WATER CHEMISTRY

IN

THERMAL POWER PLANTS
(An Overview)

Presentation by
S.K.SHARMA D.G.M(CHEMISTRY)
NCPS DADRI
NTPC LTD

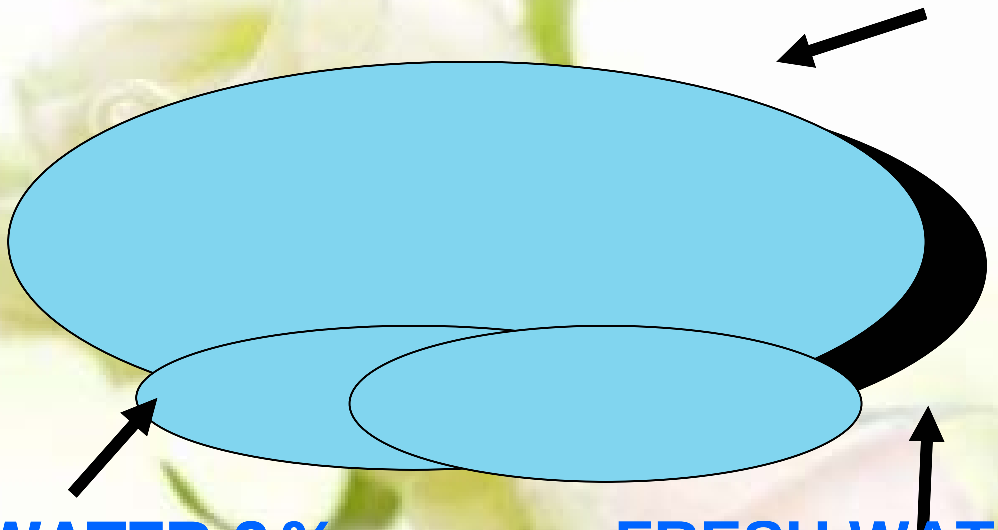
WATER

- The purest available form is from water vapour in atmosphere, as rain, snow or produced by melting of ice.
- This water on reaching the ground absorbs different types of gases from atmosphere like nitrogen, oxygen and to a lesser extent carbon dioxide.
- Other gasses like ammonia, oxides of nitrogen and sulphur etc. ,also dissolves during rain depending upon the pollution level of the atmosphere.
- Apart from this, the surface water travels to various places and catches organic matter, suspended solids etc.

SOURCES OF WATER

1. Rivers, lakes and reservoirs (surface drainage water)
2. Underground water (shallow well, deep well, springs)
3. Rain water
4. Sea water
5. Snow melting

WATER SUPPLY



- Fresh water available is scarce.
- We, the human beings, are bent upon polluting this precious resource.
- Imperative to take proper care to conserve and reuse water.

MAIN IMPURITIES IN WATER

1. Suspended (Macro size) - Sand, dirt, silt. This contributes turbidity to raw water.
2. Colloidal - Micro size particles(1-100nm)
3. Dissolved form - Alkaline salts and neutral salts, organic matter,

- Alkaline salts are mainly bicarbonates rarely carbonates and hydrates of calcium, magnesium and sodium.
- Neutral salts are sulphates, chlorides, nitrates of calcium, magnesium and sodium.

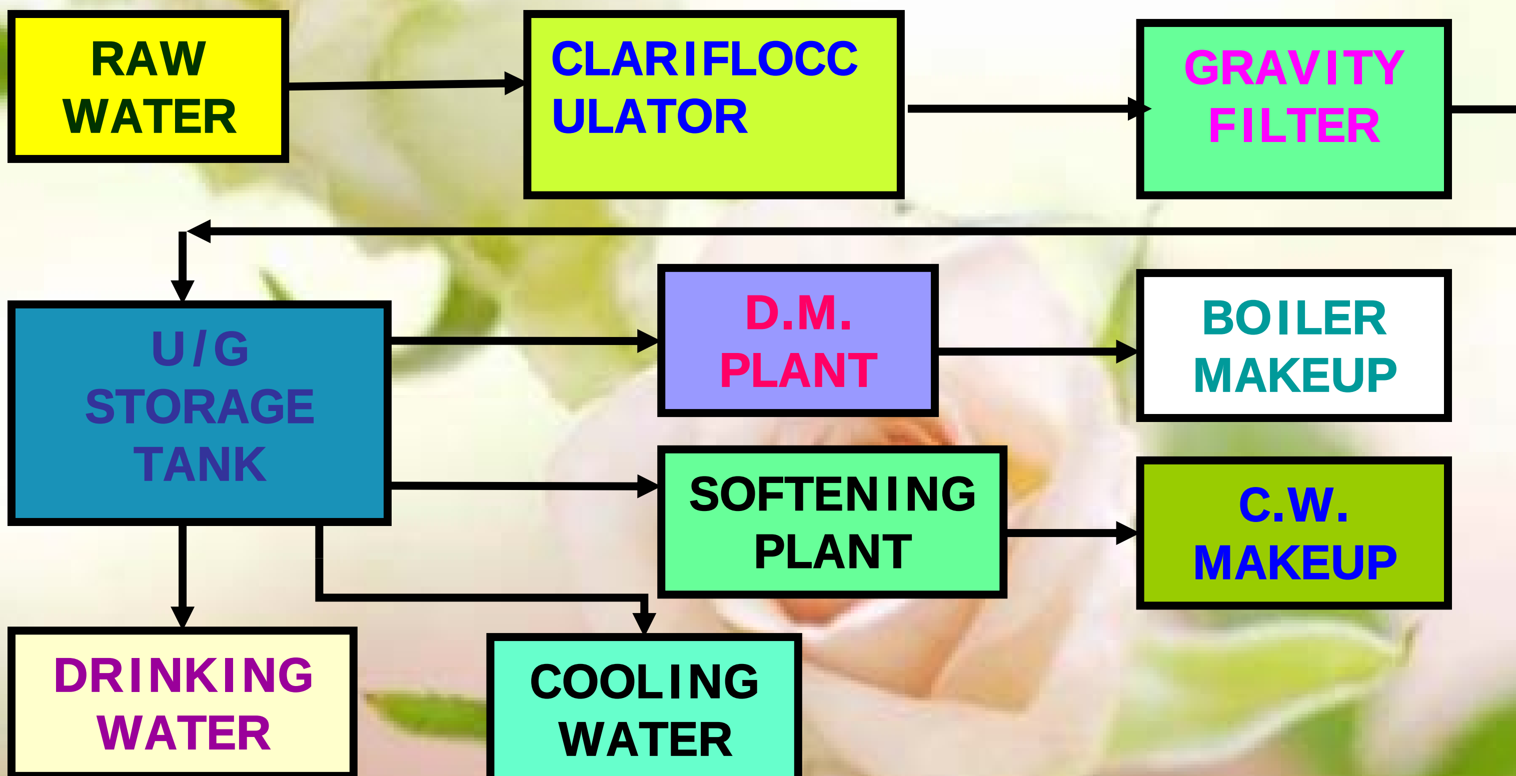
TYPES OF WATER IN THERMAL POWER PLANT

- Cooling water
- Boiler water
- Process water
- Consumptive water

WATER TREATMENT IN POWER PLANT

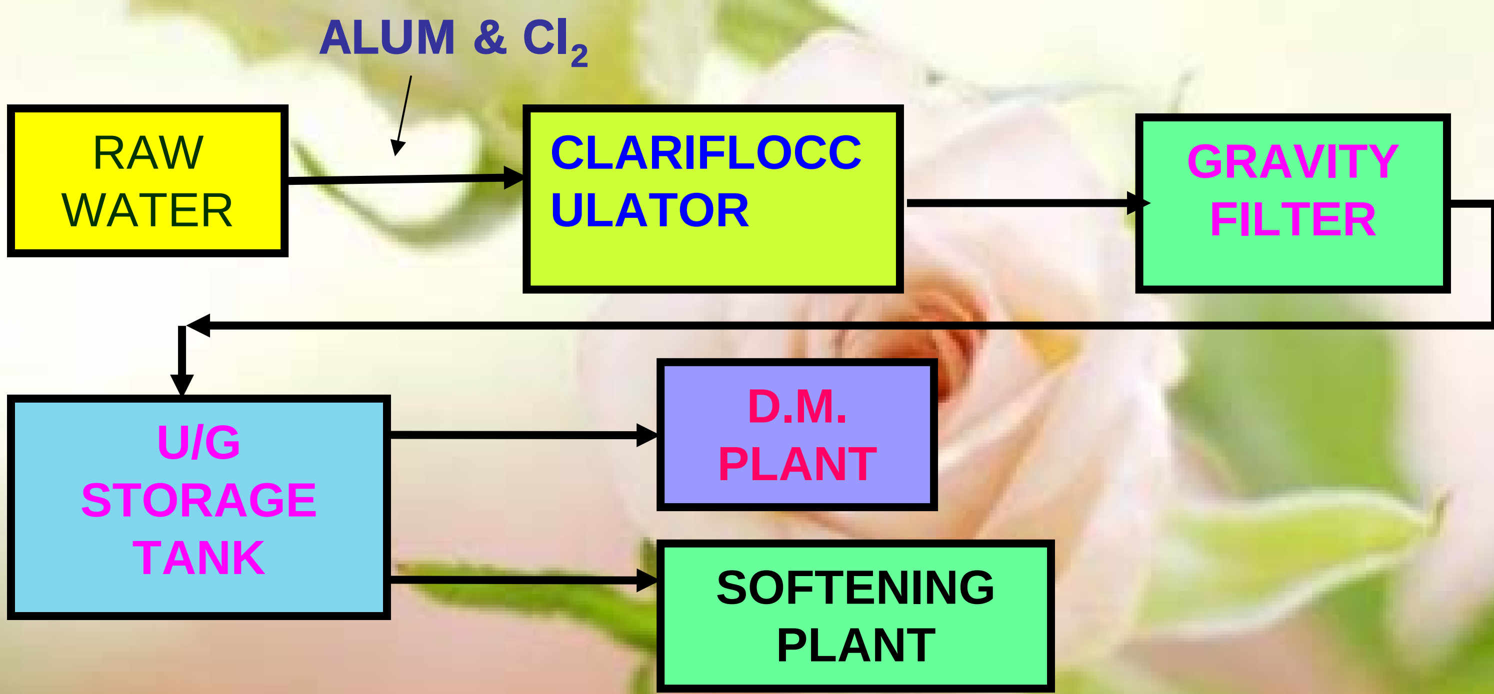
- Pretreatment of raw water
- Filter water for softening & DM plant
- Ultra pure /demineralised water for boiler make up/steam generation
- Cooling water system.
- Monitoring of steam/ water parameters & H.P./L.P. Dosing systems

WATER FLOW DIAGRAM

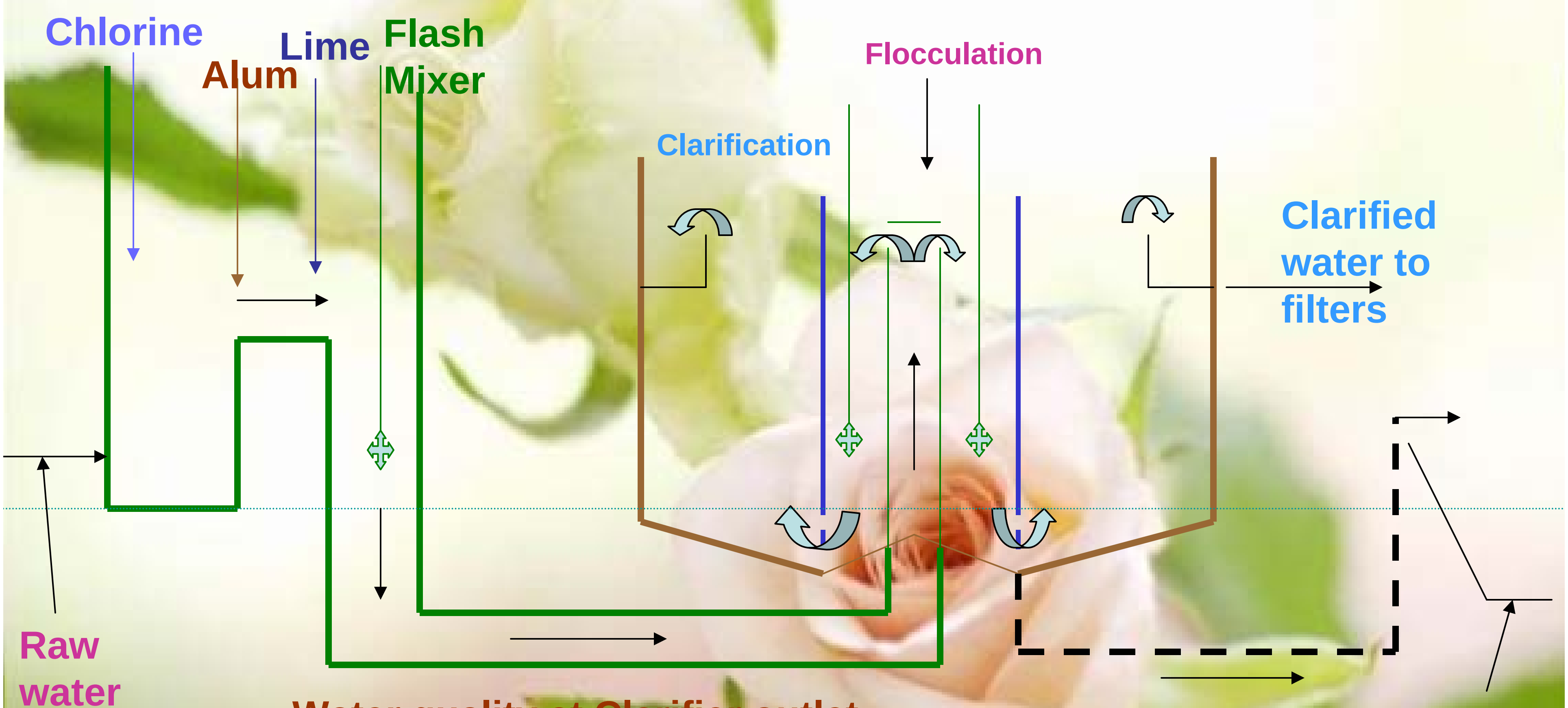


PRE-TREATMENT

Pre-treatment takes care of organics, suspended matter and colloidal silica to some extent.



CLARIFLOCCULATOR



Water quality at Clarifier outlet

Turbidity - <20 NTU pH - 5.5 to 8.0

Residual Chlorine - 0.2 ppm

DISINFECTION

Disinfection is destruction of Pathogenic bacteria, virus, germs and other organisms present in water.

It can be achieved by

- Gaseous chlorine
- Chlorine compounds such as hypo-chlorites, bleaching agent and chlorine dioxide
- Ozone
- Ultra-Violet radiation
- Hydrogen peroxide
- Heating
- Combination of the above

FILTRATION

Removal of solid particles from water by passing it through a filtering medium.

Filtration is usually a mechanical process & does not remove dissolved solids.

Filters are mainly of two types.

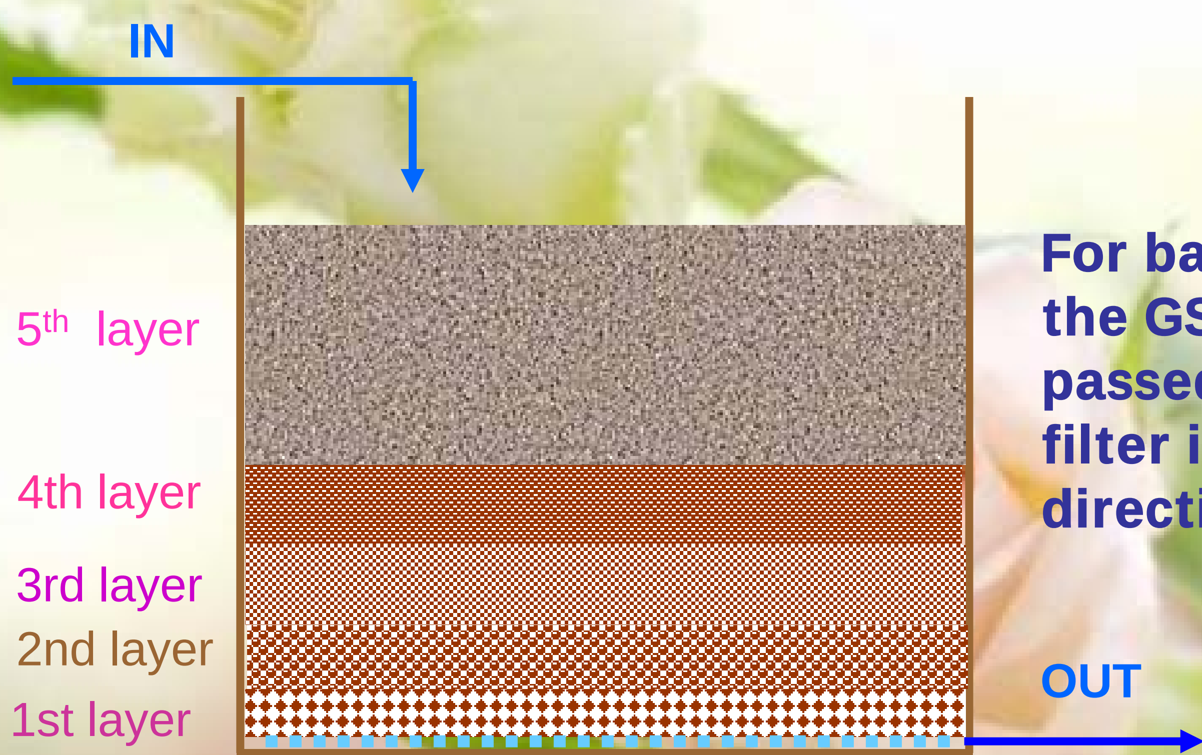
1. Pressure Filters - steel, wood or concrete containers that are open at the top and function at atmospheric pressure.

2. Gravity filters - closed, round steel shells and function with the pressure of the incoming water.

GRAVITY SAND FILTER

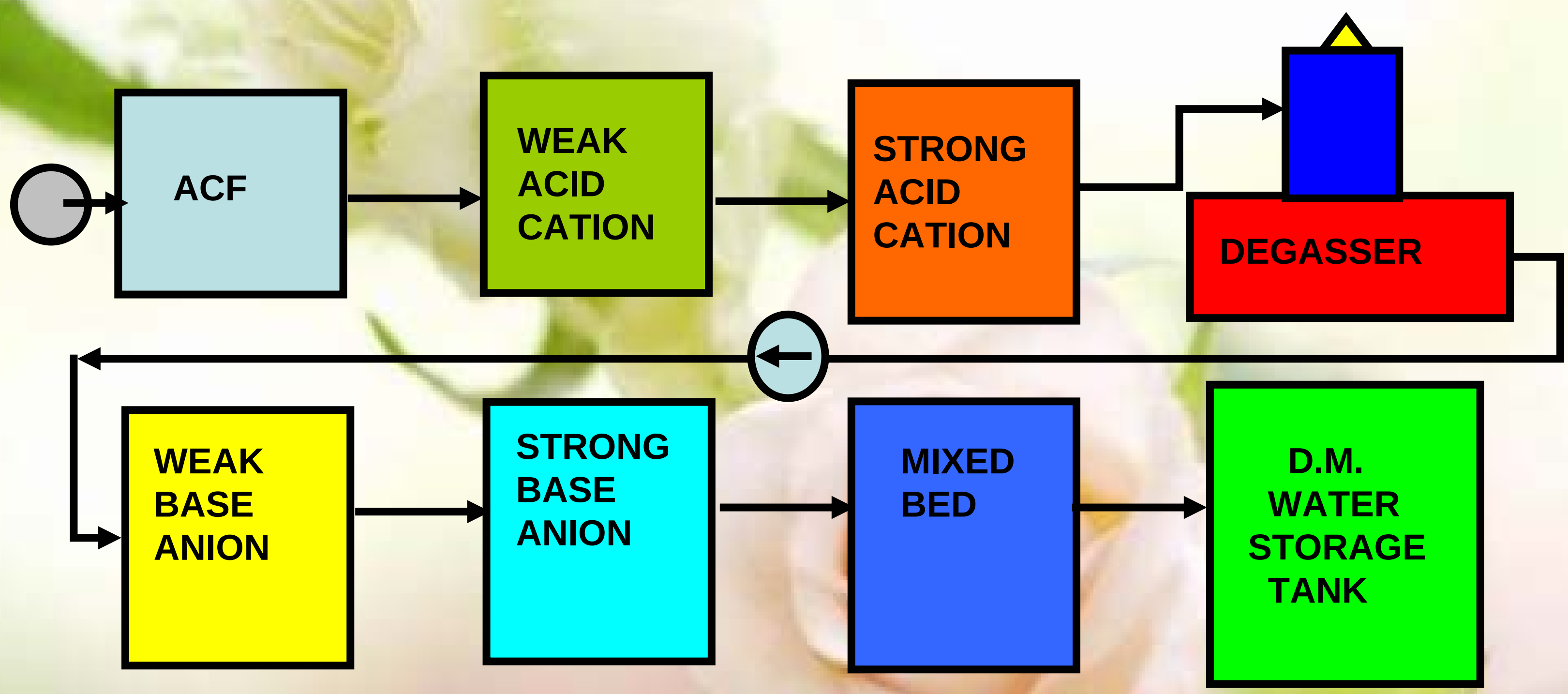
Gravity Sand Filter

Clarified water from clarifier



For back washing of the GSF water is passed through filter in reverse direction

D.M. PLANT


ACF
WEAK ACID CATION
STRONG ACID CATION
DEGASSER
WEAK BASE ANION
STRONG BASE ANION
MIXED BED
D.M. WATER STORAGE TANK

COOLING WATER CHEMISTRY

- To avoid scale formation
- To control corrosion
- To control micro biological growth
- To control vaccume in condenser

INTRODUCTION

Circulating Water chemistry is maintained primarily to control

-- Corrosion

-- Inhibit scale formation

-- To minimize micro-organism growth in condenser tube or in cooling water system.

SCALE FORMATION

- scale formation can take place in condenser of thermal power plants. This may lead to higher back pressure in condenser which in turn lead to loss in condenser vacuum that causes loss of turbine efficiency resulting in higher heat rate than designed resulting in direct energy loss.

TYPES OF COOLING WATER SYSTEM

- **Once through cooling system**
- **Open recirculation cooling system**
- **Closed cycle cooling water system**

COOLING WATER TREATMENT

- Softening plant for make up as soft water with chlorination
- Chemical treatment for scale inhibition and corrosion control
- Acid dosing with chlorination

MICROORGANISM FOULING

Micro organism growth in cooling water system leads to choking of C.W. pumps strainers and cooling tower fills which reduce effective surface area for cooling and desired cooling efficiency is not achieved which leads to higher c.w.inlet cooling water temperature and loss of condenser vacuum.

- **CHLORINATION: This is the most practiced technique for cooling water treatment in power plants. Chlorine is a powerful oxidizing agent and reacts with the nitrogenous part of microbial substances to form chloramines.**
  - $Cl_2 + H_2O \leftrightarrow HOCl + H^+ + Cl^-$
  - $HOCl \leftrightarrow H^+ + OCl^-$
  - $NH_3 + HOCl \rightarrow NH_2Cl + H_2O$ **(Monochloramine)**
  - $NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$ **(Dichloramine)**

CYCLE CHEMISTRY

➢For all ferrous feed water system, generation & transport of corrosion products – magnetite,haematite and ferric oxide hydrate occurs due to :

•Corrosion

•and,flow accelerated corrosion

of low & high pressure heaters,de-aerator,eco inlet tubing & piping, feed water piping &drain lines

• Corrosion products generated flow around the cycle, deposit in various areas and act as initiating centers for major failure mechanisms.

• And are often removed by chemical cleaning.

FEED WATER TREATMENT

- **AVT (R):**
- **Ammonia + a reducing agent**
- **ORP should be in the range: -300 to -350 mV,necessary to protect mixed metallurgy systems.**
- **AVT (O):**
- **Reducing agent has been eliminated. ORP will be positive.**

•The basis of either AVT treatment is elevated pH.

•Common alkalizing agent is Ammonia.

•AVT(R): oxygen level at CEP discharge is low enough (<10 ppb), minimum air ingress that a reducing agent could be added to produce reducing environment with ORP <0mV.

•Oxide layer of magnetite (Fe_3O_4) will be formed on all ferrous surfaces throughout the feed water systems.

•Dissolution of Fe_3O_4 depends on ORP.

•More reducing is the feed water,greater is the dissolution,and higher is the conc. of corrosion products at eco inlet.

•AVT(O): Eliminating the reducing agent minimizes corrosion product generation.

•oxygen level at CEP discharge is low enough (<10 ppb), minimum air ingress.

•As reducing agent is eliminated ORP increase to positive values i.e. in the oxidizing range, and iron levels reduced.

•There is no change in feed water oxygen level.

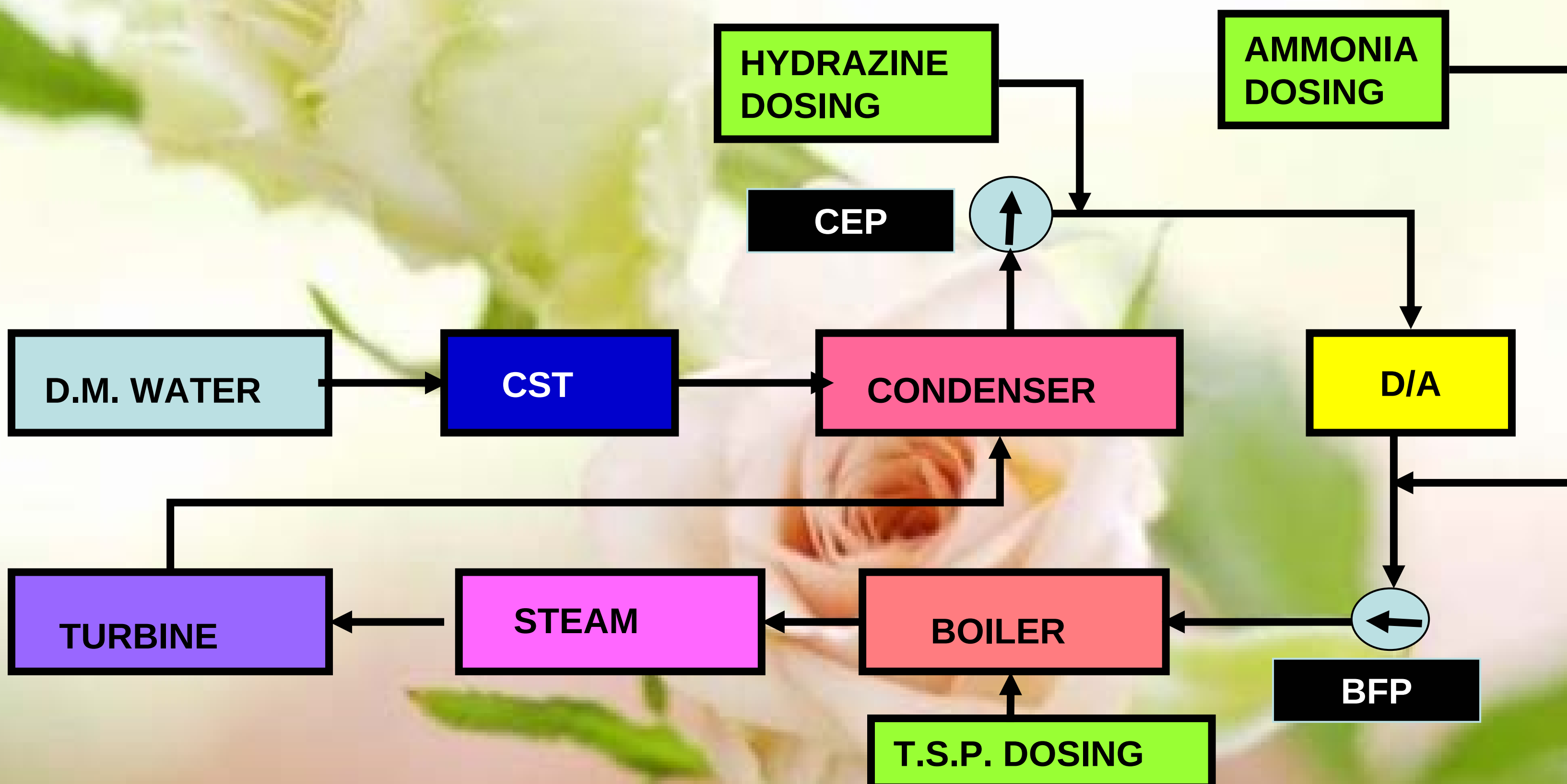
FEED WATER LIMIT FOR ALL FERROUS SYSTEM.

Parameter	AVT(O)	AVT(R)
pH	9.2-9.6	9.2-9.6
ACC	<0.2	<0.2
Fe (ppb)	<2 (<1)	<2
Cu (ppb)	<2	<2
Oxygen Feed (ppb)	<10	<5
Oxygen CEP (ppb)	<10	<10
Reducing agent	No	Yes
ORP(mV)	Not needed	-300 to -350

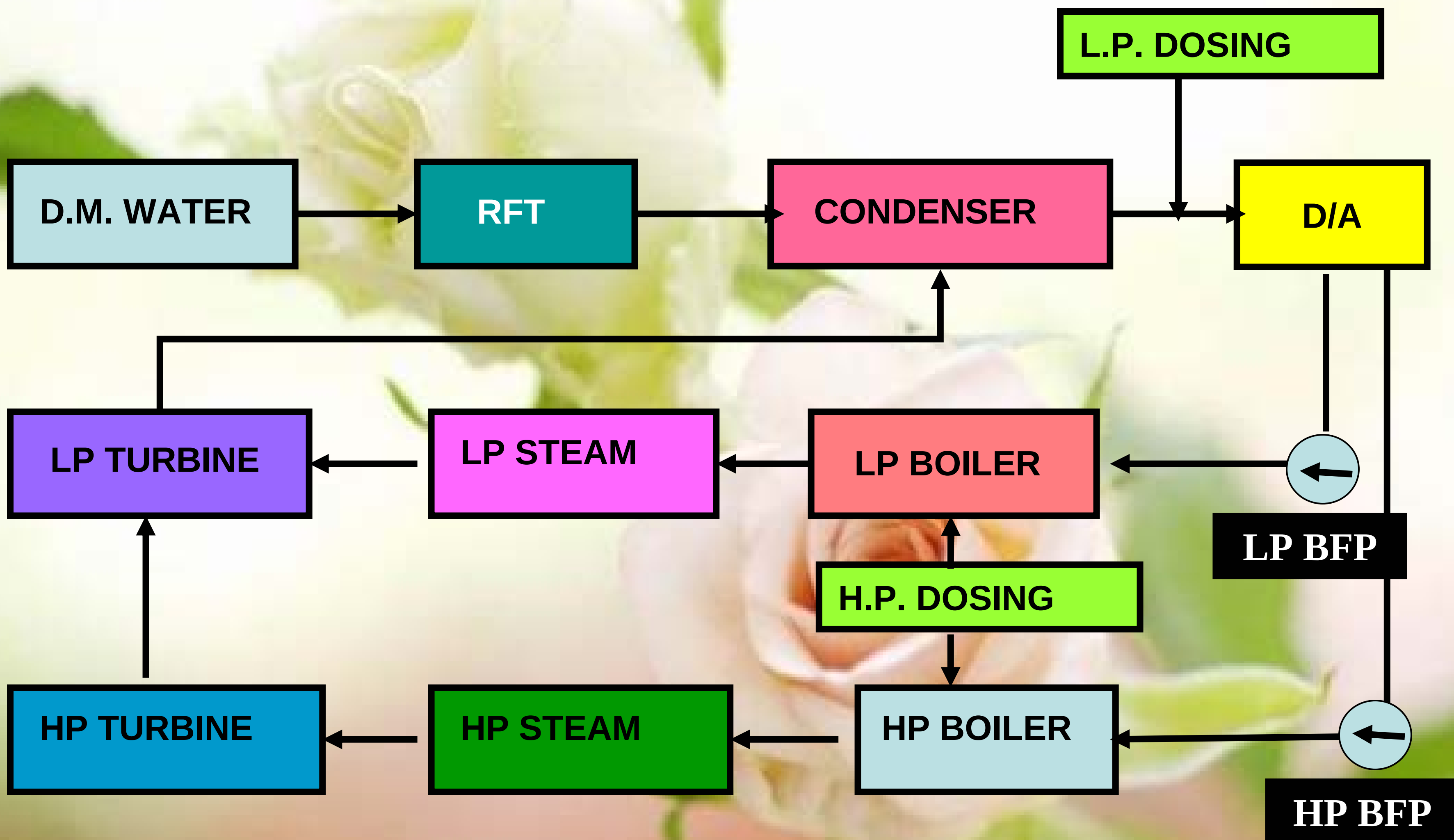
CONVERSION OF ALL FERROUS FEED WATER CHEMISTRY TO AVT (O).

- Perform baseline monitoring: feed water parameters-ACC, pH, chloride, DO, Steam parameters-ACC, Na, Chloride and silica
- Minimize air in-leakage so that DO is<10 ppb at CEP discharge.
- Stop hydrazine addition at once or in steps.
- Maintain feed water pH using Ammonia
- Monitor feed water parameters-ACC, pH, chloride, Iron, DO, copper with AVT (O)

WATER STEAM CYCLE (THERMAL PROJECT)



WATER STEAM CYCLE (GAS PROJECT)



WATER/STEAM CHEMISTRY

PARAMETERS TO BE MONITORED

- pH
- Silica
- Conductivity
- After Cation Conductivity
- Dissolved Oxygen
- Sodium
- Copper
- Iron
- Carbon dioxide
- Chloride
- Hardness

SUPER CRITICAL BOILER: CRITICAL PARAMETERS

- SUPERCRITICAL BOILER OERATE AT PRESSURE >203 Kg/cm^2 AND TEMPERATURE IS >600 deg.C
 THEREFORE THE CONSTRUCTION OF HAVE HIGH MECHANICAL STRENGTH AND LOW CREEP.

- AT SUPER CRITICAL CONDITION THE MEDIUM IS JUST A HOMOGENEOUS FLUID RATHER THAN WATER OR STEAM. THEREFORE USUALLY SUPERCRITICAL BOILER ARE OF ONCE THROUGH TYPE.

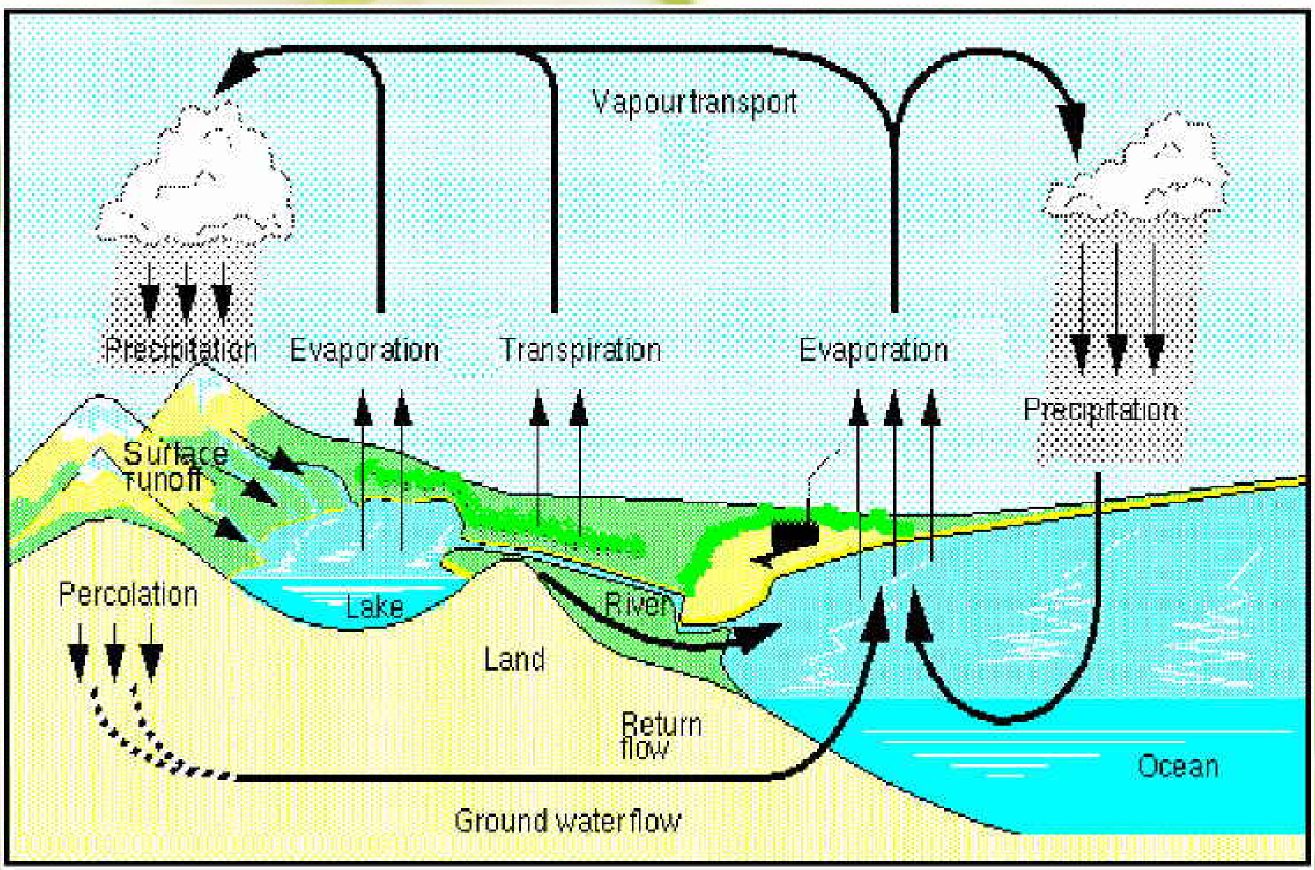
ROLE OF CHEMISTRY IN POWER PLANT

Water chemistry is important to

- **achieve higher operation efficiency,**
- **Minimize corrosion & scale formation problems and**
- **to reduce plant downtime**

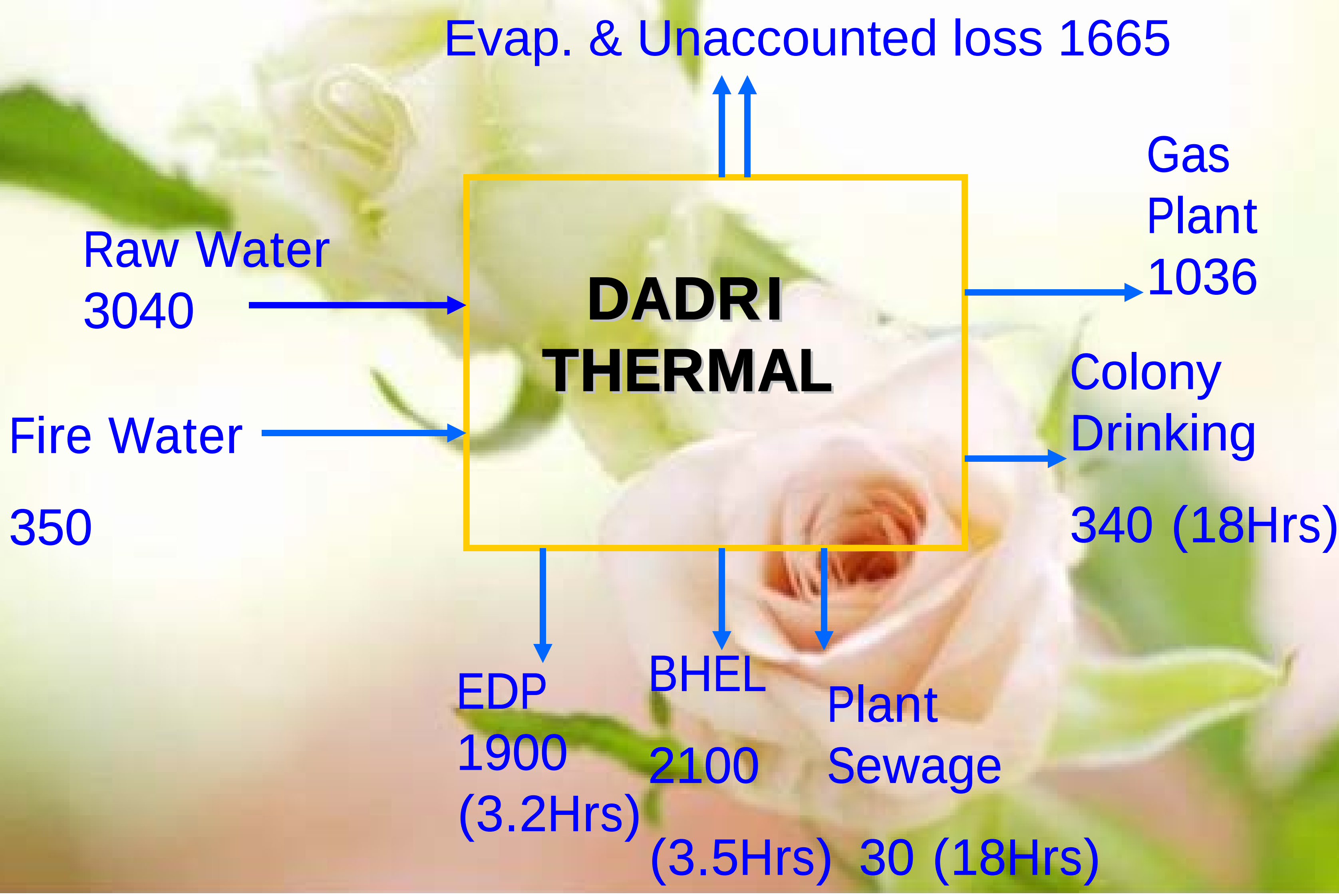
High water quality standards are to be maintained, particularly in view of upcoming super critical boilers

WATER CONSERVATION



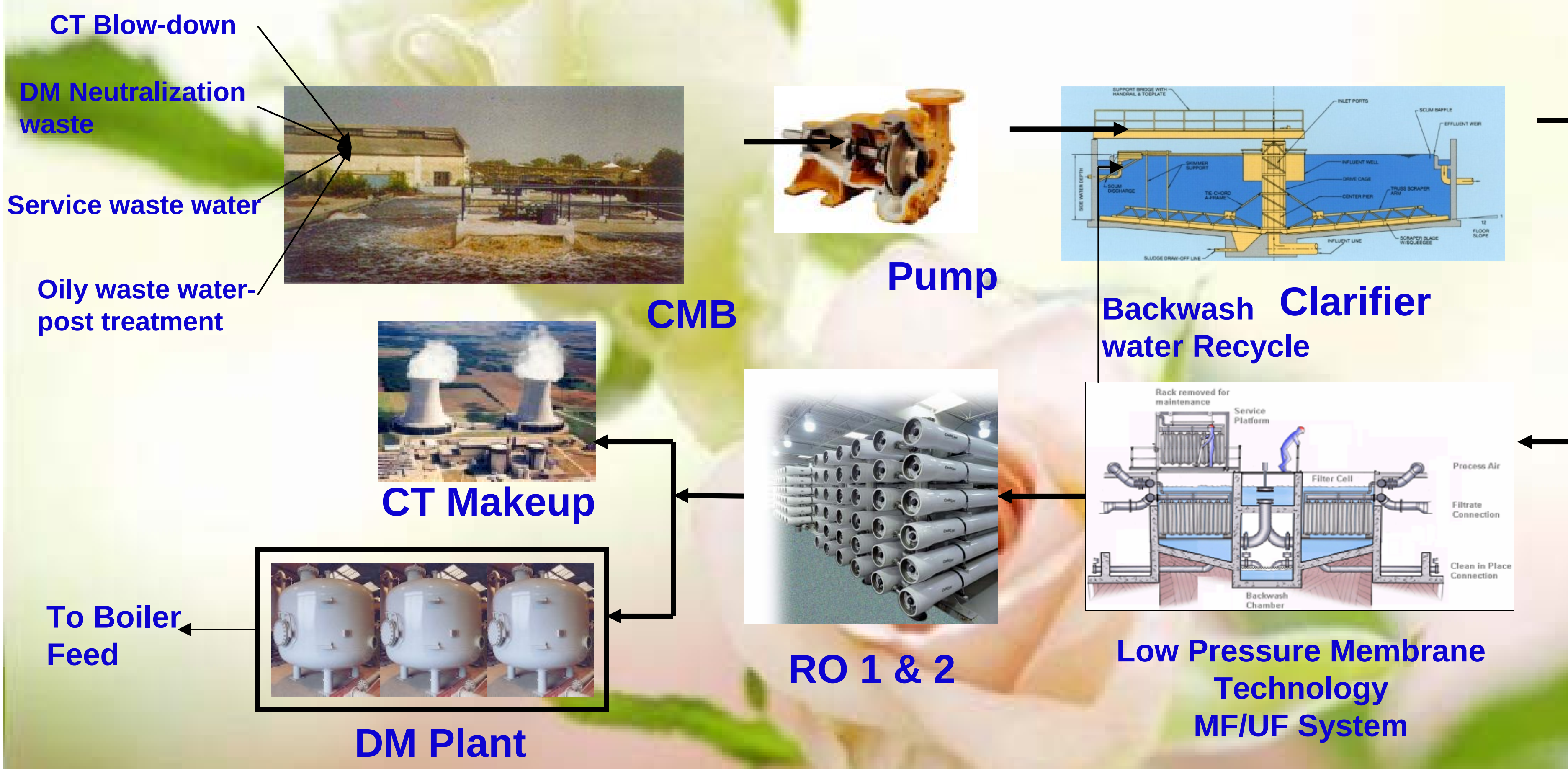
- **WASTE WATER FROM A THERMAL POWER PLANT**

WATER BALANCE (for 4 Units) (all in M^3/hr)



TREATMENT OF WASTEWATER

CASE-II : RECYCLE THROUGH MEMBRANE TECHNOLOGY

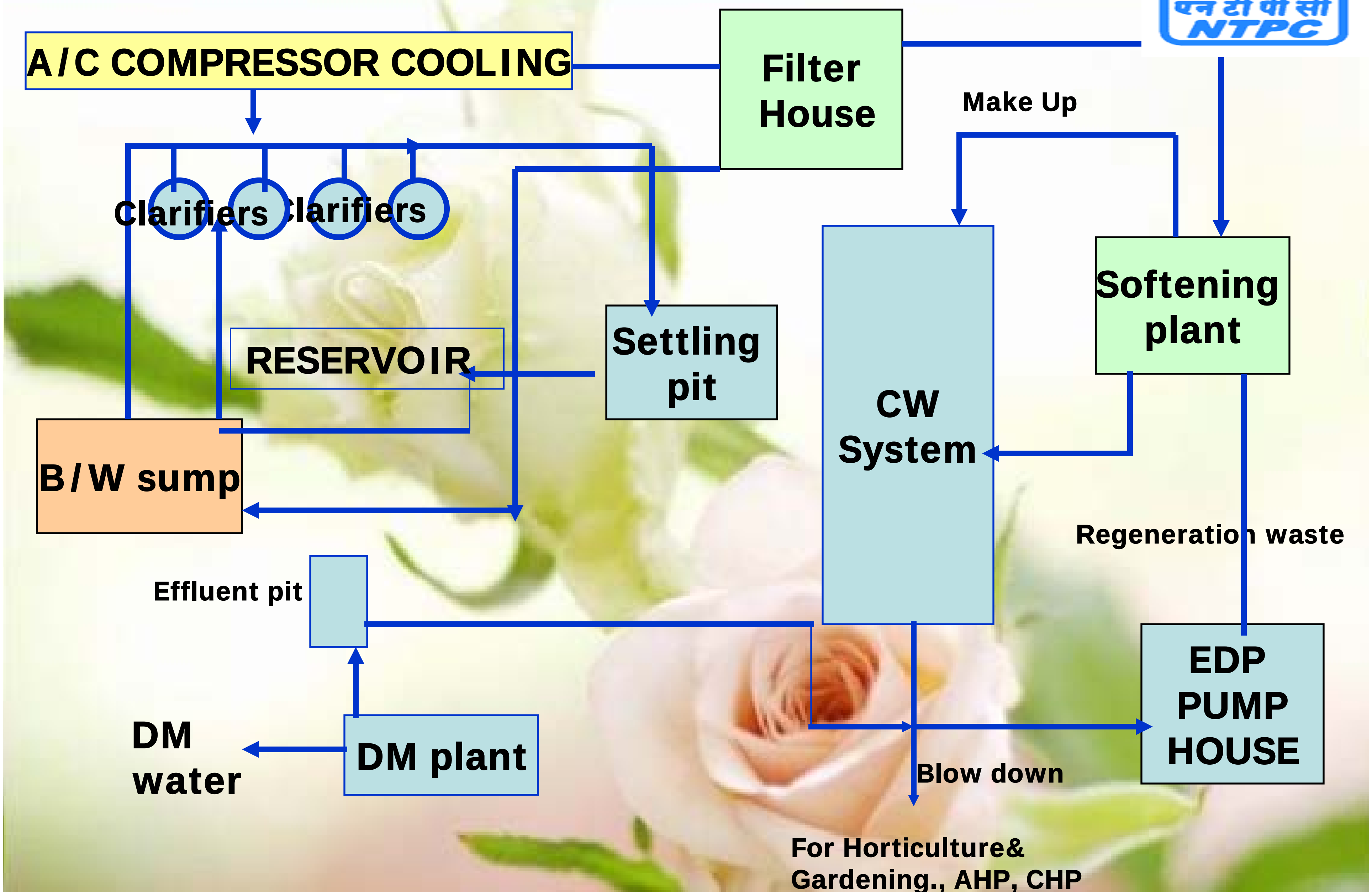


ADVANTAGES OF REVERSE OSMOSIS

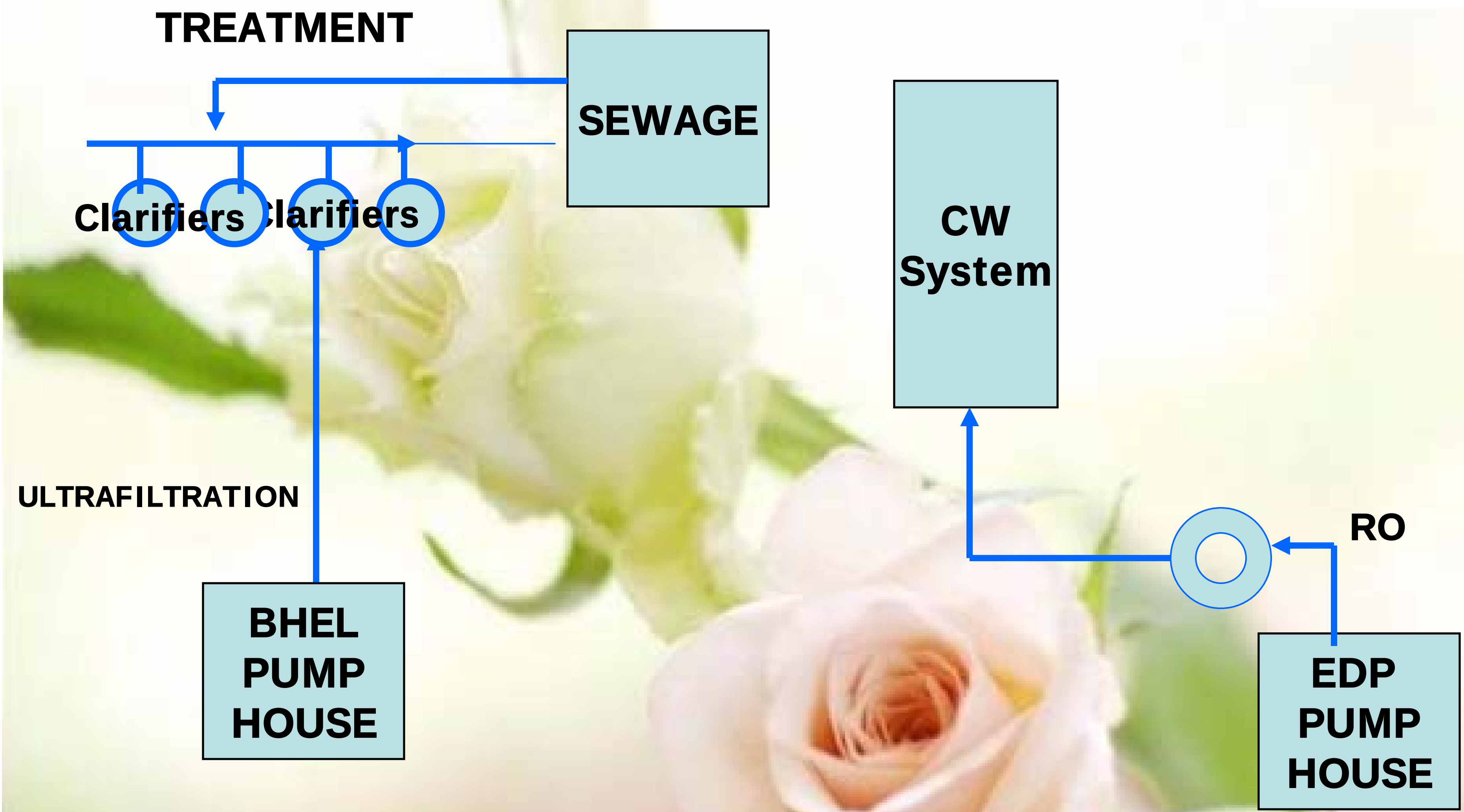
S.NO.	REVERSE OSMOSIS	DM PLANT
1	Continuous operation. No need for regeneration	1 or 2 regeneration reqd. Everyday
2	No need for bulk storage of acid/alkali	Bulk storage required
3	No effluent treatment required	Effluent treatment required
4	Operating cost mainly power, cartridge filter replacement and membrane replacement (Low operating cost except cost of membrane)	Operating cost mainly power, cost of chemicals & cost of resin (Higher operating cost)
5	Excellent silica removal	Good silica removal

Expected Reduction of Effluents & makeup water for a 1200 MW station

	Make- up water (cum/Hr)	Consumptive water (cum/Hr)	Effluents water (cum/Hr)
Conventional	9925	4030	5895
Improved Scheme	6075	4030	2045
Zero Discharge practically	4031	4030	ZERO



EXISTING SYSTEM



PROPOSED SYSTEM

WATER REQUIREMENT AT DIFFERENT COC

COC	EVOPORATION LOSS M^3/HR	DRIFT LOSS M^3/HR	BLOW DOWN REQD M^3/HR	TOTAL MAKE UP REQD M^3/HR
2	1800	50	1850	3700
3	1800	50	925	2775
4	1800	50	617	2467
5	1800	50	463	2313
6	1800	50	370	2220

CONSERVATION OF WASTE

- **Operate CW system at COC of 7.0 to 8.0 by using side stream softeners thereby conserving water due to reduced system blow down.**

- **Adopting new Technologies i.e RO (Reverse Osmosis) in combination with Mixed bed ion exchanger.**


Thanks