



## Waste water treatment systems

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THE MAIN OBJECTIVE of any waste treatment system is removal of organic and inorganic impurities from water.

The broad specification of impurities and their method of treatment is as follows:

Insoluble: By physical separation.

Soluble: 1. Inorganic - chemical treatment.  
2. Organic - Biochemical treatment.

The basic reaction in the biochemical operation is:

Organic waste + living microorganisms + Oxygen  $\rightarrow$   
 $\text{CO}_2 + \text{H}_2\text{O} + \text{more organisms}$

This reaction can be carried out in different reactors and the processes are classified as:

- Aerobic digestion.
- Activated sludge process.
- Anaerobic digestion.
- Trickling filters.
- Rotating Biological Contactor.
- Biofilter.

In addition to all these methods dissolved air flotation is also used for oil water separation.

### Rotating biological contactor

(The paper emphasises more on last two methods as the remaining are four methods well known).

It consists of closely spaced discs mounted on a common horizontal shaft, partially submerged in a semi circular tank receiving waste water. When water containing organic waste and nutrients flow through the reactor, micro organisms consume the substrata and grow attached to the disc. The rotating action imparts a shear force to the biofilm, keeping the thickness relatively constant. The rotation of the discs also mixes the liquid which keeps the stripped biomass in suspension and allows it to be carried from the reactor by the effluent.

Aeration of the culture is accomplished by two mechanisms:

- As a point on the discs rises above the liquid surface a thin film of liquid remains attached to it and oxygen is transferred to the film as it passes through air.
- Some amount of air is entrained by the bulk of liquid due to turbulence caused by rotation of discs.

The essential features of the unit are:

- The main shaft of sufficient rigidity on which circular discs are mounted. The discs could be of asbestos, cement sheets, PVC sheets, etc.

- A tank in which discs are half submerged in the waste water.
- A driving mechanism consisting of a motor and reduction gear.

### Biofilter

Biofilter is a fixed film biological reactor where the microbial growth takes place on a fixed rigid media like stone or plastic.

The influent wastewater is fed to the top of the biofilter where the reaction driven rotating distributor evenly distributes the wastewater over the plastic media within the biofilter. As the wastewater percolates down over the media, the biological population growing on the media surface absorb the soluble and particulate biodegradable organic material converting it into either cellular matter or respiration products ( $\text{CO}_2$  and  $\text{H}_2\text{O}$ ).

The cellular matter periodically sheds or sloughs from the media and passes out of the biofilters.

### Biofilter ventilation

Due to a highly biodegradable nature of wastewater, it is possible that small pockets of anaerobic biomass may periodically occur within the aerobic biofilter. The presence of these bacteria may result in the production of odorous gasses such as  $\text{H}_2\text{S}$ . The biofilter is therefore sometimes covered and ventilated using fans. This arrangement also enables exhaust gases to be scrubbed in a small chemical scrubber, hence, eliminating the possibilities of odour around the waste water treatment plant.

### Air distribution

Air distribution is a critical design features and an important factor in biofilter performance. The amount of air flow is not as significant as the requirement for positive and constant flow throughout the media. The design velocity of air through the biofilter will vary depending on the media characteristics, the biofilter configuration (particularly) the design and type of the support system) and its operational density. A velocity range of between 0.2 to 0.4m/min, with a typical design parameter of 0.3 m/min, would normally be adequate as long as the distribution is satisfactory with no stagnant areas. Without good distribution it would be necessary to supply more air either by an increased air supply or by the use of a recirculation system.

## Design procedure

### Design parameters

- BOD loading.
- Irrigation rate.
- Sludge production.
- Air requirements.

### BOD loading

2 Kg. BOD/M<sup>3</sup>/Day. Most of the designs are based on 1.2-3.5 Kgs BOD/M<sup>3</sup>/day (These values depend upon type of packing used and BOD removal efficiency achieved).

### Irrigation rate

This is required to avoid the packing to dry and is the packing characteristic.

Wetting rates are higher for rigid media around 2-3 M<sup>3</sup>/M<sup>2</sup> that the random media around 0.5-0.3 M<sup>3</sup>/M<sup>3</sup>/Hr.

### Sludge production

Sludge production depends upon

- BOD load applied.
- System efficiency.

### Air requirements

Air requirements in the biofilter depends upon

- The stoichiometric oxidation requirements.
- Efficient air distribution in the biofilter.

$$\text{Air (m}^3\text{/day)} = \frac{\text{KgBOD/day} \times \text{KgO}_2\text{/KgBOD}}{0.23 \times 0.05 \times 1.2}$$

Where,

Oxygen transfer efficiency = 5 per cent

Density of air = 1.2

Oxygen fraction of air = 0.23

Types of media

- Random media
- Rigid media

Surface area for random packing is about 200-250 M<sup>2</sup>/M<sup>3</sup>.

Recommend Max. Irrigation rate	5 M <sup>3</sup> /M <sup>3</sup> /H
Air pressure drop	0.2mm Wg/m pack depth
Minimum packed depth	Around 1.4M
Maximum suspended solids allowed	500mg/l
Freeboard	1M
Power consumed in biofilter	0.15 KWH/KgBOD removed
Max. height of a natural draft biofilter	10.5M

The designing of biofilter depends upon the packing to be used. Each packing has its own performance characteristics and hence the biofilter performance depends upon the packing used.

### Dissolved air flotation

Flotation systems can be used to treat most effluents especially those containing suspended solids, metal hydroxides, proteinous material (particulate or dissolved), fat or oil. Each system is designed to meet the specific requirements of the particular operation. The design of a specific system depends upon the factors such as the volume of wastewater to be treated the degree and nature of contamination, the extent of treatment required, and any subsequent treatment that is required for the recovered product concentrate.

### Basis of flotation

If the gas bubble is attached to a particle of suspended matter, a composite particle is created which is lighter than water and will therefore float to the surface. Therefore, it becomes essential that all the suspended particles should be attached to gas bubbles so that they all float out of the bulk liquid.

Introduction of bubbles depends largely on the mass of gas introduced. But the mass as such is not important in this application. We are interested in the number of bubbles in order to get the largest possible number of them for a given mass of gas. Small bubbles have the additional advantage that their terminal velocity is small.

In dissolved air flotation (DAF), air is fed into the sludge flow under pressure resulting in a large amount of air dissolved in the flow. Air either adheres to or is absorbed by the solid particles when the sludge flow enters the DAF tank at atmospheric pressure, the air is released from solution as small air bubbles, attached to the solid particles and floats to the surface. The sludge forms a layer at the top of the tank and is removed by a skimmer to further sludge processing.

The method used is recycle pressurisation. Part of effluent flow is pumped to a retention tank under pressure (5 to 7 bar). Air is fed into high pressure retention tank at a controlled rate. The recycle flow becomes supersaturated with air which is then mixed into flotation tank. Sludge solids are floated to the surface to form a sludge blanket and the clarified effluent is drawn-off roughly halfway up the tank depth using a sparge pipe spanning the full width of the tank. Thickened sludge is removed by a skimmer.

The actual amount of air dissolved is determined by four basic variables, pressure in the system, temp of the liquid in the system, gas composite at the air liquid interface in the pressurisation vessel and the method used to dissolve air in the system.

Equipment consists of:

- DAF float tank

- Air saturation system
- DAF recycle pump (for recycle pressurisation system)
- Air compressor or source of high pressure air
- Rapid mix and/or flocculator tanks that are separate or part of the DAF tanks.

## Design procedure

### Design parameters

- Recycle ratio.
- Air consumption.
- Flotation unit.
- High pressure tank.

### Recycle ratio

15-20 per cent of inlet system. Pumps are mounted on skid. The discharge pressure from high pressure pumps 7 bar (depending upon friction losses). Pumps are high pressure open impeller centrifugal pumps.

### High pressure tank

High pressure tank works at a pressure of 6.5 to 7 bar. HRT: 4 Min.

### Flotation tank

Cross-sectional area. Upflow velocity 3.2 M/Hr. HRT: 30-60 Min. (20 Min. absolute minimum).

Air consumption	(Kgs/Hr/M2)		
	Old	Old + solids	solids
Solid loading	4.5-8.4	4.5-8.4	20-30
Air solid ration	0.03-0.6	0.15-0.4	0.03-0.08

(As a rough rule of thumb, air consumption may be assumed to be equal to 880 L/M3 recycle/hr at 6 bar minimum.

### Level tank

10 per cent of volume of flotation tank.

### Typical removal efficiencies

BOD 20-70 per cent

COD	10-60 per cent
TSS	50-85 per cent
Oil	70-95 per cent

### Skimming units

Mounted to scrape surface of flotation tank. A bottom mounted scraper may also be fitted to clean the floor of the flotation tank. (If the specific gravity of the particular is greater than 1.2). Scrapers are normally controlled by On/off timers. These times should be adjusted to give the maximum solids content of the sludge i.e. increase off time to allow solids to increase. This is very important when dewatering/thickening activated sludge.

### Feed pumps

Progressive cavity pumps provide constant volumetric flow rate regardless of fluctuations in suction head. This advantage helps to maintain a constant level in the flotation tank.

The volumetric flow rates of centrifugal pumps vary with suction heads. Hence it is very difficult to determine the optimum height of the outflow, bellmouth, control to achieve the correct operational level for the flotation tank. In this situation some PID level controller may be required.

### Sludge pumps

Sludge pumps should also be positive displacement and be controlled by level switches in the sludge hopper if appropriate.

## References

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