CHAPTER 6

Pump and Filter for Rainwater Harvesting System

General Principles

Pumps are mechanical devices that lift water from lower to higher level by application of some form of energy. There are several types of pumps with different operating principles suitable for various conditions of use.

It is important to understand these principles so that the most efficient pumps are selected for particular type of building or application. There are positive displacement reciprocating pumps, centrifugal pumps, centripetal pumps, and centrifugal jet pumps.

The suction operation of the pump creates vacuum in its inlet chamber and the atmospheric pressure pushes the water up the pump inlet chamber. It gains energy due to the reciprocating or centrifugal action of the pump develops pressure within and enables the water to flow to higher elevations.

Suction lift is constrained by the available atmospheric pressure, as the atmospheric pressure reduces with altitude, so does the pump suction capacity. The vapour pressure of the liquid at its operating temperature also affects the suction capacity of a pump. If the available suction head is less than the vapour pressure, water will evaporate, causing a condition known as cavitation that may damage the pump due to erosion or vibration associated with it. Vapour pressure conditions arise largely in systems handling hot water.

The net available suction pressure is known as net positive suction head. It depends on various factors such as atmospheric pressure; head loss due to friction in pipe, pipe fittings and foot valve, velocity head at suction face, and vapour pressure at the operating temperature.

Pumping head is the pressure required for a pump to transfer liquid from one level to another. Total head required is computed based on static head between the centre line of the pump and the high water level, frictional losses in pipes, fittings and valves, and velocity at entry point.

Efficiency of a pump is the ratio of the network done by the pump in lifting water, to the energy applied to do the work. A pump has loss of energy due to the motive power of its driving mechanism, e.g an electric motor, engine, etc. The net efficiency of the total set is given by the efficiencies of the individual equipments.

Each pump impeller has its own operating characteristics, which define its capability and efficiency. These can either be calculated for each individual pump and its impeller or the pump characteristic read from graphs and nomographs normally furnished by each pump manufacture for their products.

Reciprocating Pumps

Reciprocating pumps are plungers or cylindrical rams that are made to move to and fro by an engine or motor crank mounted on a wheel of the drive. The movement allows pressure to build up with each stroke, which is then pushed up to higher levels in subsequent strokes. A set of valves on the suction and delivery prevents back-flow and building up of pressure.

Reciprocating pumps give a fluctuating flow, which is overcome by having two or more cylinders acting together to provide uniform flow. Reciprocating pumps generally have limited discharge capacity but generate very higher pressures.

Efficiency of the pump is quite low due to several moving parts and valves. The pumps have limited applications in building water supply systems and high-pressure applications.

Centrifugal Pumps

Centrifugal pumps (Figure 6.1) have circular impellers mounted on a shaft inside a housing known as volute. When rotated at high speed, the impeller creates a vacuum and sucks the water in the volute. The circular motion of the impeller transfers the rotating dynamic energy to water, which then develops pressure at the outlet and the water can be transferred to a higher level. Centrifugal pumps are more efficient than reciprocating pumps as they have lesser rotating parts.

Depending on the type of impellers used, the pumps have a variety of pumping applications. They are used extensively in water supply, irrigation, sewage, heating air conditioning and in domestic appliances such as air coolers, washing machines, dish washer, etc.

They can pump large volumes of water and generate high pressures up to 200m and above. Centrifugal pumps can be installed in a variety of ways and conditions as per site conditions. Surface mounted pumps are universally used for all applications under positive or negative suction conditions.

Figure 6.1: Typical Centrifugal Pump

Vertical Submersible Pumps

Vertical wet or dry-pits submersible pumps are those in which the pump is submerged in liquids and driven by a vertically-mounted motor driven by a long shaft. The motor is normally above the high-flood level or above the maximum water-level in the tanks to prevent the motor from submerging in water.

In dry-pit pumps, pumps are installed in a separate dry compartment and bearings of the pump shaft lubricated by specialized mechanism which pumps grease in the required positions.

Vertical pumps used for clear water and sewage pumping are submerged or at some level as that of the liquid and thus have positive suction. They are ideal for automatic operations, difficult suction conditions or where priming of the pump is a problem. The vertical pump shaft length is a limitation and is normally restricted to 5-6m.

Figure 6.2: Typical Submersible Pump

Fully Submersible Pumps

Fully submersible pumps (Figure 6.2) have a monobloc-type pump couple to an electric motor. The entire electrical pump and motor combination is submerged in the water. The water also acts as a coolant and the pumps have no priming problems or any limitations of suction lift.

Submersible pumps are commonly used in tubewells, deep open-wells, canals, lakes, lift irrigation and other water supply schemes.

Submersible pumps are easy to install and do not required a separate pump house above or below ground, thus saving considerably in terms of costs.

Jet Pumps

To overcome the suction limitations of surface-mounted pumps, a special suction device known as jet assembly is used to lift water from depths of 6-40m.

The jet assembly, in principle, applies additional energy at the suction point in the form of a properly designed jet in a venture tube.

The additional energy is derived from the pump itself from its delivery side. The pressure of the jet pump has to be high for the jet action, but delivery pressure is controlled by a pressure regulator.

Rainwater Pump

Pumps can be broken down into two major categories consists of clear or gray water pumps and solids handling pumps. Within these two broad categories, they are further differentiated by the type of impeller employed, the design of the motor, and the expected duty cycle.

Clear or rainwater pumps are designed to pump water that is free of trash, sewage and other large solids. These pumps employ oil filled motors. Oil transfers heat from the motor to the pump case and also lubricate the bearings and mechanical seals. Motors are rated for either intermittent or continuous duty. Intermittent duty pumps are the most common for rainwater harvesting system. They are designed for an average duty cycle of 20 min per hour. Although they can run for longer periods, their life will be shortened. Continuous duty pumps can run 24 hours per day as long as they are located in a sump where incoming water can flow over a motor. These pumps are often found in water feature or pond where 24 hour circulation is required.

The rainwater is caught in a collecting tank, from which it is pumped into a pipe system. The rainwater can then be taken from this in the same way that drinking water can. If the tank should ever run dry, it can be supplied with drinking water.

The common demands on the control system for a rainwater pump are as follows:

- The water must be available at all times.
- When the switch to drinking water takes place, no rainwater must get into the drinking water system.
- If there is not enough water in the rainwater tank, the pump cannot be switched on (run-dry protection).

Self-sucking pump with fixed flow control, especially designed for use in rainwater harvesting systems is shown in Figure 6.3. The pump curve shown in Figure 6.3 can be used to select an appropriate size of the pump which is based on the lifting head and desired flow.

The typical equipment and accessories of the pump is as follows:

- Filter with hose connection for easy cleaning
- Sound absorptive rubber stands
- Inlet plugs on pressure and suction sides
- Cable for electric connection.

Submersible pump designed for use in rainwater systems is shown in Figure 6.4. The pump is available in two different types:

- Submersible pump with float and suction pipe to be fitted into an underground tank. Flow control and control unit are mounted indoors.
- Pump with mounted pressure control for separate installation in a dry space.

The pump curve shown in Figure 6.4 can be used to select an appropriate size of the pump which is based on the lifting head and desired flow. The typical equipment and accessories of the pump is as follows:

- Float valve with suction pipe
- Sound absorptive rubber stands
- Inlet plugs on pressure and suction sides
- 20 m cable for electric connection.

The Configuration of the pumping system for rainwater tank is shown in Figure 6.5. The details of various pump installations and rainwater tank placement are shown in Figure 6.6, Figure 6.7, Figure 6.8 and Figure 6.9.

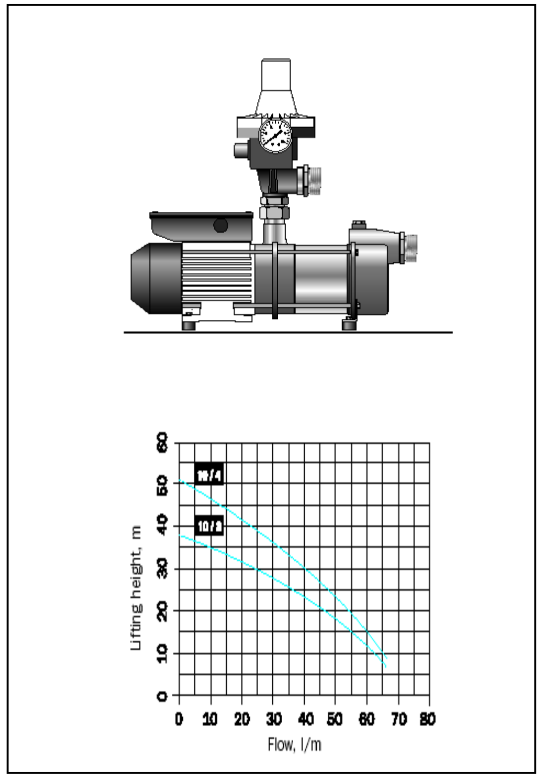

Figure 6.4: Typical Rainwater Pump for Indoor and Underground Installation

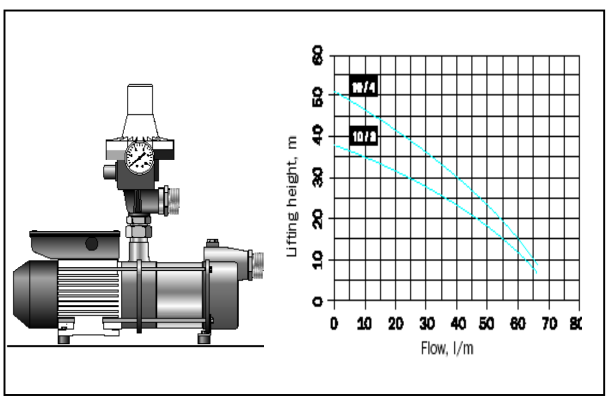

Figure 6.3: Typical Rainwater Pump for Indoor Installation

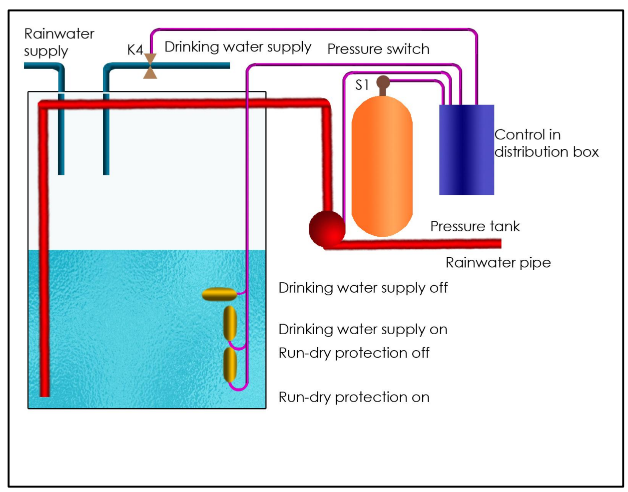

Figure 6.5: Typical Configuration of the Pumping System for Rainwater Tank

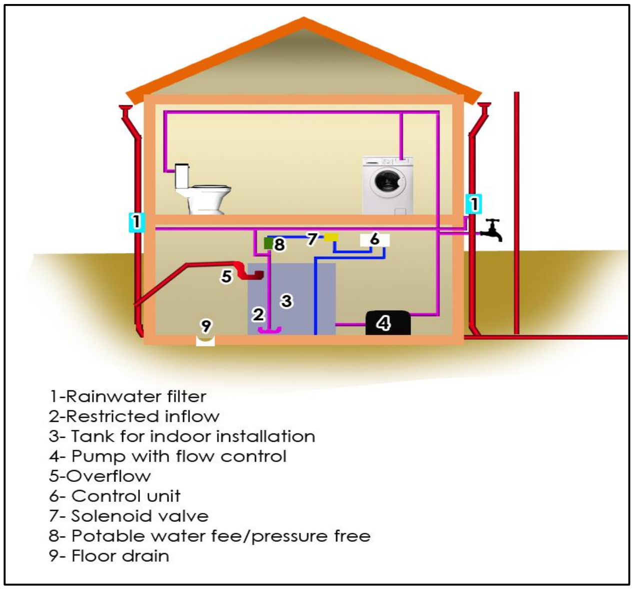

Figure 6.6: Typical Storage Tank and Pump Installed in the Basement.

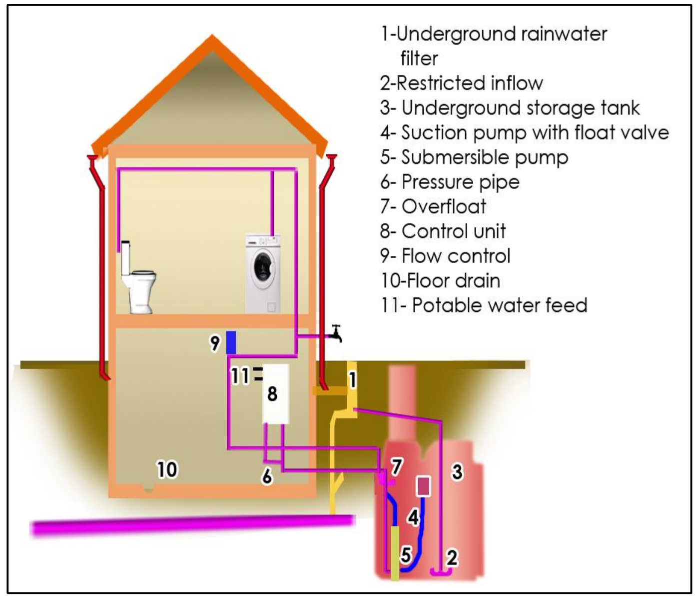

Figure 6.8: Typical Underground Storage Tank with Submersible Pump.

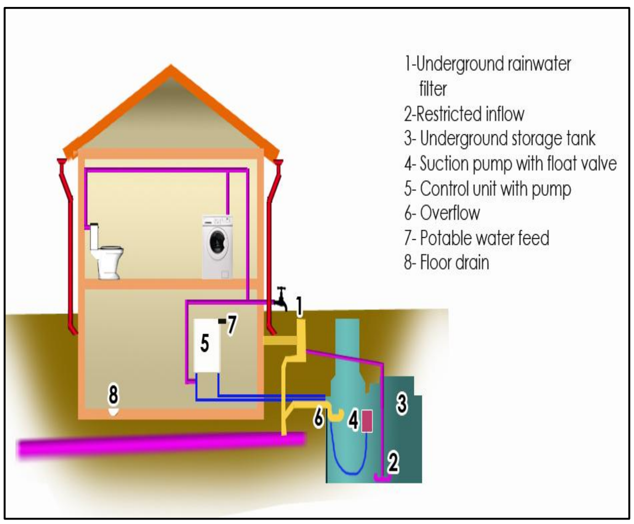

Figure 6.7: Typical Underground Tank and Pump in the Basement.

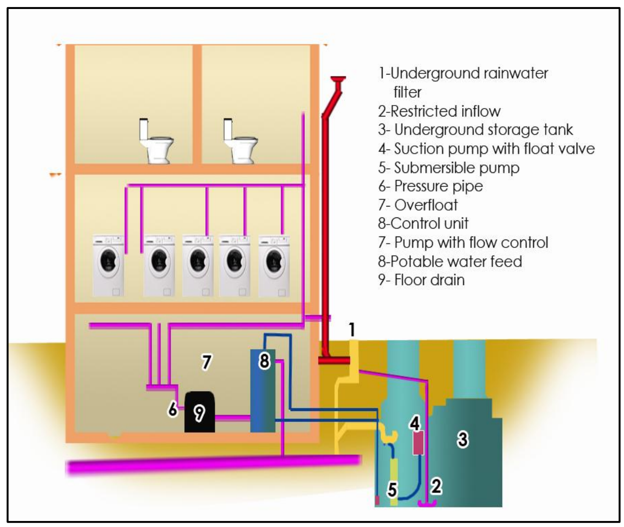

Figure 6.9: Typical Underground Storage Tank with Submersible Pump and Pump in the Basement.

Rainwater Filters

Rainwater quantity varies and is affected by environmental factors and commercial activities in the area. The addition of the rainwater filter will improve the quality of the water.

The rainwater filter can be part of the rainwater downpipe, be separate from a tank or be attached to a tank. The rainwater filter also can be installed below ground. The size and volume of rainwater filter are size as per following below;

Table 6.1 Guidelines for residential first flush quantities

Rooftops of 100m2 or smaller	25 -50 liters
Rooftops of 100m2 or larger	50 liters per 100m2

Table 6.2 Guidelines for surface catchments or for very large rooftops

Rooftops or surface catchments of 4356m2 or larger	2500 liters

(5000liters if surface contains excessive soil, dust or debris) Multiple first flush devices instead of a larger first flush may be required depending on slope of the catchments surface and time required for rainwater to reach the first flush device.

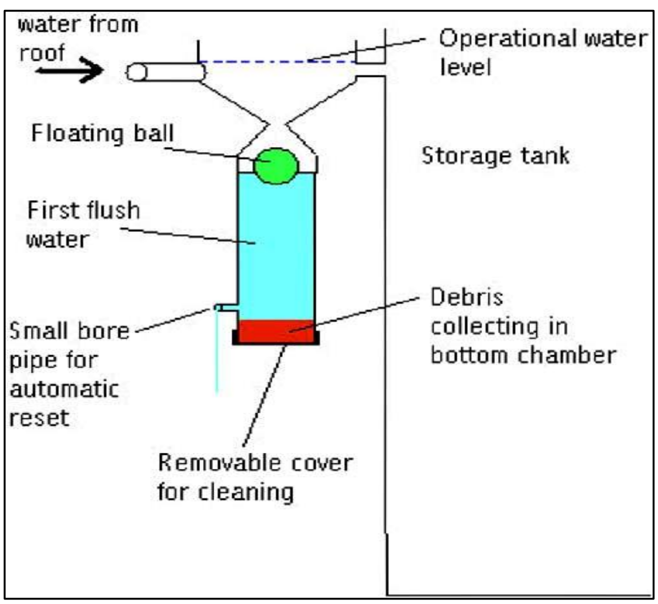

Figure 6.10 : Typical Fist Flush System

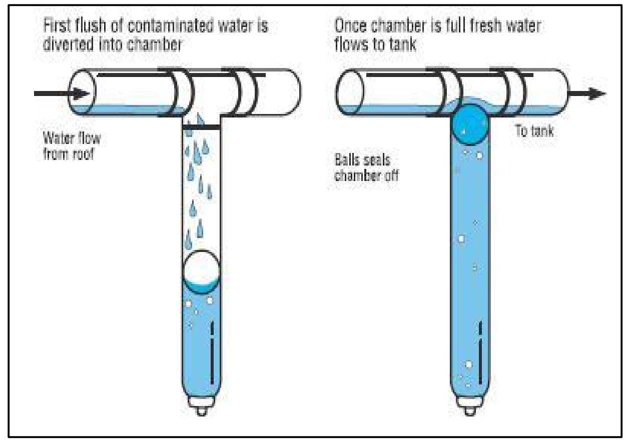

Figure 6.11: Floating Ball Valve Fist Flush System

Maintenance of rainwater filter

The rainwater filter systems are to be maintained regularly and the maintenance are to be carried out as follows:

1. Contaminated water in the rainwater filter should be drained on a regular basis after each rainfall event.
2. Remove debris whenever necessary.
3. Debris shields and vegetation traps should be cleaned regularly to allow unrestricted flows to filter storage.

Figures 6.12 and 6.13 indicate the installation of the filters in the rain harvesting system. The detail cross sectional views on the filters are shown in figures 6.14 and 6.15.

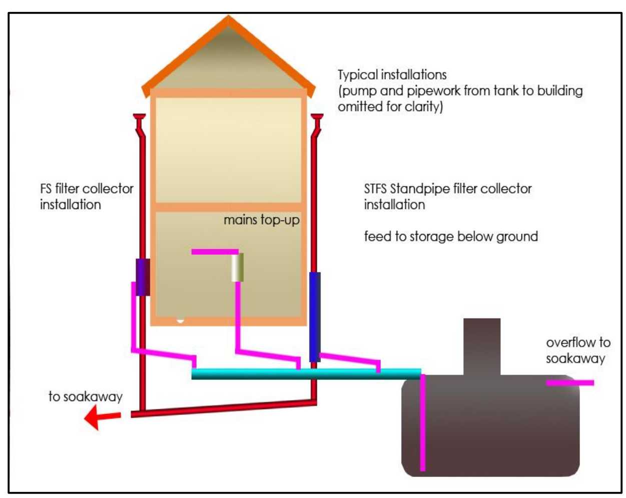

Figure 6.12: Typical Configurations of Rainwater Filters for Underground Rainwater Tank.

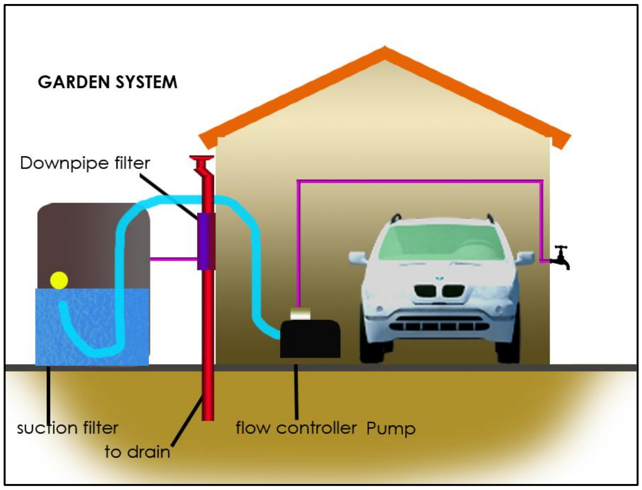

Figure 6.13: Typical Configurations of Rainwater Filters for Rainwater Tank at Ground Level.

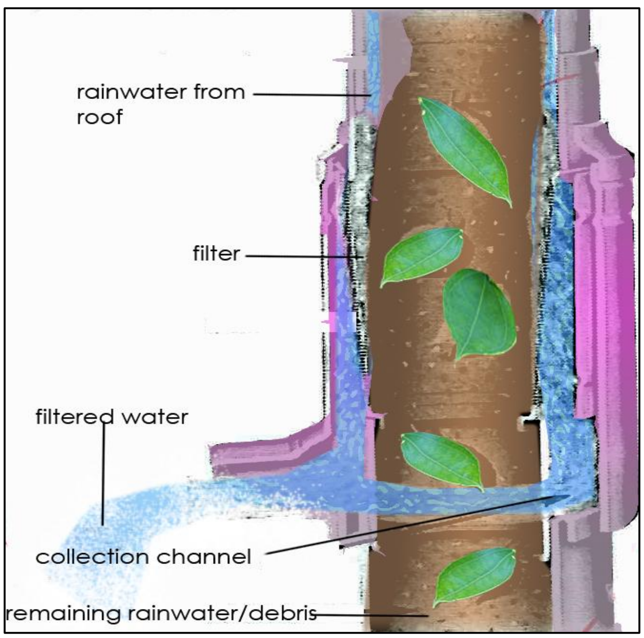

Figure 6.14: Typical Downpipe Rainwater Filter.

Figure 6.15: Typical Downpipe Vortex Rainwater Filter.