale systems built by enthusiasts using standard plumbing materials, to systems designed by professionals for large buildings or groups of buildings.

Building Type

Rainwater and greywater systems can be installed in a wide range of building types, during construction or by retro-fitting. Whether the use of such a system is appropriate for a particular building will depend on a number of factors, including the volumes of greywater and/or rainwater that can be collected and the potential demand for reused water in the building.

4. TREATMENT OPTIONS FOR GREYWATER AND RAINWATER

4.1 CRITERIA FOR SELECTION

When selecting methods of water treatment, if any, to be included in greywater and rainwater systems, the factors outlined below need to be taken into account.

End Use of the Reused Water
Different reused water qualities are required for different end uses. Table 1 provides recommended water quality criteria for the UK for different categories of end use. In applications where the degree of human exposure to the reused water is very low, such as sub-surface irrigation, no water quality limits apply and hence no water treatment process is required. In practice, however, filtration may be necessary to prevent blockages in the reuse system. At the other end of the scale, for applications, including potable uses, in which there is a high degree of human exposure to the reused water, advanced, fail-safe treatment systems are required.

Source of the Reused Water
In general, the quality of rainwater is superior to that of greywater and thus a lower level of treatment may be required. The quality of greywater varies depending on the source and treatment systems must be designed accordingly. Treatment systems must be capable of treating the rainwater or greywater to the required standard, and should be designed so that material present in the source water will not disrupt the operation of the treatment system, for example by blocking filters.

Maintenance
The majority of water treatment systems require some degree of maintenance. The level of maintenance required should be taken into account when designing systems, particularly those which are to be used in private dwellings.

Size
The size of the treatment system may be important, particularly if it is to be installed in a location where space is limited.

Reliability
If reused water is to be used in applications for which set water quality standards apply (see Table 1), a reliable water treatment system must be employed, incorporating an alarm system to warn users if any malfunction occurs.

Residual Disinfection
If storage of reused water takes place after treatment, it may be necessary for a method of treatment to be selected, such as chlorination, which creates a sufficient degree of residual disinfection.

Financial Costs
Both the initial purchase cost of a system and the running and maintenance costs must be considered.

Environmental Considerations
Possible effects on the environment should be considered, particularly with regard to residual treatment chemicals remaining in the reused water.

4.2 COMMON TREATMENT METHODS

At its most simple, water treatment may consist of coarse filtration, to remove particles such as leaves and grit from rainwater or hairs from greywater. This may then be followed by disinfection, generally using chlorine, ozone or ultra-violet (UV) light.

Particularly when greywater is reused, more advanced treatment may be required. This usually involves several stages: filtration; a secondary treatment usually either flocculation, a biological treatment or a combination of both; and disinfection. Table 2, below, lists several types of greywater treatment system, most of which would also be appropriate for rainwater treatment, and describes their principal advantages and disadvantages (adapted from Glucklich [17]).

Table 2: Some Greywater Treatment Options

Treatment	System	Advantages	Disadvantages
Physical	Settlement Tank	Inexpensive	Not very effective
	Gravel Box	Inexpensive	Not very effective; problems with removal of sludge
Biological	Rotating biological disc	Compact - can be installed inside buildings	Problems with sludge disposal; no physical filtration occurs; requires an additional tank.
Physical and Biological	Rapid sand filter	Compact - can be installed inside buildings	Problems with removal of sludge; filter easily obstructed.
	Slow sand filter	No sludge removal problems	Large, so usually requires area outside building
Disinfection	Chlorine	Very powerful and fast acting, leaves residual in treated water	Can react with some organic materials in water to form acids
	UV	Achieves very high microbiological kill rate	No residual effect; may not work effectively in water with low UV transmission
	Ozone	Achieves rapid kill; effective against many micro-organisms; reduces to oxygen; can be produced in situ	Lack of residual; not very effective in an open system; turbid water may diminish effectiveness

Recent innovations in greywater treatment include products based on membrane technology. For example, field trials of a prototype membrane treatment system designed by Anglian Water are now underway in a domestic property [18, 19].

Point-of-use (POU) treatment devices are one option to treat greywater or rainwater on a smaller scale, although their effectiveness in treating such water is currently untested [20].

5. CONCLUSIONS

There is great potential for greywater reuse and stored rainwater supply systems to be used more widely in the UK. A large number of system designs are available and several proprietary systems are currently being marketed in the UK. The only factors now limiting the use of such systems, on the same scale as some other countries, are the perceived lack of economic benefits and water quality assurances. However, a recent study [2] has shown that in a number of applications pay-back times for systems can be very short. Also, it is intended that the water quality criteria and conditions of use presented in this report, used in conjunction with the Water Byelaws [21] and existing plumbing standards such as British Standard 6700 [22], will increase confidence in systems.

The water quality criteria and conditions of use for greywater and rainwater systems presented in this report, are designed to compensate for the lack of a specific standard for their installation and use in the UK. It is recommended that such a standard should be developed, possibly by adapting the standard already produced by NSF International in the USA for wastewater recycle/reuse and water conservation devices (this is currently under revision) [14]. The resulting standard should be application specific (i.e. based on the category of use of the recycled water) and should incorporate the water quality criteria and conditions of use proposed in this report. It is also recommended that action should be taken to accredit test houses to certify systems, using the new standard.

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APPENDIX A1

Existing UK Regulations and Acts of Parliament Relating to Greywater Reuse and Rainwater Supply Systems

No. of pages: 6

Depending on the particular circumstances under which greywater reuse and stored rainwater supply systems are to operate, a number of Regulations and Acts of Parliament apply. These are outlined below [1].

Water Byelaws

Any connection of a mains water supply to a storage tank which may contain greywater or rainwater must comply with the Water Byelaws of the water supplier, in order to prevent contamination of the mains water supply. The Water Byelaws of the water undertakers in England and Wales derive from and are identical to the 1986 Model Water Byelaws published by DoE. The Water Byelaws apply where a private water supply is used as an alternative to a mains water supply. The Water Companies have a statutory duty to enforce their byelaws. Several byelaws affect the use of greywater recycling and rainwater collection.

1. In order to protect the water supply system from backflow of potentially contaminated water, byelaw 12 requires that:

   "(1) No supply or distributing pipe which conveys, or cistern which receives, water supplied for domestic purposes shall be connected so that it can convey or receive water supplied for non-domestic purposes.

   (2) Paragraph (1) shall not apply to a cistern, or to any pipe conveying water from such a cistern to a point of use if water is discharged into that cistern through a Type A air gap."

   In addition, byelaw 25 contains general requirements for protection against back-flow risk at every point of use or draw-off which is supplied with water for domestic purposes.

2. In order to prevent the contamination of stored water, byelaw 30 requires that:

   "(1) Every storage cistern for water supplied for domestic purposes, shall:

   (a) be installed in a place or position which will prevent the entry into that cistern of surface or ground water, foul water, or water which is otherwise unfit for human consumption; and

   (b) comply with paragraph (2).

   (2) Every cistern of a kind mentioned in paragraph (1) shall-

   (a) be insulated against heat and frost; and

   (b) when it is made of a material which will, or is likely to, contaminate stored water, be lined or coated with an impermeable material designed to prevent such contamination; and

[1] Regulations and Acts of Parliament relating specifically to Scotland and Northern Ireland are not included.

(c) have a rigid, close fitting and securely fixed cover which-

(i) is not airtight,

(ii) excludes light and insects from the cistern,

(iii) is made of a material or materials which do not shatter or fragment when broken and which will not contaminate any water which condenses on its underside,

(iv) in the case of a cistern storing more than 1000 litres of water, is constructed so that the cistern may be inspected and cleansed without having to be wholly uncovered, and

(v) is made to fit closely around any vent or expansion pipe installed to convey water into the cistern."

and byelaw 31 requires that:

"Every storage cistern shall be installed in a place or position such that -

(a) the inside may be readily inspected and cleansed; and

(b) any float-operated valve or other device used for controlling the inflow of water may be readily installed, repaired, renewed or adjusted"[2].

3. Byelaw 38 requires that to minimise contamination of the stored water :

"(1)Every storage cistern which has a capacity exceeding 1000 litres shall, subject to paragraph (2), be fitted with an overflow pipe and a warning pipe, and every other storage cistern shall be fitted with a warning pipe only.

(2) Paragraph (1) shall not apply to require the fitting of both an overflow pipe and warning pipe where -

(a) in the case of a storage cistern with the capacity exceeding 5000 litres but not exceeding 10,000 litres, that cistern is fitted with an instrument which indicates when the water level is not less than 25mm below the overflowing level of the lowest pipe; or

(b) in the case of a storage cistern with a capacity exceeding 10,000 litres, that cistern is fitted with an audible or visual alarm operating independently of the valve or device which controls the inflow of water and indicates when the cistern is about to overflow."

Byelaw 7 regulates the types of material that may be used in the construction or installation of pipes or water fittings which convey or receive water supplied for domestic purposes, in order to minimise contamination of the water. Compliance with BS (British Standard) 6920 is deemed to satisfy byelaw 7. BS 6920 specifies the detailed requirements for the suitability of non-metallic products, with regard to their effect on the quality of the water. Included amongst these is the requirement that the material should be deemed not to support appreciable microbial growth, a factor which is of particular importance in the design of greywater reuse and rainwater supply systems.

[2] This is accepted as being satisfied where a storage cistern has an unobstructed space above it of not less than 350 mm.

Water Industry Act 1991

Section 52 of the Water Industry Act 1991 defines the domestic supply duty of water undertakers. In subsection (1) paragraph (a) it is stated that, in relation to any premises, the duty of a water undertaker is:

"(a) to provide to those premises such a supply of water as (so far as those premises are concerned) is sufficient for domestic purposes."

Section 68 defines the duties of water undertakers with respect to water quality and states in subsection (1) paragraph (a) that:

"(1) It shall be the duty of a water undertaker- (a) when supplying water to any premises for domestic or food production purposes to supply only water which is wholesome at the time of supply."

"Wholesome" is defined in the Water Supply (Water Quality) Regulations 1989 (SI 1989/1147), later amended by the Water Supply (Water Quality) (Amendments) Regulations 1989 (SI 1989/11471/1384) and 1991 (SI 1991/1837). As long as there is a constant supply of water which is within the quality requirements set out in these Regulations (limits for selected parameters are shown in Table A1.1) then the Water Industry Act will not be infringed.

The Water Industry Act 1991 also contains a number of specific restrictions as to what may be discharged to a public sewer, particularly in separated sewage systems where there are dedicated foul and surface water sewers. Surface water is defined by Section 219(1) of the Water Industry Act 1991 as including 'water from roofs'.

Section 106 (2) b of the Water Industry Act 1991 disallows the discharge of rainwater directly into a foul sewer. However, this should not restrict the use of stored rainwater in buildings, as once the rainwater has been used for a purpose such as toilet flushing, it is no longer classified as 'surface water'.

Table A1.1: Selected Prescribed Concentrations or Values for Drinking Water Quality contained in the Water Supply (Water Quality) Regulations 1989

Parameters	Units of Measurement	Concentration or Value (maximum unless otherwise stated)
Colour	mg/l Pt/Co scale	20
Turbidity (including suspended solids)	Formazin turbidity units	4
Odour (including hydrogen sulphide)	Dilution number	3 at 25°C
Taste	Dilution number	3 at 25°C
Hydrogen ion	pH value	9.5 5.5 (minimum)
Dry residues	mg/l	1500 (after drying at 180 °C)
Total coliforms	number / 100 ml	0*
Faecal coliforms	number / 100 ml	0
Faecal streptococci	number / 100 ml	0
Sulphite-reducing clostridia	number / 20 ml	≤ 1**
Colony counts	number / 1ml at 22 °C or 37 °C	No significant increase over that normally observed

Note: *See regulation 3(6); **Analysis by multiple tube method

The Private Water Supplies Regulations 1991

The Private Water Supplies Regulations 1991 (SI 1991/2790) relate to the quality of water from private supplies for drinking, cooking, washing or food production. The 1991 Regulations were made under the Water Industry Act 1991.

The Regulations set out quality standards that water from private supplies must meet if it is to be used for the purposes listed above. These standards may be relaxed by written authorisation from the local authority under certain circumstances.

Bathing Waters (Classification) Regulations 1991

Although there are published water quality standards for drinking water (see Table A1.1) there is no guidance in the UK on the water quality required for domestic purposes (for example WC flushing) other than those which are directly potable.

One suggestion has been that until specific water quality standards for greywater re-use and stored rainwater supply systems are established in the UK, it is appropriate to use the UK's bathing water quality standards as guidelines (Bathing Waters (Classification) Regulations 1991 (SI 1991/1597); see Table A1.2). These are less stringent than the standards required for potable use and are designed for a situation in which there is physical contact with water and in which there may be occasional accidental ingestion.

Table A1.2: Selected Quality and Sampling Requirements contained in the Bathing Waters (Classification) Regulations 1991 (SI 1991/1597)

Parameter	Parametric value	Minimum sampling frequency
Micro-biological:		
Total coliforms	10,000 / 100ml	Fortnightly *(see Note 1)*
Faecal coliforms	2,000 / 100ml	Fortnightly *(see Note 1)*
Salmonella	Absent in 1 litre	*(see Note 2)*
Entero viruses	No plaque forming units in 10 litres	*(see Note 2)*
Physico-chemical:		
pH	6 to 9	*(see Note 2)*

Notes

1. Samples may be taken at intervals of four weeks where samples taken in previous years show that the waters are of an appreciably higher standard than that required for the classification in question and the quality of the waters has not subsequently deteriorated and is unlikely to do so.

2. Samples must be taken in relation to this parameter when there are grounds for suspecting that there has been a deterioration in the quality of the waters or the substance is likely to be present in the waters.

3. For details of methods of analysis and inspection, and for sampling requirements and classification criteria, see the Bathing Waters (Classification) Regulations 1991 in full.