Color removal technologies

Lecture 20
Biotech approaches

➢ Decolorization is achievable using one or combination of the following methods:
  Adsorption, Filtration, Precipitation, Chemical degradation, Photo degradation and biodegradation.

➢ Majority of the color removal techniques work either by concentrating the color into sludge, or by partial breakdown or complete breakdown of color molecule.

➢ Synthetic dyes, such as azo dyes, are resistant to microbial degradation under the aerobic conditions, because dyestuffs are designed to be resistant to chemical fading and light induced oxidative fading.

➢ Some other water soluble reactive dye treatment systems based upon aerobic and anaerobic bacterial action are used to treat textile industry waste water.

➢ Other factors involved in reducing the biodegradation of dyes include high water solubility and high molecular weight, which inhibit permeation through biological cell membrane.
Basic dyes are removed from wastewaters by adsorption on to activated sludge.

Acid dyes and reactive dyes, however, exhibit low adsorption values and thus pass through activated sludge processes unaffected.

Aerobic systems fail to remove many dyestuffs and may be subject to mechanical breakdown, expensive capital and running costs, susceptibility to shock loading, occupation of large areas of land and production of large quantity of sludge.

While anaerobic processes which convert organic contamination into methane and carbon dioxide, require less space, treat wastes containing up to 30000mg/l of COD, have lower running costs and produce less sludge.

Biotechnological solutions offer almost complete destruction of the dyestuff, with a co-reduction in biological oxygen demand (BOD) and chemical oxygen demand (COD) in a very less space.
The technology for simultaneous removal of colour, organic substances and heavy metal pollutants from textile dye wastewaters consists of three basic steps:

1. Hydrophobic precipitation of ionic dyes by proprietary surfactants I polymers,
2. Self-association to form large size aggregates and,
3. Separation of the dye aggregates from solution by filtration/floatation.

The mechanism underlying this process is based on chemical reaction, charger neutralization, and hydrophobic coagulation.

Metal contaminants in textile dyeing effluent, which are present in complex form, cannot be removed by conventional precipitation and/or reduction methods.

This process has following advantages over conventional treatment methods:

1. More cost effective
2. Much shorter retention time
3. Operative at high temperatures
4. No sludge disposal problems
5. High quality water
Comparison of Conventional Treatment Processes

- In the ozonation, the limiting factor in rate is the interface between gas and liquid and that a packed column gives more efficient use of ozone. There is a stoichiometric relationship between the amount of ozone and dye consumed.

- Oxidation with peroxide and UV causes removal of colour, which increased proportionally with the UV intensity and concentration of peroxide.

- Microfiltration removes much smaller molecules (including electrolyte).

- Electrochemical colour removal from waste water occurs by a combination of adsorption and chemical reduction.
Continuous ozonation process

- This treatment is conducted in packed columns to continuously ozonate reactive dyes in spent dye bath water by using double packed columns each having 2.8 L capacity (excluding packing). Both ceramic and glass rasching ring packed columns may be used. Colour removal and efficiency of ozone utilization improves with column packing due to improved contact.

- The colour removal increases as dwell time increases. Change in pH from 2 to 11 or temperature changes from 25 to 50°C had minimal effect on dye decolouration with ozone. Maximum efficiency of ozone treatment is achieved by contracting the ozone enriched gas stream with the most concentrated dye solution.

Ozonation of spent reactive dye bath water

- The decolouration treatment is conducted using a single packed column of 2.8 L capacity at a flow rate of 160 ml/min, which gave a dwell time of 17.5 min. in the column. The ozone flow is kept 9g/hr at 1.1% concentration in oxygen. Colour removal from 70 to 99% is obtained depending on the depth of shade dyed.

- The pH decreased during ozonation and addition of caustic soda was needed as catalyst for subsequent dyeing.
Ultraviolet light and hydrogen peroxide treatment

- Preliminary UV /Peroxide treatments made in a batch reactor. The reactor consists of a two litre graduated cylinder in which is immersed a quartz tube holding the 32 inch low intensity UV lamp. The lamp produced radiation at wave length range of 189-254 nano-meters of which 90% is at 254nm. Samples of dye solutions are checked periodically using a spectrometer for estimating the rate of decolourization.

- A Typical Example: Water soluble dyes, such as direct, acid and reactive dyes, where normally the spent dye bath has higher amounts of colour present have been studied for the effect of pH using 0.02g/l Direct Blue 25 and 0.5g/l hydrogen peroxide (50%). Maximum rate of colour removal is achieved when dye concentration is 0.05g/L at a peroxide concentration of 3.0g/l. Optimum. peroxide concentration is 3.0g/l at the highest dye concentration of 0.3g/l of Reactive Blue 21 dye.

- In case of water insoluble disperse dyes the rate of decolourization is slow. For Disperse Orange 3 an azo dye, 80% decolourization is obtained in one hour at 0.02g/l dye concentration and 0.5g/L peroxide with 9 watts per litre UV radiation.

- For Disperse Red 60, an anthraquinone dye, only 5% colour removal is obtained in the same period.

- The rate was three orders of magnitude lower for water insoluble dyes. This is much below the results achieved by biotechnological treatment.
Anaerobic-aerobic treatment processes

Azo-dye Degradation

- Decolourization of azo dye during biological effluent treatment can involve both adsorption to cell biomass and degradation by azo bond reduction during anaerobic digestion. Degradation forms aromatic amines, which may be toxic and recalcitrant to anaerobic treatment but degradable aerobically. Methods for quantitative detection of substituted aromatic amines arising from azo-dye cleavage complex.

- A simple qualitative method based on High Performance Liquid Chromatography /Ultra-Violet (HPLC/UV) techniques is used to investigate degradation, and whether the amines generated are successfully removed by aerobic treatment.

- Anaerobic treatment gave significant decolourization, and respiration-inhibition tests showed that the anaerobic effluent had an increased toxicity, due to azo-dye degradation. Polar, UV absorbing compounds generated are removed or converted to highly polar compounds aerobically.

Anaerobic Digestion

- Reactive dyes are difficult to remove from textile waste water due to their solubility and they pass through conventional aerobic biological effluent treatment systems and enter the receiving water body. Reactive dye bath effluent is discharged into a primary digester containing sludge.
The overflow is monitored for colour, sodium and sulphide concentrations. Reactive dyes are capable of forming covalent bonds between the dye molecule and the fibre. 10-50% of the initial dye load will be present in the dye bath effluent, giving rise to highly coloured effluent.

The target compound (azo dye) is not biodegradable by the microorganisms. Instead this dye acts as an oxidising agent for the reduced flavin nucleotides of the microbial electron transport chain and is reduced and decolourized concurrently. Therefore, a source of reduction resulting from the degradation of a suitable carbon source, is essential to ensure decolourization and maintain the anaerobic population.

The carbon source requirement was fulfilled by glucose in the laboratory systems; however, for large scale applications, primary and secondary sludge are the carbon sources for anaerobic digestion. The carbon is converted to methane and carbon dioxide, during which process electrons are released. The electrons react with the dye by reducing the azo bonds and thus causing decolourization.

**Anaerobic Digestors:** There are four primary anaerobic digesters and four secondary digesters, each having a volume of approximately 1.34 Ml. The primary digesters are heated to about 37°C and have a sludge residence time of between 25 and 30 days. The secondary digesters are not heated and have a much longer residence time.
Graft Copolymer of Moringa seeds with Acrylamide using for the treatment of dye effluent

- The grafted copolymer was tested for its efficiency for metal removal (Cr-VI) from tannery effluent and for color removal from textile effluent using standard spectroscopic methods.
- The efficiency of color removal was found to be 89% in just 15 min. Similar results were obtained for efficient metal removal from Textile effluents.
- The prepared graft polymers could be used also to remove color from Dye effluents. 89.09% of the color was removed in 4 hours from the dyes present in industrial effluents.
- Desorption studies were conducted to restore the biomass as a function of concentration of different desorption reagents.
- Table shows Color removal efficiency

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<th>S.N.</th>
<th>Type of Treatment</th>
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