Confederation of Indian Industry

The time is not too far,
when you'll have to pay for
every drop that you have wasted.

Let's make our future secure

Water Manual

Message from the Chairman CII Northern Region

Water is inextricably linked with every facet of human development. Its unavailability, deterioration in quality and neglect drastically impedes the quality of human life. Clearly fresh water availability is depleting due to mismanagement.

In the advent of a water crisis, industry will be hard hit and, it is therefore, incumbent upon us to undertake pro active measures for effective water management. There is an urgent need to disseminate information to all stakeholders for seeking their cooperation in better addressing the management of water.

Realizing this concern, I am pleased that CII-Northern Region (NR) is publishing a "Water Manual" which deals with the entire gamut of water management issues. This manual will hopefully be an important resource book for industry and other stakeholders in approaching the issue of water management in a scientific and integrated manner.

The NR Core Group on Water was formed under the leadership of Mr Vipin Sondhi, Managing Director & CEO, JCB India Ltd.

The publication of the "Water Manual" is the outcome of the endeavour of the members of the "Sub Group on Water Management Services," under the guidance of Mr Rajat Mukerjei, Senior Vice President, DCM Shriram Consolidated Ltd. He has been the driving force in bringing the publication in its present form.

Other members of the group are Mr Dilip Shukla, Director, Doshion Veolia Water Solutions Pvt Ltd; Mr K C Chawla, Director, Omax Autos Ltd; Mr Hariprasad Hegde, Vice President & Business Head, Wipro Water; Mr Atul Gupta, Chief Executive Officer, Pugmarks Design Studio and Mr R D Singh, Director, National Institute of Hydrology.

We are also extremely grateful to DCM Shriram Consolidated Ltd for sponsoring the publication of the manual.

May I invoke the entire CII fraternity to adopt the recommendations and showcase how industry is an active partner in the optimal management of our resources.

Harpal Singh

Harpal Singh
Chairman
CII Northern Region

Foreword

India's accelerated and continuous growth has led to an unprecedented stress on the finite and fragile water resources that are on the verge of depletion on account of overexploitation. Sectoral demands for water are growing rapidly in line with urbanization, population increase, rising income and industrial growth. The poor management of water calls for action by all stakeholders.

In the advent of a water crisis, industry will be seriously hit thereby affecting the economy of the country. Industry which consumes 8% of the water resources has taken various measures both "within the fence" and "beyond the fence" to ensure sustainable management of the depleting water resources

In order to disseminate information and create awareness among stakeholders to make an effective impact on the management of water resources the CII-Northern Region Core Group on Water is publishing a "Water Manual". The manual focuses on the efficient use of water, adoption of water minimization techniques, effective water management and recycling in the areas of process, utilities, gardening etc.

We hope the manual will be helpful in guiding various water consuming sectors to take up water management initiatives for conserving a very scarce resource; Water.

Best Wishes.

V. Sondhi

Vipin Sondhi
Chairman
CII Northern Region Core Group on Water

Executive Summary

The per capita availability of water is declining progressively owing to increasing population. Accordingly, the per capita availability of water for the country as a whole has witnessed a fall from 5177 m^3/year in 1951 to 1654 m^3/year in 2007. UNICEF report on Indian water also indicates that there will be constant competition over water amongst various stakeholders.

To address the issue of water the CII Northern region has formed a core group on water to look into various aspects of water management both 'within' and 'beyond the fence'. Accordingly five sub groups have been constituted namely Sub Group on Aqua Code and Policy Advocacy, Sub Group on Water Management Services, Sub Group on Training & Sensitization Programmes, Sub Group on Water Conclave, and Sub Group on Projects.

Adhering to the concept of 3 R's Reduce, Reuse and Recycle at a macro-level, the manual, highlights a comprehensive, holistic and sustainable management of water resources. A brief of the chapters in the “Industrial Water Manual” are as follows:

- Chapter I - Introduces to the numerous water uses in the industry and provides a skeletal view of “water intensive sectors”.
- Chapter II - Highlights the various water conservation technologies and approaches applicable in industry. It also reflects Detailed Water Audit methodology as applicable to the industry
- Chapter III - Describes the water harvesting techniques applicable in urban and rural areas.
- Chapter IV - Reflects the importance of introducing monitoring & instrumentation devices that can aid the industry in understanding as well as controlling the water consumption and various quality parameters.
- Chapter V - Demonstrates the efficacy of several domestic water conservation and landscape irrigation technologies.
- Chapter VI - Captures selective best practices implemented in the industry and benefits accrued.
- Chapter VII - Provides the prevailing water quality standards & norms.

The manual aspires in disseminating information and building the capacity of all stakeholders in addressing the issue of water management in a more comprehensive, holistic and scientific manner.

Best Wishes.

Rajat Mukerjei
Leader
Sub Group on Water Management Services

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INTRODUCTION

INTRODUCTION

1.1 Industrial water usage

Water is an essential resource for the industries. Industry depends on water, much like agriculture and domestic households depend on water.

In industry, water is generally used for the following applications.

- Cooling of steam in condenser, use in heat exchangers for the cooling of liquid, gas and solids, in humidifiers and chilling units
- Scrubbing of gases and for dust suppression
- Steam generation in boilers
- As an ingredient of the product
- For the washing of product in different stages of the processes
- Transportation and segregation of solids
- Washing of process lines, process equipment etc.
- Fire fighting application
- Indoor domestic use (bathing, drinking, kitchens, and laundries)
- landscape irrigation

The quality of water required for different applications varies with the process.

1.2 Source of water

Fig 1.0 Water Sources - River

Ground Water

The ground water is confined and separated from the surface soil by a separate stratum. The quality of water depends on the geological nature of the terrain in which the water is stored. The quality of ground water normally remains constant.

Surface Water

All flowing and stored water on the surface of the earth is classified as surface water. Its quality depends on the terrain through which the water flows as it picks up the soluble and insoluble material present. In addition to this, the gases present in the atmosphere will also get dissolve in it.

Sea Water

Sea water is having strong salinity and it varies between 30 to 45 gm/litre. In addition to this it may also turbid due to suspended particles.

The impurities generally present in water includes the insoluble material, colloidal particle, soluble minerals, salts, organic matter, planktons, gases etc.

These impurities are to be removed by treating the water through various treatment methods to meet the process requirement.

Some of the contaminants of fresh water and their treatment methods are listed in the Table 1.1.

Table 1.1 Fresh Water Contaminations and their treatment:

S No	Contamination	Treatment method
1.	Suspended matter that could be settled	Gravity settling in settling tanks
2.	Suspended colloidal particle	Coagulation and flocculation in a clarifier followed by filtration
3.	Organic matter	Coagulation and flocculation along with oxidising biocide in clarifier followed by filtration and if required filtration through activated carbon filters
4.	Colour and odour	Aeration, clarification, activated carbon filtration
5.	Dissolved gases	Aeration, degasification and activated carbon filters
6.	Hardness	Softening through ion exchange resin in sodium form, soda lime softening
7.	Dissolved salts	Ion Exchange demineralisation, Reverse osmosis, Multi stage evaporators

1.3 Water Consumption standard as per Water Cess Rule

As per Water (Prevention and Control of Pollution) Cess Rules, 1978 the permissible water consumption for industries is as described in Table 1.2.

Table 1.2 Water consumption standards for different industries

S No.	Name of Industry	Category	Maximum quantity of Water
1	Ferrous Metallurgical Steel	Iron & Steel	20 Cubic meters per tonne of finished product
2	Non-ferrous Metallurgical Produced	(A) Copper Smelters	100 Cubic meters per tonne of copper
		(B) Zinc Smelters	50 Cubic meters per tonne of Zinc metal produced
		(A) Caustic Soda	
3	Chemical	(i) Mercury cell process	5 Cubic meters per tonne of caustic soda produced (excluding cooling water) and 5 cubic meters per tonne of caustic soda produced for cooling water
		(ii) Membrane cell	5 Cubic meters per tonne of caustic soda including cooling water
4	Textile	(a) Manmade fibre	
		(i) Nylon & Polyester	170 Cubic meters per tonne fibre produced
		(ii)Viscose rayon	200 Cubic meter per tonne of fibre produced
5	Paper	(a) Small Pulp and paper	
		(i) Agro-residue based	200 Cubic meter tonne of paper
		(ii) Waste Paper based	75 Cubic meter tonne of paper
		(b) Large Pulp& Paper	
		(i) Pulp and Paper	250 Cubic meters per tonne of paper.
		(ii) Rayon grade paper.	200 Cubic meter per tonne of paper
6	Fertilizer	(a)Straight nitrogenous fertilizer. Equivalent produced.	15 Cubic meter per tonne of urea
		(b) Straight phosphate and Triple super phosphate) ex- including manufacture of any acid	2 Cubic meters per tonne of Single Super Phosphate/ Triple super phosphate.
		(c) Complex Fertilizer	15 cubic meter per tonne in case the primary product is nitrogenous fertilizer and 2 cubic meter per tonne in case the primary product is a phosphatic fertilizer. a phosphatic fertilizer.

Table 1.2 Water consumption standards for different industries

7	Processing of animal or vegetable products industry including processing of milk meat hides and skins all agricultural product and their waste,	(a) Tanneries	30 cubic meter per tonne of raw hide.
		(b) Natural rubber	6 cubic meter per tonne of rubber
		(c) Starch, glucose and related products	10 cubic meter per tonne of maize
		(d) Dairy	4 cubic meter per kilo liter of milk.
		(e) Jute	1.5 cubic meter per tonne of jute produced.
		(f) Sugar	2 cubic meter per tonne of cane crushed.
		(g) Maltry	8.5 cubic meter per tonne of grain processed.
		(h) Brewery	1 cubic meter per kilo litre of beer produced.
		(i) Distillery	15 Cubic meter per kilo litre of alcohol produced.

1.4 Water Intensive Industrial Sectors

Fig 1.4 Water Intensive Sectors

The following are some of the water intensive industries with consumption of water in the various applications.

Textile Industry:

- In boilers
- In dyeing and rinsing of yarn,
- Humidification of the yarn
- In air washers for maintaining humidity

Soft water and demineralised water are used, in bleaching and dyeing of fibres. Demineralised water is used for conditioning the air in spinning and weaving shop.

Pulp and Paper Industry

- For the steam production
- Pulp preparation
- For the transport of fibres and for making of paper.

In Paper industry the raw water is treated to remove the turbidity, colour and temporary hardness.

Automobile Industry:

Fig 1.3 Automobile Sector

Foundry Operation

- Water is used for the scrubbing of gas in case of wet scrubber arrangement.
- Second use is for the direct cooling of cupola / furnace in which the melting takes place.
- A third use is for the granulation of slag tapped from the furnace.

Machining Operation

- In this clarified water and some times soft water is the hardness is high for making coolants.
- Water is also used for the cleaning of parts after its cleaning.
- Used in boilers for steam generation and for the cooling in heat exchangers.
- Used in the paint spray booths Stamping
- In stamping operation water is used for the cleaning of the parts after its stamping and other activities.

Metal Plating

- Both clarified as well as demineralised water are used in the process.

Assembly Plants

- Water used for the cooling of welder Tips
- Water is used for the rinsing operation while applying corrosion protection metal phosphate layer
- DM water is used in the electrostatic dip unit and for the cooling of the paint solution water is used in the chillers or in the open circulating cooling tower
- Water is also used for the car wash operation also. In all these stages water is used in the air conditioner unit as well as in the operation compressors.

Chemical Industry

Chemical Industry is a major consumer of water and large quantity is used for cooling applications. In addition to this water is used in the boilers for steam generation where heating is required. Water used in the process may sometime become a part of the product. Another usage of water is for hydraulic conveying, hydraulic classification, washing and equipment cleanup. Water is also used for fire fighting.

Food Processing Industry

Fig 1.4 Food Processing Industry

In food industry the quality of water is very important, especially the water which goes along with the product. Mainly three types of water are used in food processing industry viz. process water, cooling water and boiler feed water. Process water is used for washing of raw materials and process equipments, conveying product from one area to another process area, dissolving or extracting, and addition to the finished products. Cooling water is used to condense steam from evaporators or turbines, in the operation of refrigeration equipments, to cool process equipments like cookers, compressors, jacket cooling etc. Boiler feed water is used for the steam generation for heating application or for power generation and to use the extraction steam in the process.

Sugar Industry

Sugar industry is one of the largest water users in food processing sector. Water is used to wash sugar cane, for steam production as well for cooling application.

Beverage Industry

Another, major water user in Food sector. In beverage industry water is used for steam generation, cooling of compressors and refrigeration equipment, washing of bottles and containers, for washing of equipments, etc. Some portion of the water may go along with the product also.

Fruit and Vegetable Processing

In this industry major portion of the water is used for the washing and rinsing of the raw materials, vessels and equipments. In Canneries the water is used for the cooling of cooked food contained in the cans. Water is also used for the steam generation.

Meat and Poultry

Major consumption is for washing and cleaning application.

Mining

In mining water is used for the removal of unwanted minerals from the surrounding of the ore and second is for the processing of the ore collected. The water is used as a media for transporting the finely crushed ore for cleaning and for further processing. In under ground mining water spray is used to control the dust suppression as well as for hydraulic mining.

In coal processing coal is washed in a slurry bath to remove the clay and dust or ash content and to increase the heat value.

In metal mineral industry large quantity of water is used for separating the metal containing ore fraction from the contamination by means of froth flotation or by magnetic separation by making the metal into fine powder slurry.

Aluminium Industry

Primarily the water is used as a solvent in the process. The steam produced in the process is used for the heating in various stages and the condensate is used in the boilers. In addition to this water is used as a media to transport of the solids from unit to unit. It also used as a medium for the wet grinding of the ore. Water also used for the contact cooling of the vapours and barometric condensers

Steel Industry

In this sector water is used in two ways, one is the indirect cooling by heat exchangers and in the second case direct cooling. In indirect cooling closed cycle cooling systems are normally used. In direct cooling the water is in direct contact with the material in granulation of the products, de-scaling, scrubbing of gases the effluent become dirty and needs continuous treatment.

The water is used in all sections for different applications like indirect condensation of gases, wet dust removal, cooling of furnace components, quenching of slag, cooling of different parts of converters, cooling of furnace and ladlers, cooling of ingot and electrodes, in hot rolling mills and in cold rolling mills.

Copper Industry

Copper is produced through dry and wet process depending on the nature of the ore. In copper industry copper wire bar is rolled to make sections, cables and wires. During this process the de-scaling of the metal surface is done with water.

Petroleum Industry

In petroleum industry 80 % water is used for cooling applications. Other applications include as boiler feed water and for domestic use.

Power sector

In Power sector major quantity of the water is used for condensing the steam in turbines and for the cooling of equipments. Highly pure water is used in boilers for the production of steam. In coal based thermal power plants water is required for the evacuation of solid waste, fly ash from the Electro Static Precipitator and bottom ash from the boiler. For this normally water from cooling tower blow down is used.

1.5 Water Conservation and Water Saving Potential

Water is essential to our health and to the health of our economy. As a major user of this precious resource, industry has an important responsibility to practice water conservation.

Eight Keys to Successful Water Management

1. Water management plans must be part of an integrated approach that examines how changes in water use will impact all other areas of operation.
2. Water conservation involves two distinct areas technical and human.

   A. The technical side includes collecting data from water audits and installing water- efficient fixtures and procedures.

   B. The human side involves changing behaviours and expectations about water usage and “the way things should be done.” Both areas must be addressed for a water conservation program to succeed.
3. A water conservation plan depends upon accurate data. Before water saving measures are implemented, a thorough water audit should be conducted to determine where water is being used. Then, water use can be monitored to track conservation progress.
4. A successful water conservation plan follows a logical sequence of events. Implementation should be conducted in phases, starting with the most obvious and lowest-cost options.
5. An effective plan examines not just how much water is being used, but how it is used and by whom. When analyzing a water audit, ask the next question: “Can this process be done as well or better using less water?”
6. The quality of water needed should be matched with the application. Many commercial, institutional, and industrial applications do not require the use of potable water. Whenever possible, substitute recycled water used in one process for use in another. (For example, spent rinse water can often be reused in a cooling tower.)
7. The true cost of water must be considered when conducting a cost analysis. The true cost of water is the amount on the water bill plus the expense to heat, cool, treats, pump, and dispose of/discharge the water.
8. Life-cycle costing is the key to evaluating water conservation options. Don't just calculate the initial investment. Many conservation retrofits that appear to be prohibitively expensive are actually very cost-effective when amortized over the life of the equipment.

Water Conservation Program

The Water Conservation program should transform a commitment to water conservation into a workable plan designed to systematically achieve an organization's water reduction goals. The Water Conservation program should have the resources available to create and implement specific water conservation plans and measures.

The Water Conservation program should:

1. Research institutional and regulatory considerations and constraints that will have an impact on water use decisions.
2. Review and evaluate the organization's existing or previous water conservation programs. Rate previous conservation efforts and determine their overall effectiveness. Note areas that were successful and areas that were not effective.
3. Establish a budget for the water conservation program. Secure the necessary funding.
4. Schedule onsite water audits of all water-using equipment and processes. Oversee the auditing process, both initially and during follow- up and routine inspections.
5. Create the water conservation action plan. This plan should include establishing the goals of the program as well as the details for implementing specific water conservation measures.
6. Establish the process by which the water conservation plan will be documented and evaluated.
7. Establish and coordinate an employee communications program (in conjunction with the organization's communications staff, if any). To realize maximum effectiveness, employees should be informed about the program and its goals. Employees should also be told how they can participate in the organization's conservation efforts.
8. Implement the water conservation program. Install water conservation equipment and begin water conservation

measures.

9. Evaluate the water conservation program on a regular basis. Make any needed modifications to improve water reduction efforts.
10. Report water conservation progress to top management. Fine-tune the plan if necessary to make additional water-use reductions.

Where to Begin

Effective water conservation can range from simple methods of reducing water consumption to some rather sophisticated and expensive technologies to completely eliminate water use. Based on the criteria and condition one has to decide to what extent water conservation makes sense for your company.

To Start:

1. Perform a water audit to benchmark plant-wide water use. Identify where and how water is currently being used. Track water use over several weeks.
2. Determine the cost of the water going to each process line. These costs can be used to determine the level of conservation that is feasible and to justify modifications with payback.
3. Establish a water conservation team to evaluate conservation ideas, methods and equipment.
4. Obtain conservation information from vendors, trade associations, consultants and state agencies.
5. Educate employees on the importance of water conservation and solicit employee suggestions on ways to use water more efficiently.

Company can save more than water with a conservation program. Almost every manufacturer that uses water can find some benefit in reducing, reusing or recycling water.

Reduce It!

The following low-tech conservation initiatives can pay for themselves in a very short period of time.

- Repair leaking lines, valves and water faucets. Turn off water that is not being used.
- Install flow restrictors or flow control valves to process tanks.
- Install timers and pedals to use water only when needed.
- Use conductivity meters to activate flow only when needed.
- Install multiple rinse tanks with counter current water flow.
- Agitate rinse bath water, mechanically or with air, to increase rinse bath life and rinse efficiency.
- Use drain boards, extended dwell time, slower withdrawal rates, air knives and fog nozzles to reduce drag-out.
- Use high pressure washing systems to reduce wastewater generation.
- Educate employees about the importance of water conservation.

Recycle It!

Fig 1.5 Industrial Water RO Plant

Recycled water is commonly used for evaporative water cooling, boiler make-up water, process water and maintenance. The recycling water can result in significant reductions of water use. Water recycling can also reduce the hydraulic loading on in-house pre-treatment systems and can potentially lead to the elimination of wastewater discharges.

- Reuse pre-treated water, before it is discharged, in applications that do not require fresh water.
- Consider segregating wastewater streams according to the level of contamination. Wastewater segregation can reduce the use of treatment chemicals, facilitate material recovery and allow greater reuse of water. Noncontact cooling water, for example, can often be chilled for reuse or redirected toward noncritical rinsing operations for significant water savings.
- Cooling towers are one of the most common water recycling technologies in use by industry today. By taking advantage of water's high heat of evaporation, cooling towers offer effective and relatively inexpensive cooling for a wide range of industrial uses. Companies that rely on once through cooling water may benefit from investigating cooling towers.'
- Vacuum evaporators can be used to capture high-purity, condensed process water for reuse.

Eliminate It!

Eliminating water use is generally the most difficult and expensive element in water conservation. However, the use of water has been effectively eliminated in several specific applications.

- Air cooling with fans and condensers or chillers may be effective in relieving the use of some once-through, non-contact cooling water.
- Vortex tubes are a simple and relatively inexpensive technology that can eliminate some water cooling. These devices can provide a wide range of air temperatures and have been used successfully for control cabinets in proximity to high temperatures and cool cutting surfaces. With air amplifiers, vortex tubes have been used in larger applications for cooling forged parts.
- In certain finishing applications, mechanical blasting can eliminate the need for brightening baths. This technology, however, is not widely applicable. It is relatively expensive, can be difficult to maintain and its success depends on the geometry of parts being blasted.

Ways to increase efficiency

- Install high-pressure, low-volume nozzles on spray washers

- Use fogging nozzles to cool product
- Install in-line strainers on all spray headers; inspect nozzles regularly for clogging
- Adjust pump cooling and water flushing to the minimum required
- Determine whether discharges from any one operation can be substituted for fresh water supplied to another operation
- Choose conveying systems that use water efficiently
- Handle waste materials in a dry mode if possible
- Replace high-volume hoses with high-pressure, low-volume cleaning systems
- Replace worn-out equipment with water-saving models
- Equip all hoses with spring loaded shutoff nozzles be sure these nozzles are not removed
- Instruct employees to use hoses sparingly and only when necessary
- Turn off all flows during shutdowns unless flows are essential for cleanup use solenoid valves to stop the flow of water when production stops (the valves could be activated by tying them to drive motor controls)
- Adjust flow in sprays and other lines to meet minimum requirements

Discharges that can potentially be reused:

- Final rinses from tank cleaning, keg washers
- Bottle and can soak and rinse water
- Cooler flush water, filter backwash
- Pasteurizer and sterilizer water
- First rinses in wash cycles
- Can shredder, bottle crusher
- Filter back flush

Chapter - 2
WATER CONSERVATION / MANAGEMENT IN INDUSTRIES

WATER CONSERVATION / MANAGEMENT IN INDUSTRIES

2.1 Approach and methodology

Water is becoming an increasingly expensive resource with mains, sewerage and trade effluent charges rising. However, introducing water minimisation measures is one of the easiest and most inexpensive ways to achieve cost savings.

Most companies and organisations know how much water they use, but may not always use this knowledge to help them reduce the amount of water consumed.

Companies that adopt a systematic approach to water reduction typically achieve a 20 - 50% decrease in the amount of water they use. By using less water, companies save money on both water supply and wastewater disposal. Taking action to save water may also allow companies to recover raw materials or product previously lost in effluent streams.

The true cost of water

The type of water used on-site and the type of wastewater generated by site operations/activities will determine how much your company pays for water supply and wastewater disposal.

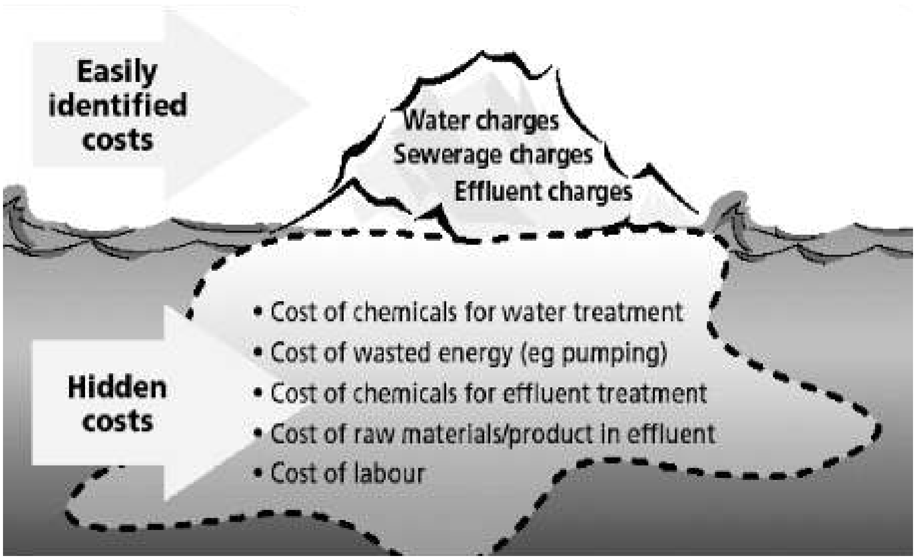


Fig.2.1: The true cost of water

Understanding where costs arise

As well as easily identified costs such as charges for water use, sewerage, surface water and trade effluent, there are many hidden costs associated with water use and disposal of wastewater. The true cost of water may be more than three times the total amount charged for supply and disposal.

Hidden costs can include

Lost product or raw materials in effluent, resulting in sale losses and increased effluent strength leading to higher trade effluent charges;

- water treatment prior to use (e.g. ion exchange or membrane technologies such as reverse osmosis), including the cost of chemicals for regeneration and replacement columns/packing materials, and the labour costs incurred in running and maintaining these systems

- the energy costs associated with heating/cooling water prior to use
- pumping costs including energy, labour and maintenance costs
- wastewater treatment prior to re-use or discharge, including the cost of acid/alkali for pH adjustment, flocculants, coagulants, pumping costs, labour and maintenance

Stages of Water Management

- Training and Awareness
- Develop Water balance
- Reduce at source
- Recycle back to process applications after treatment
- Reuse in other beneficial applications after treatment (irrigation, cooling towers, toilet flushing etc.,)
- "Monitoring" to sustain the savings

Reduce

Where water use cannot be avoided, reduce the amount of Water used reducing leaks is the most cost efficient option to minimize water consumption. Identify leaks as part of your regular maintenance program

Reuse

If you cannot reduce the amount of water being used in a process, try to use the water more than once.

Re-use offers the greatest opportunity to reduce Water Treatment and w wastewater Treatment expense.

Additionally, re-use can increase production capacity in areas limited by water supply or infrastructure.

The re-use opportunity of a plant falls primarily into three areas.

- Capturing and Re-circulating water within a piece of equipment, or to another spot on the line.
- Capturing Back flush and Rinse water for re-use in the plant.
- Capturing any available water for treatment and re-use.

Recycle

Seek an alternative water source such as treated wastewater from another process, or treated sewage effluent where health guidelines allow. Recycled water is commonly used for evaporative water cooling, boiler make-up water, process water and maintenance

2.2 Water Audit

A facility water audit or survey is the key activity of any water efficiency program. This chapter provides supplemental information and tools for the water audit team conducting the plant survey.

The first step in the quantification of water use is a water audita detailed examination of where and how much water enters the system, and where and how much water leaves the system.

Water system audits facilitate the assessment of current water uses, provide data needed to reduce water and revenue losses, and forecast future demand. With this information, a facilities manager can target System improvements where conservation efforts are most needed.

A major objective of a water system audit is estimating and reducing unaccounted-for water use. Unaccounted-for water includes losses through leaks, inoperative system Controls (such as blow off valves and altitude-control valves), and water used from unmetered sources such as wells.

Water Audit Preparation

Thorough preparation for the water audit will ensure maximum results and efficiency. Collect the following information regarding the facility's water use, and Identify all personnel familiar with the operation.

- The exact location of the facility included in the audit.
- The physical size of the facilities, including the number of buildings and floor space (in square feet) for each.
- Plumbing drawings, riser diagrams, and irrigation plans.
- Names and phone numbers of facility contacts.
- Specific services or products produced at the site:
- Record the number of meals served, number of guest rooms, and occupancy data for service establishments, such as restaurants, hotels, hospitals, military bases, and schools
- For manufacturing sites, identify the amount of water used per quantity of Product produced (that is, gallons per ton of product or gallons per gross of widgets)
- For schools and other such institutions, record the amount of water used per person per day
- The operating schedule of the facility, number of employees per shift, maintenance shifts, and other operating information.
- A water use profile (graph) showing the total water use and water used per unit of product per month.
- Copies of the proposed billing rates for energy, water, and wastewater for the next two years.
- List of all water-using equipment, including the manufacturer's recommended flow requirements.
- Inventories of sanitary fixtures and any water saving features.
- Outdoor water use and irrigation controls.
- Previous water surveys.
- All water delivery records from water meters, tank trucks, or the facilities, own wells.

Accurate water meters are essential for a valid water audit. Source water meters indicate the amount of water supplied to the site. Sub meters indicate water used for specific processes and individual buildings on the site.

We need to obtain the following information before starting the audit

- Location of all water supply meters that record deliveries from utilities, wells, and other water sources.
- Location of all on-site process and building meters.

Conducting the water audit

The next step is to conduct a walk-through survey to have an orientation of the facility. Use direct observation and measurements. Identify and record water consumption at every application. Check with equipment operators who may have important firsthand information. Use the following procedure to conduct the step-by-step survey.

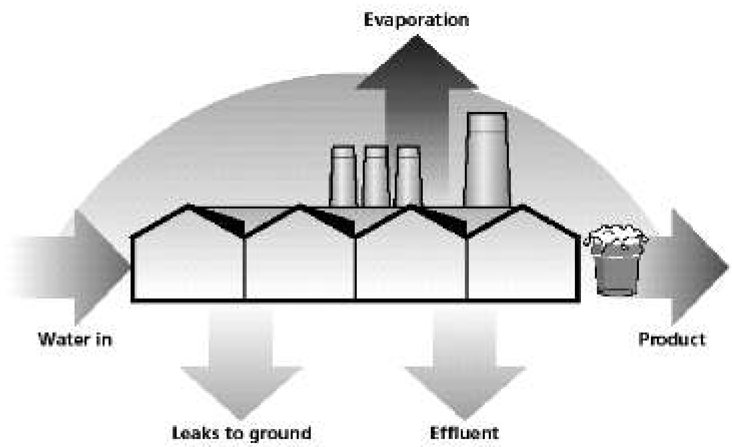
- During the walk-through, record hours of operation for each piece of equipment. Identify water piping layouts, particularly in areas of older equipment, to aid with identifying water uses. Note those pieces of equipment that have multiple uses of water (e.g., water-cooled ice machines).
- Identify water flow and quality as needed for each use. This information may be needed to determine if discharges from one use can be re-used as a potential supply for a different application. Include these parameters:
- Temperature.

- Water quality indicator parameters, such as pH, TDS, and conductivity.
- Other key water quality parameters such as BOD, COD, metals, or oil and grease.
- Measure the actual amount of water being used. The most direct way to measure flow rates is with a bucket and a stopwatch. Consider installing meters on major water using processes or plant departments to record the quantity of water used.
- Check water quantity and quality of water specified within the equipment operating manuals. Equipment sometimes is operated at higher flows than required by the manufacturer's specifications. Ask qualified engineers to review the specifications and adjust flows accordingly. Further, investigate whether the processes can still operate properly with further reductions in water flow. Be sure to record flow rates before and after changes are made to evaluate the effects of the reduced flow.
- Read water meters regularly and compare actual water use to the facility's water reduction goal. After determining daily use rates, the frequency of the readings should be adjusted to be consistent with the volume of water used, the cost of reading the meters, and potential excessive use fees. For example, large water users (more than 50,000 gpd) should continue to read meters daily. Commercial businesses using water for sanitary purposes only might read meters biweekly or monthly.
- Identify flow and quality of wastewater resulting from each use.
- Include any internally generated fluids in the water audit. Water may be generated as a byproduct of processing raw materials, such as fruits or from oil/water separation equipment. Determine the quantity and quality of these fluids and whether there are potential on-site uses for these fluids, such as housekeeping or cooling.

Use survey results to prepare a water balance diagram (See Figure 2.3) to depict all water uses from source through on-site processes, machines, and buildings, and finally, to evaporation and discharge as wastewater. If unaccounted for water is greater than 10 percent, revisit the major areas of water use, talk further with plant operators, or take additional measurements.

What is a water balance?

A water balance is a numerical account used to show where water enters and leaves your business, and where it is used within the business. It typically contains information about the amount of water used by each main process and, for some processes, can be very detailed. Presenting the water balance as a diagram makes it easy to understand and use as a management tool.



A water balance is based on the simple concept: what goes in *must* come out ... Somewhere

Fig 2.2 Basic Understanding of water balance

It is best to start by looking at your company as a whole and then adding details as you go along. It is also helpful to think of your site or company as a series of blocks, with each block representing an activity or location with water inputs and outputs

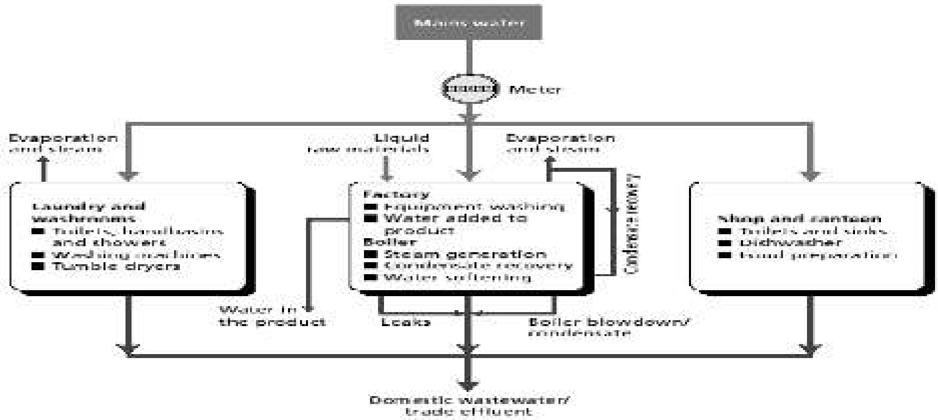


Fig 2.3: Block diagram of Water Balance Measuring In-Plant Water Usage

Sub-metering is an excellent way to accurately account for large water uses in specific processing equipment for departments within the plant. Sub-metering helps personnel become familiar with water use for all operations and indicate whether equipment is using water when it is not needed. (In some rinses, water is left running continuously, even when the need is only occasional.)

To obtain the appropriate size for a submeter, use the actual flow rate rather than just pipe size. Use temporary strap-on meters to determine the approximate flow. Then, the correct size of the positive displacement meter can be determined before installation. Temporary meters also will indicate whether it will be cost-effective to install permanent meters.

Bucket and stopwatch is a simple and accurate measurement tool. To use this method, collect a specified amount of process water for a specific time period (e.g., one quart per minute, which is equivalent to 0.25 gpm).

Micro-weirs are small hand-held weirs that are used to measure low flows of water (0.5 to six gpm) in tight spaces, such as under lavatory faucets

Use survey results to prepare a water balance diagram to depict all water uses from source through on-site processes, machines and buildings, and finally, to evaporation and discharge as wastewater. If unaccounted for water is greater than 10 percent, revisit the major areas of water use, talk further with plant operators, or take additional measurements.

Whereas water audit refers to the conducting of periodic exercises to determine water supplied into the distribution system as well as water lost and/or used within the distribution system, the water balance chart is the tool used to enhance a meaningful water audit report.

Definition of key variables in the water balance

1. System Input Volume: The volume of treated water input to that part of the water supply system to which the water balance calculation relates.
2. Authorized Consumption: The volume of metered and (or) unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so for residential, commercial and industrial purposes. Authorized consumption may include items such as fire fighting and training, flushing of mains and sewers, these may be billed or unbilled, metered or unmetered.
3. Water Losses: It is the difference between System Input Volume and Authorized Consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones. Water Losses consist of Physical Losses and Commercial

Table 1.2 Water consumption standards for different industries

<table>
<tr><td rowspan="8">System Input Volume (1)</td><td rowspan="4">Authorised Consumption (13)</td><td rowspan="2">Billed Authorised Consumption (10)</td><td>Billed Metered Consumption (2)</td><td rowspan="4">Revenue Water (17)</td></tr>
<tr><td>Billed Unmetered Consumption (3)</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption (11)</td><td>Unbilled metered Consumption (4)</td></tr>
<tr><td>Unbilled Unmetered Consumption(5)</td></tr>
<tr><td rowspan="4">Water Losses (14)</td><td rowspan="2">Apparent Losses (15) (Commercial)</td><td>Unauthorized use (16)</td><td rowspan="4">Non-Revenue Water (18)</td></tr>
<tr><td>Metering Inaccuracies and Data handling errors (6)</td></tr>
<tr><td rowspan="2">Real (Physical) Losses (12)</td><td>Leaks (7)</td></tr>
<tr><td>Bursts (8)
Leakage & Overflows at storage Tanks (9)</td></tr>
</table>

4. Billed Authorized Consumption: Those components of Authorized Consumption which are billed and produce revenue (also known as Revenue Water)
5. Unbilled Authorized Consumption: Those components of Authorized Consumption which are legitimate but not billed and therefore do not produce revenue
6. Apparent (Commercial) Losses: Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal use). Commercial losses may also be referred to as Apparent Losses or Non- Technical Losses.
7. Real (Physical) Losses: These are physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer's meter. Physical losses are also referred to as real losses or technical losses.
8. Billed Metered Consumption: All metered consumption which is also billed. This includes all groups of customers such as domestic, commercial, industrial or institutional.
9. Billed Unmetered Consumption: All billed consumption which is calculated based on estimates or norms but is not metered.
10. Unbilled Metered Consumption: Metered Consumption which is for any reason unbilled
11. Unbilled Unmetered Consumption: Any kind of Authorized Consumption which is neither billed nor metered
12. Unauthorized Consumption: Any unauthorized use of water. This may include illegal water withdrawal from hydrants (for example for construction purposes), illegal connections, bypasses to consumption meters or meter tampering.

13. Customer Metering Inaccuracies and Data Handling Errors: Commercial water losses caused by customer meter inaccuracies and data handling errors in the meter reading and billing system
14. Leaks: Water lost through leaks
15. Bursts: Water lost through bursts
16. Over flows and leaks at Storage Tanks: Water lost through overflows and/or leakage of water storage facilities.
17. Revenue Water: Those components of Authorized Consumption which are billed and produce revenue (also known as Billed Authorized Consumption)
18. Non-Revenue Water: Those components of System Input which are not billed and do not produce revenue.

Importance of Computing the Water Balance

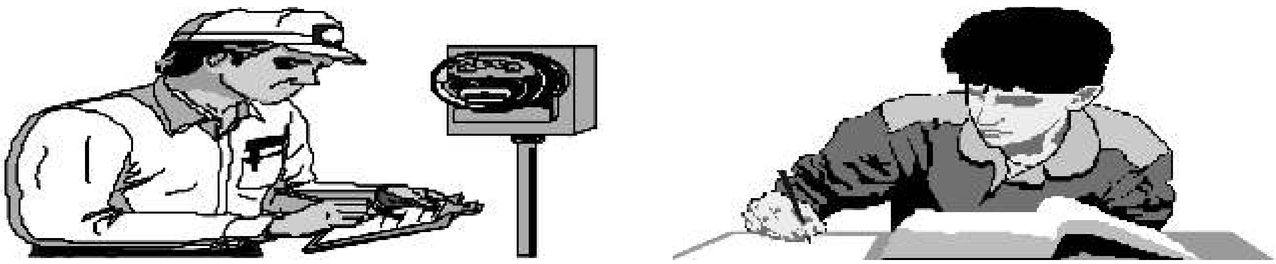


Fig 2.4 Computing of Water Balance

Developing a water balance is of paramount importance for the following reasons:

- It serves as a framework for assessing a utility's water loss situation
- Calculating the water balance
- Reveals availability/reliability of data and level of understanding
- Creates awareness of problems/issues
- Gives direction of improvements
- It also serves as a tool for communication and benchmarking
- Above all it provides significant guidance required for purposes of prioritizing attention and investments of limited resources.

Benefits of Non Revenue Water Reduction

The primary objective of developing the Water Balance is to be able to effectively prioritize investments and effectively reduce NRW.

The following benefits accrue from the reduction of NRW.

- Cleaner database and increased revenues
- More water available for consumption
- Cost reduction less chemicals and electricity optimized production
- Deferred need for investments to increase production capacity
- Reliable demand projections
- Optimized operation of the distribution system

Additional Water Auditing Tips

- Measuring tools should be used after the walk-through with facilities staff or the audit team. There is no time to start measuring flows while the assessors are being shown the facility.

- The quality of the audit depends on accurate information for the facilities manager or staff guiding the walkthrough. Always try to speak directly to line operators or staff working in the Water-consuming operations to confirm information.
- For external auditors, follow-up trips are almost a necessity when water balance calculations to estimating water use by category do not align with meter consumption records.
- Spikes on yearly water consumption graphs are a reminder to the auditor to find out the whole story of the water use history.
- While accounting for water use at large commercial and industrial facilities, it may be difficult to keep “unaccounted for” less than 10 percent. A range of six to 12 percent unaccounted for water is certainly acceptable.

Water Audit Report

Fig 2.5 Water Audit Report

Proper and efficient presentation of the water audit findings and recommendations is imperative for facility decision-makers. The water audit report should contain the following elements:

- Executive summary of the recommendations, quantifying of savings, investment costs and payback periods.
- Introduction.
- Facility description.
- Water use history for one or more years.
- Water use balance.
- Which efficiency option, technical discussions and savings calculations.
- Energy savings if applicable.
- Data normalization for follow-up with suggested time frame.

Leak Detection

Fig 2.6 Pipe line leaks

All facilities will experience some leaks. Leaks may range from a fraction of a percent up to several percent of total water use. Telltale signs of a leak include low water pressure or dirty water, or both, as well as an unusually high volume of unaccounted for water. Common locations for leaks are in piping joints, restroom fixtures, pump seals, loose nozzles/shut-off valves, drinking fountains, processing equipment and other locations. Eliminating such leaks typically includes tightening or replacing fittings.

Leaks can be identified by visual or audio observations. Water fixtures and process equipment should be observed both during use and during down time. All employees should be responsible for notifying maintenance personnel of leaks, and maintenance personnel should make leak repair a priority.

Underground or under-the-floor leaks can be detected through a leak-detection survey using the facility's water meter. To do so, all water consuming items inside and outside the building must be turned off. Alternatively, perform the survey after the last shift has left and no water is being used in the facility; then observe the water meter for a minute or more. If the meter dial moves continually during this time, a leak is indicated. Another method is to record the numbers on the meter and come back an hour later to check the reading, making sure that no water is used during this time. If the meter reading has increased, there is a leak.

Water Leak Equations

Rates of water loss for a roughly circular hole can be estimated using the Greely equation:

Q = (30.394)(A)(square root of P) Where Q is leak rate in gpm, A is the cross-sectional area of the leak in square inches, and P is the line pressure in pounds per square inch.

Leaks in joints or cracks can be estimated by this equation:

Q = (22.796)(A)(square root of P) Where Q is leak rate in gpm, A is the area of the leak in square inches, and P is the line pressure in psi. For example, a 1/32" wide crack, 1" long will use 4.5 gpm at 40 psi.

An underground leak is suspected or detected using the water meter, but the leak's location is not readily identified, it may be necessary to have a leak detection survey performed by a service firm. Such firms use state-of the-art audio sound systems to pinpoint the leak's location.

To identify a leak or problem area, a portable listening device allows the user to verify that a leak is present in a general area. The equipment consists of

- A base unit that contains batteries and electronic components that amplify leak noise and filter extraneous noise, and,
- An acoustic sensor that attaches to the road surface or pipe itself, as well as a pair of headphones.

Determining Water Loss by Leaks

Determining the volume of water loss by leaks is important to calculate both water and cost savings by repairing the leak. One of the simplest methods to determine leak loss is the bucket and stopwatch method. A small drip also can be measured by the bucket and stopwatch method. Mathematical estimates of leaks can also be used.

Water Meter Issues

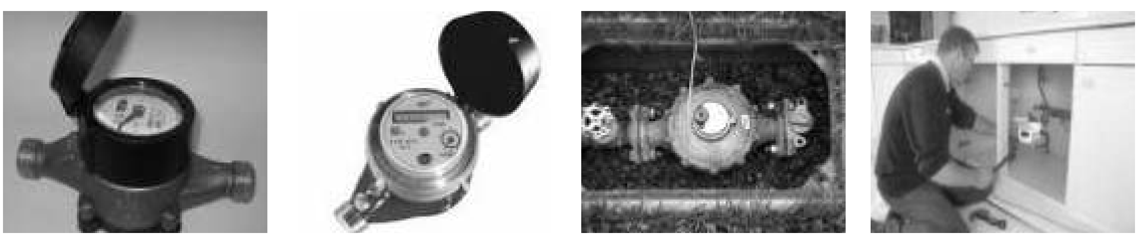


Fig 2.7 Water Meter Issues

The size and accuracy of a facility's water meter is important when accurately accounting for water use. Typical types of meters used for commercial and industrial settings include positive displacement, turbine and compound meters. Figure 6-3 shows typical applications for meter types and sizes. Water meters can become less accurate when the intended water use of a facility has changed or when substantial water conservation activities have been implemented.

Water meters should be of adequate size but not oversized. If a meter is oversized for the facility's needs, the facility could be paying unwarranted service charges for the oversized meter. Properly selected and sized water meters can become inaccurate due to wear, which is affected by age and water quality. In-place field testing using a pedometer for large meters and a portable meter test unit for smaller water meters can be conducted.

In most cases, water used for landscaping, cooling towers, etc. that is not discharged to the sewer can qualify for a rebate from the sewer district. However, the volume of water not going to the sewer must be accurately measured by a separate meter or other device to qualify for the rebate.

Table 1.2 Water consumption standards for different industries

Types of Meters and Applications		
Type	Common sizes	Typical applications
Positive displacement	5/8 - 2 inches	Commercial, medium hotels, apartment complexes and industrial plants
Class II Turbine	2 - 6 inches	Medium/large hotels, large apartment complexes to large manufacturing and processing plants
Class I turbine	8 - 12 inches	Industrial, manufacturing, processing, pump discharges
Compound, high velocity styles	2 – 4 inches	Special high and low demand applications for schools, public buildings and hospitals

2.3 Zero water discharge & Approach

What is 'Zero Discharge'?

Zero discharge means that no wastes are discharged, that everything is recycled and no pollutants are being discharged into the environment. Another term from this is totally Effluent Free (TEF) Evolution of treated waste water discharge standards is a complex process requiring thorough expertise. Zero Discharge is one such standard / requirement of pollution control authorities.

Methodology for 'Zero Discharge'

The Zero Discharge System helps to reduce unfavourable impacts on the environment. Water savings with the consequential reduction of water supply and water discharge can be achieved by this system: The Zero Discharge system saves more than 90% waste water compared to a conventional water/steam cycle.

Beside the environmental aspect the Zero Discharge Concept enhance the project profitability by life cycle cost reduction. Certainly, the economical benefit of the Zero Discharge system depends on the project boundary conditions. Protecting the environment and improving the economical situation of a project is not a contradiction.

2.4 Uses of industrial water

2.4.1 Municipal waste water treatment and reuse in industries Wastewater treatment options

Sewage treatment options may be classified into groups of processes according to the function they perform and their complexity.

Preliminary	This includes simple processes such as screening (usually by bar screens) and grit removal. (Through constant velocity channels) to remove the gross solid pollution.
Primary	Usually plain sedimentation, simple settlement of the solid material in sewage can reduce the polluting load by significant amounts.
Secondary	For further treatment and removal of common pollutants, usually by a biological process.
Tertiary	Usually for removal of of specific pollutants e.g. nitrogen or phosphorous, or specific industrial pollutants

Very few sewage-treatment facilities in most developing countries work. This is often because most technologies for sewage treatment are big, centralized schemes which have been developed in the North where adequate financial, material and human resources are available. Transferring these technologies to tropical low- and middle-income communities has many potential difficulties.

However, there are some sewage-treatment options which are more appropriate to developing country scenarios. Such systems should generally be low-cost, have low operation and maintenance requirements, and, should maximize the utilization of the potential resources (principally, irrigation water and nutrients).

Preliminary and primary treatment is common to most sewage-treatment works, and is effective in removing much of the pollution. There are many different types of secondary process. The most common are described in the table opposite, with brief comments on their suitability for low- and middle-income countries. Tertiary treatment processes are generally specialized processes which are beyond the need of most communities.

Aerobic versus Anaerobic treatment

Most conventional wastewater treatment processes are 'aerobic' bacteria used to break down the waste products take in oxygen to perform their function. This results in the high energy requirement (oxygen has to be supplied) and a large volume of waste bacteria ('sludge') is produced. This makes the processes complicated to control, and costly.

Fig 2.8 Aerobic Treatment System

The bacteria in 'anaerobic' processes do not use oxygen. Excluding oxygen is easy, and the energy requirements and sludge production is much less than for aerobic processes making the processes cheaper and simpler. Also, the temperature in which the bacteria like to work is easy to maintain in hot climates.

Fig 2.9 Anaerobic Treatment System

However, the main disadvantages of anaerobic processes are that they are much slower than aerobic processes and are only good at removing the organic waste and not any other sort of pollution such as nutrients, or pathogens. Anaerobic processes generally like 'steady' effluents they are not good with coping with variations in flow or composition. For example, anaerobic processes cannot cope with shock loads of heavy metals (from industrial processes, for example).

Fig 2.10 Waste stabilization ponds (WSPs)

The requirement in most low-income countries is for a low-cost, low-maintenance sewage treatment system. Waste stabilization ponds (WSPs) provide the best option in most cases good levels of treatment at low capital and particularly low O&M cost. In addition, it is one of the few processes which provides good treatment of pathogenic material. This has significant application potential for re-use of the treated effluent in irrigation. The major disadvantage is that significant areas of land are needed for treatment. WSPs are used in many locations worldwide, including Africa and Asia.

Any wastewater treatment plant needs significant investment and O&M and control, and therefore any decision to implement such a facility should be carefully considered. WSPs provide the best option for a low-cost, low-maintenance system which is most effective in removing the pollutants of major concern.

Re-use, Recovery

Traditionally, sewage has been seen as a *problem* requiring treatment and disposal. Most conventional sewage treatment options are based on reduction in biodegradable organic material and suspended solids. Treatment involved the 'removal' of these pollutants by converting it in to sewage sludge. The disposal of sewage sludge is a assumes high consideration in many locations, and it is often seen as an offensive product which is either dumped or burned.

The priorities in developing countries are often different from those in developed countries. Often the main issue is how to control pathogenic material, and any form of sanitation (on or off-site) should have this as its main objective. There are treatment options which can remove pathogenic material, notably waste-stabilization ponds.

Increasingly, sewage is being seen as a resource. The water and nutrient content, in particular, can be very useful for agricultural purposes (for example, through irrigation) if the sewage is treated to a suitable standard. There are treatment options which seek to use this resource potential. Traditional sewage treatment practices in South-east Asia, for example, seek to use wastes generated through pond systems which are used to cultivate fish and generate feed for animals.

Some community-based approaches (in Latin America in particular) seek to separate 'grey' wastewater (non-faecally contaminated wastewater) from 'black' (faecally contaminated) water so that they can both be recycled and re-used as appropriate. In principle, the grey water can be re-used as irrigation water, and the black water/waste treated and re-used as fertilizer.

2.4.2 Reuse of Wastewater for Agriculture

Fig 2.11 Reuse of wastewater in agriculture

In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a common practice. Wastewater is often the only source of water for irrigation in these areas. Even in areas where other water sources exist, small farmers often prefer wastewater because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers.

Concern for human health and the environment are the most important constraints in the reuse of wastewater. While the risks do need to be carefully considered, the importance of this practice for the livelihoods of countless small stakeholders must also be taken into account.

Two major types of reuse have been developed and practiced throughout the world.

Potable uses

- Direct, use of reclaimed water to augment drinking water supply following high levels of treatment
- Indirect after passing through the natural environment

Non-potable uses

- Irrigated agriculture

- Use for irrigating parks, public places of forestry
- Use for aquaculture
- Aquifer recharge (indirect reuse)

The wastewater used in irrigation can be from different sources. It can be completely untreated municipal or industrial wastewater, mechanically purified wastewater or particularly or fully purified wastewater treated biologically.

Water efficient landscaping

- Planting should be carefully specified to avoid large requirements for water. Indigenous planting and dry climate plants as aloes and succulents with low water requirements may not need irrigation at all. Clustering plants with different water requirements can also reduce water consumption as irrigation is minimized.
- The following guidelines offer suggestions for water saving:
- Hand water with a trigger nozzle fitted hose, either in the early morning or late evening, instead of during the day, and save up to 25% of water.
- Use a soil probe to measure moisture content and water only when the probe reading falls below the control level.
- Use below surface water emitters instead of above surface sprays for irrigation systems.
- This eliminates wastage through evaporation and windage.
- Use control irrigation systems to prevent watering during rain periods and within 3 days of rain.
- A moisture probe can be connected to the irrigation control to override the automatic system when soil moisture is satisfactory.
- Change the surface profile of garden beds to prevent water run-off and provide at least 4cm of mulch for garden beds to prevent evaporation.

Less frequent but heavier watering of plants and lawns will promote an increase in drought tolerance.

Reduction in fresh water consumption for irrigation and landscaping

- The minimization of fresh water requirements for irrigation and landscaping could be studied in detail. The Water management is one of the most important factors in the health of your plants. Lawns, shrubs, trees, ground covers, and annual flowers have diverse water requirements. The study for irrigation and landscaping would identify opportunities for Protecting your existing landscape investment
- Avoiding excess usage of water
- Economical use of recycled Water systems
- Where irrigation is used this should be as efficient as possible and be fed from rainwater harvesting. Drip or subsurface irrigation is water efficient and minimizes losses as a result of evaporation. Further reductions can be achieved through soil moisture meters and timers which ensure that irrigation occurs only when needed and happens at night when losses from evaporation are lowest. The horticultural requirements of your landscape would be reviewed to implement a well designed irrigation schedule.
- Furthermore, when primary options for effluent dispersal are not possible due to regulations then irrigation with reclaimed water as a dispersal mechanism becomes very attractive.

Latest technology in landscape irrigation can also help in saving water as well as money. Use of Weather Based Controller in place of a time-based controller can save 50 % of the water for the same quality of irrigation. The smart controller is departure from traditional time-based programming. It monitors 5 weather factors on a daily basis and actually adjusts each zone for you every day. It's like having your local weather man custom program your irrigation system for you every day.

Fig 2.12 Weather based Landscape Irrigation controller

Table 1.2 Water consumption standards for different industries

Advantages	**Disadvantages**	**Risks**
Improvement of the economic efficiency of investments in wastewater disposal and irrigation	Wastewater is normally produced	Potential harm to
Conservation of freshwater sources Recharge of aquifers through infiltration water (natural treatment)	continuously throughout the year, whereas wastewater irrigation is mostly limited to the growing season	groundwater due to heavy metal, nitrate and organic matter
Use of the nutrients of the wastewater (e.g. nitrogen and phosphate) reduction of the use of synthetic fertilizer improvement of soil properties (soil fertility, higher yields)	Some substances that can be present in wastewater in such concentrations that they are toxic for plants or lead to environmental damage	Potential harm to human health by spreading pathogenic germs
Reduction of treatment costs: Soil treatment of the pre-treated wastewater via irrigation (no tertiary treatment necessary, highly dependent on the source of wastewater)		Potential harm to the soil due to heavy metal accumulation and acidification

When considering wastewater reuse for irrigation, an evaluation of the advantages, disadvantages and possible risks has to be made. The following table summarizes the advantages, disadvantages and possible risks regarding water conservation, different substances in the water and influences regarding the soil.

Different sources of wastewater

Most of the examples and recent research papers are dealing with reuse of municipal wastewaters. Nevertheless it is worth to study the potential of using industrial wastewater for irrigation considering that around 20 per cent of worldwide water production is used in the industrial sector compared to 7 per cent in the municipal sector.

Among industrial wastewater it is predominantly wastewater from food processing industries that has high potential to be reused in agriculture since the main constituents are organic substances. Förster et al. (1988) investigated already in the 80s the impact on the soil, the plants and the different yields of the crops when irrigated with wastewater from food processing industries. The main outcomes were positive by means of no neg. accumulation of harmful substances in the soil and higher yields of some crops.

Table 2.4 Type of waste water and their nutrient value

Source of wastewater	Pre-treatment	**Contaminants**	**N mg/l**	**P mg/l**	**K mg/l**
Distilleries	Mechanical purification, Neutralization	Alkali, Acids, Soda, Chlorine-Compounds	25	1	20
Brewery/Malti Ng	Mechanical purification, Neutralization	Yeast, Carbohydrates, settleable solids	40	5	50
Fish Processing	Mechanical purification, fat separation, dilution, chlorination,	scale, fats, oils, org. acids, Salt, H_2O_2	500	-	-
Potato flour	Mechanical Purification	None	550	140	95
Canning	Mechanical Purification, neutralization,	salts, organic acids, detergents, corrosive Substances	60	10	35
Dairy	Mechanical Purification	Disinfectants	35	10	20
Starch	Mechanical purification, neutralization, Dilution	salts, acids	300	45	415
Cider	Mechanical purification, neutralization, Precipitation	Detergents	870	160	-
Sugar	Mechanical Purification	strontium, tar, prussic (cyanic) acid	50	10	-

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Chapter - 3
WATER HARVESTING

WATER HARVESTING

Water harvesting or more precisely rain water harvesting is the technique of collection and storage of rain water at surface or in sub-surface aquifer, before it is lost as surface run off. In artificial recharge, the ground water reservoirs are recharged at a rate higher than natural conditions of replenishment.

Need of water harvesting

- To increase the ground water level from the present level and thus to arrest the drop of ground water level.
- To compensate the low availability of surface water for domestic as well as industrial application.
- The urbanisation has reduced the natural infiltration of water due to civil construction as well as paving of open area.

Methods

- Capturing runoff from rooftops
- Capturing runoff from local catchments
- Capturing seasonal floodwaters from local streams
- Conserving water through watershed management

Design consideration

While designing the rain water harvesting system following points are to be considered.

- Hydrogeology of the area including nature and extent of aquifer, soil cover, topography, depth to water level and quality of ground water.
- Availability of source water, assessed in terms of non - committed surplus monsoon runoff.
- Hydrometerological characteristics like average annual rainfall, rainfall pattern, duration and intensity of rainfall.
- Area contributing runoff like industrial, residential, green belt area, paved areas, roof top area etc.

Techniques and Methods

Urban Area: Harvesting of Roof top rain water / storm run off

- Recharge pit
- Recharge trench
- Tube well
- Recharge well

Rural Area: Harvesting of rain water through

- Percolation tank
- Check Dams / Cement Plugs / drain bunds
- Recharge shaft
- Dug well recharge
- Ground water dams or Sub- surface dykes
- Through Gully pugs and contour bunds

3.1 Rainwater Harvesting Techniques in Urban Area

In urban areas rain water is available from roof tops of buildings, paved and unpaved areas. This water could be used for recharging aquifer by making proper collection system. The collection and recharge system designed should occupy minimum space. Some of the techniques are described below:

3.1.1 Roof top rain water harvesting through Recharge Pit

- This technique is suitable for building with minimum 100 Sq. M roof area.
- Alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, roof water harvesting can be dome through recharge pit.
- Recharge pit of 1 to 2 M wide and 2 to 3 M depth may be constructed. The filter bed can be prepared by providing about 5 to 20 cm boulders at the bottom followed by 5 to 10 cm of gravel and finally a layer of 3 to 5 cm graded sand.
- The roof top to be connected to the pit through pipe with arrangement to flush out the first rain water. (Fig 3.1)
- Mesh should be provided on the roof top to prevent the flow of leaves and solid debris to the pit.
- The top layer of the sand should be cleaned regularly to maintain the recharge rate.

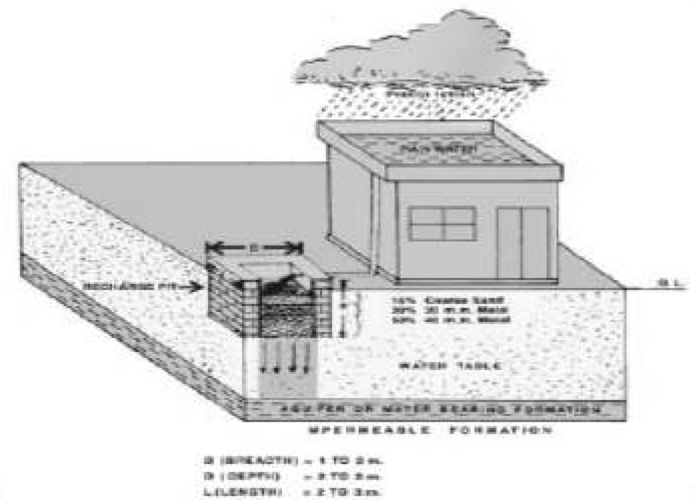


Fig 3.1: Using Recharge Pit

3.1.1 Roof top rain water harvesting through Recharge Trench

? Recharge trenches are suitable for buildings having roof area of 200-300 sq. m and where permeable strata are available at shallow depths.

? Trench may be 0.5 to 1 m wide, 1 to 1.5m deep and 10 to 20 m. long depending upon availability of water to be recharge.

? The filter arrangement all other set up are similar to recharge pit arrangement mentioned above. (Fig 3.2)

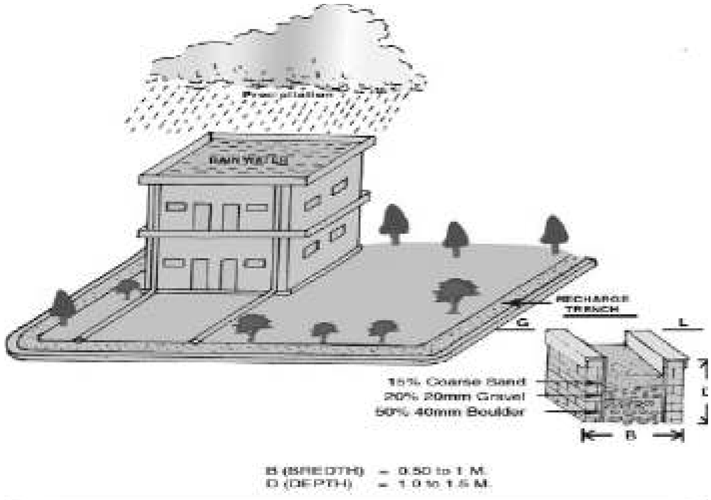


Fig 3.2: Using Recharge Trench

3.1.1 Roof top rain water harvesting through Existing Tube Wells

- In areas where the shallow aquifers have dried up and existing tube wells are tapping deeper aquifer, roof to rain water harvesting through existing tube well can be adopted to recharge the deeper aquifers.
- PVC pipes of 10 cm dia are connected to roof drains to collect rainwater. The 1st roof runoff is let off through the bottom of drainpipe. Rainwater from roofs is taken to collection/ desilting chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slop of 1:15. The filter pit may vary in shape and size depending upon available runoff and are back-filled with graded material, boulder at the bottom, gravel in the middle and sand at the top with varying thickness (0.30- 0.50m) and may be separated by screen.
- The pit is divided into two chambers, filter material in one chamber and other chamber is kept empty to accommodate excess filtered water and to monitor the quality of filtered water. (Fig 3.3)
- A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.
- The initial rain water should be drained and subsequent rain water could be charged.

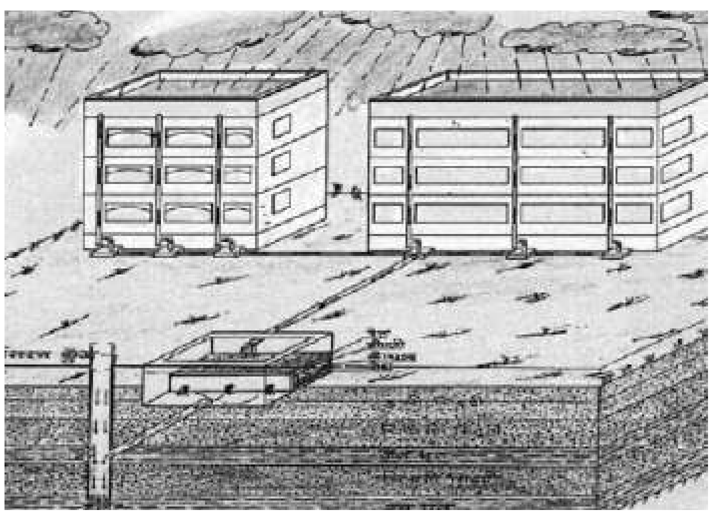


Fig 3.3: Using Existing Tube Wells

3.1.1 Roof top rain water harvesting through Trench with Recharge Well

In areas where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, the use of trench/ pits is made to store the water in a filter media and subsequently recharge to ground water through specially constructed recharge wells. (Fig 3.4)

This technique is ideally suited for area where permeable horizon is within 3m below ground level. Recharge well of 100-300 diameter is constructed to a depth of at least 3 to 5 m below the water level. Based on the lithology of the area well assembly is designed with slotted pipe against the shallow and deeper aquifer.

A lateral trench of 1.5 to 3m width and 10 to 30 m length, depending upon the availability of water is constructed with the recharge well in the centre. The number of recharge wells in the trench can be decided on the basis of water availability and local vertical permeability of the rocks.

The trench is backfilled with boulders, gravels and coarse sand to act as a filter media for the recharge wells.

If the aquifer is available at greater depth say more than 20 m, a shallow shaft of 2 to 5 m diameter and 3-5 metres deep may be constructed depending upon availability of runoff. Inside the shaft a recharge well of 100-300 mm dia is constructed for recharging the available water to the deeper aquifers. At the bottom of the shaft a filter media is provided to avoid choking of recharge well.

Fig 3.4: Using Trench with Recharge Well

3.2 Rainwater Harvesting Techniques in Rural Areas

In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and drains.

3.2.1 Rain water harvesting through Gully Plug

- Gully Plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during rainy season.
- Gully Plugs help in conservation of soil and moisture.
- The sites for gully plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds.

3.2.1 Rain water harvesting through Contour Bund

- Contour Bunds are effective methods to conserve soil moisture in watershed for long duration.
- These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the

sloping ground all along the contour of equal elevation.

- Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds.
- Spacing between two contour bunds depends on the slope the area as the permeability of the soil. Lesser the permeability of soil, the close should be spacing of bunds.
- Contour bunding is suitable on lands with moderate slopes without involving terracing.

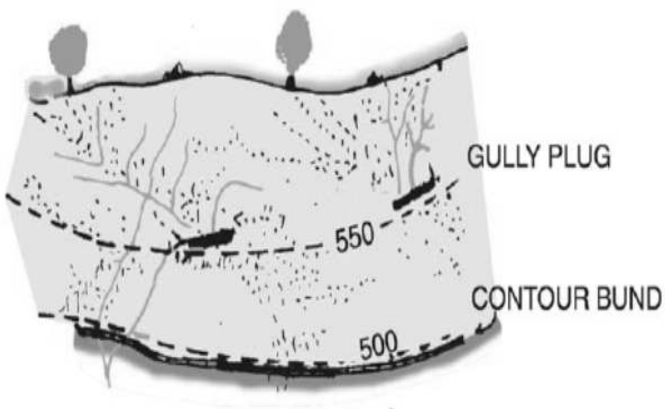


Fig 3.5 Using Gully Plug & Contour Bund

3.2.1 Rain water harvesting through Gabion Structure

- This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course.
- A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks.
- The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m.
- The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for sufficient time after rains to recharge the ground water body. (Fig 3.6)

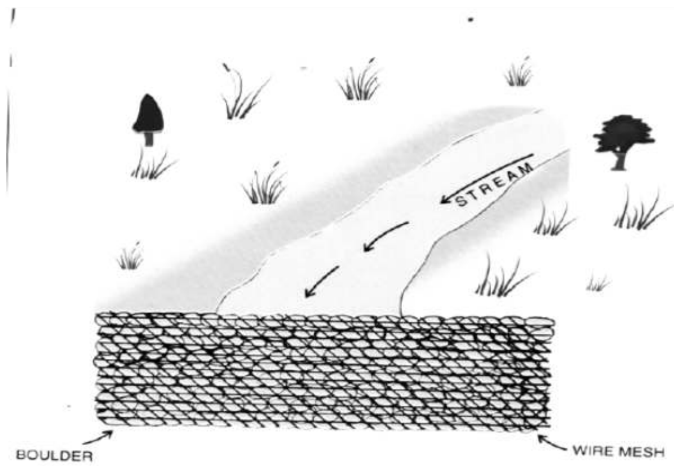


Fig 3.6: Using Gabion Structure

3.2.1 Rain water harvesting through Percolation Tank

- Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage.
- Percolation tank should be constructed preferably on second to third order steams, located on highly fractured and weathered rocks, which have lateral continuity down stream.
- The recharge area down stream should have sufficient number of wells and cultivable land to benefit from the augmented ground water.
- The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 MCM. It is necessary to design the tank to provide a ponded water column generally between 3 & 4.5 m. (Fig 3.7)
- The percolation tanks are mostly earthen dams with masonry structure only for spillway. The purpose of the percolation tanks is to recharge the ground water storage and hence seepage below the seat of the bed is permissible. For dams up to 4.5 m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.

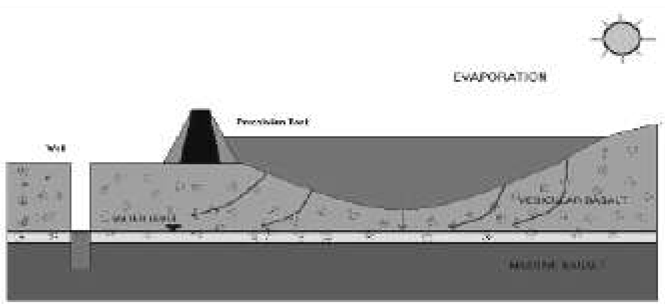


Fig 3.7: Using Percolation Tank

3.2.1 Rain water harvesting through Check Dams / Cement Plugs / *Nala* Bunds

- Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time.
- The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.
- To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale.
- Clay filled cement bags arranged as a wall is also being successfully used as a barrier across small *Nalas*. At places, shallow trench is excavated across the *Nala* and asbestos sheets are put on two sides. The space between the rows of asbestos sheets across the *Nala* is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.

Fig 3.8: Using Check Dams

3.2.6 Rain water harvesting through Recharge Shaft

- This is the most efficient and cost effective technique to recharge unconfined aquifer overlain by poorly permeable strata.
- Recharge shaft may be dug manually if the strata are of non-caving nature. The diameter of shaft is normally more than 2 m.
- The shaft should end in more permeable strata below the top impermeable strata. It may not touch water table.
- The unlined shaft should be backfilled, initially with boulders/ cobbles followed by gravel and coarse sand.
- In case of lined shaft, the recharge water may be fed through a smaller conductor pipe reaching up to the filter pack.
- These recharge structures are very useful for village ponds where shallow clay layer impedes the infiltration of water to the aquifer.
- It is seen that in rainy season village tanks are fully filled up but water from these tanks does not percolate down due to siltation and tube well and dug wells located nearby remains dried up. The water from village tanks gets evaporated and is not available for the beneficial use.
- By constructing recharge shaft in tanks, surplus water can be recharged to ground water. Recharge shafts of 0.5 to 3 m. diameter and 10 to 15 m. deep are constructed depending upon availability of quantum of water. The top of shaft is kept above the tank bed level preferably at half of full supply level. These are back filled with boulders, gravels and coarse sand. (Fig 3.9)
- In upper portion of 1 or 2 m depth, the brick masonry work is carried out for the stability of the structure.
- Through this technique all the accumulated water in village tank above 50% full supply level would be recharged to ground water. Sufficient water will continue to remain in tank for domestic use after recharge.

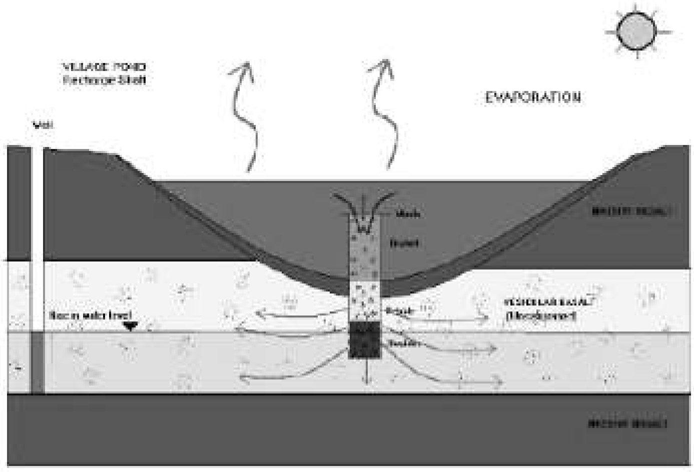


Fig 3.9: Using Recharge Shaft

3.2.6 Rain water harvesting through Dug Well Recharge

- Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same.
- The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.(Fig 3.10)
- Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.

Periodic chlorination should be done for controlling the bacteriological contaminations.

3.2.6 Ground water dams or sub-surface dykes

- Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface. By doing so, the water levels in upstream part of ground water dam rises saturating otherwise dry part of aquifer.(Fig 3.11)
- The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow out let.
- After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/ concrete wall up to 0.5 m below the ground level.
- For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 Gauges or low-density polythene film of 200 Gauges can also be used to cover the cut out dyke faces

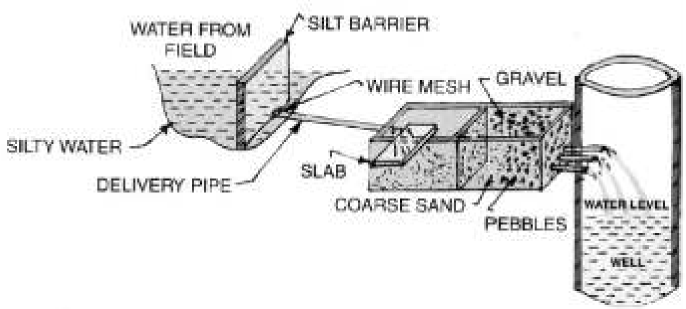


Fig 3.10: Using Dug Well Recharge

- Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir take place. The potential disaster like collapse of the dams can also be avoided.

Fig 3.11: Using Sub-Surface Dykes

3.3 Designing Rainwater Harvesting System

How Much Water Can Be Captured?

The basic rule for sizing any rainwater harvesting system is that the volume of water that can be captured and stored (the supply) must equal or exceed the volume of water used (the demand). The very basic equation to determine the possible amount of water that can be harvested from a given catchment area is shown below:

Maximum Possible Volume of Runoff from a Roof or Catchment Area (litres)	Roof or Catchment Area (m^2)	Average Annual Rainfall (mm)	Runoff Coefficient depending on the surface of Catchment Area (Fraction)

Catchment area / roof area must be the footprint / projected area. The collection surface is the "footprint" of the roof (Fig. 3.12). In other words, regardless of the pitch of the roof, the effective collection surface is the area covered by collection surface (length times width of the roof from eave to eave and front to rear).

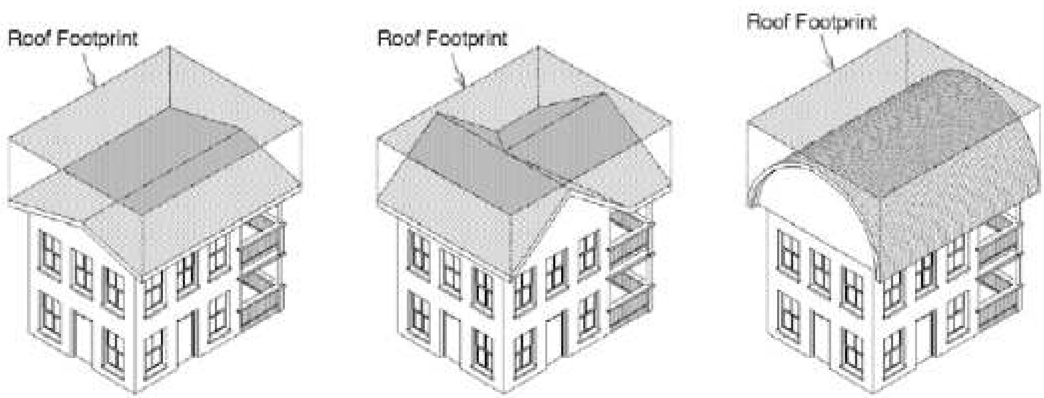


Fig. 3.12 Footprint areas of different roofs

In India the distribution of rainfall is very random and erratic. In some areas it is very scanty as low as 100mm in some part of Western Rajasthan and some areas it is very heavy as more than 11500mm in North-East states. For proper designing the RWH structure to know the average annual rainfall and average intensity of rainfall is must. These data should be considered for atleast 10 years recurrence interval.

Runoff coefficient solely depends on the roughness of the catchment or roof material. It varies between 0 to 1 and always lesser than 1. Smoother the surface; higher the runoff coefficient. Table 3.1 shows the value of runoff coefficient for various roof materials.

Table 1.2 Water consumption standards for different industries

Type of Catchment	Coefficients
Roof Catchments	
- Tiles	0.8- 0.9
- Corrugated metal sheets	0.7- 0.9
Ground surface coverings	
- Concrete	0.6- 0.8
- Brick pavement	0.5- 0.6
Untreated ground catchments	
- Soil on slopes less than 10 per cent	0.0 - 0.3
- Rocky natural catchments	0.2 - 0.5
Untreated ground catchments	
- Soil on slopes less than 10 per cent	1.0 - 0.3
- Rocky natural catchments	0.2 - 0.5

Source: Pacey, Arnold and Cullis, Adrian 1989, Rainwater Harvesting: The collection of rainfall and runoff in rural areas, Intermediate Technology Publications, London

Calculating Storage Capacity and Design of Storage Tank:

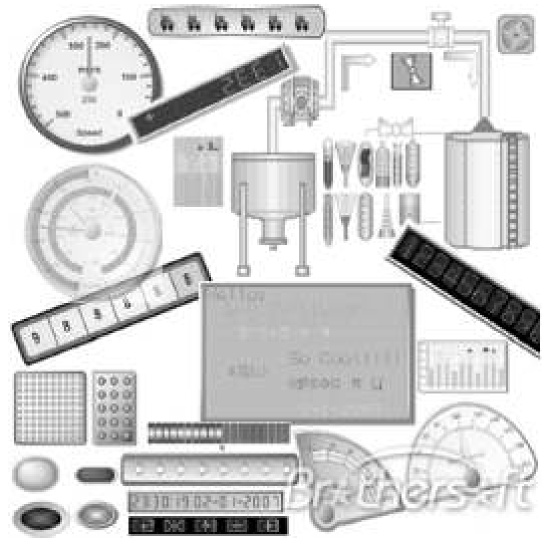
Storage capacity depends on the maximum quantum of water that can be harvested within the facility. Once we finalized the design volume from either of the above method, the design of storage tank can be done accordingly.

Volume of rectangular Tank = (Length X Width X Depth)

Vol. of Circular Tank = p/4 X $(\text{Dia})^2$ X Depth

With known volume and convenient assumed depth the rest of the dimensions can be figured out and the best suitable combination can be adopted. In case if the dimensions are too large to be practical, you can go for multiple numbers of tanks of smaller sizes.

Chapter 4
MONITORING & MEASUREMENTS



MONITORING & MEASUREMENTS

Monitoring and measurement are two most important things in effective industrial water management. It is applicable in case of both water and electricity; if you cannot measure it you cannot conserve it.

4.1 Benefits of Better Water Measurement

Besides proper billing for water usage, many benefits can be derived by upgrading water measurement programs and systems. Although some of the benefits are intangible, they should be considered during system design or when planning water measurement upgrade. Good water management requires accurate water measurement. Some benefits of water measurement are:

- Accurate accounting and good records help allocate equitable shares of water between competitive uses both on and off the plant.
- Good water measurement practices facilitate accurate and equitable distribution of water within district or farm, resulting in fewer problems and easier operation.
- Proper recording and monitoring leads to develop a clear Water balance of any plant which is the primary key to water conservation programme
- Accounting for individual water use combined with pricing policies that penalize excessive use.
- Atleast 2% of the water saving can be easily achieved by just measuring and monitoring in the plant.

4.2 Metering & Measurement

Metering here refers to measuring water flow rates and quantities at various points of uses. These readings of water measurement at various points can be developed into a database or water record of particular premises or industry. There are varieties of water measuring devices available in the market as per the functional requirement. Based on the water flow these can be broadly classified into two categories:

A. Water Measuring devices for open channel flow

B. Water Measuring devices for conduit flow

4.3 Water Measuring devices for open channel flow

In normal course, the open channel flow water measurement is not very popular among industries. These types of devices are mainly functions in canal head works, municipal water supply head works, large STPs, ETPs & CETPs. Some of the most common water measuring devices for open channel flow are as under:

V-Notch

In the case of *rectangula*r and trapezoidal weirs, water flows through a sharp-edged rectangular or trapezoidal notch. In the case of v-notch weirs, water flows through a sharp-edged (usually) 90 degree-angled notch. This weir is especially good at handling a wide range of flows. (Fig 4.1)

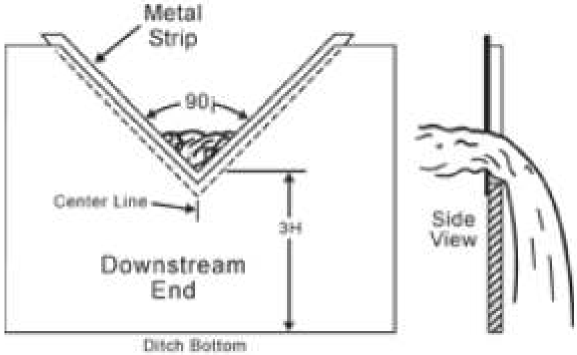


Fig 4.1: Sectional View of V - Notch

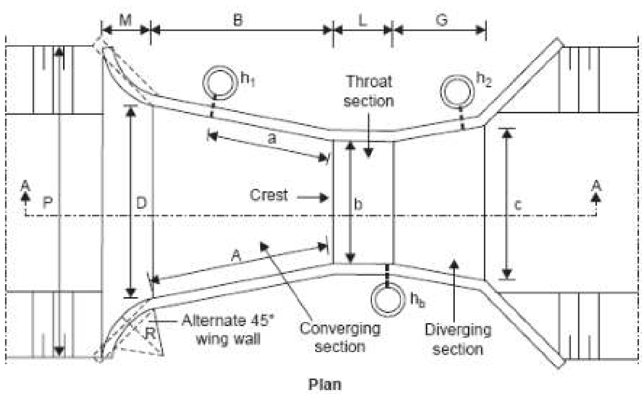
Flumes

A flume is a flow measuring device formed by a constriction in an open channel. The constriction can be either a narrowing of the channel or a narrowing in combination with a hump in the invert. The main advantage of a critical-depth flume over a weir is in situations when material (sediment or sewage) is being transported by the flow. There are two category of flumes Long-Throated Flumes & Short-Throated Flumes. The later one is most commonly used and known as Parshall Flume.

Short-Throated Flumes (Parshall Flume)

In these flumes, the curvature of the water surface is large and the flow in the throat is not parallel to the invert of the flume. The principle of operation of these flumes is the creation of critical conditions at the throat. However, non-hydrostatic pressure distribution (due to large curvature of flow) does not permit analytical derivation of the discharge equation. Further, energy loss also cannot be assessed. Therefore, it becomes necessary to rely on direct calibration either in the field or in the laboratory for the determination of the discharge equation. The designer does not have complete freedom in choosing the dimensions of the flume but has to select the closest standard design to meet his requirements. Such flumes, however, require lesser length and, hence, are more economical than long-throated flumes. One of the most commonly used short-throated flumes is the Parshall flume which has been described here.

Parshall designed a short-throated flume with a depressed bottom (Fig. 4.2) which is now known as the Parshall flume. It consists of short parallel throat preceded by a uniformly converging section and followed by a uniformly expanding section.



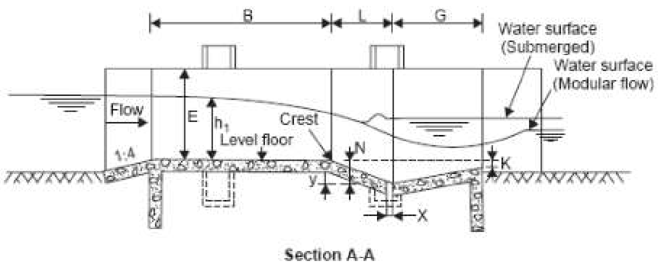


Fig. 4.2 Sectional View of Parshall flume

There are 22 standard designs covering a wide range of discharge from 0.1 litre per second to 93 m^3/s.

Weirs

Weirs have been in use as discharge measuring devices in open channels for almost two centuries. A *weir* is an obstruction over which flow of a liquid occurs (Fig. 4.3). Head *H* over the weir is related to the discharge flowing and, hence, the weir forms a useful discharge measuring device. Weirs can be broadly classified as thin-plate (or sharp-crested) and broadcrested weirs.

Submerged Orifices

An orifice used as a measuring device is a well-defined, sharp-edged opening in a wall or bulkhead through which flow occurs. For irrigation use, orifices are commonly circular or rectangular in shape and are generally placed in vertical surfaces, perpendicular to the direction of channel flow. Submerged orifices are often used where ditch slope is insufficient for weirs.

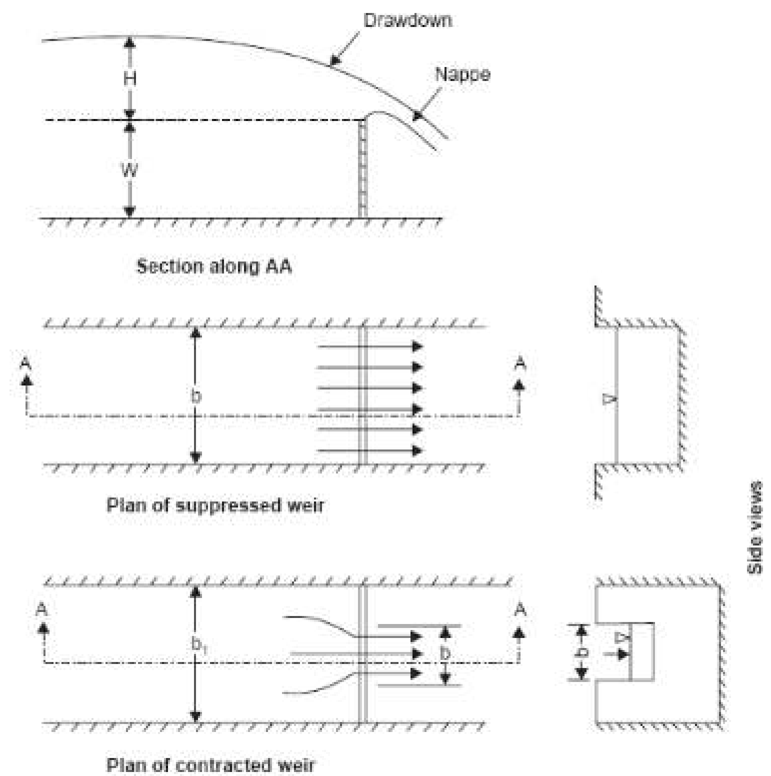


Fig. 4.3 Flow over suppressed and contracted weirs

They generally cost less than weirs and can fit into limited spaces, but are susceptible to trash build-up. Water flowing through an orifice is discharged below the downstream water surface. For this device to be accurate, it must be submerged.

A submerged orifice and the same orifice discharging freely have nearly the same coefficient of discharge. Submerging an orifice provides the capability to measure relatively large flows with a small drop in water surface, conserving delivery head compared with weirs. However, the submerged orifice requires head measurements upstream and downstream. The difference between the two heads is used in the following orifice equation. A free- flow measurement requires measurement of only one upstream head.

$$Q = C_d A_O \sqrt{2gH}$$

C_d = Discharge coefficient (No unit)

A_O = Orifice area (m^2)

g = Gravitational constant (m/s^2)

H = Center line head (m)

Current meters

Current meters are velocity measuring devices that sample at a point. Each point velocity measurement is then assigned to a meaningful part of the entire cross section passing flow. The velocity-area principal is used to compute discharge from current-meter data. Total discharge is determined by summation of partial discharges. Data are usually determined over a useful range of total discharges. These discharges are related to measured water surface elevations related to a fixed head measuring device to provide a rating curve. After full confidence in the rating is attained, the calibrated head measurement device and cross section may be used as a gauging station. (Fig 4.4)

Fig. 4.4 Typical submerged type current meter

4.4 Water Measuring devices for conduit flow

Flow in a pipeline can be measured very accurately if the correct measuring device is installed and used properly. These devices need periodic calibration and maintenance, and water must be relatively (in some cases, very) clean. Accurate measurement requires full pipe flow. Generally, maximum industries having conduit pipeline system of water distribution and the flow measurement in conduit is done flowmeter. Pipeline flow is measured by either intrusive devices or external devices.

4.4.1 Intrusive flow meters

These are located inside the pipe or inserted through the pipe wall) Intrusive flow meters include Venturi, nozzle, and orifice plate meters that measure flow through a constriction within the pipe. None have moving parts. They require little maintenance in clean water and are installed directly in the pipeline.

Propeller meter:

Propeller meters are commercial flow measuring devices used at the ends of pipes and in conduits flowing full and under pressure (figure 4.5). Propeller meters use multiple blades made of rubber, plastic, or metal. The propeller rotates on a horizontal axle geared to a totalizer that displays total volume that has passed the meter. The propellers are sometimes hung from a sealing plate with a gasket to seal around a saddle opening on the top of the pipeline. Others have propellers supported by spiders in short, permanent tubes for connection into pipeline flow. Some meters also display instantaneous discharge rate with indicator hands on dials. Propeller meters can pass some debris, but even moderate amounts can foul the blades.

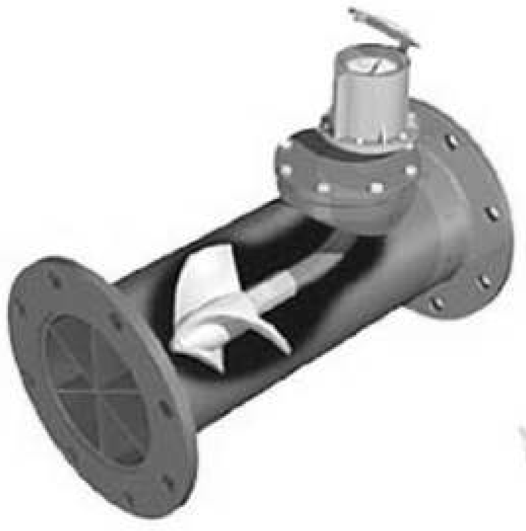


Fig 4.5 A cross sectional view of a Propeller meter

The meters are available for a range of pipe diameters from 2 to 72 inches. They are normally designed for water flow velocities up to 5 meter per second (m/s). The accuracy of most propeller meters varies from +/-2 to +/-5 percent of the actual flow.

Magnetic flow meters

The most common flow meter apart from mechanical flow meters is the magnetic flow meter, commonly referred to as a "mag meter" or an "electromag". A magnetic field is applied to the metering tube, which results in a potential difference proportional to the flow velocity perpendicular to the flux lines. The physical principle at work is Faraday's law of electromagnetic induction. The magnetic flow meter requires a conducting fluid, e.g. water, and an electrical insulating pipe surface, e.g. a rubber lined nonmagnetic steel tube. (Fig. 4.6)

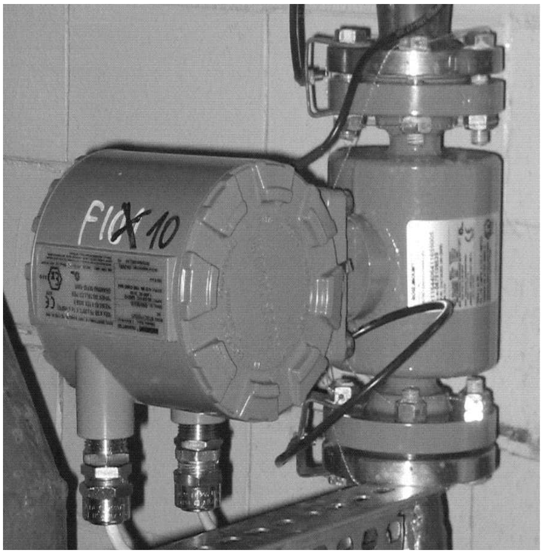


Fig 4.6 Industrial magnetic flowmeter

Pitot Tubes

A Pitot tube is a pressure measurement instrument used to measure fluid flow velocity. The straight upstream tube, which is connected perpendicular and flush to the inside wall of the pipe so it does not sense any velocity force, is a called a piezometer. Water rises in the piezometer to an elevation that only balances the pressure head in the conduit. This open tube has a right-angle bend that is inserted into conduit flow with its horizontal leg pointed upstream and parallel to velocity. Water runs into the tube and rises into the vertical stem until its weight balances both the force of the pipeline pressure head and the force of approach velocity that has been converted to velocity head by stagnation at the tip. In this form, the pitot tube is sometimes called a total head tube. Pitot tubes are inserted into the side of a pipe. They require drilling a hole through the pipe (allowing the insertion of the tube), making them less convenient and common than propeller meters.

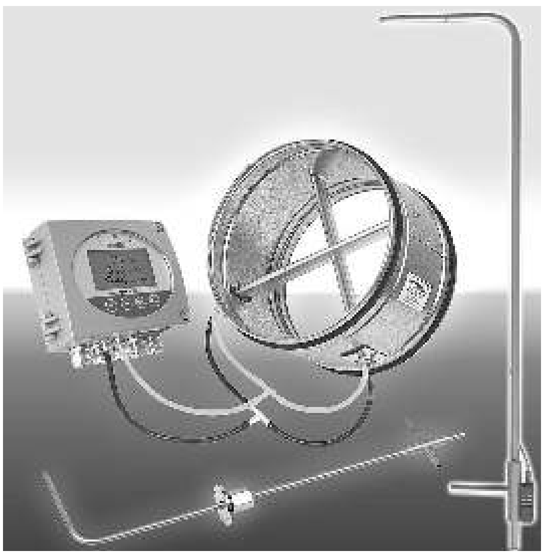


Fig 4.7 Pitot Tube

4.4.2 Non-intrusive (external) flow meters

Non-intrusive (external) flow meters send ultrasonic or acoustic waves through a pipe and take very accurate measurements of Doppler shift or transit time to calculate flow rate. These devices are clamped onto the outside of the pipe wall (nothing is physically inserted into the pipe) which makes them extremely quick and convenient to use. Several types of ultrasonic meters are currently on the market. They are costly, in the range of Rs. 75,000 to Rs. 4,50,000 although prices are dropping, and some training is required for accurate measurements.

Doppler-Type Acoustic Flowmeter

The Doppler flowmeter measures the velocity of particles moving with the flowing fluid. Acoustic signals of known frequency are transmitted, reflected from particles, and are picked up by a receiver. The received signals are analyzed for frequency shifts (changes), and the resulting mean value of the frequency shifts can be directly related to the mean velocity of the particles moving with the fluid. Doppler flowmeter performance is highly dependent on physical properties such as the liquid's sonic conductivity, particle density, and flow profile. Likewise, non uniformity of particle distribution in the pipe cross section results in a computed mean velocity that is incorrectly weighted. Therefore, the meter accuracy is sensitive to velocity profile variations and to distribution of acoustic reflectors in the measurement section. As a result, the meter is sensitive to changes in density and temperature. These problems make Doppler flowmeters unsuitable for highly accurate measurements.

Ultra-Sonic Flowmeter

The cross-correlation meter employs two transverse acoustic signals separated by a short distance (fig. 4.8). Under no-flow or laminar-flow conditions, the two signals received are identical to those transmitted. When turbulent flow occurs, the movement of an eddy through a beam causes a change in the acoustic signal which has a unique signature. An electronic signal processor is used to compare the two received signals. When two identical signals are found, the time and distance (between the acoustic transmitters) information is used to compute velocity. If the flowing fluid is homogenous and has no eddies (laminar flow), this type of meter will not work. This meter measures an incorrectly weighted mean velocity. Therefore, the measurement is susceptible to an inaccuracy associated with variations in velocity profiles.

Fig 4.8 Ultra Sonic Flowmeter

4.5 Instrumentation & Automation

Instrumentation means how you have utilizes the various instruments in your process in order to optimize the operation, minimize the water & Electricity consumption.

Automation is the second stage of instrumentation. Once you instrumented your process operations then for further efficiency and accuracy the automation comes into the picture. It takes control over the entire process operation with pre-programmed data sets. Thus automation enhances the efficacy of system as compared to manual system. Installations of Electro-mechanical flow meters which are connected with a log-book in a computer are the clear examples of a good automation.

4.5.1 PH Meter (batch and on-line)

A pH meter is an electronic instrument used to measure the pH (acidity or alkalinity) of a liquid (though special probes are sometimes used to measure the pH of semi-solid substances). A typical pH meter consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading.

For very precise work the pH meter should be calibrated before and after each measurement. For normal use calibration should be performed at the beginning of each day. The reason for this is that the glass electrode does not give a reproducible electro motive force over longer periods of time.

Calibration should be performed with at least two standard buffer solutions that span the range of pH values to be measured. For general purposes buffers at pH 4 and pH 10 are acceptable.

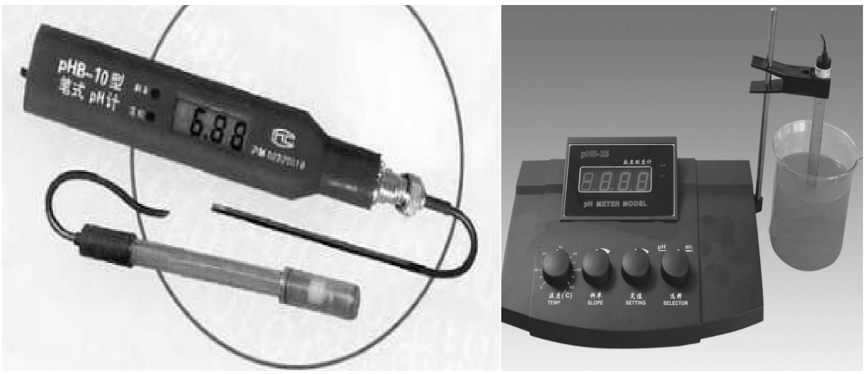


Fig 4.9 Batch Type pH Meters

4.5.2 Electrical Conductivity Meter (batch and on-line)

An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution. Commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water. Use for batch and on-line control of incoming process water, rinse water treatment, re-circulating system and waste water treatment.

Fig 4.10 Online & Batch Electrical conductivity meters

Online EC meters are very useful in blow down operation of boiler in any thermal power plant. These are ideal for chemical processing, food processing, aquarium, pharmaceutical, hydroponics and waste control industries as these units generally have their own captive power plant.

A variety of EC meters are available in the market with wide working range and high accuracy; one can opt as per their specific requirement.

4.5.3 TDS Meter (batch and on-line)

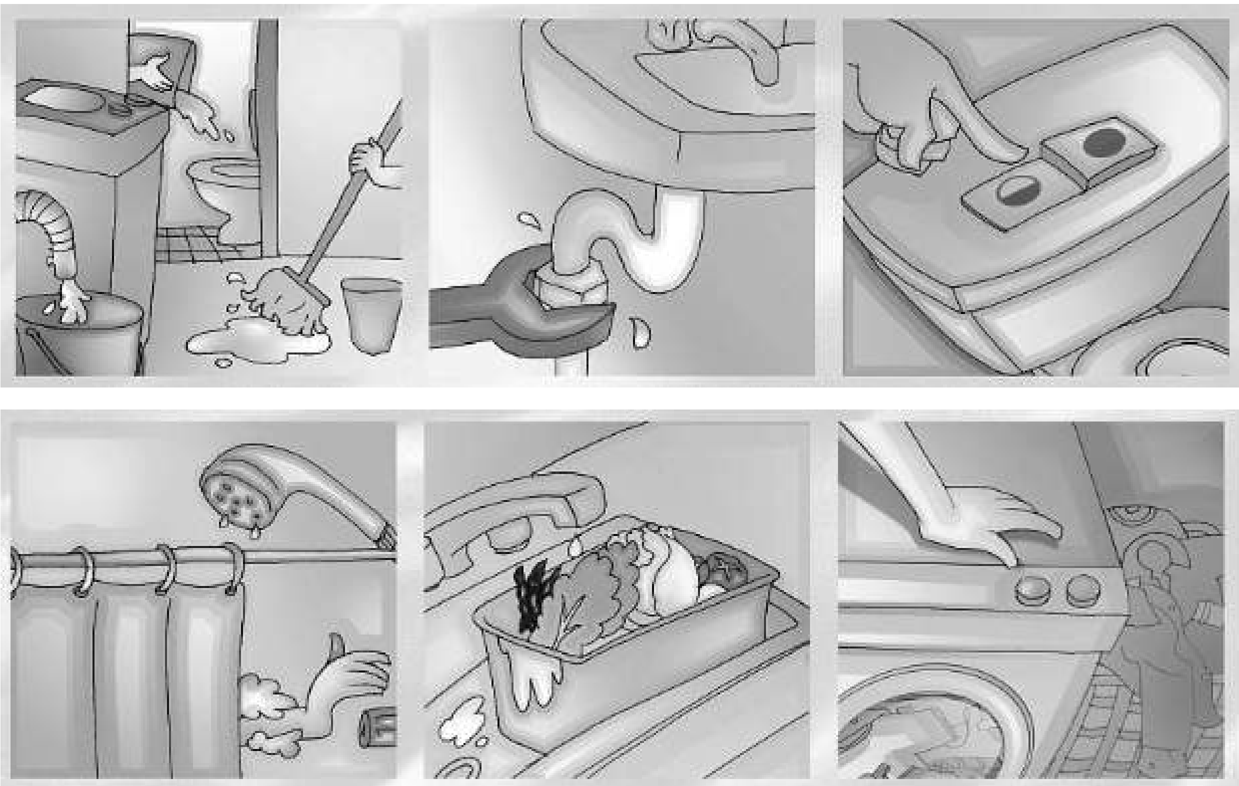
A TDS Meter indicates the amount of total dissolved solids (TDS) in a solution. Since dissolved ionized solids like salts and minerals contribute to the conductivity of a solution, a TDS meter measures the conductivity of the solution then converts that figure to an estimated TDS reading.

Fig 4.11 Online TDS Meter

A TDS meter typically displays the total weight of dissolved solids as a proportion of one litre of water. The unit used by most TDS meters is parts per million (ppm). For example, a TDS reading of 1 ppm would indicate there is 1 milligram of dissolved inorganic solids in each 1 litre of water.

Dissolved organic solids such as sugar, and microscopic solid particles such as colloids, do not significantly affect the conductivity of a solution so they are not measurable by a TDS meter.

Chapter 5
DOMESTIC WATER CONSERVATION



DOMESTIC WATER CONSERVATION

Domestic water conservation technologies can be used effectively in any residential, institutional, and commercial buildings to ensure conservation of water. These technologies are helpful in areas where water use has been restricted because of scarcity or dwindling supplies. However, these technologies can be used anywhere in almost any kind of building.

5.1 Water efficient fixtures

Low water use fixtures are designed to use less water while maintaining the same level of performance as older fixtures. A variety of water-efficient fixtures and appliances are available in the market. Faucets, showerheads and toilets are just a few examples of the fixtures available in water efficient models. Although water efficient fixtures use less water, they provide the same or even improved level of performance compared to non-efficient models. Water efficient fixtures can be slightly more costly than older fixtures. But when you add the savings on your monthly water bill, money saved far outweighs any additional amount spent on the actual fixture.

There are a number of aspects and components of water systems in any plant area and commercial buildings that can contribute to achieve water conservation in domestic water usages. These are described below:

Water meters:

The mains water meter in a building should be located where it can be easily read, in order to monitor consumption. In addition, sub metering should be provided for areas with substantial water requirements such as large irrigation systems. This allows water consumption to be monitored more closely, and controlled. Proper measurement and monitoring can ensure reduction in the consumption of water between 5-15%. However the percentage reduction depends on the present operating practices of the building.

Water pressure:

High water pressure can result in wastage as flow rates of taps and showers are increased. Correct water pressures should therefore be specified and pressure reducing valves used, if necessary.

Wash hand basin taps:

Large quantities of water can be wasted when taps are left running. This is often the case in wash hand basin taps. To reduce wastage the following measures can be taken:

- Flow rates: Taps with flow rates of under 6L/minute should be specified. Where flow rates are higher than this, constrictors and aerators can be used to reduce flow rates.
- Usage: The length of usage can also be controlled through metering and demand taps or taps fitted with proximity sensors.

Electronic Taps (e-taps):

The latest trend in industries is to install electronic taps (e-taps). The advantages of using e-taps are as mentioned below:

- Unlike conventional taps, there is no twisting or turning in e-taps. They have a sensor, which cuts off water supply completely when not in use. This helps in saving 40% water during hand wash
- E-taps enable hands free operation. No fear of cross contamination or contact with germs. E taps score very high on hygiene. It is the most ideal choice for multipurpose and multi user washrooms.
- E-taps can work efficiently up to raw water TDS of 2000 ppm.

- The touch free electronic taps, available in AC and DC models consume minimal power only. The AC model has an efficient battery back-up, while the DC model runs on just 4 alkaline batteries.
- Operation of Electronic Taps

Fig 5.1: Electronic sensor taps

This has been successfully implemented in several hotels & restaurants. Of late, several industries have also started installing E-taps in their premises. Thus, it's a proven fact that there is always a good potential to optimize the fresh water consumption by replacing the existing taps with e-taps.

Foam taps:

Conventional taps are used in all hand wash areas which results in large quantity of fresh water.

Fig 5.2: Foam Type Taps

Foam taps are a better fit in these high consumption areas. They consume 25-30% less than the conventional taps.

Showers:

Where possible, baths should be avoided and showers, which use less water, should be specified. The specification of showerhead and controls can support efficiency in the following ways:

- Flow rate: Maximum flow rates of 10L/minute should be specified for showers.
- Usage: Usage can be controlled by shower valves that control the amount of water that is used

Hot water pipes:

Large amounts of water are wasted when people run taps waiting for water to become warm. This wastage can be reduced by minimizing the length of piping from the point at which water is heated to where it is used. Therefore solar water heaters and geysers should be located as close as possible to areas where hot water will be consumed. In addition, hot water pipes should be insulated to ensure that water in the pipe is still warm when the hot water taps are next switched on.

Toilets:

Toilets which require large amounts of water should be avoided. Ideally, toilets that do not require any water, such as composting toilets, should be used. However, if this is not possible, toilets that use the minimum amount of water possible should be used. This can be achieved through specifying low flush toilets which do not require more than 9L/flush or through dual-flush mechanisms that enable users to use a half flush, of say of 4.5L, when full flushes are not required.

- The cisterns in toilets are old conventional type which consumes large quantity of water during flushing. The old type of closet consumes about 11 litres per flush.

Fig 5.3: Dual flush Type Flushing System

The latest model closets are water efficient and operate in dual mode with single flush releases 3 litres and dual flush releases 6 litres per flush. This results in large quantity of water savings.

Urinals:

Waterless urinals have become increasingly popular now a day among most of the corporate. These use valves or chemicals to avoid using water to flush urinals and can result in significant water consumption savings. It is however important to understand, and address, the maintenance requirements of this equipment to ensure that this remains effective. Where water is used for flushing urinals, highly efficient devices should be specified, and flush rates set as low as possible. The latest trend in industries is to install e-flush urinals. The advantages of using e-flush urinals are as mentioned below:

- E-flush urinals are fitted with a sensor, which senses the usage and flush with water for few seconds after use. This helps in saving 70% water during urinal flush

Fig 5.4: E- Flush Urinals

- E-flush urinals enable hands free operation and score very high on hygiene. It is the most ideal choice for multipurpose and multi user washrooms. E-flush urinals can work efficiently up to raw water TDS of 2000 ppm.

- The touch free e-flush urinals available in AC and DC models consume minimal power only. The AC model has an efficient battery back-up, while the DC model runs on just 4 alkaline batteries.

Waterless Urinals:

A more recent innovation is urinals that use no water at all. The innovation is secured with several patents. Models utilize a trap insert filled with a sealant liquid instead of water. The lighter-than-water sealant floats on top of the urine collected in the U-bend, preventing odors from being released into the air. Although the cartridge and sealant must be periodically replaced, the system saves anywhere between 15,000 and 45,000 gallons (approx. 55,000 and 170,000 liters) of water per urinal per year. (Fig. 5.5)

Other companies do not use a cartridge; instead they have developed an outlet system that traps the odor, preventing the smell often present in toilet blocks. They can be installed in high-traffic facilities and in situations where providing a water supply may be difficult or where water conservation is desired. Due to high-level water restrictions, Brisbane has mandated conversion to waterless urinals and flush urinals are rarely seen.

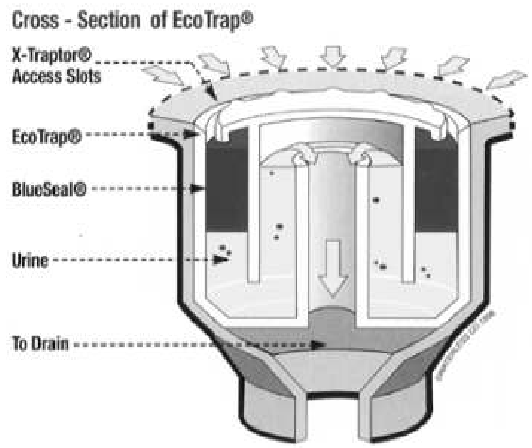


Fig 5.5 Waterless Urinal

Water consuming devices:

Large water consuming devices such as swimming pools and large ornamental ponds should be avoided as their water consumption requirements as a result of evaporation can be high. If however, these cannot be avoided, they should be replenished from rainwater storage and covered when not is use to reduce evaporation.

5.2 Reuse & Recycle of water

While recycling is a term generally applied to aluminium cans, glass bottles, and newspapers, water can be recycled as well. Water recycling is reusing treated wastewater for beneficial purposes. Recycled water is most commonly used for non-potable (not for drinking) purposes, such as agriculture, landscape, public parks, and golf course irrigation. Other non-potable applications include cooling water for power plants and oil refineries, industrial process water for such facilities as paper mills and carpet dyers, toilet flushing, dust control, construction activities, concrete mixing, and artificial lakes.

Water is sometimes recycled and reused onsite; for example, when an industrial facility recycles water used for cooling processes. A common type of recycled water is water that has been reclaimed from municipal wastewater, or sewage. The term water recycling is generally used synonymously with water reclamation and water reuse. (Fig. 5.6 indicates water recycling treatment and its uses)

Benefits of Water Recycling:

In addition to providing a dependable, locally-controlled water supply, water recycling provides tremendous environmental benefits. By providing an additional source of water, water recycling can help us find ways to decrease the diversion of water from sensitive ecosystems. Other benefits include decreasing wastewater discharges and reducing and preventing pollution. Recycled water can also be used to create or enhance wetlands and riparian habitats.

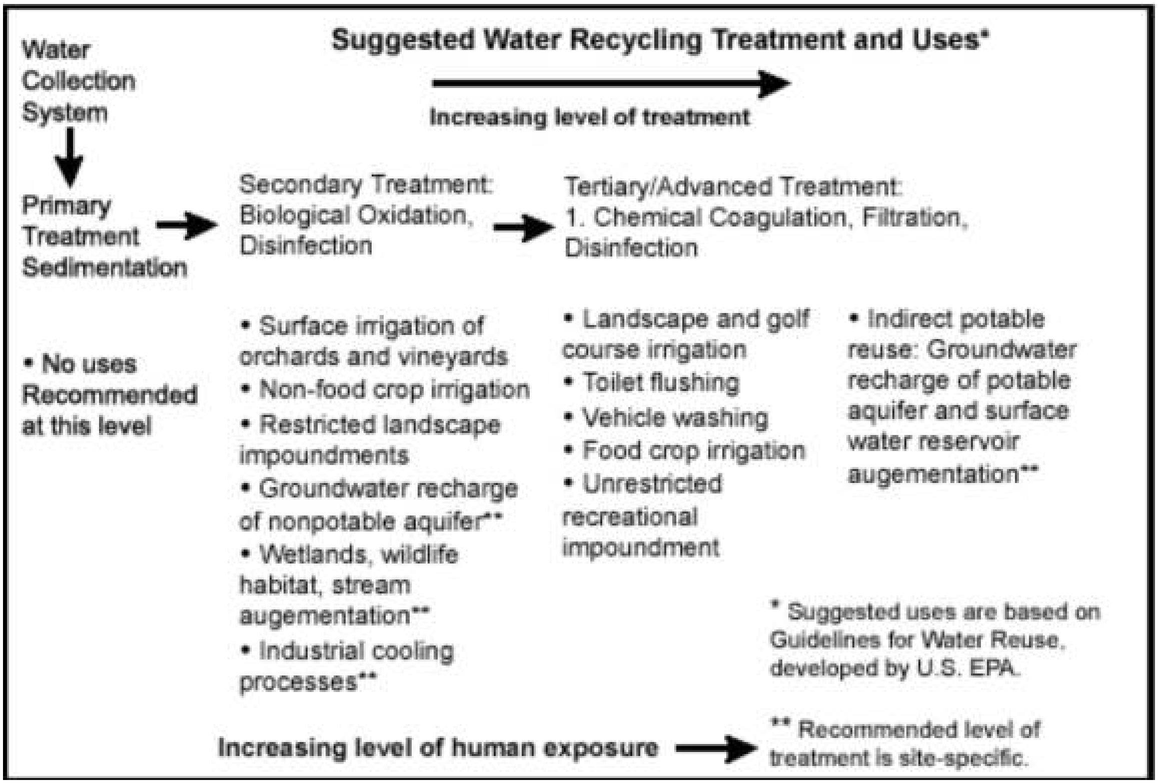


Fig 5.6: Flow diagram of Water Recycling Treatment & uses

Water Recycling Can Decrease Diversion of Freshwater from Sensitive Ecosystems:

Plants, wildlife, and fish depend on sufficient water flows to their habitats to live and reproduce. The lack of adequate flow, as a result of diversion for agricultural, urban, and industrial purposes, can cause deterioration of water quality and ecosystem health. Water users can supplement their demands by using recycled water, which can free considerable amounts of water for the environment and increase flows to vital ecosystems.

Water Recycling Decreases Discharge to Sensitive Water Bodies:

In some cases, the impetus for water recycling comes not from a water supply need, but from a need to eliminate or decrease wastewater discharge to the ocean, an estuary, or a stream. By avoiding the conversion of salt water marsh to brackish marsh, the habitat for two endangered species can be protected.

As water demands and environmental needs grow, water recycling will play a greater role in our overall water supply. By working together to overcome obstacles, water recycling, along with water conservation can help us to conserve and sustainably manage our vital water resources.

A number of terms are used while referring about recycling and reusing water for industries or other purposes.

- Water reuse - making use of water from diverse sources, other than the fresh drinking water supply.
- Direct reuse - involves using rainwater, greywater, stormwater or wastewater without treatment.

- Recycled water (sometimes called 'reclaimed water') - wastewater or stormwater treated to a high standard as appropriate for particular uses in homes, agriculture or industry.
- Sewer mining - the process of tapping directly into a sewerage system, (either before or after a sewage treatment plant), and extracting wastewater for treatment and reuse as recycled water.
- Greywater - the wastewater generated in homes, except from the toilet. Depending on the purpose, greywater may be used treated or untreated.
- Blackwater - all of the components of domestic sewage.
- Stormwater - runoff from roofs, roads and driveways. Stormwater must generally be treated for use. Water caught in rainwater tanks is suitable for some uses.

Chapter 6
BEST PRACTICES & CASE STUDIES

CASE STUDIES

Water management practices all over the world have been constantly been updated and implemented in the various industrial sectors. This chapter in the manual would deal with the latest on going best practices in water management across the varied sectors of Indian Industry. The manual tries to highlight some of the chosen best practices by giving the objective of the project, results or benefits and the methodology or approach for achieving the benefits.

The following are the list of best practices that are chosen for show casing the various voluntary initiatives taken by industries.

1. Case study of a Zero Discharge Plant
2. Reduce Water Consumption & Effluent Generation by Recycle & Reuse
3. Air Cooled Condensers
4. Boiler blow down water to be used as cooling tower make up water
5. Reuse of final rinse water for glass bottle wash Line
6. Reuse of Power Plant Blow down for make up
7. Recycle of Backwash Water by Installing Tube Settler
8. Installation of oil skimmer to re-use water for cleaning
9. Soft water make up reduced by re-circulating Gas Cleaning Plant (GCP) water
10. Recirculation of jet condenser & vacuum pump water through cooling tower

1. Zero Discharge Plant

Objective	Conservation of Fresh Water, meeting regulations on discharge & ensuring water security at a Refinery
Results	• The plant treats 4 MLD of Refinery Waste for reuse. • Saves 4 MLD of fresh water and Rs. 408 Lacs per year
How achieved?	Installation of RO and UF combination for treating waste water Economics • O&M costs at Rs.19/m3 • Capital & Int. repayment Rs.14/m3 (estimated) • Fresh water costs Rs.60/ m3 • Investment made Rs 10.5 crore

2. Reduce Water Consumption & Effluent Generation by Recycle & Reuse

Objective	Efficient Water Management and Reduction in Effluent Generation
Results	• Reduced water consumption from an anticipated figure of 1065KL/day to 610 KL/day by Recycle & Reuse • Reduced effluent generation from 600 KL/day to 480KL/day
How achieved?	Recycle of less contaminated water through UF / RO system. • Process improvements and reuse of water. • Implemented in 4 months • Investment- Rs. 35 Lacs. • Saved- Process water - 455 M3/day at Rs.62/M3 and Effluent -120 M3/day at Rs.38/M3 • Total saving Rs.120 Lacs per annum

3. Air cooled condensers

Objective	Air Cooled Condensers in place of conventional cooling towers
Results	• Water savings 6.1 million m^3 over a period of 3 years • Saving of Rs. 1900 Lakh over a period of 3 years • Now Water Consumption is 102 lit/MWH instead of 2500 lit/MWH as earlier
How achieved?	• Installed Air cooled condensers in place of conventional cooling Towers • Cost of the project : Rs 1500 lakh • Annual Cost saving : Rs 642 • Payback period : 28 months

Air cooled condensers

4. Boiler blow down water to be used as cooling tower make up water

Objective	Boiler blow down water to be used as cooling tower make up water
Results	• Water Savings - 146 Kilo Liters / year • Money Saving - Rs. 0.46 Lakhs / year • Load of the ETP has been reduced
How achieved?	Simple Piping arrangements with a small pump has been made to shift the blow down water to CT make up • Investment: Rs. 0.12 Lakh • Pay back Period: 3 months

Cooling Tower

5. Reuse of final rinse water for glass bottle wash line

Objective	Reuse of final rinse water for glass bottle wash line
Results	• Water Savings - 21000 Kilo Liters / year for 500 bottles per minute line operated for 16hours a day • 75.82 % reduction in water consumption per case • Reduction in effluent from 450 KL to 150 KL / day • Saving in Power & chemical consumption • 30,000KL of Water is drained & replenished once in 15 days • Drained water is used for floor washing and non process applications
ow achieved?	• Earlier Final rinse water used for floor washing & non process areas • Make up was done daily @450KL/day • 60 -70% rinse water collected and sent to recovery plant • Treatment done using weak acid cation combined with recovery plant ACF, Sand filter, polishing unit & online UV for final rinse water and reused • Investment Rs.2 lakhs only for online UV

Glass Bottle Wash Line

6. Reuse of Power Plant Blow down for make up to clarifier after gas scrubber

Objective	**Reuse of Power Plant Blow down for make up to clarifier after gas scrubber**
Results	Water Savings - 5,71,852 KL per year • Money Saving Rs. 80Lac per year • 3500 KL/day of fresh water saved and reduced effluent discharge to ETP • Reduction in precipitation of deposits in cooling towers • Frequency of maintenance of cooling tower reduced to once in a year
How achieved?	• Blow down was earlier discharged to rivers • Earlier pH of clarifier after scrubber was < 7.5 which led to huge deposition in cooling towers • pH increased to 9.5 in clarifier after make up with highly alkaline power plant blow down water instead of fresh water leading to deposition in clarifier itself reducing the deposition in the cooling tower • Investment: Rs. 55 Lac • Payback Period: 8.25Months

Clarifier

7. Recycle of Backwash Water by Installing Tube Settler

Objective	Reuse of back wash water in pre-treatment section
Results	• Water savings of 30 m3/day
	• Complete saving of fresh water for back wash
How achieved?	• Tube settler plant is introduced and back wash water is passed through Tube settler • Total cost of the project : 4.5 lakhs • Cost Of Water : Rs 1.00/ m3 • Payback period : 18 months

Tube Settler

8. Installation of oil skimmer to re-use water for cleaning

Objective	Installation of oil skimmer to re-use water for cleaning
Results	• Water savings of 96 m3/ annum • Reduction in cost for wastewater treatment
How achieved?	Oil skimmer introduced • Water reused • Fresh water savings up to 96 m3/year • Cost of the project : Rs 39,000 • Cost of raw water: Rs 12.00/m 3 • Pay back period: 2.8 years

Oil Skimmer

9. Soft water make up reduced by re-circulating Gas Cleaning Plant (GCP) water

Objective Results	Soft water make up reduced by re-circulating Gas Cleaning Plant (GCP) water • Water savings of 96250 m3/annum • Cost savings of Rs 3.9 lacs/annum
How achieved?	• GCP waste water earlier going to ETP • Fresh soft water was used for gas cooling • Part of the GCP recirculation water processed through Pressure Sand Filter and used for gas cooling • Investment Rs. 5.5 lacs;

Gas Cleaning Plant

10. Recirculation of jet condenser & vacuum pump water through cooling tower

Objective	Recirculation of jet condenser & vacuum pump water through cooling tower
Results	Water savings of 500 m3/day
How achieved?	• CD Filter vapours condensed in jet condenser & non condensable ejected by a vacuum pump • A cooling tower installed to recycle the return water from jet condenser & vacuum pump

Cooling Tower

Chapter 7
STANDARDS & NORMS

WATER QUALITY STANDARDS AND NORMS

Fresh water is a finite resource essential for use in agriculture, industry, propagation of wildlife & fisheries and for human existence. India is a riverine country. It has 14 major rivers, 44 medium rivers and 55 minor rivers besides numerous lakes, ponds and wells which are used as primary source of drinking water even without treatment.

Most of the rivers being fed by monsoon rains, which are limited to only three months of the year, run dry throughout the rest of the year often carrying wastewater discharges from industries or cities/towns endangering the quality of our scarce water resources.

7.1 Water quality and its management

The water quality management with aims at achieving the following main objectives

- For rational planning of pollution control strategies and their prioritisation
- To assess nature and extent of pollution control needed in different water bodies or their part
- To evaluate effectiveness of pollution control measures already is existence
- To evaluate water quality trend over a period of time
- To assess assimilative capacity of a water body thereby reducing cost on pollution control
- To understand the environmental fate of different pollutants.
- To assess the fitness of water for different uses.

This chapter deals with the water quality management in industries. The quality of water required for consumption is also presented in table 1.1 for various applications. This chapter also deals with the standards and norms to be adopted by industries prescribed by Central Pollution Control Board (CPCB) for effluent discharge.

The quality of water required would be based on the following categories namely input raw water, soft water, clarified water, DM water, Electro-de-ionized water, RO treated water and effluent water generated in an industry.

According to a concept developed by CPCB on “designated best use” (DBU) water bodies are put to several uses. Each of the use demands highest quality of water which could be termed as “designated best use”, and accordingly the water body is designated. Primary water quality criteria for different uses have been identified. A summary of the use based classification system is presented in table 7.3

Table 7.1 List of industry specific water usage pattern with quality of water

Industry	Typical usage pattern	Quality of water
Textile	Boilers, dyeing and rinsing of yarn, Humidification of the yarn and air washers for maintaining humidity	Soft water / demineralised water for bleaching and dyeing of fibres. Demineralised for conditioning the air in spinning and weaving Shop.
Pulp and paper	Steam production, pulp preparation, transport of fibres and for making of paper	Raw water is treated to remove the turbidity, colour and temporary hardness.
Automobile	• Foundry Operation Scrubbing of gas in case of wet scrubber arrangement, Direct cooling of cupola / furnace in which the melting takes place and Granulation of slag tapped from the furnace. • Machining Operation Cleaning of parts • Paint booths Used in the paint spray booths • Stamping Cleaning of the parts after its stamping • Metal Plating • Assembly Plants Cooling of welder tips, Rinsing operation while applying corrosion protection metal phosphate layer, the electrostatic dip	Raw water Clarified water and/ or soft water Clarified water and/ or soft water Clarified water and/ or soft water Both clarified as well as demineralised water are used in the process DM water
Chemical	Cooling applications, steam generation, process may some time become a part of the product, hydraulic conveying and hydraulic classification, washing of equipment and cleanup and fire fighting.	Raw water, DM Water, soft water, clarified water
Food processing	Washing of raw materials and process equipments, conveying product from one area to another process area, dissolving or extracting, and addition to the finished products To condense steam from evaporators or turbines, in the operation of refrigeration equipments, to cool process equipments like cookers, compressors, jacket cooling	Process/ raw water Cooling water

Industry	Typical usage pattern	Quality of water
Textile	Boilers, dyeing and rinsing of yarn, Humidification of the yarn and air washers for maintaining humidity	Soft water / demineralised water for bleaching and dyeing of fibres. Demineralised for conditioning the air in spinning and weaving Shop.
Pulp and paper	Steam production, pulp preparation, transport of fibres and for making of paper	Raw water is treated to remove the turbidity, colour and temporary hardness.
Automobile	● Foundry Operation Scrubbing of gas in case of wet scrubber arrangement, Direct cooling of cupola / furnace in which the melting takes place and Granulation of slag tapped from the furnace. ● Machining Operation Cleaning of parts ● Paint booths Used in the paint spray booths ● Stamping Cleaning of the parts after its stamping ● Metal Plating ● Assembly Plants Cooling of welder tips, Rinsing operation while applying corrosion protection metal phosphate layer, the electrostatic dip	Raw water Clarified water and/ or soft water Clarified water and/ or soft water Clarified water and/ or soft water Both clarified as well as demineralised water are used in the process DM water
Chemical	Cooling applications, steam generation, process may some time become a part of the product, hydraulic conveying and hydraulic classification, washing of equipment and cleanup and fire fighting.	Raw water, DM Water, soft water, clarified water
Food processing	Washing of raw materials and process equipments, conveying product from one area to another process area, dissolving or extracting, and addition to the finished products To condense steam from evaporators or turbines, in the operation of refrigeration equipments, to cool process equipments like cookers, compressors, jacket cooling	Process/ raw water Cooling water

	Steel Indirect cooling by heat exchangers, direct cooling, de-scaling, scrubbing of gases. indirect condensation of gases, wet dust removal, cooling of furnace components, quenching of slag, cooling of different parts of converters, cooling of furnace and ladlers, cooling of ingot and electrodes, in hot rolling mills and in cold rolling mills. Copper De-scaling of the metal surface	Process / raw / DM water Soft water/ DM water
Petroleum	80 % water is used for cooling applications, boiler feed water and for domestic use.	Process/ raw /DM water
Power	Condensing the steam in turbines, cooling of equipments, boilers, evacuation of solid waste, and fly ash from the Electro Static Precipitator and bottom ash from the boiler.	Process/ raw/ cooling water blow down

The parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies. Central Pollution Control Board (CPCB), Ministry of Environment & Forests (MoEF), Government of India has been in the forefront to collect, collate and disseminate technical and statistical data relating to water pollution.

Water samples could be being analysed for 28 parameters consisting of 9 core parameters, 19 other physico-chemical and bacteriological parameters apart from the field observations. Besides this, 9 trace metals and 22 pesticides are also analysed in selected samples. Bio-monitoring could also be carried out on specific locations.

In view of limited resources, limited numbers of organic pollution related parameters are monitored i.e. micro pollutants (Toxic Metals & POPs) can be analysed once in a year to assess the water quality. The table 7.2 shows the list of parameters analyzed for water quality assessment.

Table 7.2 List of Parameters that could be considered for assessing water quality

Core parameters (9)	General Parameters (19) in mg/L	Field Observations (7)	**Bio-Monitoring (3)**	**Trace Metals (9)** in m g/L	**Pesticides (7)** in m g/L
1. pH 2.Temperature 3.Conductivity 4.Dissolved Oxygen 5. BOD 6.Nitrate N 7.Nitrite N 8.Fecal Coliform 9.Total Coliform	1.Turbidity, NTU Sodium 2.Phenolphthalin alkalinity, as $CaCO_3$ Total Dissolved Solids, mg/L 3.Total Alkalinity, as $CaCO_3$ Total Fixed Dissolved Solids, mg/L 4.Chlorides, mg/L Total suspended Solid, mg/L 5.COD, mg/L Phosphate 6.Total Kjeldahl - N, as N mg/L Boron, mg/L 7. Ammonia - N, as N mg/L Magnesium, as $CaCO_3$ 8. Hardness, as $CaCO_3$ Potassium, mg/L 9. Calcium, as $CaCO_3$ Fluoride, mg/L 10. Sulphate, mg/L	1. Weather 2.Approximate depth of main stream / depth of water table 3. Colour and intensity 4. Odour 5.Visible effluent discharge 6.Human activities around station 7. Station detail	1.Saprobity Index 2.Diversity Index 3.P/R Ratio	1.Arsenic 2.Nickel 3.Cadmium 4.Zinc 5.Copper 6.Mercury 7. Lead 8.Iron (Total) 9.Chromium (Total)	BHC (Total) DDT (Total) Endosulphan Dialdrin Aldrin Carbamate

7.2 Water quality monitoring

Water quality management is for a great deal controlled by authorization of discharges of dangerous substances for which monitoring of discharges, effluents and influenced surface water is essential. Water quality monitoring is a complex subject, and the scope of it is both deep and wide. Water quality monitoring has a direct relation with chemistry, biology, statistics and also economics.

Its scope is also related to the types of water uses and functions which are manifold and the nature of the sources of water such as surface water (rivers and lakes), sea water groundwater. Water quality monitoring involves 8 steps as explained below:

Step-1 Setting Water Quality Monitoring Objectives

Step-2 Assessment of Resources Availability

- Laboratory facilities and competence
- Transport
- Manpower adequate number and competence

Step-3 Preliminary Survey

- Map of the area
- Background information
- Human activities
- Potential polluting sources
- Water abstractions and uses
- Hydrological information
- Water regulation

Step-4 Approach to Sampling

- Selection of sampling locations
- Optimum number of locations
- Parameters to be measured
- Frequency of sampling
- Component to be samples water, sediment or biota

Step-5 Sampling Methods

- Representative sampling
- Field testing
- Sample preservation and transport

Step-6 Laboratory Work

- Laboratory procedures
- Physical, chemical analysis
- Microbiological and biological analysis

Step-7 Data Management

- Storage
- Statistical analysis
- Presentation
- Interpretation
- Reporting

Step-8 Quality Assurance

- Production of reliable data
- Quality control
- Internal Analytical Quality Control
- External Analytical Quality Control

Table 7.3 Summary of the use based classification system

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1. Total Coliforms Organism MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25°C micro mhos/cm Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l

The CPCB has made available the guidelines for the effluent discharge of different industries. The following are the list of industries covered under these guidelines available at

Http://www.cpcb.nic.in/Industry_Specific_Standards.

1. Battery Manufacturing Industry
2. Oil Refinery
3. Bullion Refining
4. Oil Drilling & Gas Extraction Industry
5. Environment Standards for Coal Mines
6. Organic Chemicals Manufacturing Industry
7. Coal Washeries
8. Coke Ovens
9. Diary Industry
10. Dye & Dye Intermediate Industry
11. Edible Oil & Vanaspati Industry
12. Electroplating Industry
13. Fermentation Industry (Distilleries, Maltries & Breweries)
14. Fertiliser Industry
15. Flour Mills
16. Food & Fruit Processing Industry
17. Glass Industry
18. Paint Industry
19. Pesticide Industry
20. Petro-chemicals
21. Pharmaceuticals Industry
22. Pulp & Paper Industry (Small)
23. Refractory Industry
24. Slaughter House, Meat & Sea Food Industry
25. Small Scale Industry
26. Soda Ash Industry
27. Starch Industry
28. Sugar Industry
29. Hospital Wastes
30. Synthetic Rubber
31. Hotel Industry
32. Inorganic Chemical Industry
33. Iron & Steel Plant (Integrated)
34. Jute Processing Industry
35. Leather Industry
36. Man-made Fibre Industry
37. Natural Rubber Processing Industry
38. Tannery
39. Thermal Power Plant
40. Thermal Power Plant (Gas/Naptha Based)
41. Thermal Power Plant : Temperature Limit for Discharge of Condenser Cooling Water
42. Water Quality Standards for Coastal Waters Marine Outfalls


References

Reference:

1. The Nalco Water Hand Book, Second Edition, Frank N. Kemer
2. Water treatment Hand Book by Degremont, Vol. 1
3. A Water Conservation Guide for Commercial, Institutional and Industrial Users by New Mexico Office of the State Engineer
4. Water conservation tips for industry Public Information Centre, Toronto
5. Water conservation tips for industry Connecticut Department of Environmental Protection
6. Rain water Harvesting Techniques to Augment Ground Water-Ministry of Water Resources, Central Ground Water Board
7. U.S. Bureau of Reclamation. 2001. Water Measurement Manual. U.S. Department of the Interior, Washington, DC.
8. http://www.epa.gov/region09/water/recycling/
9. http://www.sydneywater.com.au/Water4Life/RecyclingandReuse/RecyclingAndReuseInAction/RecyclingWhatItIs.cfm
10. http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/wmm.html
11. http://www.cpcb.nic.in/upload/NewItems/NewItem_116_Guidelinesof%20waterqualitymonitoring_31.07.08.pdf
12. Water & Wastewater Treatment options, http://www.lboro.ac.uk/well/
13. www.wikipedia.org
14. CII - Detailed Water Audit Reports
15. www.google.com

About CII Water Institute

CII - Water Institute is a joint initiative of the Confederation of Indian Industry (CII) and the Government of Rajasthan.

The CII-Water Institute envisages promoting comprehensive water management strategies and acting as a single point solution for water related problems. For ensuring the sustainability of the institute, the same will cater variety of services relating to water management to the industry. The overall objective is to address the critical aspect of water at the national and state level.

Services Rendered

Industrial Water Management

- Water Audit
- Training Programme on water management
- Facilitating Implementation of "Zero Water Discharge"
- Propagation of water saving equipments and devices

Facilitating PPCP projects in water through IBAW

Facilitate policy frame work at state and national level for urban water management wastewater reuse

Facilitate improved water and waste water management in municipalities

Promote rain water harvesting in industry, commercial and residential complexes

Promote water efficient devices

Events

- Water Summit
- Water Award
- Water Investors Meet

Contact Details :

CII

Confederation of Indian Industry
CII - Water Institute
C - 32, 1st Floor, Pankaj Singhvi Marg, Lal Kothi Scheme, Near Vidhan Sabha,
Jaipur - 302015. Rajasthan
T: +91(141) 5112350 / 70
F: +91(141) 5112360
www.greenbusinesscentre.com / www.cii.in

Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes.

CII is a non-government, not-for-profit, industry led and industry managed organisation, playing a proactive role in India's development process. Founded over 115 years ago, it is India's premier business association, with a direct membership of over 7800 organisations from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 90,000 companies from around 396 national and regional sectoral associations.

CII catalyses change by working closely with government on policy issues, enhancing efficiency, competitiveness and expanding business opportunities for industry through a range of specialised services and global linkages. It also provides a platform for sectoral consensus building and networking. Major emphasis is laid on projecting a positive image of business, assisting industry to identify and execute corporate citizenship programmes. Partnerships with over 120 NGOs across the country carry forward our initiatives in integrated and inclusive development, which include health, education, livelihood, diversity management, skill development and water, to name a few.

Complementing this vision, CII's theme for 2009-10 is 'India@75: Economy, Infrastructure and Governance.' Within the overarching agenda to facilitate India's transformation into an economically vital, technologically innovative, socially and ethically vibrant global leader by year 2022, CII's focus this year is on revival of the Economy, fast tracking Infrastructure and improved Governance.

With 64 offices in India, 9 overseas in Australia, Austria, China, France, Germany, Japan, Singapore, UK, and USA, and institutional partnerships with 213 counterpart organisations in 88 countries, CII serves as a reference point for Indian industry and the international business community.

CII Headquarters
Confederation of Indian Industry
The Mantosh Sondhi Centre, 23, Institutional Area
Lodi Road, New Delhi 110003
Phone : 91-11-24629994 - 7
Fax : 91-11-24626149 / 24633168

CII Northern Region Headquarters
Confederation of Indian Industry
Block No. 3, Dakshin Marg, Sector 31
Chandigarh 16047
Phone : 91-172-2602365, 2605868, 2607228
Fax : 91-172-2606259

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