# Importance and Methods of Disinfection of Recycled Waste Water


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# The Need for Water Reuse

- Water is a finite resource.
- It is becoming increasingly more expensive.
- Water scarcity is a real issue.
- Heavy irrigation and landscaping demands.

# Need for Disinfection

**Wastewater reuse requires effective measures to protect public health and to ensure that the impact on the environment is sustainable.**

# Need for Disinfection

- Typical tertiary treated wastewater samples (before disinfection) contain coliform counts in the range of $10^5$ to $10^{12}$ CFU / 100 mL.
- On average, this is equal to more then **1 lac colony forming units** per 100 mL of the sample.
- Therefore, while the tertiary treated water might appear transparent and clear to look at, it contains an abundance of disease causing microorganisms that must be thoroughly disinfected before use.

# The Need for Disinfection

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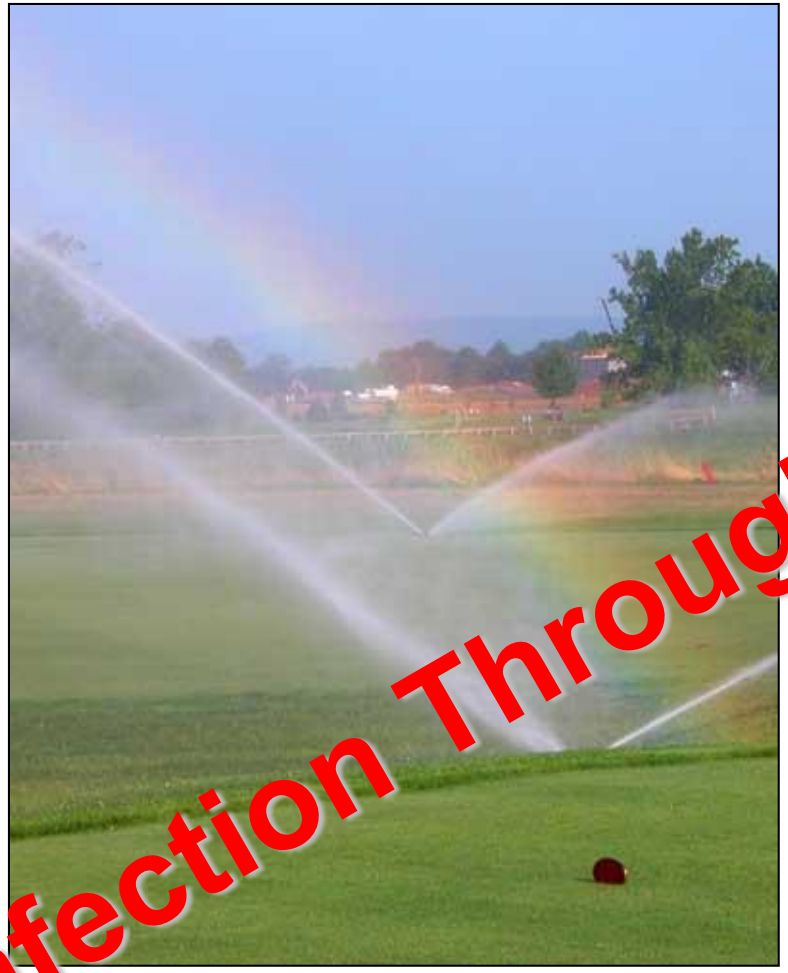
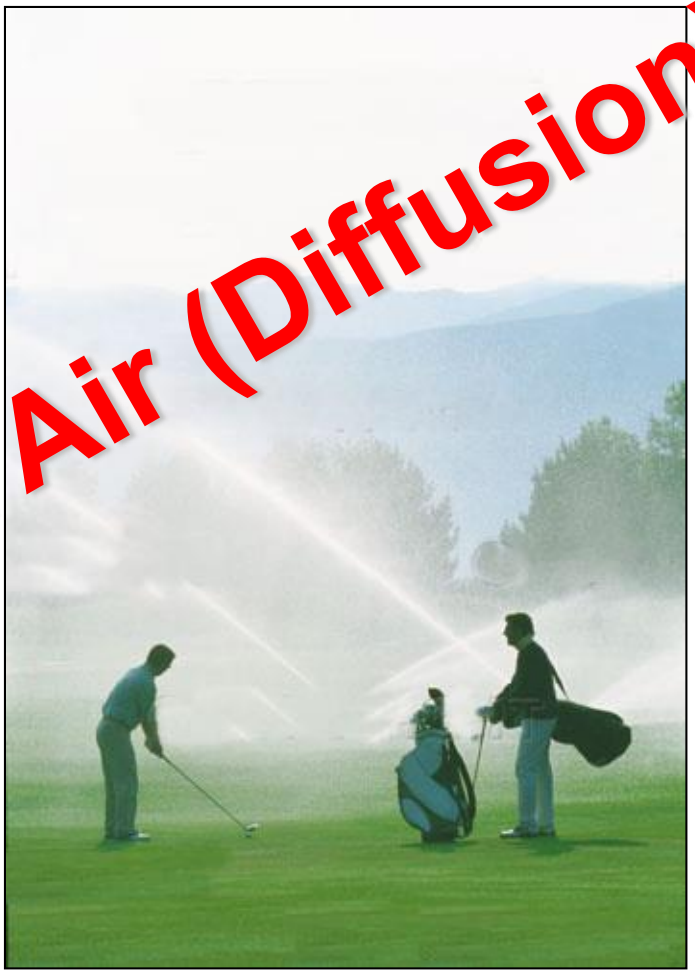
## Microorganisms Typically Present in Wastewater

| Organism | Disease Caused | Organism | Disease Caused |
|---|---|---|---|
| **Bacteria** | | **Helminths** | |
| Escherichia coli | Gastroenteritis | Ascaris lumbricoides | Ascariasis |
| Leptospira (spp.) | Leptospirosis | Taena solium | Taeniasis |
| Salmonella typhi | Typhoid fever | Trichuris trichiura | Trichuriasis |
| Salmonella (=2100 serotypes) | Salmonellosis | | |
| Shigella (4 spp.) | Shigellosis (bacillary dysentery) | | |
| Vibrio cholerae | Cholera | | |
| **Protozoa** | | **Viruses** | |
| Balantidium coli | Balantidiasis | Enteroviruses (72 types) e.g., polio echo and coxsackie viruses | Gastroenteritis, heart anomalies, meningitis |
| Cryptosporidium parvum | Cryptosporidiosis | Hepatitis A virus | Infectious hepatitis |
| Entamoeba histolytica | Amebiasis (amoebic dysentery) | Norwalk agent | Gastroenteritis |
| Giardia lamblia | Giardiasis | Rotavirus | Gastroenteritis |

# The Need for Disinfection



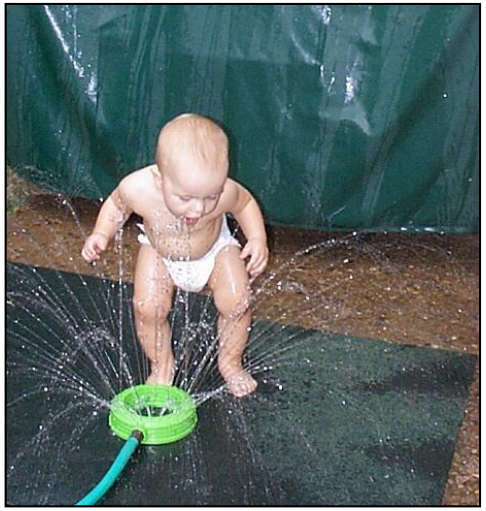


Infection Through Air (Diffusion)

# The Need for Disinfection

**Infection Through Cuts and Wounds**

# The Need for Disinfection



Infection Though Direct Contact

# Water Reuse Guidelines

- In India, there are currently no unified norms or guidelines for the unrestricted reuse of effluent.
- Therefore for practical purposes a good set of guidelines to follow would be of the US EPA which presently regulates effluent quality limits and wastewater treatment processes for unrestricted reuse applications.
- “Unrestricted Reuse” refers to the use of recycled wastewater in applications where human contact is possible.

# Water Reuse Guidelines

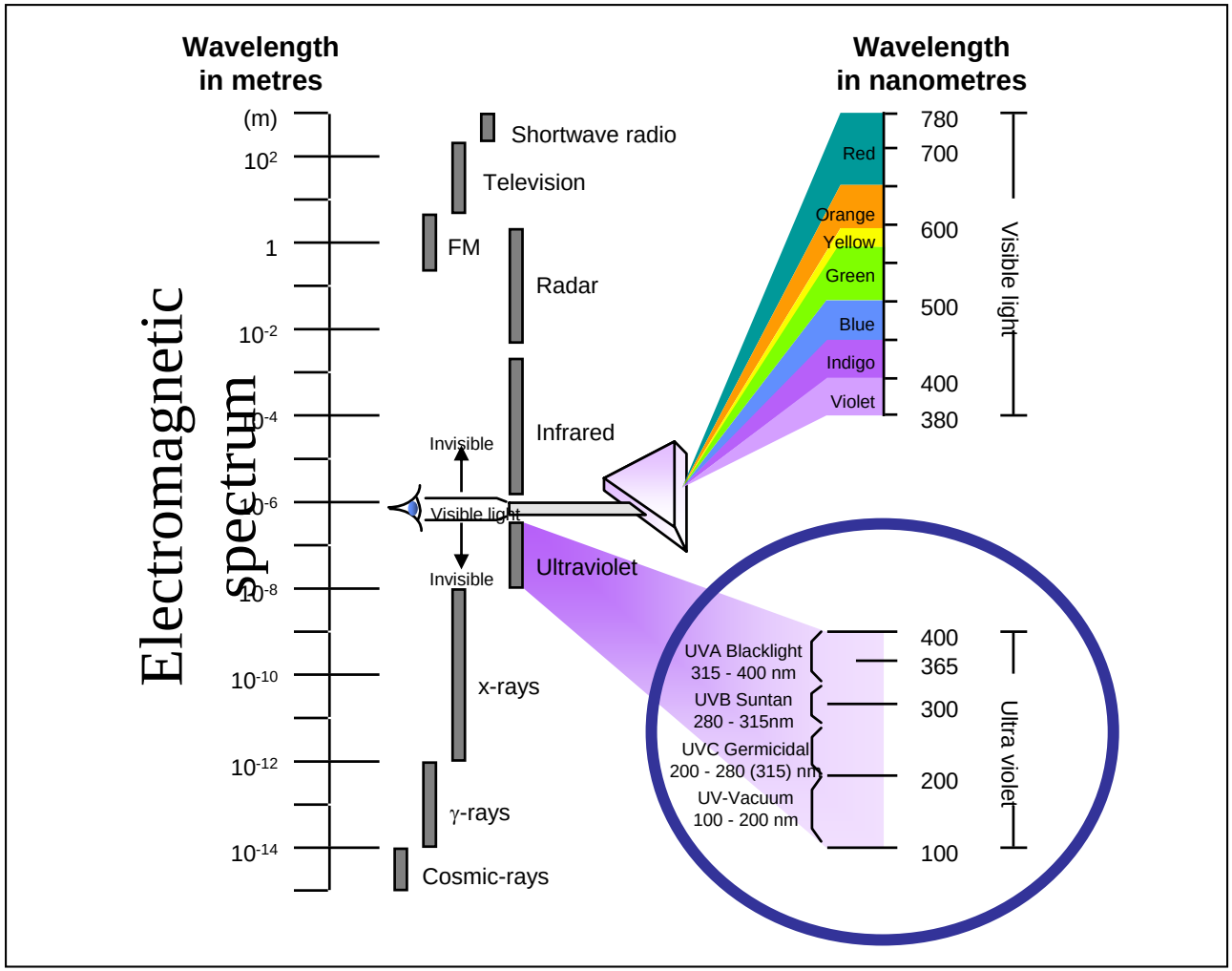
| State | Irrigation of Raw Food Crops | Indicator / 100 ml | Turbidity | TSS |
|---|---|---|---|---|
| California | Yes | ≤ 2.2 TC<br>7 day median | ≤ 2 NTU | 20 – 30 mg/L |
| Florida | No | Non Detectable FC<br>75% samples | ≤ 2 NTU | ≤ 5 mg/L |

Regulations for Unrestricted Reuse Applications (Crook 1996, US EPA 1992)

# The Need for Disinfection

UV is the **only** technology which can provide the **high level of disinfection** required (in a simple and cost effective manner) so that the water can **safely** be reused.

# The Light Spectrum




Alfaa ultraviolet water purifiers incorporate ultraviolet light energy to eradicate microbiological contamination.

# UV Spectrum

UV = invisible light

Ultraviolet

UV-A Blacklight
315 - 400 nm

UV-B Suntan
280 - 315nm

UV-C Germicidal
200 - 280 nm

Vacuum UV
100 - 200 nm

400 nm

315 nm

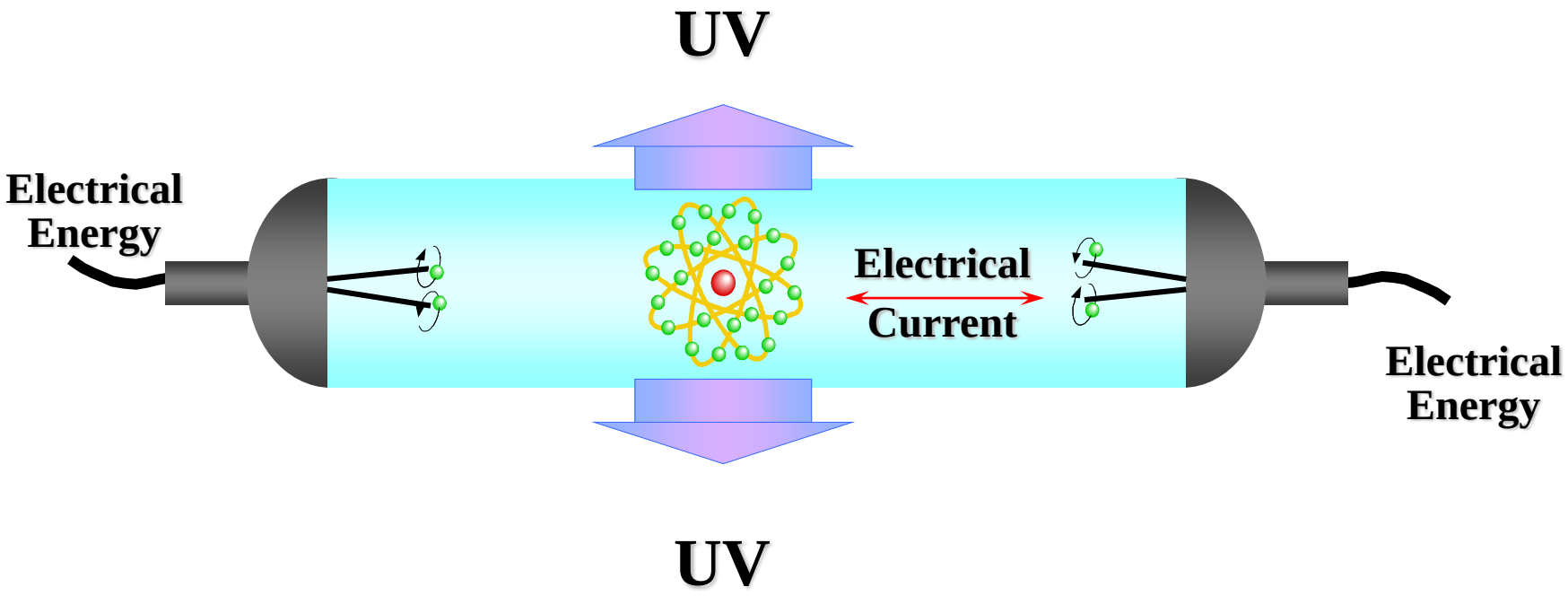
280 nm

200 nm

100 nm

Increasing
Photon Energy

# UV Lamps




The UV lamp emits powerful ultraviolet light energy at a wavelength of 253.7 nm.

# Basic UV System Components

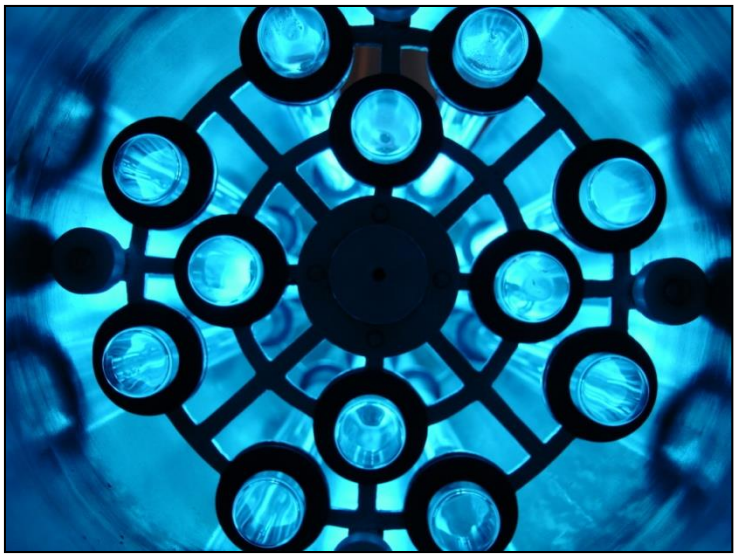

**Control Panel**

# Basic UV System Components


**UV Reactor Chamber**

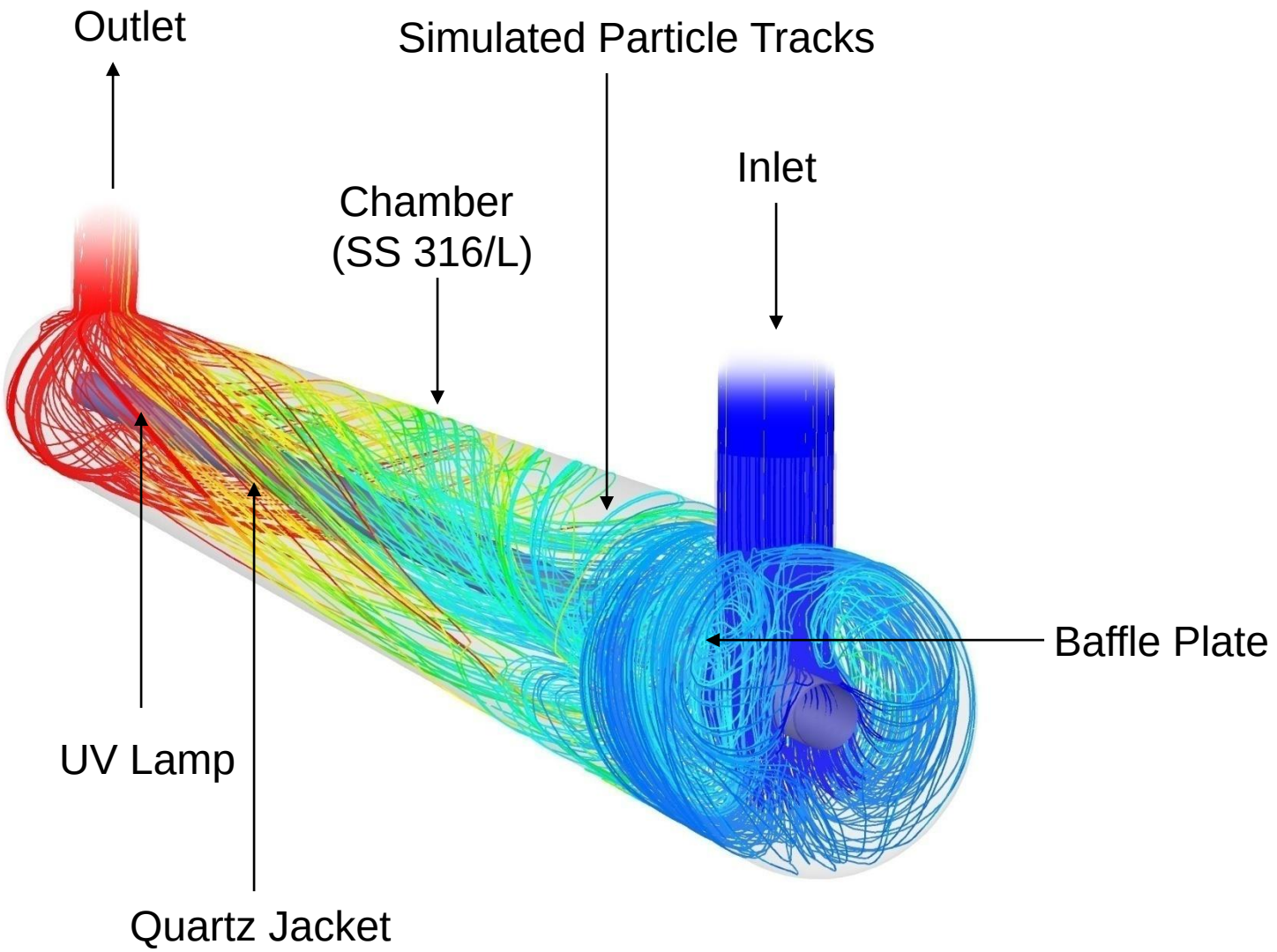
# Basic UV System Components

**UV Monitoring System**

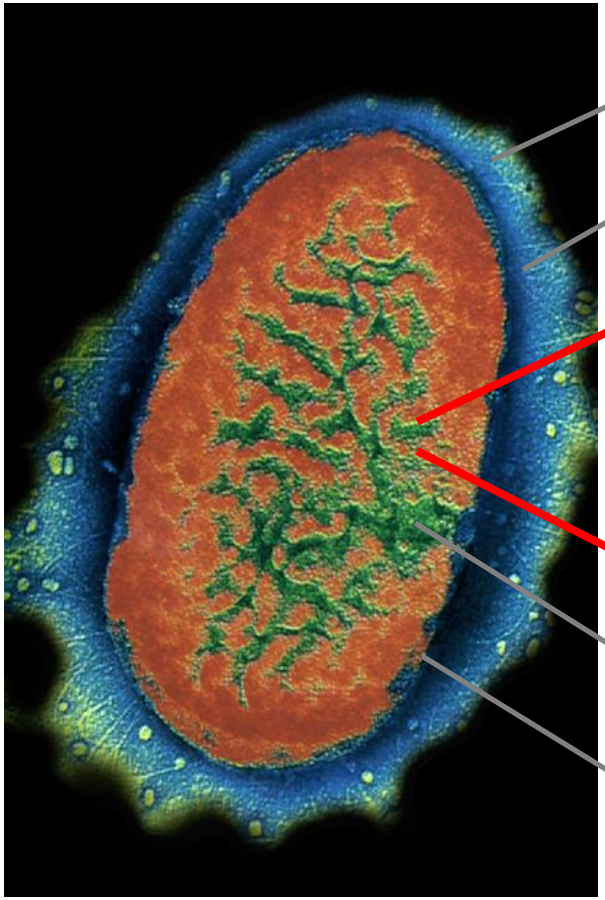


**Automatic Wiper System**

# Basic UV System Components (Simplified)



# Microorganism



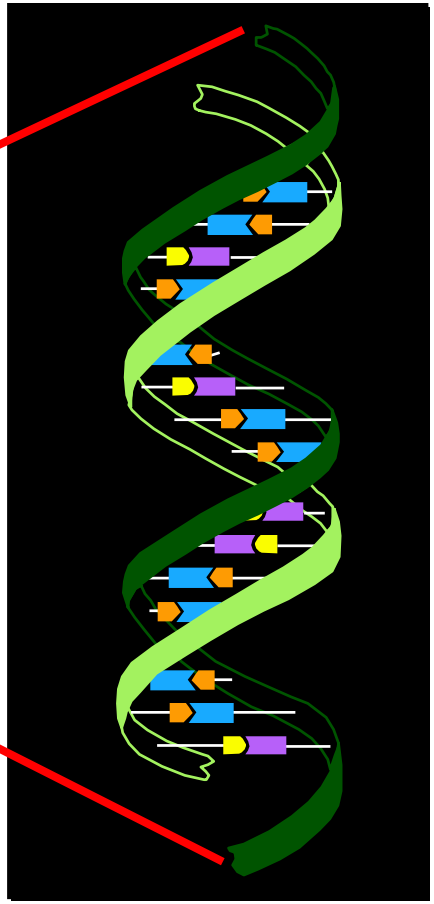
Capsule

Cell wall

Nuclear material

Cell membrane

Example



Adenine

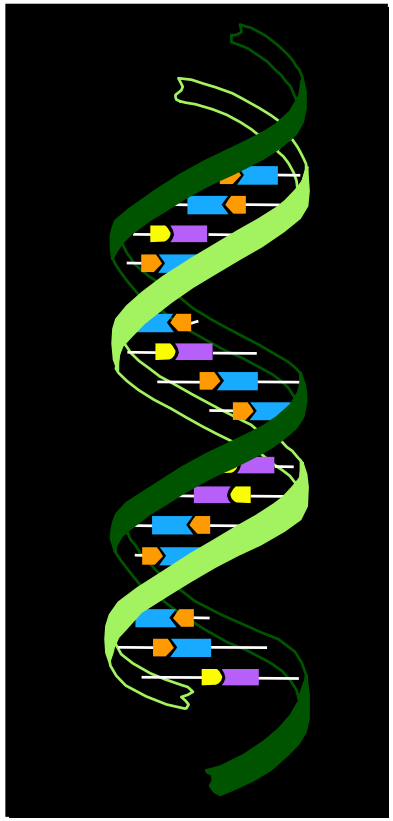
Thymine

Cytosine

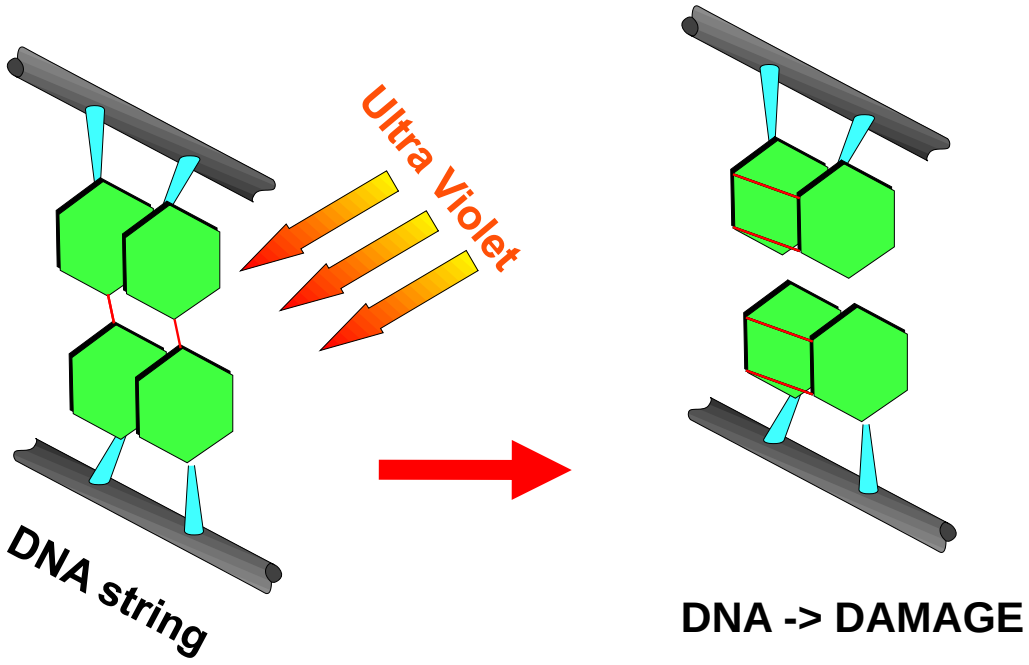
Guanine

DNA

# Effect of UV on Microorganisms



DNA string

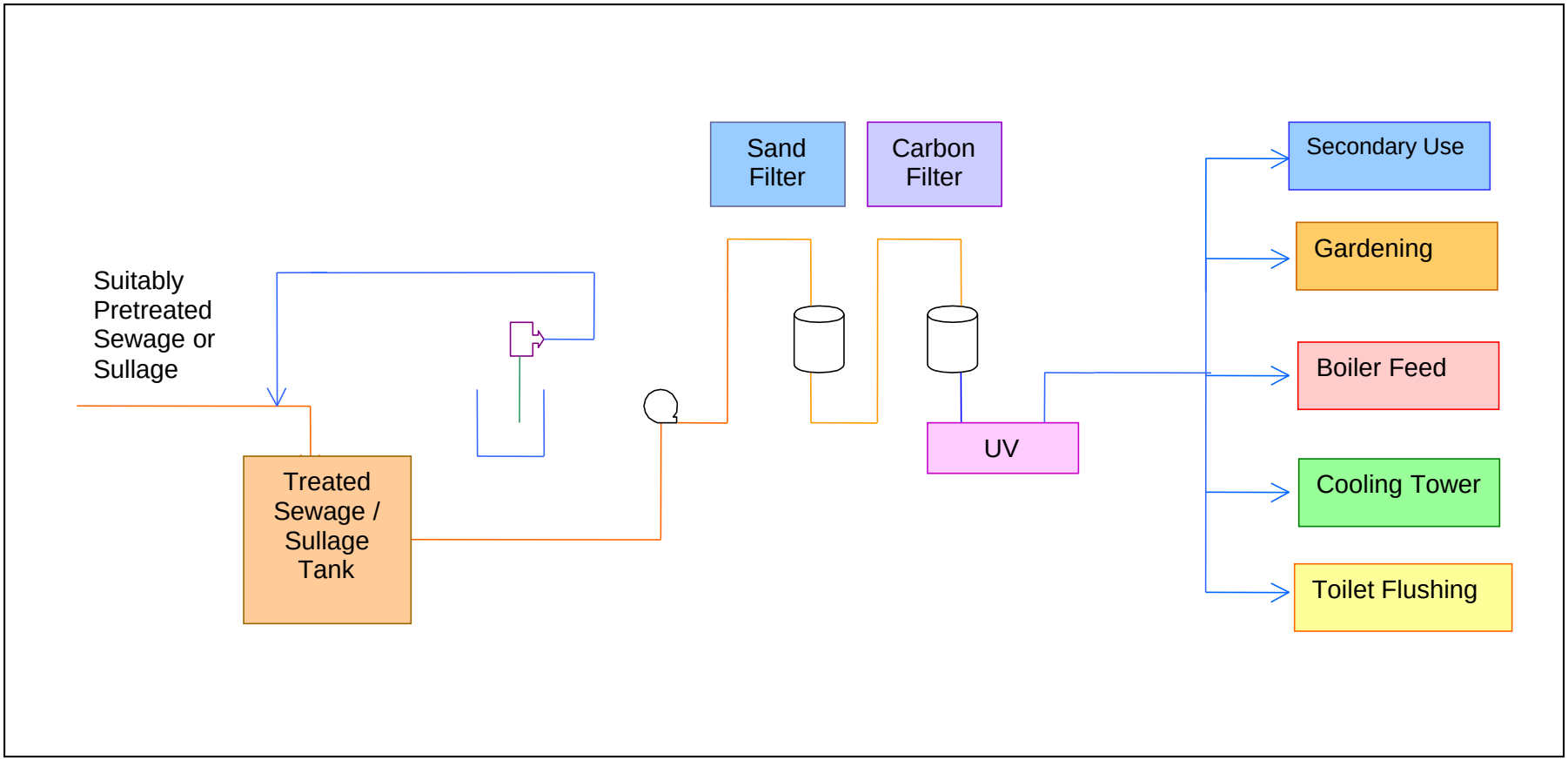



Vital genetic components contained in microorganisms absorb the light energy; this disrupts the DNA and inactivates the microorganism.

# Water Reuse Guidelines

- Acceptance of UV disinfection technology in California was preceded by extensive pilot and full-scale studies.
- This research formed the basis of the “UV Disinfection Guidelines for Wastewater Reclamation in California” (NWRI 1993).
- The guidelines for unrestricted reuse of reuse of effluents require:
  - Turbidity < 2 NTU
  - TC ≤ 2.2 CFU / 100 mL
  - 4-log inactivation of poliovirus.
  - A UV dose of about 140 mW-sec/cm2.

# Typical Wastewater Recycling Flowchart



# Installation Photos

← Outdoor Installation

Indoor Installation →

# UV vs. Chlorine

- If chlorination is to be effective, typically, a *minimum* of 5 ppm chlorine must be dosed before discharge.
- The average dosing in most plants where water is recycled is usually around 10 ppm.
- Chlorine forms many bi-products which are dangerous and harmful.
- If the water being discharged is to be reused, de-chlorination might also be required as excess residual chlorine in the water can affect plants and landscaping.

# Reasons to Choose UV over Chlorine

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## Chlorine Residual Limits

- For reuse, de-chlorination might become essential.
- **UV Disinfection is a physical process which requires no chemicals and which generates no residual.**

# Reasons to Choose UV over Chlorine

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## Formation of Chlorination By-Products

- Forms trihalomethanes which have been found to be cancer causing.
- **UV is an environmentally friendly solution that produces no trihalomethanes and carciogens.**

# Reasons to Choose UV over Chlorine

## Land Requirements

- Large contact tanks are required for chlorination to provide adequate residence time.
- **UV doses for disinfection are delivered instantaneously (in a few seconds) and there is no need for large tanks, leading to significant space (and therefore cost) savings.**

# Reasons to Choose UV over Chlorine

## Operator Safety

- Accidents pertaining to Chlorine (leaks and spills) can lead to severe burns, permanent vision damage, and lung damage.

- **UV disinfection presents no safety, handling, flammability or explosion issues. The risk of operator exposure to UV is extremely low.**

# Reasons to Choose UV over Chlorine

## Convenience

- Constant supervision is required from both the purchase and engineering departments to ensure that there is always an adequate supply of chlorine available in the plant.
- Plant operator also needs to ensure that the chlorine storage tank is always topped up and that the chemical is being dosed properly.
- **UV disinfection requires very low maintenance and operating hassles. No chemicals are needed and only annual lamp replacement is required.**

# Reasons to Choose UV over Chlorine

## Virus Inactivation

- UV has proved very effective in inactivating viruses as compared to chlorine.

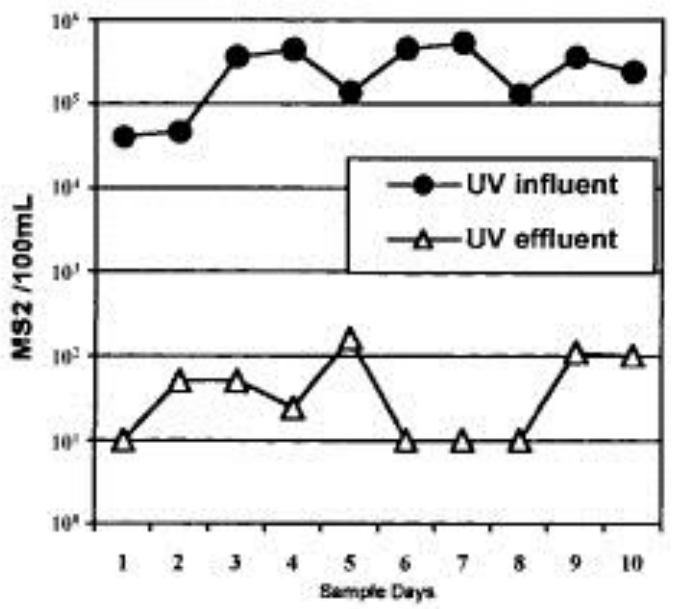



Figure 1 UV inactivation of MS2

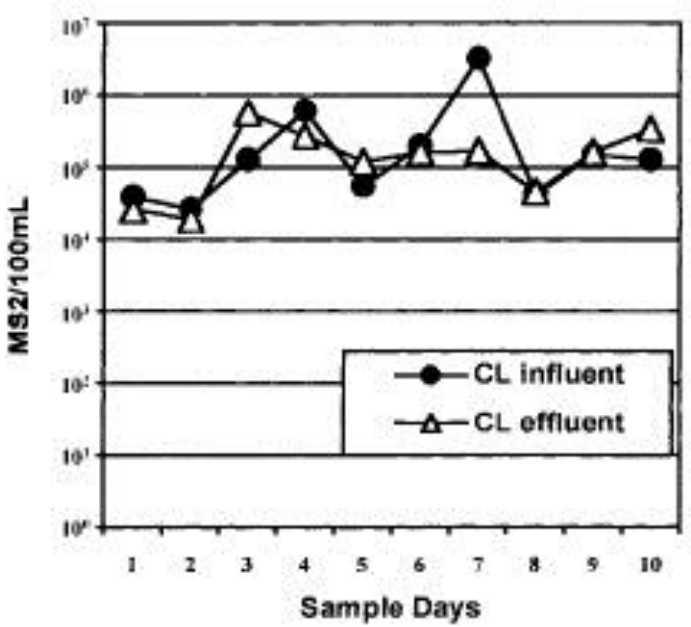



Figure 2 Chlorine inactivation of MS2

# UV vs. Chlorine

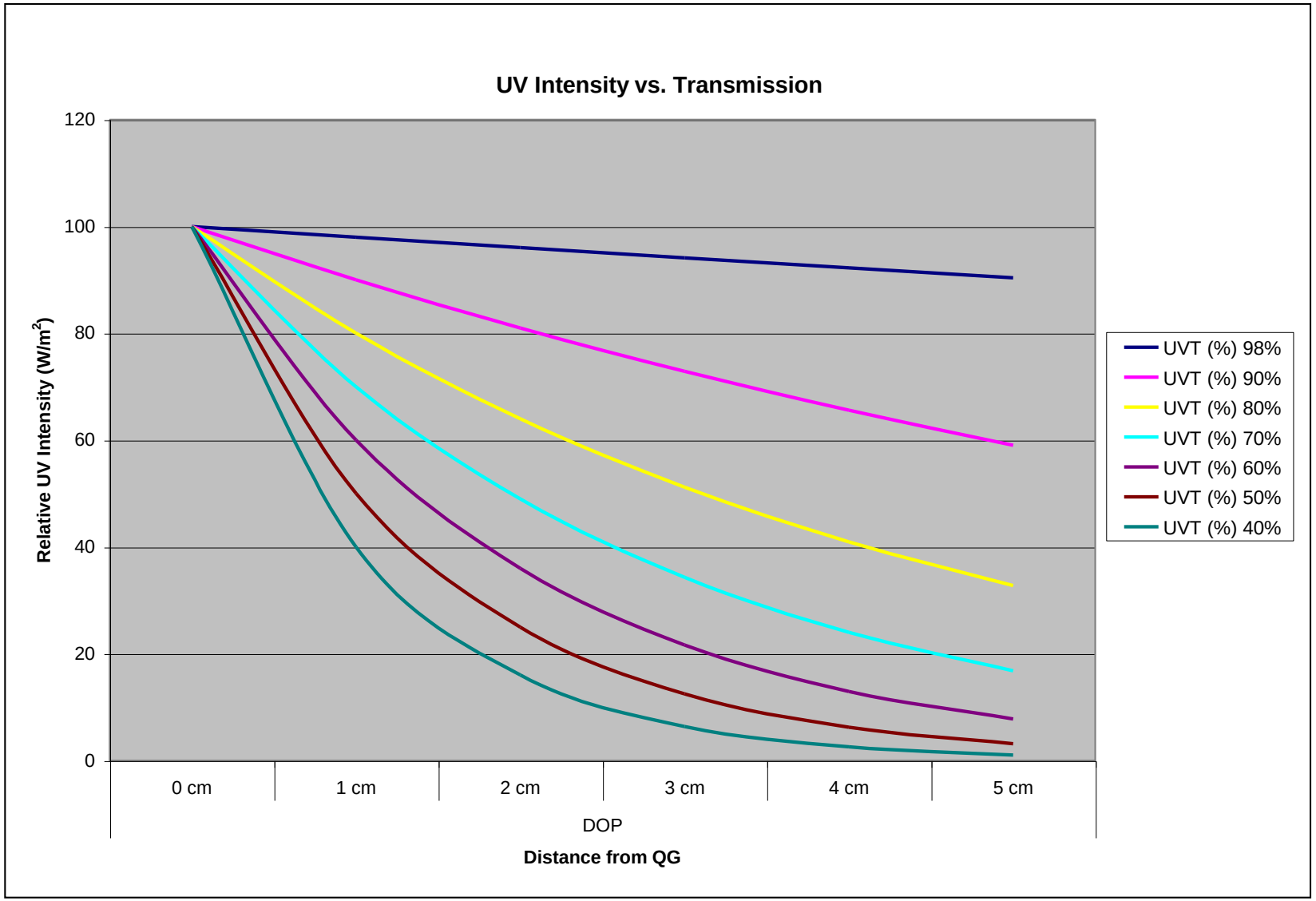
For Small Wastewater Recycling Plants
(< 1 MLD)

- These plants typically use “liquid chlorine” (sodium hypochlorite), which leads to excessively high running costs in the long run.
- Monitoring of the chlorine dosing is a full time activity to ensure that the chlorine does not run out and that the correct amount is being dosed.
- UV is a much more convenient and cost effective solution, with payback periods in many cases as **less as 1 to 2 years**.

# Factors Affecting UV Disinfection

- UV Transmission
  - Optical transmission of UV @ 254 nm through the water column.
  - Dependent on the organic and in-organic composition of the water.
  - Turbidity and TDS also plays a role.
  - Requires a UV capable spectrophotometer for its measurement.

# Factors Affecting UV Disinfection



# Factors Affecting UV Disinfection

- TDS & Turbidity
  - TDS plays a direct role in UV disinfections as large suspended particles act like a ‘shield’ for microorganisms.
  - Therefore, to achieve the high levels of UV disinfection required for wastewater recycling, filtration (sand filter / MGF) is highly recommended.

# Influent Parameters to the UV System

| 30 Samples (5 Plants) | UVT (%) | Turbidity (NTU) | TSS (mg/L) |
|---|---|---|---|
| Average Data | 69 | 1.4 | 2 |
| Data Range | 62 – 81 | 0.5 – 4 | 0.2 – 10 |
| Plant with lowest UV dose demand | 76 | < 1 | < 1 |
| Plant with highest UV dose demand | 69 | 0.5 – 2.2 | 0.5 – 6.3 |

**Averaged Effluent Quality Parameters For Coagulated Filtered Effluents**

# UV System Validation

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**How do you know that the UV System is working?**

- By testing the quality of output water from the UV unit microbiologically.
- By using the Alfaa German DVGW UV monitor to check the UV radiation.

# Measurement of UV Radiation

- The disinfection potential of a UV system is monitored by **continuous measurement** of the irradiance by using a UV intensity sensor.
- Intensity sensors are used to indicate **UV dose delivery** by providing information related to UV intensity at a point inside the reactor.
- The intensity measured by it **responds to changes** taking place inside the reactor such as lamp power output, lamp aging, lamp sleeve fouling, and change in UV transmission of the water.

# Factors Affecting UV System Performance

**The Alfaa UV Monitor Will Indicate “Low Dose” in the Event of the Following Circumstances:**

- Turbidity.
- UV absorbing organic & inorganic matter.
- Low voltage.
- Quartz glass scaling.
- High / low lamp wall temperature.
- Weak lamp.
- Lamp failure.

# The Alfaa UV Monitor

- All new Dry type UV monitor meets stringent **German DVGW standards**.
- Can be swapped/replaced while the system is **online**.
- Built in hour counter and lamp replacement reminder.
- Interfaces with **PLCs** and other CPE using standardized outputs such as **4-20 mA loop, RS485, and MODBUS**.
- **Standby monitor** can be kept for redundancy or to crosscheck the functioning of the installed monitor.

# Case Study
# DIL Ltd. - Thane


**Site**: DIL Ltd. – Thane

**STP Type**: Activated Sludge Process

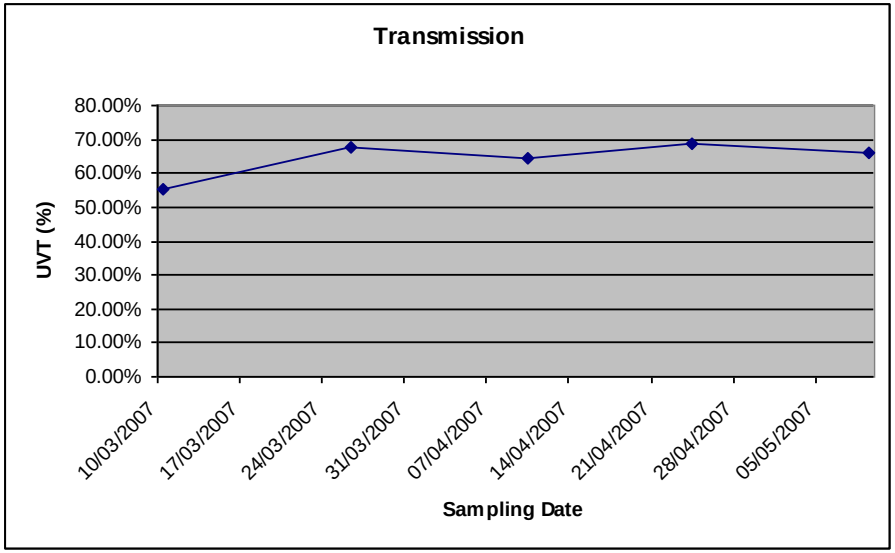
**Plant Capacity**: 120 KLD

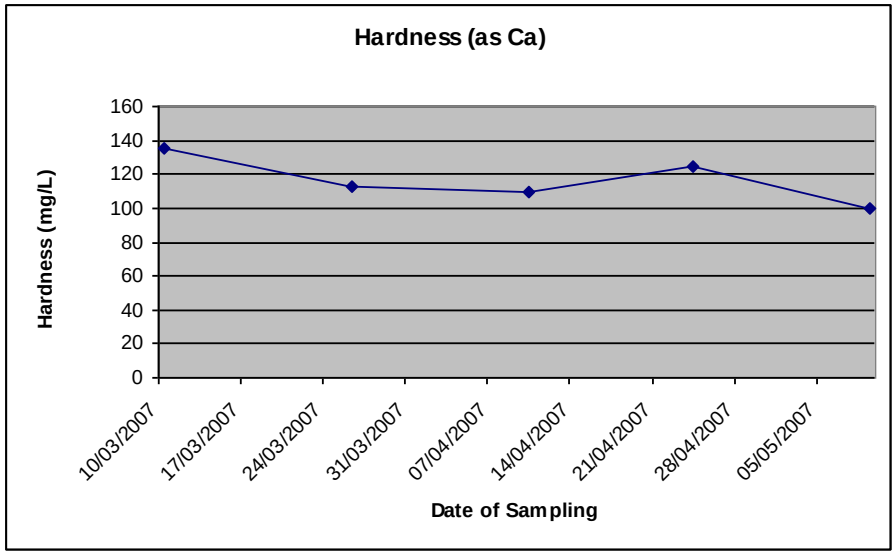
**Reuse Purpose**: Gardening & toilet flushing (proposed)

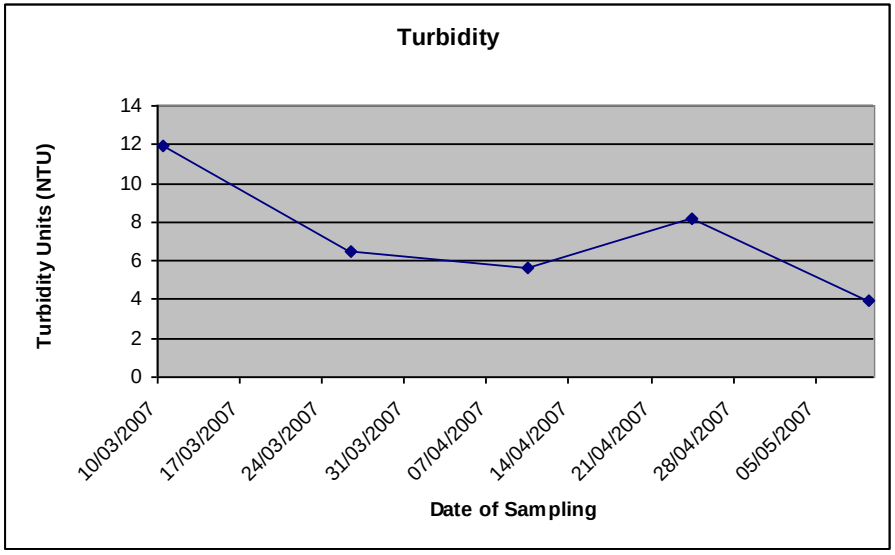
**Process:**

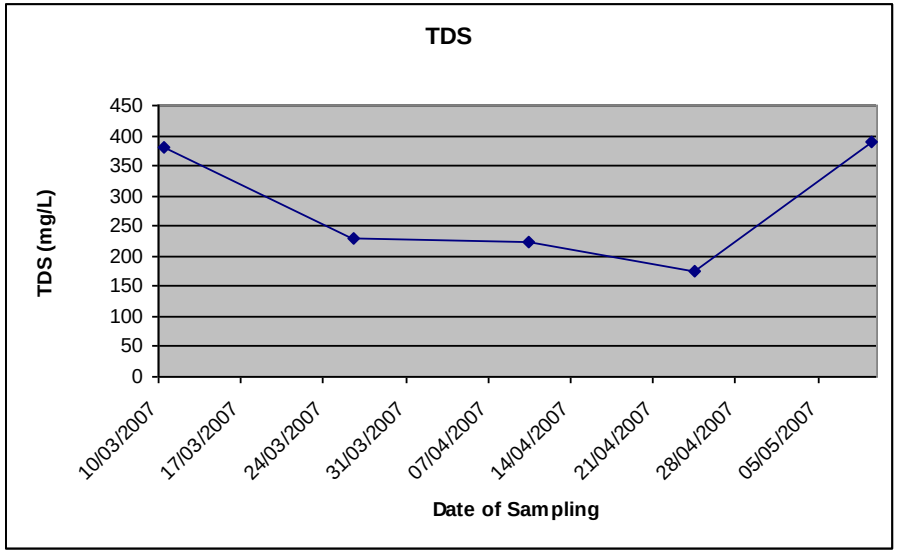
Primary Screening & Sedimentation ▸ Acid Dosing ▸ Biological treatment (Aeration tank) ▸ Clarifier (with alum dosing) ▸ Storage tank ▸ Sand Filter ▸ UV ▸ Final storage ▸ User points.

# Inlet Parameters to the UV System

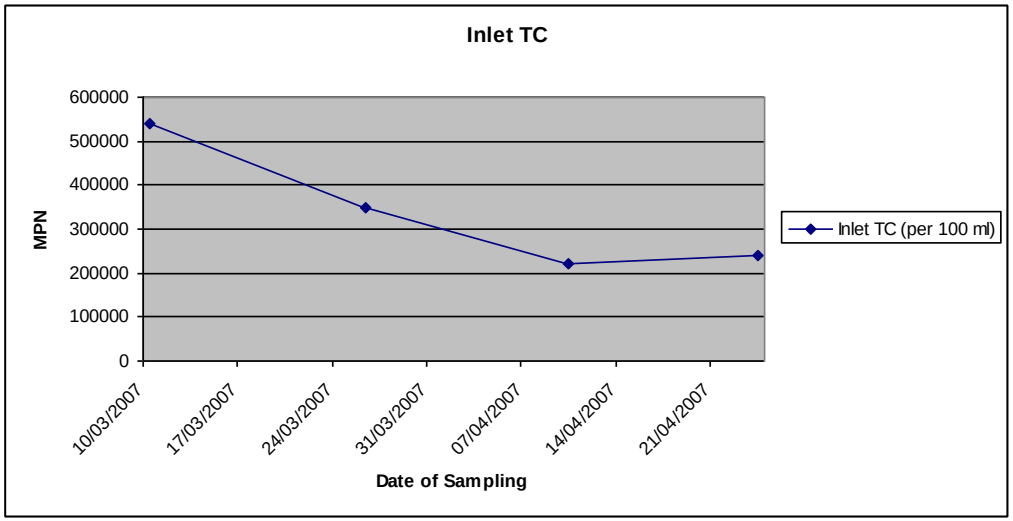


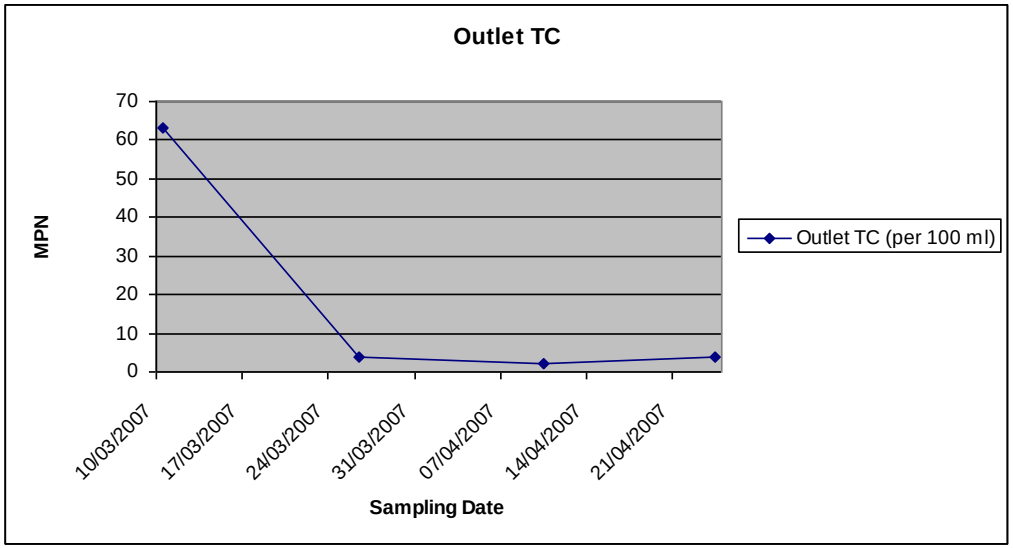



# Total Coliform (TC)




| Sampling Date | 10/03/2007 | 26/03/2007 | 10/04/2007 | 24/04/2007 |
|---|---|---|---|---|
| Inlet TC (per 100 ml) | 5,40,000 | 3,50,000 | 2,20,000 | 2,40,000 |
| Outlet TC (per 100 ml) | 63 | 4 | 2 | 4 |
| **TC Log Reduction** | **3.93** | **4.94** | **5.04** | **4.78** |

# Sample Installation: DLF Cyber City, Gurgaon

**Site**: DLF Cyber City, Gurgaon

**STP Type**: Extended Aeration

**Plant Capacity**: 10 MLD

**UV Dose: 30,000 uW-sec/cm$^2$**

**Discharge:** Reuse of irrigation, CTM

**Output: TC < 10 MPN/100ml**

# Sample Installation: Lavasa Lake City WWTP

**Site**: Lavasa Lake City, Maharashtra

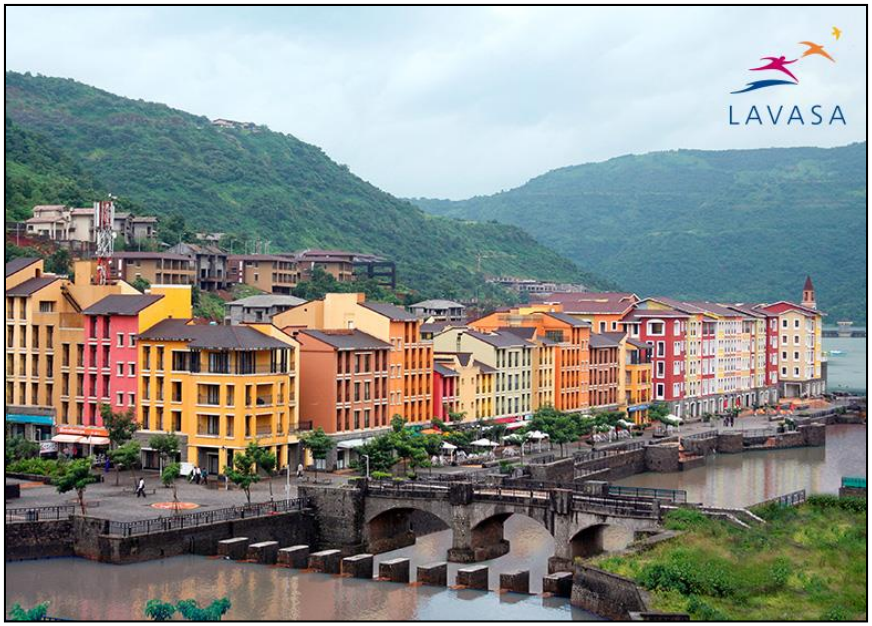
**STP Type**: Conventional

**Plant Capacity**: 2.4 MLD

**UV Dose: 40,000 uW-sec/cm²**

**Discharge:** Discharge into Dam

**Output: TC < 200 MPN/100ml**




# Sample Installation: DLF IT Park, Hyderabad


**Site**: IT Park, Hyderabad

**STP Type**: SAFF

**Plant Capacity**: 1.2 MLD

**Reuse Purpose**:

Gardening and Cooling Tower Makeup

**Process:**

Primary Screening & Sedimentation ▸ Biological treatment (Aeration tank) ▸ Clarifier ▸ Storage tank ▸ Sand Filter ▸ UV ▸ Carbon Filter ▸ Softener ▸ Final storage ▸ User points.

# Sample Installation: DLF IT Park, Hyderabad


Location


UV System

Secondary Treatment


Overview of the Tertiary Treatment

# Sample Installation: Microsoft Campus


**Site**: Microsoft Campus, Gacchibowli

**STP Type**: SAFF

**Plant Capacity**: 1 MLD

**Reuse Purpose**:

Landscaping and Cooling Tower Makeup

**Process:**

Primary Screening & Sedimentation ▸ SAFF Reactor ▸ ▸ Storage tank ▸ Sand Filter ▸ Carbon Filter ▸ Softener ▸ UV ▸ Final storage ▸ User points.

# Sample Installation: Microsoft Campus


Location

UV Reactor


Location


Tertiary Treatment

# Conclusions

- Proper disinfection of wastewater is essential before recycling.
- In the interest of public health and welfare, it is important that proper guidelines and norms be established for disinfection. These norms need to be strictly implemented.
- UV is the only technology which can provide the high level of disinfection required (in a simple and cost effective manner) so that the water can safely be reused.
- Essential to design the system based on the effluent characteristics.
- Chlorination has many disadvantages and is also very expensive in the long run. The use of the same is also being phased out in most developed and developing countries.
- The UV system needs to be well designed and efficient in order to get desired results.

# Thank You

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# Thank You!