

**REVIEW OF LITERATURE**

## 2. REVIEW OF LITERATURE

### 2.1 Water treatment

Water treatment process is used to remove the contaminants present in the water and so the water becomes fit for its desired use ([http://en.wikipedia.org/wiki/water\\_treatment](http://en.wikipedia.org/wiki/water_treatment)). Various methods have been used for the removal of dyes from wastewater. These include Flocculation, Coagulation, Ion- exchange, Sedimentation, Membrane filtration and Adsorption etc...

The treatment processes are generally divided into three types. They are

- ◆ Primary treatment process
- ◆ Secondary treatment process
- ◆ Tertiary treatment process

#### 2.1.1 Primary treatment process

Primary treatment is the first stage, in which the substances that are easy to take out of wastewater are removed. These include oils, grease, rocks, grit and trash ([http:// zero carbon house. eu/ types- of- wastewater treatment- plants- j116\\_ en.html](http://zero carbon house. eu/ types- of- wastewater treatment- plants- j116_ en.html)). The remaining liquids are subjected to Secondary treatment process.

#### 2.1.2 Secondary treatment process

Secondary treatment process removes the dissolved and suspended biological matter ([http:// en.wikipedia. org/ wiki/ sewage\\_ treatment](http:// en.wikipedia. org/ wiki/ sewage_ treatment)).

#### 2.1.3 Tertiary treatment process

Tertiary treatment improves the water quality before putting the water back into the environment. This process involves the use of construction of a lagoon or artificial wetland with reeds. In this process the excess of nitrogen and phosphorus are removed ([http:// zero carbon house.eu/ types- of- wastewater treatment- plants- j116\\_ en.html](http:// zero carbon house.eu/ types- of- wastewater treatment- plants- j116_ en.html)).

#### Coagulation

Coagulation removes dirt and other particles suspended in water. This process involves the addition of the chemical substance called alum which produces positive

charges to neutralize the negative charges on the particles. Then the particles can stick together, forming larger particles which can be more easily removed (<http://techalive.mtu.edu/meec/module03/WastewaterRegulations.html>).

### **Flocculation**

Flocculation is a process of contact and adhesion whereby the particles of dispersion form larger-size clusters (<http://en.wikipedia.org/wiki/Flocculation>).

### **Sedimentation**

Sedimentation is a physical water treatment process using gravity to remove the suspended solids from water ([http://en.wikipedia.org/wiki/Sedimentation\\_water\\_treatment](http://en.wikipedia.org/wiki/Sedimentation_water_treatment)).

### **Electrodialysis**

Electrodialysis process involves the removal of contaminants from water by using an electric current to pull ionic impurities through ion selective membranes and away from the purified water. This process release H<sub>2</sub> gas which is potentially dangerous and liberates caustic soda (<http://www.apswater.com/page46.html>).

### **Reverse osmosis**

Reverse osmosis is a water treatment process which forces water through an extremely fine membrane to remove the dissolved minerals. Purified water then passes through the membrane and gets collected in a storage container. This process is used to provide small amount of high quality water for drinking, automatic humidifiers and watering plants ([http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex5432](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex5432)).

### **Ion- exchange method**

Ion- exchange method is used to denote the processes of purification, separation and decontamination of an aqueous and other ion containing solutions with solid polymeric or mineralic 'ion exchangers'. Ion exchangers are either cation exchangers that exchange positively charged ions (cations) or anion exchangers that exchange negatively charged ions (anions). ([http://en.wikipedia.org/wiki/Ion\\_exchange](http://en.wikipedia.org/wiki/Ion_exchange)).

### **Adsorption**

Adsorption method is the most widely used technique for the removal of dyes from industrial effluents. For this method, commercially activated carbon is used because

of its excellent adsorption capacity. But, due to its high cost many researchers have focused on the development of low- cost adsorbent for the dye removal

♣ **Kishor Sarkar *et al.*, (2012)**, prepared a cross- linked O- Carboxymethyl Chitosan (OCMCTS) with various degree of substitution for the removal of Crystal Violet (CV) dye from an aqueous solution. The experimental data obtained fitted well to Langmuir adsorption isotherm rather than Freundlich adsorption isotherm which indicate the monolayer formation of CV dye onto OCMCTS during adsorption process.

♣ **Nazari Moghaddam *et al.*, (2009)**, used a solid adsorbent prepared from Fly ash, Clay and Sand in the proportion of 50, 25 and 25 % respectively to remove Methylene Blue dye from an aqueous solution. From the results obtained, it was found that the adsorption efficiency increases with decrease in flow rate.

♣ **Satish Patil *et al.*, (2011)**, studied the Crystal Violet (CV) dye adsorption onto different natural materials (Mangrove plant leaf powder, Mangrove plant fruit powder, Mango leaf powder, Tamarind fruit shell powder, teak tree bark powder and Almond tree bark powder) by batch experiments The calculated  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  values showed favorable, spontaneous, endothermic physical adsorption with increased disorder and randomness at the solid- solution interface of CV dye with the adsorbents used in this study.

♣ **Sunil Kumar and Arti Jain (2010)**, used the low- cost adsorbent, spent tea leaves (STL) for the removal of Crystal Violet (CV) dye from an aqueous solution. The adsorption capacity of dye was found to increase with the increase of pH and temperature.

♣ The Sorption of cationic dyes Crystal Violet (CV), Malachite Green (MG) and Rhodamine B (RB) onto Cobs- carbon was studied by **Yakout and Ali (2011)**. The parameters studied were contact time and pH. Among Langmuir and Freundlich adsorption isotherms, the former adsorption isotherm fitted well.

♣ **Prasad Sudamalla *et al.*, (2012)**, studied the adsorption capacity of adsorbent prepared from Mango seed on removing the Crystal Violet dye from an aqueous solution. The adsorbent has the removal efficiency of 89% when the temperature, pH,

initial concentration and adsorbent dosage were 40<sup>0</sup> C, 6.00, 50 mg/L and 0.075g respectively.

♠ **Bellir Karima *et al.*, (2010)**, used a naturally present and abundant clay adsorbent namely Bentonite for the removal of Methylene Blue dye from an aqueous solution. Batch experiments were conducted by varying the parameters such as initial dye concentration, initial pH, adsorbent dosage and contact time.

♠ **Rammel *et al.*, (2011)**, used soft water algae, *Chaetophora elegans* to remove the organic pollutants and a Crystal Violet (Cationic dye) from an aqueous solution. It has been found that the sorption process depends on contact time, pH, adsorbent dosage, the salinity and initial dye concentration. The calculated  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  values indicate that the adsorption process were spontaneous, endothermic and more randomness.

♠ **Ahsan Habib *et al.*, (2006)**, used a low- cost adsorbent, Tuberoses sticks for the removal of Methylene blue dye from an aqueous solution at 25<sup>0</sup> C by varying the parameters such as contact time, initial dye concentration, pH and adsorbent dosage. The maximum removal of dye (80%) was obtained at 30 minutes contact time.

♠ **Yue- Ming Chen *et al.*, (2011)**, reported that the low- cost soil Nano- Clays (particle size < 100 nm) have the efficiency to remove two different toxic cationic dyes, Crystal Violet (CV) and Methylene Blue (MB) from an aqueous solution. It was concluded that the soil Nano- Clays have the adsorption capacity of about two to three times higher than that of soil Clays having particle size 2000 nm.

♠ **Verma and Mishra (2010)**, carried out the kinetic and adsorption isotherm studies of adsorption of Crystal Violet, Direct Orange and Magenta dyes onto rice husk activated carbon. The adsorption of dyes have been best described by Pseudo first order rate equation and Freundlich adsorption isotherm. Thus, rice husk carbon has an ability to adsorb the dyestuffs from an aqueous solution.

♠ The removal of Methylene Blue (MB) and Crystal Violet (CV) dyes by adsorption using Sugarcane stalk adsorbent was reported by **Gamal El-Sayed *et al.*, (2011)**. The removal efficiency of both dyes were found to be effective at pH 9 and when the temperature gets increased from 25 to 55<sup>0</sup> C, the amount of MB and CV dye adsorbed increased from 18 to 24% and 27 to 48% respectively.

♣ **Saeedeh Hashemian (2011)**, studied the adsorption of Methylene Blue dye using rice bran activated carbon and  $\text{CuFe}_2\text{O}_4$ / rice bran. The maximum adsorption of dye was attained within 60 minutes of contact time. The adsorption isothermal data could be well interpreted by the Langmuir adsorption isotherm model.

♣ The three cationic dyes Crystal Violet (CV), Methylene Blue (MB) and Malachite Green (MG) were removed from an aqueous solution in single and tertiary systems using bottom ash adsorbent was reported by **Gandhimathi et al., (2012)**. It was found that the adsorption capacity gets increased in the order of  $\text{MB} < \text{MG} < \text{CV}$  and  $\text{MB} < \text{CV} < \text{MG}$  for single and tertiary system respectively. Pseudo second order rate equation fitted better than Pseudo first order rate equation.

♣ Hydrolyzed oak sawdust composite (HOSDC) was used as a low- cost adsorbent to remove Methylene Blue dye from an aqueous solution by **Abd El-Latif et al., (2010)**. The thermodynamic parameters such as standard Gibbs free energy ( $\Delta G^0$ ), standard enthalpy ( $\Delta H^0$ ), standard entropy ( $\Delta G^0$ ) and activation energy ( $E_a$ ) calculated showed that the adsorption process was spontaneous and endothermic in nature.

♣ **Semra Coruh et al., (2012)**, studied the adsorption capacity of Fly ash adsorbent for the removal of Crystal Violet dye from an aqueous solution. At pH 9.0, the removal efficiency of adsorbent was found to be 98.20%. Thus, the fly ash can be used as an alternative adsorbent material for the removal of CV dye from wastewaters.

♣ **Jayaraj et al., (2012)**, carried out the adsorption of three dyes namely Crystal Violet, Methylene Blue and Malachite Green using Chlor- alkali waste adsorbent. The adsorption followed Pseudo second order kinetics and data fits the Langmuir and Freundlich adsorption isotherms.

♣ **Meenakshi Sundaram and Shahul Hameed (2012)**, carried out the adsorption of Crystal Violet dye onto commercial activated carbon and activated carbon prepared from *Syzygium cumini* seed. The extent of dye removal increased with decrease in the initial concentration of the dye and increased with increase in contact time, amount of adsorbent used and the initial pH of the dye solution.

♣ Batch adsorption studies were carried out for the removal of Methylene Blue, a cationic dye from an aqueous solution using Sawdust (SD) and Sawdust coated with

Polypyrrole (PPy/SD) as adsorbents by varying the pH from 2 to 12. Increase in pH of dye solution increases the extent of dye removal (**Ansari and Mosayebzadeh, 2010**).

♠ **Nidheesh *et al.*, (2012)**, studied the adsorption kinetic behavior of Crystal Violet dye from an aqueous solution onto bottom ash adsorbent. It was found that the adsorption efficiency of bottom ash decreased from 89.85 to 23.1% as the particle size of adsorbent increased from < 75 to 300- 600  $\mu\text{m}$ .

♠ **Narayana Saibaba *et al.*, (2011)**, used waste prawn shell as an adsorbent for the removal of Crystal Violet dye from an aqueous solution. The adsorption efficiency of adsorbent for the dye removal was found to be 92% when the optimum temperature, pH, contact time, adsorbent dosage and initial dye concentration were 20<sup>0</sup> C, 12, 90 min, 0.41 g and 53 ppm respectively.

♠ The adsorptive removal of Crystal Violet dye from an aqueous solution using cocoa shell adsorbent was studied by **Theivarasu *et al.*, (2011)**. Langmuir, Freundlich, Temkin and Dubinin- Radushkevitch (DR) adsorption isotherms were studied. Among these, Langmuir adsorption isotherm was best fitted than other adsorption isotherms.

♠ The adsorption of Crystal Violet dye from an aqueous solution using activated carbon obtained from Golbasi lignite was carried out by **Tolga Depci *et al.*, (2012)**. Langmuir adsorption isotherm fitted well and the adsorption followed Pseudo second order rate equation. The calculated  $\Delta G$  and  $\Delta H$  value indicates that the adsorption process was thermodynamically favoured.

♠ Bio- adsorption of Crystal Violet dye onto sugarcane baggase adsorbent was studied by **Mahesh *et al.*, (2010)**. It was found that the raw baggase adsorbent act as a more efficient adsorbent than chemically activated baggase adsorbent for the dye removal from an aqueous solution.

♠ The adsorption kinetics and equilibrium isotherm studies of Crystal Violet dye on chitosan adsorbent was studied by **Mona Shouman *et al.*, (2012)**. Pseudo second order rate equation and Langmuir adsorption isotherm followed well and based on Dubinin-Radushkevitch adsorption isotherm it was suggested that the adsorption process was Chemisorption.

♣ Removal of Methylene Blue dye from an aqueous solution by adsorption onto Semi-interpenetrating hydrogel composed of poly (acrylamide-co-acrylic acid) and polyvinyl alcohol was studied by **Zendehdel *et al.*, (2010)**. It was found that hydrogel composite has removed 95% of Methylene blue dye from wastewater and do not release any harmful materials into water.

♣ **Papita Das *et al.*, (2012)**, used chemically treated rice husk (CTRH) adsorbent for the removal of Crystal Violet (CV) dye from aqueous systems. The removal efficiency of the adsorbent was found to be 98.85% at pH 8, when the adsorbent dosage used was 5g and at the agitation speed of 150 rpm. Thus, CTRH can be used as an effective biosorbent for the removal of CV dye.

♣ **Tahir *et al.*, (2008)**, used bio- adsorbents such as *Ulva lactuca* and *Sargassum* (Maine algae) for Methylene Blue dye removal from effluents by batch adsorption method. Almost 96% removal of dye was achieved using such bio- adsorbents. Temperature study was carried out in the range of 303 to 318 K and it was found that percentage removal of dye from an aqueous solution decreases with rise in temperature.

♣ Studies on the removal of dyes like Reactive Orange 16, Reactive Violet 5, Methylene Blue and Crystal Violet from the industrial effluents using hydrolyzed polyacrylonitrile textile fiber (HPAN) sorbent was carried out by **Suteu *et al.*, (2009)**. The experimental results showed that HPAN can be used as a better sorbent for dyes removal from an aqueous solution.

♣ The adsorption of Crystal Violet and Rhodamine B dyes from an aqueous solution onto activated carbon obtained from *Phragmites australis* (Common Reed) was studied by **Shouman and Rashwan (2012)**. Batch experiments were conducted by varying the parameters like temperature, pH, contact time and adsorbent dose.

♣ A comparative study between commercially activated carbon and a low- cost adsorbent, Water Hyacinth for the removal of Methylene Blue dye from industrial effluent was carried out by **Sachin Kanawade and Gaikwad (2011)**. From the results, it was found that the adsorption of Methylene Blue dye onto commercial activated carbon follows both Langmuir and Freundlich adsorption isotherms whereas the activated carbon prepared from water hyacinth followed Langmuir adsorption isotherm.

♠ **Prasad and Santhi (2012)**, used *Acacia nilotica* leaves as an adsorbent for the removal of dyes Crystal Violet and Rhodamine B from an aqueous solution. The removal efficiency increased with increase in agitation time. Thus, the eco- friendly adsorbent was expected to be economically feasible for the removal of Crystal Violet and Rhodamine B dyes from an aqueous solution.

♠ **Velmurugan *et al.*, (2011)**, used Orange peel, Banana peel and Neem leaves as adsorbents for the removal of Methylene Blue dye from an aqueous solution. Among these adsorbents, the adsorption capacity of Orange peel was found to be more effective compared to other low- cost adsorbents.

♠ Removal of dyes like Methyl Orange and Methylene Blue from wastewater using Sawdust and Sawdust- fly ash as sorbents was studied by **Dora Lucaci and Anca Duta (2011)**. Freundlich adsorption isotherm was the best fitted isotherm in this study.

♠ **Nagarethinam Kannan and Mariappan Meenakshi Sundaram (2001)**, carried out a comparative study between Commercial Activated Carbon and activated carbons obtained from Bamboo dust, Coconut shell, Groundnut shell, Rice husk and Straw for the removal of Methylene Blue dye from an aqueous solution. The adsorption kinetics was found to be first order with respect to intra- particle diffusion rate equation.

♠ Removal of Crystal Violet dye from an aqueous solution using *Gmelina arborea* bark adsorbent was studied by **Angelie Jover *et al.*, (2012)**. The thermodynamic parameters such as enthalpy and free energy values were negative suggesting the adsorption process were exothermic and spontaneous.

♠ **Ma *et al.*, (2004)**, used a bimetallic system of iron and copper, (Fe/Cu system) to decolourize Methylene Blue dye from an aqueous solution and the coloured wastewater from a plant. The Fe/Cu system effectively removed the colour of both Methylene Blue and the coloured wastewater from effluent of the wastewater treatment plant with maximum colour removal efficiencies of 98 and 88 % respectively, in batch test.

♠ **Sarioglu and Atay (2006)**, reported that biosolid (waste sludge) can be used as an adsorbent for the removal of Methylene Blue dye from wastewater. Batch adsorption studies were carried out by varying the parameters such as pH ranging from 3 to 11,

biosolid dosage, initial dye concentration and contact time. The adsorption process was found to be slightly endothermic in nature.

♣ A natural clay material, Ghassoul was used as a low- cost adsorbent to remove Methylene Blue dye from wastewater by **Elass *et al.*, (2010)**. The contact time required for maximum removal of dye was found to be 90 minutes.

♣ **Farooqui *et al.*, (2012)**, studied the adsorption of Crystal Violet dye onto low- cost adsorbent materials namely Cassia siamea, Albizia labbeck, Nerium indicum, Duranta erecta and Potato husk by varying the parameters such as initial dye concentration, pH, adsorbent dosage, temperature, contact time and ionic strength. The thermodynamic parameters  $\Delta G$  and  $\Delta H$  values obtained in this study at different temperatures were negative indicates that the adsorption process were spontaneous and exothermic.

♣ **Ehrampoush *et al.*, (2011)**, used  $\text{TiO}_2$  nano- particles as an adsorbent for the removal of Methylene Blue dye from textile synthetic wastewater. The results revealed that  $\text{TiO}_2$  can be used as an effective adsorbent to remove colour and dyes from wastewater.

♣ **Raghuvanshi *et al.*, (2004)**, used sugarcane by- product, the baggase as an adsorbent to remove Methylene Blue dye from an aqueous solution. It was found that chemically activated baggase was more effective in removing the dye from wastewater compared to that of raw baggase.

♣ Removal of dyes such as Methylene Blue and Methyl Orange from wastewater using an activated carbon prepared from coconut shell fibers were carried out by **Kunwar Singh *et al.*, (2003)**. It has been found that Methylene Blue dye adsorption onto activated carbon takes place through a film diffusion mechanism at lower and higher concentrations, while Methyl Orange dye adsorption occurs through particle diffusion at higher concentrations and through film diffusion at lower concentrations.

♣ A comparative study between Raw Pummelo Peel (RPP) and sodium hydroxide treated Pummelo Peel (TPP) were conducted to remove Methylene Blue (MB) dye from an aqueous solution by **Changwei Hu *et al.*, (2009)**. The Langmuir adsorption isotherm fitted well for both the adsorbents RPP and TPP. Thus, it was concluded that Pummelo Peel pretreated with 0.1 M NaOH has better potential than RPP and thus TPP can be used as a low- cost adsorbent for the removal of MB dye from an aqueous solution.