A BASIC RAINWATER HARVESTER

INTRODUCTION

Rainwater harvesting has been practiced for over 4,000 years. Nowadays it is utilised mainly in Africa, the East and in the drier parts of the U.S.A. Rainwater harvesting is the collection, conveyance (usually by pipe) and storage of rainwater. As a rule, rainwater has greater purity than groundwater supplies (wells, streams, etc). It is relatively free of nitrates and pesticides, and some other contaminants. However, it still requires filtration and purification. Filtration removes particulate matter such as grit and dust from the water. Purification is the process that makes the filtered water safe for humans to drink (potable), by removing or destroying harmful bacteria and viruses. Leaves, bird droppings and dust are present on roofs and other water catchment areas, particularly after a long dry spell of weather. Pathogens such as harmful bacteria and viruses are also present.

Rainwater is soft and a pleasure to shower or bath in, is generally better for plants, and its use results in less limescale in kettles, etc, than mains water. Rainwater also has superior cleansing properties, and usually a better taste. In the West we greatly undervalue water; having a mains supply means we only have to turn on a tap for instant potable water. We do not normally have to carry it for a distance from a well or other source. For that matter, few Westerners have to concern themselves with the regular maintenance and cleaning that rainwater harvesting involves. The owner of the rainwater harvester (RWH) is also responsible for the purity of any potable water produced.

The small RWH shown here only has sufficient capacity to complement the mains water supply. It is a basic, unpressurised (gravity) system with a modest roof collection area and storage capacity. Filtration is achieved by using gravel and sand, and purification by activated carbon, with the option of further purification. The installation is independent of and not connected to the mains water supply. A moderately experienced DIY person can build this RWH, or perhaps a more complex system. If unsure of how to do the job, or of its possible impact on domestic water regulations and home insurance, it is best to enquire. Most information on RWH's comes from abroad, mainly the U.S.A. The RWH described here uses parts and materials that are readily available in the U.K.

Every dwelling and the lie of the land around it is unique. Rainfall distribution and quantity over a year vary greatly around the world. The number of occupants and their water usage also varies widely. As a result of this, the capacity and design of RWH's are highly individual. The example described here is one particular system in a particular dwelling. It is strongly recommended that as much as possible is read about RWH's and water purification, especially the sources given at the end of this document.

The main advantages of a gravity RWH over a pressurised, sophisticated system are greater reliability, lower cost, and no need for an electrical supply. With this RWH all construction, maintenance and repair can be undertaken inexpensively at local community level or by an individual – no specialised components or skills are required. As low cost and simplicity are priorities, it was decided to install a basic gravity RWH.

The main disadvantage is the very low pressure usually associated with gravity systems. Appliances such as washing machines and dishwashers normally need at least half of typical mains water pressure in order to work properly. In addition the relatively weak pressure means that it takes far longer to fill a kettle or other vessel of a given capacity with water. A pressurised system is more versatile in that water can be pumped to an upper floor from ground-level storage, and is more flexible to install.

DESIGN

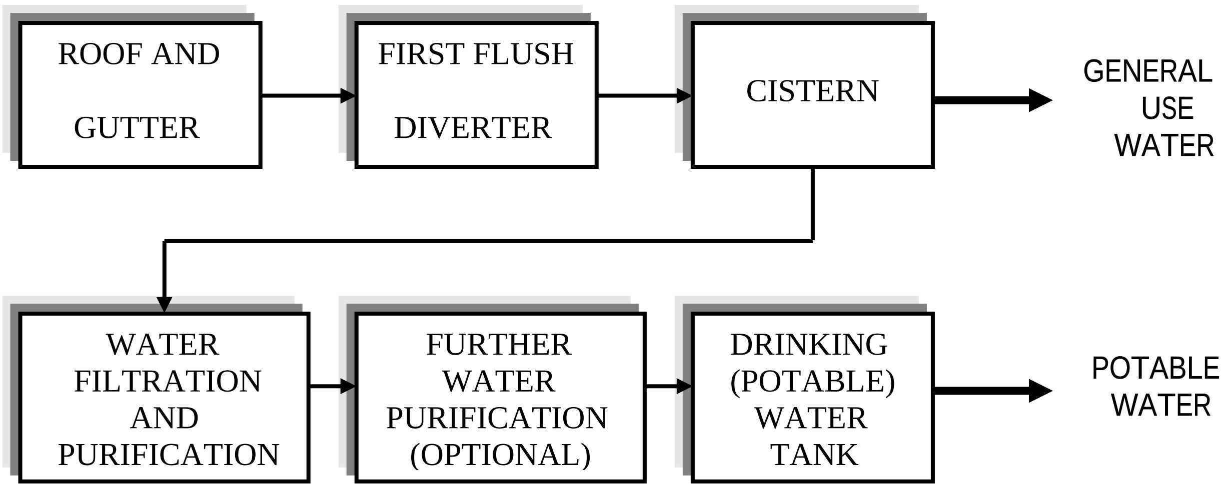


FIGURE 1

Figure 1 shows the basic elements of the RWH. The roof is the collection or catchment area for the rainwater; the guttering transports the water to the first flush diverter and the cistern. After a dry spell of weather there will be an accumulation of bird droppings, dust and other matter on the roof. During the first rainfall following a dry period (first flush), the first flush diverter diverts a quantity of water, which contains most of this matter, from the water storage cistern. Then the cleaner water is diverted to the cistern, which is the reservoir of unfiltered and unpurified water for use by the household. There are two feeds from the cistern – one for general use water, the other for the filtration and purification of water intended for drinking.

Filtration is achieved by gravel, which filters out the larger particles of matter; and sand, which filters out small particles and harmful bacteria, etc. The activated carbon purifier removes a range of chemical contaminants from water, but not all. Nearly all of those that it cannot remove are not present in rainwater. Activated carbon purifiers also improve the taste of water; for example they absorb chlorine. For extra safety, a further stage of purification could be added. Possibilities include ultra-violet irradiation (which requires electrical power), reverse osmosis, or a fine-pore ceramic purifier. One or more of these would be required for a groundwater supply. Note that filters and purifiers can drastically cut down the flow-rate, and with this RWH the pressure may be too low for additional filters. Finally, the filtered and purified water feeds the clean water tank from which drinking water is drawn.

Anyone installing a RWH needs to know how much rain is likely to be collected by the roof over the course of a year. Also, estimates for the quantity of water to be diverted by the first flush diverter (FFD) and the capacity of the cistern are required.

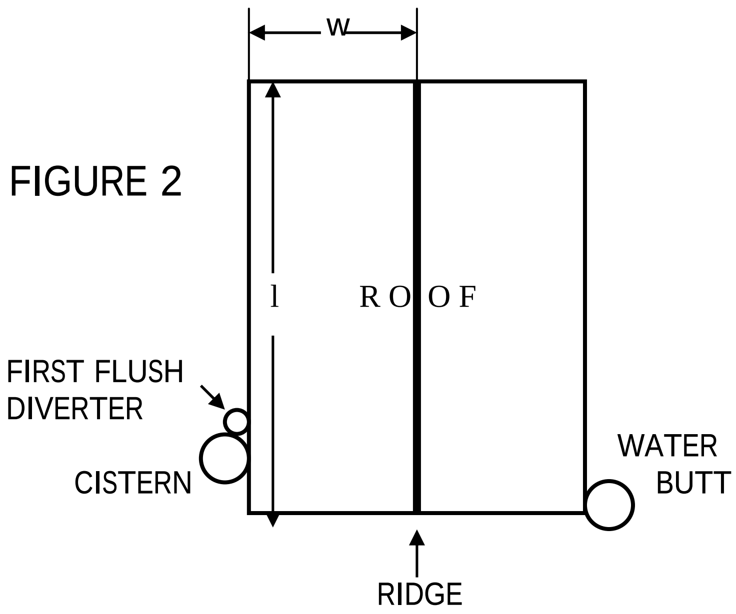
Metric units are used throughout. Their use avoids any confusion or error regarding, for example, the Imperial (British) gallon and the smaller American gallon; many information sources are from the U.S.A. Materials purchased in the U.K. are usually supplied in metric quantities or sizes. Below are some conversions: -

1 Imperial gallon = 4.56 l
1 U.S. gallon = 0.83 Imperial gallon = 3.79 l
1.2 sq yards = 1 sq m
0.98 Imperial ton = 1 metric tonne = 1,000 kg

Units: - l = litres, ml = millilitres, kg = kilogrammes, m = metres, mm = millimetres.

Figure 2 is a plan view. First, the amount of rainwater collected from the roof per annum has to be worked out. In this installation, half of the roof feeds the cistern and the other half feeds a water butt; see Figure 2. The area of the roof is measured as seen from the air, and the slope is not taken into account for RWH. Measurements are made at ground level.

FIGURE 2



The mean annual rainfall (mar) for Worcestershire, U.K. is about 0.67 m. The efficiency of collection (e) for a rough-tiled surface is about 80% (a corrugated iron roof would be over 90%). The roof (collection area) is 9.3 m long and 3.5 m wide.

The collection area (a) = l * w = 9.3 * 3.5 = 32.55 sq m.

Rainwater collected = mar * e * a = 0.67 * 0.8 * 32.55 = 17.45 cu m or 17,450 l per annum.

Allowing for a drier year than average, and losses from the FFD, say 12,000 l would be harvested. If one person uses 25 l of water per day, he or she will use :-

Days in year * daily consumption = 365 * 25 = 9,125 l total per annum.

Enough water would be harvested for the single occupant of this dwelling with a generous margin. For two people, both sides of the roof could be utilised by joining the two gutters together with downpipe and combining them for a single feed to the first flush diverter and cistern.

Next, the FFD chamber capacity needs to be calculated. The Texas Guide on Rainwater Harvesting recommends an allowance of 0.42 to 0.84 l capacity per sq m of roof area (converted figures); 0.6 l per sq m of roof area will be allowed.

For a roof area of 32.55 sq m., the FFD capacity = 32.55 * 0.6 = 19.5 l.

Finally, the capacity of the cistern is worked out. This depends on the rainfall pattern (e.g. rainy season followed by drought), the mean annual rainfall, the number of occupants in a dwelling and how much water each person requires. In the U.K the rainfall is distributed fairly evenly throughout the year, so the storage cistern can be smaller than in a country with a 6 month dry season i.e. 2 to 3 months of storage will suffice in the U.K. as opposed to 6 months or so. An example is given below.

Allowing for a maximum of 80 days of dry weather (or very little rainfall), and one person using 25 l of water per day, the cistern capacity is :-

80 * 25 = 2,000 l of cistern capacity per person.

Note that this quantity of water weighs 2 metric tonnes. The cistern would need to be strongly supported with a sound foundation.

INSTALLATION

The guttering needs to be checked for condition, repaired if necessary, and cleaned out. If there are overhanging trees nearby, leaf guards (strips of plastic mesh which clip to the top of the gutters) can be fitted. A 6 to 10 mm mesh filter is fitted to the top of the downpipe to prevent larger debris on the roof from being washed into the RWH – check regularly.

A simple FFD can be made from 110 or 165 mm outside diameter plastic underground drainage pipe, available from builders' merchants. This pipe and fittings are quite expensive and it will pay to shop around, and also to see what can be scrounged. A large plug is fitted to the bottom of the chamber for the regular cleaning out of accumulated debris (see Figure 3 overleaf). During the first rainfall after a dry spell, the chamber fills with the calculated amount of water; when it is full, water is diverted to the cistern. The chamber is continuously drained from a 1 to 1.5 mm hole drilled in the pipe some 120 to 150 mm from the bottom, or a tap set to drip can be fitted. The runoff can be used for watering the garden or fed to the original downpipe drainage point.

The FFD can be fitted with a floating ball as shown in Figure 3. This seals off the pipe when the chamber is full. This makes the FFD more effective than if there is no floating ball. However, RWH's tend to be used in warm climates; in a UK winter it is possible that ice may damage the floating ball assembly or prevent it from working. It was decided not to fit one.

The length of pipe needed to provide the required FFD chamber capacity can be worked out. For 110 mm pipe, a 1 m length contains 8 l of water; a 1 m length of 165 mm pipe contains 18 l. The length of pipe required is the capacity of the FFD previously calculated (19.5 l) divided by 8 for 110 mm pipe, or 18 for 165 mm pipe.

For this installation, length of pipe = 19.5 / 18 = 1.08 m.

This is measured from the hole or tap to the bottom of the "T" junction near the top of the FFD. For a large roof the pipe can be arranged as a large "U" shape if necessary.

The cistern is the most expensive part of the installation. Cisterns are made from materials including fibreglass, plastics, galvanised sheet metal and concrete. Concrete and galvanised metal cisterns are lined to prevent these materials from affecting water quality. Fibreglass or plastic cisterns, available from builders' merchants, are probably the best option. The cistern should be opaque to inhibit the growth of algae, and protected from sunlight. Any openings need removable covers or screens to keep out insects and small animals; access is required for cleaning. Plain net curtain supported by wire mesh can be used, and will provide pre-filtering for incoming water. Clean this out regularly. The cistern needs to be sited as high as possible, particularly for a gravity system. It must be placed on a stable, level foundation, possibly concrete over hardcore, depending on soil type and cistern capacity.

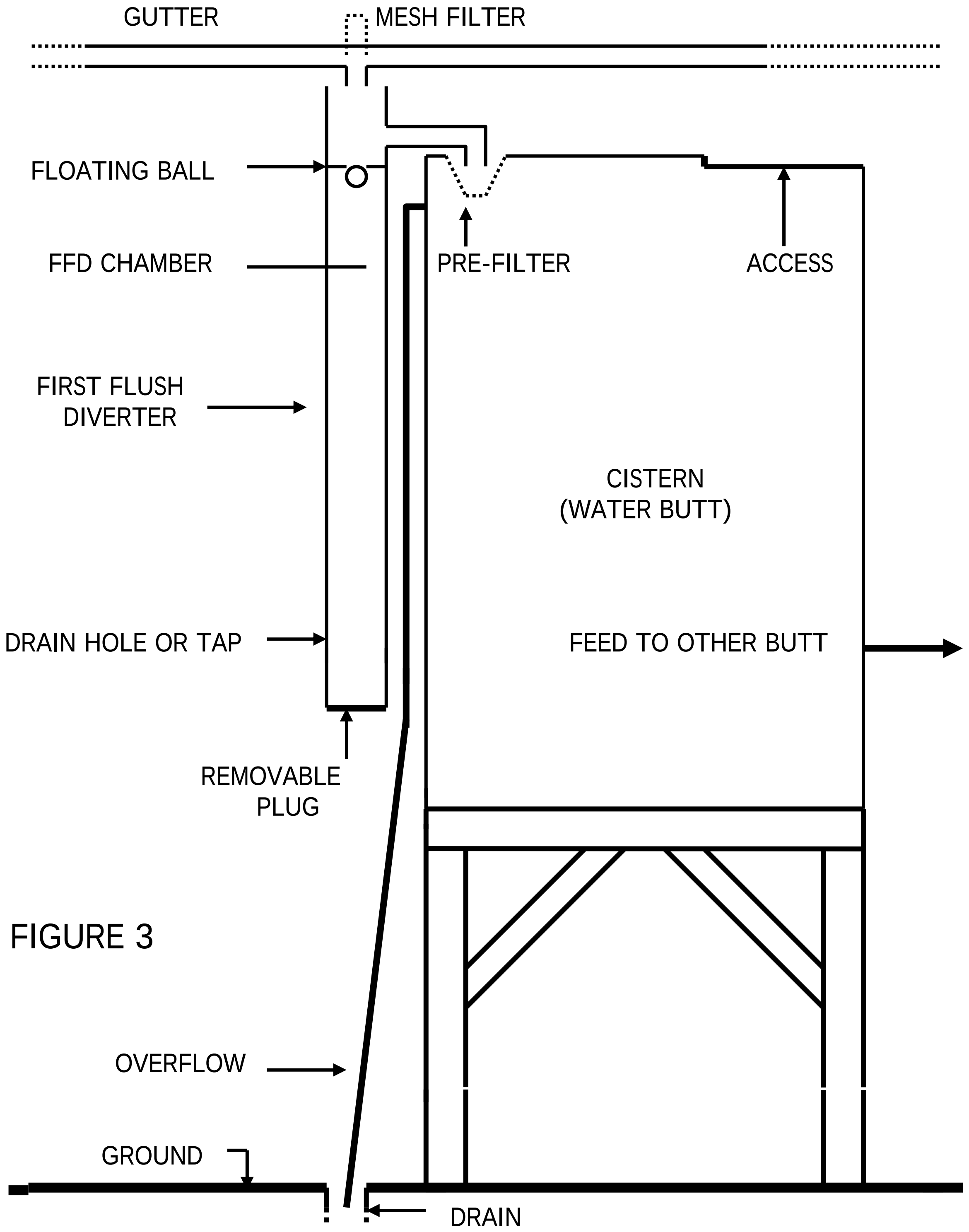


FIGURE 3