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PHOTOCATALYTIC TREATMENT OF SOME DYES SOLUTIONS AND IT'S INFLUENCE ON THE GROWTH OF *ALLIUM CEPA* (ONION)

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ABSTRACT

Photocatalytic degradation of some dyes was investigated in the presence of ZnO as semiconductor. The effect of various parameters like pH, concentration of ZnO and concentration of dyes were standardized in terms of minimum time required for bleaching of coloured solutions. The growth of plant like *Allium Cepa* was studied under such photocatalytic conditions. The influence of this photocatalytic treated water on the biochemical parameters like-Sugar, protein and chlorophyll contents were also observed.

Key words: Dye, Photocatalytic treatment, *Allium cepa*.

INTRODUCTION

Water, which is essential for life, is contaminated by chemical and microbiological contaminations, thus, poses a problem. Dyes are extensively used in the textile industries. These industries produce large volume of coloured dye effluents, which are toxic and non-biodegradable. Dyes create several environmental pollution problems by releasing toxic and potential carcinogenic substrates into the aqueous phase. Various chemical and physical processes such as precipitation, adsorption by activated carbon, reverse osmosis and ultra filtration can be used for colour removal from textile effluents. Each method has its advantages and disadvantages.

The photocatalytic bleaching was found to be the most promising and efficient process in dealing with environmental pollution, wastewater treatment, etc., in which the semiconductor particles act as photocatalysts or short-circuited micro-electrodes on excitation. This method involves the generation of hydroxyl radicals and use of these radicals as the primary oxidant for degrading organic pollutants.

The photocatalytic degradation of textile azo dye Sirius Gelb GC on TiO_2 or Ag-TiO_2 particles in the absence and presence of UV-irradiation effect has been reported by Ozkan et al.[1] Ameta et al.[2] reported photobleaching of basic blue 24 using photocatalyst and also studied the role of surfactant in this photobleaching reaction. Mu et al.[3] performed the photocatalytic degradation of orange II in presence of Mn^{2+}. Daneshwar et al.[4] conducted the photocatalytic degradation of azo dye acid red 14 in water on ZnO as

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an alternative catalyst to TiO_2. Maruthamuthu et al.[5] assessed the photocatalytic activity of Bi_2O_3, WO_3 and Fe_2O_3 selecting photodecomposition of peroxo monosulphate in visible radiations as the model. Ranjit et al.[6] used Fe_2O_3 and ZrO_2-Fe_2O_3 coupled photocatalys for photocatalytic reduction of nitrite and nitrate ions to ammonia. Baxi[7] has reported the photocatalytic oxidation of oxalic, malonic, succinic, glutaric and adipic acids over semiconducting iron (III) oxide powder. Use of semiconducting iron (III) oxide in photocatalytic bleaching of some dyes were studid by Ameta et al.[8] where as, photocatalytic degradation of methylene blue by CNT/TiO_2 composites prepared from MWCNT and titanium n-butoxide with benzene was observed by M.L. Chen et al.[9]

EXPERIMENTAL

Part-I : Photocatalytic bleaching of dye

Various dyes (acidic and basic) were used in the present investigation. All the solutions were prepared in doubly distilled water. The dye solution and ZnO as a semiconductor were mixed in a 100 mL beaker. Irradiation was carried out keeping the whole assembly exposed to the sunlight. The intensity of light was measured with the help of a solarimeter (SEM CEL 201). A water filter was used to cut out thermal radiations. The digital pH meter (Systronic Model 335) was used to measure the pH of the solution.

RESULTS AND DISCUSSION

The photocatalytic degradation of dyes were observed at respective λ_{max} shown in the Table. It was observed that the absorbance of the dye solutions in presence of semiconductor was much low as compared to sample without semiconductor at the same time intervals. It means that the rate of this photocatalytic degradation is favourably affected by zinc oxide in the case of this system.

Effect of pH

The pH of the solution is likely to affect the bleaching of the dye and hence, the effect of pH on the rate of bleaching of dye solutions was investigated in the pH range. The value of optimum pH, amount of semiconductor and appropriate wavelength for the photocatalytic bleaching of dyes-Methylene blue, Malachite green, Eosine yellow, Congo red and Nigrosine are 7.5, 0.020, 664 nm; 6.5, 0.015, 616 nm; 8.0, 0.010, 515 nm; 10.0, 0.020 g, 488 nm and 10.0, 0.020 g, 570 nm respectively.

It has been observed that the rate of photocatalytic bleaching of these dyes increase on increasing the pH in the alkaline range. This can be explained on the basis that as the pH of the medium is increased, there is a corresponding increase in the concentration of OH^- ions. These OH^- ions will adsorb on the surface of the semiconducting zinc oxide, making it negatively charged. Thus, there will be a coulombic attraction between semiconductor surface and cationic dyes. This results in an increase of rate of photobleaching of all the dye on increasing pH.

Effect of dye concentration

The effect of dye concentration was also observed by taking different concentrations of the dyes. The rate of photocatalytic bleaching of dyes was found to increase on increasing the concentration.

It may be due to the fact that as the concentration of dye was increased, more dye molecules were available for excitation and consecutive energy transfer. As a result, increase in the rate of bleaching was observed. The rate of photocatalytic bleaching was found to decrease with further increase in the concentration of the dyes, i.e. above their corresponding limits. This decrease may be attributed to the fact that the dye itself will start acting as a filter for the incident light. It will not permit the desired intensity of light to reach the semiconducting zinc oxide particles; thus, decreasing the rate of photocatalytic bleaching of the dyes.

Mechanism

On the basis of these observations, a tentative mechanism for photocatalytic bleaching of dyes may be proposed as – Dye absorbs radiations of suitable wavelength and is excited to its higher energy state.

$$\text{Dye} \xrightarrow{h\nu} \text{Dye}^*$$

$$\text{SC} \xrightarrow{h\nu} e^- (\text{CB}) + h^+ (\text{VB}) \text{ or } \text{SC}^*$$

$$h^+ + OH^- \longrightarrow OH^\bullet$$

$$\text{Dye}^* + {}^\bullet OH \longrightarrow \text{Leuco [Dye]}$$

$$\text{Leuco [Dye]} \longrightarrow \text{Products}$$

CONCLUSION

Photoinduced electron transfer reactions have attracted the attention of photo-chemists all over the world, because these reactions are capable of converting toxic compounds into non-toxic or less toxic materials. The photocatalytic bleaching of dye using low cost semi conducting powder like zinc oxide may open new avenues for the treatment of wastewater from dyeing, printing and textile industries. Not only this, the treated wastewater may also be used for cooling, cleaning, waste land irrigation, etc., which is not possible otherwise with coloured water. Time is not far-off, when photocatalytic route will be firm footed as a promising technology in wastewater treatment.

Part-II : Effect of Photocatalytically treated dye water on the growth of *Allium Cepa*

Effect of treated and untreated dye solutions on growth of *Allium Cepa* was observed and the effect on some biochemical parameters was also studied[10] and this was again supported by many workers[11] -Sugar, protein and chlorophyll contents were estimated by established methods. The obtained data are summarized in the following Table and comparative study of these is graphically repented in the following graphs.

Table 1. Growth Parameters under the Influence of Photocatalytically Treated Dye Water

S. No.	Dyes	Growth of Root (cm)	Growth of Shoot (cm)	% Sugar Root	% Sugar Shoot	% Protein Root	% Protein Shoot	Chlorophyll a (mg/g tissue)	Chlorophyll b (mg/g tissue)
1	Methylene blue	9.5	5.1	2.8	4.9	0.48	0.84	0.113	0.049
2	Malachite gree	10.0	8.9	2.9	5.0	0.54	0.83	0.065	0.060
3	Eosine yellow	10.0	9.1	2.2	4.3	0.40	0.65	0.190	0.080
4	Congo red	10.3	7.1	2.8	5.0	0.42	0.75	0.103	0.048
5	Nigrosine	10.7	7.8	2.5	4.9	0.45	0.79	0.110	0.054

Fig. 1: Picture showing the comparative growth of *Allium Cepa*

The graphical presentation for the comparative growth observed under photocatalytic condition are given below.

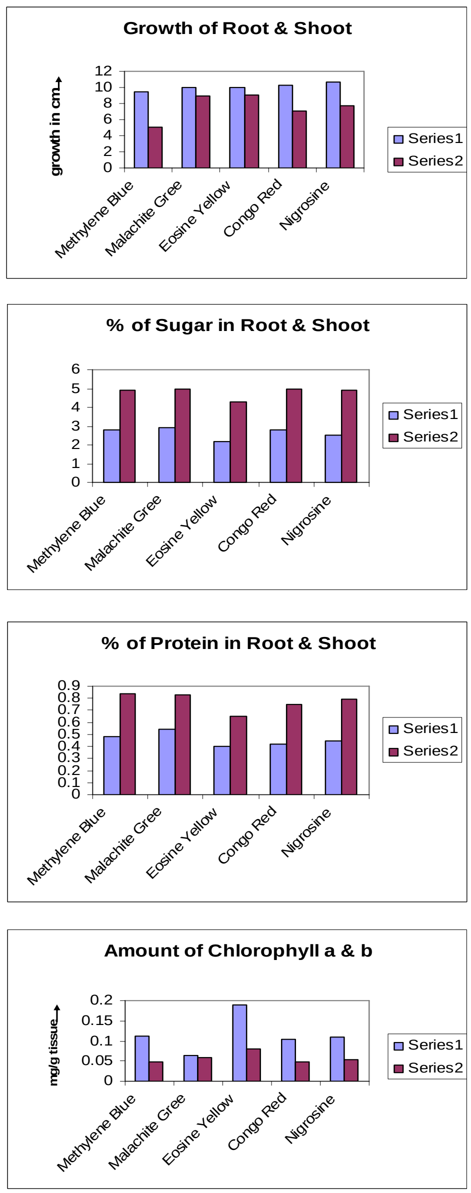

Fig. 2

It has been observed that there is a prominent difference in the growth of *Allium Cepa* grown in different treated and untreated dye solutions and normal water. There was no root or shoot growth in onion grown in dye solution for first few days and after four days, the bulb of onion starts deteriorating where as a prominent root and shoot emerged in onion grown in treated dye solution, these observations suggest that some toxic characteristics are there in dye solution, which inhibits the growth of *Allium cepa*. When this dye solution was bleached photocatalytically, it loses its toxic nature and this may give normal plant growth. It was also observed that the growth in treated dye solution was more as compared to the growth in normal water. This may be attributed to the fact that nitrogen content in the photocatalytically treated water is increased which supports the growth[12]. This is also supported by the work done by Mehta et al.[13-15]

Thus the effluent from dyeing industry should be treated before its disposal at outside the industrial area. The wastewaters from the dyeing industry will have an adverse effect on growth of *Allium cepa*, but if it is treated and then disposed off, it may restore the quality of water required for normal growth of the plants.

Fig. 3: The effect of treated and untreated dye water on the number of seed germination

CONCLUSION

It was observed that there was a prominent growth and increased sugar and protein percentage and chlorophyll content in onion grown in photocatalytically treated effluent. Based on the above results, photocatalytic treatment of wastewater can be considered as an effective method, which will help in reusing the effluent from dye industry for irrigation purposes.

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