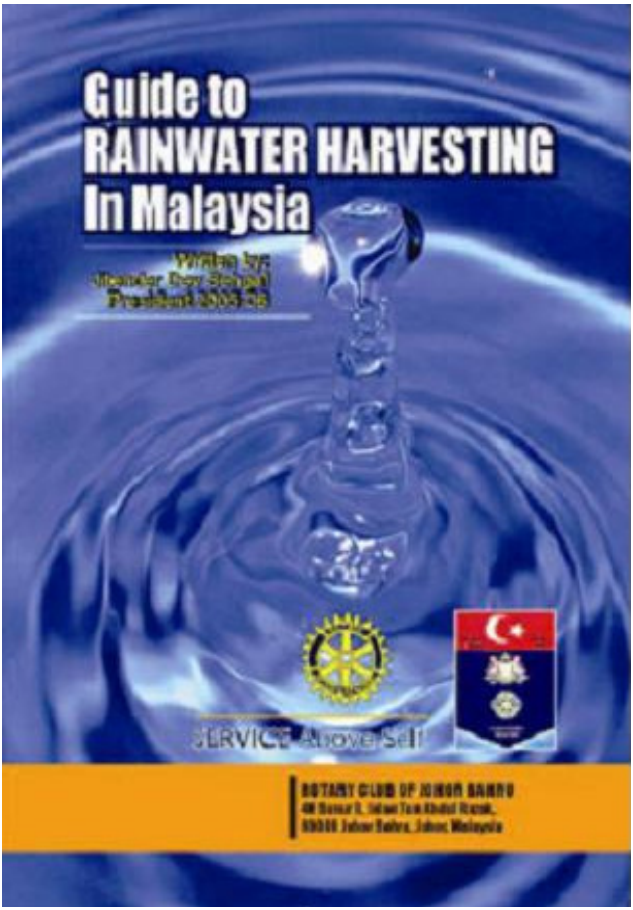
Guide to
RAINWATER HARVESTING
In Malaysia
SERVICE Above Self

A Guide To Rainwater Harvesting in Malaysia

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FOREWORD

Carl-Wilhelm Stenhammar, 2005 – 06 President of Rotary International, in his Theme Address to 2005 International Assembly at Anaheim, USA, stated that `*The United Nations calls the global water crisis "a threat to economic development, to poverty reduction, to the environment, and to peace and security." …… and more than one billion people don't have clean, safe drinking water.*' He urged the Rotarians all over the world to do what they can and improve the availability of clean water in the world.

The Author, Rotarian Jit Sehgal, in this year of his Presidency of the Rotary club of Johor Bahru, inspired by the RI President, has written this guidebook to remind Malaysians on how to harness this primary natural resource of clean water that is delivered free to our rooftops, by Mother Nature. The author is a highly qualified chemical engineer, with more than fifty years of experience in industry and is eminently positioned to research and write on this topic. The content of this booklet deserves serious attention by all.

Although the Country enjoys abundant resource of fresh water, already there are areas where water supply becomes inadequate, and rationing is resorted to. Following the guidelines of this booklet, no doubt, will benefit the population, and the environment as stated in the booklet, both in the short and long term.

Ir John Cheah Kam Loong P.I.S Johor Bahru
Past District Governor 1990-91 November 19, 2005
Rotary International District 3310

🗁🖒Introduction

Water is an essential component for sustaining life. Life on our planet as we know it would not have come into being without it, nor can it be sustained in the absence of water. Our bodies consist mostly of water. We need water for drinking, cooking, washing, agriculture, to run our industries, and for transportation on the waterways, and in a myriad other ways that form part of our everyday living. For as long as water is abundantly available, we take it for granted; when in scarcity however it becomes our most precious resource. Ask any desert dweller about water to understand its real value.

Did you know that although 70% of our earth is covered with water, only 3% of this water is fresh? Out of this, 2% is locked up in the form of ice, and it is only the balance 1% of water that recycles through the evaporation / condensation cycle, that flows into the rivers and lakes, to be used by mankind.

The history of rainwater harvesting in Asia can be traced back to about the 9th or 10th Century to the small-scale collection of rainwater from roofs and simple brush dam constructions in the rural areas of South and South-east Asia. Rainwater collection from the eaves of roofs or via simple gutters into traditional jars and pots has been traced back almost 2,000 years in Thailand. Rainwater harvesting has also long been used in the Loess Plateau regions of China.

In Malaysia, we are blessed with an ample supply of water thanks to abundant rains. However, increasing usage by our industry, in agriculture and by household users is straining our existing water supply infrastructure. The costs of adding to this infrastructure and that of replacing the ageing system are further burdening our Exchequer.

At present we primarily depend upon rainwater that falls over the hills and in the countryside and which is then collected into large reservoirs and as ground water. This water is then pumped into treatment plants and from

there distributed through the water mains and a network of pipes.

However perhaps we should pause to think that clean water is also being delivered to us right on our roof tops as rain but that we let this run off into storm water drains, where it ends up causing flooding and soil erosion on its way to the rivers and sea. In fact, the rainwater falling on our rooftops is one of the purest forms of natural water that nature provides us, yet we simply let it flow away.

This booklet presents some useful information on rainwater, and aims to provide an understanding of many of the relevant aspects of rain with a view to harvesting it for both domestic and industrial use directly from our rooftops, thereby allowing us to benefit from this bountiful resource delivered free to us by nature. A simple method of harvesting rainwater, storing and using it is described.

The Water Cycle

The never-ending exchange of water from the atmosphere to the oceans and back again is known as the hydrologic cycle. All forms of precipitation (hail, rain, sleet, and snow), and consequently all movement of water in nature, forms part of this cycle.

Precipitation stored in streams, lakes and in soil evaporates while water stored in plants transpires to form clouds, which both absorb solar heat and form the store of water in the atmosphere. When the atmospheric conditions reach a level of super saturation, a state achieved as a result of increased humidity combined with changes in temperature and pressure, this water is released in the form of rain, sleet, snow or hail, which falls as a result of the force of gravity to the earth.

This cycle continues, and results in shifting water from sea level all the way into the mountains and back into rivers, lakes and the sea etc.

Quantitative estimates of water resource in Malaysia

According to the **International Commission on Irrigation and Drainage**[1] "Rainfall (in Malaysia) generally occurs throughout the year, but there is some concentration due to the North-East and South-West monsoons. The mean annual rainfall averages about 2,300 mm, while the annual potential evaporation averages about 1,500 mm.

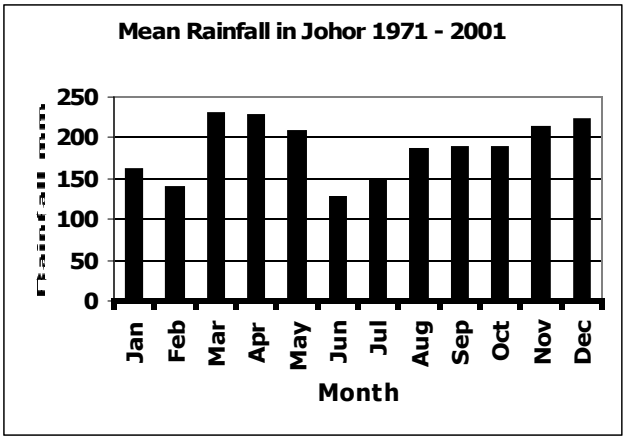
The total annual surface water resource is estimated to be 566,000 million KL per year and of this 26 % is in Peninsular Malaysia, 54 % in Sarawak, and the remaining 20 % in Sabah. **Groundwater resource is estimated to have a safe yield of 14,700 million m3 per year in Peninsular Malaysia,** 5,500 million KL per year in Sarawak, and 3,300 million KL per year in Sabah.

The present annual total consumptive use of water is estimated to total 10,400 million KL for irrigation. 4,900 million KL for domestic and industrial water supply. On the whole, Malaysia has sufficient water resources for development to meet

all the demand ***provided there is proper water resources development, conservation and management***."

Rainfall in Johor:

Figure shows the monthly rainfall pattern in Johor for the period 1971 – 2001[2].



It is to be noted that monthly rainfall in Johor averaged at 187 mm with a maximum of around 230 mm occurring during monsoon periods.

Thus, on a typical rooftop catchment's area of 100 sq m, average monthly incidence of rainfall is estimated at 18.7 KL (equivalent to roughly three barrels of

200 liters each day). This is a significant amount of water sufficient to meet most of the requirements of a typical Malaysian household.

Benefits of Rainwater Harvesting:

There are many benefits to be derived from harvesting this bountiful flow of rainwater on our rooftops.

For the user, the benefits to be derived are:

- Independent and ample supply of water in the dwelling.
- Water received is free of costs. Use of this water significantly reduces water bills for purchased water from municipal supply.
- Costs incurred for purifying the water for potable use are nominal.
- For users located in the rural areas, an independent supply of water avoids the cost of installing a public water supply system.

For the environment, there are many advantages as well:

- Harvesting rainwater is not only water conserving, it is also energy conserving since the energy input required to operate a centralized water system designed to treat and pump water over a vast service area is by-passed.
- By capturing water directly, we can significantly reduce our reliance on water storage dams. This places less stress on these water storage facilities and can potentially reduce the need to expand these dams or build new ones. Avoiding having to build additional dam reservoirs consequently avoids ecological damage to the area to be submerged.
- Rainwater harvesting lessens local soil erosion and flooding caused by the rapid runoff of water from impervious cover such as pavements and roofs as some rain is instead captured and stored. A reduced level of storm water require smaller sized storm water drainage systems and also helps in reducing soil erosion into the waterways,

preventing damage to the surrounding areas.

- Secondary use of grey water (water once used in showers etc.) further reduces the need for processing effluent water in treatment plants before discharge into the waterways.

For the Government:

- Reduce the burden for new investment to build, operate and maintain additional water supply systems such as reservoirs, water treatment plants and distribution systems necessary to meet the ever-increasing demands for water.

- Save on land area committed to store water in artificial lakes built for the purpose

Collecting the rain that falls on a building to be used nearby is a simple concept. Since the rain harvested in this manner is independent of any centralized system, this activity promotes self-sufficiency and also helps to foster an appreciation for this essential and precious resource.

Rainwater quality

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose. Although scientific measurements are used to define water's quality, it's not a simple thing to say that "this water is good," or "this water is bad." After all, water that is perfectly good to wash a car with may not be good enough to serve as drinking water. When the average person asks about water quality, he probably wants to know if the water is good enough to use at home, to play in, to serve in a restaurant, etc., or if the quality of water is suitable for aquatic plants and animals.

Rainwater has a distinct advantage over other water sources in that it is one of the purest sources of water available. Droplets of rainwater contain mainly the following impurities:

- Dissolved oxygen from the air in contact (beneficial to living beings)
- Dissolved carbon dioxide from the air (like that in soda water, but to a much lesser content)

- Nitrogen oxides formed by thunder lightening (imparts very dilute acidity to the water)

- Sulfur dioxide gas contained in the combustion gases from burning of fuels on the ground (imparts very dilute acidity to the water)

However, the impact of these contaminants on water purity is negligible for most uses. Although the pH of rain is below neutral, it is only slightly acidic, and the smallest amount of buffering can neutralize the acidity. The low total dissolved salts and minerals levels found in rainwater allow for minimal addition of neutralizing chemicals to adjust the pH to near neutral where necessary.

Upon contact with surfaces such as roofs, gutters etc., the water may pick up soluble and insoluble impurities and microbial contaminants that it comes in contact with. The amount of impurities picked up naturally depends upon the material used for the construction of the surface over which the water runs, and its state of cleanliness. In Malaysia,

where most roofs are built from terracotta or ceramic tiles, with a sloping orientation, and frequent rainfall, the accumulation of debris is minimal, and what there is, is easily washed away during the first flush of rain. It is important to ensure that this washing away does take place because contaminants such as dried leaves from trees, bird droppings, settled dust on rooftops need to be excluded. Installing very simple traps to bypass the initial portion of rainwater ensures that only clean water is collected.

With this provision of automatically separating the first flush of rainwater prior to collection into storage, rainwater quality almost always exceeds that of ground or surface waters since rainwater does not come into contact with soil and rocks where it may dissolve salts and minerals. Further, it is not subject to many of the pollutants that often are discharged into surface waters such as rivers, and which can contaminate groundwater.

It should be noted however that rainwater quality could be influenced by the locality where it falls since localized industrial emissions will affect its purity. Thus, rainwater falling in non-industrialized areas will probably be superior to that in cities dominated by heavy industry.

Aesthetic concerns such as color, taste, smell, and hardness comprise the secondary testing criteria used to evaluate publicly supplied water. When assessed according to these characteristics, rainwater proves to be of better quality than well or municipal tap water. Inorganic impurities such as suspended particles of sand, clay, and silt found in groundwater contribute to the water's color and smell.

Rainwater is the softest natural occurring water available, with a hardness of zero for all practical purposes. When used with detergents for washing purposes, it can significantly reduce the quantity of detergents and soaps needed for cleaning, as compared to typical municipal tap water. Additionally, soap scum and hardness deposits disappear, and the need for a water softener, often

an expensive requirement for well water systems, is eliminated. Water heaters and pipes will be free of deposits caused by hard water and should last longer.

Rainwater's purity also makes it an attractive water source for certain industries for which pure water is a requirement. This is of particular interest to industries where pure water is produced using expensive and energy intensive processes, such as computer microchip manufacturing, electronic components, pharmaceuticals and certain food industries. Since rainwater contains almost no dissolved minerals and salts it approximates distilled water quality. For people on restricted salt diets, this represents a decisive advantage over other water sources.

Caution: If it is intended to be used as drinking water, it is advisable to subject the rainwater to testing by a Certified Test Laboratory to conform to potable water standards.

Water needs of a typical household

Water is needed for various purposes. Some of the uses can be considered essential while some others may fall in the category of being peripheral in nature.

a. **Essential Uses:**

This category consists of uses for water that are related to food and hygiene in a household. These are:

- Toilets flushing – typically 7 L per flush
- Floors mopping and washing – typically 20 L per room each time.
- Bathing (personal and pets) – typically 10 L per minute in a shower.
- Washbasin usage – typically 5 - 10 L per minute while brushing teeth and shaving etc.
- Clothes washing – typically 100 – 150 L per wash cycle.

- Machine dishwashing – typically 50 L per dishwater cycle.

- Hand dishwashing – typically 5 – 10 L per minute under a running water tap in a washbasin.

- Cooking (potable)

- Drinking (potable)

b. Peripheral Uses:

- Gardening – typically 10 - 15 L per minute from a gardening hose. 5 – 10 L per minute from a sprinkler head (depending upon size of the sprinkler head and water pressure).

- Washing of cars, motorbikes etc. – typically 10 L per minute from a wash spray gun.

- General outdoor washing

The actual quantity of water usage by a household therefore depends on the number of occupants, user habits, number of vehicles maintained, gardening needs, and the physical size of the household premises.

Quantitative potential of harvesting from the roof tops

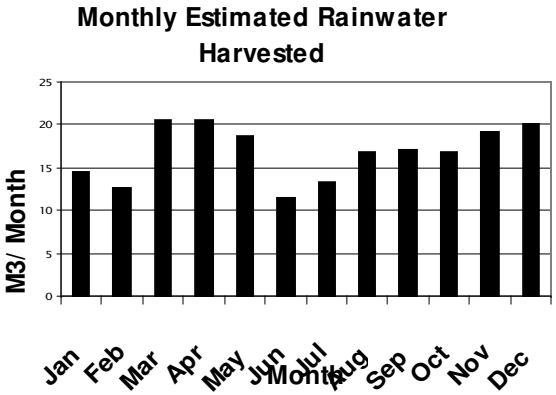
For Households: As mentioned earlier, Malaysia receives 2,300 mm of rainfall on the average, during a year. Based on a catchment's area of 100 sq m (typical rooftop size of an average dwelling) this amounts to receiving 230 KL of rainwater on a roof in a year.

As noted above, in order to ensure that only clean water is collected for use, it is essential to segregate the initial rainfall that may contain contaminants such as bird droppings, dried leaves, dirt etc. that would have collected on the catchment's area between rainfalls. Typically 50 L of the initial rain falling on a 100 sq. m area needs to be discarded. Since rain occurs intermittently throughout the year the number of times roof washings need to be diverted depends upon the number of rainy days in a year. While detailed reliable data of rainy days is not available (and varies from year to year), conservatively one may assume that rainfall occurs over half the number of days in a calendar year. Thus an

estimated amount of 10 KL of rainfall needs to be discarded annually as contaminated water before collection of clean water for domestic use.

Therefore it is reasonable to assume that approximately 220 KL of clean rainwater can be collected from a 100 sq. m catchment's area of domestic rooftop, providing an average daily supply of 600 L (approx three barrels of 200 L) available water for use. For most households in Malaysia, this constitutes a major part of the water consumed. The bar chart below shows the average monthly rainwater that may be collected from a 100 square meter roof top catchment area.

Further, since rainfall is an intermittent phenomenon, sufficient storage capacity needs to be made available to create a buffer and ensure that there is a continuous supply for use.



For Industrial Users: The potential for harvesting rainwater for industrial uses is greater due to the availability of much larger rooftop catchment areas. In establishments, using multiple buildings and sheds, centralized collection tanks should be considered. Typically, total catchment area of 10,000 Sq. M provides a potential rainwater collection of 23,000 KL annually. Due to a very low mineral content, demineralization of this water makes it attractive for uses as boiler feed water, and other applications where soft water is used. Significant savings in costs are envisaged.

Rainwater Harvesting Method

Rainwater is harvested using an installation of pipes and tanks in an arrangement that allows for automatically diverting the first flush of rain that is contaminated with dirt etc deposited on the catchment's area followed by collection in a storage tank for further use. The installation also includes a system of supply to water user outlets via pumping or gravity depending upon the arrangement. In certain instances, provisions may also be made for chemical dosing and water filtration.

Components of an Installation:

The Installation for rainwater harvesting consists of the following components.

Catchment Area: Catchment area is the surface area from which rainwater can be collected as clean water. Usually, this comprises the roof over a house, and any associated covered portions of the dwelling, including sheds, factory roofs etc. that are situated above ground level.

Concreted or tiled pathways should not be included, since these surfaces are normally heavily contaminated with dirt, oil spills, soil bacteria etc. The size of a roof catchment area is the building's footprint under the roof. The catchment surface is limited to the area of roof, which is guttered. A simple method to calculate the size of a catchment area would be to multiply the length and the width of the guttered area that forms the boundary of the catchment surface. Often, the roof area is divided into several guttered zones. A sum of all these areas provides the total catchment area that is available for rainwater harvesting.

Caution: Rainwater collected from surfaces containing lead should not be considered for any potable use.

Gutters: These are the transport channels often shaped as half rounds, or as 'V' or 'U' shaped open top channels that are placed to collect the water run off from the catchment area. Gutters are normally adequately sized to allow flow of all the collected water from the catchment area during heavy downpour conditions. It is advisable to install wire

mesh screens over the gutters to avoid clogging of the downspout attached to the gutters. The outside face of the gutter should be lower than the inside face to encourage drainage away from the building wall.

Downspouts: These are vertical or slanting pipes that receive water from the Gutters and transfer the collected water into roof washers. An adequately sized downspout should be able to handle all the rainfall collected from the catchment area. Downspouts designed to handle 5 cm of rainfall during a 10-minute period are considered adequate. Downspouts are typically made of the same material as the gutters but of a smaller cross section.

Roof washer: This is a purpose built combination of a screen to collect debris that may have fallen on the catchment area during dry periods between rainfalls and a stand pipe (or a small container) of sufficient volumetric capacity to receive and by-pass the first flow of rain and wash away any dirt, bird droppings etc. that may have collected on it before collecting clean rainwater into the storage tank. It is a simple device with no moving

parts, located at a convenient and easily accessible height. It requires occasional attention to clear away accumulated debris if there is any. The device consists of a funnel with a wire mesh screen fitted on it, with a standpipe of 150 to 200 mm diameter underneath (or a container), that collects the first flush of rainfall. Once it has filled up with the first flush of water, the rest of the water overflows into the downspout connected to the storage tank. **The roof washer is sized to collect at least 30 liters of water for every 100 sq m of catchment area**. One has the option to either drain away the water in the roof washer or use it for any non-potable purpose rather than wasting it. One must be extra careful about roof washing, if the collected rainwater is to be used for human consumption.

Specially designed automatic diversion valves are also used as roof washers to drain away the initial flow of rainfall prior to collection, as an alternative to the above method. However, these are not currently available in local market.

Note: Trimming of any tree branches that overhang the roof is

strongly recommended since these branches are perches for birds and produce leaves and other debris.

Piping: The connection between the standpipe and storage tank is a pipe of sufficient size to allow rapid flow of clean rainwater into the storage tank. PVC or Galvanized Iron pipes are commonly used for this purpose.

Storage Tank: A storage tank of sufficient capacity to receive hold and supply rainwater forms an important part of the installation. The tank should be sized such that it maximizes the collection of rainwater from the available catchment area, and also provides sufficient storage capacity to meet the water needs between refills with rainwater.

For an average household, a Storage Tank of 1,000 L – 2,000 L capacity (to collect rainfall on 100 sq m catchment's area) is considered adequate in view of the frequent rainfall pattern in the region.

There are several factors to be taken into consideration while selecting a suitable

location for a tank. Among the important ones are:

Space and aesthetic considerations – a tank may be located above or below ground depending upon space available, and harmonizing with the surroundings. If supplementary water were to be received occasionally from road tankers, easy access to the tank for this purpose would be an important consideration.

Hygiene – the tank should be placed in locations away from sources of polluting smells such as toilets, animal shelters, septic tanks etc. This is of particular importance if the water is to be used for potable purposes. The tank should also be easily accessible for inspection, addition of chemicals (when needed) and ease of cleaning out when necessary. A tight-fitting cover is essential to prevent evaporation, mosquito breeding, and to keep insects, birds, lizards, frogs and rodents from entering the tank. A tank located in a shaded area away from sunlight, helps in keeping the stored water cool, reducing the incidence of algal and bacterial growth in the stored water.

Elevated Location – a tank located at a height obviates the need for pumping out the water for ground level usage such as washing of cars, gardening etc. However, a pump will be necessary to supply water to any user points above the level of the tank. A tank filled with 1000 liters of water weighs over a ton. Care should be taken to provide supports and foundation sufficient for the size of the tank installed.

Water storage tanks can be either of prefabricated type or built on site. Prefabricated tanks made of Polythene, PVC, Stainless Steel, Galvanized Iron, Precast Cement, Fiberglass, are readily available. Tanks may also be built on site using reinforced cement concrete or masonry. Such tanks should be suitably waterproofed and sealed, to prevent contamination of contained water.

Water Treatment: As mentioned earlier, the rainwater as it falls on the catchment's area is very clean, and contains minimal impurities. However, once rain comes in contact with the collection surface, it can wash many types of bacteria, molds, algae, protozoa and other contaminants into the collected

water. Health concerns related to bacteria, such as salmonella, e-coli and legionella, and to physical contaminants, such as pesticides, lead, and arsenic, are the primary criteria for drinking water quality analysis. Falling rain is free of most of these hazards. Choice of treatment depends upon its ultimate use.

If the rainwater is intended for use *inside* the household, either for potable uses such as drinking and cooking or for non-potable uses including showering and toilet flushing, appropriate filtration and disinfection practices must be employed.

If the rainwater is to be used *outside* for landscape irrigation, where human consumption of the untreated water is less likely, the presence of contaminants may not be of major concern and thus treatment requirements can be less stringent or not required at all.

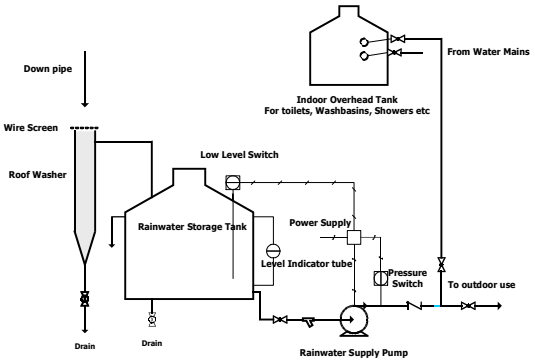
Rainwater contains almost no dissolved minerals and salts and is near distilled water quality. Total dissolved minerals and salts levels average about 10 milligrams per liter (mg/L). Total Dissolved Solids (TDS) can range as high as 50 mg/L and as low as 2.0 mg/L.

These values are very low when compared to city tap water, making rainwater virtually sodium free. The pH of rainfall would be 7.0 if there were nothing else in the air. However, as rain falls through the air, it dissolves carbon dioxide that is naturally present in the air and becomes slightly acidic. The resultant pH is 5.6; however, any sulfates or nitrates dissolved from the air will lower this number below pH 5.6. Although the pH of rain is below neutral, it is only slightly acidic, and the smallest amount of buffering can neutralize the acid. The low total dissolved salts and minerals levels found in rainwater permit even very small amounts of baking soda (one level tablespoon per 500 liters) to adjust the pH to near neutral. If you plan to use your harvested rainfall for drinking water, have the water tested by a certified laboratory.

Conveying: Depending upon the location of the storage tank and the level at which the water is to be used, delivery system for the treated rainwater may be either by gravity or through a pump.

Typical Household Installation:

Figure below shows a scheme of arrangement to provide for pressurized discharge of water using an automatic operating pump.



Rain Water Harvesting System

Leaf Screen and Roof washer:

This consists of a simple standpipe (typically a PVC pipe of 150 mm diameter) of sufficient length (or a container) to accommodate 30 – 50 liters of water, fitted with a coarse screen on a funnel at the top to trap leaves etc. It has a valve at the bottom to drain away the washings collected into it (alternatively, the drain valve can be replaced with a weep hole

for slow self draining). A 50 mm pipe branches from near the top and is connected to the collection tank to receive overflow of the rainwater for collection after the roof washer is filled up with the initial flow of rain. The roof washer may be located adjacent to the storage tank, to allow for short piping connection to it.

Cisterns or Storage Tanks: Typically a plastic water tank of 1000 – 1500 Liter capacity is used. The tank should be located at a height of approximately one meter above the ground for easy discharge of water.

Conveying: For transfer of water to indoor overhead tank, an inline water filter must be installed. Installing a second inlet connection below the rainwater inlet connection should provide for make up of water from municipal mains. This arrangement ensures receiving of municipal water when the water level in the indoor tank drops to a level that automatically opens the valve connected to municipal supply.

A gardening hose suffices for the purpose of use of water for garden uses, car washing, and floor washing etc.

Water Treatment: None or minimal treatment may be necessary for non-potable uses of this water. Use of two tablespoonful of household bleach may be added to a full tank to avoid growth of algae in the tank.

Use of two heaped tablespoons of baking soda (to neutralize acidity) and two tablespoonful of household bleach (for safeguarding against growth of algae) is recommended for a 1000 L of water collected.

It is to be noted, that rainwater must not be used for drinking or cooking purposes unless it has been tested for potability by authorized testing laboratory and certified as fit for this purpose.

Estimated Cost of installing a System for a Household:

Breakdown of an estimate for a system that is adequate for a household to collect and store 1000 L of rainwater is given below. Actual cost however may vary according to the particular location and type of system adopted.

Estimate of Cost for Installing a Rainwater Harvesting System

ITEM	Cost RM
Storage tank (1000 L fibreglass) C/w feed funnel & Strainer	**600**
Water Pump	**450**
Pipes and valves	**200**
Electric connection	**75**
Total	**1,275**

(Excludes transport and labor cost)

🗁🗏🖋Tips for reducing water usage:

General:

- Practice routine common sense leak detection.
- Periodically "zero read" water meter for leaks
- Replace worn valves, faucet washers, O rings

In the Bathrooms and toilets:

- Install ultra-low flush toilets
- Use water-wise showerheads that use 10 l per minute

- Use faucets that flow at 5 L per minute.
- Minimize running the water tap while brushing teeth and shaving
- Turn off shower while soaping the body.
- Take shower of approx. ten minutes or less.
- Check the toilet tank for leakage into the toilet bowl. To do this, add food color to a toilet tank. Appearance of color in the toilet bowl shows a continuous leak and wastage of water.

In the kitchen:

- Avoid pre-rinsing of dishes before loading dishwasher.
- Soak dishes before hand washing to remove stubborn deposits.
- Avoid overloading clothes washing machine and thus need for rewashing.
- Always run full load of clothes wash.
- Peel and clean vegetables in a bowl of water instead of in running water.

Car washing:

- Use pressure spray gun for rinsing the car after soap.
- Avoid using open-ended hose.
- Use bucket and sponge for soaping the car.

Watering the lawns:

- Use a sprinkler instead of flooding the lawn with water. Use a cut open empty sardine can on the lawn to know how much water has been sprinkled.
- Water your lawns in the morning or evening to minimize evaporation loss.
- Use hand held shower bucket for watering the plants, shrubs etc. instead of flooding the beds.
- Use a layer of organic mulch around the plants to reduce evaporation of water.

Careful implementation of these measures can reduce water consumption by up to thirty percent.

Acknowledgements:

Some of the information contained in this Guide has been garnered from various sources on the Internet. Due to the varied nature of the sources, it is not physically possible to acknowledge these sources individually.

Professor Dr. R Narayanan, Professor of Civil Engineering, University of Manchester, England, for reading the manuscript and making valuable suggestions for improvements.

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About the Author:

Jitender Dev Sehgal was born in Lahore in undivided India (now in Pakistan), and migrated to New Delhi during the partition of the Country. He obtained a Degree Bachelor of Science with Honours in Chemistry from the University of Delhi and a second Degree of Bachelor of Science in Chemical Engineering from the Institute of Technology, Banaras Hindu University in India. He went on to the renowned Massachusetts Institute of Technology, Cambridge, Mass., USA, where he earned a Masters Degree in Chemical Engineering in 1959. While at MIT, he worked as a Research Scientist, carrying out research into methods for ultimate disposal of radioactive wastes from nuclear power reactors. Upon return to India, he worked as a Research Scientist in the well-known Bhabha Atomic Research Centre in Mumbai. He then moved to work with Unilever Research Laboratories in India and Europe where over the next 20 years he developed his career in research in chemical technology development. He relocated to Malaysia in 1979, and has worked in various managerial positions in the palm oil refining industry in the country for over 25 years. His interest in environment protection, and developing environment friendly manufacturing processes has continued throughout his working carrier as a research scientist as well as CEO of various companies. He has played a key role in establishing a unique manufacturing plant for recycling industrial wastes generated by the palm oil processing industry in Malaysia, thus allowing that industry to avoid polluting the environment. He is currently Managing Director of a Malaysian Company offering innovative technological solutions to process industrial wastes.

The author has been a committed member of the Rotary International since 1980. He is a member of the Rotary Club of Johor Bahru, and was also a Charter Member of Rotary Club of Pasir Gudang. He has held various positions in these Clubs, before becoming the President of Rotary Club of Johor Bahru 2005 – 06.

This booklet is the result of his personal and professional interests and the inspiration given by Carl-Wilhelm Stenhammer, President of Rotary International 2005 – 05, who has stressed the importance of conserving world's water resources for the future.

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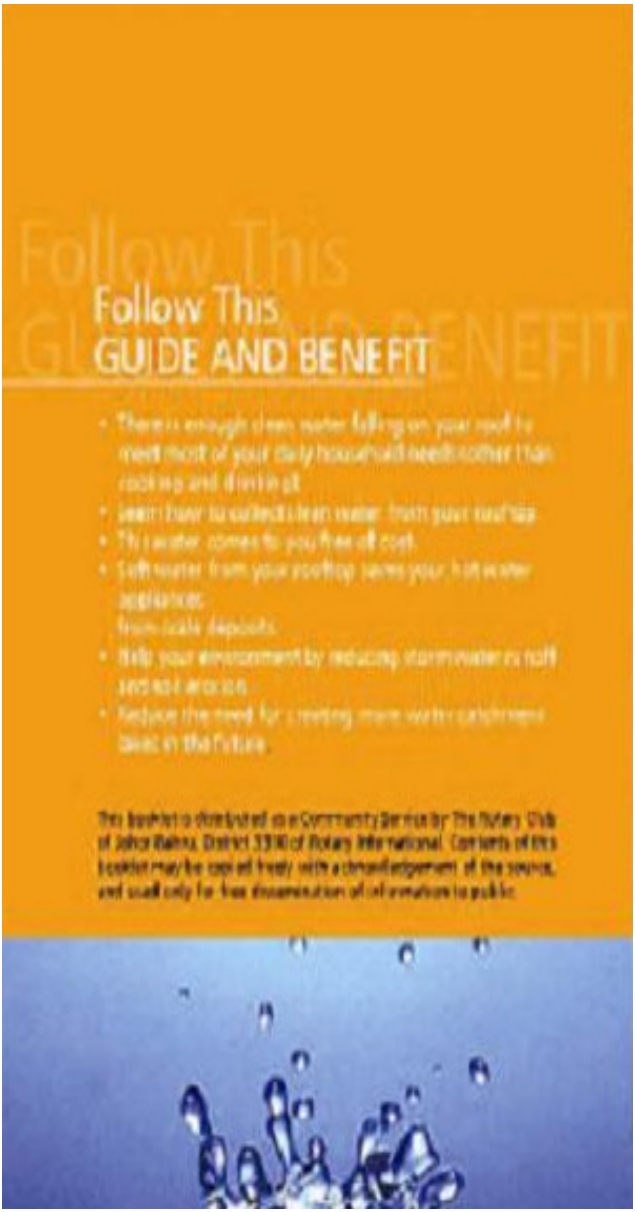
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