

Lesson 8: Chemical processes. Wastewater disinfection

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Annotation

- Technological scheme of wastewater treatment is shown.
- Fundamentals of chemical oxidation, stripping of ammonia, as well as the methods of disinfection of waste water - chlorination, ozonation, and ultraviolet irradiation are reviewed.

Keywords

- WASTEWATER, TECHNOLOGY, POLLUTION, MICROORGANISMS, DISINFECTION, OXIDATION, CHLORINATION, OZONATION, ULTRAVIOLET RADIATION.

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- Chemical oxidation
- Ammonia stripping
- Disinfection processes of ww

Introduction

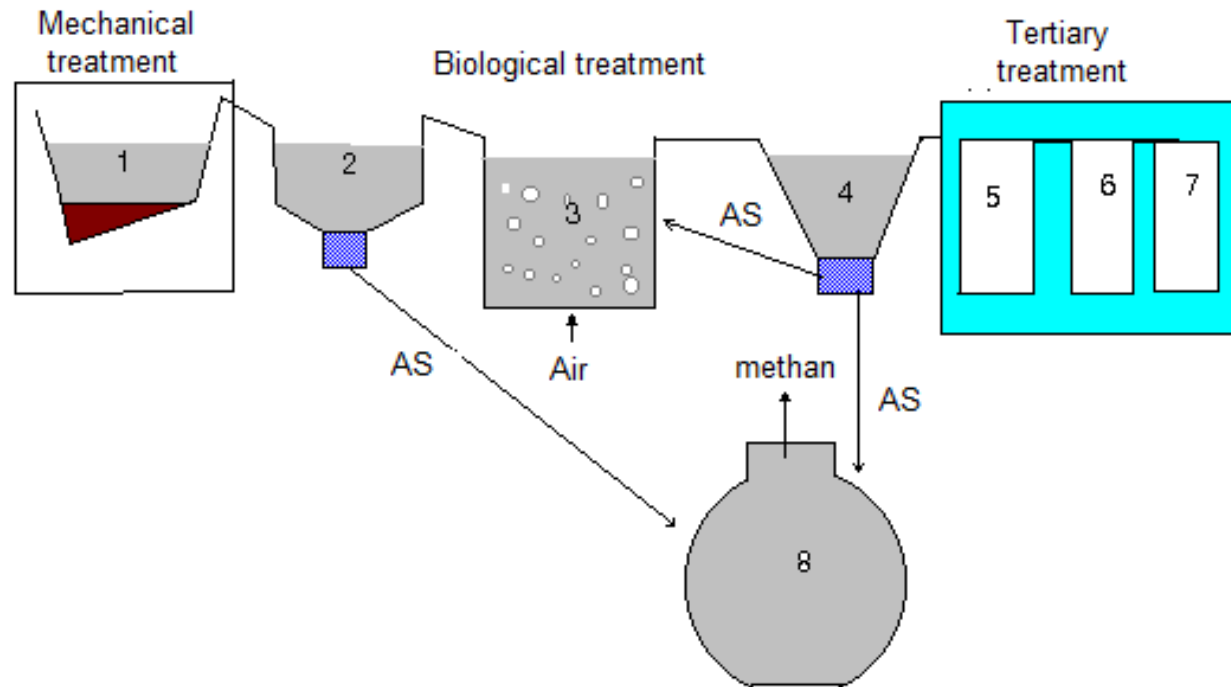
Why should we treat the wastewater?

- Wastewater may contain high numbers of microorganisms, protozoa, organic and toxic substances, helminth eggs. If non-compliance with these requirements the water pollution, violation of self-purification processes and the subsequent violation of the biocenosis may occur.



Introduction

Waste water treatment plant

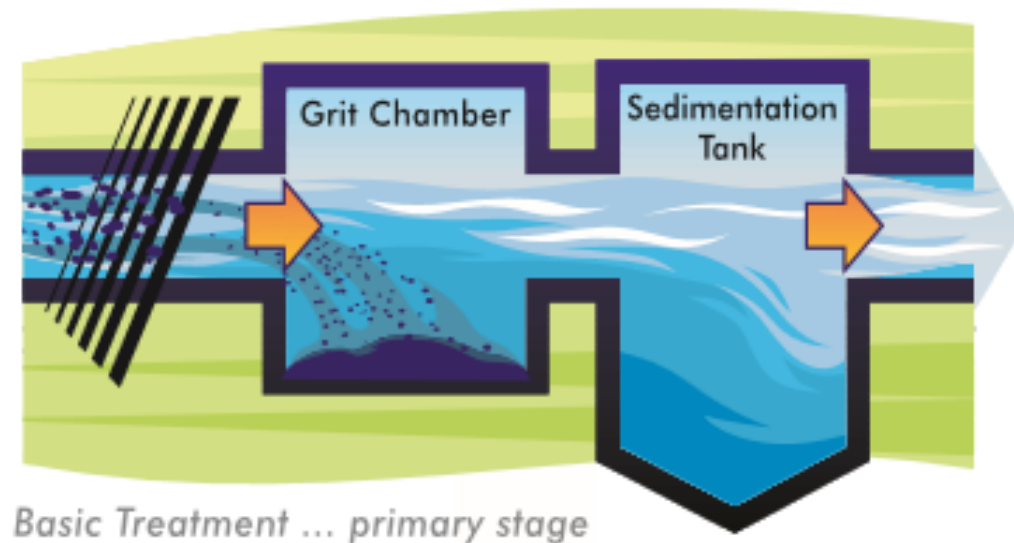


1 - grit chambers; 2 - primary sedimentation tanks; 3 - aeration tank; 4 - secondary sedimentation tanks; 5 - biological ponds; 6 - clarifier; 7 - chemical treatment; 8 - methan tank; AS - activated sludge.

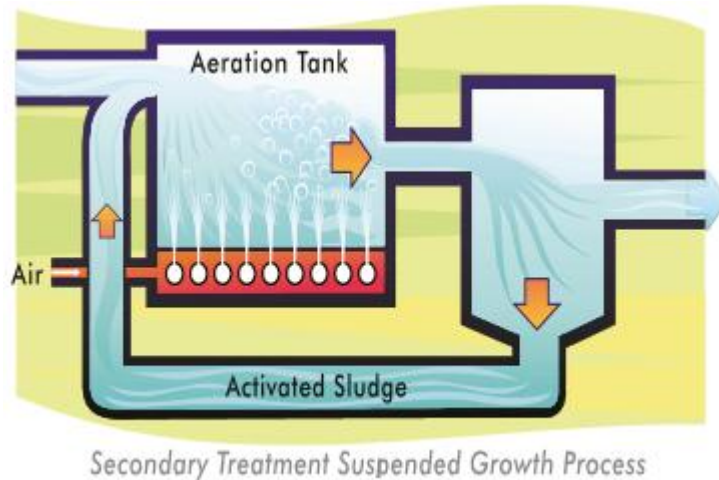
Introduction

Mechanical treatment

The scheme begins with mechanical cleaning. It is most often used gratings and grit chambers. Gratings are delayed largest impurity. Grit chambers are necessary in order to retain the sand, including other small particles.



Introduction



Secondary treatment

In the aeration tank, wastewater is vigorously mixed with air and microorganisms acclimated to the wastewater in a suspension for several hours. This allows the microorganisms through their enzymes to break down the organic matter in the wastewater. The mass of microorganisms grows and the excess biomass (including discharged microorganisms) is removed by settling.

Introduction

Tertiary treatment

Biological ponds are artificially created ponds for biological wastewater treatment based on the processes that occur in the self-purification of water bodies. Ponds have a small depth - 0.5 - 1m. This provides a significant surface of contact with air and water to provide the entire heating of the water column and its mixing.

The duration of being water in the pond - 8 - 12 days. The fish can be bred in these ponds.

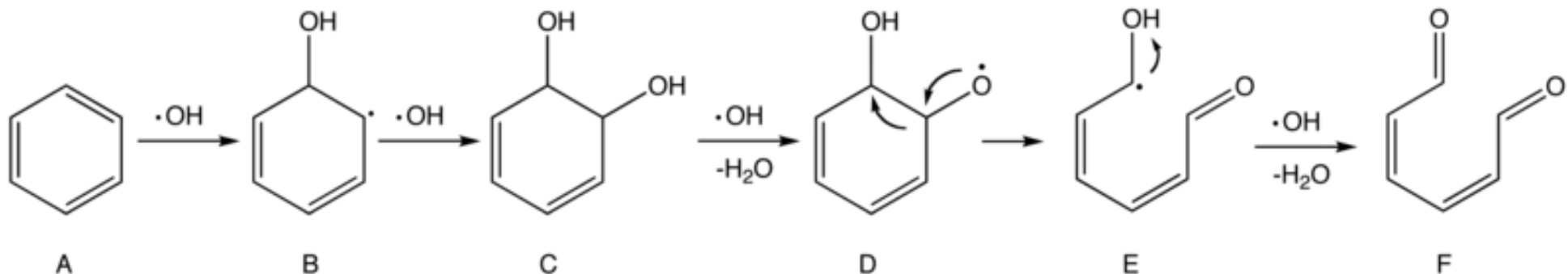


Chemical oxidation

- **Oxidation processes**, are a set of chemical treatment procedures designed to remove organic (and sometimes inorganic) materials in waste water by oxidation through reactions with hydroxyl radicals ($\bullet\text{OH}$). In real-world applications of wastewater treatment, however, this term usually refers more specifically to a subset of such chemical processes that employ ozone (O_3), hydrogen peroxide (H_2O_2) and/or ultraviolet radiation.

Chemical oxidation

- The OP procedure is particularly useful for cleaning biologically toxic or non-degradable materials such as aromatics, pesticides, petroleum constituents, and volatile organic compounds in waste water. Additionally, OPs can be used to treat effluent of secondary treated wastewater which is then called tertiary treatment.



Chemical oxidation

The mechanism of $\bullet\text{OH}$ production depends on the sort of OP technique that is used. For example, ozonation, UV/ H_2O_2 and photocatalytic oxidation rely on different mechanisms of $\bullet\text{OH}$ generation:

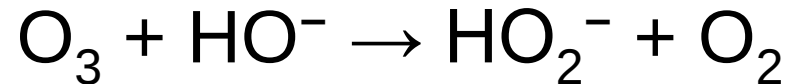
•UV/ H_2O_2 :



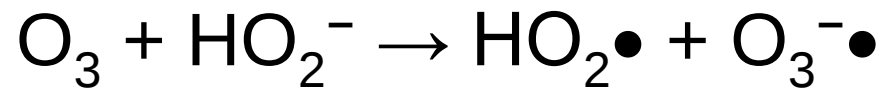
Homolytic bond cleavage of the O-O bond of H_2O_2 leads to formation of $2\bullet\text{OH}$ radicals

Chemical oxidation

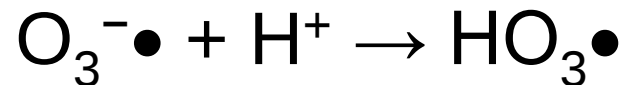
•Ozone based OP:



Reaction between O_3 and a hydroxyl ion leads to the formation of H_2O_2 (in charged form)



A second O_3 molecule reacts with the HO_2^- to produce the ozonide radical



This radical gives to $\bullet\text{OH}$ upon protonation



Ammonia stripping

- In a waste stream, ammonium ions exist in equilibrium with ammonia.



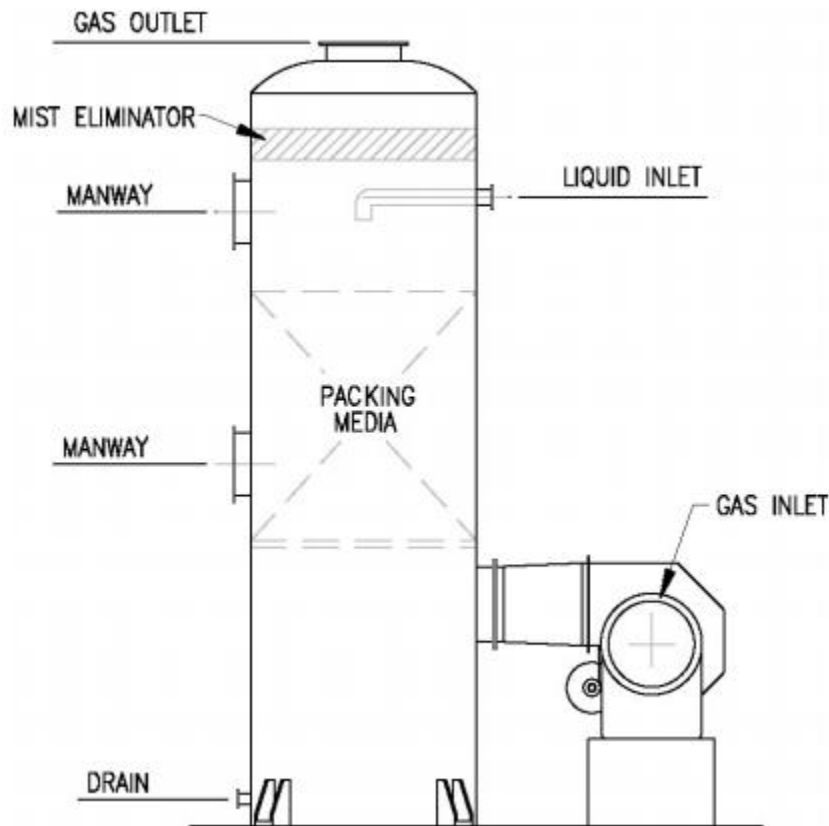
- 1. Below pH 7, virtually all the ammonia will be soluble ammonia ions.
- 2. Above pH 12, virtually all the ammonia will be present as a dissolved gas.
- 3. The range between 7 and 12, both ammonium ions and dissolve gas exist together.
- 4. Percentage of dissolved gas increases with temperature and pH. Where temperature and pH favor removal of ammonia from solution.

Ammonia stripping

In the stripper, the pH and temperature are adjusted before the water enters the stripper.

As the water is distributed over the internal packing media, it is broken up into small droplets which create a tremendous amount of surface.

Air enters the bottom of the tower from a fan and travels upward through the packing. Since the ammonia is partially present as a dissolved gas, some of the ammonia transfers from the water to the air.



Disinfection processes

- The purpose of disinfection in the treatment of waste water is to substantially reduce the number of microorganisms in the water to be discharged back into the environment for the later use of drinking, bathing, irrigation, etc.

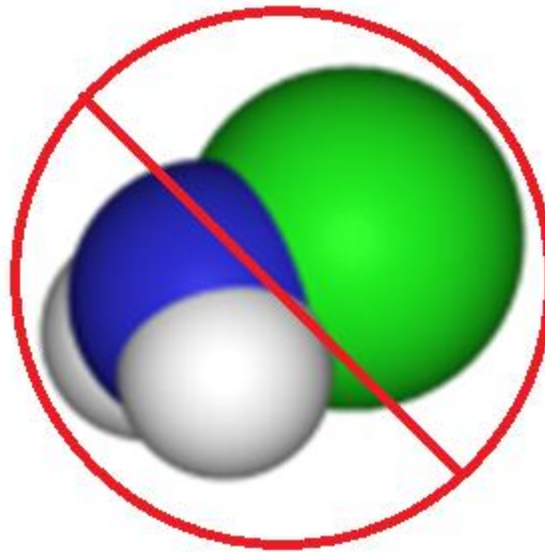


Disinfection processes

- Common methods of disinfection include:
 - **chlorination;**
 - **ozonation;**
 - **ultraviolet light.**

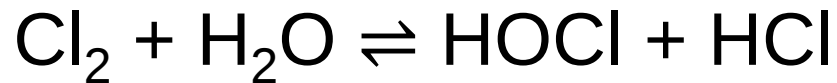
Disinfection processes

- Chlorine and its compounds possess a high bactericidal effect. It is explained by the action of chlorine and its compounds on bacterial cell protoplasm enzymes and microorganisms, which leads to their death.
- Chloramine, which is used for drinking water, is not used in the treatment of waste water because of its persistence.



Disinfection processes

- When dissolved in water, chlorine converts to an equilibrium mixture of chlorine, hypochlorous acid (HOCl), and hydrochloric acid (HCl):



- In acidic solution, the major species are Cl_2 and HOCl, whereas in alkaline solution, effectively only ClO^- (hypochlorite ion) is present. Very small concentrations of ClO_2^- , ClO_3^- , ClO_4^- are also found.

Disinfection processes

The amount of active chlorine introduced per volume unit of waste water, is called chlorine dose and expressed in g/m^3 .

- To reduce Coli-forms by 99.9% the following chlorine doses are required, g/m^3 :
 - After the mechanical purification 10;
 - After chemical cleaning 3-10;
 - After the complete biological purification and partial 3-5;
 - After filtration on sand filters 2-5.



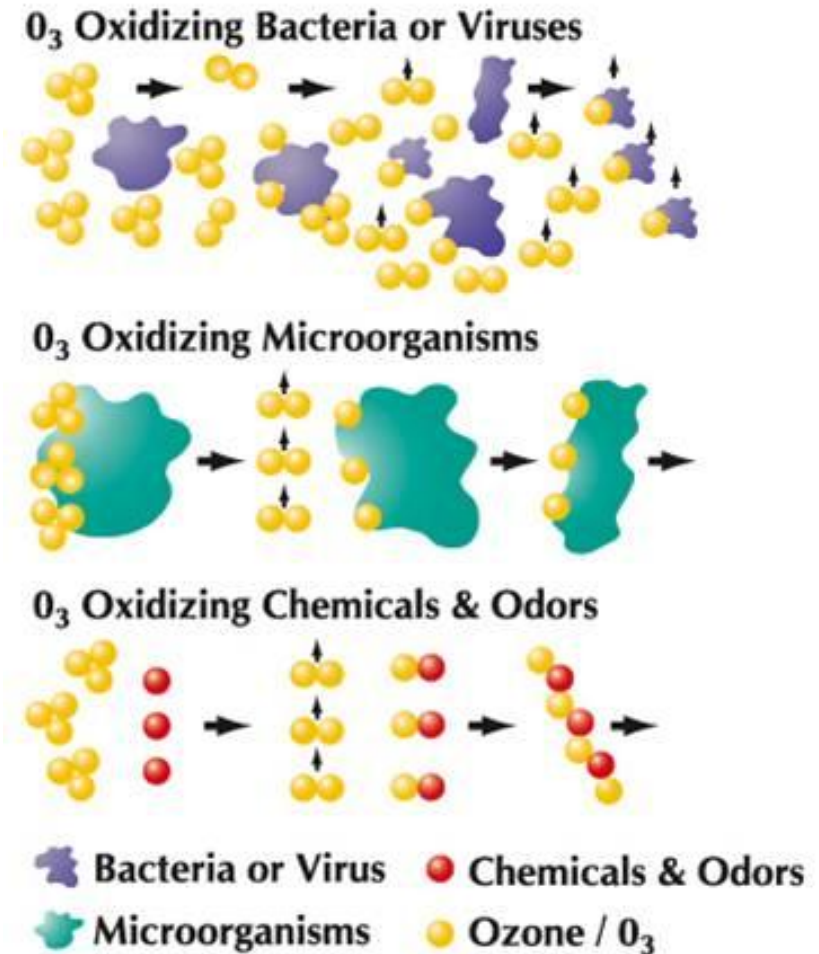
Disinfection processes

- One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine may also be capable of chlorinating organic material in the natural aquatic environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated, adding to the complexity and cost of treatment.

Disinfection processes

Ozonation

- Total virulent and bactericidal effect is achieved when using ozone. Ozone oxidation can effectively decolorize both drinking and waste water, improves taste, eliminates odors and flavors, holds a deep water disinfection.



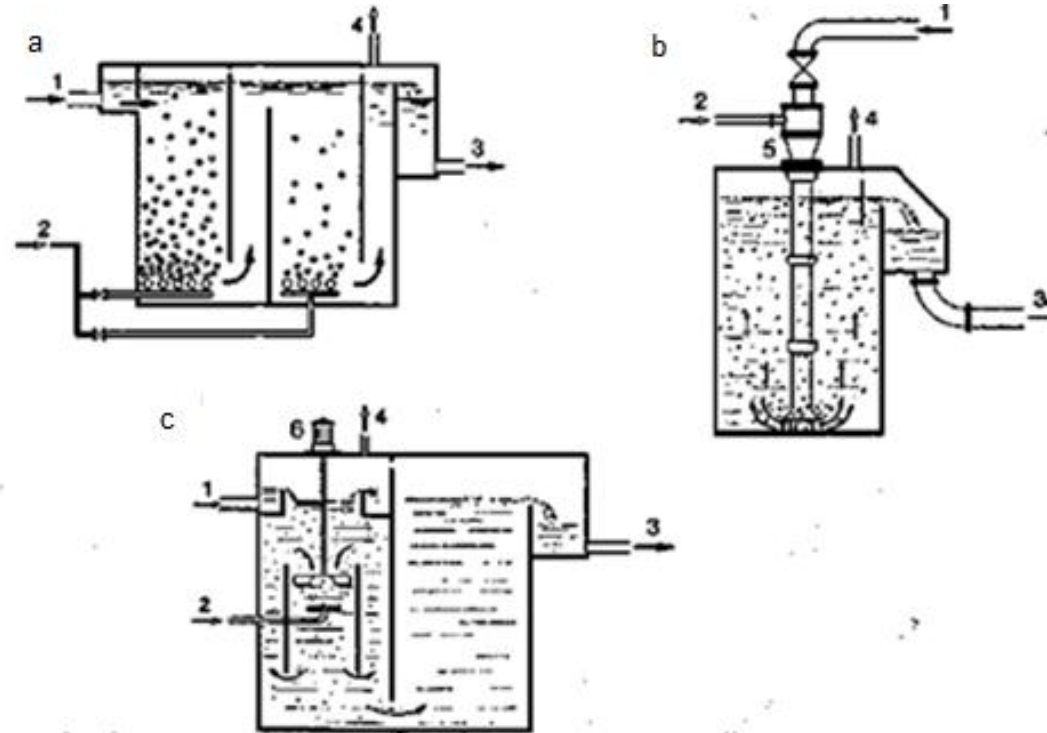
Disinfection processes

a - two-section bubbling chamber;

b - camera equipped with an injector;

c - camera equipped with an impeller;

1,3 - wastewater supply and disposal of treated water;
2 - supply of ozone-air mixture;
4 - release of ozone-air mixture;
5 - an injector;
6 - an impeller unit



contact chamber with
injection of the ozone-air
mixture with wastewater

Disinfection process

UV irradiation

- Wastewater treatment process is significantly reduced when used in conjunction of ultrasound and ozone, ultraviolet radiation and ozone. Ultraviolet radiation accelerates oxidation in 10^2 - 10^4 times.

The oxidation process can be divided into **two stages**:

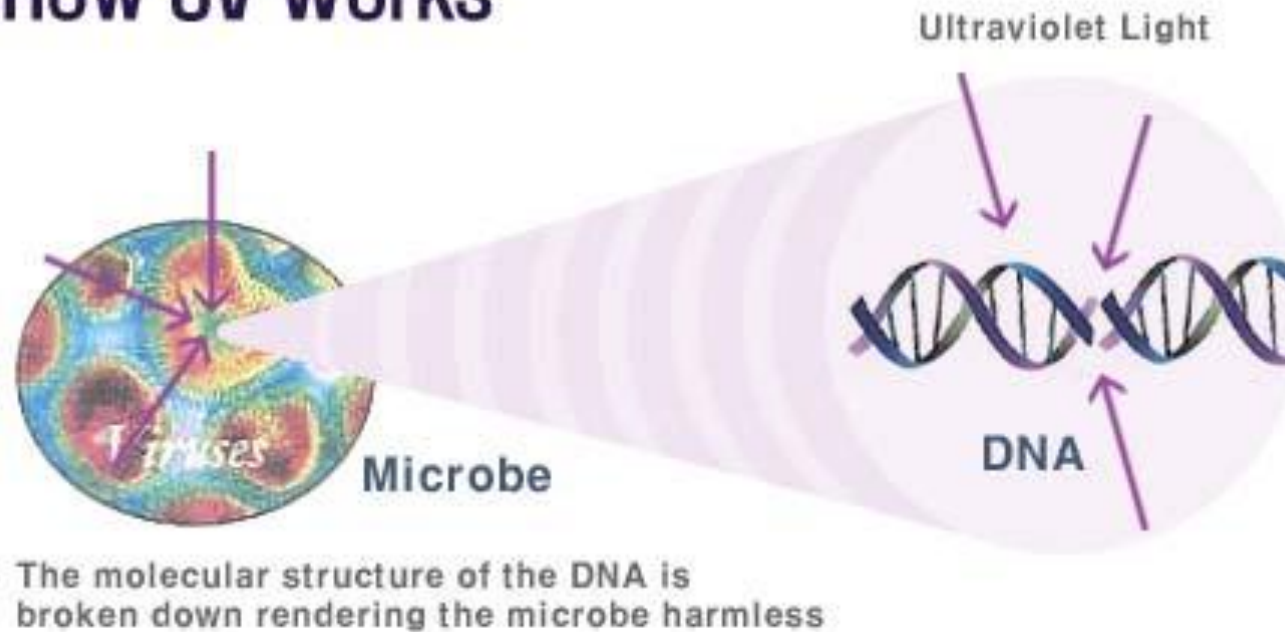
- the photochemical excitation of molecules by UV irradiation;
- oxidation by ozone.



Disinfection processes

- **Disinfectant (bactericide) effect** has only a part of the spectrum of UV-radiation in the wavelength range 205-315 nm with maximum effectiveness of 260 ± 10 nm.

How UV Works



Disinfection processes

- The most important quality of UV wastewater treatment is the absence of a change in its physical and chemical characteristics even at doses much higher than practically necessary.
- The widespread method of UV disinfection of wastewater explained by its **advantages** such as:
 - versatility and effectiveness of the impact on the various microorganisms in water;
 - ecological, safety for human life and health;
 - relatively low price;
 - low operating costs;
 - low capital cost;
 - ease of maintenance facilities.

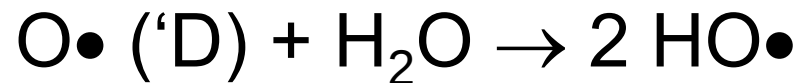
Disinfection processes

- A serious **drawback** of UV disinfection is the absence of aftereffect, i.e. purified water can become contaminated again in subsequent stages of processing or transport.
- UV radiation kills microorganisms water, but the cell walls of bacteria, fungi, viruses protein fragments remain in the water.

Complex method of UV irradiation and ozonation of wastewater is the most effective way to overcome the shortcomings

Disinfection processes

Photochemical phenomena of system water-oxygen-ozone-hydrocarbons led to the synthesis of hydroxyl and hydroxyde-peroxyde radicals. When used as a radiation source for mercury lamps with low or high-pressure ozone decomposition process proceeds to $O\bullet$ ('D), which is a singlet, and therefore reacts with wastewater at high speed with forming a radical $HO\bullet$ by the following mechanism:



Mercury lamps
with
different
pressure

