RAINWATER & YOU

100 WAYS TO USE RAINWATER

authored & edited
by
Group Raindrops

RAINWATER & YOU

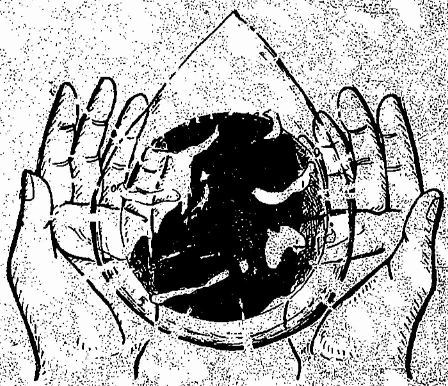
The first book of its kind and it...

①
explains everything about *rainwater utilization* clearly and completely,

②
overflows with *innovative ideas* of collecting, storing, purifying, and supplying rainwater,

③
provides *numerous examples* of individual houses, public facilities and large buildings to illustrate the major points in design and maintenance, and

④
guides readers in the *proper use* of rainwater.



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published
by
the Organizing Committee
for the Tokyo International Rainwater Utilization Conference

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FOREWORD

We decided to translate this book to help network the information on rainwater utilization in Japan and around the world. From August 1 to 6, 1994 the Tokyo International Rainwater Utilization Conference took place in Sumida City, Tokyo on the theme "Rainwater Utilization Saves the Earth – Form a Friendship with Raindrops in Cities." This conference was held under the auspices of the Organizing Committee for the Tokyo International Rainwater Utilization Conference, and co-organaized by Sumida City and the Japan • International Rainwater Catchment Systems Association.

It is estimated that 60% of the world population will concentrate into. urban areas by the middle of the 21st century. This conference attempted to join the wisdom of the world on rainwater utilization and join hands to seek a way for saving the earth using rainwater. In summer 1994, Japan suffered from a severe water shortage, so this conference received much publicity in the media and the attendants of the conference totaled nearly 8,000 from all over Japan. From overseas, we had 26 participants who are actively promoting rainwater utilization in their countries: citizens, representatives of civil organizations, employees of local governments, scholars and researchers from Botswana, Kenya, Tanzania, China, Indonesia, Singapore, Sri Lanka, Thailand, Denmark, France, Germany, the Netherlands and the United States. They earnestly discussed ways to harmonize rain with city planning. As a result, the following five points were confirmed:

1. Population in Asia, Africa and Latin America will continue to concentrate into large cities and, as a result, those cities will confront the problem "Urban Droughts and Urban Floods" which Tokyo faces now;
2. The lessons that Tokyo has learned thoroughly rejecting rain and continuing to dump rainwater into sewers, and Tokyo's newly acquired wisdom on rainwater use techniques will undoubtedly contribute to resolving "Urban Droughts and Urban Floods;"
3. Rainwater utilization is an internationally shared responsibility considering the "sustainable development" of cities;
4. Rainwater utilization is directly related to acid rain and air pollution;
5. Creating new rainwater culture in which cities can live more harmoniously with rain is required.

This conference has produced constructive results in techniques and policies regarding rainwater utilization, and has changed people's way of thinking toward rain. Among them the largest product was networking of rainwater utilization information on a global scale. We want to advance rainwater utilization further by maintaining this worldwide network. So we ask all people interested in rainwater utilization or those actually using rainwater in different parts of the world to write about ideas or practical examples of rainwater utilization. We sincerely look forward to sharing in your wisdom.

March 31, 1995

Makoto Murase

Makoto Murase,
Secretary-General
Organizing Committee for the Tokyo International Rainwater Utilization Conference

CONTENTS

In the world, a few drops of rain mean life for some people.
There are also those that trade in rainwater.
The annual average rainfall in Japan amounts to double
that of the world average.
However, in urban areas most of the rainwater is dumped into the sea.
We are wasting city water in watering plants, washing machines,
and flushing toilets, while we are suffering from water shortage.
Japan is an enigmatic country to the rest of the world.

PREFACE

Rainwater and Us/100 Ways to Use Rainwater

We are publishing this book hoping people will value rainwater more highly and use it more effectively.

Whenever Tokyo has run out of water in the past, the government has easily been inclined to construct dams upstream. However, the development of giant dams devours vast tracts of forest and farmland, and demands enormous sacrifices of the local residents. We propose to build tens of thousands of "mini dams" (rainwater tanks) in urban areas instead of continuing to build giant dams upstream because Tokyo is endowed with far more rainfall than the amount of water demand.

Tokyo has fully covered its ground with asphalt and concrete, thoroughly rejecting rainwater. Consequently, it has ended up as a hot, thirsty and flood-suffering city. We want to restore sound regional water circulation and make cities in which people can live in harmony with rain our legacy to future generations. We can control urban floods by storing rainwater from roofs and the ground surface, and infiltrating it into the ground. The stored water can be used for non-drinking purposes and emergencies, enabling us to secure some degree of the self-support of water supply.

Promoting underground infiltration of rainwater can prevent cities from being plagued with thermal pollution and water shortage, and help improve the urban environment. It also contributes to groundwater recharge so that we can drink good tasting groundwater. Rainwater utilization ultimately leads to the comprehensive resolution of water resources problems and the environmental problems in urban areas.

This book is not a scientific treatment on rainwater utilization. This is a guidebook with the following five characteristics:

1. This book is a treasure chest full of ideas that anyone can use anywhere.
2. The background of rainwater utilization varies completely in urban areas, rural areas and remote islands. This book discusses the essential differences. You will undoubtedly be surprised at how vast the study of rainwater utilization is.
3. The different designs of rainwater utilization system and points for maintenance are clearly illustrated for people who want to try them.
4. Many examples of actual uses in individual houses, large buildings and community facilities are introduced. These will help us change cities into urban centers in which we can live in harmony with rain.
5. The conditions and examples regarding rainwater utilization

overseas are also introduced. You will discover just how blessed Japan is with rain. Your thoughts toward rain will change.

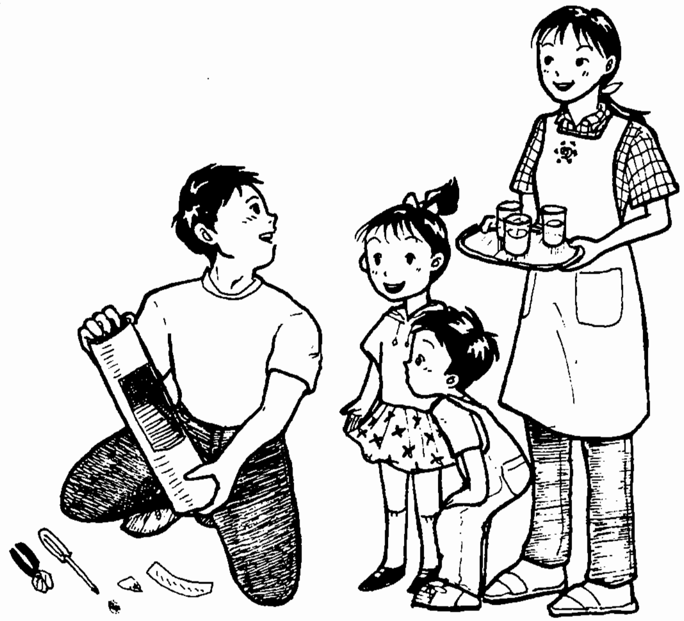
"Group Raindrops" compiled this book. Some members of the Group belong to the technical study group of the Organizing Committee for the Tokyo International Rainwater Utilization Conference which was held in Sumida City, Tokyo in August 1994. The technical study group is committed to the development of techniques for anyone to use rainwater anywhere. The product of our efforts can now be seen in the construction of housing complexes, gas stations and shopping malls with rainwater utilization systems.

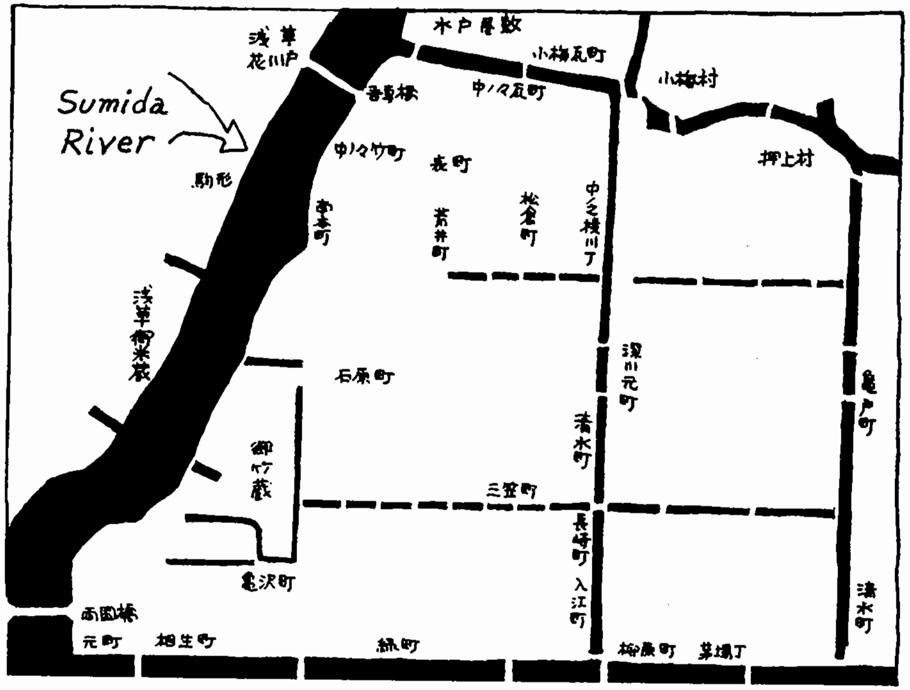
We also held a contest and solicited ideas to use rainwater from all over the world. We received many innovative and wonderful ideas, 116 from Japan and 7 from abroad. We also visited Botswana, Kenya, Tanzania and Hawaii to study various local techniques. This book reports our findings as well. The ultimate goal of Group Raindrops is to change the current city structure in Japan to the one in which people can live in harmony with rain, based on wisdom of forerunners in this field. We hope this book helps achieve that goal.

CHAPTER

1 DEVICES TO USE RAINWATER

DIFFERENT IDEAS FROM DIFFERENT PEOPLE

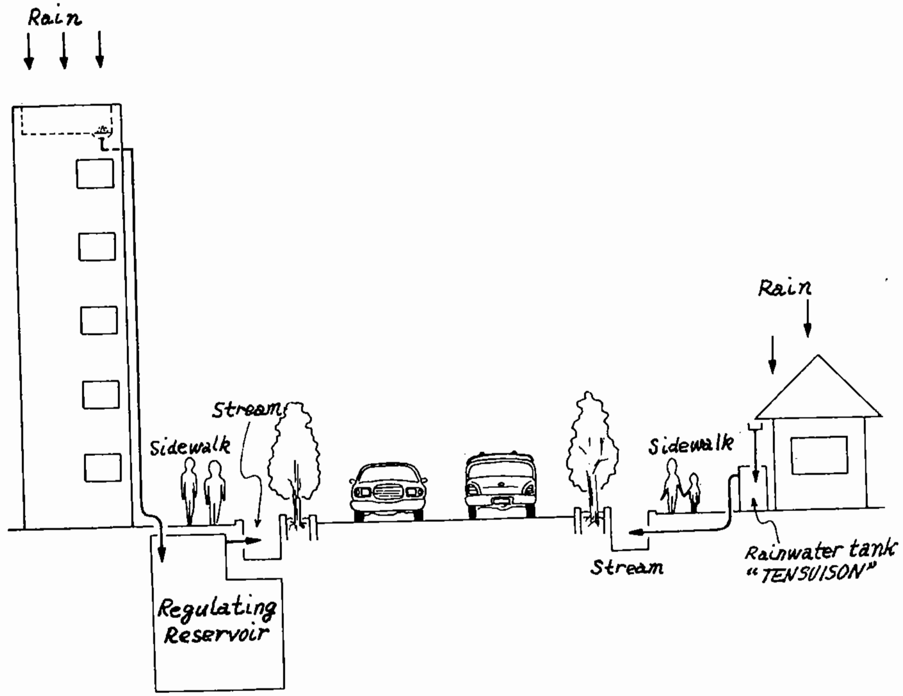




— Honjo and Its Neighborhood in 1855 —

In 1982, when the construction of Ryogoku Kokugikan (Sumo Wrestling Arena) was decided, some members of the present Group Raindrops set out to study rainwater utilization. At the time, the members requested the Sumo Association, through the Sumida City Office, to use rainwater from the large roof for non-drinking purposes and for the local emergency water supply. They considered that rainwater utilization should be promoted not only on an individual basis but also on a regional or community basis, the latter way being the more effective. As a result, a rainwater utilization system was introduced into the Ryogoku Kokugikan construction. In 1989 the Group members compiled their ideas into the "Sumida Oasis Concept"and submitted it to the city authorities as a suggestion.

Many waterways used to spread north to south and east to west in Sumida City connecting to the Sumida River, the Ara River or Tokyo



Bay. Today most of them have been turned into roads. However, the members suggested in the concept that part of the lost waterways should be brought back as streams with walkways so that people can enjoy water. Moreover, the development of the waterfront should be respected as a basic policy in regional development planning. The water of the streams should be supplied with rainwater from the roofs of nearby buildings and housing complexes.

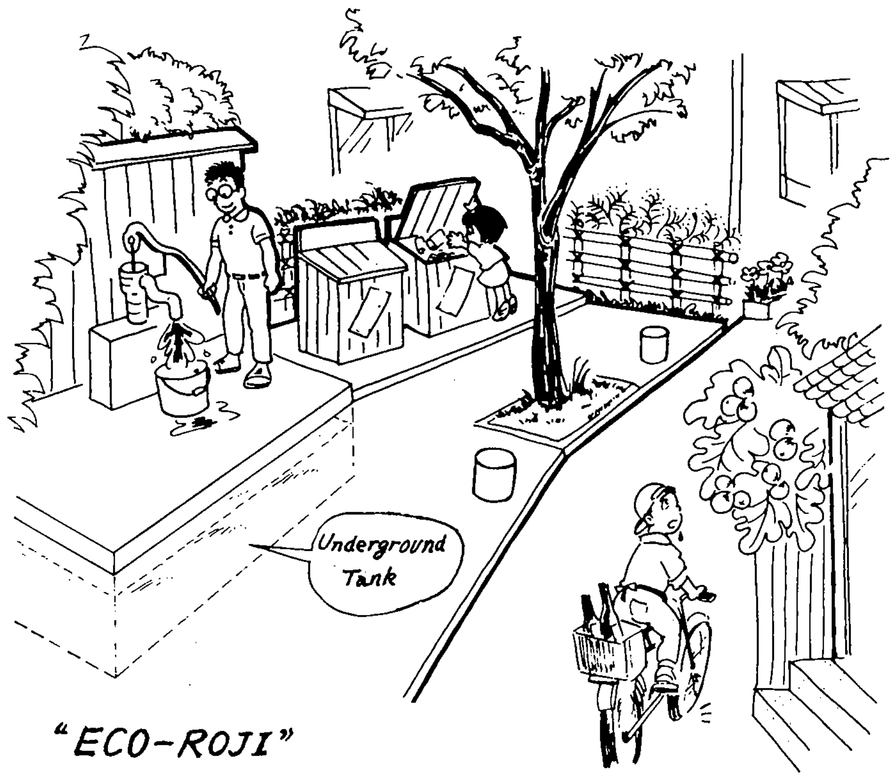
Unfortunately, the entire concept failed to be realized. However, some of the ideas described in the concept have been put into practice in Sumida City and other places. These ideas also encouraged residents as well as specialists to spawn new creative ways of using rainwater. Although this concept is now five years old, the members believe that its context remains new, significant, practical and innovative.

Corner Community Rainwater Tank "Tensuison"

In days of old, there used to be rainwater tubs in many places in community. They were always covered with lids, and buckets were stacked on top like a pyramid. Today in Sumida City, a lot of red-painted drums full of drinking water are set along the roadside for fire fighting. The members who compiled the Sumida Oasis Concept proposed to store rainwater instead of drinking water in the drums.

Rainwater could be stored in tanks installed in strategic locations on the ground. The amount of rainwater to be dumped into street gutters and sewers should be minimized. The stored rainwater would be used in community for watering plants and other similar uses; and in emergency, it would be used for fire fighting and as the alternative to drinking water. Each rainwater tank would be equipped with a hand pump and a faucet, so the water would be available to anyone. The members named this tank *Tensuison*, which means to "respect the blessed rainwater."

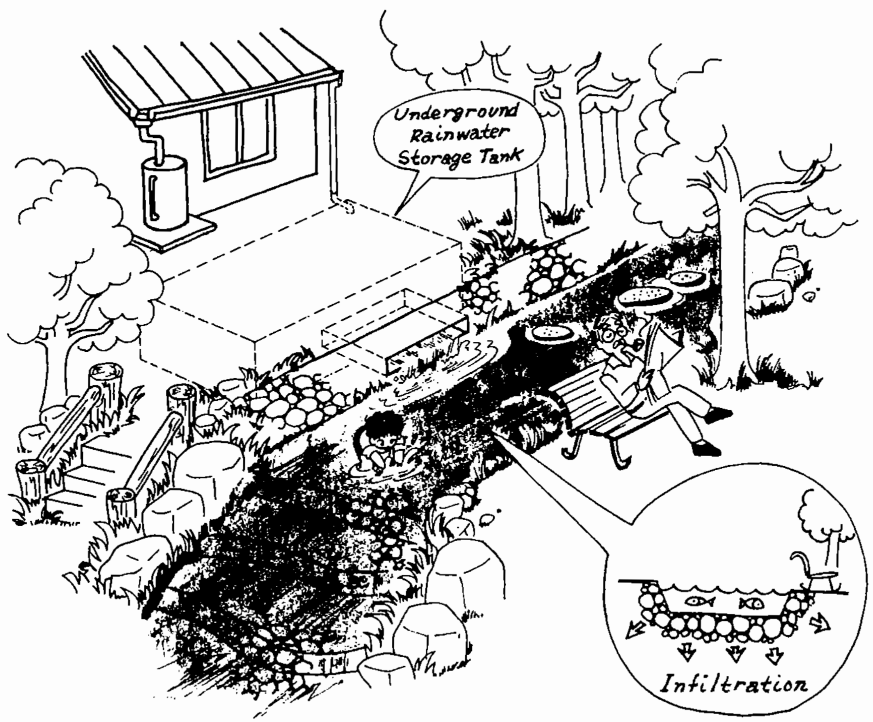
Reminiscence of the Old Rainwater Tub



They mapped out this idea in the Sumida Oasis Concept.

When you walk around the Ichitera-Kototoi district of Sumida City, you will come across a street called Eco-*Roji* (*roji* means "street" in Japanese) and find street furniture called *Rojison*, literally "to respect alleys". *Rojison* has an underground tank to store up to 10m^3 of rainwater and a hand pump. This serves as a water resource for watering plants and as an emergency rainwater storage system in the community. You will also find royal purple color tanks with faucets in front of houses. The idea of *Tensuison* born in the Sumida Oasis Concept has been realized in the Ichitera-Kototoi district in many forms.

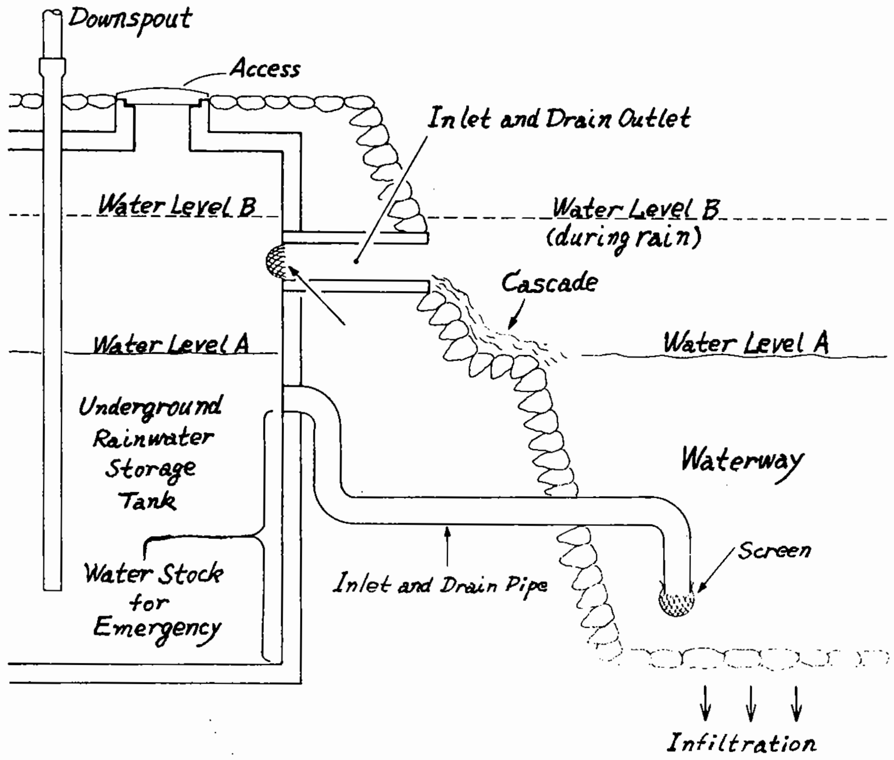
Controlling the Amount of Tank Rainwater



All of the collected rainwater can not be stored in such tanks as *Tensuison.* The capacity of a rainwater storage tank is calculated on the local average rainfall. Therefore, in times of prolonged or heavy rain, the rainfall can exceed the tank's capacity. In the Sumida Oasis Concept, we proposed to revive lost waterways into which part of the excess water (overflow) could be discharged, and infiltrate the remaining part into the ground. Excess water can overflow from a tank into a waterway through a cascade. However, when the tank runs out of water, the water flows back into the tank from the waterway. The cascade is a waterfall designed like stairs.

Permeable blocks should be placed around *Tensuison* so that the overflow from the tank can infiltrate into the ground. Because so much ground surface nowadays is covered with asphalt or concrete and concrete is cast deep into the ground, so the water cycle has been cut off

Infiltrating Excess Rainwater into the Ground



and the underground has fallen short of water. The shortage of groundwater reduces geostatic pressure of ground and causes subsidence. Therefore, rainwater infiltration is also an important part of the rainwater utilization.

The bottoms of waterways also should be made of permeable material. The bank should be made of stones instead of concrete blocks. Furthermore, the bank should be sloped so that people can have access to the water. The ideal goal is to create an environment for fish or crabs to live in the crevices of the stones. If the waterways are fully revetted with concrete, no one can enjoy the beauty of streams.

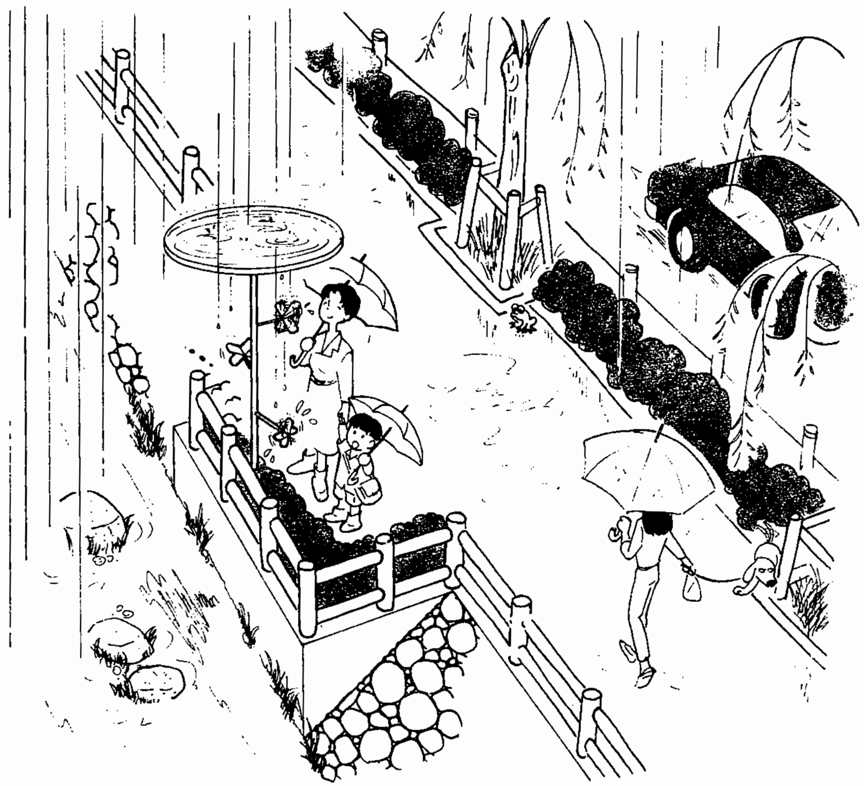
Devices to Enjoy the Blessed Rain

In the Sumida Oasis Concept, we proposed to build walkways beside the waterways for people to enjoy taking a walk. The walkways have some terrace areas sticking out over the waterway banks for people to rest. In addition, we proposed to put some eye-catching and ear-tinkling gadgets using rainwater on the terrace areas. We asked several people to design these rainwater "works of art." As a result, many creative designs were received, two of which are described herein.

The first one is titled "Rainwater Fountain." Rainwater is stored in a *Tensuison* rainwater tank on the other side of the walkway, and water flows from the tank to the fountain through a sloped connecting pipe. The water flow can be accelerated along the slope so that it gushes up out of the fountain center. There was another similar design of building a spring in the center of the terrace area.

The second work of art is titled "Rainwater Wheel." Rainwater is

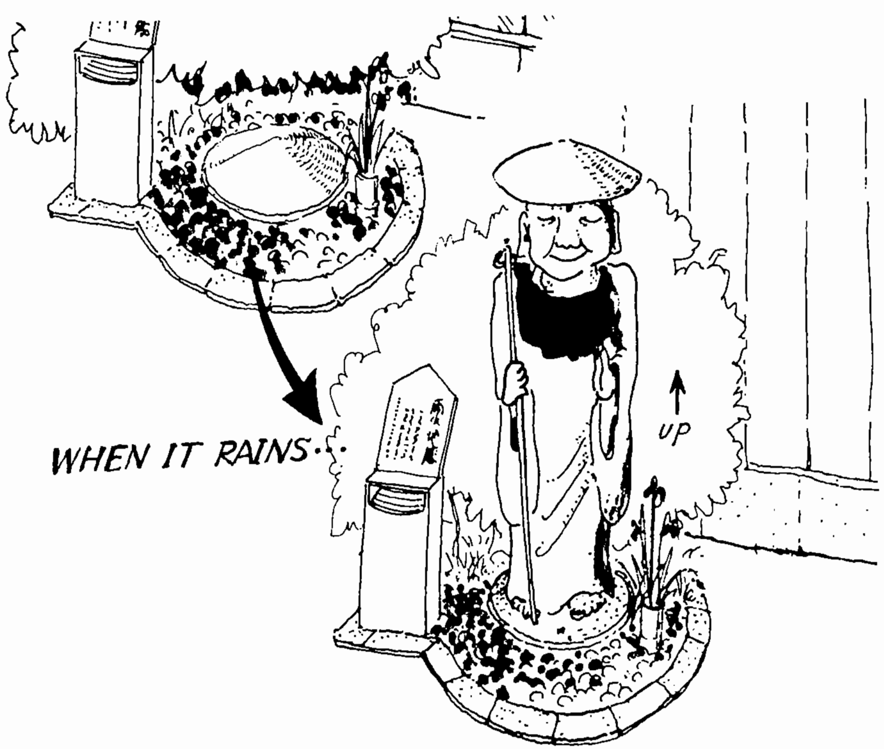
"Rainwater Wheel" Being Rotated by Raindrops



caught on a large disk set on the top of a pole. The disk has several holes. Many pinwheels are attached to the pole. Rainwater drains through the holes of the disk onto the pinwheels and makes them rotate. The pinwheel is covered by a thin metal layer and has a feather. It is colored in yellow and brown stripes, so that it looks like a sunflower when it rotates. The rotation speed changes by rainfall and we can enjoy a variety of sunflowers.

People usually prefer sunny days to rainy days. Clear skies brighten our depressed feelings. When it rains, we hesitate going out because the sidewalks are slippery; and what is worse, there is the possibility of rainwater leaks, floods and landslides in heavy rain. However, we can not live without rain. Rainwater Wheel was designed to encourage people to respect our blessed rain. It brings a song to our lips, "Turn around, turn around, Rainwater Wheel, . . ."

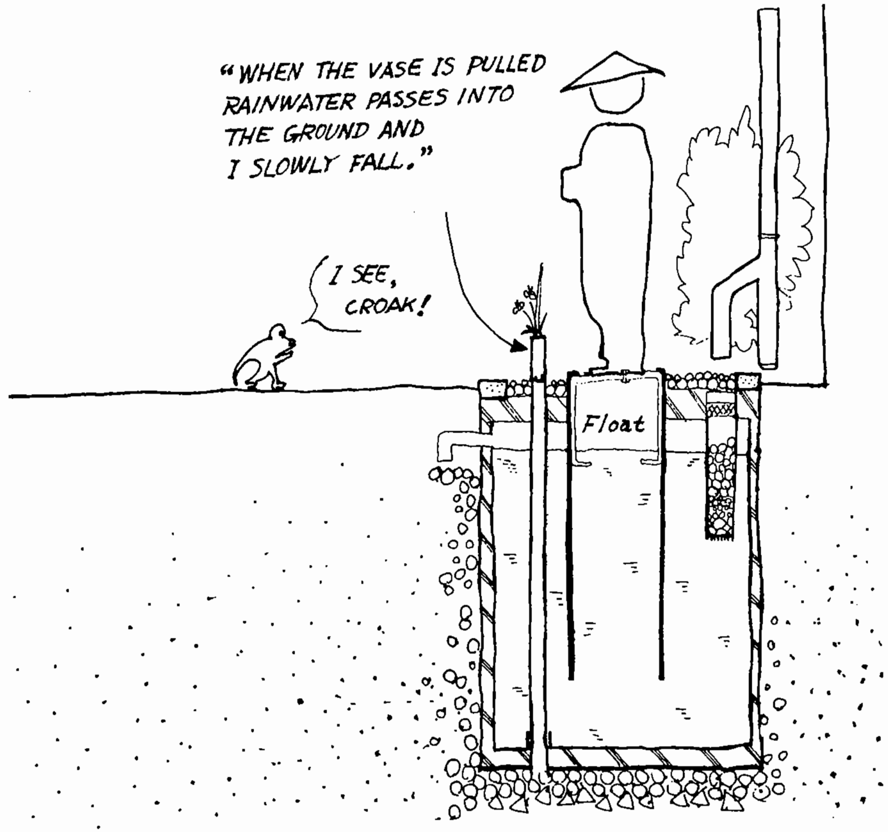
"*Rainwater Jizo (Statue of Rainwater God)*" *Serving as a Water Level Gauge*



Masaki Matsumoto, one of Group Raindrops members, proposed to build Rainwater *Jizo* (a statue of a rainwater god) which also serves as a water level gauge and a symbol to promote rainwater utilization. This is a device using buoyancy: as rainwater fills the storage tank, the statue comes up out of the ground, and as the stored water is pumped out or infiltrates into the ground, the statue sinks into the ground. When the statue reaches the bottom, we can only see its hat as the lid. A signboard beside it says a promotional catch phrase for rainwater utilization: "Rainwater is a Blessing of God." In front of the statue, an offering box is also placed.

Jizo statues used to be popular in Japan. We could find them all over the country. The statues were often shrouded by big trees which indeed seemed to be a home of nymphs. Little boys and girls would stand under the trees with the *Jizo* to shelter themselves from the rain.

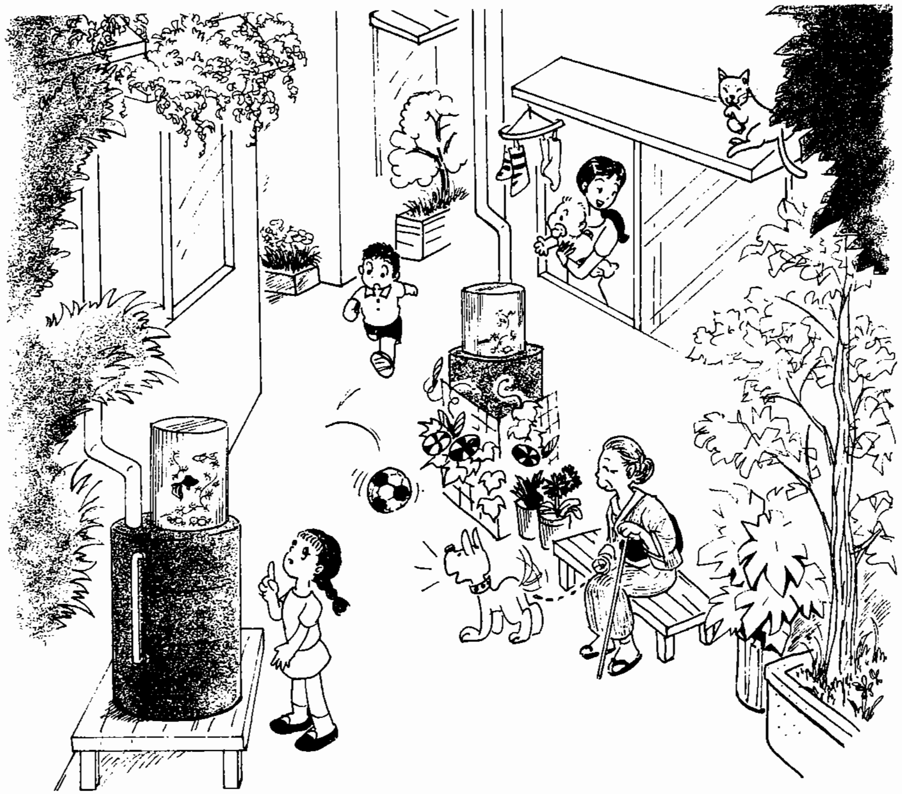
Symbol of Rainwater Utilization



Jizo was so generous that even if children threw stones at it or turned its bib around backwards, it overlooked their mischievousness. Masaki Matsumoto says, "*Jizo* is a reminiscent scene of the good old days downtown, so I suggested *Jizo* as a symbol to promote rainwater utilization. However, there is an alternative, if you like. In Japan, we have a legendary popular frog-like creature called *Kappa*. It is also a statue image that could be used. It is especially suitable for Sumida City because there used to be many rivers and waterways, *Kappa* habitats, and Sumida City also has much folklore regarding *Kappa*."

In old days, there was a famous *Jizo* statue in the precinct of Nanzoin Temple that no longer exists. This statue was called "*Jizo* to bring rain." Legend has it that in dry spells it would rain, if people rolled a straw rope around the entire statue and prayed for rain. We hope our "Rainwater *Jizo*" will grant our request to bring rain.

"Community Miniature Aquarium"

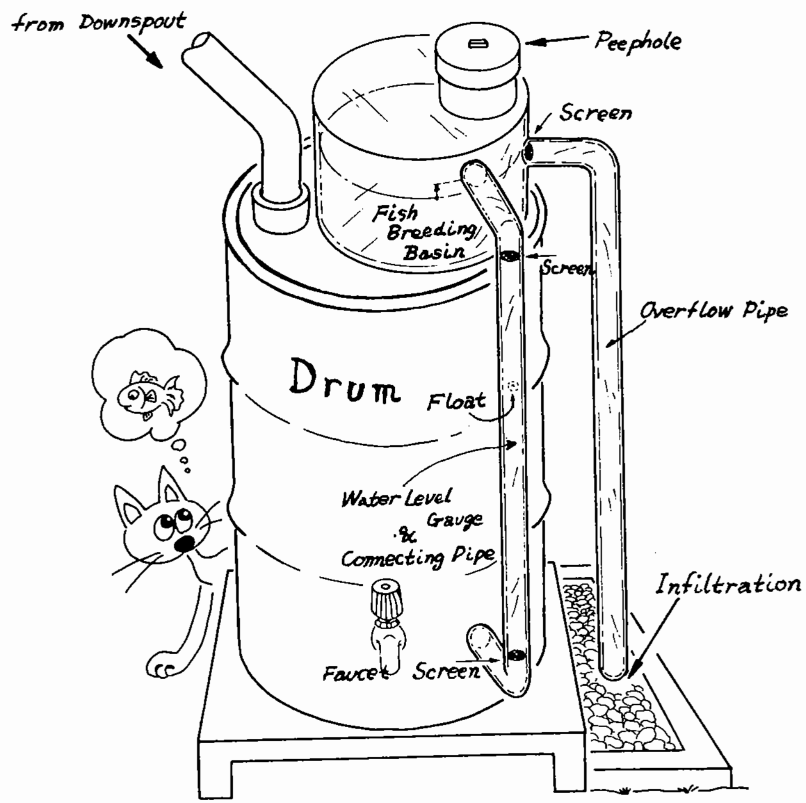


Ryu Ichikawa, one of Group Raindrops members, proposed a "Community Aquarium." He intended to make a simple rainwater tank from a recycled drum enjoyable by attaching a fish breeding basin.

He has loved fish since his boyhood. Whenever he came back from elementary school, he would grab a landing net and a bucket, and go to a neighboring river to catch some fish. He would bring back some of his catch, release them into a small pond in his house yard, and enjoy watching them swim. He came up with this idea, hoping to create an opportunity to play with fish for children living in urban areas where there are no rivers for fishing.

The device is very simple. Rainwater is collected into a drum from a roof through a downspout. When the drum is filled to its capacity, the water pressure pushes the water into a fish breeding basin attached to the drum through a connecting pipe. The connecting pipe also serves as a

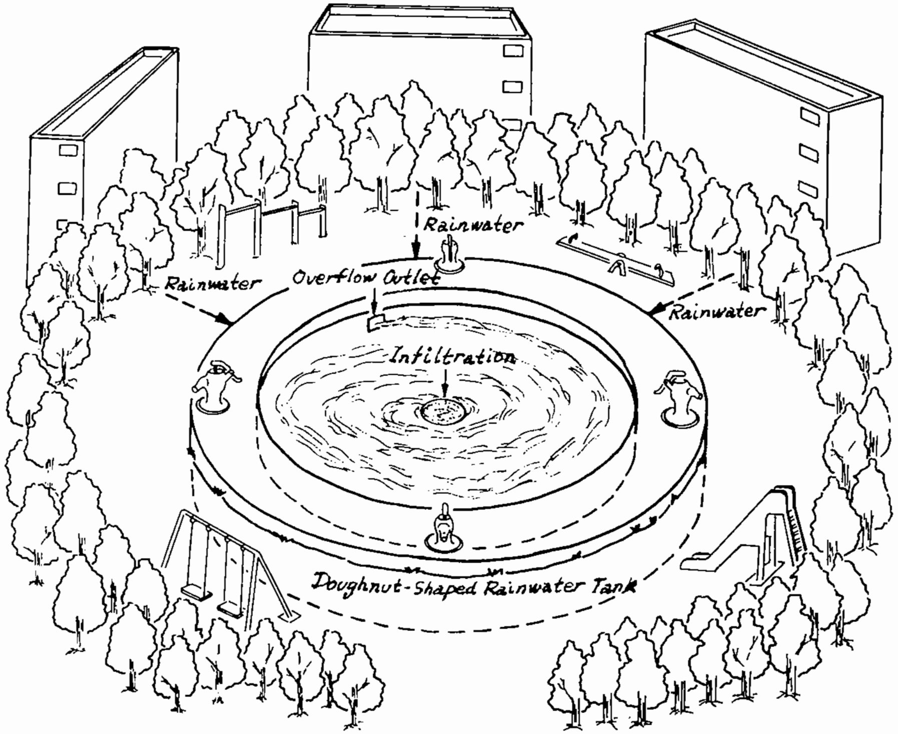
Rainwater Tank with a Fish Breeding Basin



water level gauge. When the water level of the fish breeding basin exceeds an certain level, the excess water is infiltrated into the ground through an overflow pipe. Particles and dirt contained in rainwater are settled at the bottom of the drum. Therefore, when the rain ends and you open the faucet, you can obtain clean water.

In Yanaka, Tokyo the Community Aquarium is popular among children living in the district. It is a basin made of a recycled jar, pot or hibachi. River creatures are bred in it. We can imagine a charming picture: as rainwater tanks with fish breeding basins are placed in many locations and many varieties of fish are swimming in them. Children are feeding and watching the fish.

A "Maimaizu (Snail) Pond" in a City Park

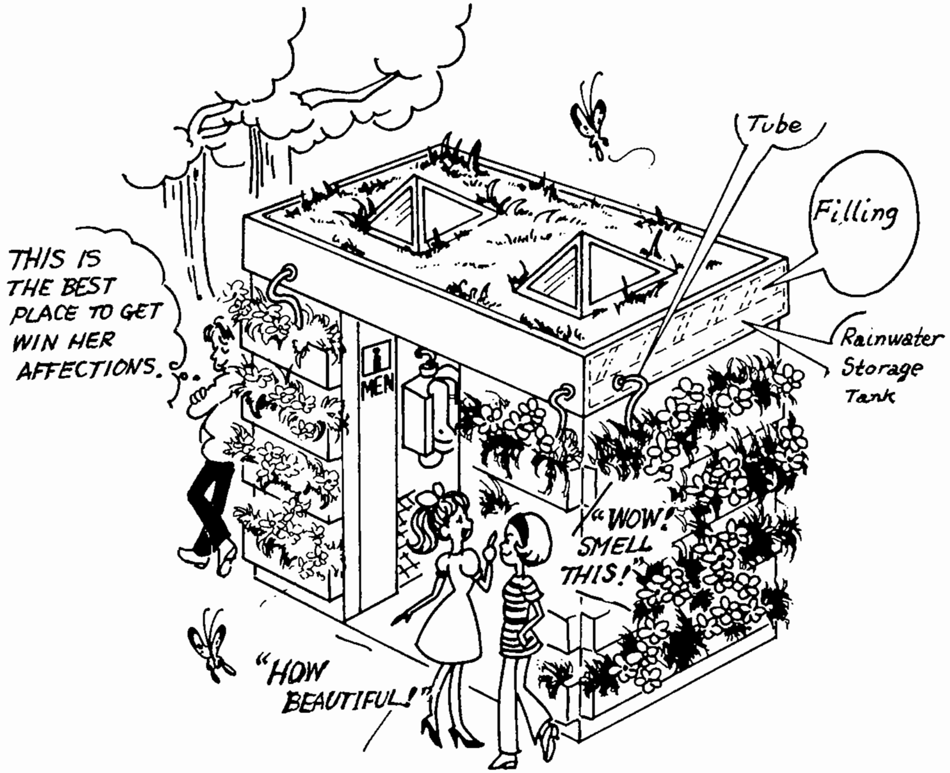


Pocket Park proposed by people involved in the Sumida Oasis Concept is a city park that takes advantage of the plentiful rainwater.

In this park, there is a doughnut-shaped underground rainwater storage tank. Rainwater is collected into the tank from the roofs of nearby housing complexes. The inside of the doughnut-shape is slightly hollowed and spirals down. Rainwater from the ground surface of the Pocket Park and overflow water from the storage tank run down along the spiral slope and gradually infiltrate into the ground from the center of the hollow. When it rains, the hollowed part becomes a puddle; and when it stops raining, the spiral slope appears at the bottom of the puddle.

Years ago people that lived in the Tama area in west Tokyo used to descend a swirling slope holding a bucket and draw water from a *maimaizu* (snail) well because the groundwater level was too low to dig

Devices for Enjoyable Ground Infiltration

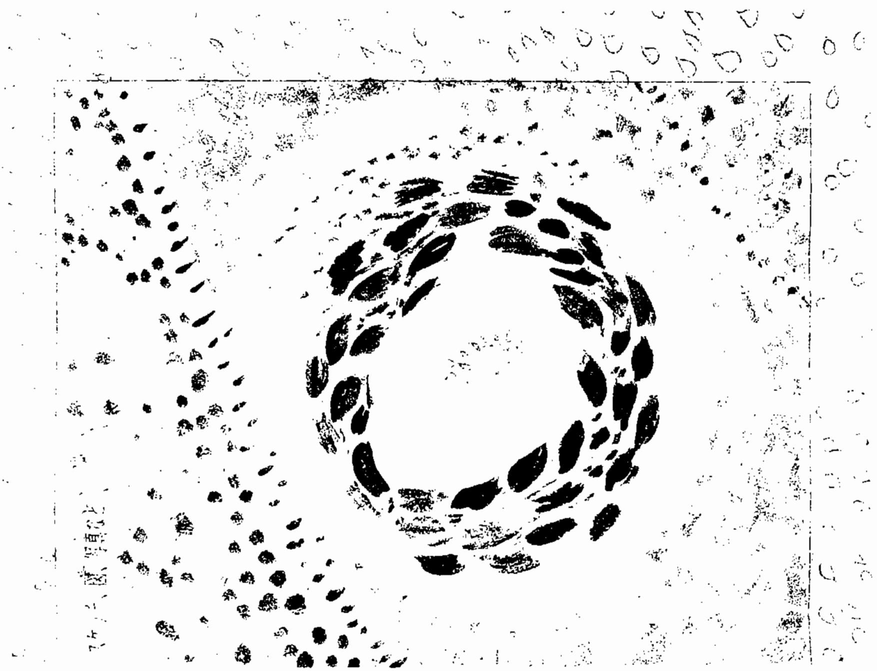


a vertical well in that area. The Pocket Park idea is derived from this *maimaizu* common well of the Tama area.

Benches, slides, swings and sandboxes are placed around the tank, and trees are planted around the perimeter of the park. Rainwater is also collected into a rainwater storage tank installed under the roof of a public lavatory in the park. Together with rainwater pumped up from the doughnut-shaped storage tank, this water is used for flushing toilets as well as for watering plants.

There was another proposal for a rainwater fountain *Amamizu-Kozo* (Rainwater Boy Bonze) in the form of *Shoben-Kozo* (Pissing Boy) statue, and water from rainwater storage tanks installed beneath nearby elevated highways would be used for the fountain.

"The Beautiful Rain that Falls . . . ,"

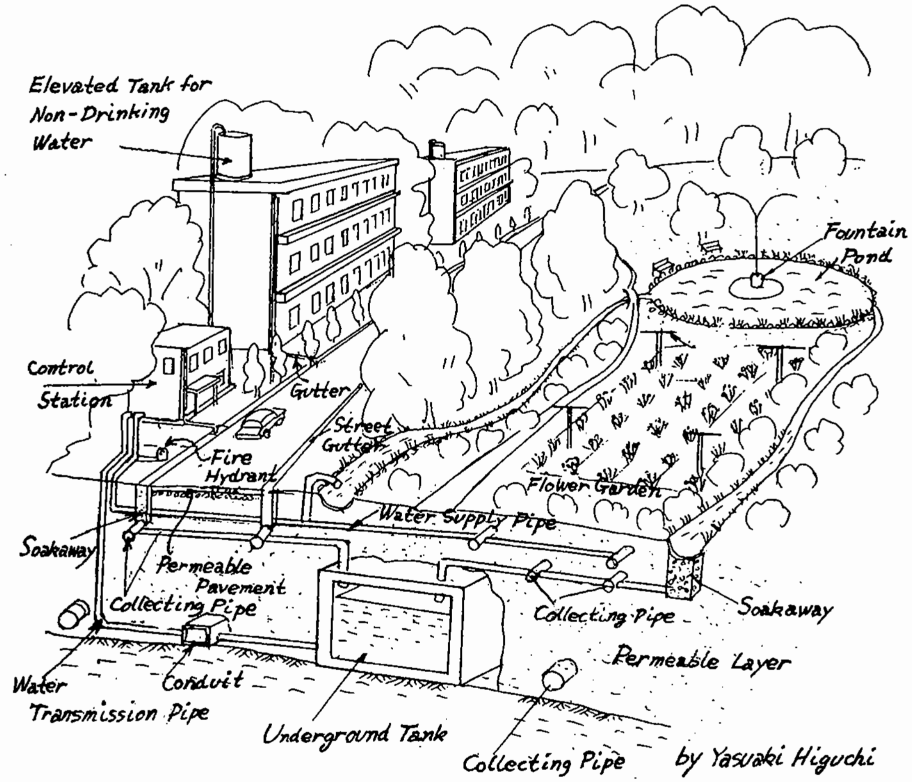


The Rainwater Utilization Idea Contest was held in conjunction with the Tokyo International Rainwater Utilization Conference to collect ideas and designs from around the world. The contest attracted 116 ideas from Japan and 7 from abroad.

A Japanese fifth grader, Akiko Shigihara participated in the contest, and her title was "Eco-Friendly Rainwater Infiltration for under the Park Areas." Her brother, Takaaki Shigihara, also participated in the contest and his title was "Energy of Bouncing Raindrops on the Rooftop." Both were awarded Excellent Prizes.

In her proposal Akiko Shigihara said, "While flying to Europe, I saw the clear sky, the breathtaking beauty of snow on Mt. Everest, white ice fields of Siberia, and Mont Blanc from the plane. Everything was fantastic! Rain in Sumida comes from the clouds that seem to swell with hope under the beautiful sky, so beautiful the rain seems to be the

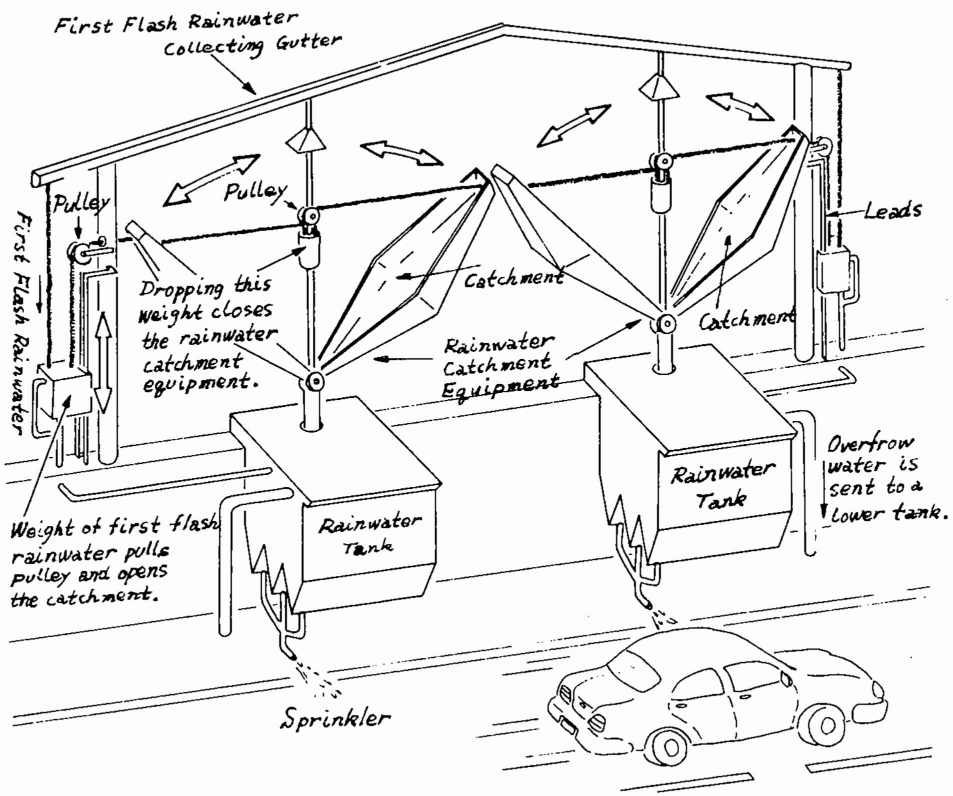
Let's Return Purified Rainwater to Mother Nature!



cloud's teardrops. Rainwater breathes life into trees, plants, flowers and people. Rainwater is the water of life for all living things because rain comes from beautiful Mother Nature. So, it is our duty to return rain to Nature as it is. I want rainwater to be returned underground through purifiers installed in parks, open land areas, gardens and so on. My idea for a purifier is to set a fine mesh to prevent dirt from dropping, with gravel, charcoal and sand under the mesh to filter the rainwater." Her impressive idea is the essence of rainwater utilization.

We also introduced the layout of Yasuaki Higuchi's idea "Collective Rainwater Utilization System" which had a similar concept as Shigihara's.

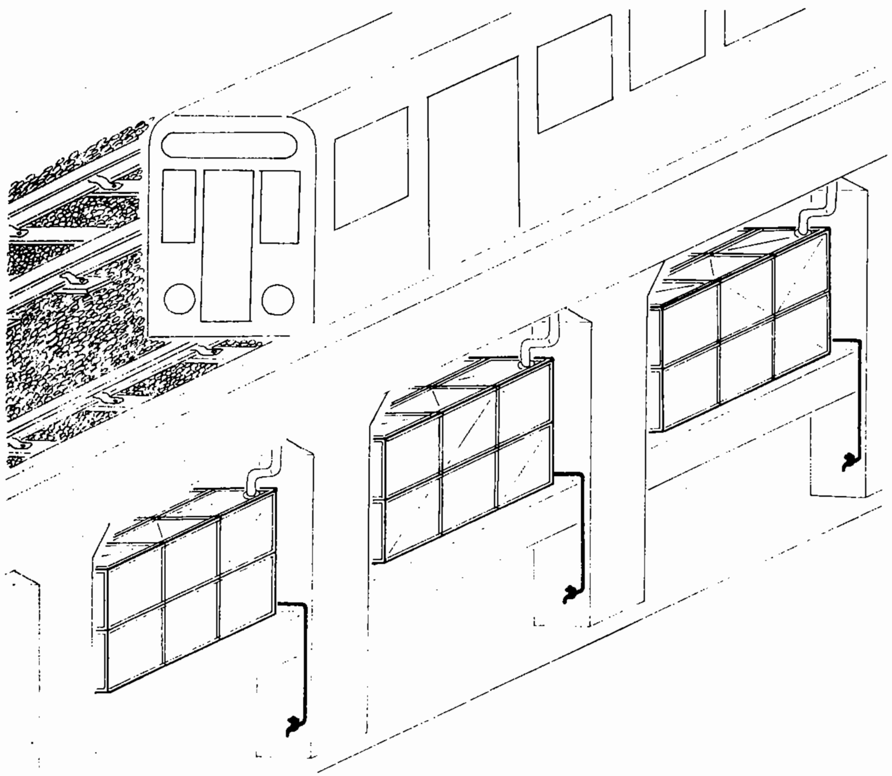
Using the Space under Elevated Highways for Rainwater Storage



Considering the width of drain pipes and the space underneath the girders of elevated highways or railways, the idea of using that space for rainwater storage sounds very practical. We found out that a number of rainwater storage devices are registered after checking rainwater utilization technology patents. Two Japanese proposed this idea in the Rainwater Utilization Idea Contest. Takashi Higuchi won an Idea Prize, and his idea concerned space utilization under elevated railways. Katsumi Tamura's Excellent Prize idea titled "Hello" is intended to make the dreary space under elevated expressways more pleasant.

The Tokyo Expressway is approximately 230km long. With a width of about 16m, the road surface area will be 3,680,000m^2 and multiplied by Tokyo's annual average precipitation (1,500mm) totals 5,520,000m^3 of rainwater. This is equivalent to 4.4% of the amount of water that Tokyo draws from the Yagisawa Dam per year (126,000,000m^3);

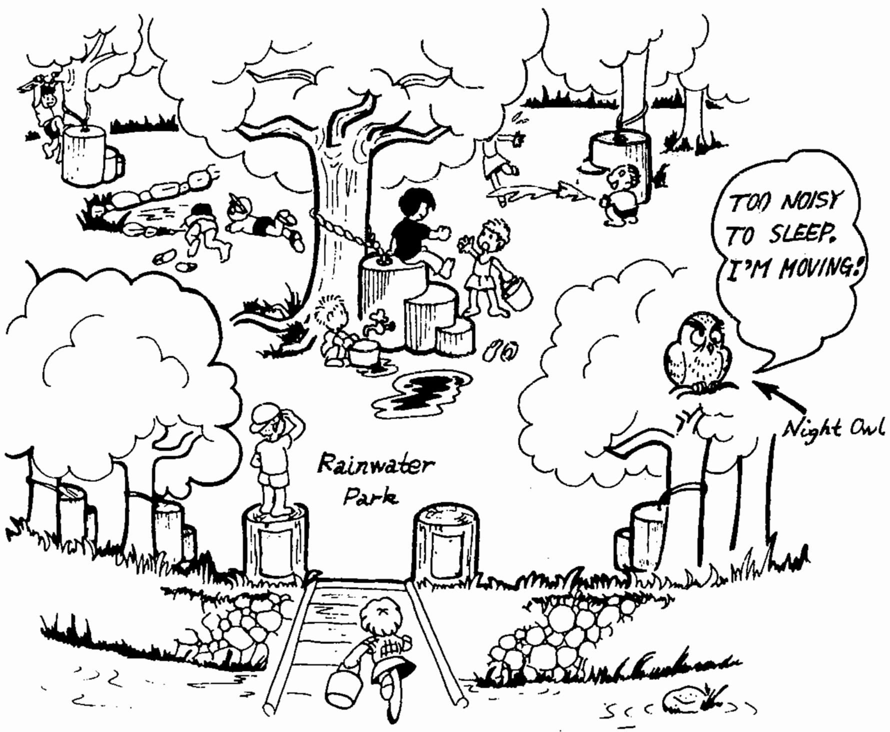
Expressway Public Corporations and Railway Corporations: Think about It, Please!



however, most of this rainwater is dumped into rivers through sewers. Although some of the space under those elevated expressways and railways is used as roads, parks or parking lots, most of it remains unused.

It is difficult to secure space for rainwater storage in crowded urban areas. Installing rainwater storage tanks under existing roads or buildings is also difficult because of costs and maintenance problems. Even if we wait for further redevelopment, the number of roads and buildings that can be changed will be limited, and few open areas may be available. Therefore, unused space under elevated expressways and railways is valuable, and must be used for rainwater storage. Moreover, the burden on sewer systems will be lessened. Expressway Public Corporations and Railway Corporations: Please consider this idea!

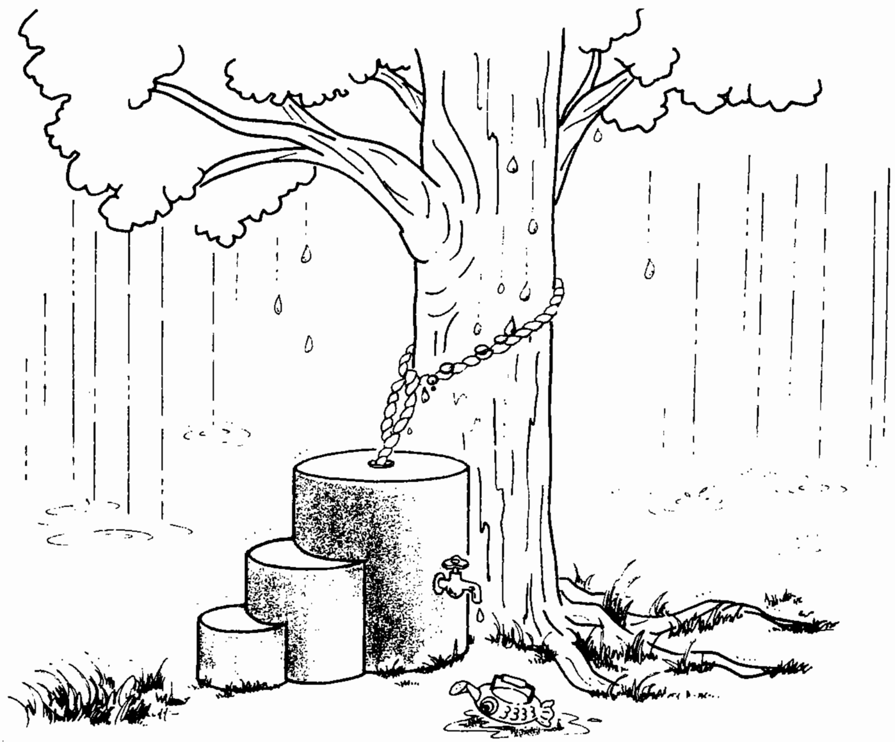
Playground with "Tensuison" and Trees



An Italian architect once said that the only things children need in a playground are plenty of water and trees with strong branches. Children instinctively know how to play only with water and trees. He thought an excessive number of Japanese playgrounds were designed by adults. While working on the Sumida Oasis Concept, we thought: "How about a playground without swings, slides, jungle gyms, or other such things; just one with water and trees only." Of course, the water would be rainwater.

A playground is surrounded by trees, and some of them are broad-leaved trees with branches strong enough for climbing or hanging from. *Tensuison* is attached at the foot of trees and also used as a foothold. A tree is encircled by a straw rope about 30cm above the top of *Tensuison*, and both ends of the rope go into a hole in *Tensuison*'s lid to collect rainwater. This idea was inspired by the *Shide* rainwater

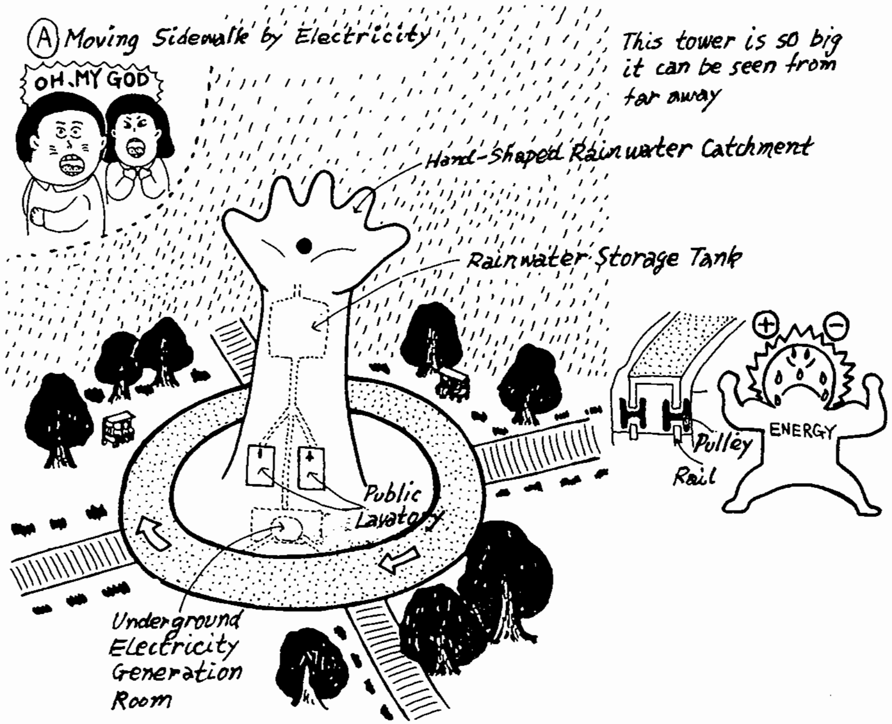
Inspired by the "Shide" Wisdom of the Outlying Island People



collection system that collects raindrops from tree leaves by using ropes and has been used from old times in the outlying islands. However, this alone can not collect enough rainwater, so underground tanks which collect and store rainwater from roofs of nearby buildings are also used.

Each *Tensuison* has a faucet, and a basin is placed under the faucet. Children can play with the water, and they are allowed to do anything innocent with water. We ask children to give water to flowers and trees. In the middle of the playground, *Amamizu-Kozo* (Rainwater Boy Bonze), the symbol of the park, smiles at all the children.

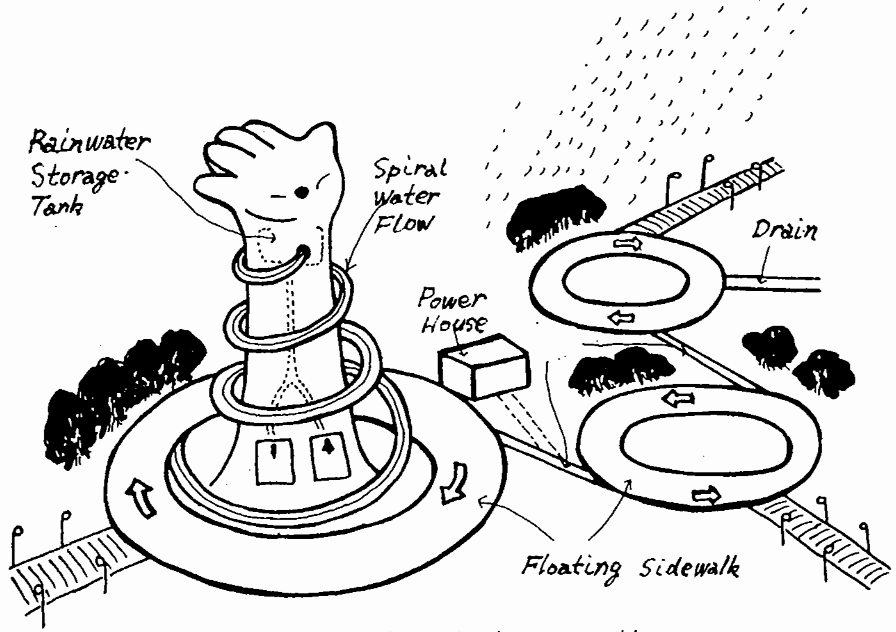
Grand Prize — "Rainwater Park"



"Rainwater Park" by Yasushi Niwa won the Grand Prize in the Rainwater Utilization Contest. A landmark tower resembling a forearm and hand open toward the sky is built in the center of a park signifying that the rain we catch is a gift from God. Also, rainwater is collected from the palm of the tower hand into a rainwater storage tank installed inside the tower. Part of this rainwater is used for public lavatories at inside the tower. Another part flows down through the spiral lower parts of the tower. Another part flows down through the spiral water pipes and generates electricity. This electric power drives revolving sidewalks and electric cars for children.

It was raining from the morning when Yasushi Niwa read the article about the contest in a magazine. At that time he felt gloomy and did not feel like doing any work or going out because of the depressing rain, so he started thinking about how to use rainwater while killing time. He finally came up with this "Rainwater Park" idea.

Park Attractions Run by Rainwater-Power Generation

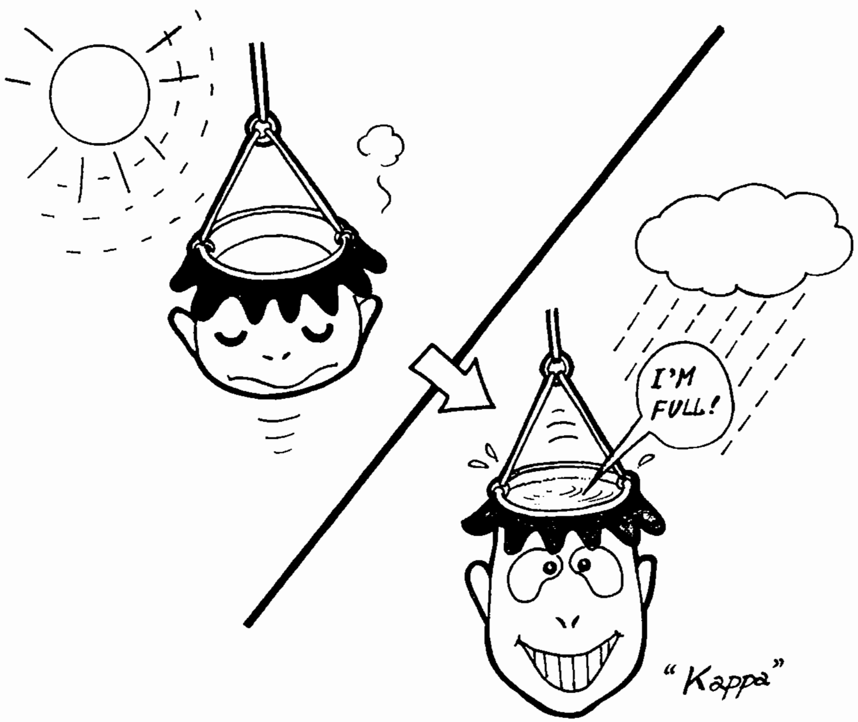


B : Moving Sidewalk by Floatation

The idea of a tower shaped like a forearm and hand, and mechanisms that only operate on rainy days dovetailed with the purpose of the contest. Therefore, his idea was unanimously nominated for the Grand Prize.

A revolving sidewalk looks very difficult to operate; however, it floats on the rainwater that was used for power generation and drained, so it does not require that much power. If you walk along on moving sidewalks in train stations or airports in the opposite direction, you inconvenience others; but on the revolving sidewalk in this park, you can go in any direction and get on and off at will. The kind of amusement children can enjoy there will be very interesting.

Enjoyable Rainwater Utilization

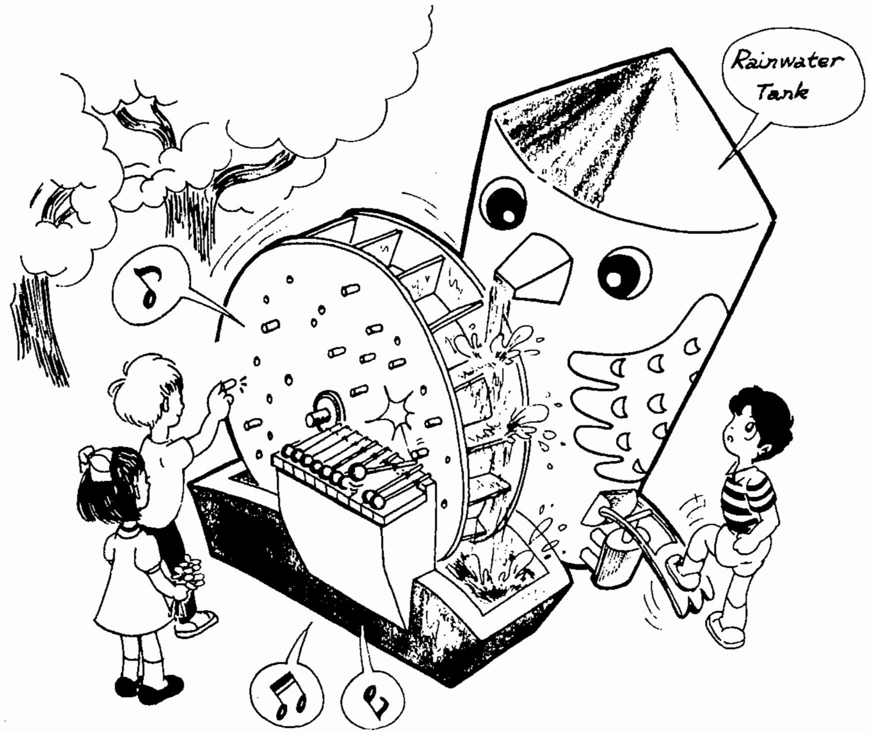


Years ago children used to hurry home singing "Kaeru ga naku kara kaero." (It's time to go home because the frogs are croaking.) Frog croaking was a sign of evening or approaching rain. However, the only frogs you will see in urban areas nowadays are just table or shelf decorations; they neither jump nor tell the weather.

Airtight windows shut out not only the noise of the streets, but also the sound of raindrops hitting the windows. Therefore, seeing a rainy scene is like seeing silent movies, and it is still charming; however, we can not enjoy the pitter-patter chords of raindrops.

Rainfall intensity meters have been installed on the roofs of Ryogoku Kokugikan and the Tokyo Metropolitan Government Office. An electric signal notifies a computer system in the central management room directly of the degree of rainfall intensity; but the signal does not forecast rain as frogs do, nor does it tell the people in the streets how

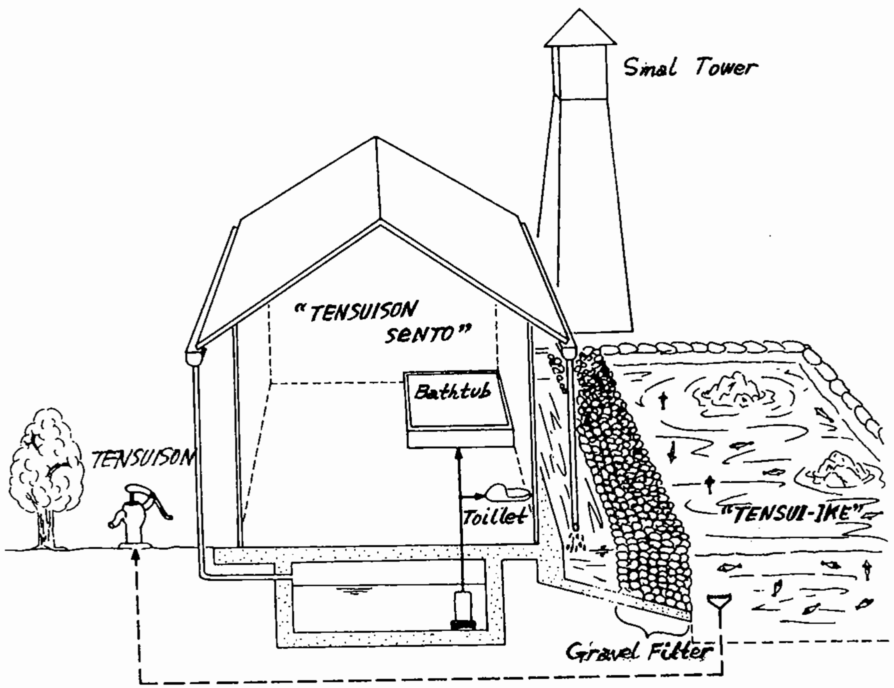
"Kappa" that Wakes up on Rainy Days



hard rain falls. If the electric signal sent to the computer could be converted into lighting and projected on an illuminated bulletin board, people could enjoy a unique environmental display.

Thinking about rainwater utilization in a playful way, we worked on ideas. Kazunobu Hotta proposed "*Kappa* (Japanese legendary frog-like creature) that Wakes up on Rainy Days." This is a *Kappa*-shaped container made of canvas fabric for tents that forecasts rain. Hanging many *Kappa* containers from trees on paths along waterways or in Rainwater Park would be fun, and using them as a signal that tells us how much rain falls would be helpful. Masaki Matsumoto, one of Group Raindrops members, had an idea of "Uryukin," musical instrument played by rainwater. Water running from a rainwater storage tank rotates a waterwheel. Sticks attached to the side of the waterwheel strike notes on a xylophone as the waterwheel revolves.

"Tensuison Sento" (Public Bath) – the Earth Takes a Bath!

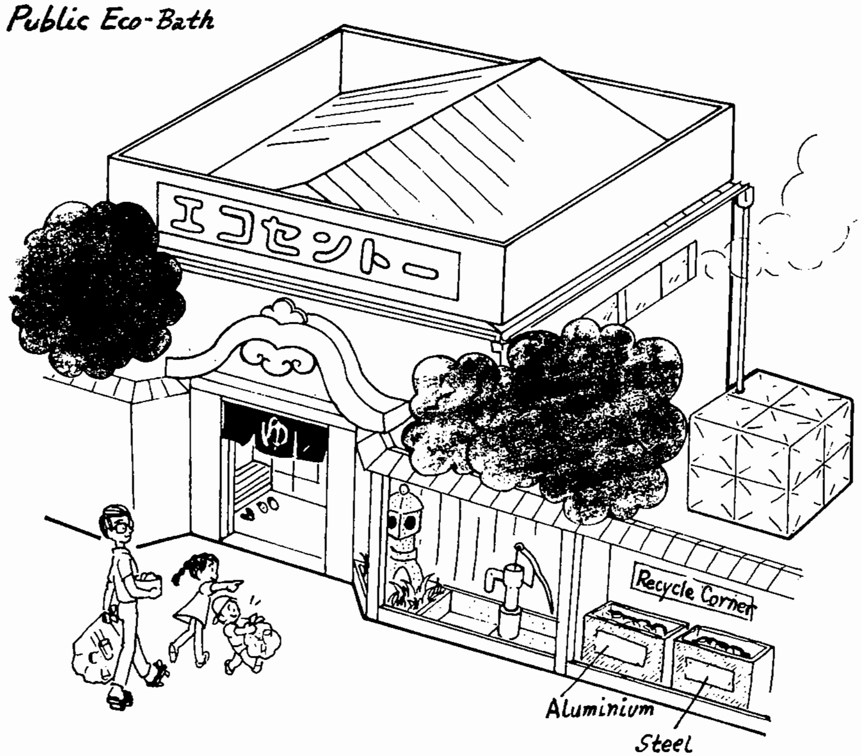


A public bath using rainwater was proposed in the Sumida Oasis Concept. Rainwater is collected from the roof of the public bath and used for flushing toilets, watering plants, fire-fighting and as emergency drinking water.

According to the proposal, the name of the public bath would be *Tensuison Sento*, and it has a distinctive Edo-period (1603-1867) appearance. A rainwater pond landscaped with little bushes is in the garden and a small tower with an elevated tank stands beside the pond. Rainwater is pumped up from an underground storage tank to the elevated tank and supplied by using gravity.

Unfortunately, *Tensuison Sento* remained only an idea; however, it was the prototype for the privately-run Eco-*Sento* located at Ishihara, Sumida City better known by the name of "Mikokuyu" owned by Shigeru Ito. Public baths used to be popular and serve as community

"Eco-Sento"

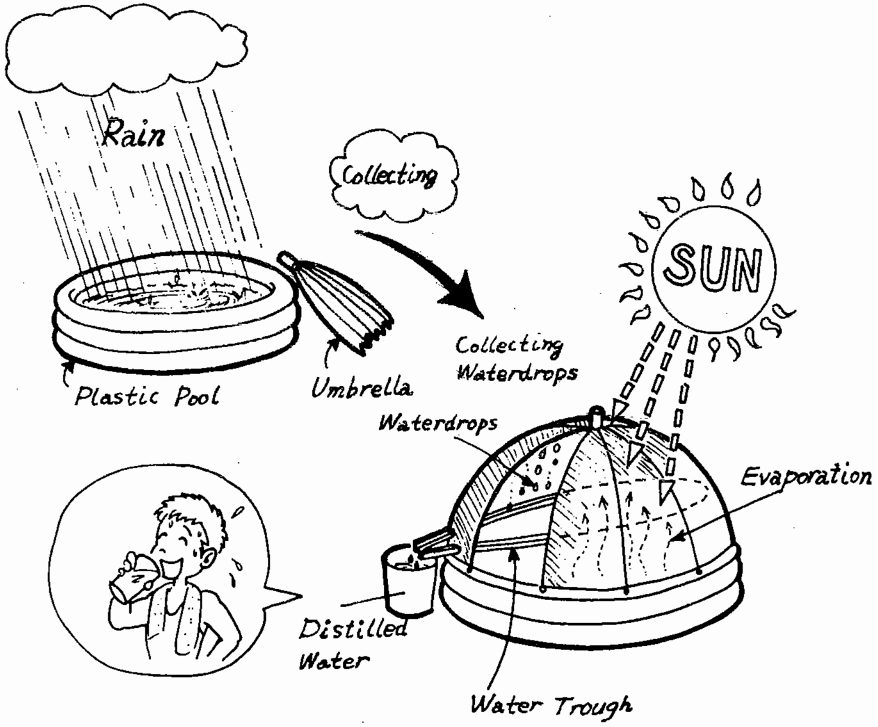


centers, but have disappeared one by one. However, Mikokuyu has become an "Eco-Center" (a play on the similar sounds of *Sento* and *Center*) serving as not only a center for communication, but also a center for environmental activities of the people in the area.

The rainwater utilization concept was applied when Mikokuyu was remodeled in 1991. Although water for bath tubs and showers is city water and mineral water, rainwater collected from the large roof of the public bath is used for a small pond and for toilets.

In addition, a "recycle corner" for empty can collection has been made. Empty cans are rinsed out with the rainwater collected in *Rojison*, and are kept there until recycle trucks come.

Wisdom of Purifying Rainwater

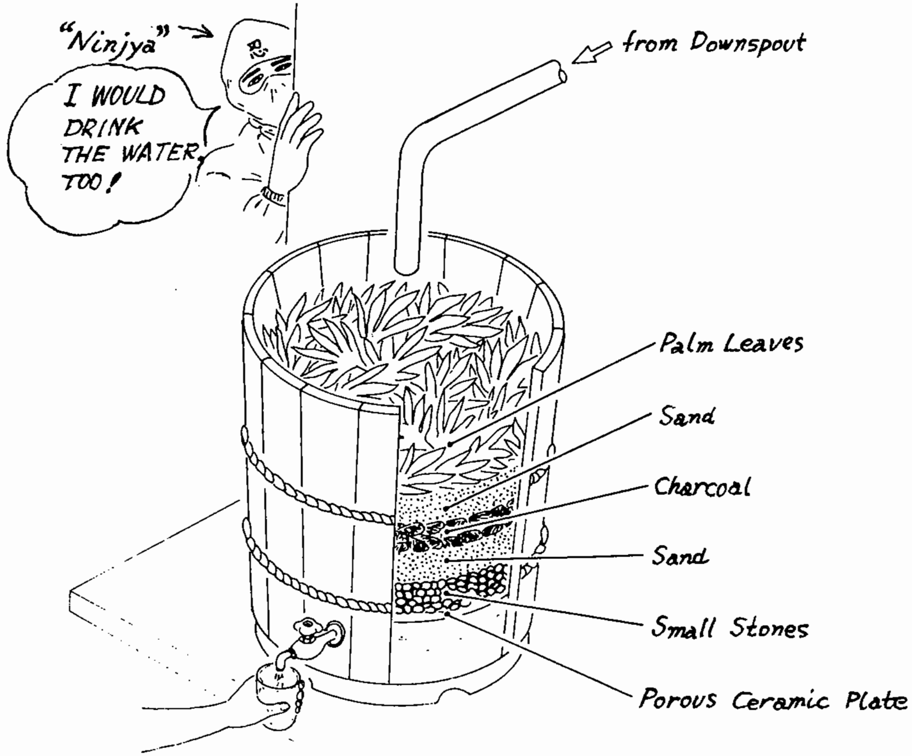


Yoshitaka Yamashita's Idea (Application)

Water is legally classified into three categories: drinking water (city water), non-drinking water (rainwater, grey water, etc.) and wastewater. Using rainwater for public baths and public swimming pools is limited by public health laws and regulations. The water for public baths and swimming pools must be drinking water. If rainwater is purified and its water quality exceeds the standard by law, it is drinkable. However, a considerable amount of equipment is required. The larger the rainwater volume becomes, the more equipment and cost are needed. Although public loans are available because the national and local governments encourage rainwater utilization, the types of projects and the amount of loans are limited. Therefore, rainwater utilization is mainly for flushing toilets, watering plants and washing cars because there is little need to worry about the water quality.

People living in places without city water supply, springs and wells

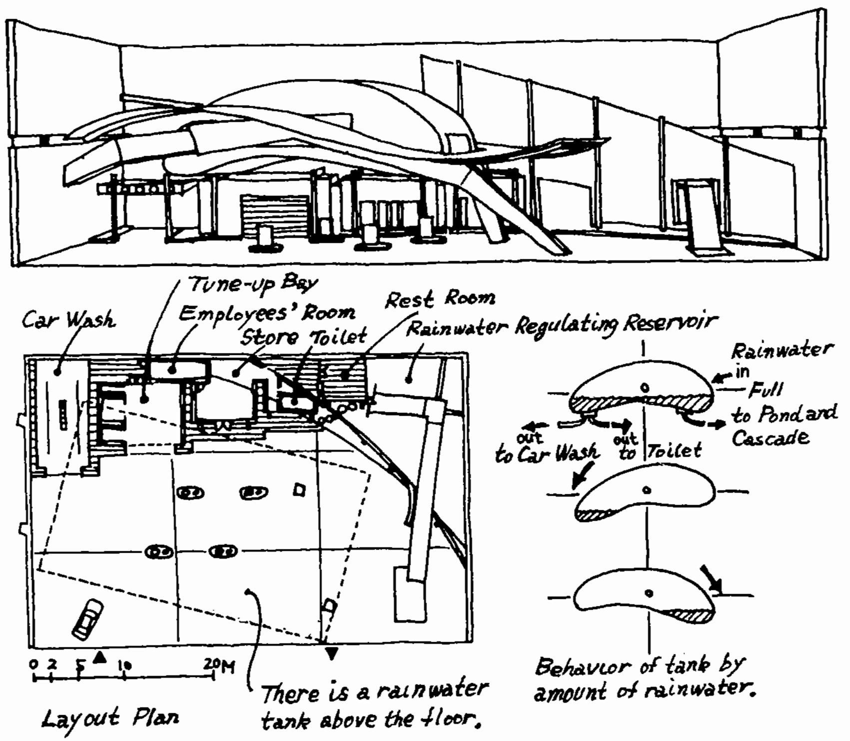
Reconsidering Our Life Style



would collect and purify rainwater for drinking. People living in the Izu Islands, the Amami Islands, or on Zamami Island in Okinawa are still doing this. It would be better if urban rainwater were drinkable, but air pollution makes it difficult. In urban areas rainwater falls through the polluted air and becomes contaminated. It is not easy to purify such rainwater to the drinkable level.

Rainwater will be depended on as drinking water when dams dry up or city water supply pipes are destroyed by calamities. To do that, we need not only to work on creating effective purification systems, but also to reconsider our life style and make a concerted effort not to pollute air even further.

Rain Breathes Life into the Corner Gas Station

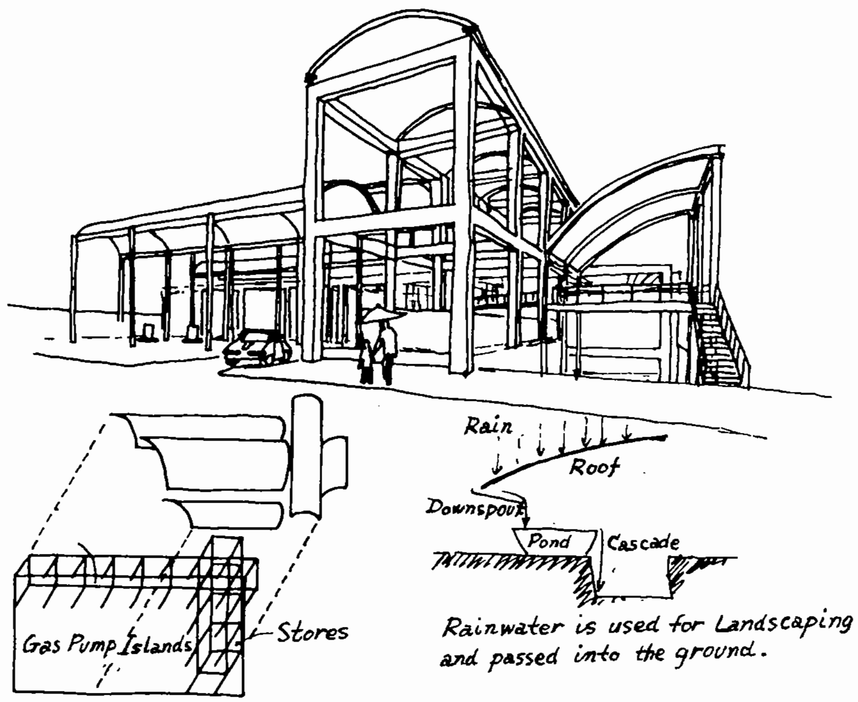


"Tank-Asaurs"~Rain Breathes Life into— by Hideaki Kurokawa

There are more than 50,000 gas stations throughout Japan. Most of them are equipped with car wash machines, using about 150ℓ of water for washing a car. In addition, washing machines at gas stations are going all day for cleaning towels used for wiping windows. Water is also spilled over the surface of gas pump islands to prevent static electricity. All in all, much city water is used at gas stations. However, plenty of rainwater could be collected from canopy roofs covering the gas pump islands. Gas stations fit the need for rainwater utilization and are suitably constructed for rainwater utilization.

Graduate students of Nobuhiro Suzuki, Professor of Architecture, at the Science University of Tokyo, challenged a design exercise entitled "Rain Breathes Life into the Corner Gas Station." The points of this theme were to design a gas station using rainwater not only for washing cars or sprinkling, but also for something that would enable customers

Water Design Appeals to the Five Senses



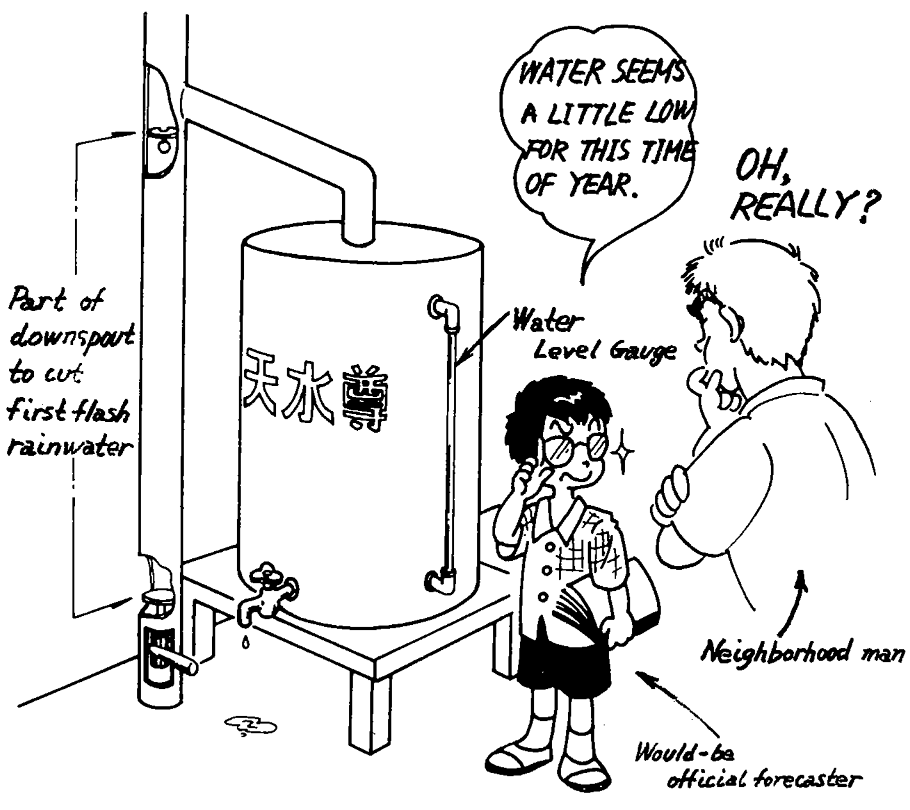
"Design of Gas Station Using Rainwater" by Keitaro Maeda

and passers-by to enjoy the scene and the sound of rain; and including an element not only for the people that come there or walk by, but also for birds and trees. The students designed their dreams freely ignoring actual limitations.

A plan was proposed: make areas where customers can rest, an artificial rainwater waterfall, a rainwater curtain, a waterway, a *Tensuison* pond, and a miniature garden in the space. The plan included many elements that show how hard rain falls, how rain runs down the gutters, how floors and walls become wet, and how rain reflects light.

There was another proposal called "City Oasis." In that plan, trees are planted on the canopy roof, and rainwater infiltrates into the ground breathing life into the plants.

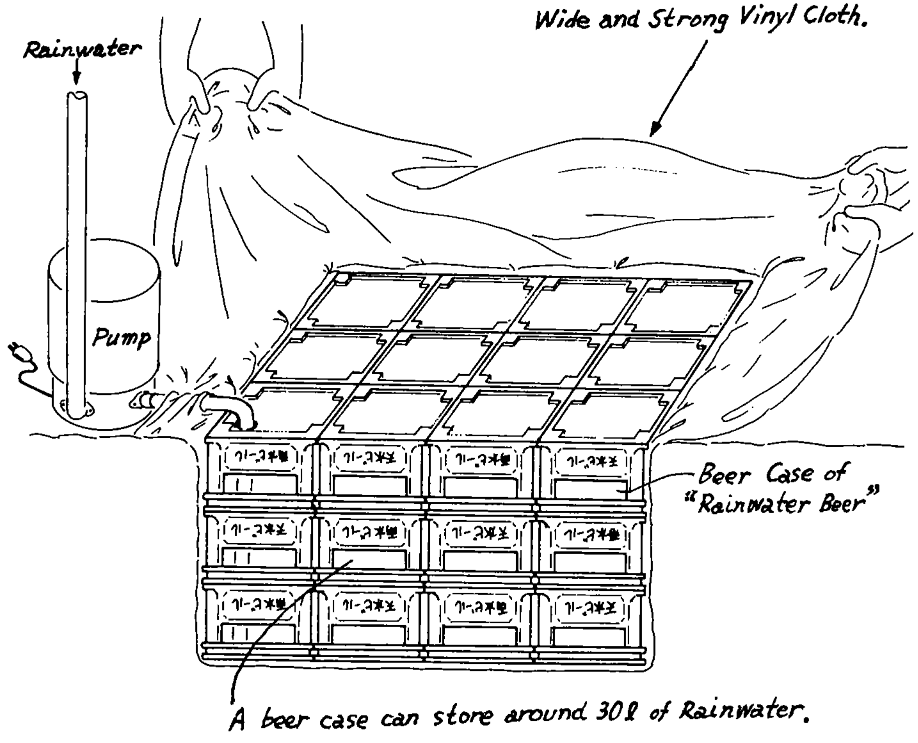
Simple Rainwater Storage Tanks for Home Use



The most difficult problem in promoting rainwater utilization at home is securing rainwater storage space and a large volume of rainwater. When building a new stand-alone house, a reinforced concrete rainwater storage tank should be set underground. This tank can also serve as the foundation of the house, so neither extra space nor so much money is required. Moreover, it can store plenty of rainwater and the rainwater can be used for watering plants, flushing toilets, washing cars, and water for emergency uses. In an existing house, build a rainwater storage tank under the garden, or buy a ready-made rainwater tank and place it in the garden or on the side of the house entrance. However, since it is difficult to store a large volume of rainwater due to space limitations, the use of rainwater is limited.

To build a rainwater storage tank in a garden only extra-wide vinyl sheets used in the construction industry, some plastic beer cases, a

Using Beer Cases and Buoys

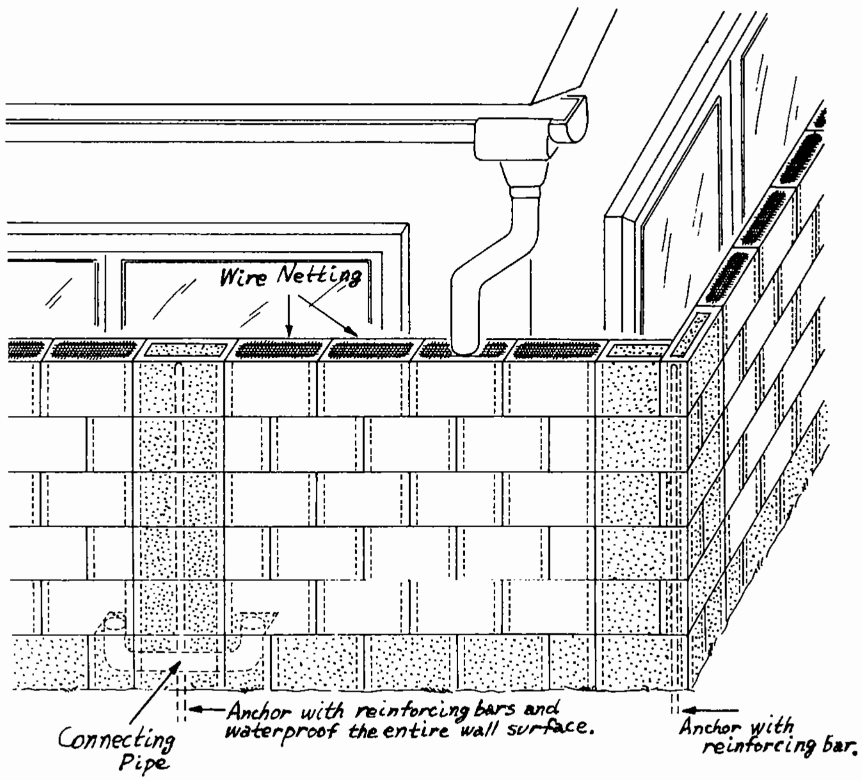


polyvinyl chloride tube and a pump for a well are needed. First, dig a hole and cover the hole with a vinyl sheet. Second, put some beer cases into the hole upside down and cover them up with another vinyl sheet. Finally insert a polyvinyl chloride tube as an intake and install a pump. It costs about 50,000 yen (500 dollars*), mostly for the pump.

Nobuo Tokunaga makes *Tensuison* rainwater storage tanks inexpensively, and it is he who has promoted the installation of *Rojison* in the Ichitera-Kototoi district, Sumida City. Because he has an inventive nature and earnestly desires to promote rainwater utilization, he began to make *Tensuison* by hand. Tokunaga's *Tensuison* is made of a polyethylene buoy used in fish breeding farms. He attaches a faucet and a water level gauge made of a transparent pipe to the buoy, and makes an intake from a downspout. It is 60cm in diameter and 90cm in height with a capacity of 200ℓ. It costs about 50,000 yen including a metal stand.

*Dollar said in this book is US dollar.

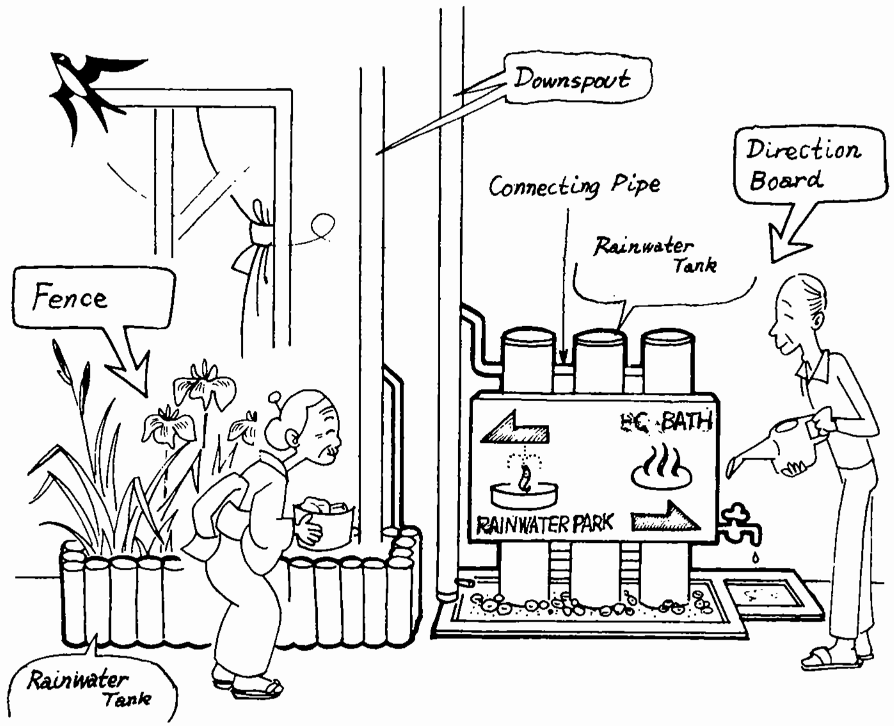
At a Glance It Looks Like a Typical Concrete Block Wall, But . . .



If your house stands side by side to a neighbor's house with only a very small backyard, what would you do for space for a ground-level or underground rainwater storage tank? This is a common problem in using rainwater in densely populated areas.

Well, you can cope with this problem by transforming walls or fences into an "ultra-thin rainwater tank." This tank is made of concrete blocks and looks like just an ordinary concrete block wall. However, each block is hollow so rainwater can be stored inside it. The blocks should have no partitions inside and no recessed ends. Preferably it should be waterproof. Blocks should be placed alternately on a foundation of reinforced concrete being anchored by reinforcing bars at every wall corner and every 1.8m. The blocks anchored by reinforcing bars should be filled in with concrete. Pipes to join each block section should be incorporated into the lowest layer. This represents the

Rainwater Tank Using Dead Space

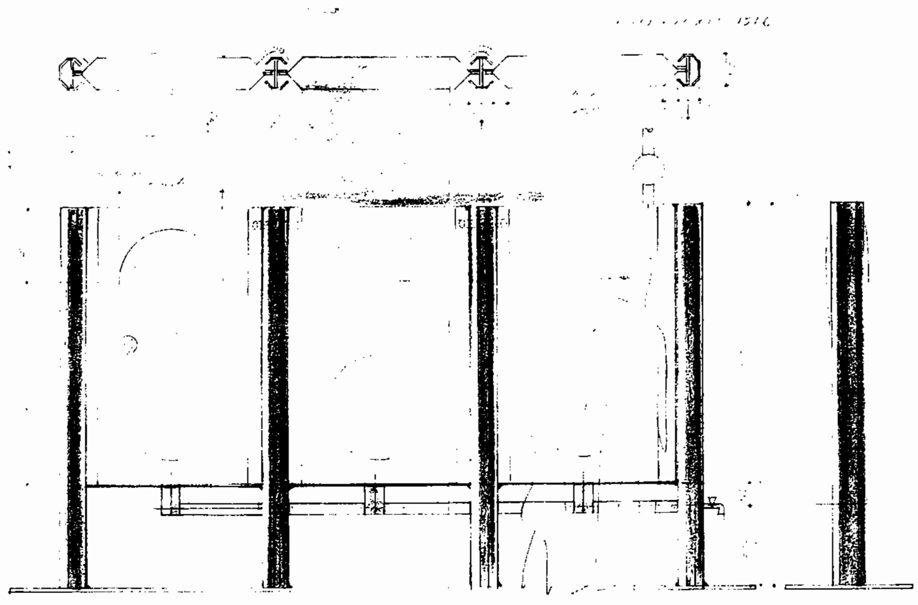


application of an idea we observed while visiting Botswana, Africa to study local rainwater utilization techniques in summer 1993.

At the "Rainwater Utilization Idea Contest," a Best Effort Prize was awarded to Yoshihiko Kanbara for his invention "Rainwater Tank Using Dead Space" originating from the same idea, but utilizing the concrete block wall to an even greater extent. In his idea, even the foundation was also used as part of the rainwater storage tank.

The idea of our member Hajime Fukano also comes from the same principle. He made a tank using 100㎜ diameter polyvinyl chloride pipes. Pipes are stood side by side, each pipe connected to its adjoining pipes with a connecting pipe. He proposed to use this pipe tank as a fence around a yard. It is very easily made, and it does not look like a rainwater storage tank if some plants are placed around it. It can also be used as a support for a signboard.

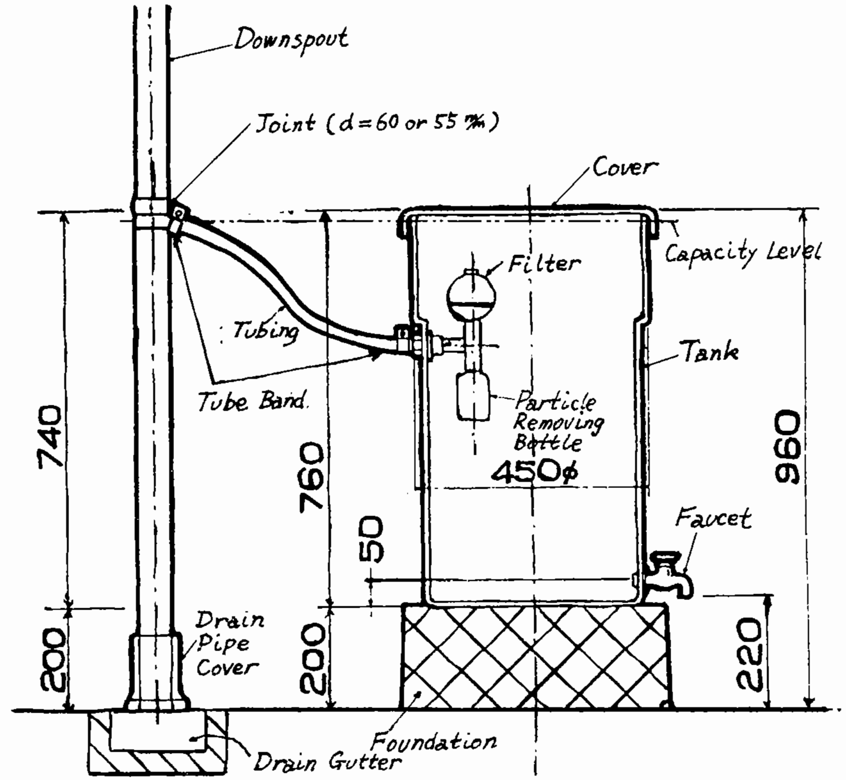
Commercialization of a Space-Saving Rainwater Storage Tank



At the event named "Rainwater Land" held at the same time as the conference, two companies in Tokyo exhibited space-saving-type rainwater storage tanks. Totetsu Manufacturing Co., Ltd. exhibited the "Fence-Type Rainwater Tank" made of stainless steel and Toyo Chemical Corporation's Department of Building Materials displayed a compact-style systematic container for storing rainwater made of plastic and named "Rain Oasis."

The Fence-Type Rainwater Tank is unit-style and space-saving-type. It is assembled by connecting stainless tank units side by side that are 15cm thick, 130cm high and 84.2cm wide. Each tank unit (151ℓ) is connected by a pipe with backflow check valves, and functions as one tank. It is a fashionable tank that can be used not only in individual houses, but also in stores and office buildings. Totetsu Manufacturing Co., Ltd. has been developing rainwater storage tanks using polyvinyl

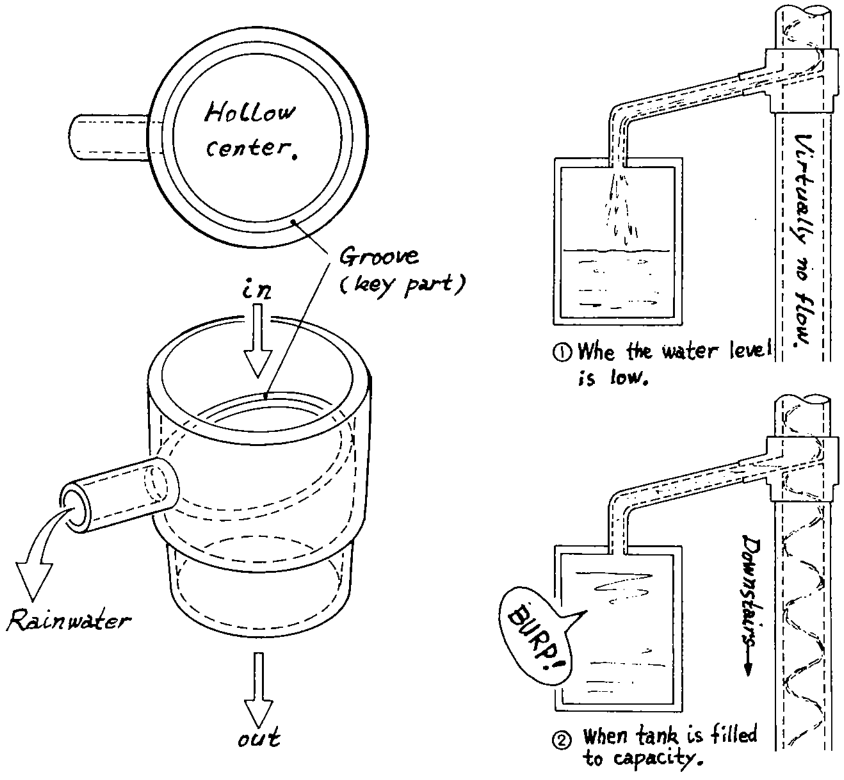
Challenge by Enterprises to Promote Rainwater Utilization



chloride pipes, separate rainwater flowing system incorporated into a downspout to cut first flash rainwater, and underground infiltration plants. This company is very eager to expand their rainwater utilization business.

On the other hand, Toyo Chemical Corporation's "Rainwater Oasis" is a cylindrical rainwater storage tank (diameter=45cm, capacity=100ℓ) equipped with a sedimentation device and a filter to clean rainwater. It is functional and so compact that it occupies little space on the balconies of housing complexes. Anyone can easily install this tank for 38,000 yen (380 dollars) by merely cutting a downspout and applying an "intake joint." Toyo Chemical Corporation is the first company that has introduced a polyvinyl chloride downspout in Japan. The company has a strong interest in rainwater utilization and is developing a more sophisticated version of Rain Oasis.

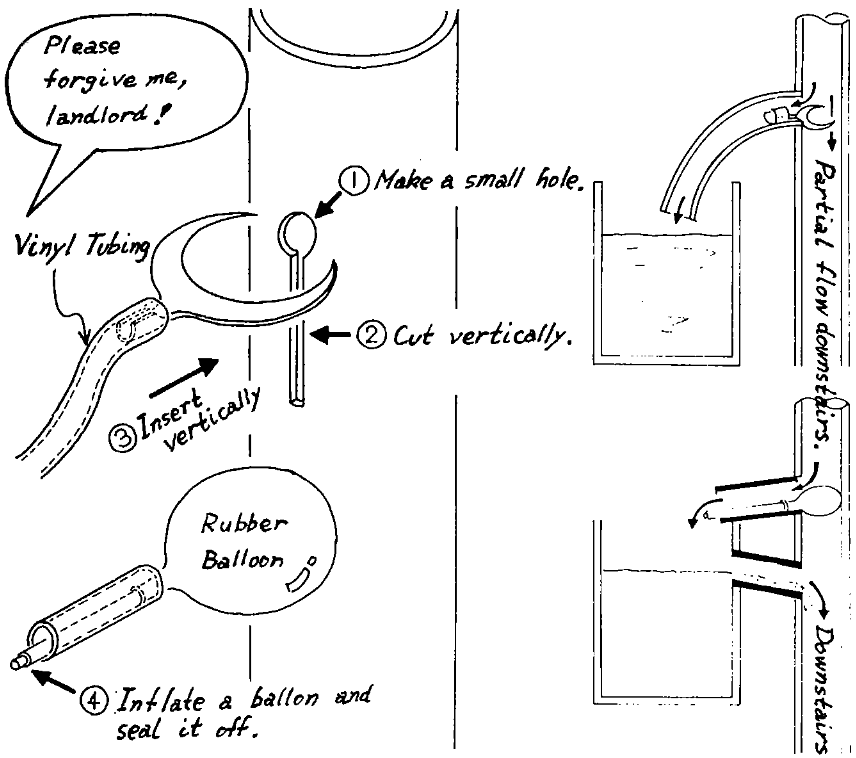
How to Collect Rainwater at Housing Complexes — Part 1



How does each household collect rainwater at a housing complex? Katsuji Ando solved this question by inventing a special joint for downspouts. He found that most rainwater pouring through a downspout from a roof and a balcony drain goes down along the inside of the downspout. He invented a ring of a certain width to be put inside the downspout joint. During the experiment, most rainwater pouring down the downspout was separated by the ring at the joint, and then went into another pipe connected to a rainwater storage tank. Rainwater continued pouring through the joint until the tank was filled to its capacity. When the tank was filled, rainwater resumed going down through the downspout. As a result, every household obtained rainwater, not only upper floors.

Yuko Kanbayashi also came up with an idea based on the same principle which could be easily implemented. Take a thin metal strip or

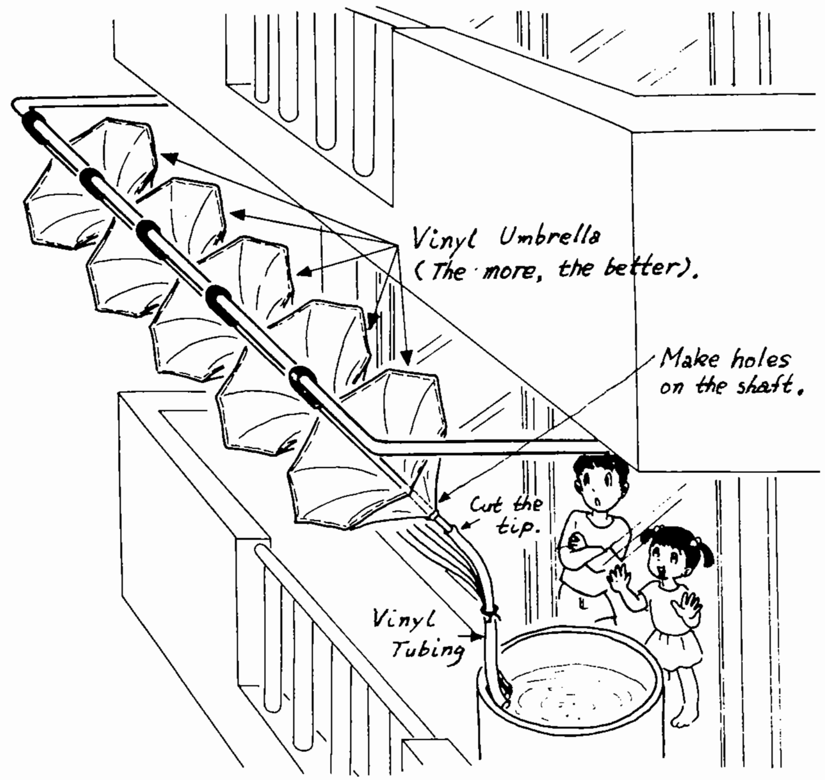
Collecting Rainwater from a Downspout



a plastic board and cut it into a round shape of the same diameter as that of a downspout. Next, cut it into a horseshoe-shaped ring with the ends being pointed. A small round hole should be made on the side of the downspout; then cut just below it vertically so that the horseshoe-shaped ring can be put into the downspout vertically. After inserting the ring into the downspout, turn it 90 degrees. Last, attach a vinyl tube to the ring (the horseshoe-shaped ring should have a small handle).

If this seems to be rather time-consuming, try Ryu Ichikawa's "balloon" rainwater catchment. A balloon is inserted through a small hole made on the side of a downspout. It is then inflated with air becoming a substitute for the ring. Two pipes connecting a downspout and a rainwater tank—one for water to flow into the tank and one for the return of the excess water from the tank to the downspout when the tank is filled—enable rainwater utilization by all tenants.

How to Collect Rainwater at Housing Complexes — Part 2

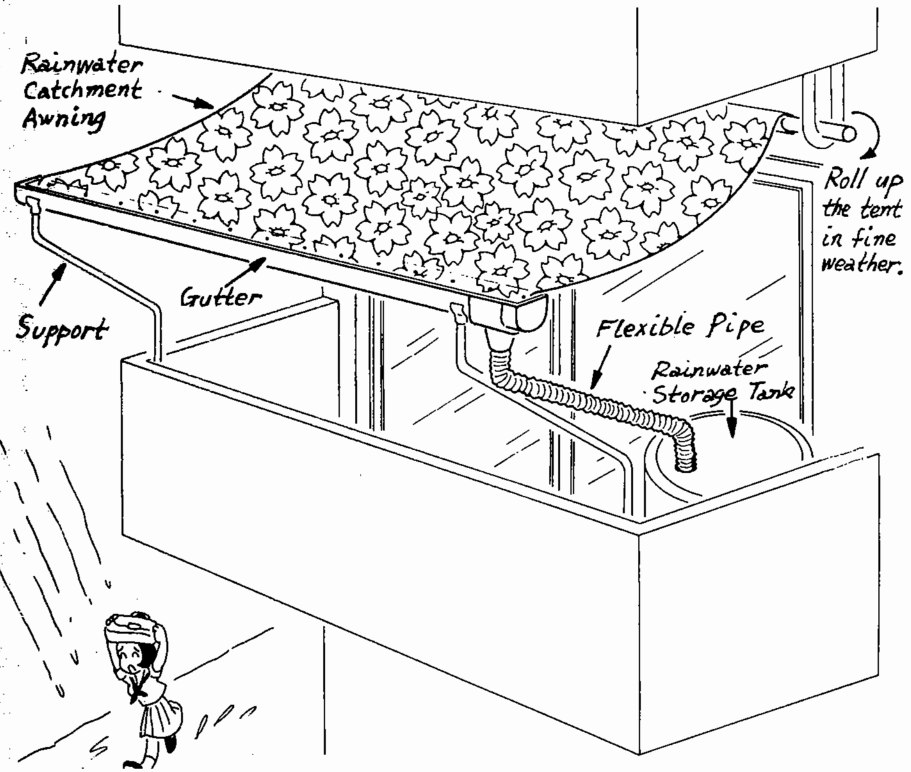


What is a "Rain-Blooming Flower?" Is it a tropical flower that blooms when rain falls or a paper flower that opens when it is put in a glass of rainwater?

If you have extra vinyl umbrellas you bought in unexpected rains, why not make extra good use of them? Yuko Kanbayashi came up with a creative idea. First, make two holes in the shaft of an umbrella just where it joins the ribs. Then, cut off about 1cm of the shaft tip. Attach a vinyl tube to the cut tip. Hang several opened umbrellas in the same fashion on a washline pole from their handles. Simply hang them upside down. These umbrellas will collect rainwater that will flow through the vinyl tube. This way of collecting rainwater is very easily done even at housing complexes.

Any umbrella with a pipe-like shaft (hollow inside) can be used. Yuko Kanbayashi, an umbrella "maniac," always thought it a pity that

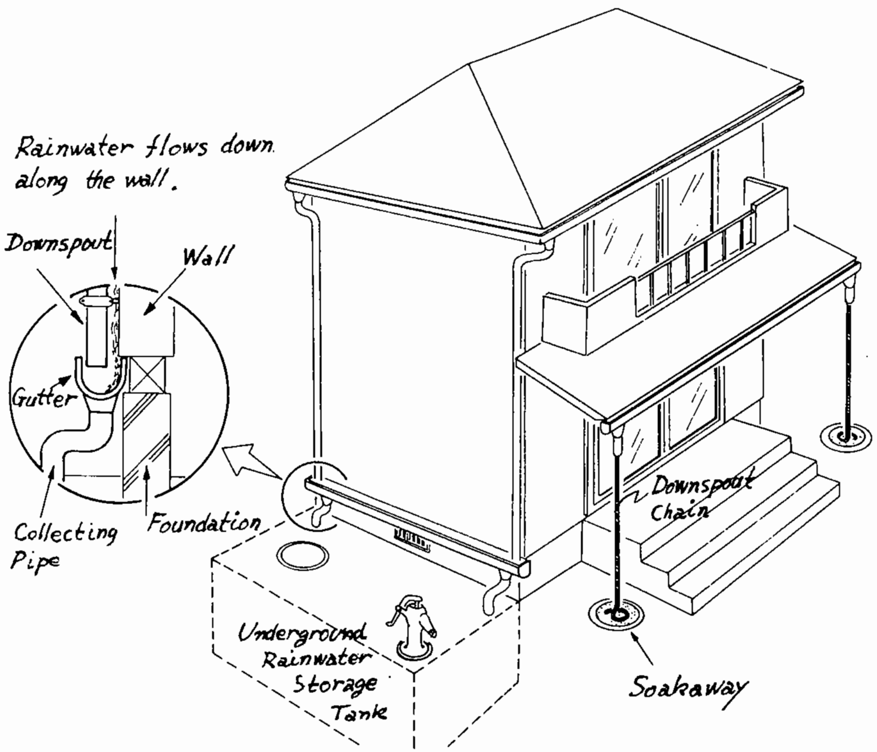
What is a "Rain-Blooming Flower?"



some umbrellas were used only once and then thrown away. So, she came up with this idea.

There were other members that hit on the idea of having flowers bloom on rainy days, Kaoru Hotta and his son. They transformed a sunshade awning on the balcony into a rainwater catchment. All that need be done is just fixing the end of the awning into a polyvinyl chloride gutter, and join a flexible pipe (instead of downspout) to the gutter. Recently, the awning designs are very colorful, so if many of this kind of rainwater-catchment-"flowers" bloom on balconies, what a pleasant sight it would be!

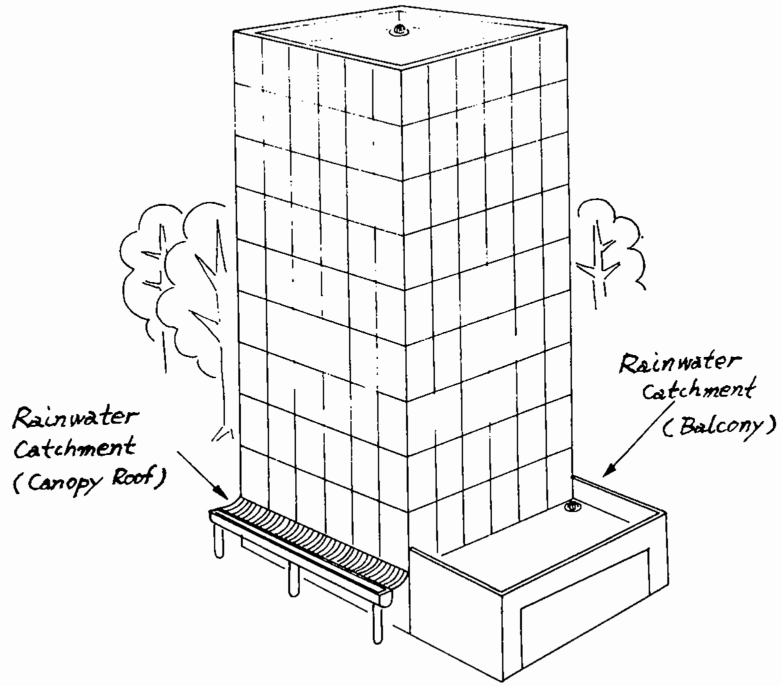
Walls Can be a Rainwater Catchment



Collecting rainwater from the roofs and rooftops facing the sky is common, but rainwater can also be collected from vertical surfaces of buildings because rain does not usually fall exactly vertically. In most cases, it falls on a slant. In some cases, it "falls up." This is why we make the walls of houses and buildings waterproof, and caulk around the windows. If we simply rely on roof eaves and neglect other ways of preventing rainwater from leaking through, rainwater will come in through the cracks around the window frames or the eaves fittings.

Traditional Japanese houses used to have long circling eaves that prevented rainwater from hitting the walls, windows, doors and veranda. However, currently, the depth of eaves exceeding 1.2m is counted as part of the square measure of the building, so an increasing number of buildings now have shallow eaves to gain more space inside the buildings*. Helped by sophisticated aluminum window sashes fewer

Let's Collect Rainwater from Walls and Building Window Glass.

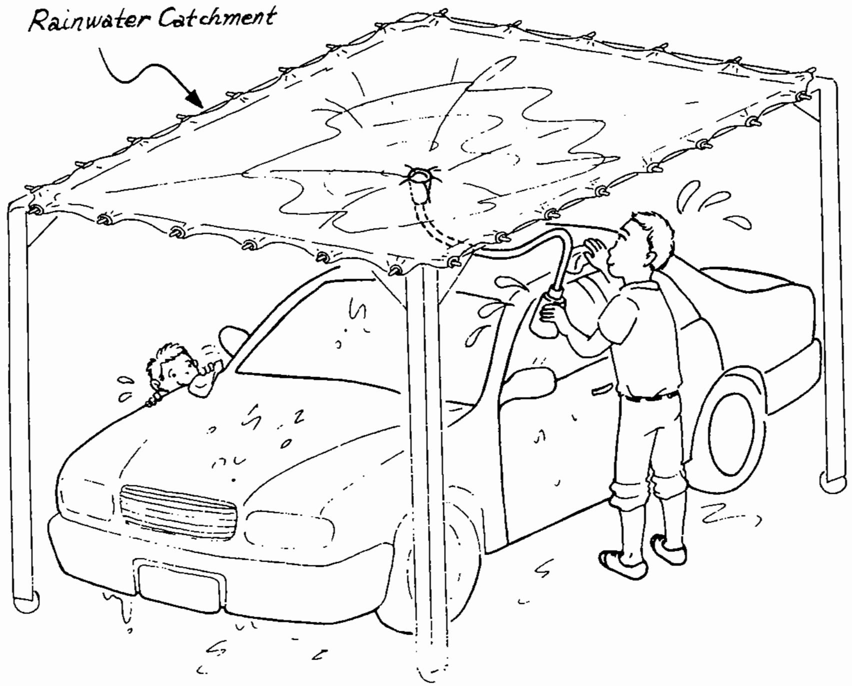


eaves have been observed these days. Kiyoshi Sato, a member of Group Raindrops and an architect, proposed using the rainwater flowing down the walls. At the Rainwater Utilization Idea Contest, there were some ideas that considered the rainwater flowing on the walls of buildings. Kazuo Nagado proposed collecting this rainwater by constructing eaves on the first floor.

The amount of rainwater collected from a vertical surface of a building has been considered to be 50% of that from a horizontal surface of the same area, but there is a report that it actually measured 7%. Even if it were only 7%, the total amount of collected rainwater would be great because even one wall of a building is several times as large as its rooftop and there are many tall buildings in urban areas.

*Japanese Building Standards Act restricts the ratio of the total floor area of buildings to the site area.

An Always-Clean Car

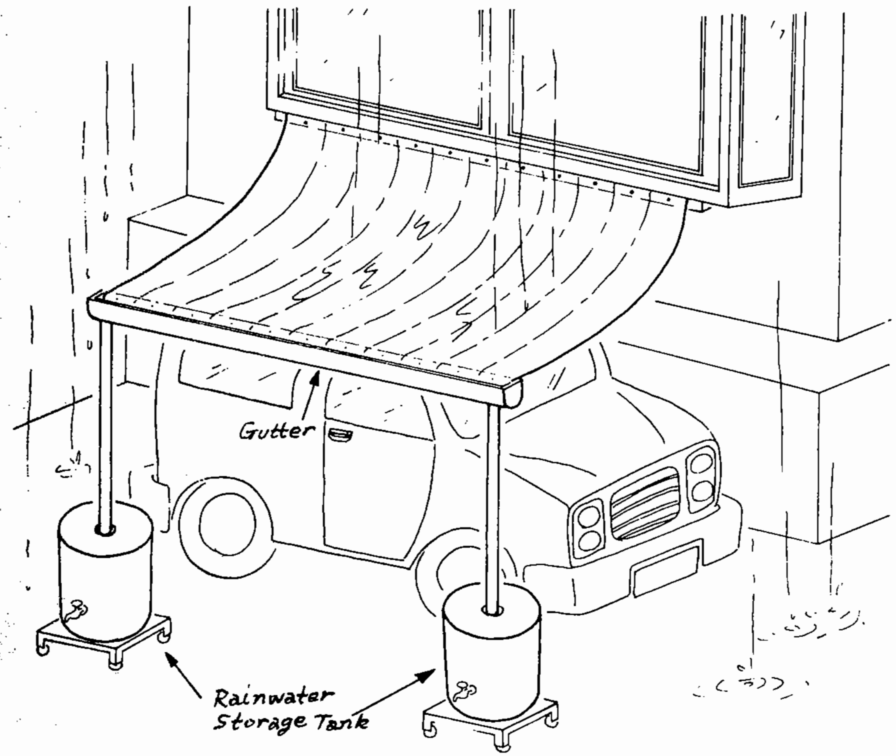


Here's a story from our group members that visited Hawaii to see facilities using rainwater:

Half of the cars running around in Hawaii were made in Japan What surprised us more was that the cars they drove on the streets every day had rust and holes from erosion. The beach is close, so cars tend to become salt damaged. This is understandable, but in Japan we hardly ever see such old junkers. This is not because people in Hawaii do not take good care of cars nor are they lazy, but the customs and cultures of both countries are different. They might be taking much more care of their cars than Japanese do, who scrap cars after only a couple of years of use.

Japanese people clean their cars very often. Thus, car washes are always full on weekdays and weekends. One wash uses 150ℓ of water. People wax their cars until they really shine. One hundred fifty liters of

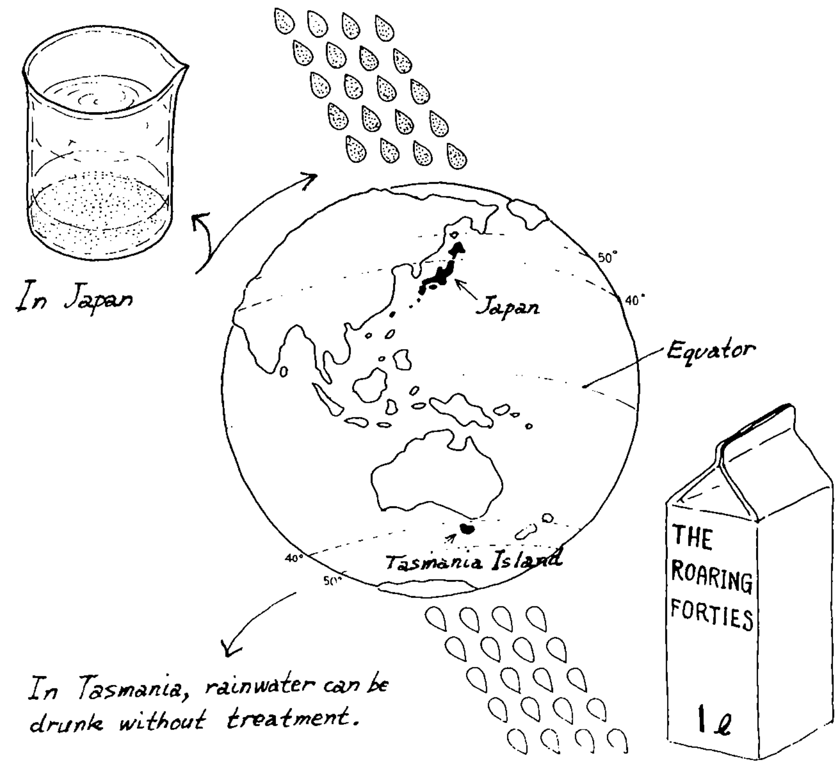
Washing Cars with Rainwater is Quick and Effective



water is 75 times the 2ℓ minimum water requirement for subsidence per person per day, so people in Hawaii, where water resources are scarce, will be shocked to hear this. However, in fact, due to the chlorine in our city water, the longevity of our cars has been shortening.

So, Hidetake Nagashima came up with an idea to use rainwater for cleaning cars. His idea is to stretch a sunshade sheet loosely on four standing polls and collect rainwater in it. A hose can be attached at the center of the sheet when we wash cars. His invention won a Best Effort Prize at the Rainwater Utilization Idea Contest because it can be put into practical use easily. Another practical idea was proposed by Kaoru Hotta: collect rainwater from a garage roof, and store it in a tank at the bottom of the roof supports.

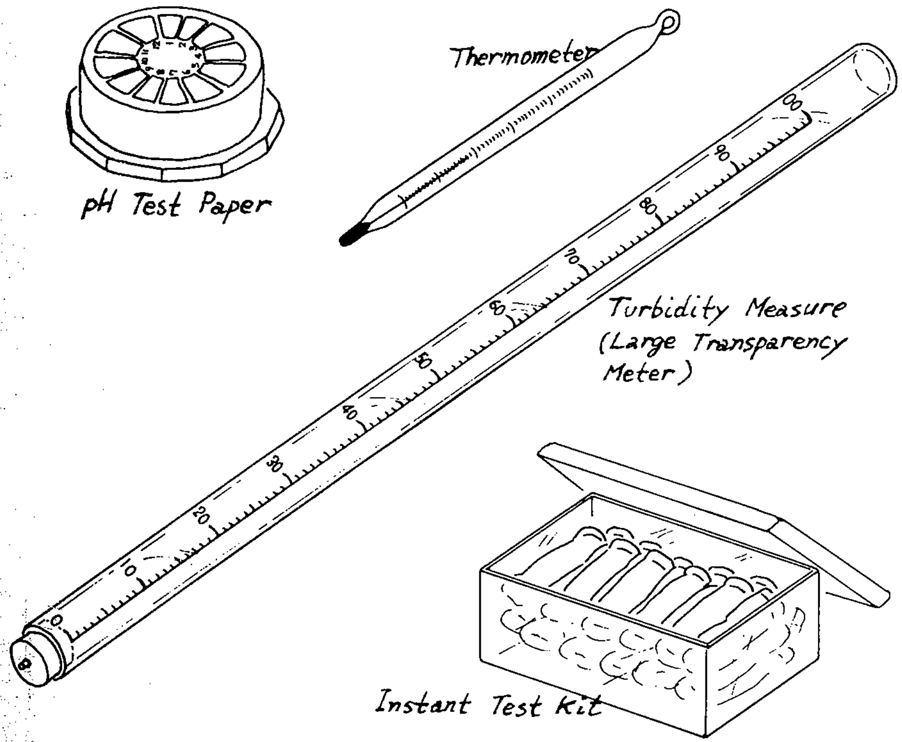
Worrying about the Quality of Rainwater You Collected?



There is a country that sells rainwater packed in paper cartons. The words "THE ROARING FORTIES" are printed on them. The dictionary tells us this means the rainstorm area in the North Atlantic at latitude 40 to 50 degrees north where many developed countries with environmental destruction are located. The stormy westerlies carry dirty air, so rainwater is not clean. This dictionary's explanation confused us because countries in this area should not be selling such a carton of dirty rainwater. When we paid closer attention to the description on the carton, we found it was produced on Tasmania Island which is located *at latitude 40 to 50 degrees south separating the Indian and the Pacific Oceans and is the southernmost area of Australia. This description* cleared everything up. Tasmania is said to have the cleanest air in the world, so rainwater there must be the purest.

When we examined rainwater in Sumida City, we found that it was

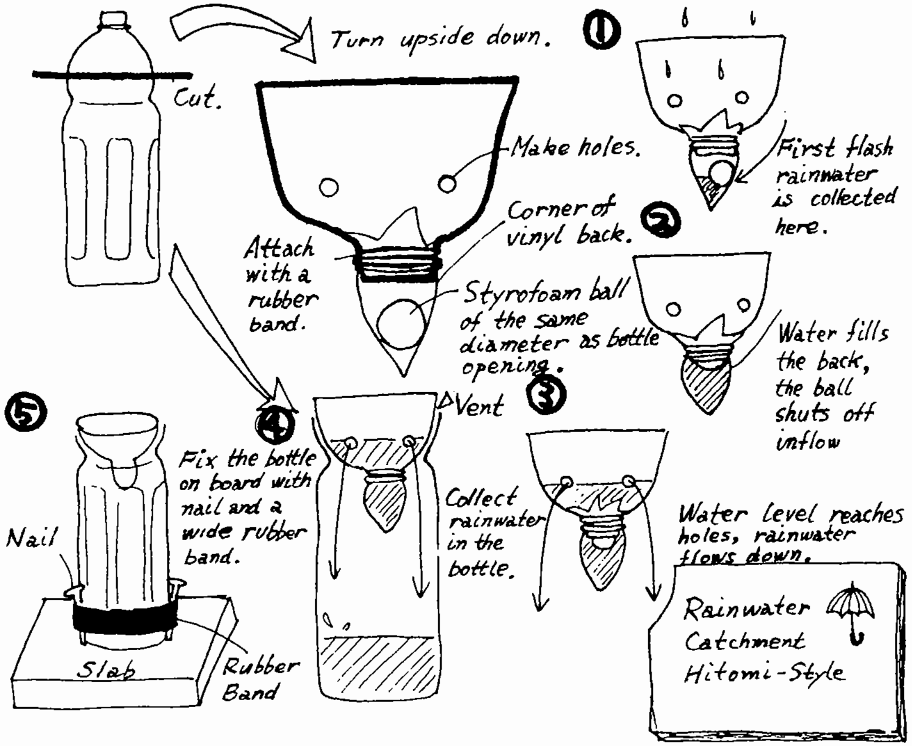
Eliminate Worries by Regular Checks



not pure, but it is clean enough to be used as non-drinking water and there is no need to worry about damaging any plumping facilities. Rainwater that falls at the beginning of a storm is called "first flash rainwater" and is the dirtiest. However, through the sedimentation process, its quality can approximate that of city water. If boiled, it becomes drinkable. However, black particles consiting of soot from cars and factories, soil and sand accumulate in the sedimentation tank over a year's time. The results of water examination vary due to the length of storage, climate and location. Acid rain also worries us.

In conclusion, regular attention must be paid to the quality of rainwater. With small devices (a thermometer, a pH test paper, an instant test kit, a transparency meter, and transparent vinyl bags), we can check water quality by ourselves. A thorough examination can also be conducted by public health centers for a fee.

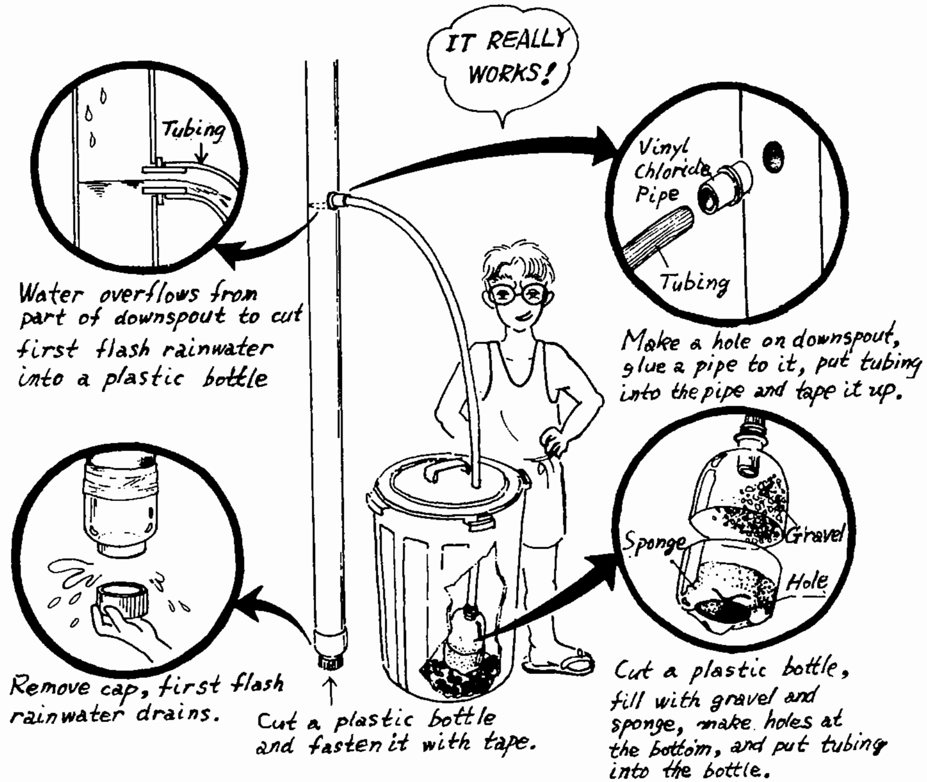
How to Avoid Collecting First Flash Rainwater



Tatsuo Hitomi, a member of our group, created a device with which we can easily collect rainwater to examine the state of acid rain by reusing an empty plastic bottle. The main materials are a 1.5ℓ plastic bottle, a styrofoam ball (slightly larger than the diameter of the bottle mouth), a small thin vinyl bag, a rubber band and some pebbles. First flash rainwater can be collected merely by hanging this device outside. Water quality can be examined with a pH test paper and an instant test kit.

Rainwater with pH5.8~8.6 (the lower the number, the more acid) is satisfactory; but in some areas in Tokyo, pH4 can be found. This is mainly the case for first flash rainwater; and over time, the air becomes cleaner and the pH value eventually settles down to the standard range. Therefore, we must cut first flash rainwater to be able to use rainwater. The less the storage time, the more the necessity for it grows. Members of

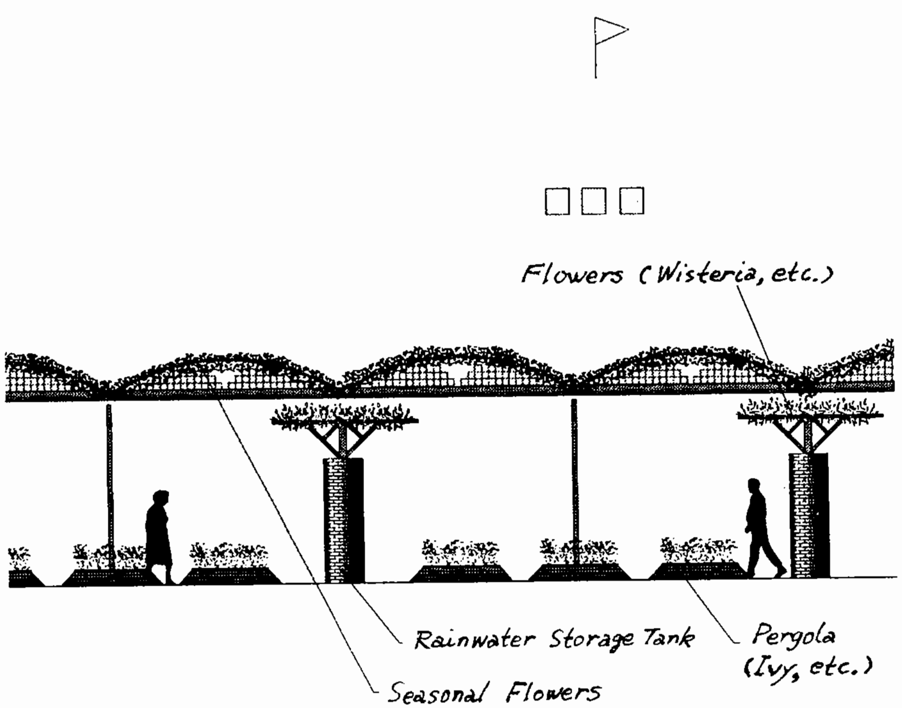
Homemade Device to Cut First Flash Rainwater



our group are making several devices for this purpose, all of which are based on one concept: when the attached sub-storage tank becomes full with first flash rainwater, the overflowed rainwater goes into the main storage tank.

In Masaki Matsumoto's idea, the bottom part of a downspout is used as the first flash water cutting tank. An intake is set at about 1.2m above the bottom; and when first flash rainwater reaches the intake, the less dirty rainwater begins to pour into the main storage tank through a vinyl tube. At the end of the vinyl tube, a simple filter is applied so the rainwater will be purified.

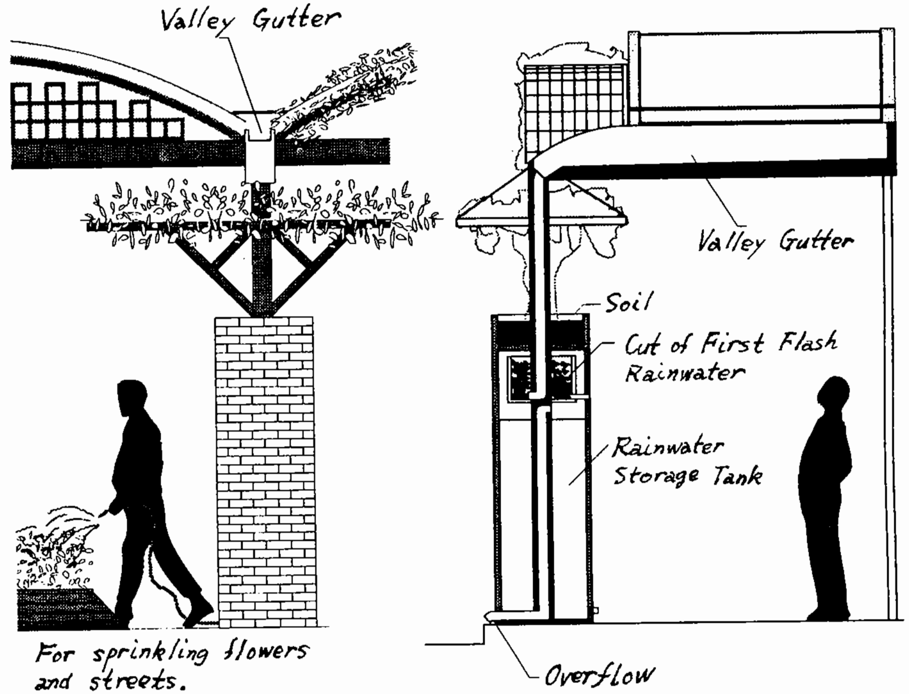
Refreshing Shopping Malls by Rainwater



The Sumida Oasis Concept, proposed by the members of our group in 1989, called for rainwater utilization to be implemented in every community. A shopping mall at Ishihara 3-chome, Sumida City, is trying to use rainwater from arcades. It is a shopping mall with a "Eco-*Sento* (public bath)" and is one place where the concept is likely to be realized.

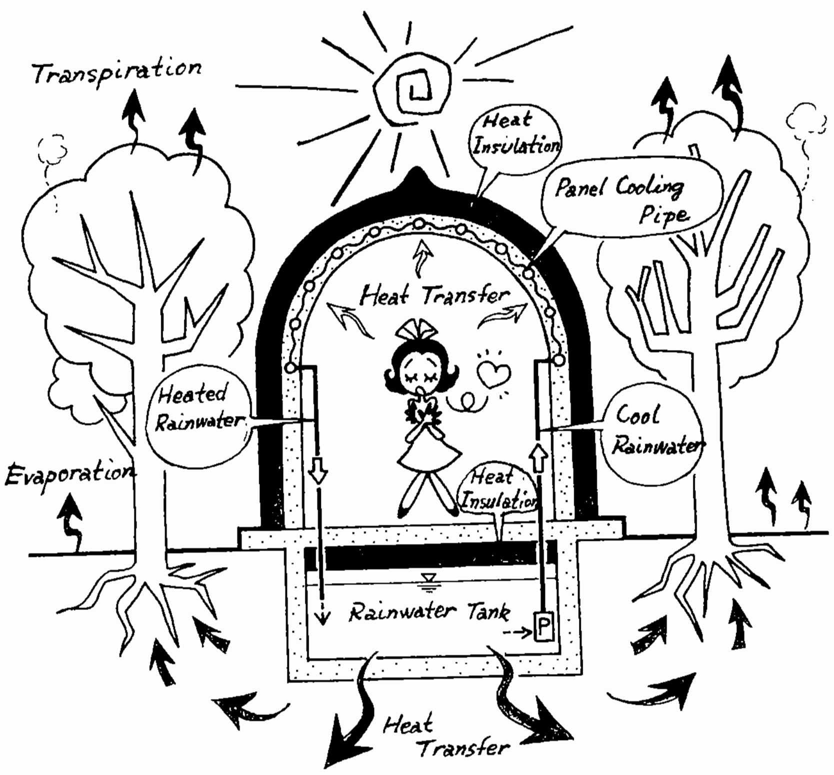
From the middle of the 1950s, arcade construction flourished throughout Japan. There was no concept of rainwater utilization at that time. We were overly concerned about ways of shutting out rain and sunlight that troubled shopping malls. Rainwater went directly into sewers. Even if trash blocked the gutters, neither cleaning nor repair was done. As time passed, gutters became damaged beyond use. If they had been left unrepaired, the image of the shopping center would have been damaged.

Shopping Mall Arcade Blessed by Rain



Many shopping malls removed the arcades; however, the Ishihara 3-chome shopping mall decided to turn its arcade into an "Arcade Blessed by Rain." It is a plan to use rainwater in the gutters and from the roofs of surrounding buildings constructively. Rainwater in excess of 700m^3 a year can be collected merely through the gutters. Transparent materials through which sunshine can penetrate are planned to be used to make the arcade bright. To remove the dirt out of the gutters and to soften the severe summer sunlight by means of cooling the eaves, automatic sprinklers are incorporated. Solar cells are installed to supply electricity to the sprinklers, illumination and other devices using rainwater. Plants are to be set on the eaves, walls and streets and to be watered by rainwater. For this purpose, this shopping mall has petitioned the Tokyo Metropolitan Government for a subsidy for arcade renovation.

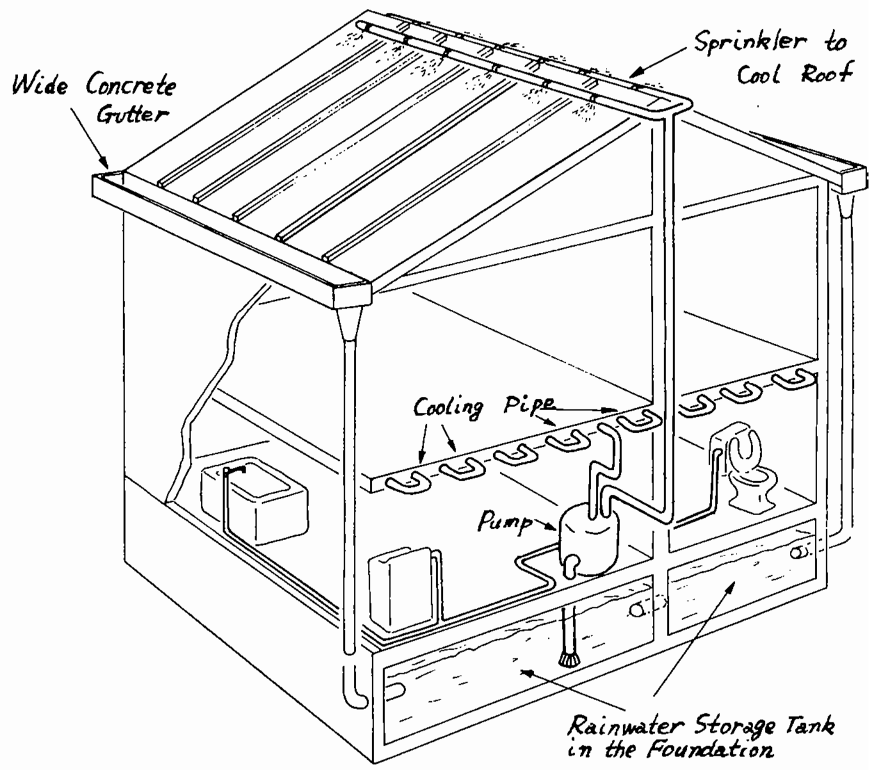
A Natural Air-Conditioner



Rain showers soften the reflection of sunlight, and generate factors to reduce heat and produce air currents. Water sprinkled on the ground has the same effect. In summer, in regions along the coast, cold winds convey comfort to people even inside houses while wind bells hung from the eaves ring. However, the wind suddenly stops blowing at a certain time in the evening, an "evening calm." We used to get through this uncomfortable hot evening calm by sprinkling water in the garden. A member of Group Raindrops and an architect, Kiyoshi Sato, survives this evening calm by pumping up stored rainwater and sprinkling it on the roof. He has long recommended a natural air conditioning system by radiation and air currents rather than the conventional air-conditioning system that forcibly circulates air.

Air-conditioning systems circulating air by mechanical convection often generate air that is either too cool or too hot. They consume too

Applying a Principle of Rain Showers



much energy and have adverse effects on the human body. When the temperature of the air is slightly lower than that of our bodies, even a small air current could decrease the body temperature. Thus, we feel cool. This is why we feel cool when we fan ourselves with our hands. As long as rooms are open and the buildings—walls and roofs—are not sweltering from strong sunlight, hot temperature can be avoided with a little wind. Kiyoshi Sato has installed rainwater pipes throughout the back of the ceiling of his house to circulate rainwater in summer and has also set a sprinkler on the roof. These systems cool the structure and, as a result, radiation and air currents cool the rooms. Rainwater is collected into a 40m³ underfloor tank in the foundation and is pumped up to the cooling pipes. The rainwater temperature in summer is cooler than that of the air, so this rainwater can cool the house without further processing.

Column: Country Report

Rainwater Catchment Louver—Botswana

New Alternative Devices

In summer 1993 some members of the technical study group for the Tokyo Conference visited Botswana and two other African countries to study local rainwater utilization techniques.

First, the members visited the Botswana Technology Center (BTC). Here they are developing and teaching different techniques necessary to help the rural communities: how to use equipment to distill waste water using solar energy, how to use devices to pump up groundwater using wind power, and rainwater utilization techniques.

The BTC building itself was built to demonstrate how to use rainwater. Rainwater is collected mainly from the roof of the main building and the parking lot surface. Screens and baffle walls are set to remove particles contained in rainwater. The most outstanding point is that rainwater is also collected from a louver. A wooden louver attached to the eaves was originally devised to control the sunlight from the window by opening and closing. In addition, it serves as a rainwater catchment when it closes during rain. There is a grapevine pergola outside the window that also helps cut out the radiant heat in summer.

Under the annex building is a rainwater storage tank that helps cool the building's floor. The stored rainwater is used for flushing toilets and it is also pumped up with a hand pump to water plants.

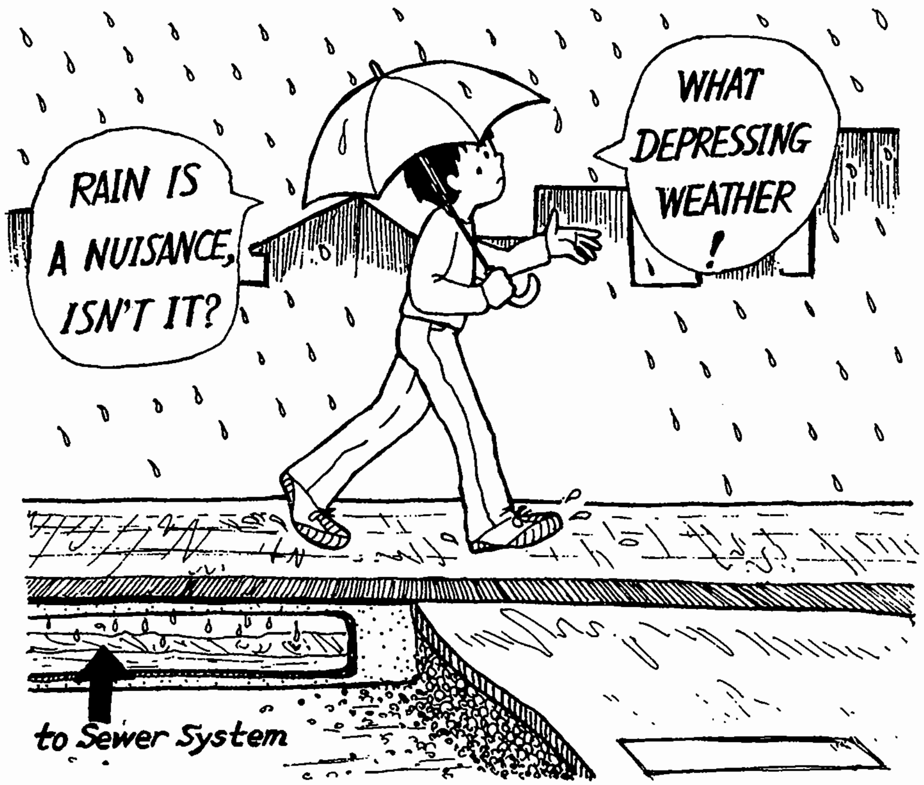
In Botswana, the members met Gosta Ingvar Nilsson, a Swedish plant pathologist running a farming company named SANIT AS. He has been developing various interesting devices to use rainwater for growing plants. The most impressive one is a concrete block wall serving as both a rainwater utilization system and a multi-tiered planter. Concrete blocks are placed crossing alternately to build a wall. Nilsson fills the hollows of the concrete blocks sticking outside with soil, and grows vegetables and flowers there. Rainwater is stored in the hollows of the other blocks. The rainwater is pumped up with a solar cell-driven pump and is poured onto the top of the wall. The water flows down through each block, watering plants. The water passing through the wall is stored and used again. Nilsson is confident in saying that people can restore green flora and vegetation in the desert land of Botswana which suffers from scarce rainfall and long droughts. His ideas can be applied in Tokyo, too.

CHAPTER

2 BACKGROUND OF RAINWATER UTILIZATION

SELF-SUPPORT · CIRCULATION · HARMONY

Large Cities Selfishly Continue to Depend on Huge Dams

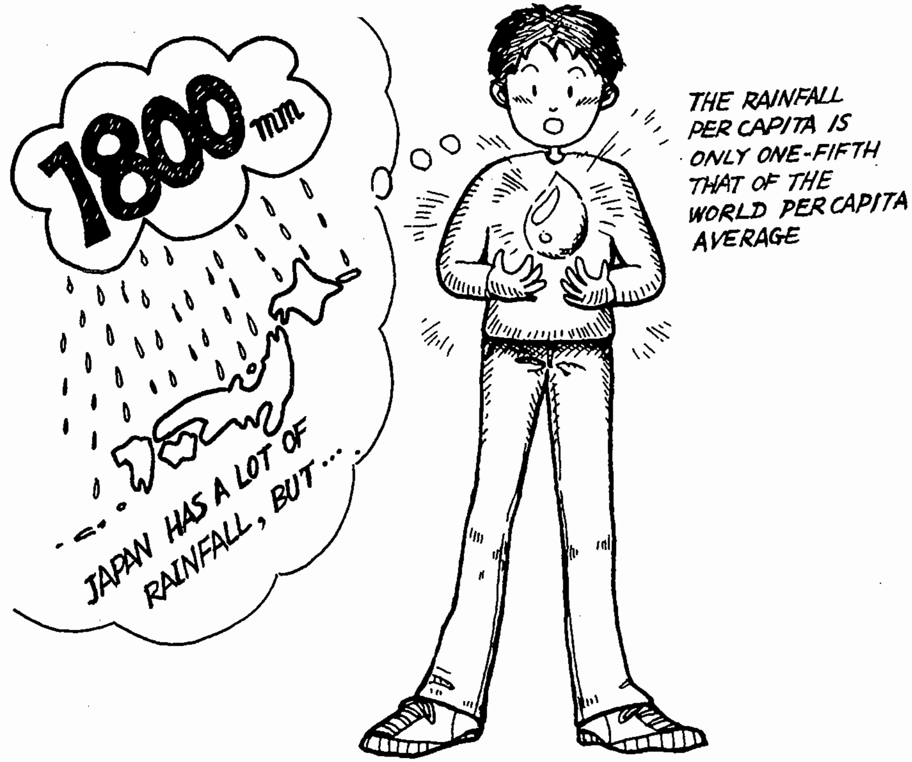


Many Japanese people understand rainwater utilization is important to countries of little rain, but do not understand why *they* should be concerned about its generally abundant rainfall every year.

The average yearly precipitation in Japan is about 1,800㎜, nearly twice that of the world average. However, the amount of the average water vapor in the upper air is about 22㎜ per year. This means that the water vapor in the air is changed about 81 times a year and replenished every 4 to 5 days. This matches the frequency with which low pressure systems pass over the Japanese archipelago.

In Japan 120,000,000 people live in a very small area. Japan's yearly water resource per capita is about 6,000m^3, which represents only 20% of the world per capita average. In Tokyo 12,000,000 people live in a 1,778km^2 area, so the Tokyo's yearly water resource per capita is about 207m^3 representing only a mere 0.6% of the world per capita average.

Wasting 1,500mm of Rainwater a Year



Therefore, rainwater in Tokyo is a very important resource. However, instead of cherishing it, we continue to dump it into sewers. At the same time, without serious consideration, we think we can always construct huge dams farther upstream if more water is needed. In short, we have lapsed into selfish thinking: "It is really a lot of trouble when it rains in Tokyo; we want it to rain a lot in water supply reservoir areas instead of in the city."

Thus, what should be done from now on is to regard the value of rainwater that continues to be dumped into sewers as a potential water resource, to construct a large number of "mini dams" (rainwater tanks) in urban areas through a grassroots effort, and to try to plan for an independent water supply. These are our primary objectives of rainwater utilization.

Water Resource Development at the Expense of Villages

Four hundred years ago Kanda Josui, a channel of spring water 20km from the center of Edo City (Tokyo) was constructed to provide water supply. About 340 years ago, water was drawn from the Tama River 40km away. Water supply presently depends on huge dams in the mountains 190km from the center of Tokyo. Primarily scarce water resources have hampered the growth of cities, but Tokyo has survived this difficulty by finding one remote water resource after another.

However, the construction of huge dams has caused the plundering of trees upstream in the mountains and ruined vast tracts of farmland resulting in eradicating centuries-old village culture. Even though the residents of those villages were financially compensated for relocation, the destruction of the precious culture can not be replaced. One perspective is that residents of Tokyo have forced people in those upstream areas to make enormous sacrifices.

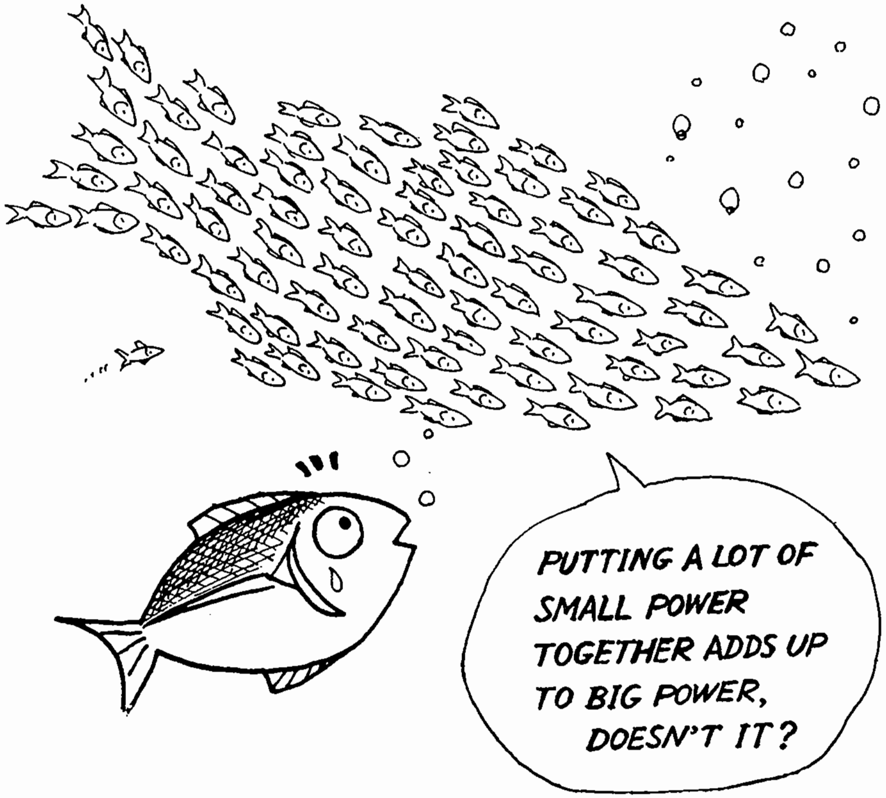
As a result of the construction of many dams in the upper part of

Huge Dam Construction Impossible due to Scarcity of Suitable Sites

the Tone River, the number of potential new dam construction sites has greatly decreased. Even already-planned dam construction has been delayed due to opposition from residents. The amount of water stored by dams has been decreasing due to accumulating earth and sand.

To address such problems, Tokyo Governor at the time Shunichi Suzuki together with Eishiro Saito, the then chairman of the Federation of Economic Organizations, called for the "Plan for Dividing of the Shinano River" in 1987 aiming at constructing a super huge dam with a water storage capacity of 1,000,000,000m^3 by building a tunnel through the Mikuni Mountains to draw water from the Shinano River. The governor of Niigata Prefecture, Takeo Kimi, strongly opposed this idea insisting "Drawing water from the Shinano River is an 'easy' solution without making any effort to secure your own water resources just because the Tone River seems to be unsuccessful." It is wrong to rely so heavily on water resources of other prefectures.

City-Built "Mini Dams"

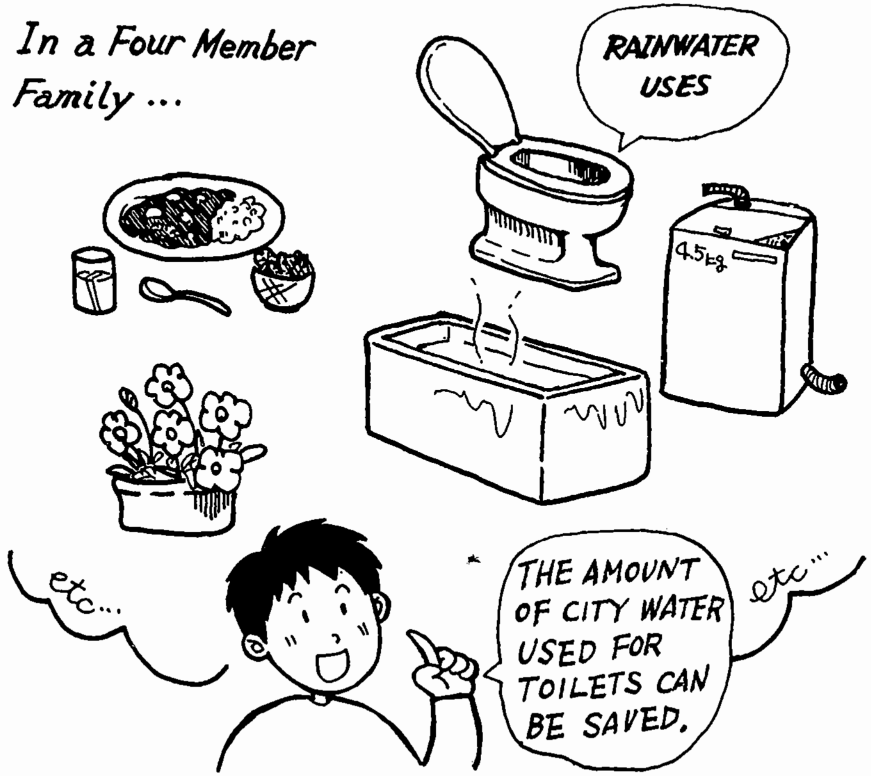


Even the news of long dry spells and naked bottoms of dried-up reservoirs do not surprise people in Tokyo anymore. However, of course, usually dams are located far from their homes and they can not even go to see them even though they want to do so. Awareness and knowledge of dams might be developed more easily if water resources were close to where people lived and if they were aware of using them every day.

Making our own water resources begins from our efforts to store rainwater. If all the households in Tokyo collected rainwater, the total volume of water storage would be staggering. The number of houses in Tokyo is about 1,500,000 and the average roof size is about 60m². Based on the yearly precipitation of 1,500mm, the yearly potential water storage is:

$$60m^2 \times 1.5m\ (1{,}500mm) \times 1{,}500{,}000\ houses = 135{,}000{,}000m^3$$

Rainwater Tanks Can Supply 29% of Water Needs

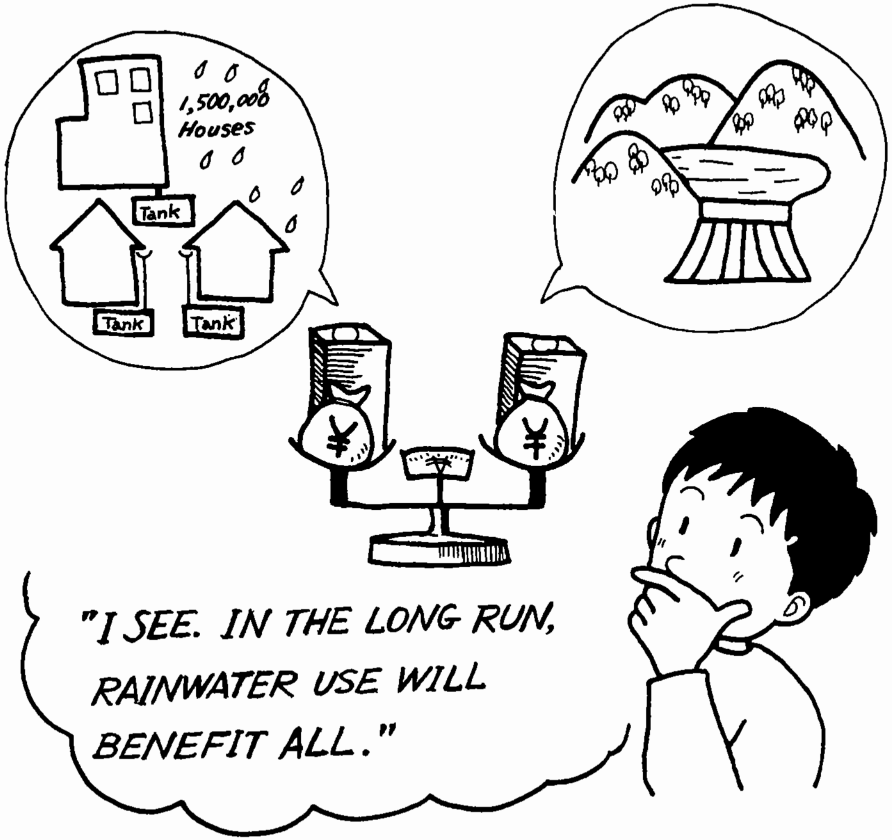


It is worthy to note that this number surpasses the yearly water supply of 126,000,000m³ to Tokyo by the Yagisawa Dam in Gumma Prefecture. In short, a multitude of "mini dams" equals one huge dam. How much of the daily water supply can be covered by rainwater if each household installs devices for rainwater collection? The average number of family members of a stand-alone house is 4 and usually uses about 790ℓ of water per day. Therefore, the percentage of the rainwater that can cover the daily water supply considering the loss of rainwater collection is:

$$(60m^2 \times 1.4m) \div (800\ \ell \times 365days) \times 100 = 29\%$$

The amount of water used for toilets is about 22% of the total water consumption of one family, so this amount can be furnished completely by rainwater alone.

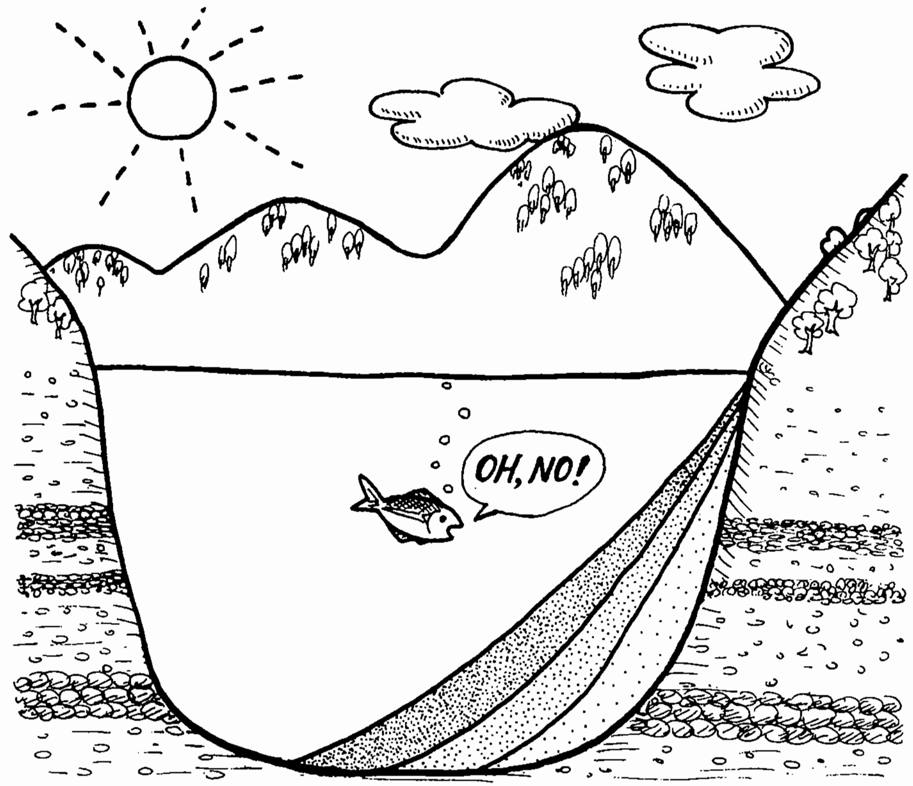
"Mini Dams" are Economical



The Naramata Dam opened in 1990 with a water storage capacity of 85,000,000m^3 in the upper part of the Tone River. It took 17 years and cost 135,200,000,000 yen (1,352,000,000 dollars) to construct. This did not include compensation for residents' housing because there were neither farm houses nor farmland. It was very expensive but it was only 10 to 20% of the total cost of constructing a dam and of supplying water to Tokyo houses. In thinking about the cost of city water supply, we tend to think only about the cost of dam construction. However, numerous other costs are involved: water supply to purification plants from rivers, water purification, water supply to households from purification plants, and other costs. Accordingly, the entire cost should be considered as 5 to 10 times the cost of dam construction.

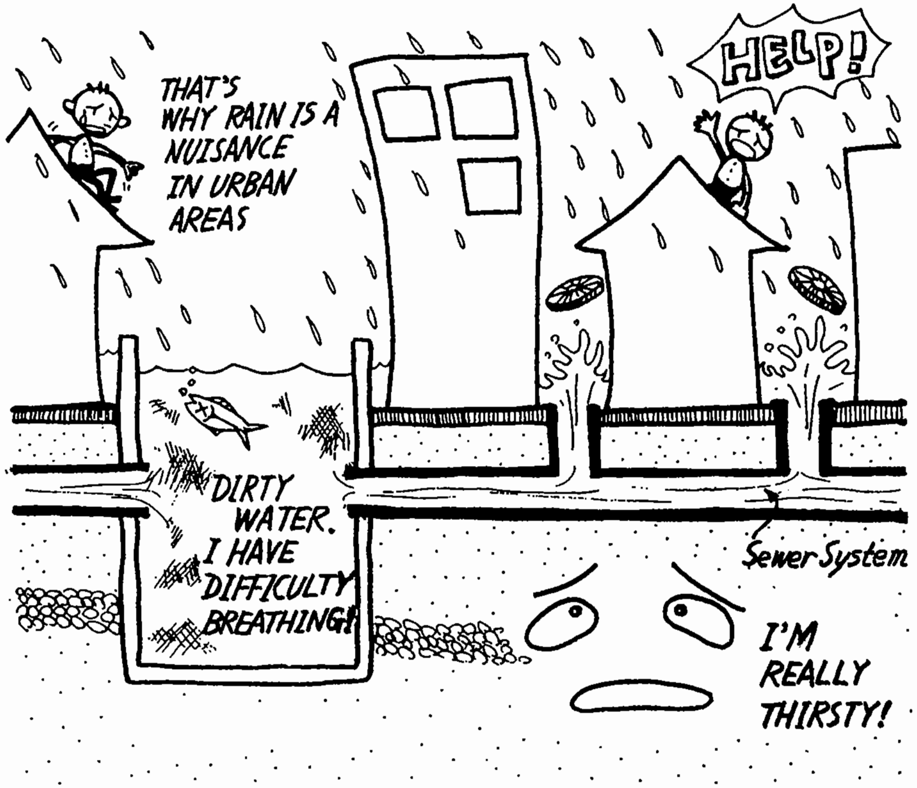
Furthermore, due to the decreasing number of suitable dam sites, the entire cost for dam construction is expected to increase even more in the future. Also, there are cases where dams become filled up by earth and sand. The Yagisawa Dam, proud of having the largest water storage of 175,800,000m^3 in the Tone basin, is said to have accumulated 23,000,000m^3 of sand over the 15 years since its construction. A major concern is that its water storage capacity will be cut to half in 50 years.

Only 500,000 Yen ($5,000) is Needed per Household



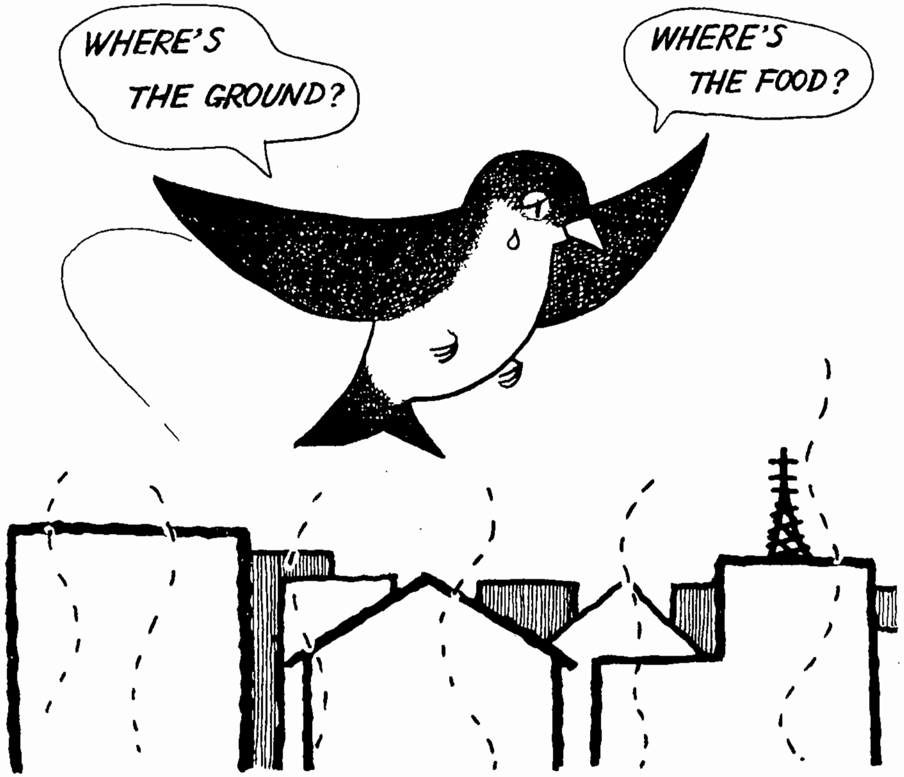
On the other hand, "mini dams" (facilities using rainwater) can be set up in a short time and there is no fear of capacity decreasing due to the sand accumulation. Neither additional cost for water supply nor energy cost is required. Maintenance is very easy. Currently, the installation cost of rainwater utilization equipment of a 10m^3 tank per house is about 500,000 yen (5,000 dollars). If such equipment is installed in 1,500,000 houses, the total volume of water storage becomes 15,000,000m^3 and installation cost is 750,000,000,000 yen. Costwise, a multitude of "mini dams" is comparable to a huge dam.

Are We at Fault for the Constant Dumping of Rainwater?



The Tokyo Metropolitan Government has been fixing sewers to alleviate floods in the city. Even though the diffusion of sewers has reached almost 100%, sewage backs up and "urban floods" occur when small- and medium-sized rivers overflow in heavy rain. Streets in urban areas have been covered by more and more asphalt and concrete, so rainwater can not infiltrate into the ground. Consequently, a huge volume of rainwater pours into the sewers all at once resulting in frequent urban floods. Even if such urban floods do not occur, raw sewage would pour into rivers and the sea from thousands of drains and a few dozen sewage pumping stations when rainfall exceeds 15㎜. Sewers in Tokyo are called "combined-type" which drains all the sewage—rainwater from roofs and roads, sewage from kitchen sinks and toilets, and wastewater from factories—through one main sewer pipe. Thus, if this "combined" sewage pours into rivers and the sea, serious environmental pollution will occur.

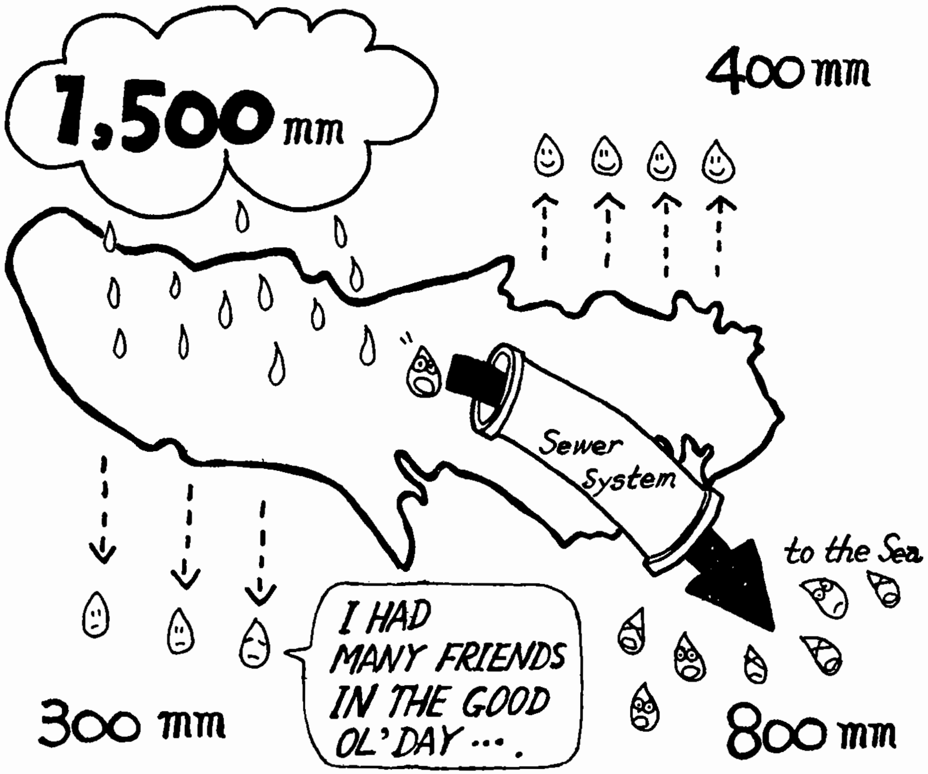
Urban Floods, Pollution of Rivers and Seas, and Sultry Summer Nights



This asphalt/concrete syndrome badly affects human health and the ecosystem. In Tokyo summers, air-conditioners have become indispensable and their excess use has caused problems in the normal sweating process. The number of children who can not control their body temperature is purported to have increased. Although the number of days hit by a heat wave has increased only slightly during the past 100 years, the number of sultry summer nights has continued to increase over the last 60 years. Thermal conductivity of asphalt/concrete is high, and the heat seeps deeper during scorching midsummer daytime. This stored heat radiates from asphalt/concrete at night.

Another problem is that asphalt/concrete pavement has hampered the infiltration of rainwater, so groundwater could not be recharged and has been exhausted. Consequently, the ground surface has dried up. Swallows can not return to the center of Tokyo because soil for their nests and bugs for their sustenance have disappeared.

Land in Urban Areas Drying Up

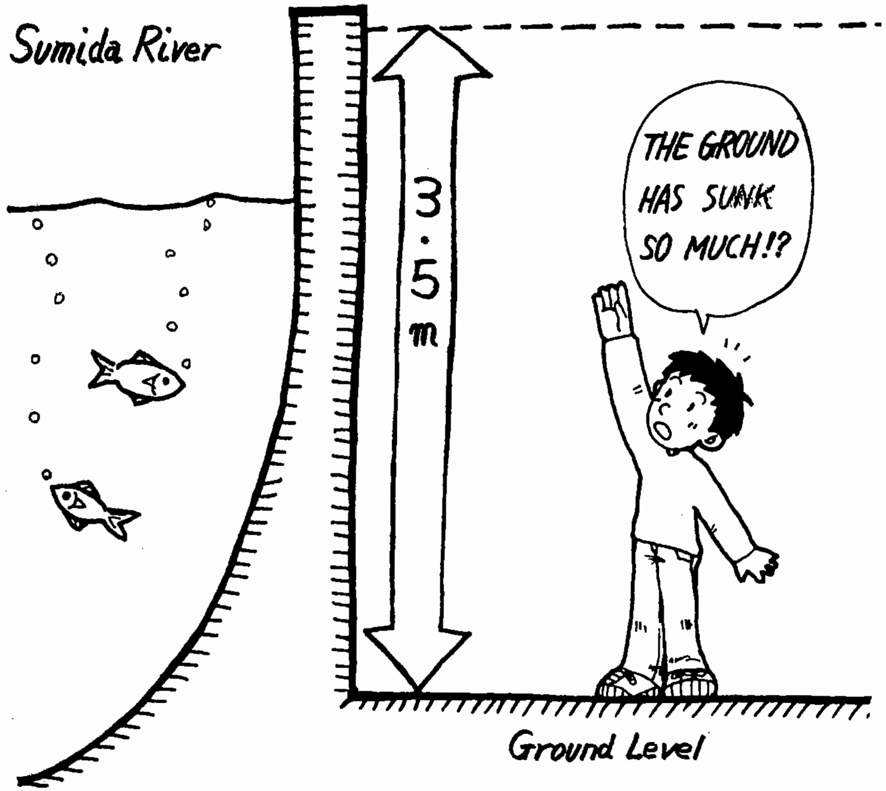


Forty some years ago, people considered that out of 1,500mm/year of rainfall in Tokyo, about 400mm evaporated, 500mm went into rivers and the sea, and 600mm infiltrated into the ground. Rainwater that infiltrated became groundwater, 300mm of which became spring water gushing out from various parts of Tokyo.

The Tokyo area is mostly occupied by the vast Musashino Plateau spreading from the Ome area 180m above sea level down to the east and northeast. When water circulation was actively functioning in the Musashino Plateau, there was a multitude of wells in Tokyo and people enjoyed delicious spring water. Rainwater infiltrated into the ground and flowed to Tokyo Bay. Part of it gushed out as springs in the areas around 50m above sea level a little to the east and in the easternmost part of the plateau.

However, in the 1950s and the 1960s, factories and buildings

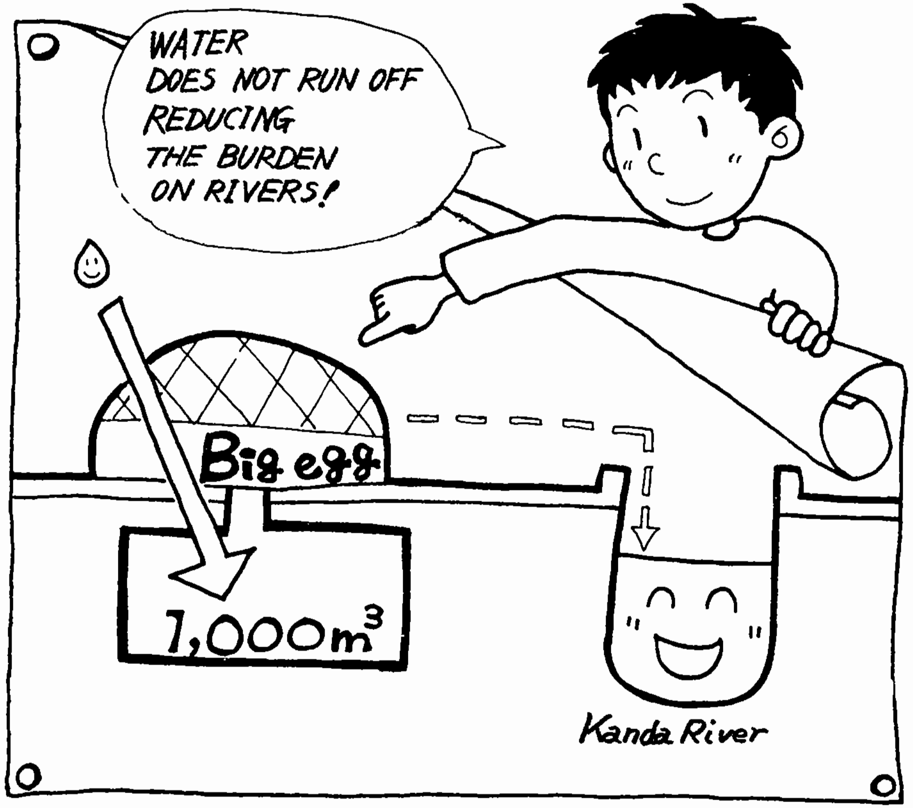
Ironical Contrast between Droughts and Floods



pumped up groundwater from deep wells excessively disregarding Nature's water circulation. Consequently, shallow wells dried up resulting in subsidence. Subsidence cases in downtown Tokyo were especially serious: part of Sumida City sank 3.5m at the deepest. Most of the city became lower than the level of rivers, called "zero-meter zone." Since this disaster, the Tokyo Metropolitan Government has been implementing regulations to control the pumping up of groundwater.

However, springs in Tokyo have not been fully revived yet because rainwater can not infiltrate into the ground easily. At present, the amount of rainwater that infiltrates into the ground is reportedly 300mm /year at best, about half that in the past. As a result, the amount of water in springs has lessened to a mere 30 to 100mm/year. On the other hand, the amount of yearly rainwater flowing into rivers and the sea has become 800mm, 300mm above the level in the past.

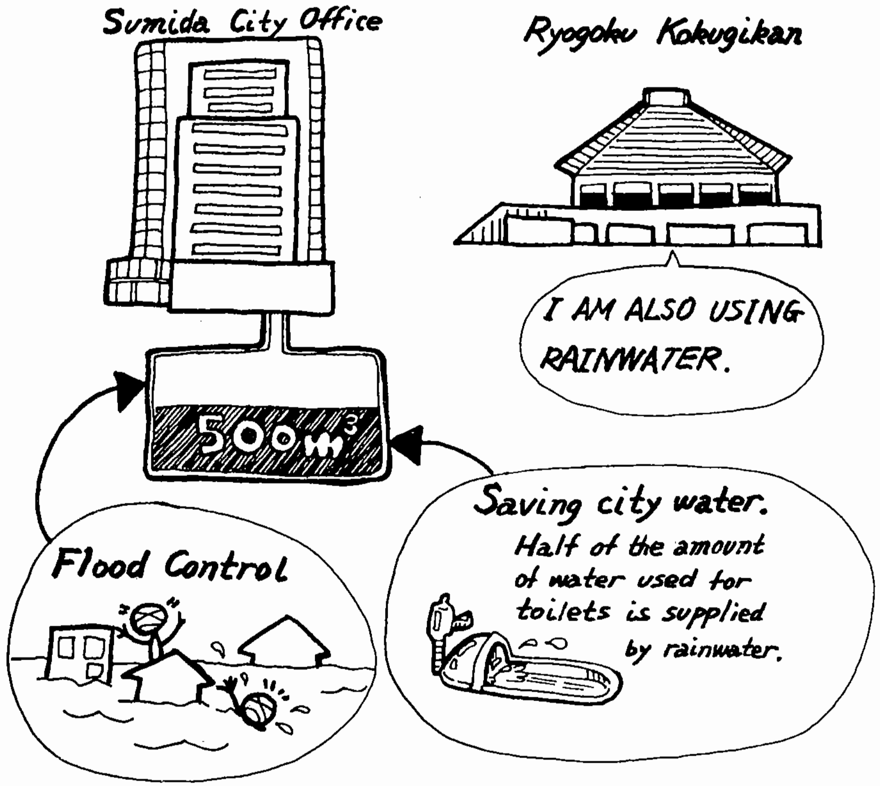
Temporary Rainwater Storage — Drainage is not the Only Solution



Conventional measures to contain urban floods were based on one idea: "If rainwater can not be sufficiently removed by the use of sewers and rivers, then rivers should be deepened and widened or huge underground tanks or large-scale retarding basins should be built for temporary storage of rainwater. Only after the water of rivers decreases from their maximum levels can stored rainwater flow into them." However, storing rainwater in the area where rain has fallen might be more rational. Also, large underground structures cut groundwater veins and deplete groundwater as subways and sewers do.

Every year, the Tokyo Metropolitan Government has been spending hundreds of billions of yen in repairing rivers, constructing large underground rainwater storage tanks, and increasing the number of sewers and sewage pumping stations. However, urban floods are not likely to cease. Why not spend this money, then, in building rainwater storage tanks and infiltration plants instead of in such eco-unfriendly

Let's Collect, Store and Use Rainwater, and then Return It to Mother Nature

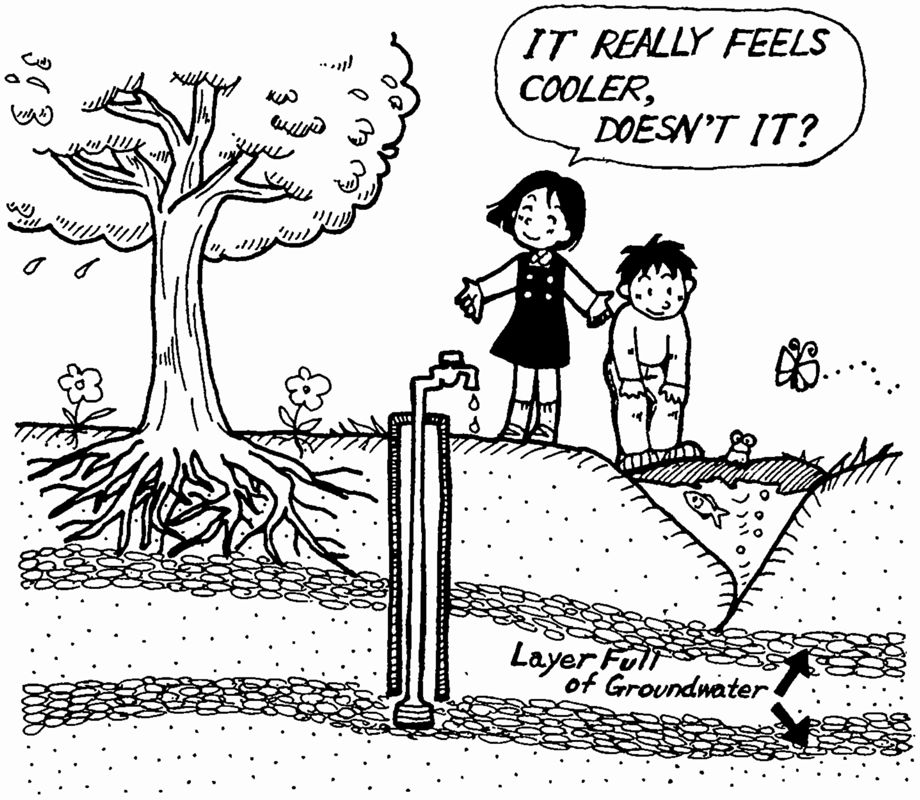


and outdated ways?

A rainwater tank of about 1,000m³ was installed at the Tokyo Dome with government help. The national government provided financial assistance because preventing all the rainwater from flowing into the Kanda River all at once in a rainfall proved more effective and more efficient.

The rainwater storage tank employed by the Sumida City Office was also a 1,000m³ type, but usually it stores only 500m³ at most. The other half of the space is saved to control floods. In short, this rainwater tank has two simultaneous functions: effective use of water resources and prevention of urban floods. In the past a survey conducted by the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan asking building owners the reasons of adopting rainwater utilization, and many respondents indicated the prevention of urban floods as the primary reason.

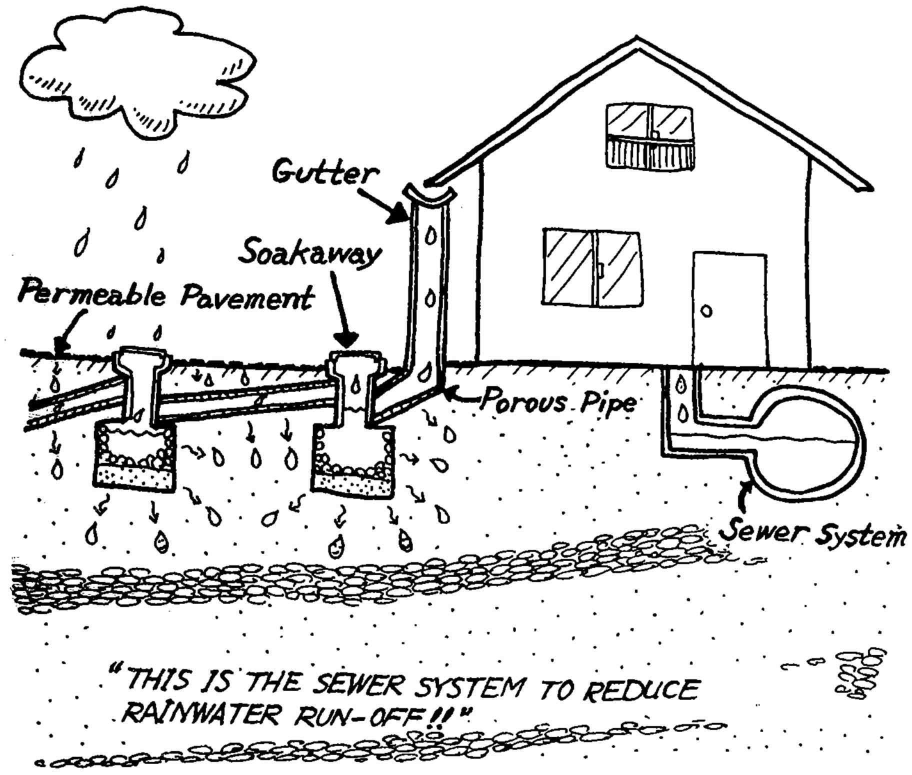
Environmental Improvement by Underground Infiltration



Eivironmental improvement can be achieved by using rainwater collected from roofs and infiltrating it back into the ground. Urban floods would be eliminated because rainwater would not be dumped into sewers all at once. At the same time, excess raw sewage would no longer to be dumped into rivers and the sea from drainage and sewage pumping stations resulting in the environmental protection of rivers and the sea.

The water level of many city rivers drops during dry spells and even slight rains cause muddy streams. However, if conscious efforts were made to infiltrate rainwater, groundwater would become abundant, springs would be revived and an adequate amount of river water could be maintained. A sustainable flow of water would enhance the self-purification function of rivers resulting in the revival of clean streams. The "heat island phenomenon" in urban areas could also be prevented. The air temperature above permeable pavement is 3°C lower than that

Permeable Pavement Lowers Temperature by 3°C

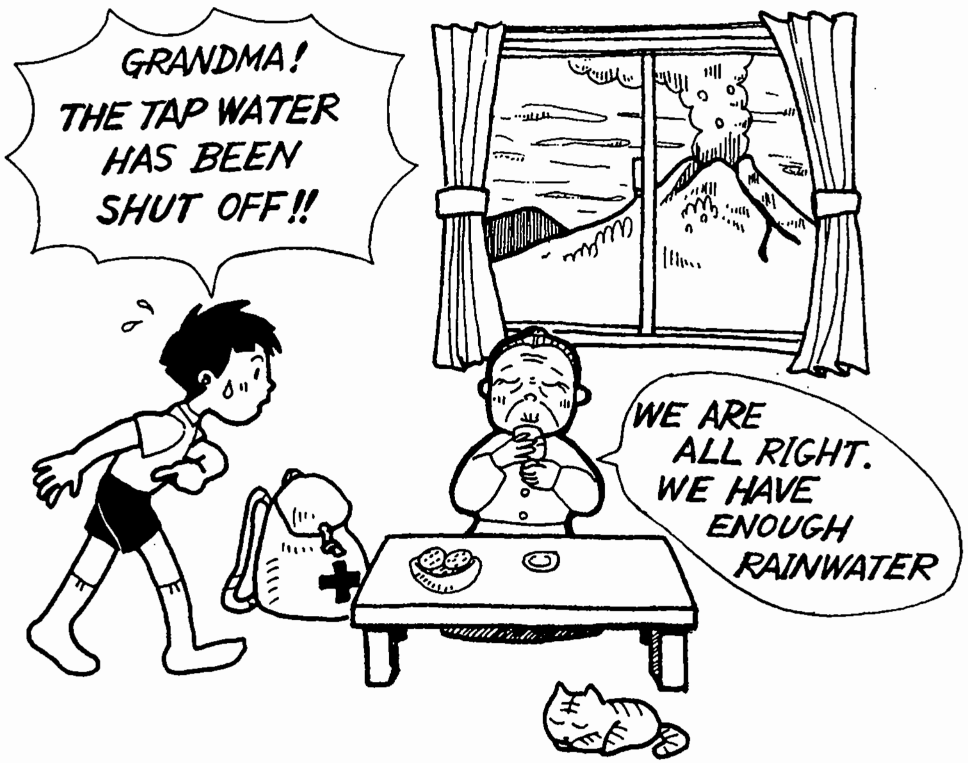


above conventional pavement.

Conventional sewers have been classified into two types: 1) those that combine all rainwater and sewage into one pipe, and 2) those that separate them into different pipes. However, rainwater has been dumped into sewers in both types. Recently, a new sewer design controlling rainwater run-off is drawing much attention. Through the use of this system, rainwater infiltrates into the ground and waste water goes into sewers. That is, as much rainwater as possible is soaked up by the ground, not dumped into sewers. This system has been widely adopted in Nerima City, Tokyo and other cities.

Akishima City, Tokyo depends completely on groundwater as its city water resource, but a housing complex in the city takes rainwater from the roofs and other surfaces, and infiltrates it into the ground. While preventing urban floods, rainwater infiltration plays an important role in helping to preserve our precious groundwater.

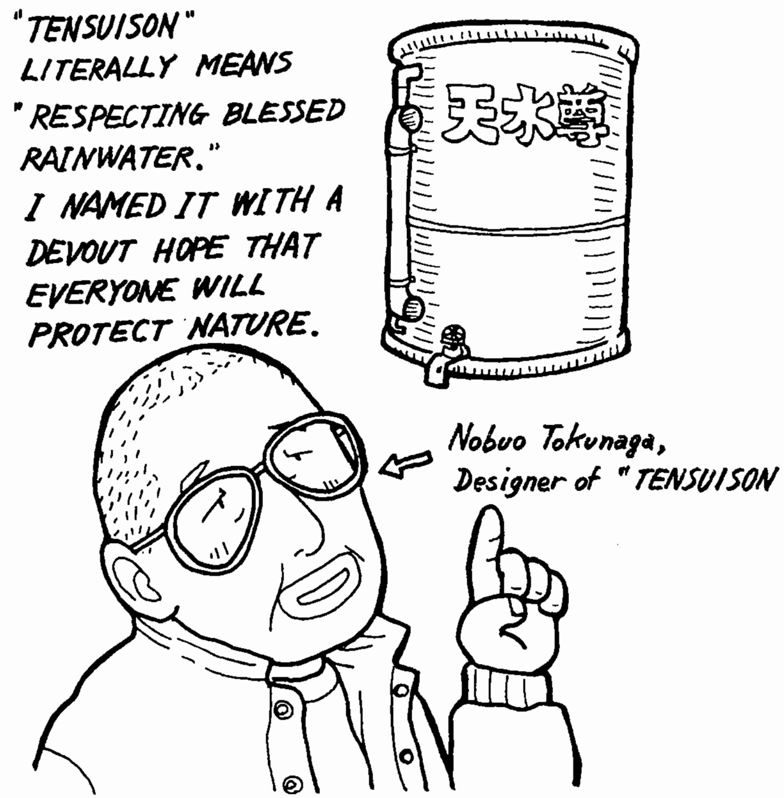
Water Collected in the Neighborhood can Prevent Panic



In November 1983, Mt. Oyama on Miyake Island erupted and many houses in the Ako district were buried in lava. The water system on the island was heavily damaged and the water supply was cut off for a month. If a great earthquake were to cause such damage to the Tokyo Metropolitan Area, confusion would erupt. But panic did not prevail on Miyake Island. Since city water had been of such low quality with much salt and minerals, the island residents themselves installed rainwater tanks and have used rainwater collected from roofs for drinking and cooking from days of old. When the water supply was cut off, FRP tanks were installed that were brought over from the mainland to be used for supplemental drinking water supply, and the tanks were reused as rainwater tanks after the water supply system was restored.

In 1923, 40,000 lives in Sumida City were claimed by the Great Kanto Earthquake and the water supply system was also damaged heavily. Although water was supplied from the Marunouchi area, it did

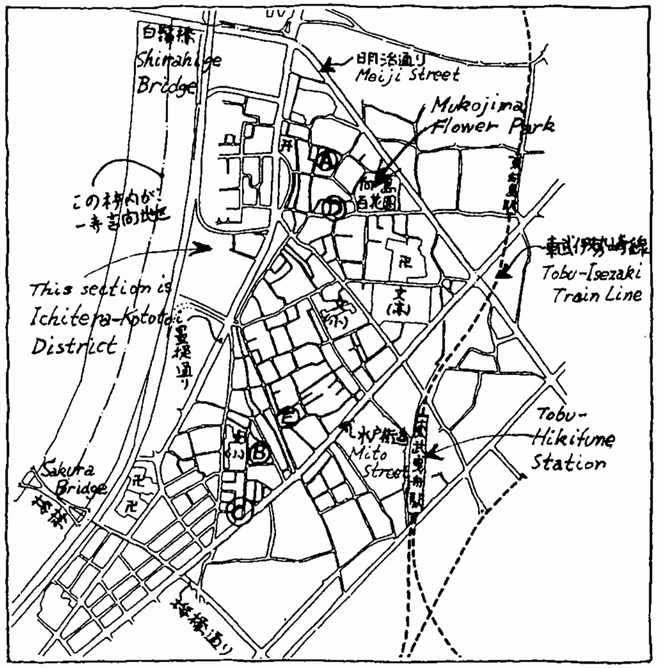
"Tensuison" — Part of the City's Emergency Planning



not work well. Instead, the city could manage to get through the crisis by restructuring the well in former Ryogoku Kokugikan. These examples indicate that the rainwater collected in the city can protect its residents in emergency. And, at the same time, storing rainwater in tanks at various locations can upgrade safety in the city.

Many years ago rainwater storage buckets were prevalent and were used for fire fighting. *Tensuison* (Chapter 1) designed by Nobuo Tokunaga originated from these rainwater storage buckets. The price of a *Tensuison* is less than 50,000 yen (500 dollars) and it can store 200 ℓ of rainwater. Now, nearly 100 *Tensuison* have been installed all over Tokyo and stored rainwater is being used for watering plants, and is also available for drinking water in emergency. A tank of water can provide enough drinking water for about two weeks for a family of four.

Community Spots for Disaster Prevention



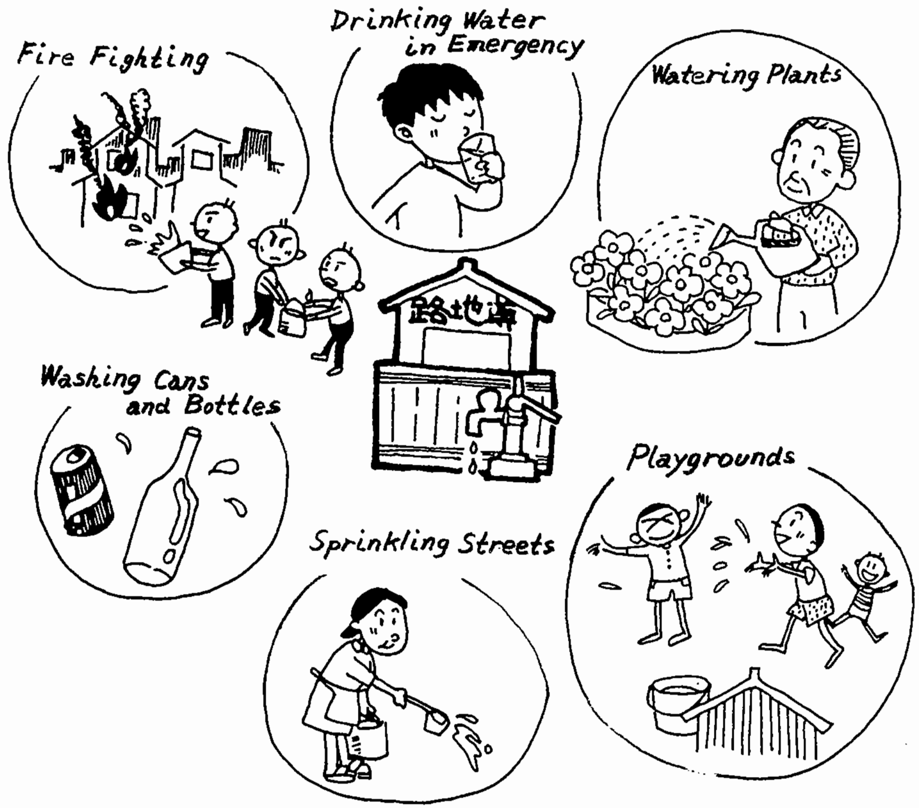
"ROJISON" in Sumida City
Ⓐ: No. 1, Ⓑ: No. 2, Ⓒ: No. 3, Ⓓ: No. 4, Ⓔ: No. 5

It has been thought that storing city water in underground tanks in parks was best for emergency. But the quality of the water in such tanks is not so good because it remains unused throughout the year. On the contrary, in case of *Tensuison*, water quality remains good because rainwater is once stored, then used, and then stored again.

Rojison is the kind of *Tensuison* commonly used in community. By June 1994, four *Rojison* were installed in the Ichitera-Kototoi district. *Rojison* was conceived by local residents. They check and maintain the *Rojison* voluntarily. Sumida City paid all construction costs.

Eco-*Roji* is a community space used for disaster prevention and collection of recyclable materials. Eco-*Roji* designs were patterned after alleys with common wells that once existed in Japan and are reminiscent of the life in the good old days. The most recent community space *Hatohotto* is a small park which includes a modern version of a rainwater utilization system. Additionally, there is a vegetable garden

"Rojison" Nurtures a Feeling of Shared Responsibility among Residents



called Mukojima *Yuki* Garden. The Garden has a *Rojison* which can store 9 m^3 of rainwater daily for organic vegetable growing. The *Rojison* has a device capable of providing enough water for fire fighting even during times of little rainfall. *Yuki* Garden was named by the very creative local residents. It is a pun on different meanings of *Yuki* in Japanese: "organic," "seasonal" and "brave."

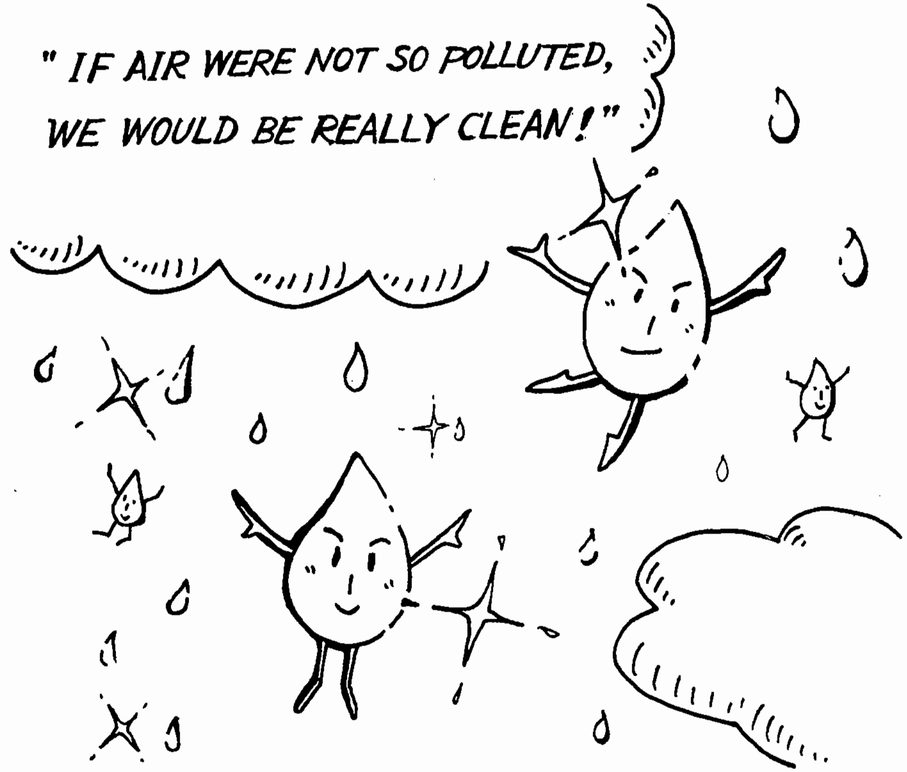
People once used to strengthen their friendships by gathering and talking at common wells on street corners, and now *Rojison* has become such a community space where people can reinforce their ties with one another. We can not manage to get over crises in emergency without strong ties among community people. *Rojison* in Sumida City plays an important role not only in securing water for emergency but also in nurturing a feeling of shared responsibility and cooperation for disaster prevention among city residents.

Dangerous Elements of "Grey Veil" in Tokyo

Looking around at the view of Tokyo from the top floor of the Tokyo Metropolitan Government Office building on a sunny day, you will find that Tokyo and its surroundings are heavily covered with dirty air. Looking down from the sky, you will see that Tokyo seems to be wearing a "grey veil." And this veil is one cause for making the city warmer in the same way as glass in a greenhouse. Dust particles discharged from cars and factories keep floating in the air, combining with particles of mist and clouds, and produce a grey veil.

As we store rainwater, we can see the elements that compose this grey veil. In a year after storing rainwater, you will find black particles that have settled and accumulated at the bottom of a tank. These black particles are considered to be the components of emission from diesel cars. In Tokyo, it is said that the number of people suffering from hay fever and lung cancer is increasing; and very recently, it was found that

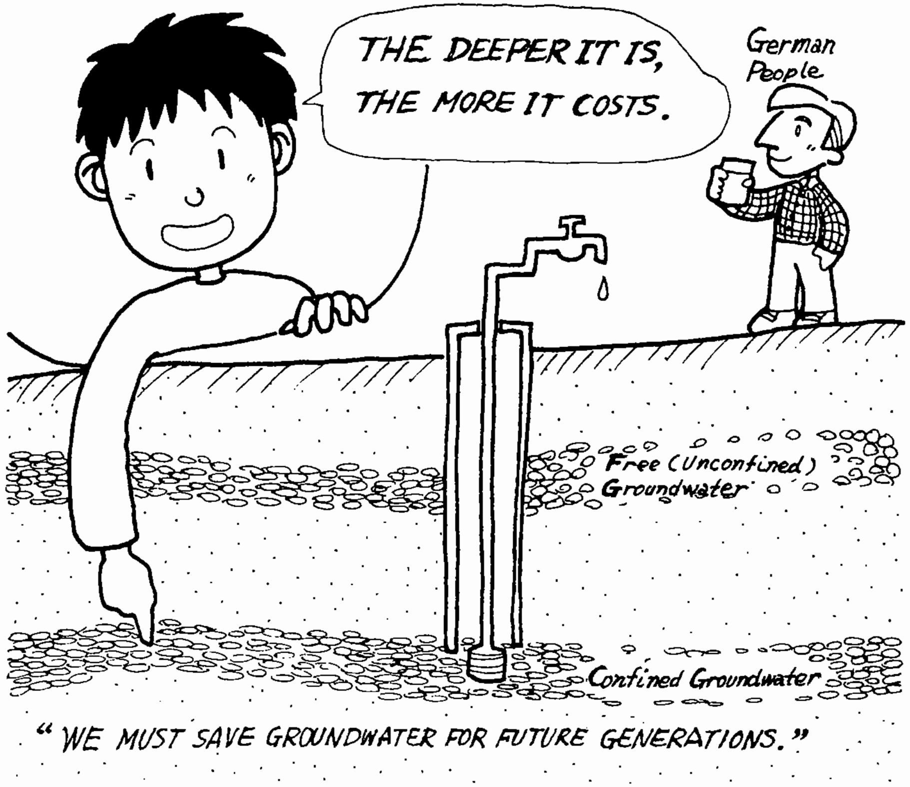
Rainwater Storage Reveals Tokyo's Dirty Air



pyrene hydrocarbons, one group of the elements of emission from diesel cars, trigger hay fever. Also in Tokyo, the death rate from lung cancer is skyrocketing and pyrene hydrocarbons are suspected as one cause of lung cancer.

Acid rain results from nitrogen dioxide in the the exhaust emission from autos, factories and buildings being mixed with rain. Since the atmosphere contains carbon dioxide, the stored rainwater is slightly acid, but acid rain is much more acid than normal rainwater. Fortunately, Tokyo has rain every 4 or 5 days and it sweeps the air up. But if Tokyo rarely had rain, and had a dry season like Thailand, air pollution in Tokyo would become more serious.

Rainwater Utilization for Groundwater Conservation



The purposes and background of rainwater utilization vary country to country. For instance, in Germany, rainwater utilization is promoted to conserve groundwater, a resource of city water. There are two kinds of groundwater. One is called "free (unconfined) groundwater" which is stored in the impermeable stratum up to nearly 30m below the ground surface. The other is called "confined groundwater" which is preserved in the lower impermeable stratum of 30 to 400m below the surface. Confined groundwater is pumped up for the city water supply in most cities; however, overpumping of confined groundwater makes free underground water dry up and causes subsidence.

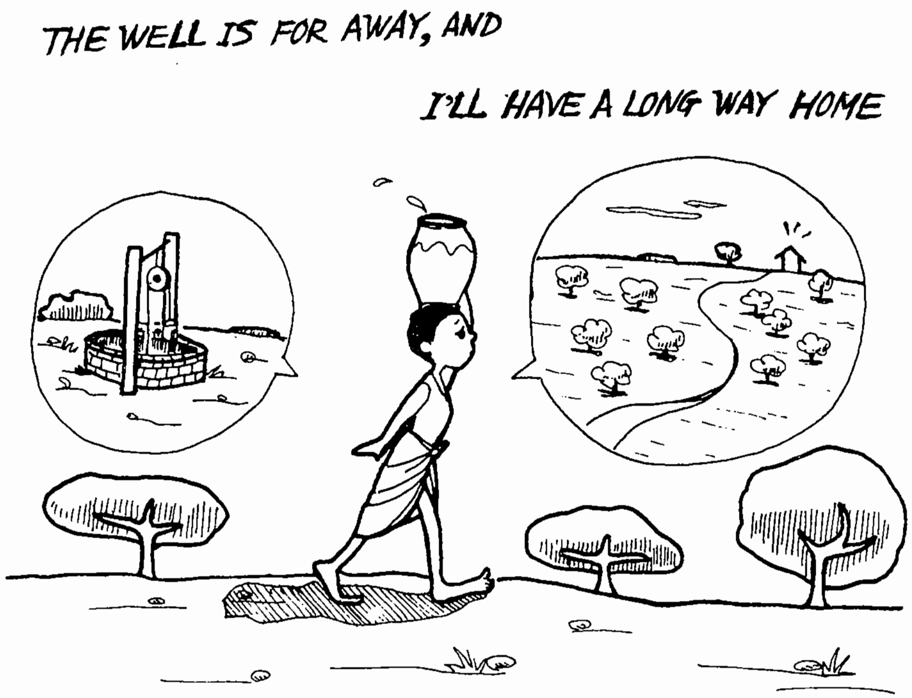
Confined groundwater is made when free groundwater has been preserved over several strata that are less permeable and its preservation process takes a long time. That is why confined groundwater is named "fossil water." In the same vein, we should think of effective ways of

German Cities Promote Rainwater Utilization

using confined groundwater so that future generations will also have their own water resource.

In many cities in Germany, confined groundwater is used as a resource for city water, and in Osnabrück and in Erlangen rainwater utilization functions to conserve confined groundwater because rainwater utilization results in reducing the amount of groundwater pumped up. Although Germany has half the rainfall of Japan, both the public and city governments are actively promoting rainwater use; and also, the city governments are financially supporting the development of rainwater utilization. The rainwater utilization system in Germany is basically the same as Japan's: rainwater collected from roofs is stored in an underground tank made of concrete with a capacity of $6m^3$ and used for flushing toilets, washing clothes and other purposes; overflow water from the tank is infiltrated into the ground to recharge groundwater.

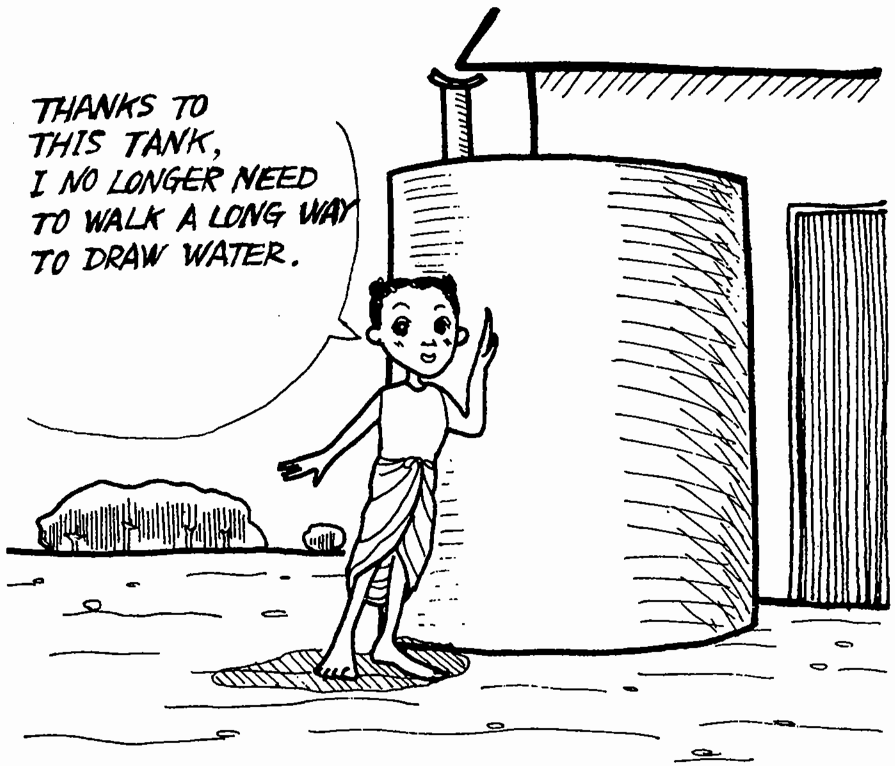
Trudging 5km for Water



The members of the technical study group of the Tokyo International Rainwater Utilization Conference visited Kenya to see local rainwater utilization. In Kenya, they saw a donkey pulling a cart with a drum full of 200ℓ of water without a driver. Since a family of 6 or 7 and their livestock consume 400ℓ of water a day, the donkeys have to go back and forth twice a day. For families that have neither donkeys nor carts, women and children have to carry water pots instead. It is less burdensome on their way with empty pots, but they have to walk for several hours with pots full of water when they return home. The distance totals about 5km, putting the water pots on their heads or on their backs. It is truly a time-consuming burden for women and children.

Foster Plan (Plan International), an international foster parents NGO, is supporting the installation of rainwater tanks to reduce their burden of drawing water in Kenya. A person in a developed country

Installation of Rainwater Tanks to Reduce Hard Work



who can afford to foster a child in a developing country becomes a financial supporter of a certain child. This financial assistance is used not only to raise the educational level and living standard of the foster child, but also to improve housing conditions or to establish other facilities in the area where the child lives. Rainwater tanks have been installed using part of foster parents' assistance. In Kenya's neighbor Tanzania the installation of rainwater tanks is actively promoted so that Tanzanians may be freed from the burden of drawing water.

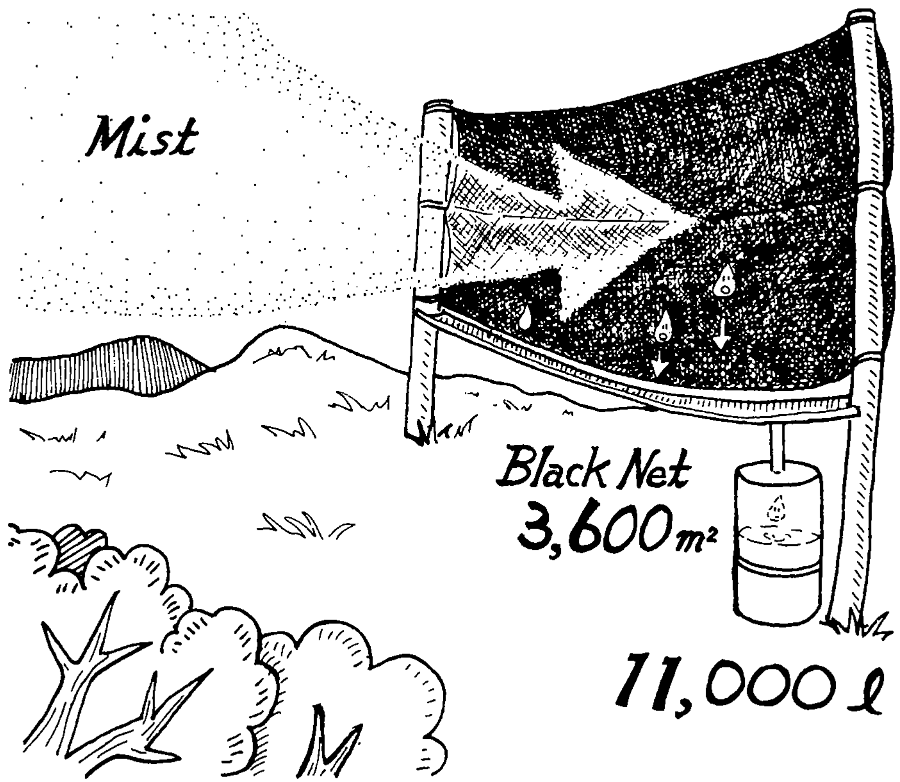
There are many children in the world who drink the water of dirty rivers and die from infectious disease. Rainwater collected from roofs is safe to drink. However, we find in some cases that people dip dirty containers and unwashed hands into the rainwater in tanks, so the stored rainwater becomes infected. Therefore, more thorough sanitary guidance is required.

Tin Roofs to Collect Rainwater.

A standard currency used in Botswana in Africa is "pula" meaning rain, and "thebe" meaning raindrops is used as a smaller denomination. This indicates that rain is a very important natural resource in Botswana. In fact, the annual precipitation in the southern part of Botswana is 250mm, only 17% of Tokyo's. In addition, rainfall is concentrated on just several days of the year and sometimes people experience a year of no rain. Actually, in the 1980s, rain did not fall for five consecutive years.

In Japan, we have to consider how to deal with overflowing water from rainwater storage tanks; but in Botswana, people have to collect as much rainwater as possible. Since rainwater collected from roofs can not fully satisfy the needs of people in Botswana, those living in agricultural areas used to collect rainwater from the ground surface, too. Rainwater from the solid ground is filtered by simple devices and stored in underground rainwater storage tanks.

Collecting Water from the Mist of the Andes



However, since the collected water remains dirty because of, for instance, excreta of livestock, corrugated tin roofs have been introduced to collect rainwater under the guidance of Botswana Technology Center (BTC), the country's technical research and development center for solar heat and rainwater utilization. It costs 3,600 pula (1,800 dollars) to install a rainwater tank and build a tin roof. This amount equals 50% of a family's annual income in this area. Because of the high cost, rainwater tanks are sometimes stolen.

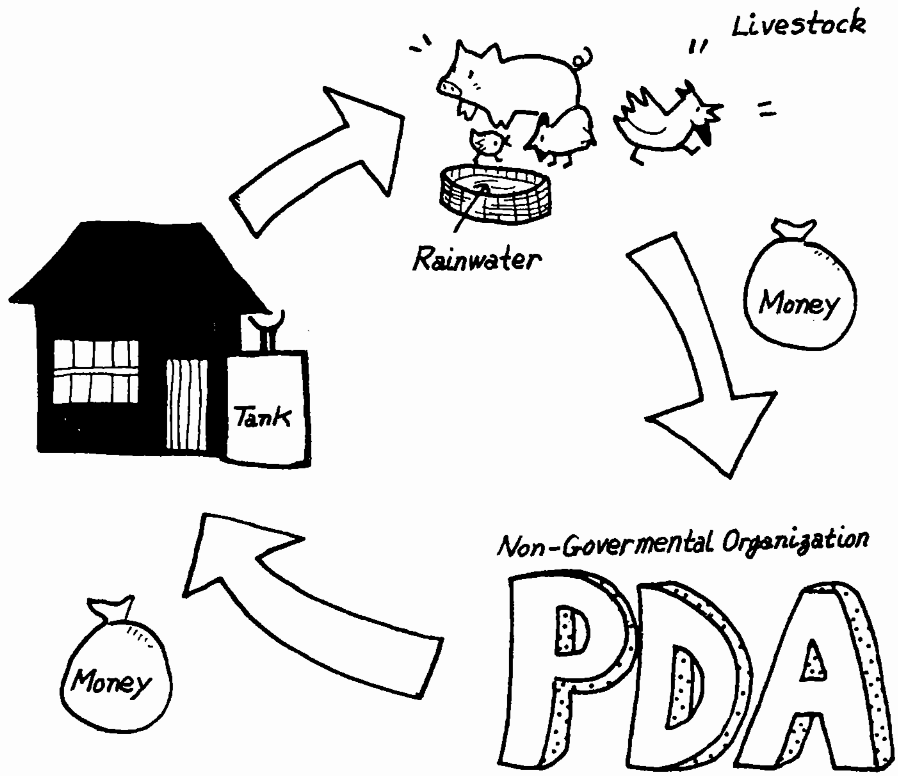
In the Andes in South America, rain rarely falls but mist often hovers over the ground. A 3,600m² black net is put up to collect mist and get water. At maximum, 11m³ of water can be collected per day through this method.

Getting through the Dry Season with Rainwater from the Rainy Season

There is no big river in the agricultural areas in the northeast of Thailand. Since the upheaval of the sea formed the land, groundwater is too salty to drink. As a result, rainwater use has long been developed in this area. Annual precipitation is about 1,300mm, but it seldom rains in the dry season from October to January. Therefore, rainwater is only collected in the rainy season. Rainwater tanks, of 11m³ 0.6m³ water jars and smaller water pots have been used to store rainwater.

Lately, a non-governmental organization, Population and Development Association (PDA) has enriched the area's development through the installation of rainwater tanks and, as a result, rainwater tanks have proliferated throughout the area. PDA loans money to a family that wants to install a rainwater tank; the family receiving financial assistance raises livestock using rainwater and repays with the income from livestock sales. PDA's activities have succeeded in installing

Rainwater Tanks Satisfy both Thirst and Budget



12,000,000 rainwater tanks and water jars up in this area. The installation of rainwater tanks has rapidly developed in this area because the people decided to install rainwater tanks on their own initiative and were not forced to do so by the national government. PDA's activities are financially supported by Germany and Australia.

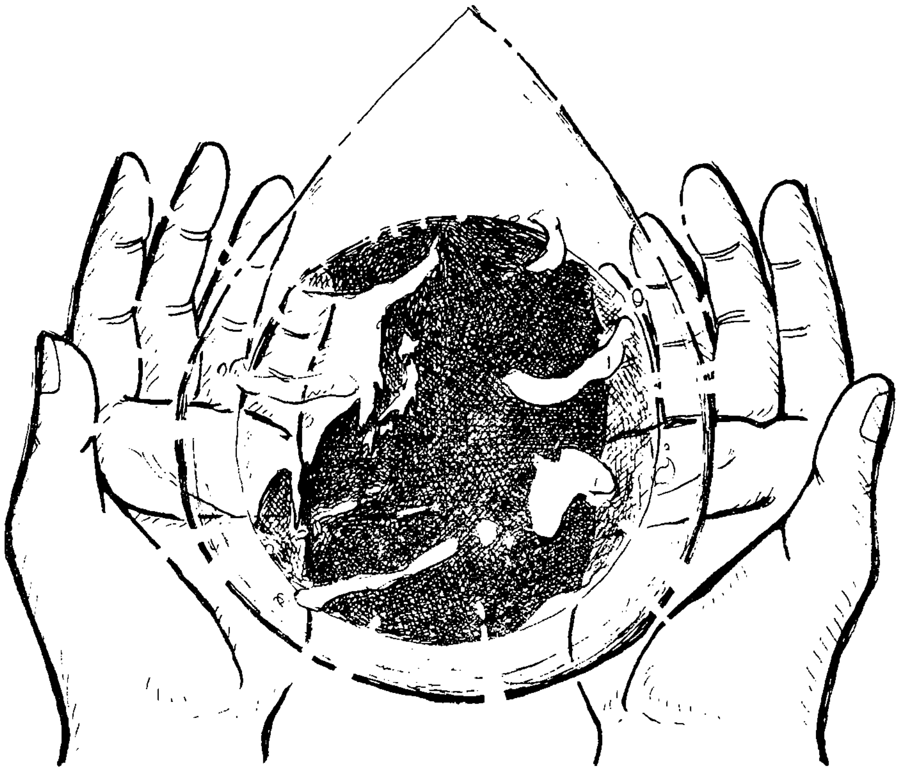
Rainwater tanks in Thailand used to be made of concrete reinforced with bamboo, but since termites ate the bamboo and caused water leaks, iron reinforced concrete is now the norm. Some rainwater tanks in Thailand can remove first flash rainwater. A pipe for sedimentation with a detachable bottom is equipped outside of a rainwater storage tank and first flash rainwater is discarded through the pipe while the bottom is detached; and after raining for a while, the bottom of the pipe is closed and the tank begins to store rainwater.

Rainwater Utilization is a Worldwide Topic

Singapore has bought water from Malaysia for a long time. In 1992 the country started using rainwater at Changi Airport. Rainwater is collected from runways and used for flushing toilets. In Yogyakarta, Indonesia rainwater infiltration was made mandatory to conserve groundwater, their resource of city water. In Germany, rainwater utilization is actively promoted to conserve groundwater as mentioned previously. Denmark and the Netherlands are making efforts to promote rainwater utilization in the same way as Germany.

In Tokyo, rainwater utilization and infiltration have been promoted by the active participation of residents to prevent urban floods and to restore springs. The story about rainwater use in Sumida City has already been described. In Koganei City, 17,650 soakaways were installed in individual houses with the support of the city government. If rainwater infiltration into the ground successfully developed all over the

First Step for Building Sustainable Cities



Musashino Plateau, Tokyo would be able to enjoy once-dried-up springs again.

Water problems such as dry spells, urban floods and shortage of groundwater that Tokyo is now facing are seen in cities all over the world in different degrees. It is estimated that 60% of the world's population will live in urban areas at some time in the 21st century. This indicates that cities need to promote rainwater utilization and infiltration to secure the self-support of their water supply, and to restore and protect sound regional water circulation. These are the initial steps for creating sustainable cities: cities that can maintain sustainable development. To achieve such development, it is very important to network cities that have been promoting rainwater utilization to exchange information on rainwater use. The Tokyo International Rainwater Utilization Conference paved the way for establishing such a communication network.

Breeding Fish by Rainwater Utilization—Sri Lanka

First Prize of Overseas Entries in the Rainwater Utilization Idea Contest

In October 1993 the technical study group of the Tokyo Conference placed an ad in *Water Line*, a magazine on alternative technology for water resources, to invite ideas on rainwater utilization from overseas. From among seven entries the rainwater utilization project in a church in Sri Lanka won the First Prize because it dovetailed with the theme of the conference in that it has made a great contribution to improving the living standard of the local people and emphasized community involvement.

Ceylon Church is a Christian missionary and welfare institution located on a hill 90 m above sea level in a suburb of Galle City. It takes care of poor children, and pregnant and breast-feeding mothers. It also provides rehabilitation programs to drug addicts and vocational training to young people and women without jobs. The church once relied on two 22.5m deep wells as its water resource. But in recent years one well dries up for almost six months every year. The groundwater level lowered due to the heavy cutting of trees and the large-scale granite mining.

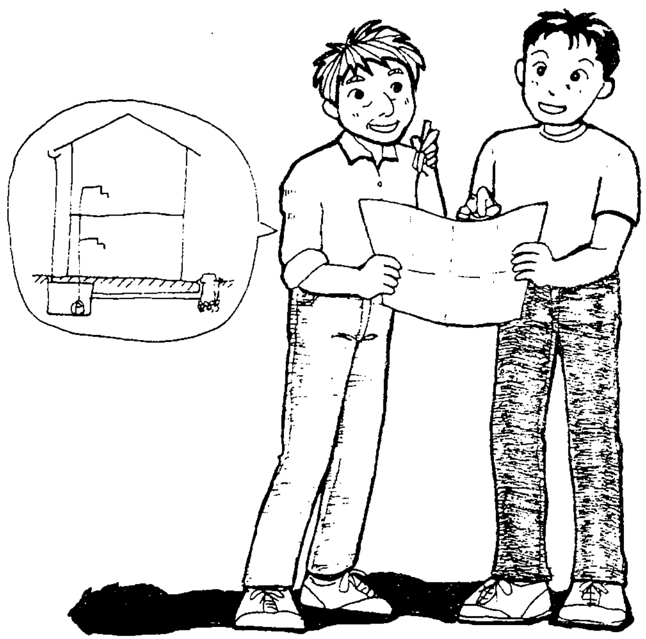
An alternative water resource had to be considered because people there had to go down the hill to obtain water. The three ideas proposed were the following: pull in water by branching from the main water pipes, dig another well and use rainwater. It turned out that water could be supplied only up to the middle of the hill by the first idea. Then two 75m deep wells were dug, but they also eventually dried up. Thus became the turn for the third idea.

Some parts of Sri Lanka have an annual precipitation of well over 2,000㎜, but Galle City with less rain represents almost the same precipitation as that of Tokyo, about 1,450㎜. The people decided to collect rainwater from a 630 m^2 roof into a 189 m^3 tank. Collected water is used for washing and bathing, and in emergency it is filtered and boiled for drinking. A sedimentation tank equipped with a valve was well devised to cut out rainwater for the first 10 minutes from the beginning of rain after a dry spell. Overflow water from the tank is reserved in a 90 m^3 spare tank to breed fish. If no rain falls for 60 days, the water in the spare tank is used to supplement the water of the main tank. Fish breeding has brought more income to the community and contributed to preventing the breeding of mosquitoes.

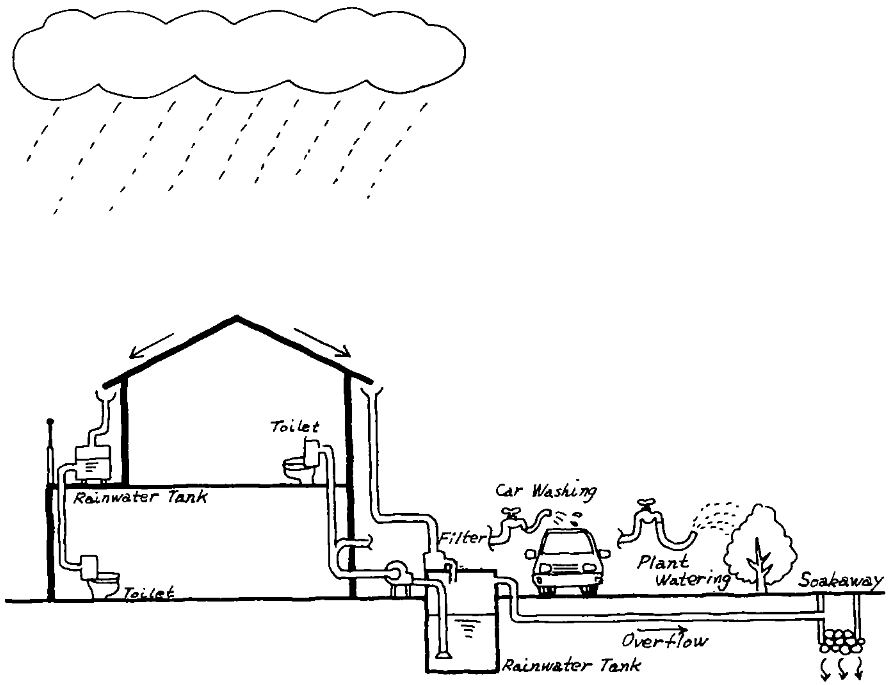
CHAPTER

3 TECHNOLOGIES FOR RAINWATER UTILIZATION

SYSTEMS TO COLLECT, STORE AND USE



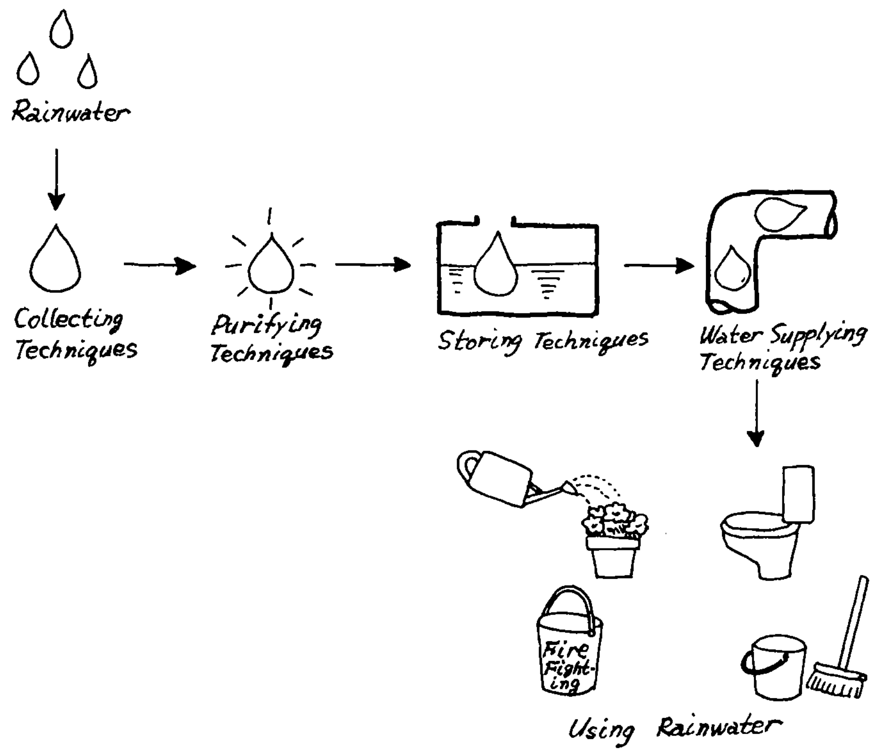
Techniques to Treat Rainwater and Wastewater Separately



Rainwater utilization treats rainwater and wastewater separately. A part of used rainwater is drained into sewers, a part is infiltrated into the ground, and a part is recycled. Excess rainwater is infiltrated into the ground directly. Only wastewater is drained off into sewers. The technology to operate a plumbing system based on this main principle is the technology that supports rainwater utilization, an integrated technology made up of the following functional techniques:

① Collecting rainwater from roofs, etc.;
② Storing rainwater in tanks, etc.;
③ Qualifying rainwater;
④ Supplying rainwater to the place of use;
⑤ Draining excess rainwater in heavy rain;
⑥ Supplementing rainwater by city water in times of shortage;

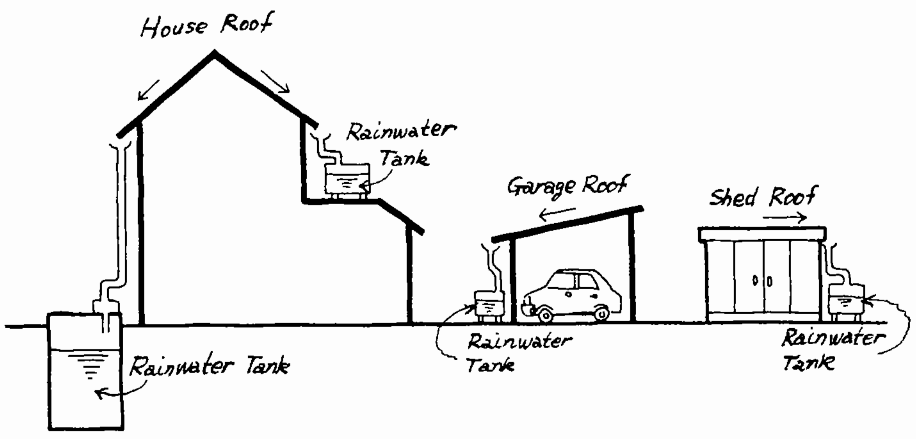
Creative Device Setup



⑦ Cutting off contaminated rainwater when rain starts.

Rainwater is utilized by combining these functional techniques selectively to set up an optimum device for structures and purposes of use. It is important to work out a creative device and incorporate it into the system. Since rainwater utilization has been embraced gradually, various rainwater use techniques have been developed as necessary, but much room for improvement still remains. This chapter mainly deals with crucial points of each functional technique in discussing rainwater utilization for stand-alone houses, housing complexes, small office buildings and city facilities such as public lavatories, parks and streets.

Ensuring the Largest Possible Area for Rainwater Catchment



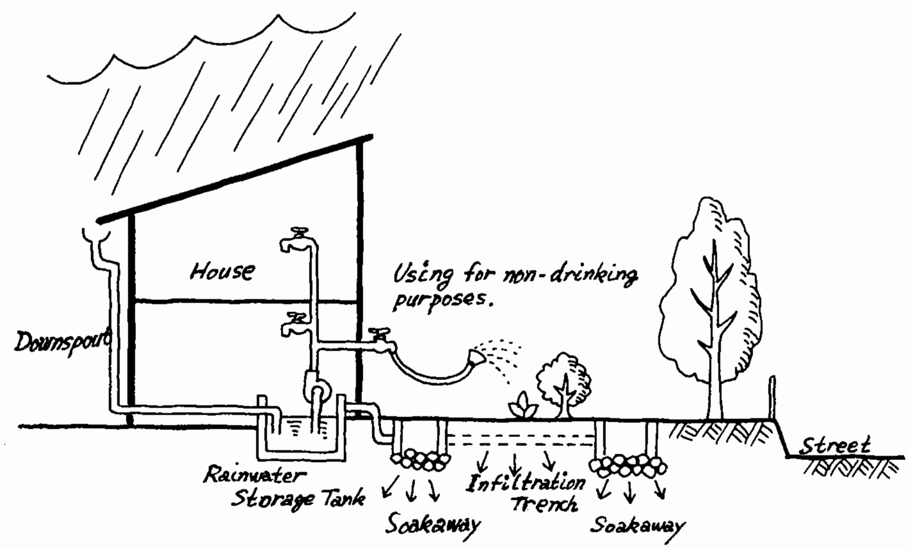
Rainwater can be collected from roofs of houses, arcades, factories and warehouses.

In stand-alone houses, rainwater is collected from roofs of houses. This is easy to put into practice whatever structure the houses may have. What you should do is collect rainwater running into the eaves-gutters without drainage. The roofs of sheds and parking garages are other resources for rainwater catchment. Also, rainwater can be collected from eaves, sunshade awnings and balcony floors. As large a water catchment area as possible maximizes the benefits from the blessed rain.

If the roof area is not large enough, it may be possible to have nearby public facilities redirect rainwater from their roofs. It may not be too difficult to collect rainwater flowing down the walls of houses. Some places with few water resources such as remote islands collect rainwater by covering the surface of a mountain slope with concrete.

Rainwater should be collected free of dirt and other trash. Rainwater collected into a storage tank is used for flushing toilets,

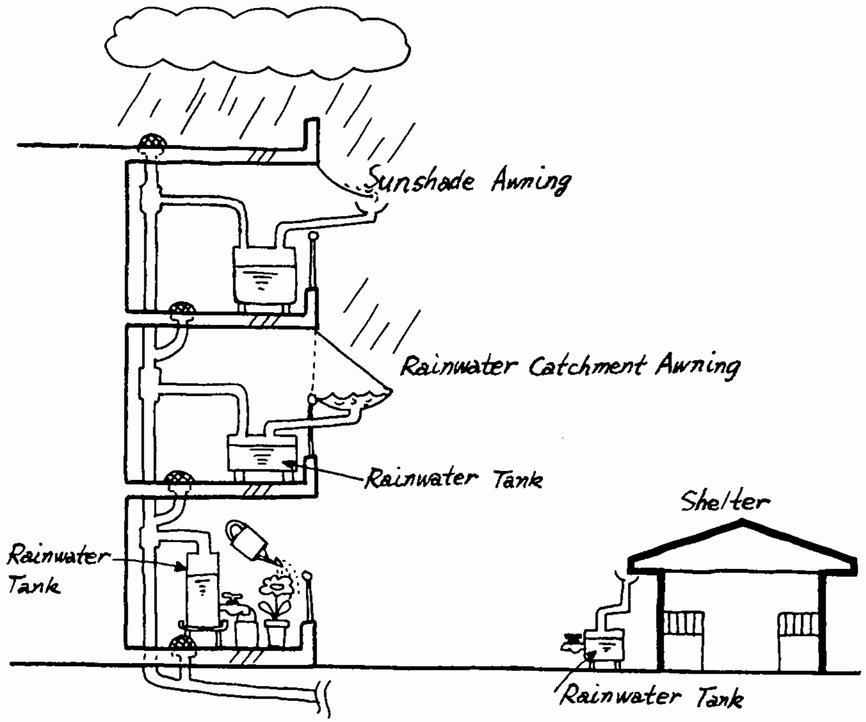
Fundamentals of Rainwater Utilization Technology for Stand-Alone Houses



watering plants, washing cars and cleaning houses. It is essential that all family members be concerned about rainwater utilization. They must join in cleaning the roof surface and gutters, and in maintaining the storage tank to ensure the good quality of the collected rainwater.

The better the quality of rainwater, the wider range of its use you can expect such as supplemental water for a tropical fish breeding basin. In the regions less equipped with water facilities such as remote islands, rainwater is boiled and used as drinking water. Every effort should be made so that rainwater overflowing out of storage tanks infiltrates into the ground.

Limited Usage in Each Household

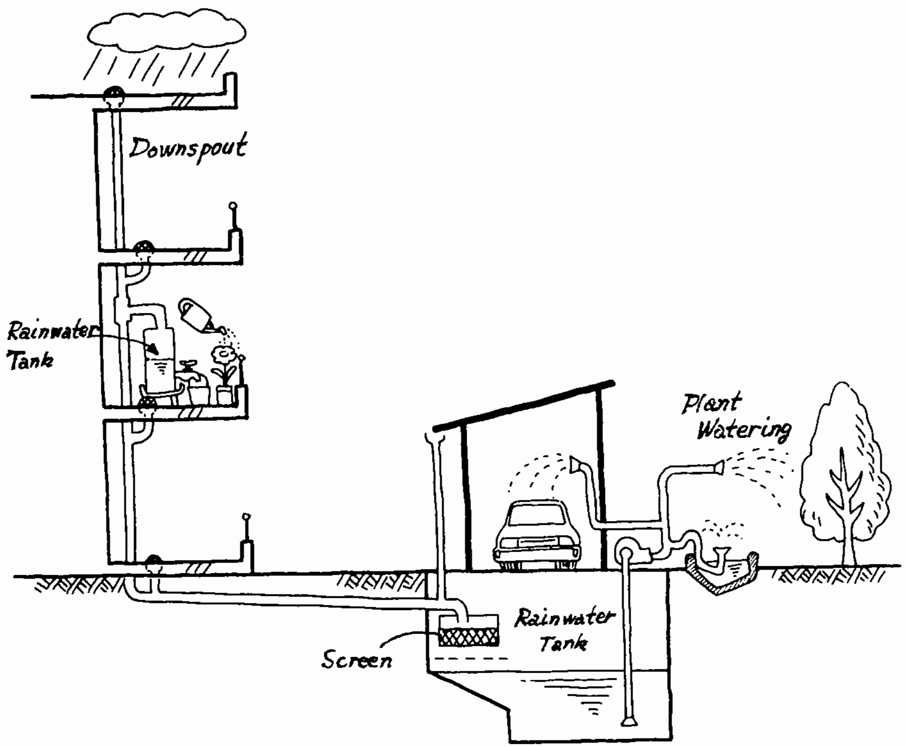


Rainwater utilization in housing complexes usually has limited catchment areas, storage places and storage capacity if not so designed when built. Uses are usually limited to plant watering and emergency water. Unlike in stand-alone houses, renovation of pipes is not easy, so rainwater application can not expand even to toilet flushing.

Catchment and storage places are balconies or terraces. Rainwater is collected into a vinyl sheet laid over the balcony floor or into a rainwater catchment awning modified from a sunshade awning or into a catchment sheet stretched out from the balcony when it is raining.

If other residents agree, you can use the rainwater running down from the upper floors, or can share (when necessary) the rainwater stream coming down from the rooftop through the downspout by installing a rainwater separation unit to the pipe. This is technically possible. If all residents agree, rainwater can be collected from the

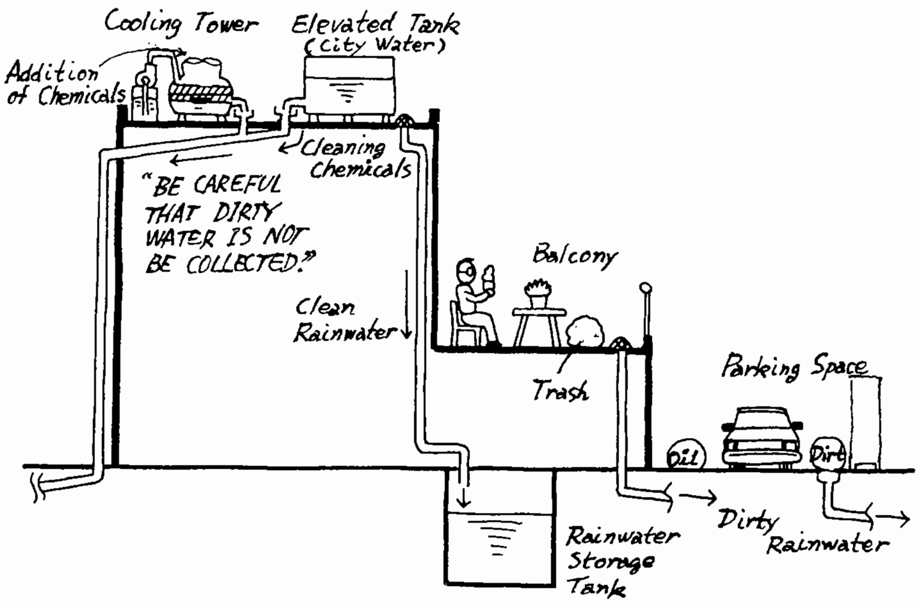
Basic Rainwater Utilization Technique in Housing Complexes



rooftop into a storage tank on the uppermost balcony. The collected rainwater overflows into the storage tank on the next highest floor, and then to that on the next floor. Every household on every floor can use rainwater in turn. In this case, the size and the installation site of rainwater storage tanks, and overflow method should be identical.

Even for existing housing complexes, it is relatively easy to utilize rainwater for common purposes such as car washing, general tools rinsing, garbage collection area cleaning, community area cleaning, or plant watering. For these purposes, it is reasonable to collect rainwater from the bottom of a nearby downspout into a storage tank installed where rainwater is used.

Usage Limited by Catchment Area Location



The cleanness of rainwater is determined by the collecting source. Meanwhile, the required level of cleanness is contingent on the purpose of use. Thus, the collecting source should be specified according to the usage, or a required level of cleanness should be attained through certain treatments such as filtration.

Relatively high quality rainwater can be obtained from rooftops that are not used by living beings If trash is removed, it can become drinking water. In fact, such rainwater is applied as drinking water and domestic use water in general in the areas where there are neither natural springs, wells nor water supply systems. Better rainwater can also be obtained from walls and glass surfaces. Rainwater from building roofs, balconies and roof terraces is not so clean because these places are used by men and animals, but poses no problem when it is used for flushing toilets and watering plants.

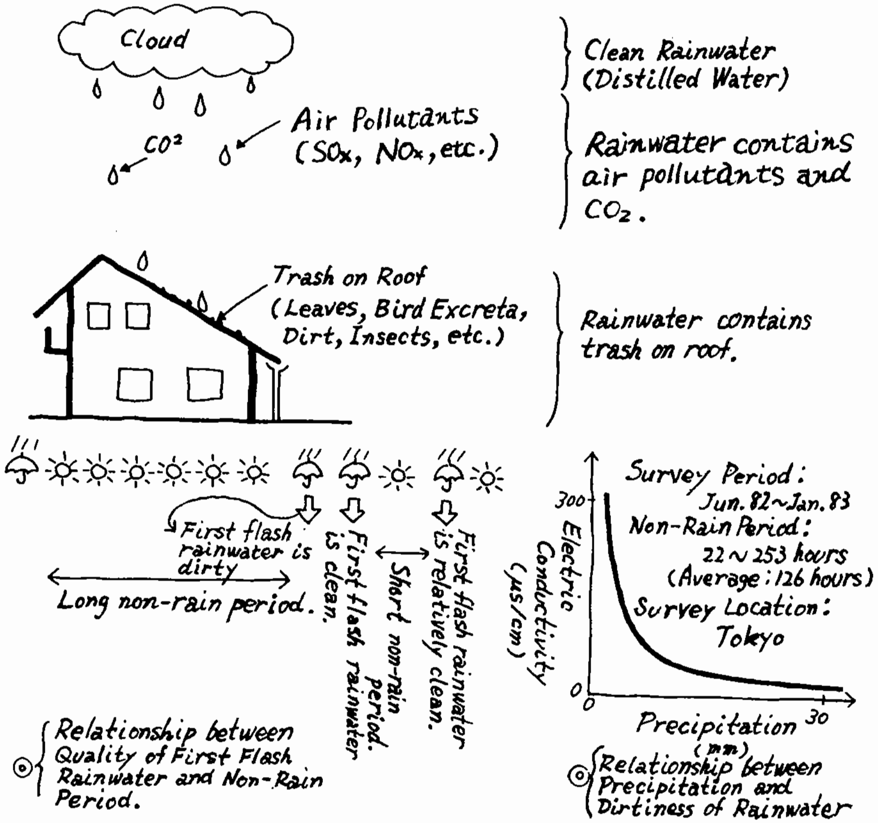
Rainwater from Rooftops can be Potable

Degree of Cleanliness	Rainwater Catchment Area	Rainwater Uses
A	Roof (Places not used by people and animals.)	Toilet flushing, Plant watering, Purified water is potable.
B	Roof (Places used by people and animals.)	Toilet flushing, Plant watering, Other non-drinking uses.
C	Artificial ground area, Parking space.	" (Treatment needed)
D	Road, Elevated Railway	" (Treatment needed)

In housing complexes, however, washing machine drainage from an upper balcony is sometimes discharged down through the downspout. You should not use such a balcony downspout as a source of rainwater collection. You should also check if there is any cooling tower or elevated tank on the building rooftop. The cooling tower discharges salt-rich water into the downspout during summer, and the water drained from the elevated tank into the downspout after cleaning is contaminated by cleaning chemicals. During and just after any cleaning, collection should be discontinued or the usage should be limited.

Rainwater collected from the artificial ground or parking lots had better be used for flushing toilets even if it is filtered. Rainwater from roads and train tracks contains oil, dirt, soot, metal powder and other harmful substances, so filtration is essential and its usage is confined to toilet flushing.

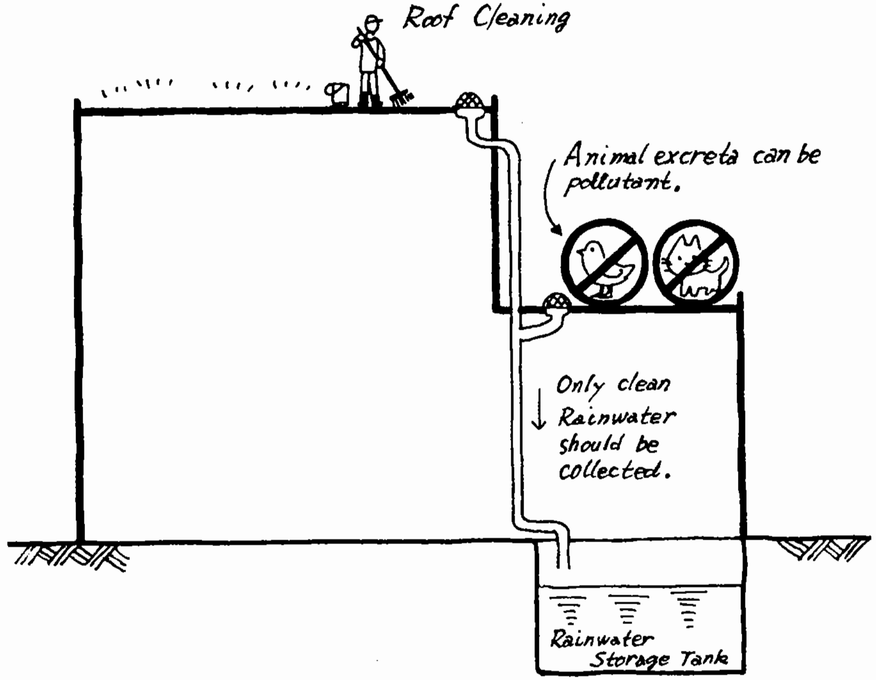
Severe Contamination of First 1mm Drops of Rain



Rain washes off suspended particles in the air while falling. Rain in urban areas contains harmful substances such as sulfur dioxide and nitrogen oxides discharged from cars and factories. Also, dirt and soot containing such harmful substances are deposited on or attached to catchment areas such as roofs causing rainwater contamination. Contamination is especially heavy with the first raindrops after a long dry spell. Up to the first 1㎜ of rainfall is so heavily contaminated that it can not be recommended even for non-drinking uses. Thus, first flash rainwater must be eliminated from catchment.

When a storage tank can store a large amount of rainwater, first flash rainwater represents only a small portion. Furthermore, constant automatic removal of this first flash rainwater would require a high capital investment. In such installations first flash rainwater tends to be left in the storage tank. In stand-alone houses with a much smaller

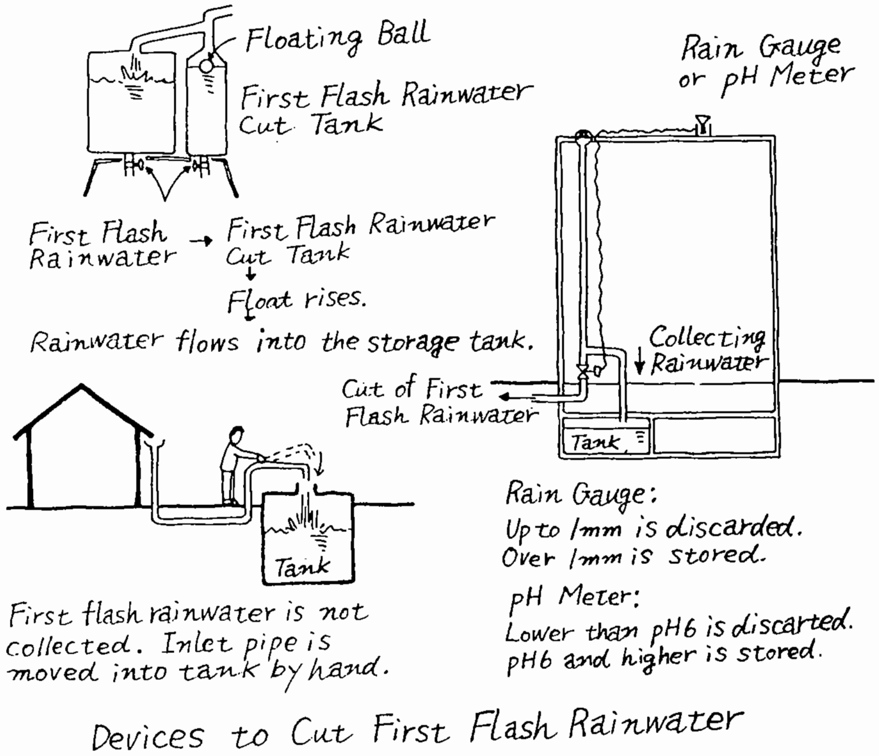
Keeping Catchment Areas Clean



storage tank, however, first flash rainwater should be discarded.

While there is no way to prevent contaminants in the air from dissolving and tranferring to rainwater, further contamination can be avoided by maintaining clean catchment areas. Rooftops are exposed to dirt and soot, or excreta of cats and birds. You should try to keep these animals off rooftops. Once a rooftop becomes dirty, it is hard to clean. You may use collected rainwater for cleaning catchment areas. If such preliminary care is ignored, many more complicated steps become necessary to obtain clean rainwater.

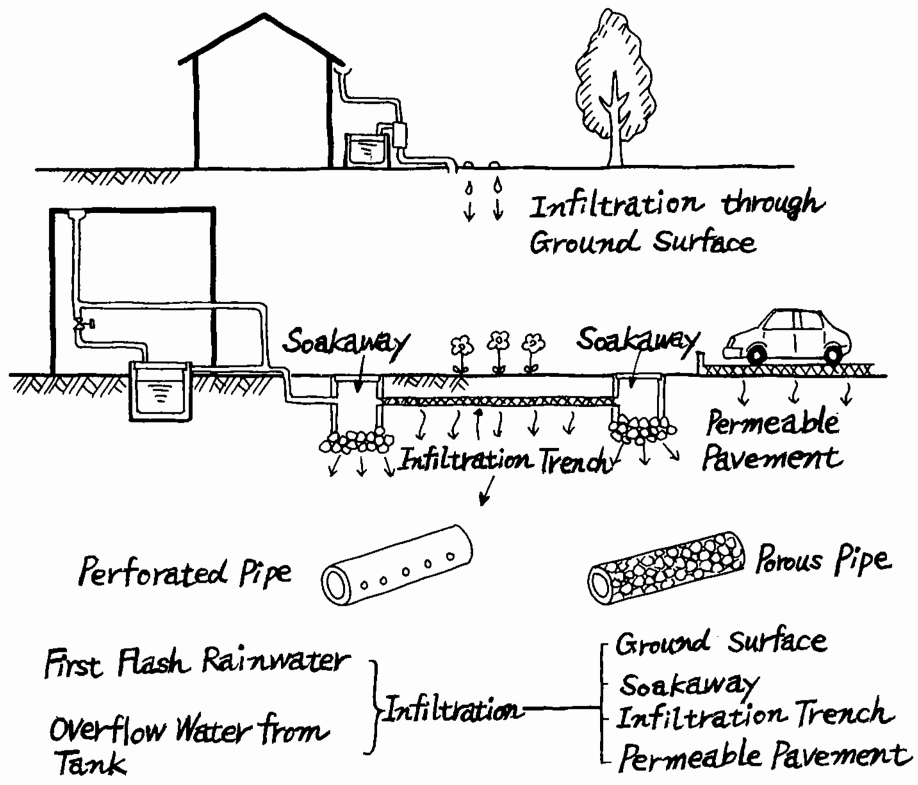
Device for Automatic Removal of First Flash Rainwater



A large-scale rainwater utilization system is equipped with a rain gauge that is directly linked to an automatic valve of a rainwater collecting pipe to cut off first flash rainwater selectively. This linking device is expensive and is ill-suited for general households.

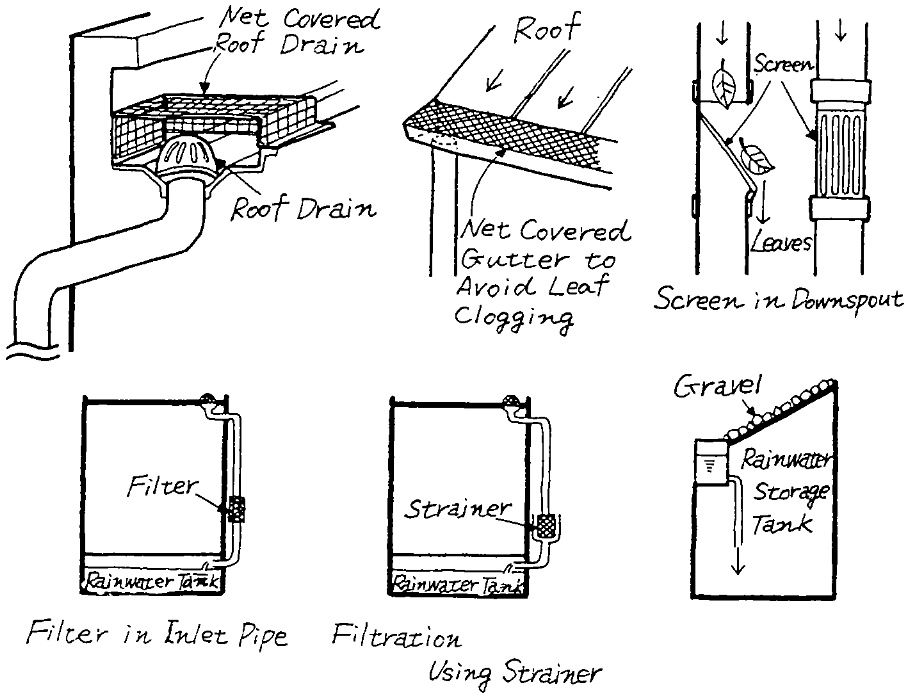
It may be possible to cut off first flash rainwater by connecting the downspout and the rainwater storage tank with a pipe only some time after it begins to rain. However, this method is not so practical because someone needs to attend to this when it starts to rain. We have discussed possible devices to facilitate automatic cut-off of first flash rainwater. Nobuo Tokunaga proposed a device to cut first flash rainwater by installing a small tank on the route between the downspout and the storage tank. Rainwater flows into the small tank first; and when the tank becomes full, a floating ball set in the small tank closes the outlet of the tank. Running rainwater then flows into the main storage tank.

Underground Infiltration of Removed Rainwater



Other devices similar in principle were suggested. A separate tank for first flash rainwater installed; and when it becomes full, rainwater flow is switched toward the main storage tank. Yet, all methods call for discharge of first flash rainwater collected in the separate tank to be emptied before the next rainfall. The discharged first flash rainwater should be infiltrated into the ground. However, direct and immediate infiltration would damage underground condition, so first flash rainwater should be infiltrated gradually through infiltration trenches and soakaways together with overflow water from storage tanks. During infiltration, rainwater is filtered through the soil or is purified by microbes biologically to be reproduced as clean groundwater.

Intercepting Obstacles

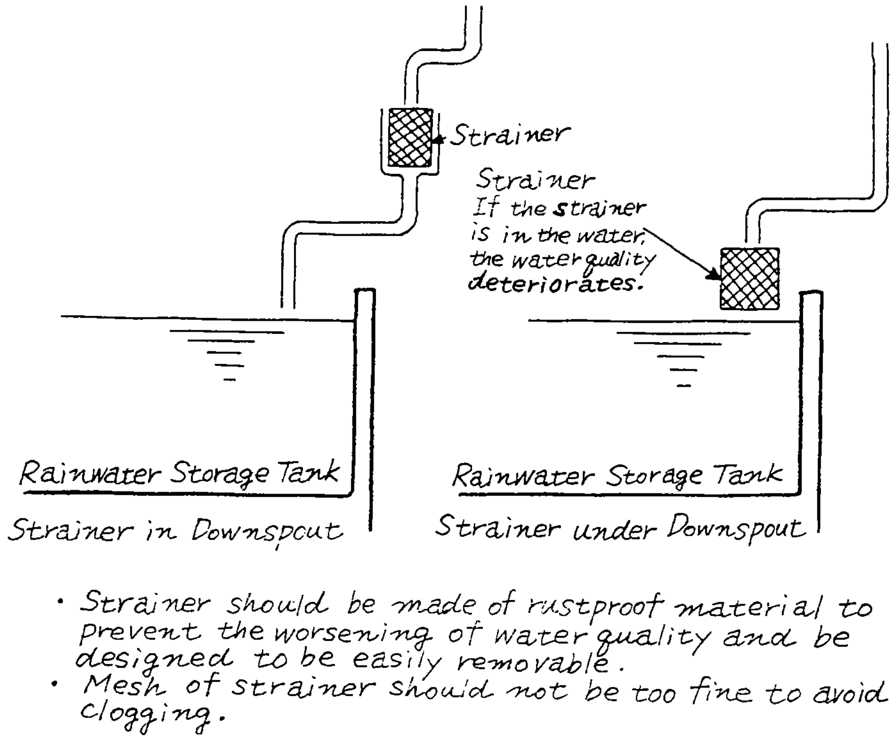


Leaves, dirt or sand gathering around a roof drain or in gutters would also pollute rainwater; and, moreover, would cause a leak due to poor drainage. Frequent cleaning is not practical for this uppermost part of the house or building, so it is necessary to prevent such obstacles from coming together with rainwater into downspouts. In addition, you have to clean the roof drain, the gutters and also the catchment area especially after a long dry spell or after strong winds blow. In autumn, you may have to do cleaning more often to remove leaves.

In Hawaii, where rainwater is fully utilized as a water resource for domestic use including drinking water, nets are installed in gutters to catch obstacles. The nets are available at supermarkets and used in many households. Screens are put in downspouts. Incoming obstacles hit the screen and automatically drop out from the downspout.

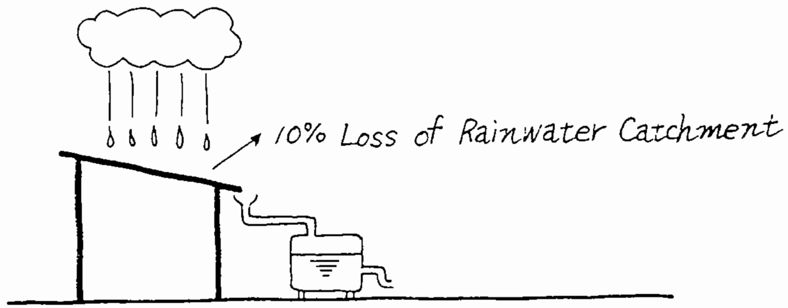
Another way is to incorporate a ready-made cartridge-filter into the

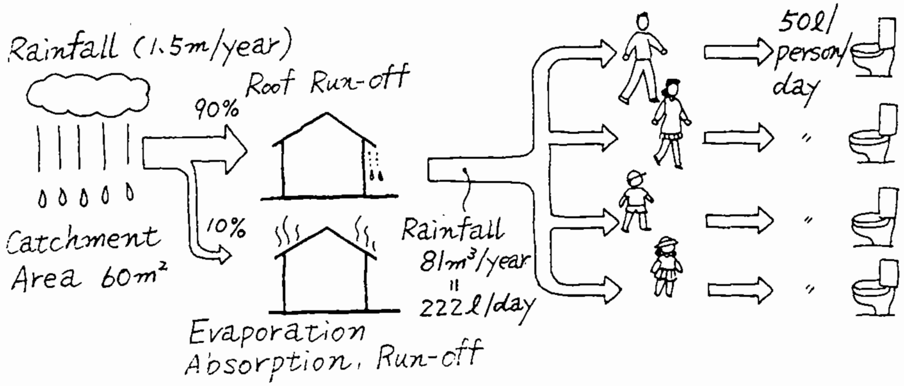
Using Nets or Screens



downspout. The cartridge must be replaced regularly. It is also possible to install a net or screen just before rainwater enters the storage tank. This method makes removal of obstacles easier than when the net or screen is put in place around the roof drain or in the gutters. A variety of nets are available, ranging from an ordinary net to the screen usually used for sewage treatment; choice depends upon the location of the catchment area. A net or screen mesh of 2-3mm to 10mm is suitable.

Catchment Area of 60m² Provides 222ℓ of Rainwater





Once it is determined where rainwater is to be collected, you can calculate the volume of rainwater collected from the catchment area. The relevant equation is as follows:

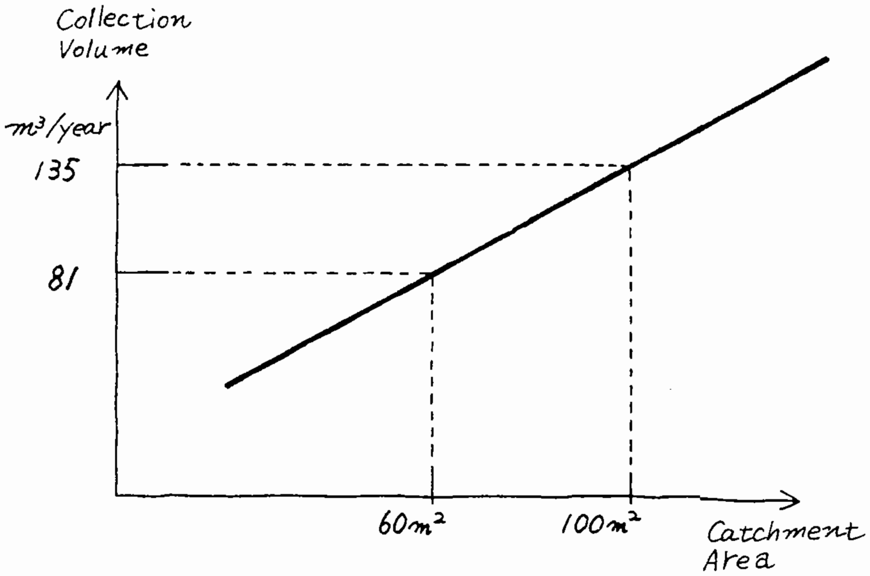
Rainwater Catchment Volume (m³) =

Catchment Area (m²) × Rainfall (m/year) × Coefficient of Runoff

Given that a catchment area is 60 m², an annual average rainfall is 1.5m and a coefficient of runoff is 0.9, the volume of rainwater collected in a year becomes 81m³. This makes 222 ℓ (81,000 ℓ ÷ 365 days) of collected rainwater a day.

An average amount used for flushing toilets is 50 ℓ/person/day. Thus, the 60m² catchment area can provide the amount of water needed for 4 people. However, this figure of 222 ℓ/day is calculated on the assumption that all the rainwater collected can be stored. Therefore, to be more accurate, any overflow volume from the storage tank which

70% of Rainfall is Usable

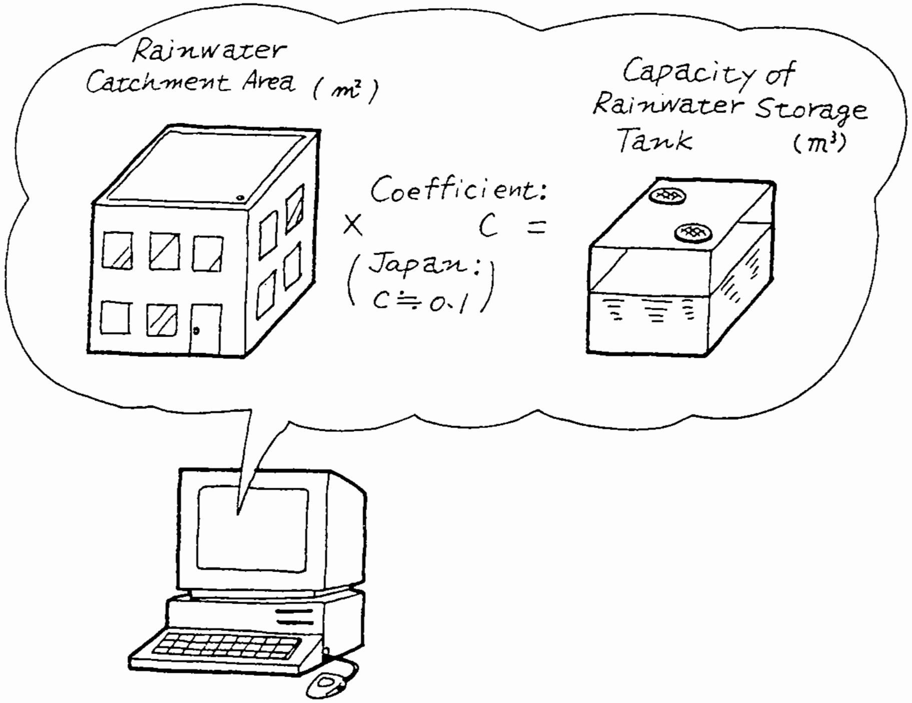


Relationship between Rainwater Catchment Area and Collection Volume (Precipitation: 1,500mm/year)

happens in heavy rain should be deducted. The volume of water that can be stored in a tank is generally 80% of the total rainwater collected. The above example thus gives an effective storage volume of 178ℓ/day, which represents 70% of the total rainfall on the catchment area. Also it is about 90% of the amount of water necessary for flushing toilets for 4 people a day (178ℓ ÷ 200ℓ × 100).

The above calculation suggests that a storage tank with a capacity of 200ℓ should be sufficient. However, it is not sufficient when the water is used for another purposes such as watering plants or emergency reserves. Furthermore, Tokyo has rainfall once every 4 days on the average, but may have no rainfall for an entire month. Considering all these factors, the storage tank should have a capacity of more than 20 to 30 times that of the amount of water used for toilets in a day by a family of four (200ℓ × 20～30 = 6,000ℓ), and should be filled up when there is rainfall.

Capacity of Storage Tank is Determined by Size of Catchment Area



The capacity of storage tank is generally determined by the size of catchment area. This is shown by the following equation:

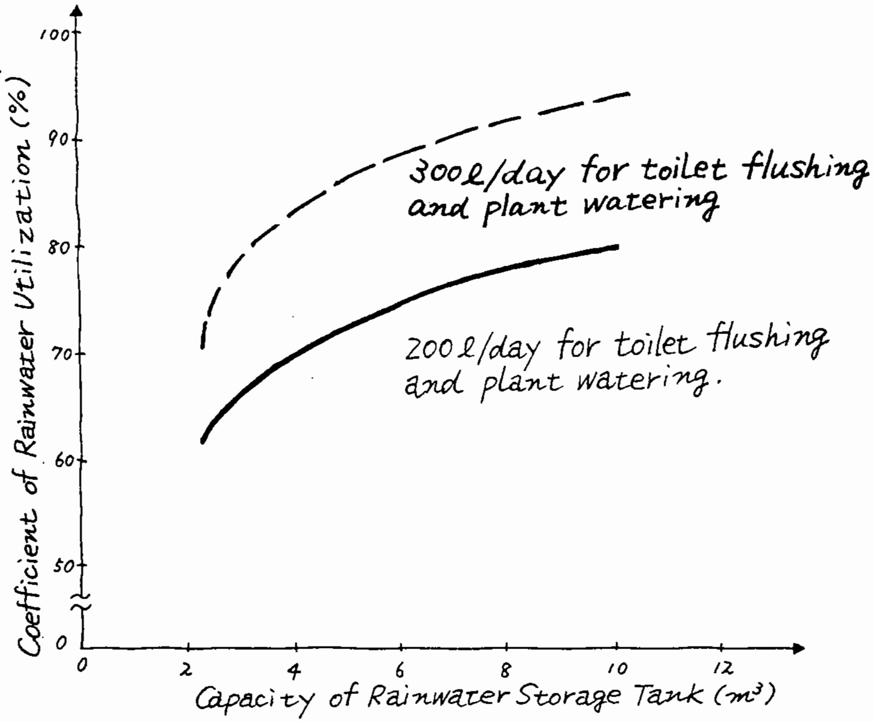
Catchment Area (m^2) × Coefficient C (m)

= Capacity of Rainwater Storage Tank (m^3)

Theoretically, the coefficient C should be a value reflecting regional characteristics in rainfall, etc.; but based on past data, C = 0.1 is set as a standard value applicable nationwide. When the size of catchment area is $60m^2$, the reasonable capacity of the storage tank is $6m^3$. If this capacity is ensured, 70% of the rainfall on the catchment area can be utilized. The percentage of effective water used is called "coefficient of rainwater utilization."

It appears that the larger the capacity of the storage tank, the higher the coefficient of rainwater utilization becomes due to smaller overflow volume. However, this is not always true. Even if the tank capacity is

Larger Capacity is Not Necessarily Good



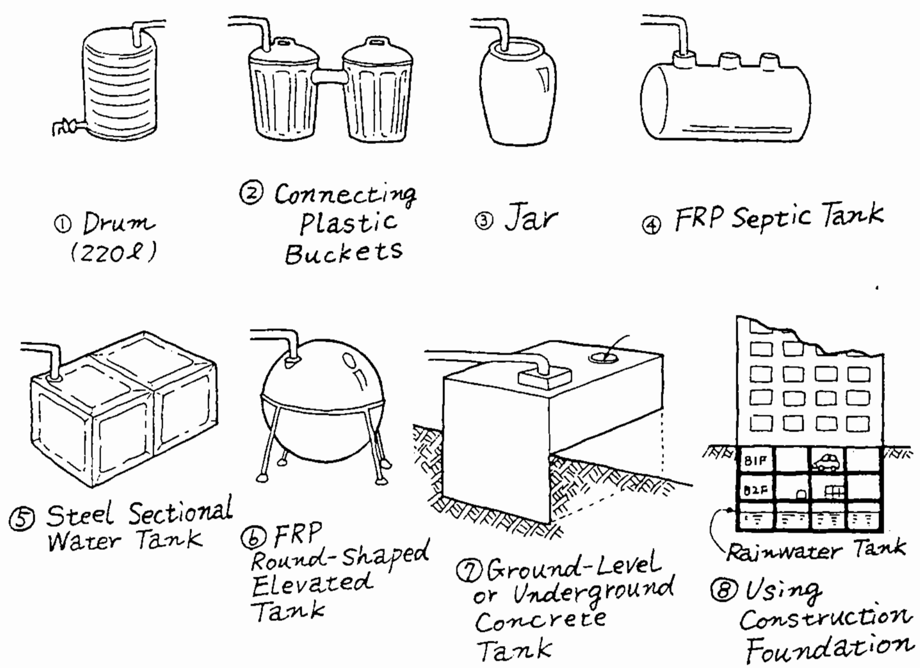
* Coefficient of Rainwater Utilization: ratio of the amount of rainwater used for flushing toilets, watering plants, etc. to the amount of rainwater collected from roofs, etc.

increased by 50%, the growth of coefficient of rainwater utilization is confined to 5 to 10%. That is, a larger storage tank capacity is not necessarily beneficial. Existing structures especially have difficulties in ensuring a place for a rainwater storage tank. It is thus more advisable to make the capacity of the storage tank as close as possible to the proper storage capacity calculated according to the above equation, and supplement any shortage by city water.

When building a new structure, it is permitted to deduct the area for a rainwater storage tank within a given limit (0.25 of the standard floor ratio* from the floor area ratio prescribed by the Building Standards Act (= to deduct the floor area of the tank from the total floor area of the structure).

*Japanese Building Standards Act restricts the ratio of the total floor area of buildings to the site area to provide comfortable town spaces in a city.

Three Essential Conditions for Rainwater Storage Tanks



Any vessel or container may be a rainwater storage tank if the following three conditions are fulfilled:

① No leakage;

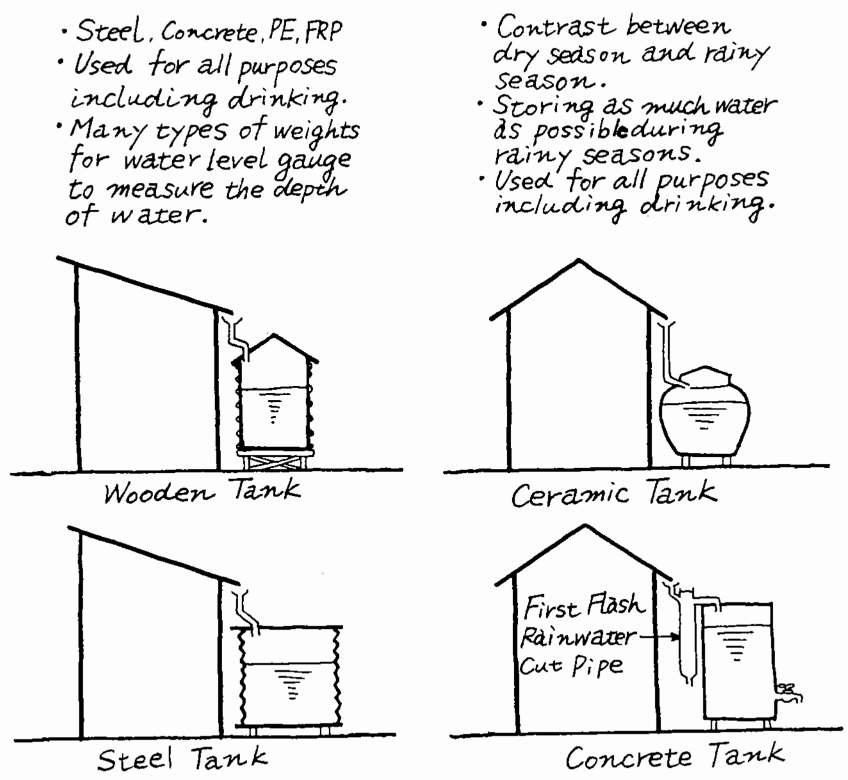
② It is made of a material that contains no ingredients that could dissolve and transfer to rainwater, thus contaminating it, and that is sunproof to prevent algae from growing;

③ It has a lid to prevent dirt and vaporization, and it is designed so that the inside can be easily cleaned.

Different types of storage tanks in shape, material and structure are used in different places depending on the usage, purpose of facilities, style of construction, storage capacity and installation site. Ready-made storage tanks may be installed simply, and in some cases tanks are assembled or built on site.

Water jars, pails or barrels have long been used as simple rainwater

Water Level Gauge Helps

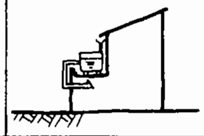
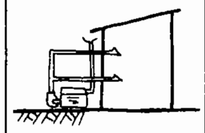
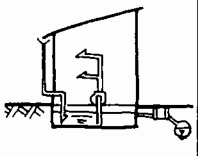
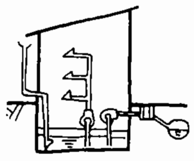


Different Types of Rainwater Tanks Overseas

storage tanks. Drums and plastic buckets are now used as smaller containers (less than 500ℓ). Ready-made rainwater tanks are also available. Larger containers (500ℓ or more) are sectional tanks made of steel, stainless or FRP; or reinforced concrete storage tanks. FRP septic tanks are sometimes converted into rainwater storage tanks.

In some countries with little rainfall and regular dry seasons, the storage tank is mostly round in shape, and made from locally available materials such as wood, steel, concrete and plastic. The tank is usually set on the ground. In the regions with no water supply system nor groundwater, rainwater is the only water resource for domestic use including drinking. In these areas, the devices to clean rainwater and store it without contamination are essential for life. Silt traps and sedimentation pipes that also serve as first flash rainwater cut units are integral parts of such devices.

Balcony Storage in Stand-Alone Houses

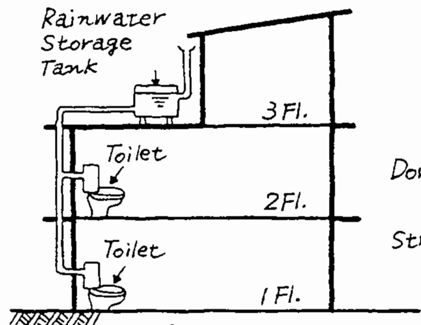
Location	Model	Application
Rooftop		• House • Small Office Building
Ground Level		• House • Office Building
Underground (Overflow water drains into sewers without a pump.)		• House • School Building • Office Building
Underground (Overflow water drains into sewers with a pump.)		• Large Building • Underground Garage

Rainwater storage tanks are installed either on rooftops (including balconies), on the ground or underground. Stand-alone houses are usually equipped with portable storage tanks on their rooftops or on the ground. In some cases, reinforced concrete framed box-type foundations are built as a rainwater storage tank, or a tank is installed in the ground under the porch, the terrace of the first floor or a garage. Some tanks are put in the often dead space under the stairs.

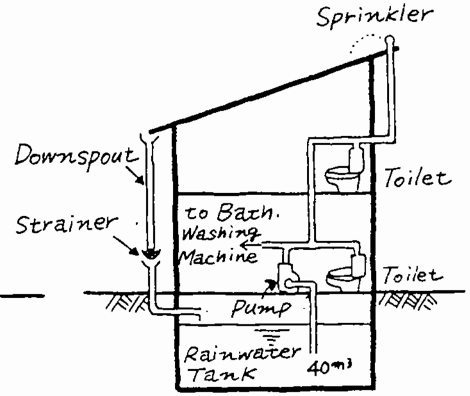
Larger facilities generally have rainwater storage tanks underground or under the floor of the lowest level. Underground installation has a difficulty in discharging overflow by gravity, and probably requires mechanical discharge by pumps.

If a two-story stand-alone house collects rainwater from the roof and stores it in a storage tank installed on the balcony or roof-terrace on the second floor, it is possible to supply the water to toilets downstairs

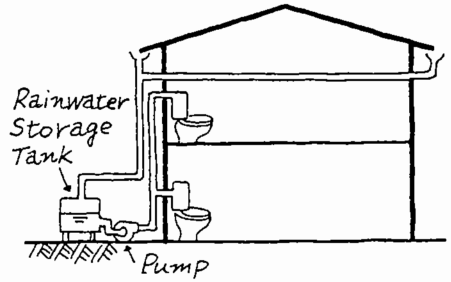
Places of Installation May Affect Housing Structure



Rooftop Tank



Underground Tank in Stand-Alone House



Ground-Level Tank

by gravity. Meanwhile, if the storage tank is installed on the ground-level terrace, in the garden or underground, then it is necessary to pump the water up to supply it to the upper levels.

In considering equipment cost and maintenance, the best method is to install the tank on the second floor; and the next best choice is to install it on the ground. However, there may be a restriction on the tank size capable of being installed on the second floor. Too large a capacity of tank adversely affects the housing structure and cost. To install the storage tank just under the roof or in the loft may most fit the simple purpose of collecting and utilizing rainwater. However, the housing structure such as beams, columns and foundation should be sufficiently solid and firm.

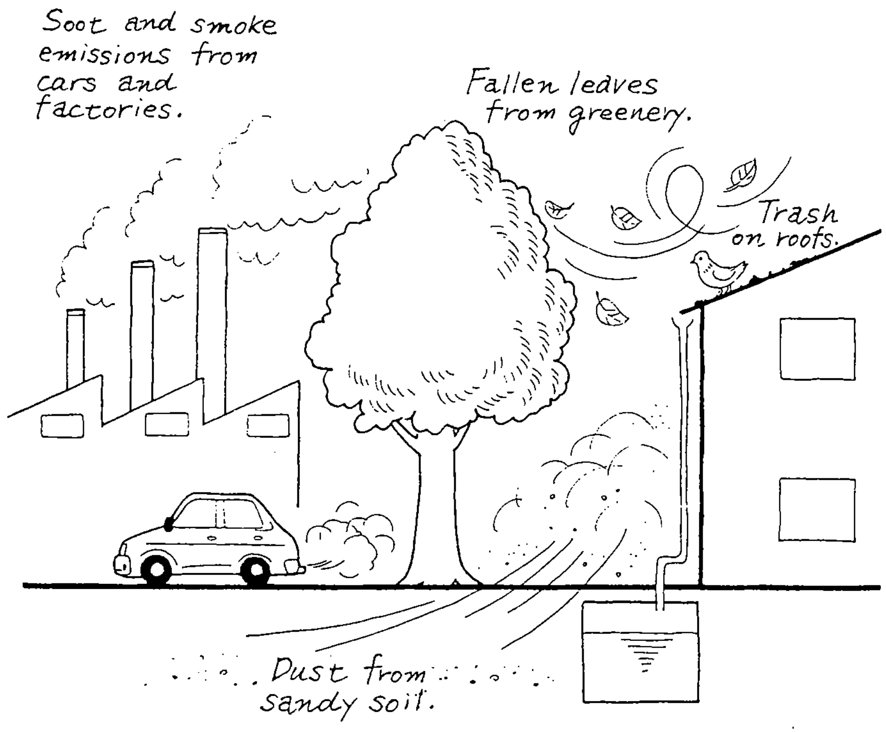
Water Quality Levels Differ by Application

Rainwater Uses	Treatment of Water
Plant watering	No treatment is needed.
Sprinkler Fire fighting Cooling water for air-conditioners	Treatment is needed to maintain the storage and supply equipment in a good condition.
Pond/Fountain Toilet flushing Clothes washing/Car washing	Hygienic treatment is needed because the human body can touch the water.
Pool/Bath Drinking/Cooking	Disinfection is needed because the water is drunk directly or indirectly

The quality of rainwater varies with the degree of air pollution as well as with the cleanness of the catchment. These conditions also depend on the environment surrounding the structure. This point should be considered in discussing the methods to clean the rainwater. For example, if your house is surrounded by trees, a strainer or a screen is indispensable to keep leaves out. If there is a sandy area or open land nearby, sedimentation or filtration will be necessary to remove dirt. Meanwhile, the methods should differ with the purpose of use.

For example, when rainwater is used for drinking, bathing, washing or for wherever rainwater directly contacts the human body, special treatment such as disinfection is needed. However, for non-drinking uses, simple physical treatment including dirt removal by a strainer or sand removal by sedimentation suffices. Too complicated a treatment would merely result in increased costs and cumbersome maintenance. Rainwater

Easy Removal by Strainer and Screen



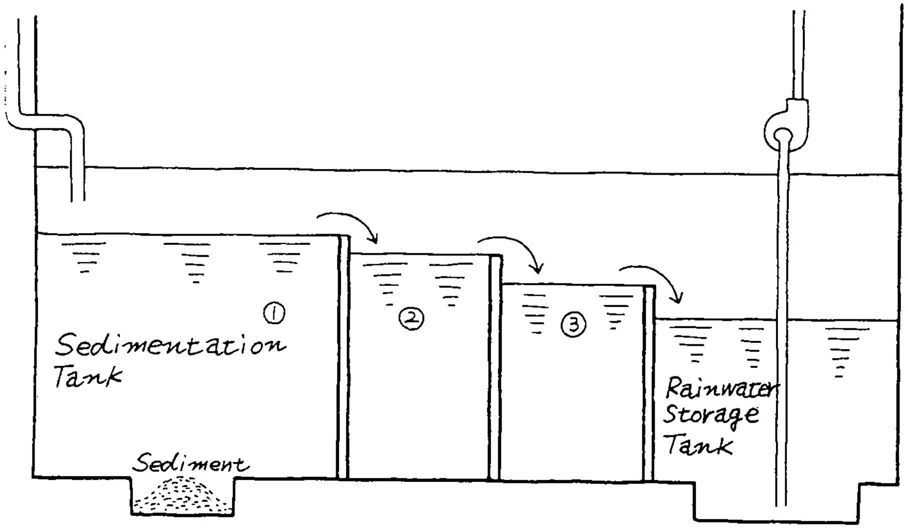
treatment methods should be as simple as possible according to the purpose of use and the quality of rainwater.

Most of the substances mixed into the collected rainwater are dirt and sand from the catchment area. Leaves and other trash should be removed before they come to the rainwater storage tank by the following devices:

① Putting a filter net directly on the inside of the collecting pipe.
② Putting a strainer just under the inlet of the tank. In this case the strainer should not be dipped into the water, but be set slightly above the water level to remove the debris from the rainwater and prevent leaves from rotting in the water.

Either way is very simple to perform and easy to maintain. All that needs to be done is to check the strainer or screen regularly and discard any dirt or leaves.

Using the Clear Water through Sedimentation



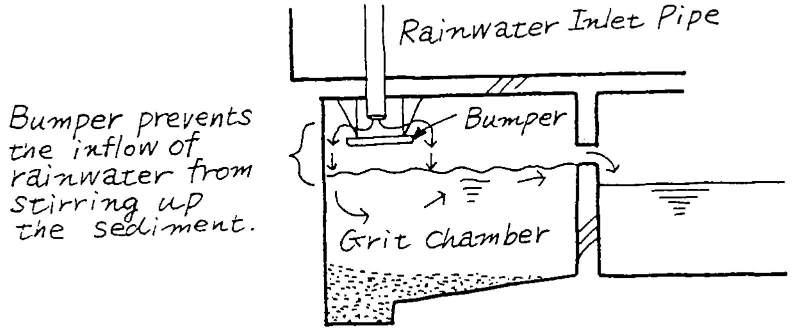
- Water overflows from sedimentation tank ① into ② and finally into ③. A longer detention time raises the **sedimentatin effect.**
- The amout of sediment gradually decreases from ① to ②,③, while the particle's size becomes smaller from ① to ②,③.

A grit chamber and a sedimentation tank are often incorporated into a rainwater storage system to remove soil and sand from rainwater. They are designed to use only the clear layer at the top of the water by settling soil and sand in the grit chamber, and suspended particles in the sedimentation tank by gravity.

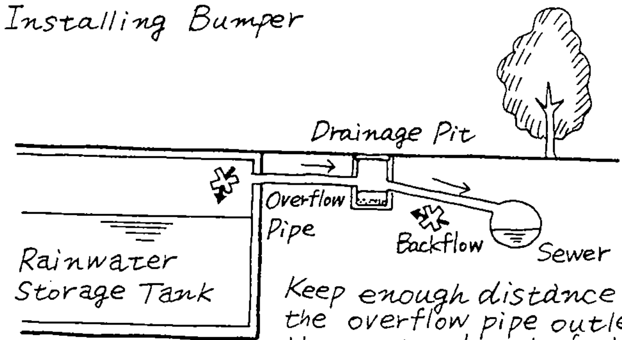
A grit chamber, installed immediately preceding a sedimentation tank, retains rainwater for 30 to 60 seconds at which time soil and sand settle to the bottom. Then the water goes to the sedimentation tank where suspended particles slowly settle for 2 to 3 hours due to their specific gravity being heavier than that of water. The proper storage time depends on the kind of suspended particles to be settled. The sedimentation tank capacity is larger than that of the grit chamber for the longer storage time.

The bottoms of both grit chamber and sedimentation tank should be

Filter Equipped Tank is Convenient for Home Use



① Installing Bumper

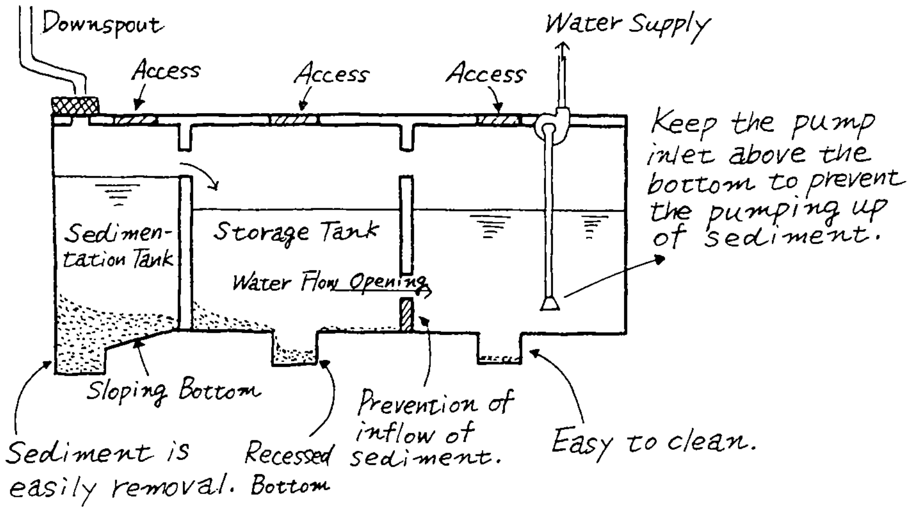


② Prevention of Backflow

sloping or recessed so that sediment can be easily accumulated. Access is necessary for inside checks and sediment removal. Each tank has a bumper just below the rainwater inlet preventing rainwater in heavy rain from gushing in and stirring sediment.

An orthodox way is to install a grit chamber and a sedimentation tank separately preceding a rainwater storage tank; but partitioning a rainwater storage tank into a grit chamber, a sedimentation tank, and a storage tank is also effective enough. When the rainwater storage tank capacity is less than 10 m^3, only a sedimentation tank is installed. For ordinary household use, a wire screen or a layer of gravel is attached to a rainwater tank instead of a grit chamber and a sedimentation tank to purify water by filtration.

Longer Storage Time Makes Sedimentation Tank More Effective, But . . .



Technical Points for Large Rainwater Storage Tank

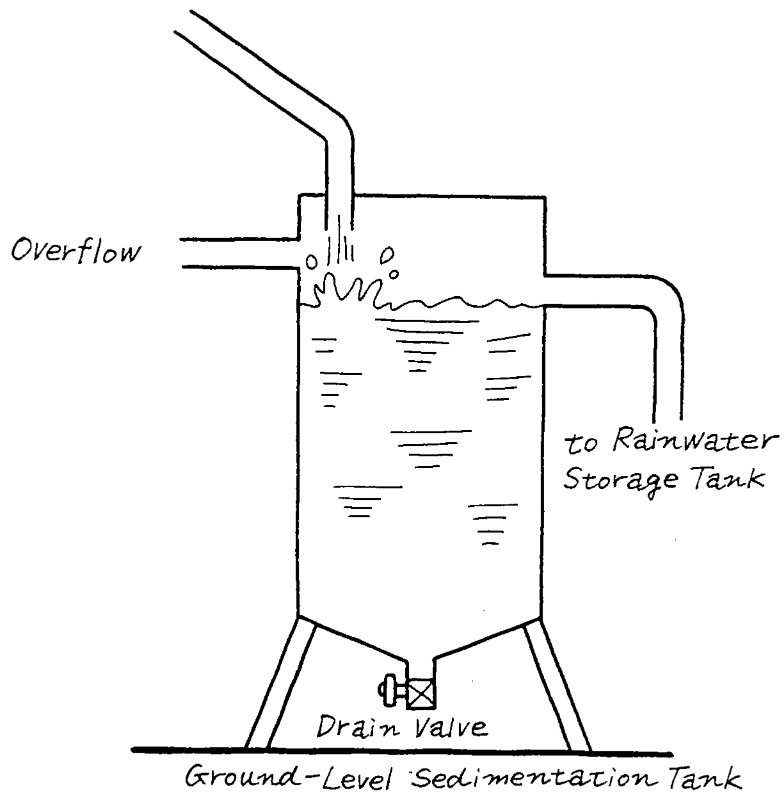
1. Prevention of trash from flowing into tanks. → Screen
2. Prevention of sediment diffusion. → Grit Chamber, Sedimentation Tank
3. Prevention of the pumping up of sediment. → Barrier Wall, Keeping pump inlet high.
4. Removal of sediment → Drain Pipe. Sloping the bottom of tank. Catch Pit. Access, Hand Hole.

Rainwater collected from catchment areas contains particles of various sizes and weights from minute ones floating in the air to pebble-sized particles in catchment areas or in downspouts. These impurities are removed simply by gravity in the previously mentioned sedimentation tanks.

A sedimentation tank helps decrease the amount of impurities in rainwater that flows into a storage tank, extending the interval between each tank cleaning. Making a sedimentation tank so that it can be cleaned separately saves time and energy. In the case of a ground-level sedimentation tank, a drain valve at the bottom would be very convenient, particularly in a place with many impurities, because sediment can be drained merely by opening the valve by hand.

As mentioned before, a bumper should be attached just below the rainwater inlet to lessen rapid rainwater flow. If the bumper surface is

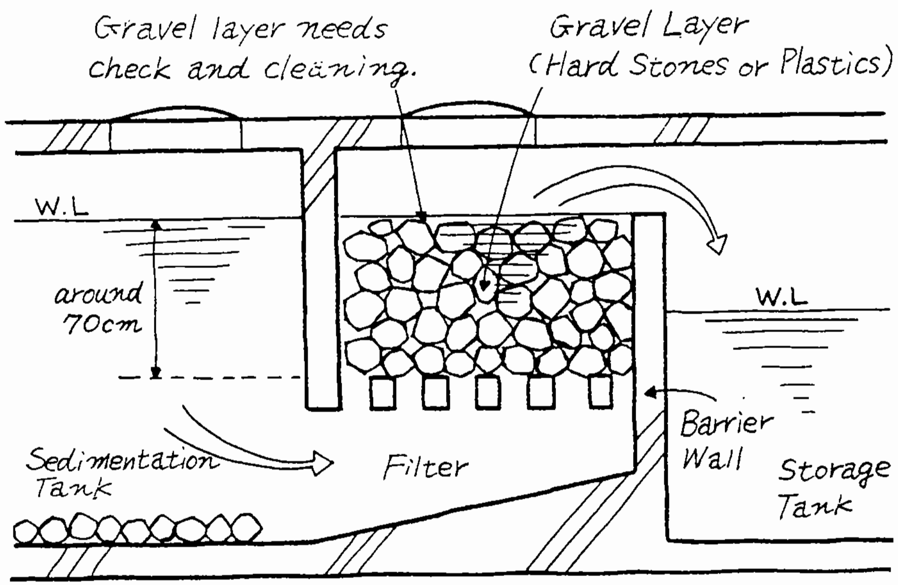
Design to Clean Sedimentation Tank Separately



made of artificial turf-like material, not only a stronger buffer function but also a filtering effect can be expected.

The larger the capacity of a sedimentation tank, the greater its effectiveness becomes because rainwater is stored in it much longer, so more minute impurities can be removed. When it rains heavily, a great amount of rainwater gushes into the clear water and stirs sediment causing the water to revert back to its former dirty state. Therefore, double, triple or multiple sedimentation processes increase tank effectiveness. However, this is cost effective only for large-scale rainwater utilization facilities, and requires much maintenance.

Simple Filtration without Power-Driven Equipment

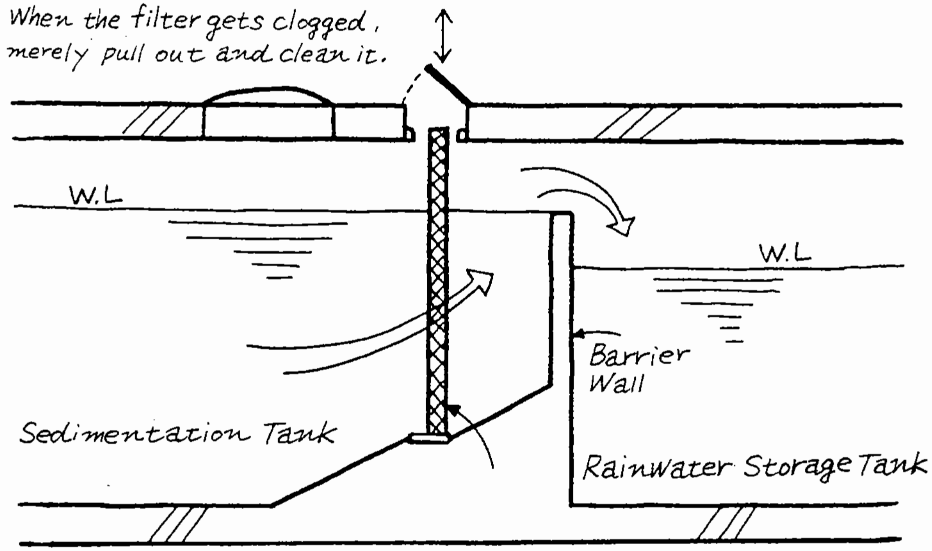


Gravel Filtration

Some soil, sand and dust are too light or too small to be removed only by a sedimentation tank. A more effective way is to install a filter adjoining a sedimentation tank. There are various ways of filtering among which are the following and are adequate for rainwater:

① Filtration with a gravel layer.
Hard stone like granite of 7 to 8cm in diameter is appropriate for gravel layer filtration, but plastic similar in shape may be also used. The gravel layer thickness alters filtration effectiveness; but in terms of maintenance, not so thick a layer is preferred. About 70cm is suitable. It is necessary to check it regularly and remove accumulated soil and sand in the gravel layer. This can be done easily by putting crushed stones in a basket or a framed netting so that they can be taken out and cleaned together in the container.

Using a Gravel Layer or Filter

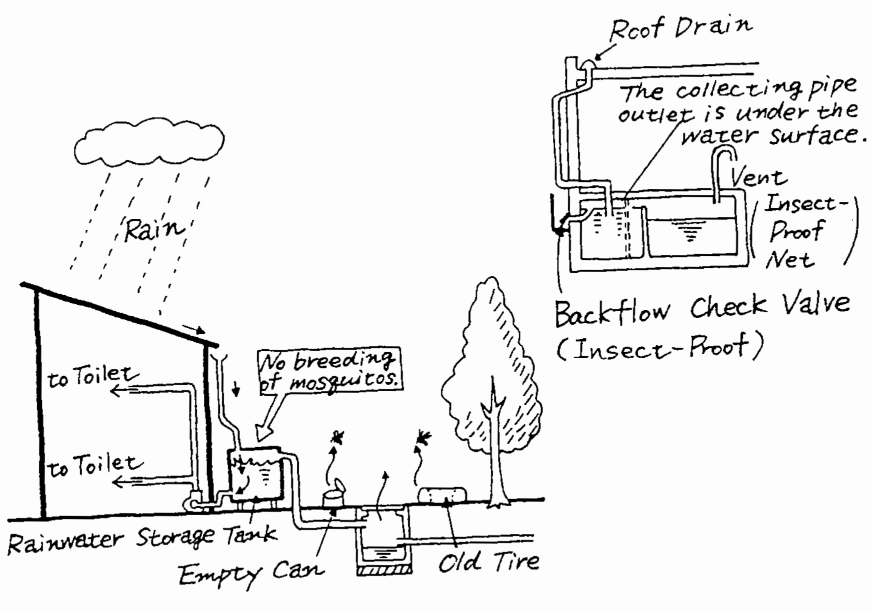


- Rainwater flows through the filter into the storage tank.
- Filter should be made of rustproof material.
- Extremely fine filter could be used, because it is after sedimentation.

② Filtration with a metal or resin filter.
The finer mesh of a filter improves the filtration effectiveness but it adds to clogging making regular checks and cleaning essential. Cleaning is easier compared with gravel filtration because the filter only needs to be pulled out and washed.

Neither the gravel layer system nor the filtration system requires special power-driven apparatus. Other methods include automatic revolving cleaning strainers, microstrainers with fine-mesh filters, and grit filters, but all these might be excessive equipment if the rainwater is used for purposes not requiring high water quality.

No Need to Worry about Mosquito Larvae



Rainwater in storage tanks is not be retained long, so mosquitos do not breed in them. Mosquitos breed rather in drainage pits or stagnant water.

Insect-Proof Device for Water Supply Pipe and Tank

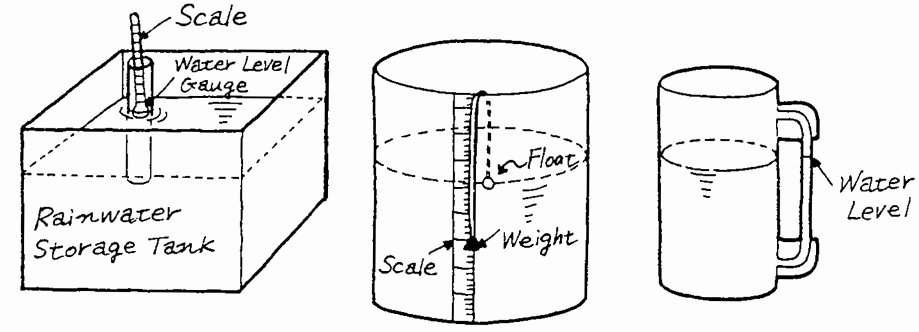
There is no need to worry that mosquito larvae will hatch in rainwater storage tanks and that mosquitoes will breed there. The tank rainwater is used regularly and replenished often. Even if larvae are mixed in rainwater, or a mosquito enters a tank to spawn eggs inside when the lid is open for cleaning, the larvae can not breed. Many months of dry weather would dry up rainwater tanks. The little remaining water should be taken out while cleaning the inside.

If there is still worry, the rainwater can be drained from the tank by adjusting the water level shown by the water level gauge attached to the tank according to the rainfall predicted by the weather forecast. It is a perfect way of getting rid of old rainwater. The drained rainwater, of course, should be infiltrated into the ground.

A water level gauge is essential for controlling the water volume in a rainwater storage tank. One type is a floating ball gauge. It is designed

Adjusting Storage Volume According to Weather Forecasts

Different Water Level Gauges



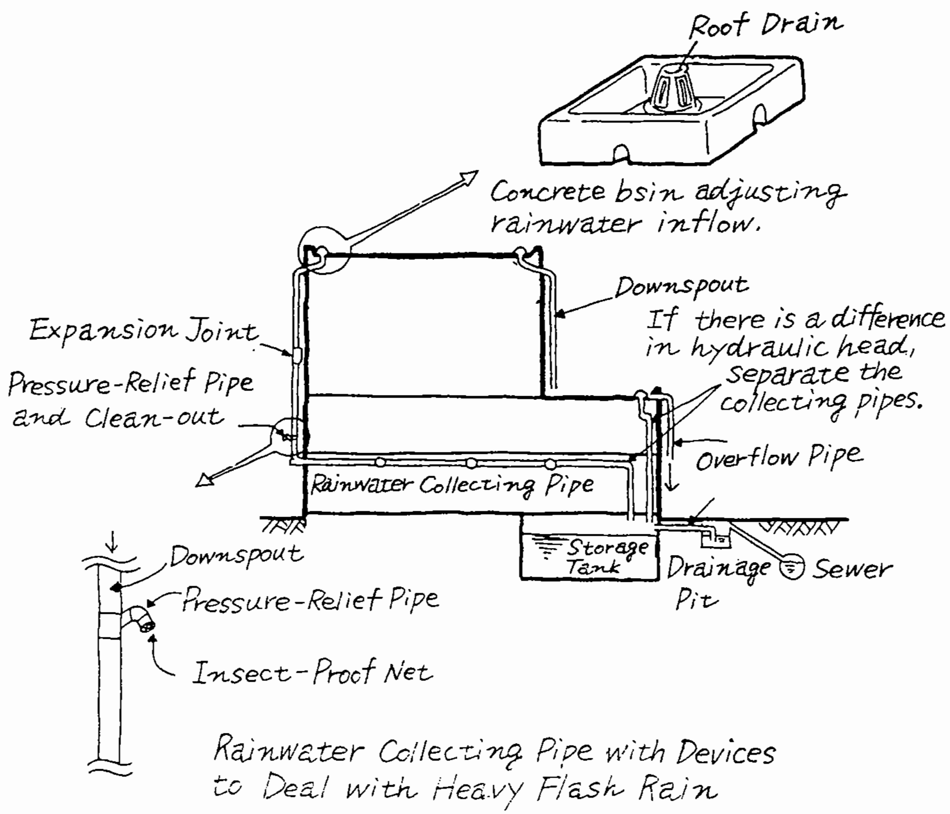
Float Water Level Gauge — Float Water Level Gauge in Hawaii — Water Level Pipe Gauge

- Float Type: Inexpensive. Suitable for rainwater tanks.
- Electrode Rod Type: More expensive. Used for break tanks and elevated tanks. Control of pumps.
- Electrostatic Type: Expensive, accurate.
- Water Level Pipe Type: Inexpensive. Algae can hamper scale reading.

so that a floating ball in a tank moves up and down according to the water level and a needle attached to it indicates the water level. Another type is a pipe gauge, a transparent pipe connected vertically to the bottom of a rainwater tank. The level of the rainwater that enters the pipe shows the water level of the tank.

When there is a rainwater drainage pit or a rainwater trench, the drain is easily clogged due to poor maintenance causing the likelihood of mosquito larvae breeding. Since such neglect is possible, it would be wise to make a drainage pit permeable so that the rainwater in the pit can infiltrate into the ground. It is best to take preventive measures to avoid the stagnation of rainwater. This is an eco-friendly measure against mosquito problems.

Protecting Rainwater Utilization Facilities from Heavy Rain

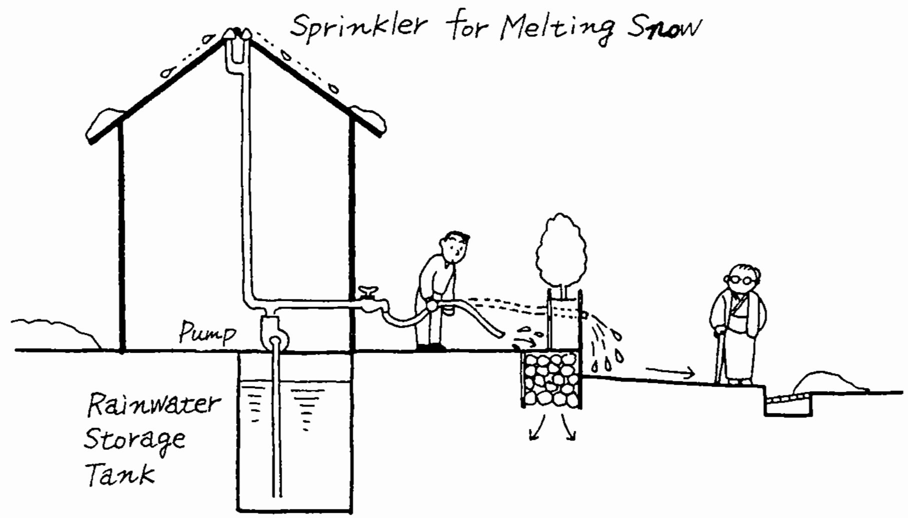


Rainwater Collecting Pipe with Devices to Deal with Heavy Flash Rain

When a great amount of rainwater gushes into a storage tank through a rainwater collecting pipe in heavy rain, soil and sand accumulated at the bottom are stirred up causing equipment trouble. What is worse, excess water will overflow. When collecting water from a roof, an inlet control device should be incorporated into a roof drain, or a concrete frame should be built surrounding the roof drain so that rainwater can be prevented from gushing into the collecting pipe. These measures alone are insufficient because rainwater stays on roofs temporarily which may cause water leaks. Therefore, an outlet for overflow water should be made in addition to the collection inlet.

The diameter of the rainwater collecting pipe, in this case, should be smaller than that of the overflow pipe. A short pipe for relieving the pressure of the collecting pipe should be attached to the vertical part of the collecting pipe to prevent abnormal pressure from being produced

Stored Rainwater Can Help in Occasional Snowfalls

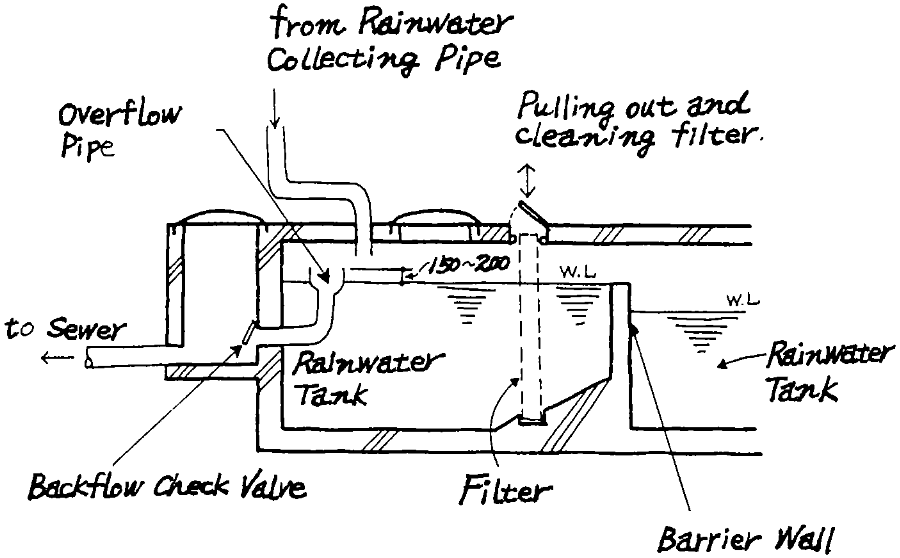


Melting Snow Using Rainwater

inside. For small-scale rainwater utilization equipment for home use, a detachable collecting pipe is an effective solution. The collecting pipe is removed when heavy rain is forecasted. Another way is to empty the rainwater tank by draining the water in advance.

Concerning the precautionary measures for snowfalls, stored rainwater is of great help. Every time heavy snow falls in urban areas unaccustomed to snow, confusion results: trains derail, cars skid triggering accidents, and people slip and fall ending up in the hospital. To prevent these from happening, sprinkle stored rainwater over roofs, gardens and roads to melt the snow. The rainwater utilization system of Ryogoku Kokugikan is equipped with such a snow melting device. At home, this can be done without installing any special equipment.

Be Careful of Level Differences in the Tank, Pipe and Trench

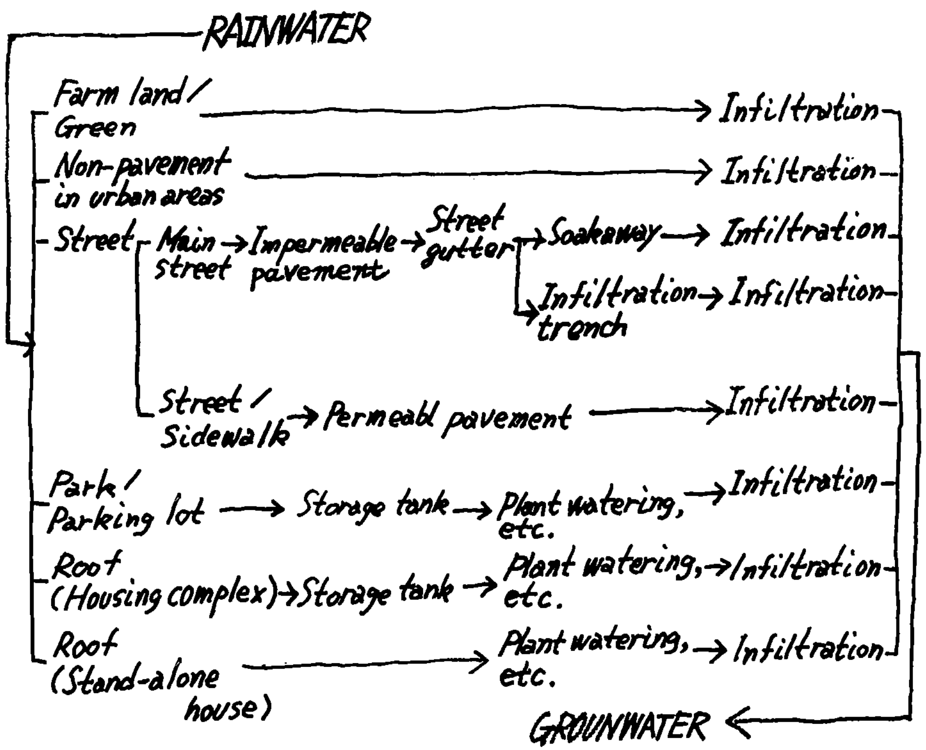


The rainwater overflowing from a rainwater storage tank is to be discharged through an overflow pipe into a soakaway to infiltrate. The overflow pipe only has water running through it during rainfall, and it can be a route for mosquitoes to enter the rainwater storage tank. Putting a net over the outlet of an overflow pipe will prevent their invasion.

For underground rainwater tanks, backflow could happen due to the level difference between the water of a tank and a soakaway. It is necessary to be careful of the level at which an overflow pipe is attached and also to install a backflow check valve. An air gap should be fully taken at the end of the discharging side of the overflow pipe.

When a drainage pit needs to be constructed to the overflow pipe, it should conform to the soakaway structure with a permeable bottom. When installing a pump for overflow, a backflow check valve should also be installed and steps should be taken against entry of mosquitoes

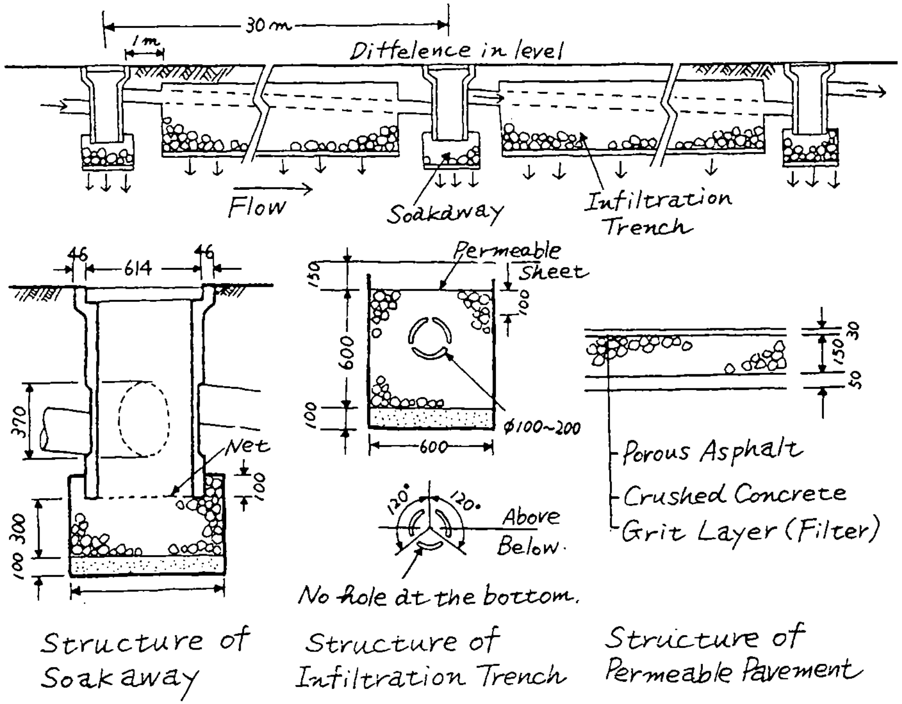
Preventing Backflow with a Backflow Check Valve



from the discharging side as in the case of a pipe without a pump.

Overflowing water from a rainwater tank is precious rainwater, a blessed gift from Nature. It is important to try not to discharge it into sewers, and to contribute to the prevention of urban floods as well as to the restoration and secureness of sound regional water circulation. Even if you have no choice but to discharge overflow rainwater directly into sewers because of site restrictions or other reasons, you should be careful of the points that are mentioned earlier in attaching an overflow pipe.

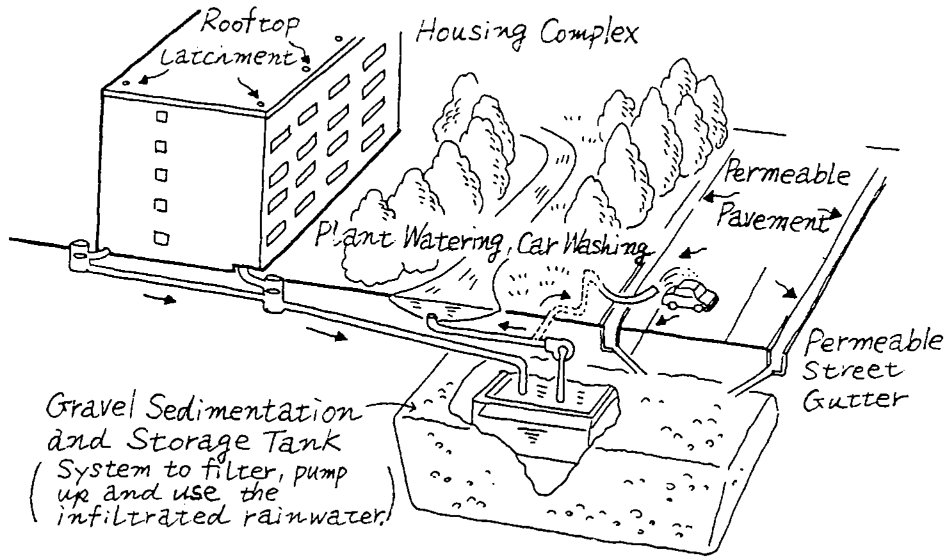
Installing an Infiltration Trench and Soakaway



Not only collecting rainwater from roofs into storage tanks and using it, but also infiltrating overflow water and rainwater in open areas into the ground through infiltration trenches will regenerate sound regional water circulation and be effective for urban flood control. Especially in urban areas underground infiltration of rainwater revives dried-up groundwater, prevents subsidence, cultivates greenery, and moistens the air.

Among devices to infiltrate rainwater into the ground are infiltration trenches, soakaways, infiltration ditches, infiltration wells, and permeable pavements. Infiltration trenches, soakaways, and permeable pavements apply to individual residences. Rainwater flowing through a downspout is induced into an infiltration trench or a soakaway and is gradually infiltrated into the ground. Large grounds like parking lots or roads should have permeable surfaces minimizing

Rainwater Utilization → Underground Infiltration → Groundwater Recharge → . . .

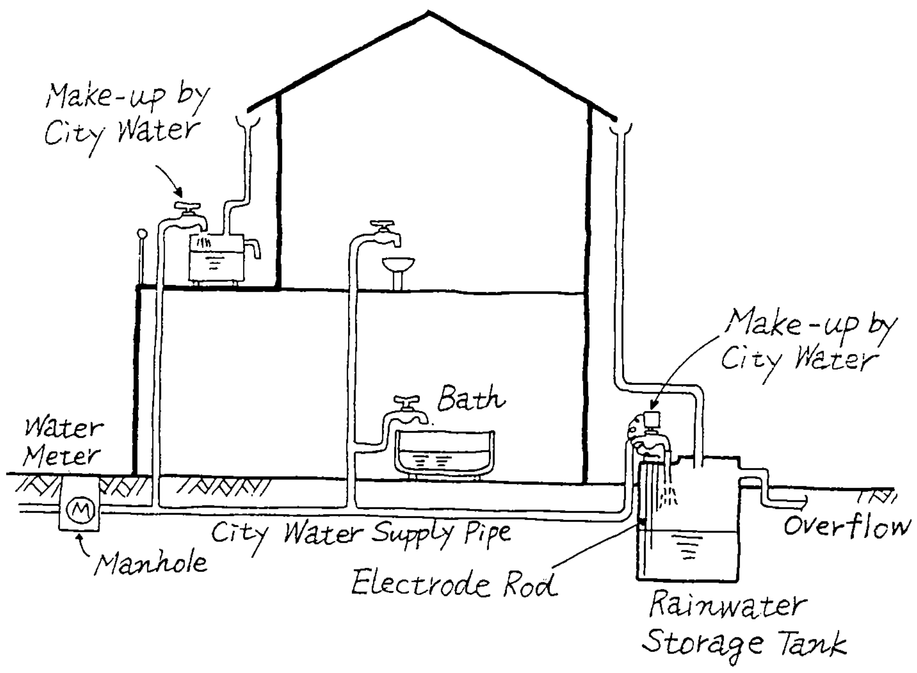


Rainwater Utilization and Infiltration

rainwater run-off into street gutters.

Not only overflow water from rainwater storage tanks but also rainwater used for washing cars, washing clothes, cleaning, and cooling should be returned underground. This is a gentle consideration for the surrounding underground and greenery. One report states that the Musashino Plateau in Tokyo is experiencing difficulty in growing cedars and other trees that require much water around the roots. Rainwater infiltration promotes groundwater recharge, saves and cultivates greenery, revives groundwater, and controls the "heat island phenomenon" in urban areas. Restoration of once-dried-up springs can be also expected. Rainwater utilization, underground infiltration, groundwater recharge, and vegetation growth are all intertwined as already mentioned in previous chapters.

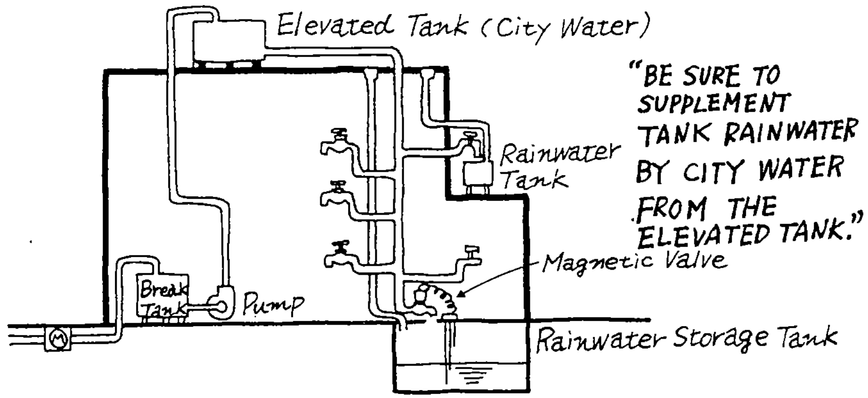
Supplementing Rainwater by City Water

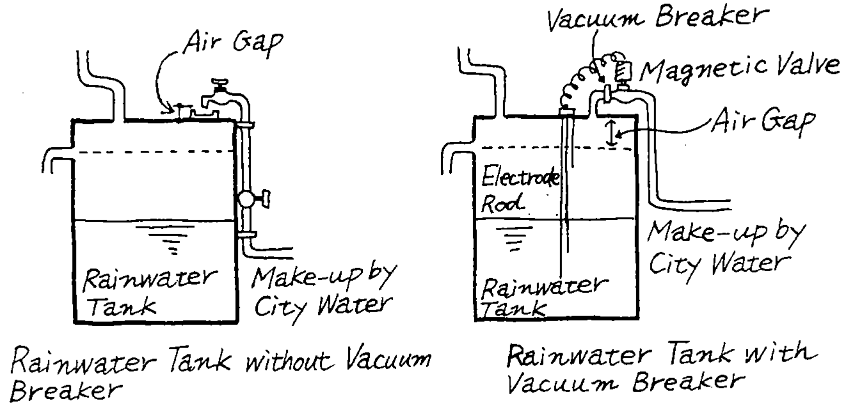


When rainwater is used for flushing, toilets become unusable when the rainwater storage tank runs out of water. It is necessary to supplement tank rainwater by city water and ensure a certain quantity of water in a storage tank when there is no rain. Large-scale rainwater utilization facilities are designed to be supplemented by city water automatically with a float valve or an electrode rod reacting to open the valve of the make-up water pipe when the tank water level falls below a certain point. The tank water may also be supplemented simply by opening the valve by hand when necessary.

When an elevated tank is installed for city water supply, make-up water should be also provided from this elevated tank to the rainwater storage tank. City water consumption is less in buildings using rainwater than in other buildings, so city water tends to be stored for a long time in elevated tanks deteriorating water quality. Using city water to

Supplementation through a Make-up Water Tank is Preferred

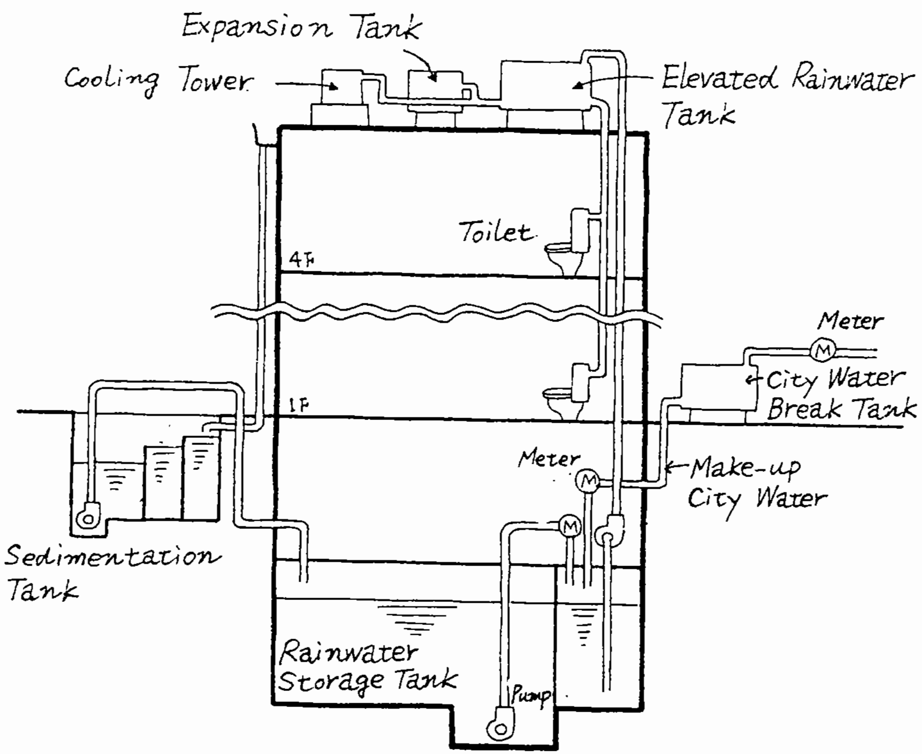




supplement tank water contributes to the metabolism of water and maintains its quality. When the capacity of the elevated tank is calculated on the assumption of rainwater utilization, there is no needless water storage in the elevated tank, so the rainwater storage tank should be connected directly to the break tank.

Whether through an elevated tank or by the direct connection with a break tank, care should be taken not to trigger backflow from the rainwater storage tank to the make-up water pipe. Usual measures against backflow include making an air gap between the outlet of the make-up water pipe and the rainwater storage tank inlet, and installing a vacuum breaker, a device to increase inside pressure by automatic air suction when negative pressure is produced inside the make-up water pipe. In addition, a "make-up water tank" should be installed to the make-up water pipe just before the rainwater storage tank, if possible.

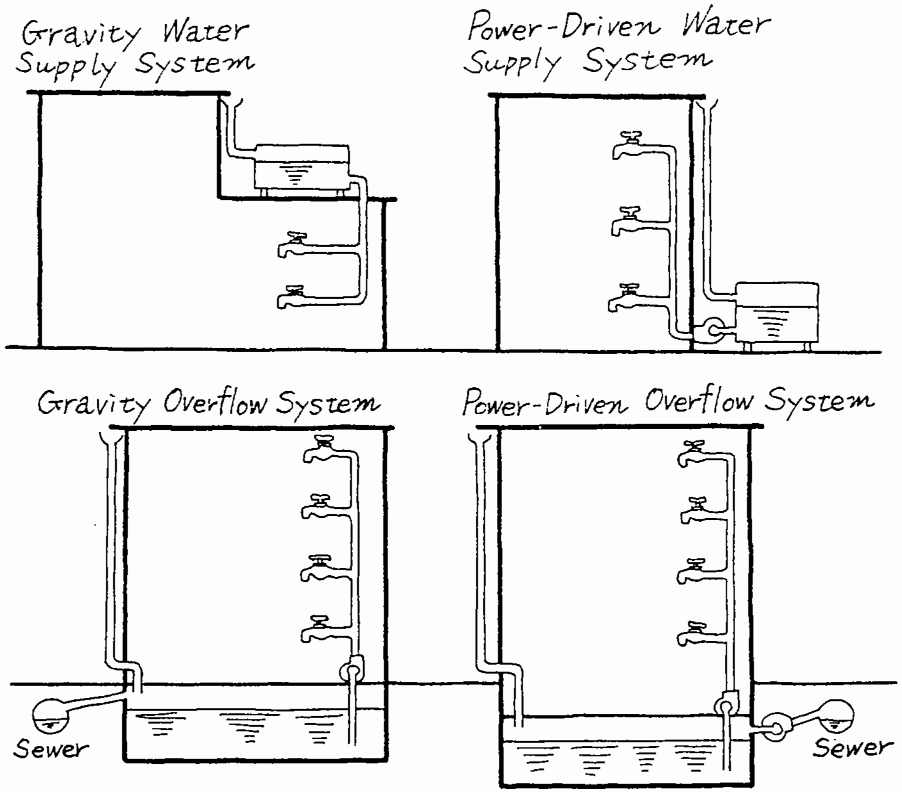
Water Supply from an Elevated Rainwater Tank



In tall multi-story buildings city water is drawn into a break tank through a supply pipe from a main pipe under a road. The water is then supplied to each room. The break tank is usually installed either aboveground or underground. If water is supplied only by a pump directly from the break tank to each room, the water pressure becomes too strong or too weak depending on the floor height. Adjusting the pressure requires a complicated device, so an elevated tank is installed on the rooftop into which water is pumped up from the break tank below. Water is then supplied to each room by gravity.

An elevated tank is sometimes used in the rainwater utilization system. The material and structure are basically same as those for the city water supply system, but care should be taken to avoid materials through which light easily penetrates such as FRP and to use light-proof materials instead so that algae do not grow inside tanks.

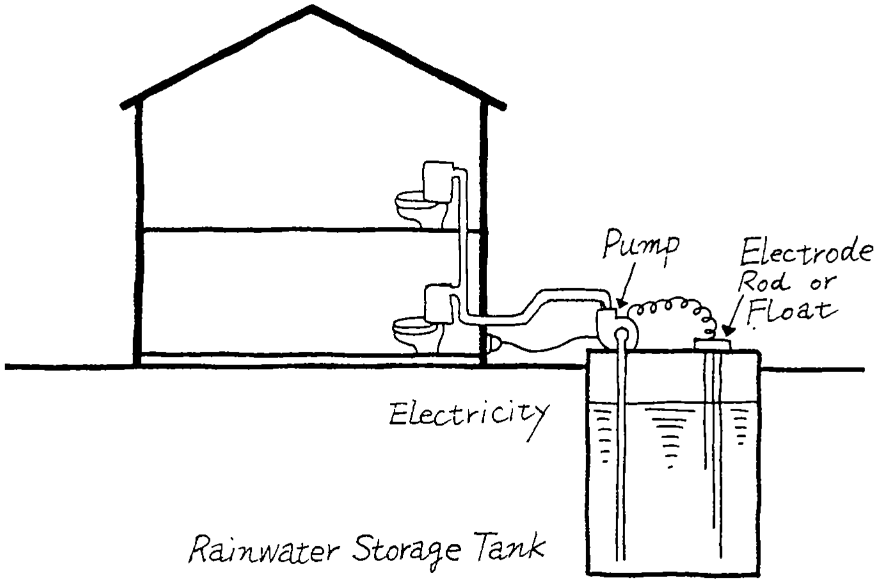
Pumping System for Stand-Alone Houses



As previously mentioned, a make-up water tank should be installed to the make-up water pipe to supplement rainwater by city water, maintain the pressure inside the make-up water pipe, and prevent the backflow of rainwater into the city water pipes. When an elevated tank for rainwater is installed, this elevated tank can also serve as a make-up water tank. That is, it is possible to supply city water from the elevated city water tank directly to the elevated rainwater tank.

An elevated rainwater tank is not necessary for low-rise buildings such as stand-alone houses. Installation does not cause an adverse effect, but increases construction and maintenance costs. Directly pumping-up water supply is recommended.

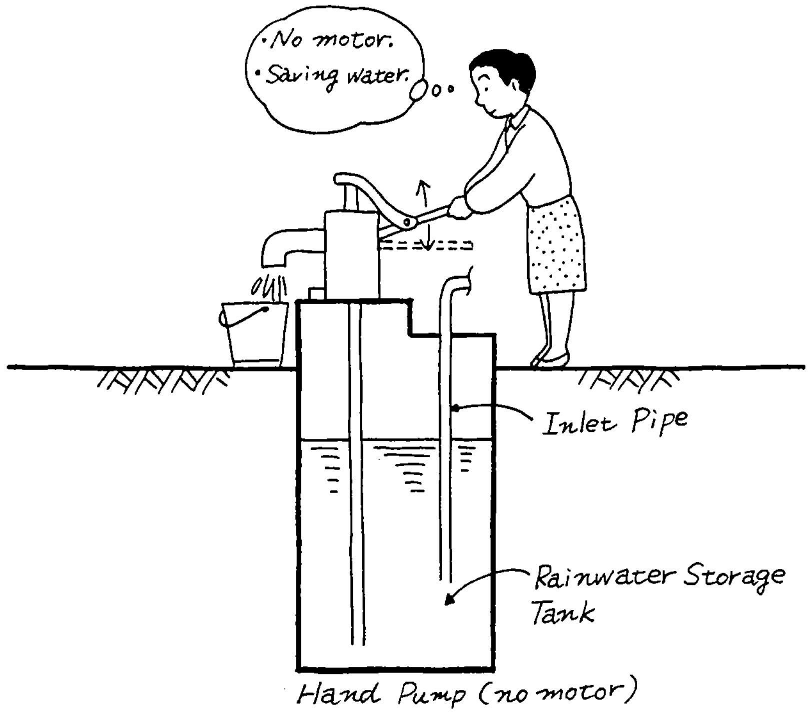
Pumping System is Same as for City Water



A water pump is necessary to bring water up from a rainwater storage tank aboveground or underground to an elevated rainwater tank on a rooftop, or to supply water to toilet flush tanks on the second floor and above. There are two kinds of water pumps, submersible pumps and above-floor pumps. As for the both pumps, small types operate on 100-volts and 200V for large ones. An electrode rod or a float to detect water level should be attached to a rainwater storage tank so that a water pump will stop automatically when the storage volume decreases below a certain level. This is the same mechanism used in city water break tanks.

Two water pumps should be installed for large-scale rainwater utilization as in the case of city water break tanks. When one of the pumps fails, changeover to another one is possible, uninterrupting pumping. In small-scale rainwater utilization for stand-alone houses,

Realizing the Importance of Rainwater Utilization by Using a Hand Pump

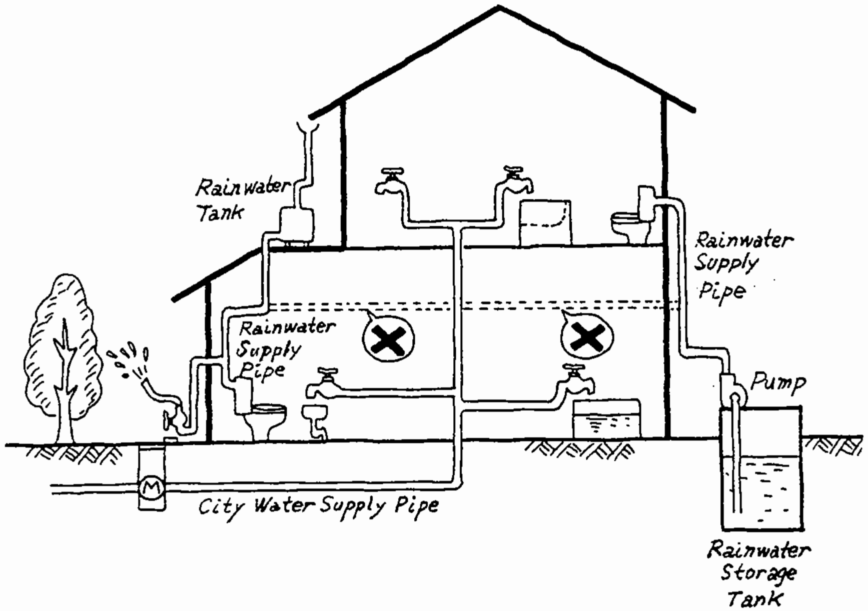


Eco-Friendly System that Can be Used in Power Failure

one water pump would be sufficient if repairs can be prompt in breakdowns. Regarding the model, small types used for wells could work in supplying water to toilet flush tanks. A hand pump could function satisfactorily in using rainwater for watering plants or washing cars.

A hand pump works in power failures. Furthermore, pumping a handle each time reminds people of the significance of rainwater utilization as well as the concept of saving water. Even if it is troublesome, a hand pump is more valuable than a mechanical pump that provides as much water as you like by opening a faucet. So a hand pump is recommended for domestic use particularly considering the education of children.

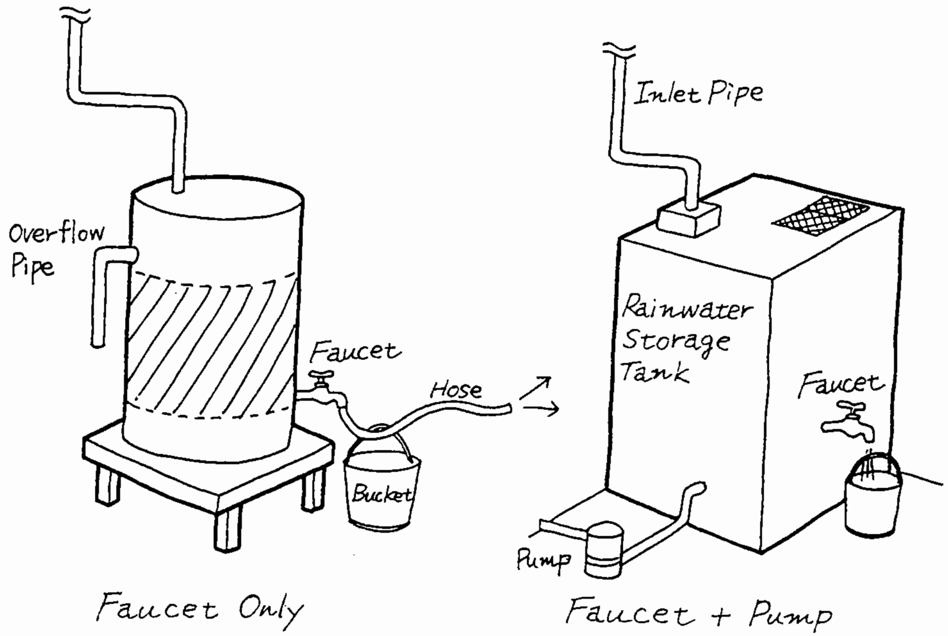
Never Connect a Rainwater Pipe to a City Water Pipe!



Rainwater supply pipes are installed for outdoor and indoor use as a separate system from city water pipes. Care should be taken that a rainwater supply pipe never be connected directly to a city water supply pipe. The direct connection of these two pipes, known as "cross-connection," would cause rainwater to flow into city water pipes and contaminate the water. Measures to prevent cross-connection are recommended such as painting rainwater supply pipes for easy identification. When a house is newly built, extended, or renovated involving plumbing work, ensure that city water pipes and rainwater pipes are not connected together by mistake.

A faucet may be attached to a rainwater storage tank in a yard or on a balcony so rainwater runs from the faucet into a bucket or a watering can directly or through a hose connected to it. The installation cost is very inexpensive because the installation of rainwater supply pipes

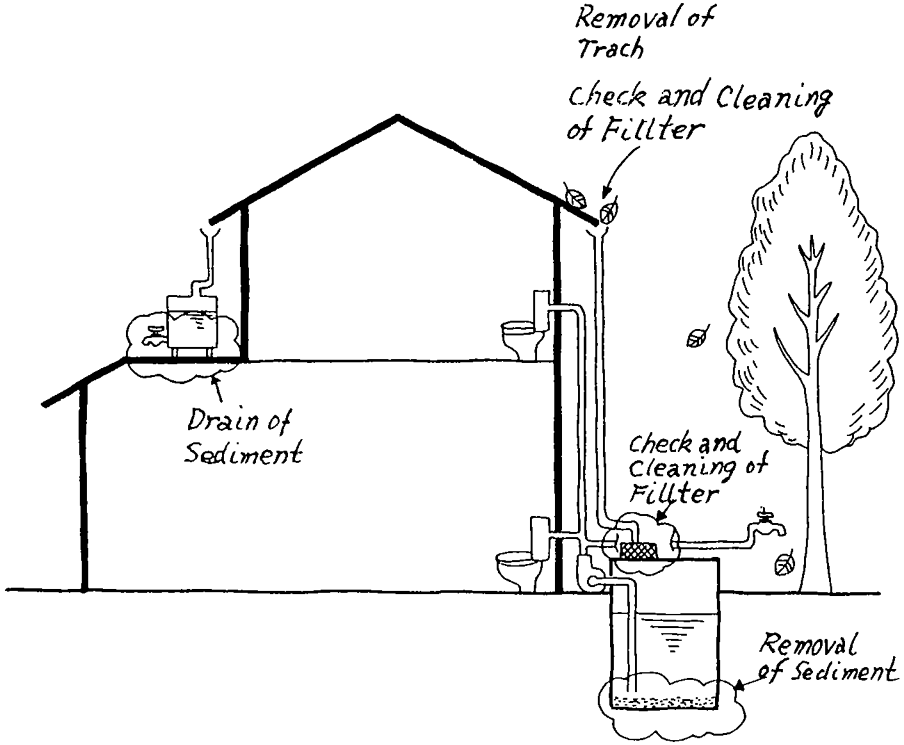
Be Sure to Attach One Faucet at Least



is not necessary. The faucet diameter should be generally about 13 mm although it varies depending on where and how rainwater is used. The faucet should be installed at the lower part of the rainwater tank, but slightly up from the bottom because sediment in the tank would flow out together if the faucet were too close to the bottom.

When a rainwater storage tank is placed on the ground, at least one faucet should be attached to draw water directly from the tank, even if rainwater supply pipes and a water pump are installed. In this way, sampling tests of water quality are facilitated.

Never Neglect Regular Checks and Cleaning!



Maintenance of rainwater utilization equipment is very important for the collection, storage, and use of clean rainwater. This responsibility rests with the residents. It is a good idea for family members to make an yearly plan rotating responsibilities:

① Catchment area—Trash and animal excreta in catchment areas including roofs must be cleaned off regularly. Especially in the season with many fallen leaves frequent cleaning is required to prevent downspout clogging.

② Grit chamber, sedimentation tank, screen—In the off-rainy season grit chambers and sedimentation tanks should be cleaned completely. For ground-level rainwater tanks, sediment is removed from the drain pipe at the bottom of the tank. The inside should be cleaned every one to five years depending on the volume of sediment. Trash clinging to screens should be frequently removed.

Use a Working Plan to Maintain Rainwater Utilization Facilities

— Let's Make a Check Note ! —

Part	Contents of Check	Period	Cleaning Interval	Check, Cleaning	
Roof	Removal of leaves, bird excreta, etc.	1x/yr	1–5 Years	94/5/15	
Gutter/Downspout	" /Leaks	2x/yr	1–5 Years	"	94/11/13
Screen	Removal of leaves, dirt, etc.	1x/yr	1–3 Years	"	94/6/17
Sedimentation tank	Check and removal of sediment and dirt	2x/yr	1–3 Years	"	94/11/3
Rainwater tank	"	"	1–5 Years	"	"
Pump	Unusual operation	"	—	"	"

③ Filter—Soil, sand and trash caught by filters should be removed regularly. Filter material should be replenished or replaced when it decreases or when it becomes unable to extract soil and sand. The inside should be cleaned every one to three years.

④ Rainwater storage tank—Inside checks should be conducted about twice a year when sediment is removed. The inside should be cleaned according as necessary. Thorough maintenance of catchment areas, sedimentation tanks and filters reduces the frequency of inside cleaning to once a year to every five years.

⑤ Rainwater supply equipment—Make sure that mechanical devices such as pumps are working normally by checking at least every three months. Other devices should undergo a check about every six months and be maintained in the same way as city water supply equipment.

Waikiki Means Spring Water – Hawaii

Groundwater-Rich Eastern Parts, and Western Parts Using Rainwater

The 29 members of the technical study group visited Hawaii in March 1994 to see how rainwater is used. We wondered what the water resource of 1,160,000 residents and 6,000,000 tourists per year was. On the island of Oahu, groundwater is the main water resource. In fact Waikiki means "spring water." It can be said that volcanic activity created a huge water jar in the island underground.

Heavy rain falls on the eastern side of the mountains when clouds full of moisture are blown from the sea over the mountains by northeast trade winds. The annual rainfall is 7,620㎜, which is 5 times that of Tokyo. Most of the rainwater is preserved in the impermeable layer of volcanic rocks and the water serves as a resource for city water. In the areas without a volcanic rock layer, rainwater permeates down into the deep aquifer called "water lens." Sea water also soaks into the stratum, but rainwater floats over sea water since it is lighter than sea water. In recent years, however, the problem of salination has arisen due to the excessive pumping of groundwater.

On the island of Oahu, rainwater has been collected for daily use in the hills with no city water supply and little groundwater, and in the western side of the mountains with scarce rainfall. Nearly 110 individual households use rainwater there. One hundred and twenty year-old redwood water tanks with capacities of 20 to 50m^3 found on the island of Hawaii substantiate the fact that rainwater use began there long ago. Nowadays tanks are made of concrete or steel since redwood is very expensive. When water runs short in some places that often have no rain for a long period, water is brought in and supplied by trucks at 9 dollars per cubic meter.

The quality of rainwater in Hawaii is high because the air is not polluted. However, other problems exist. Rainwater catchment areas and street gutters tend to become dirty due to leaves and bird excreta since houses are surrounded by trees. Moreover, lead may dissolve and transfer to rainwater from roof paints and rustproof nails making maintenance hard. Harvey E. Finch from the island of Hawaii has come up with a screen to put into downspouts to remove leaves. He stores rainwater after filtering and chlorinating it. In Hawaii, no government aid is extended to rainwater utilization facilities developed by the local residents. The people seem to think that they should secure water on their own if there is no city water supply because they live there by choice.

REFERENCES

PROFILES OF RAINWATER UTILIZATION

VISITING FACILITIES WITH RAINWATER UTILIZATION SYSTEMS

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PROFILES OF RAINWATER UTILIZATION

VISITING FACILITIES WITH RAINWATER UTILIZATION SYSTEMS

Kiyoshi Sato's House

This is a stand-alone house built in 1987. Since then many magagines and newspapers have featured this house as a forerunner of structures employing full-scale rainwater utilization systems.

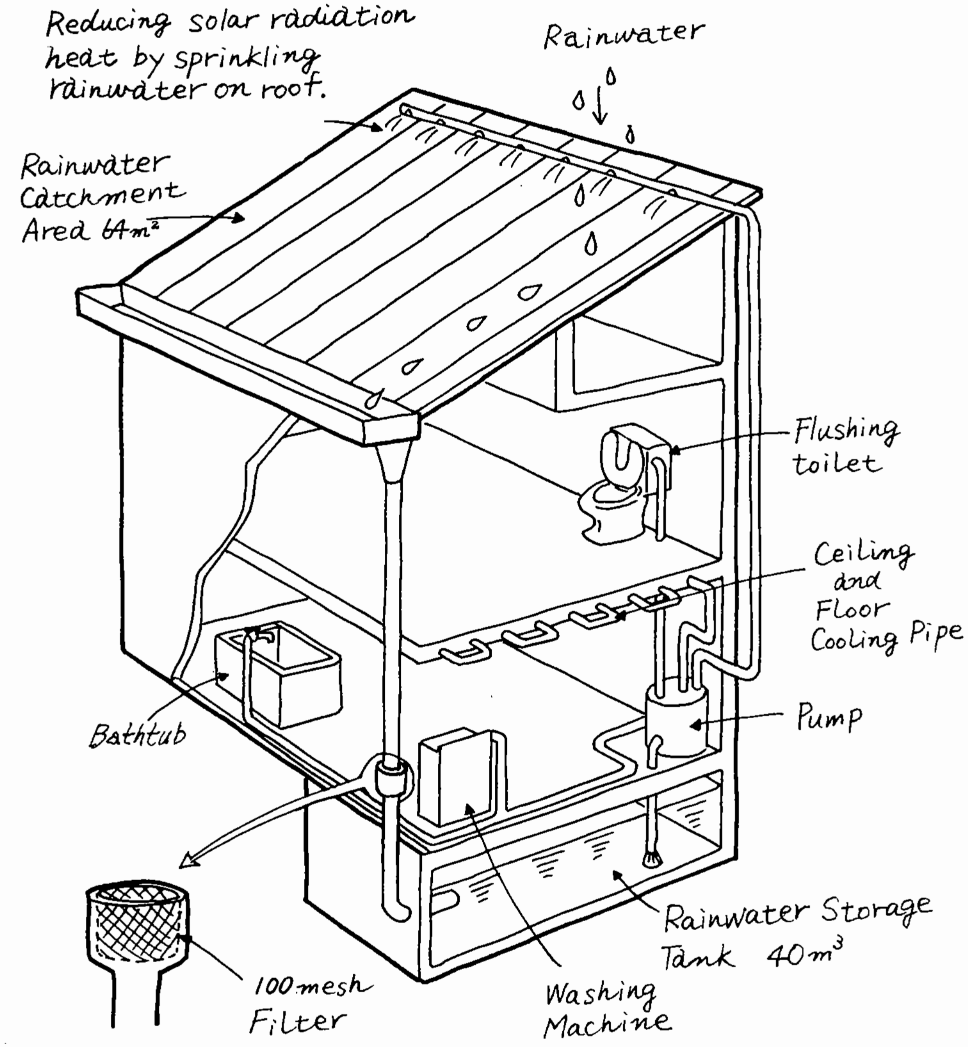
This house has a 40m³ underground rainwater storage tank into which rainwater is collected from its roof. The stored water is mainly used for flushing toilets and the water is also used for a washing machine if there is enough.

This house is located in the river basin of the Shingashi River, a tributary of the Ara River, which frequently floods in heavy rain. Therefore, when architect Kiyoshi Sato designed his new house, he decided to install a large underground rainwater storage tank to use rainwater at home thinking that it would help control floods.

This house demonstrates many ideas of using rainwater in individual houses. For example, he is trying to cool the rooms by spreading many rainwater pipes throughout the back of the ceiling. The room temperature drops about 3°C, when rainwater passes through the pipes. Sato says that he can live comfortably even in the Japanese sweltering summer only with some electric fans supplementing this system. He is also trying to cool his house by sprinkling the stored rainwater on the roof and cooling the concrete structure. In addition, he is looking for the best filter system to make rainwater even cleaner: filling soil in the 70mm-wide eaves gutters and setting strainers and screens in the inlet pipe to the storage tank.

Data ——

Building Use: Stand-Alone House
Materials: Reinforced Concrete (1st and 2nd floors), Wood (3rd floor)
Total Floor Area: 130m²
Rainwater Uses: Toilet Flushing, Plant Watering, Cooling Water for Air Conditioner
Rainwater Catchment Area: Roof, 64m²
Rainwater Storage Tank: Underground, 40m³
Location: Saitama Prefecture
Construction Date: December 1987
Designer: Alternative Technology Planning Architectural Firm



Professor Suzuki's House

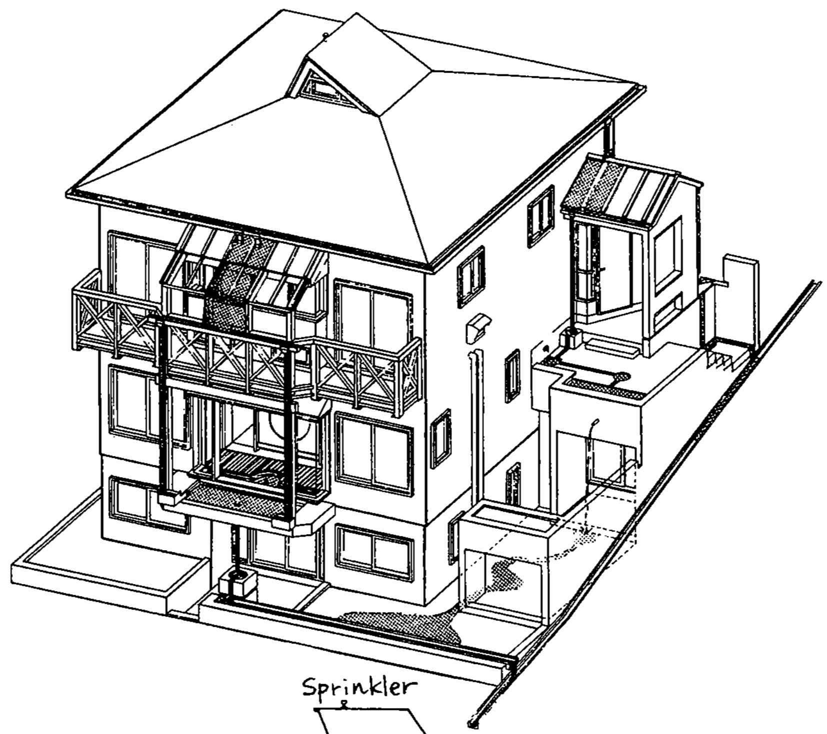
This is the best example how to "design rain." Many devices have been introduced to this house to incorporate rain into the daily lives of the occupants and to live in harmony with rain. The structure was designed by Nobuhiro Suzuki, a professor of the Science University of Tokyo. He is also well-known as one of the leading architects specializing in landscape architecture using water.

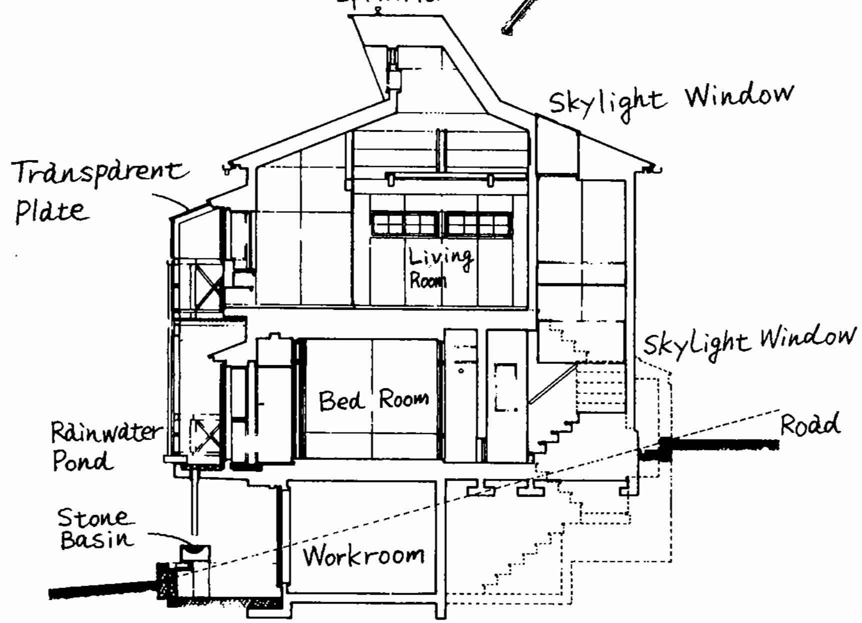
In front of the living room on the second floor is a polycarbonate panel structure that also serves as a skylight window. We can enjoy the interesting patterns painted by the rain on the panel. On the balcony of the first floor is a rainwater pond with a "mini-fountain" in its center. The fountain makes the pond surface ripple. A black bamboo bench sits beside the pond creating an exquisite combination. The pond also serves as a water resource and a "solar pond" to sprinkle water on the roof and cool the house by radiation. Rainwater flows in a wide polyvinyl chloride gutter crossing over the balcony. Rainwater flows down along the outside of a stainless pipe from the pond to a stone basin placed just under the balcony.

Children in the neighborhood can be seen washing their hands with the water and birds perch on the basin to drink it. The water overflows from the stone basin and runs past the front door making a small cascade. Then it slowly passes into the ground wetting white stones in the small courtyard. The courtyard also serves as a retarding basin to store rainwater temporarily in heavy rain.

Data——

Building Use: Stand-Alone House
Materials: Wood (1st and 2nd floors), Reinforced Concrete (basement)
Total Floor Area: 136m²
Rainwater Uses: *Mental Relaxation Purposes*, *Environmental Control Purposes*, Non-Drinking Purposes, Groundwater Recharge
Rainwater Catchment Area: Roof, 64m²
Rainwater Pond: Balcony, 0.2m³
Location: Saitama Prefecture
Construction Date: June 1989
Designer: Nobuhiro Suzuki





Minami Family House

This house was built not only to find ways to lead a more comfortable and convenient life, but also to find ways to live in harmony with the natural environment and to save the resources:

Rainwater utilization — A 20m³ rainwater tank was built under the floor.

All the water for toilets is supplied with the rainwater. If the tank is filled to its capacity, the excess water overflows and infiltrates through a soakaway.

Solar thermal power generation — Equipment to generate electricity from solar energy is set on the roof. Masako Minami sells electricity generated with it to the Tokyo Electric Power Company. Its generation power is 2.2kw/day and the monthly sales to the power company amounts to around 3,000 yen (30 dollars) per month.

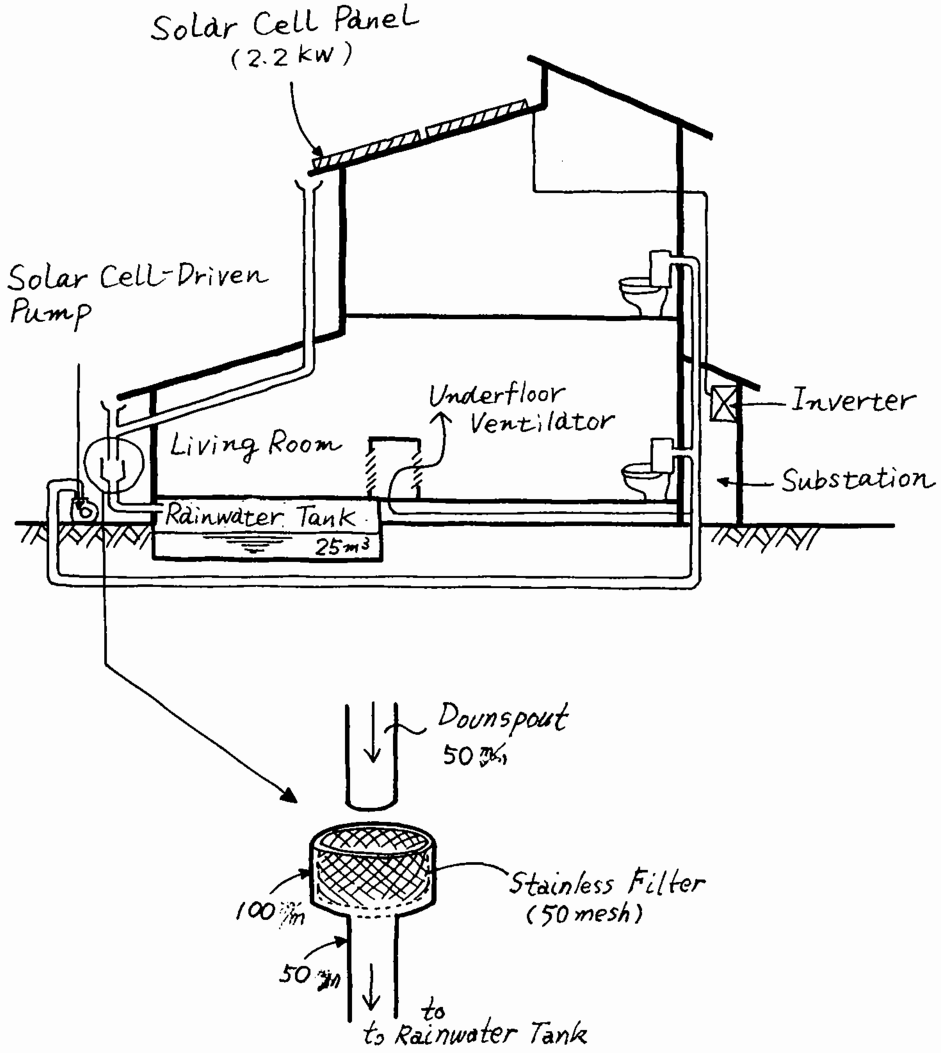
Solar water heater — This house has a solar water heater composed of glass panels and vacuum tubes. The controversial CFCs are unnecessary for this heater. This heater uses the pressure of city water, so hot water can be supplied around the house effectively.

Non-CFCs — The temperature under the floor remains at around 24°C even in summer. An underfloor ventilator was devised so that the cool air could be driven from under the floor into each room. This air-cooling system can be an alternative to conventional air-conditioners using CFCs as a coolant that are detrimental to the ozone layer.

Others — Most of the timber used for this house is domestic. A system to reuse bathwater for washing machines has also been employed.

Data ——

Building Use: Stand-Alone House
Materials: Wood (1st and 2nd floors)
Total Floor Area: 108m²
Rainwater Uses: Toilet Flushing, Plant Watering
Rainwater Catchment Area: Roof, 94m²
Rainwater Storage Tank: Underground, 25m³
Location: Chiba Prefecture
Construction Date: December 1993
Designer: Alternative Technology Planning Architectural Firm



Katsuko Nakayama's House

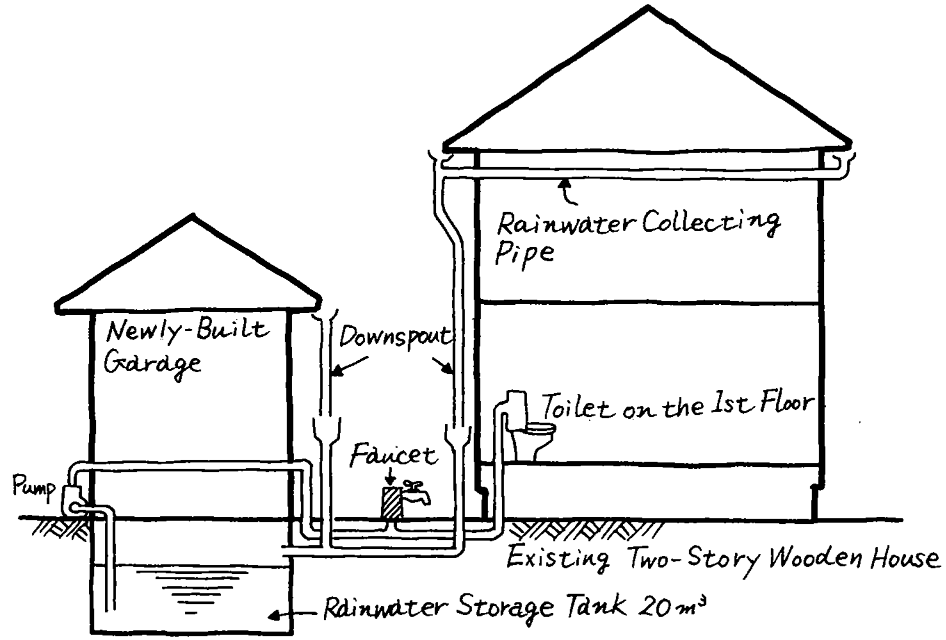
This is an example of an existing house that was renovated by installing a concrete rainwater storage tank underground. A garage was built on the ground above the tank.

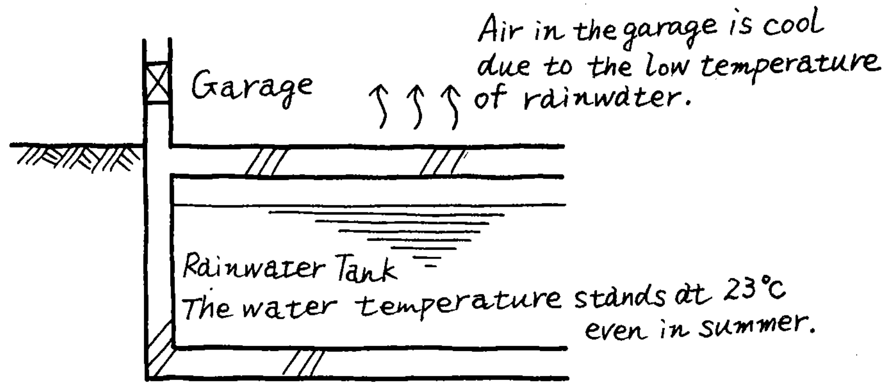
Katsuko Nakayama, the owner of this house, serves as a municipal assembly member of Machida City, Tokyo as well as being a homemaker. She has been sincerely tackling environmental problems. She thought that rainwater is sufficiently clean that people should not waste it by dumping it into sewers without using it. She renovated her house and installed a rainwater utilization system to demonstrate how to use rainwater hoping that the system would become popular in the community.

The stored rainwater is used for flushing toilets, washing cars and watering plants. The monthly average volume of the city water used at Nakayama's house is 10 m³, while the corresponding volume of the rainwater amounts to 5m³. In other words, rainwater accounts for one third of the entire 15m³ of water used at the house for a family of two.

Data——

Building Use: Stand-Alone House
Materials: Wood (1st and 2nd floors)
Total Floor Area: 138m²(house)+18m²(garage)
Rainwater Uses: Toilet Flushing, Plant Watering, Car Washing
Rainwater Catchment Area: Roof, 110m²
Rainwater Storage Tank: Underground, 20m³
Location: Machida City, Tokyo
Construction Date: June 1993
Designer: Alternative Technology Planning Architectural Firm





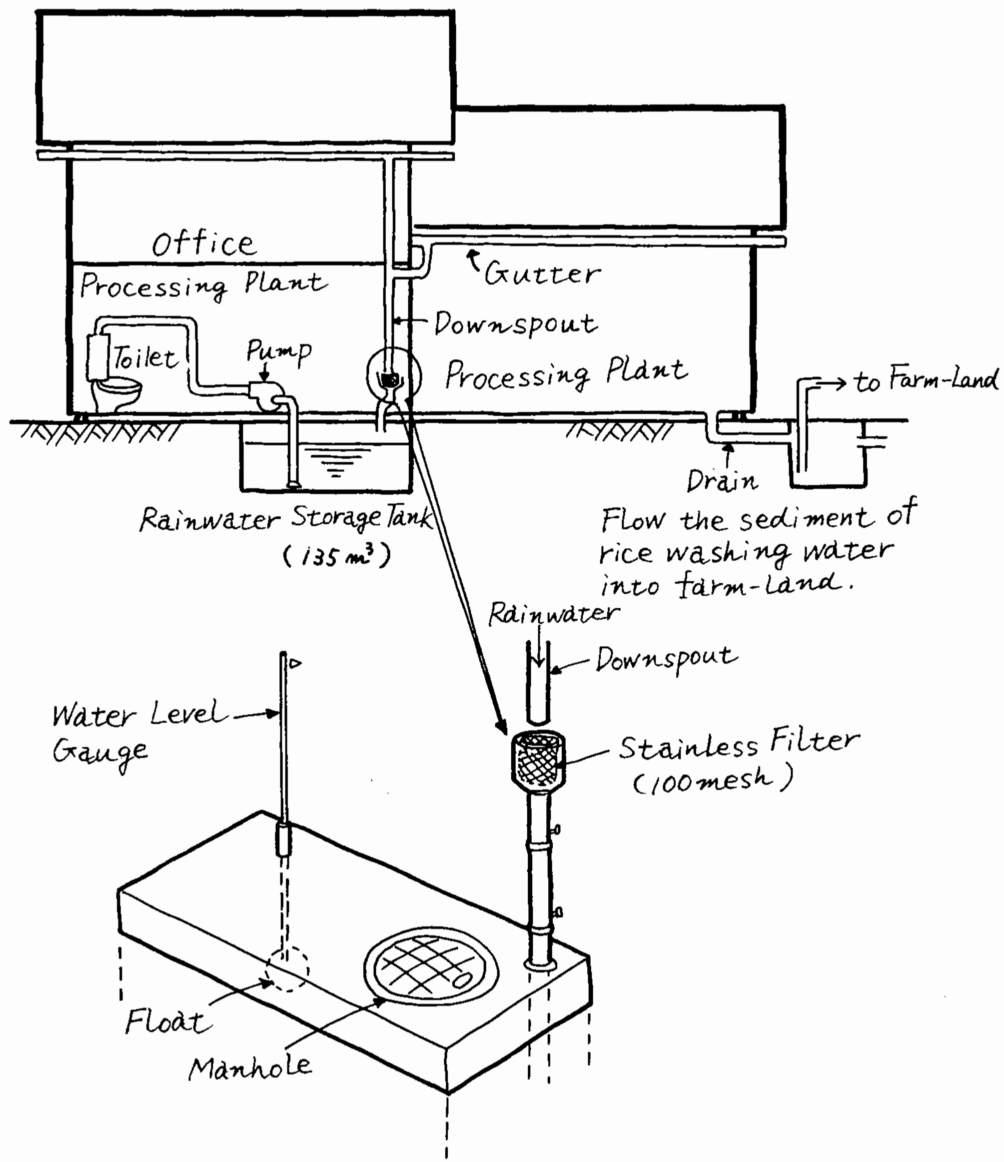
Mochi (Rice Cake) Processing Plant in Akita Prefecture

Akita is a rice-producing district and famous for its delicious rice. Since government policy changed toward partially opening the market to imported rice in 1994, farmers have been forced to worry about the competition with the foreign rice in addition to the damage from cool summers and the persistent pressure to reduce rice acreage from the national government. Therefore, nowadays the local farmers not only have to produce and sell delicious rice, but also have to process it into value-added products.

Under such circumstances, some local farmers in Ogata Village, Akita prefecture decided to build a cooperative *mochi* processing plant. A great amount of water is used for washing rice. The land of Ogata Village was reclaimed from the sea, so the quality of groundwater is not so high. Some residents obtain drinking water from other places. Therefore, the farmers planned to use rainwater for washing rice and reuse the used rainwater for farming after sedimentation treatment. As a result, a rainwater utilization system has been introduced into this processing plant.

A 135m³ rainwater storage tank was built underground. In the first stage of the plan, the stored water is used for flushing toilets and watering plants. In the future, the water is planned to be used for washing rice, the original goal. Hopefully, then, *mochi* will be popular nationwide as "Rainwater *Mochi*."

Data——
Building Use: Processing Plant
Materials: Wood (1st and 2nd floors)
Total Floor Area: 435m²
Rainwater Uses: Toilet Flushing, Plant Watering
Rainwater Catchment Area: Roof, 185m²
Rainwater Storage Tank: Underground, 135m³
Location: Akita Prefecture
Construction Date: December 1993
Designer: Alternative Technology Planning Architectural Firm



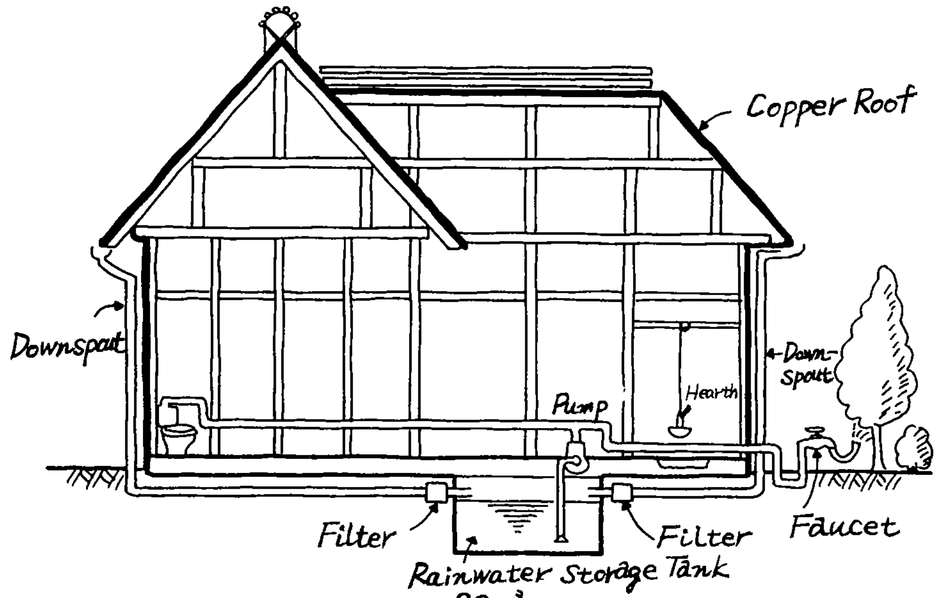
Buckwheat Noodle Restaurant

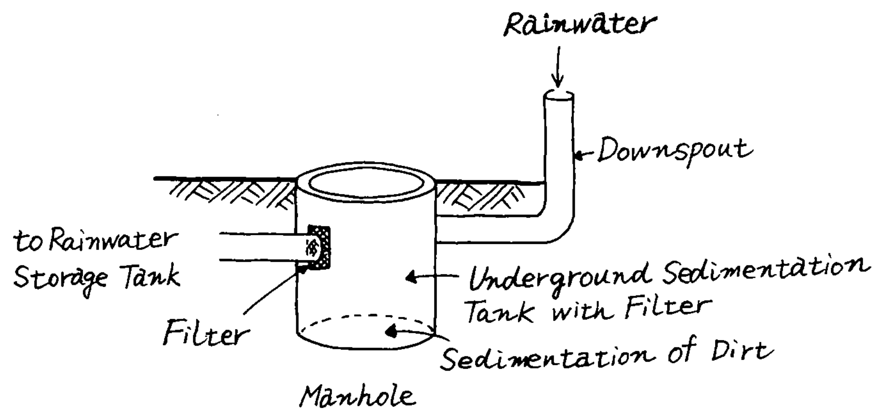
This buckwheat noodle restaurant was designed imitating a Japanese traditional L-shaped structure. It creates a quiet atmosphere with a copper roof and Japanese traditional style mud plaster walls. This building was designed from the eco-friendly point of view and was awarded a prize from Saitama Prefecture for its commitment to environmental protection in November 1993.

A concrete rainwater tank is installed under the restaurant floor and the stored water is used for flushing toilets and other non-drinking purposes. Rainwater is collected from the copper roof, so the collected water is slightly greenish due to the copper rust, but this is hardly noticeable.

The proprietor of the restaurant has been sincerely conscious of environmental problems and sternly requested the designer to install a rainwater utilization system. The sign on the toilet wall saying "This toilet is using rainwater" catches the attention of customers. Another unique point is that this restaurant uses a replenishible energy resource as part of its fuel for heating instead of using kerosene which contributes to the depletion of natural resources and adds to pollution.

Data ——
Building Use: Restaurant
Materials: Wood (1st and 2nd floors)
Total Floor Area: 250m²
Rainwater Uses: Toilet Flushing, Plant Watering
Rainwater Catchment Area: Roof, 200m²
Rainwater Storage Tank: Underground, 80m³
Location: Saitama Prefecture
Construction Date: February 1993
Designer: Alternative Technology Planning Architectural Firm





Apartment House "Clivia"

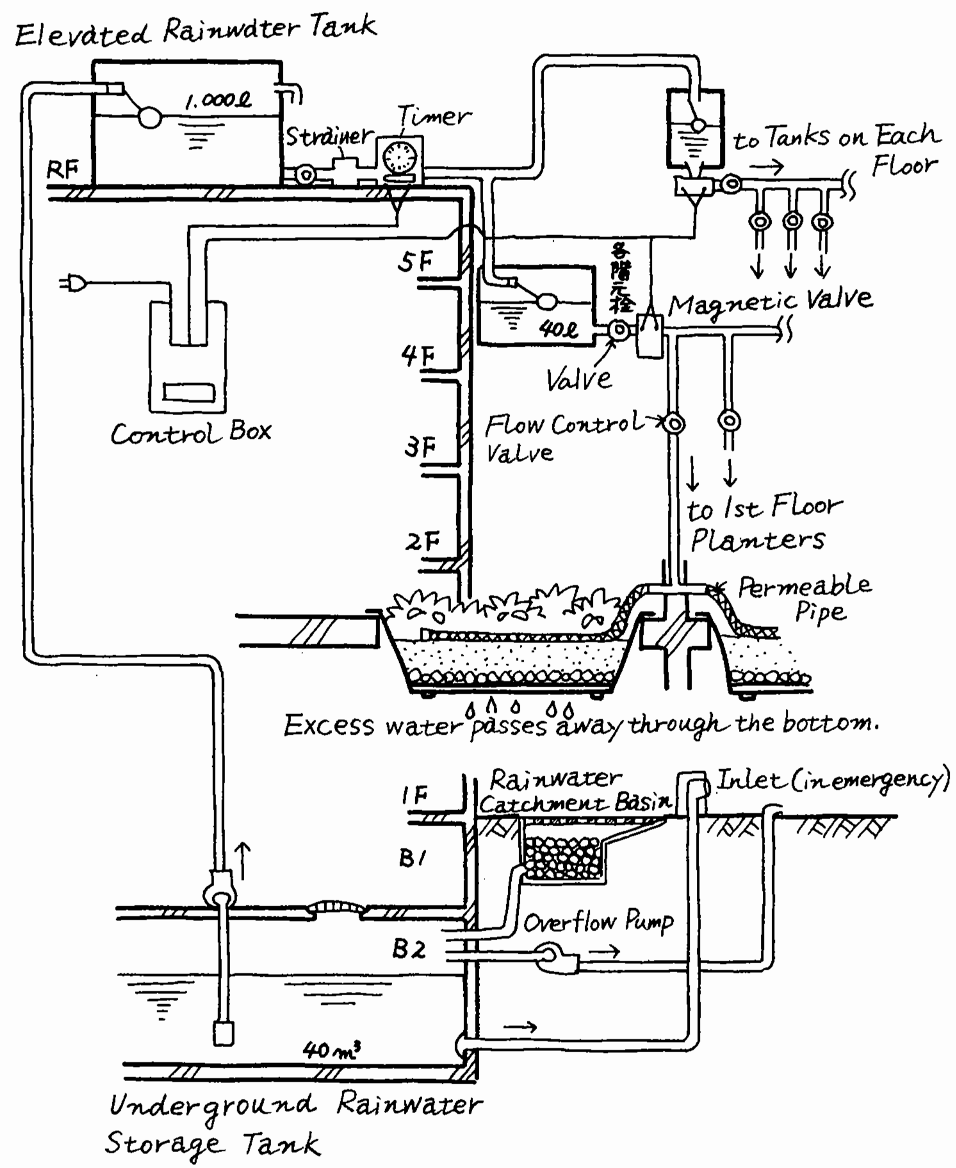
This apartment house is named after the flower "clivia." It is easy to understand that each balcony of this apartment house is full of greenery because the owner is a landscaper. It is truly amazing how the water is pumped up from a storage tank set on the second floor below ground level to automatically sprinkle greenery on each balcony.

The capacity of the rainwater storage tank is 40 m^3. Rainwater is collected from the rooftop and the flat ground surface paved with concrete around the building. The collected water is filtered through screens and is stored in the tank. The system is designed to use the rainwater for sprinkling greenery on balconies and for fire fighting.

In front of the building, there is an old tall chinquapin (chestnut family) tree and its green leaves are the symbol of this apartment house. The parking lot and the ground around the tree are paved with permeable material.

This is the best example of making the living environment more comfortable by linking rainwater utilization to vegetation. This building was awarded a prize from the Ministry of Construction in "Flower City Competition of 1991." The equipment to supply the rainwater automatically to each balcony is working properly.

Data——
Building Use: Apartment House
Materials: Reinforced Concrete (1st through 5th floors, basement)
Total Floor Area: 1,386m^2 (39 Apartments)
Rainwater Uses: Plant Watering, Fire Fighting
Rainwater Catchment Area: Roof, 800m^2
Rainwater Storage Tank: Underground, 40m^3
Location: Suginami City, Tokyo
Construction Date: April 1990
Designer: Oikawa Architectural Design Office



Environmentally-Conscious Housing Complex in Koganei City

This is a three-story housing complex employing the leading architectural techniques to protect environment: greening of the entire structure, a basement-radiant air-cooling system, a rainwater utilization system, solar cells and devices to reduce garbage.

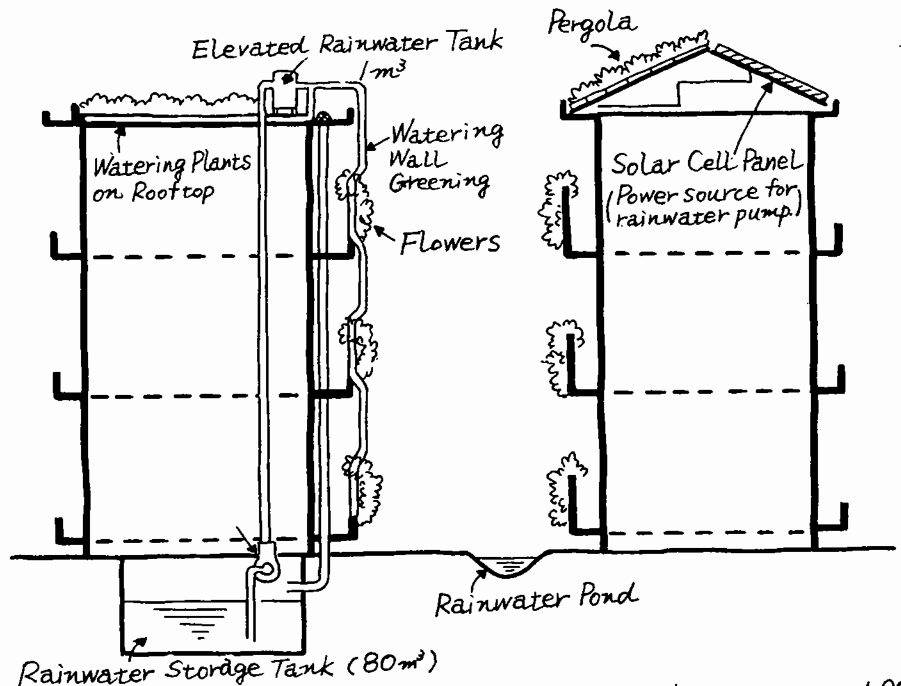
The rooftops have been filled with soil, and pergolas and vegetable gardens have been made. The soil and the creepers hanging from the pergolas prevent the concrete rooftops from overheating by the sun and help cut the heat radiation of the top floor apartments. In addition, the soil can aid in the control of any flooding around the buildings in heavy rain by absorbing the rainwater on the rooftops.

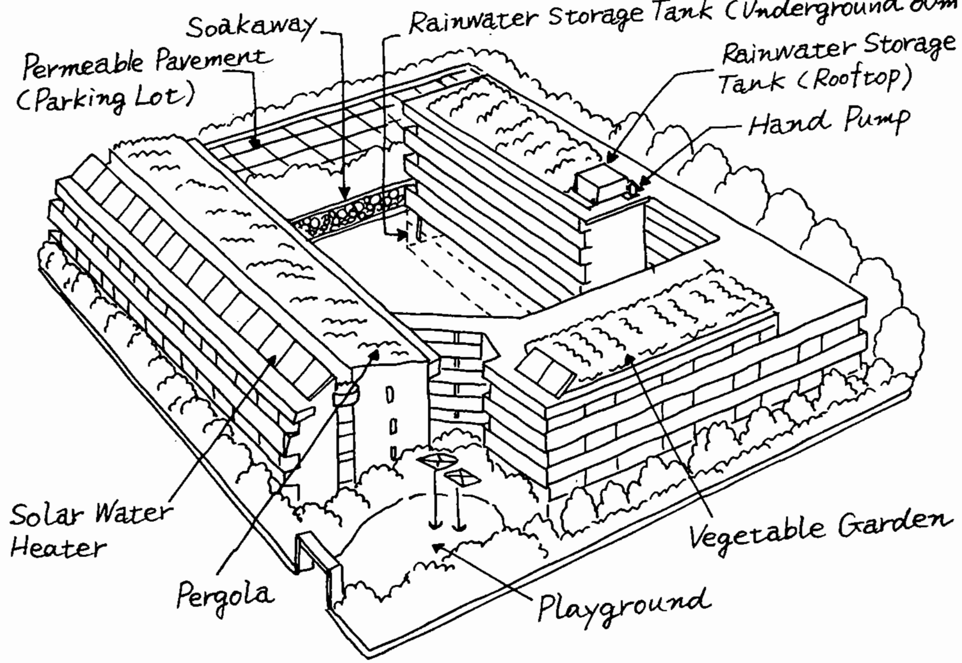
Balconies and outside walls are full of greenery creating a refreshing atmosphere. Rainwater is used for sprinklers. The rainwater is collected from the rooftops and stored in an underground tank. The stored rainwater is pumped up with a solar cell-driven pump to the elevated tank on the rooftop. Part of the rainwater is also fed to a pond in the courtyard. A windmill stirs the pond water while maintaining the quality of water and also delighting the residents' sense of beauty.

Koganei City offers to subsidize the implementation of rainwater infiltration systems. Therefore, soakaways have been installed in this housing complex and the excess rainwater is infiltrated into the ground through the soakaways and permeable pavements.

Compost containers have also been installed on the rooftops. A device to ventilate rooms through underground pipes has also been partially introduced.

Data ——
Building Use: Housing Complex
Materials: Reinforced Concrete (1st through 3rd floors)
Total Floor Area: 2,960m²
Rainwater Uses: Sprinklers(for Rooftop Gardens and Balcony Plants), Streams, Pond
Rainwater Catchment Area: Roof, 600m²
Rainwater Storage Tank: Underground, 80m³
Location: Koganei City, Tokyo
Construction Date: December 1994
Designer: Sekkei Keikaku Co., Ltd. and
Alternative Technology Planning Architectural Firm





Toppan Printing Co., Ltd. Honjo GC Building

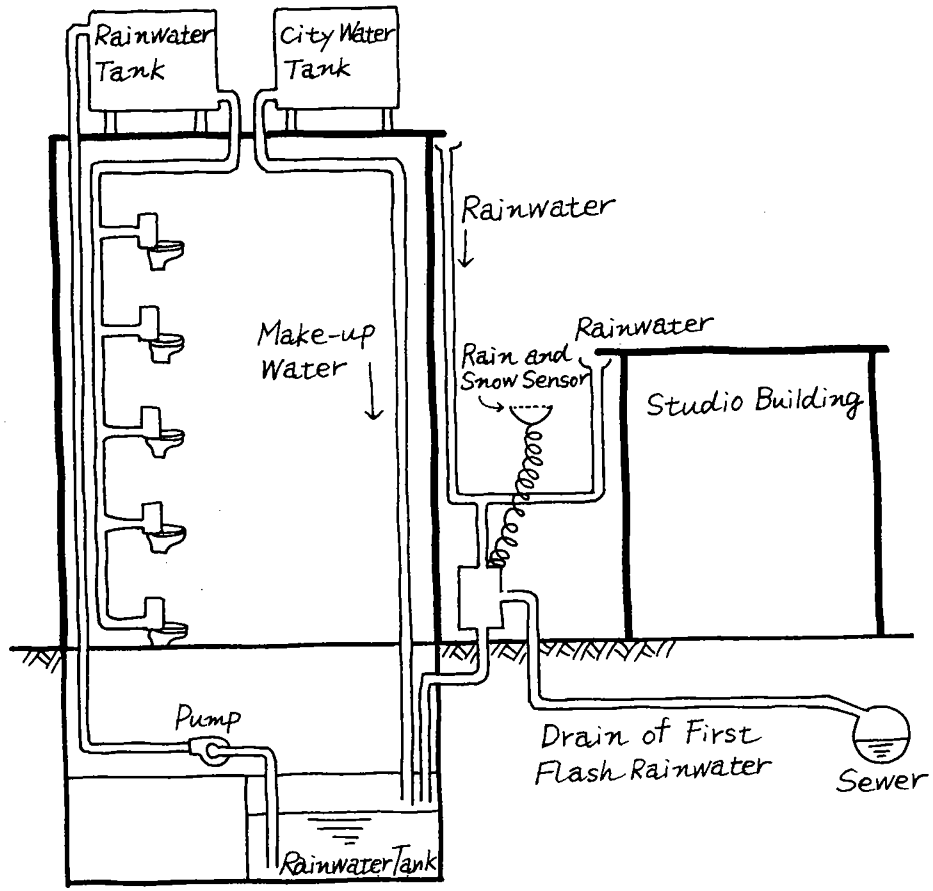
When Toppan Printing Co., Ltd. built an annex building, a rainwater utilization system was included in the design.

The company announced its "Earth Environment Statement" in 1992. Therefore, the company readily agreed to Sumida City's request to include rainwater utilization system in the new building design considering that contributing to sound regional water circulation by installing such a system dovetailed with the statement's objectives. The company immediately changed the ongoing construction planning for the annex building and invested an extra 15,000,000 yen (150,000 dollars) in the full-scale rainwater utilization system.

The most outstanding characteristic of this building is a device that automatically cuts first flash rainwater containing dirt and particles by using a rain and snow sensor. Rainwater is collected from the rooftops of the new annex building and a previously existing studio building, and is stored in an underground tank. The water is pumped up to an elevated tank on the rooftop and is used for flushing toilets. When the tank is filled to its capacity, a valve closes automatically shutting off the flow of rainwater into the underground storage tank. When, on the other hand, the rainwater level in the tank is low, water is automatically supplied from the city water system.

Data——

Building Use: Office
Materials: Reinforced Concrete (1st through 8th floors, basement)
Total Floor Area: 13,270m²
Rainwater Uses: Toilet Flushing
Rainwater Catchment Area: Roof, 2,667m²
Rainwater Storage Tank: Underground, 356m³
Location: Sumida City, Tokyo
Construction Date: December 1994
Designer: Kajima Corporation



Eco-Friendly Public Lavatory

Recently in Japan, more and more public lavatories have been refurbished to make them bright and clean, and have been designed to look fancier. Public lavatories designed from the eco-friendly viewpoint can be seen in many locations. One example is a public lavatory built in Hirano Cherry Park in Adachi City, Tokyo. On the roof of the lavatory is a $170m^2$-deep pond in which rainwater is stored. Soil is placed around the pond, and greenery is planted.

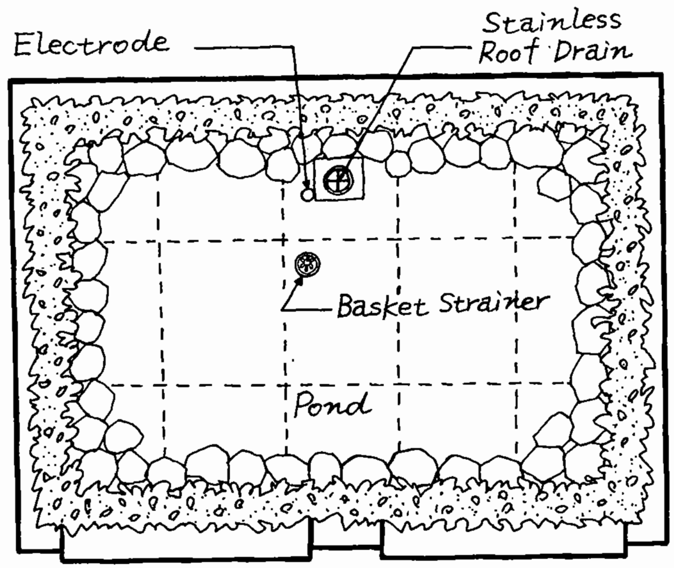
When it rains, the water of the pond overflows into the soil around the pond and ultimately into the ground. In this way the plants on the roof and the ground can obtain water. When there is no rainwater in the pond, city water is supplied. This is a new pilot model of public lavatory to improve its image drastically.

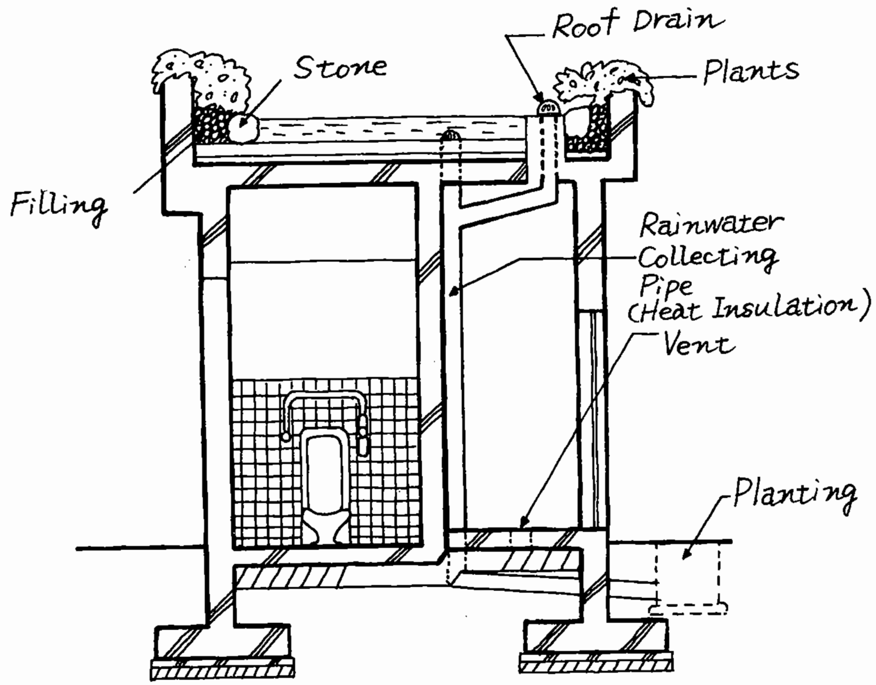
Masayo Uchiyama employed at the Adachi City Office was in charge of the planning of this lavatory. She says, "I designed it to create a bird sanctuary by setting a rainwater pond on its roof and producing a 'mini-ecosystem' there. I wanted many birds and dragonflies to gather here. There is a room to study nature in the community center next to this lavatory. From its window, I can see many birds perch on the lavatory's roof. I'm looking forward to seeing dragonflies lay eggs there and to seeing those eggs hatch."

In the future, plants will grow around the lavatory and have many flowers. Their fragrance will mask the unpleasant odor from the lavatory and their beauty will delight passers-by.

Data——

Building Use: Public Park Facility
Materials: Reinforced Concrete (1st floor)
Total Floor Area: $10m^2$
Rainwater Uses: Bird Sanctuary, Plant Watering
Rainwater Catchment Area: Roof, $10m^2$
Rainwater Storage Tank: Rooftop, $1.7m^3$
Location: Adachi City, Tokyo
Construction Date: December 1993
Designer: Park Division of the Adachi City Office





Rain Breathes Life into Corner Gas Station (practical version)

A rainwater storage tank for washing cars. When it rains, rainwater overflows from the tank making a cascade and rotating a waterwheel, and ultimately breathes new life into plants and the earth. This corner gas station is a place where people can be refreshed.

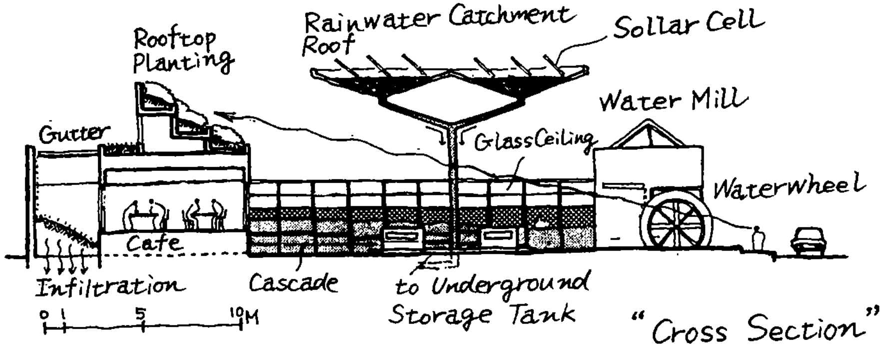
Economical car washing system: When thirty cars are washed per day, the amount of water used per month totals more than 100m³. When the water pipe's diameter is 75㎜, the monthly water cost will be 80,000 yen; and 130,000 yen in the case of 100㎜. However, if all the water is supplied by rainwater, only 20,000 yen to maintain the rainwater utilization system and a small cost to use sewers are necessary. The rainwater is free of chemical compounds and a solar water heater can provide hot rainwater, so this system is significantly effective.

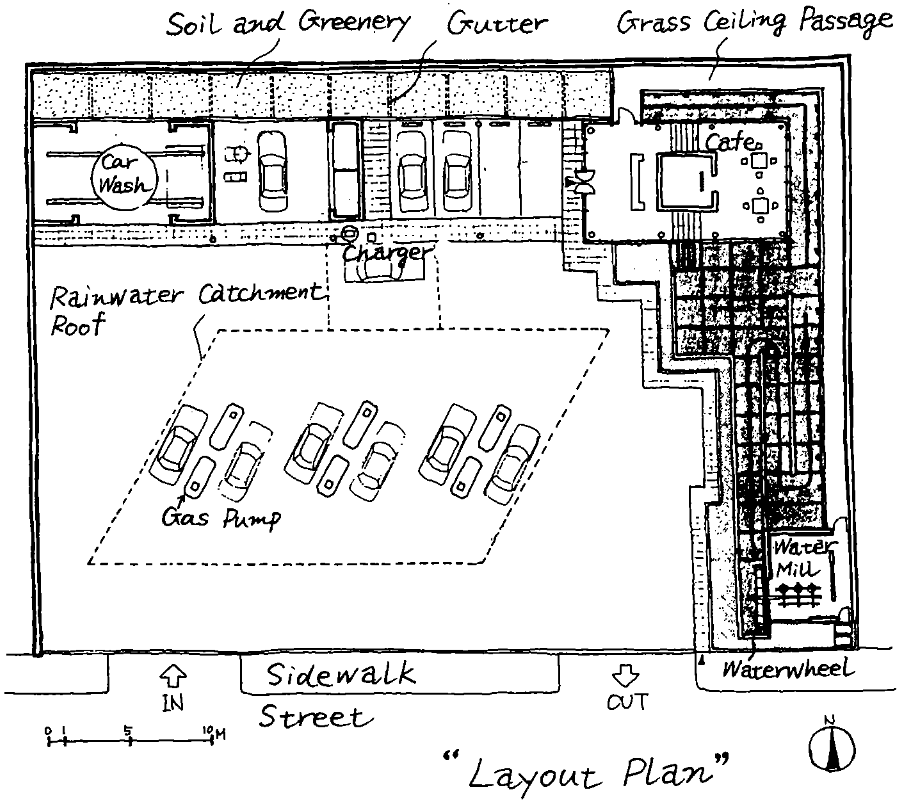
Refreshing atmosphere: Dewy stones and a stream will refresh the customers and passers-by. When you look out from the coffee corner, you can enjoy the silver spray of a waterwheel and the pounding sound of a wooden motor. The scene makes us reminiscent of our old hometowns.

Groundwater recharge: Part of the roof area and the ground are covered with soil and plants. Rainwater makes the plants greener and passes through the soil slowly. The clean water filtered by the soil is reused for watering plants. Storing rainwater temporarily in the soil helps control urban floods. The water that infiltrates deep into the ground will come out again onto the ground some day and feed our future generations.

Data——

Building Use: Gas Station
Materials: Steel
Area: Land Area 1,800m², Building Area 250m², Green Area 350m²
Rainwater Uses: Car Washing, Toilet Flushing, Plant Watering Cleaning, Rotating a Waterwheel
Rainwater Catchment Area: Canopy Roof, 380m²
Rainwater Storage Tank: Underground, 100m³
Location: Tokyo
Construction Date: In the planning stage
Designer: The Study Group of Nobuhiro Suzuki,
Professor of Architecture, the Science University of Tokyo





Heading toward City with Self-Supporting Water Resource

Shigesou Hayama, *Manager of Tetens Consulting Engineering Co., Ltd.*

1. *Rainwater Utilization around the Imperial Palace*

Edo City (former name of Tokyo) with a population of over 1,000,000 was one of the biggest cities of the world in the Edo period (1603-1867). It lacked purification and sewage treatment plants, but it is thought to have been a clean city. Water was supplied not from dams 200km away but from the nearby Tama River and springs, or from wells; that is, collected rainwater. Raw sewage was used as organic fertilizer for vegetable cultivation and rainwater naturally infiltrated into the ground or drained into waterways.

People in the Edo period lived more harmoniously with rain, and Edo City successfully controlled its water supply with self-supporting water resources and sustained a sound regional water circulation. Can the same situation be realized in the Tokyo of today which has swollen to ten times its Edo-period size? Considering effective rainwater utilization for non-drinking purposes, for emergencies, and for the prevention of urban floods, I think being self-supporting in water resources should be promoted. A water supply system should not cover too wide an area, but be localized, for example, a small district or a building even though it may not be so efficient.

The total volume of water leakage in Tokyo subways was estimated at 8,500,000m^3 in 1984, 13,000,000m^3 in 1989. Most of this water was not be used but merely dumped into rivers or sewers at a cost to taxpayers. Spring water naturally coming out into the pits of subways should be collected and used for non-drinking purposes just as rainwater is. If water pipes were spread over the ceilings of subway stations to cool the concrete, the effects of air conditioning could be expected. Or how about pouring the collected spring water into the moat around the Imperial Palace?

The moat around the Imperial Palace is 378,000m^2 in total area and an average of 1.27 m in depth, so the total volume of the water approximates 481,000m^3. It is estimated that the moat was more than 2m deep when the Edo Castle was built in 1457. But now, due to the mud deposits, part of the moat has become half its original depth and quite turbid. If the moat were dredged and water from the subways were added to the natural spring water of the moat, the moat would be restored to its original Edo-realized, the overflow from the moat that usually drains away into sewers could be supplied to nearby public buildings and possibly be used in emergency.

2. *Library of Sophia University*

Our research group (the late Isao Oshida, professor emeritus, Sophia University; Ichiro Kawahara, professor, Hosei University; Kiyoshi Sato, Makoto Murase and me) proposed using rainwater around the Imperial Place to Chiyoda City and the Tokyo Metropolitan Government, but regrettably it is still a dream.

Meanwhile, I participated in developing the basic design for the Sophia University library and I proposed the active introduction of an environmentally conscious design including solar energy as low quality heat, solar light, natural ventilation, radiant heating and cooling system, and rainwater utilization.

We received a subsidy from the Ministry of International Trade and Industry because the plan included implementing heating and cooling, and hot water supply systems based on solar energy. Also, we introduced solar photovoltaic power generation and natural ventilation (adopted the German Dreh-Kipp sash window). As for rainwater, we determined its uses as non-drinking water mainly for flushing toilets. Approximately 5,000 people a day were expected to enter the building that has three floors below ground level, nine floors above and a 2,340m^2 roof. Since simple filters were used, the system construction cost was only 13,000,000 yen (130,000 dollars), being repaid in eight years. Now the city water cost has been cut by slightly less than 2,000,000 yen per year.

Other university buildings constructed after this project introduced rainwater utilization. In fine weather, heating and cooling, and hot water supply systems powered by solar energy are used; and in rainy weather, rainwater is stored for further effective utilization. Facilities with rainwater utilization systems in which I have been involved now number more than 20.

I also participated in designing of Ryogoku Kokugikan (Sumo Wrestling Arena), and examined the possibility of rainwater utilization there. Sumo tournaments are held in January, May and September, so rainwater can be stored for the 3-month interval between each tournament. In addition, the arena was planned to have an 8,400m^2 roof. I firmly believed that this arena could employ an ideal rainwater catchment system from the large roof. Fortunately, with commitment of Sumida City, the plan was implemented.

GLOSSARY

First Flash Rainwater: The initial rainwater of poor quality that contains pollutants in the air (soot, sulfur oxides, nitrogen oxides) and dirt from catchment areas. Therefore, to use good–quality rain water, first flash rainwater should be removed. This refers to "Cut of Rainwater."

FRP: Fiber Reinforced Plastic

Grey Water: Wastewater treated for non–drinking purposes such as toilet flushing, plant watering and as cooling water for air–conditioners. Grey water must not be used for washing hands, washing faces or bathing because of the likelihood of intake some by mistake.

Groundwater Recharge: This means to return extra surface water and used groundwater to an aquifer artificially to prevent subsidence and supplement groundwater.

Infiltration Trench: A trench filled with gravel having à porous concrete pipe or a perforated infiltration pipe going through in its center. Collected rainwater infiltrates into the ground through the gravel layer.

Soakaway: A 25 to 60cm diameter cylindrical rainwater catch inlet made of porous concrete having its wall and bottom filled with gravel to infiltrate collected rainwater into the ground. This inlet is installed in the yard ground. Conventional rainwater catch inlets are made of impermeable material, so the rainwater pours from a downspout into an inlet flows, then into the sewer through a drain pipe. However, a soakaway infiltrates rainwater collected from roofs through downspouts into the ground.

POSTSCRIPT

A Guide for the Practical Utilization of Rainwater

"I need some information on how to use rainwater. I wonder if you know some guidebooks."

"I would like to observe some rainwater utilization systems firsthand. What kind of systems can I visit?"

"I am thinking of introducing a rainwater utilization system since I will build a new house. What should I do to begin with?"

These questions are frequently put to the Organizing Committee for the the Tokyo International Rainwater Utilization Conference by many people from all over the country. Public interest seems to be growing since people have become familiar with the conference through newspaper and television coverage. Unfortunately, however, no guidebooks on rainwater utilization systems for the general public have been published yet and the secretariat of the conference have not been able to cope with the people's needs for information. This situation urged us to compile information into this book.

Many of the members of Group Raindrops have actually been involved in design, research and development of different rainwater utilization systems. Therefore, we have been engaged in writing and editing this publication hoping that our experience could be of some help to people that want to promote rainwater utilization.

The main cause of water shortage and floods in Tokyo has been the lack of perspective for "self-supporting water resources" and "sound regional water circulation." The Tokyo International Rainwater Utilization Conference was aimed at revitalizing Tokyo by learning from successful practices of rainwater utilization in foreign countries while informing the world of Tokyo's examples to serve as a 'lesson.' Also, in many cities in developing countries demand for water has shot up due to a rapid concentration of population and, consequently, excessive pumping of groundwater has caused serious subsidence. Urban floods also frequently take place whenever it rains heavily.

The world population is presently 5,000,000,000. It is likely to exceed 8,500,000,000 by the year 2025, 60% of which will live in urban areas. "Urban Droughts and Urban Floods" will certainly pose graver problems than ever in many parts of the world. Rainwater utilization which could solve these problems comprehensively is a common agenda item not only for Tokyo, but also for cities all over the world.

The theory of rainwater utilization should be further strengthened to promote its practical use on a global scale as we approach the 21st century. Theory needs to be translated into practice, and the results of practice need to be theorized. Information exchange regarding the theory and practice on rainwater utilization is now required among citizens, officials of national and local governments, engineers and researchers.

The Tokyo International Rainwater Utilization Conference was held from August 1 to 6, 1994. Staff of civil organizations, officials of national and local governments, engineers and researchers promoting rainwater utilization participated in this conference from 16 nations in Africa, America, Asia and Europe and from many parts of Japan. With this conference, the initial step was taken to create an information exchange network to save the planet by rainwater utilization.

In 1995 the 7th International Rainwater Catchment Systems Conference is scheduled to be held from June 19 to 25 in Beijing. We hope the success of the Tokyo Conference will be carried over to the Beijing Conference. We also expect that this publication will help facilitate rainwater utilization furthermore and extend interregional networks of rainwater utilization on a global scale.

In conclusion, we would like to express our deep thanks to the local governments of Sumida City, Tokyo; Okinawa Prefecture; Koshigaya City, Saitama Prefecture; and Osnabrück City, Germany, the research institutes of Botswana Technology Center (BTC), Water and Sanitary for Health Project (WASH) of the United States and University of Hawaii Water Resources Research Center; and civil organizations and NGOs of Population and Community Development Association (PDA) of Thailand and PLAN International Kiambu of Kenya, all of which have provided us invaluable materials. We would also like to extend our special gratitude to Aiichiro Nagao, president of Hokuto Syuppan Co., Ltd. Finally, we thank Nichibei Kaiwa Gakuin for their wholehearted work in translating this book into English.

March 1995
Group Raindrops