PUBLISHED ON 29TH FEB 2012

A COMPARATIVE STUDY OF THE SEED GERMINATION OF *PHASEOLUS AUREUS* UNDER SOME PHOTOCATALYTIC CONDITIONS

MAYANK R. MEHTA[1], RUPAL P. PATWA [2], NOOPUR R. GOYAL [3] AND VIPUL P.PRAJAPATI [4]

[1&2] SHRI P.H.G.MUNI. ARTS AND SCIENCE COLLEGE, KALOL-382721 (GUJARAT), [3] M.G.SCIENCE INSTITUTE, AHEMDABAD-380009 (GUJARAT) & [4] SHETH M.N.SCIENCE COLLEGE, PATAN-384 265(GUJARAT), INDIA,

vipul_hely@yahoo.com

ABSTRACT:

Aqueous solutions of various dyes were treated photo catalytically using ZnO as semi conductor. Various parameters like pH, concentration of ZnO and concentration of dyes were standardized in terms of minimum time required for bleaching of coloured solutions. This treated dye water is used to grow pulses (*Phaseolus aureus*). The number of seeds of *math* germinated and time required for the same was also noted.

KEY WORDS: *Dye, Bean Germination, Photo Catalytic Bleaching.*

INTRODUCTION:

Water is one of the fundamental requirements of life and any undesired addition of chemical substances leads to its contamination and makes it unfit for human utility. Generally, various dyes found in industrial effluents, ultimately, enter the aquatic ecosystem and can create various environmental hazards. These have very adverse and sometimes irreversible effects on animals and plants. The main purpose of wastewater treatment is the removal of these toxic substances and colour and try to make the water usable for industrial or domestic use. Various methods like adsorption, osmosis, flocculation, etc. have been used traditionally to remove these dyes from the water bodies, but these methods have many disadvantages.

Semiconductor photocatalytic oxidation is a new modern water treatment technology. It has many advantages such as high efficiency, low energy-consumption, moderate condition, extensive applicability and decrease in secondary pollution. Zinc oxide is one of the most promising materials for optoelectronic application because of its wide band gap (3.37 eV) and large exciton binding energy (60 meV). It can be used as catalyst and photocatalyst under the ultraviolet radiation ($\lambda \leq 368$ nm) to resist bacteria, eliminate odor, disinfect, refine and protect the environment. Therefore, ZnO will play an important role in the treatment of contamination.

Nano-ZnO has been widely studied as catalyst. Especially in recent years, ZnO was used as effective, inexpensive, nontoxic semiconductor for the degradation of a wide range of organic chemicals [1–6]. Exhaustive researches in the field of photocatalysis have shown various fascinating applications of photocatalytic reactions based on the use of semiconductors. 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.*7 Ameta *et al.*8 reported photobleaching of basic blue 24using photocatalyst and also studied the role of surfactant in this photo bleaching reaction. Mu Y*et al.*9 performed the photo catalytic degradation of orange II in presence of Mn2+. Daneshwar *et al.*10 conducted the photocatalytic degradation of azo dye acid red 14 in water on ZnO as an alternative catalyst to TiO_2. Maruthamuthu *et al.*11 assessed the photo catalytic activity of Bi_2O_3, WO_3 and Fe_2O_3 selecting photodecomposition of peroxo mono sulphate in visible radiations as the model. Ranjit *et al.*12 used Fe_2O_3 and ZrO_2-Fe_2O_3 coupled photo catalyst for photo catalytic reduction of nitrite and nitrate ions to ammonia. Baxi13 has reported the photo catalytic oxidation of oxalic, malonic, succinic, glutaric and adipic acids over semiconducting iron (III) oxide powder. Use of semi conducting iron (III) oxide in photocatalytic bleaching of some dyes were studied by Ameta *et al.*[14]

Photo catalysis can prove to be very effective method to treat dyed water if the treated water can be reused. Looking to the scarcity of water several workers have reported its' use for irrigation as it can enhance plant growth[14, 18]. Several studies done to study impact of photocatalytically treated water on *Allium cepa* and other crops are cited in literature [15, 16].

MATERIALS USED:

The following chemicals used in the present work

No.	Dye	Specification
1	Brilliant Green	C.D.H.
2	Fuchsin Basic	B.D.H.
3	Fuchsin acidic	B.D.H.

4	Rose Bengal	Hi Media
5	Toluidin Blue	L.C.
6	Methylene Blue	Reidel
7	Malachite Green	S.D. Fine
8	Eosine Yellow	B.D.H.
9	Congo Red	S.D. Fine
10	Nigrosine	S.D. Fine

Experimental

Part-I Photo catalytic 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 solari meter (SM 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.

Part-II: Germination study

Healthy seeds of *Phaseolus aureus were* allowed to germinate in two Petri-dishes and lined with filter paper moistened with treated and untreated dye solutions at optimum conditions of light and temperature. The seeds were not allowed to dry and solutions were added periodically. The percent germination of seeds was observed every 24 hours. Number of germinated seeds was observed for untreated and treated dye solutions. Shoot length was measured in cm till 10 days.

RESULTS AND DISCUSSION:

Part-I Photo catalytic Bleaching of Dye

The photocatalytic degradation of dyes was 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 favorably 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 as shown into the table.

Table-1 Bleaching of Dyed water at different pH & Amount of Semiconductor

No.	Dye	Optimum pH	Amount of ZnO gm	λ max nm

1	Brilliant Green	7.2	0.010	611
2	Fuchsin Basic	9.0	0.020	544
3	Fuchsin acidic	10.0	0.030	522
4	Rose Bengal	10.1	0.030	544
5	Toluidin Blue	10.8	0.020	665
6	Methylene Blue	7.5	0.020	664
7	Malachite Green	6.5	0.015	616
8	Eosine Yellow	8.0	0.010	515
9	Congo Red	10.0	0.020	488
10	Nigrosine	10.0	0.020	570

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 semi conducting 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 photo bleaching 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 photo catalytic bleaching of dyes may be proposed as –

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

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

$$h^+ + OH^- \xrightarrow{h\nu} OH^*$$

$$Dye^* + {}^*OH \xrightarrow{h\nu} \text{Leuco [Dye]}$$

$$\text{Leuco [Dye]} \xrightarrow{h\nu} \text{Products}$$

Dye absorbs radiations of suitable wavelength and is excited to its higher energy state. The semiconducting zinc oxide utilizes the incident light energy to excite its electron from valence band to the conduction band, thus leaving behind a hole. This hole can abstract an electron from hydroxyl ions to generate hydroxyl radicals. These hydroxyl radicals will then oxidize the dye to its leuco form, which may ultimately degrade to products. The participation of *OH radical as an active oxidizing species was confirmed by using hydroxyl radical scavengers, where the rate of bleaching was drastically reduced.

Part-II: Germination study

As can be seen from the Table 2 treated solutions of all dyes gave better germination as compared to non treated dyed solutions. Methylene blue gave best results with total 10g of seeds germination followed by fuschin basic and nigrosine. Malachite green and brilliant green gave similar results with both treated and non treated solutions. Enhanced germination is mainly due to release of OH^- ions which in turn depends on molecular structure of the dyes [17].

Graph 1 shows the data for number of seeds germinated. Out of 20 seeds methylene blue resulted in germination of 11 seeds which was at par with normal water.

Graph 2 shows result of shoot growth measured as length in cm. as far as shoot length is concerned Nigrosine gave best result with an average of 6.58 cm of all the 7 seeds which germinated in treated solution. Toludine blue gave 6.02 cm of shoot length.

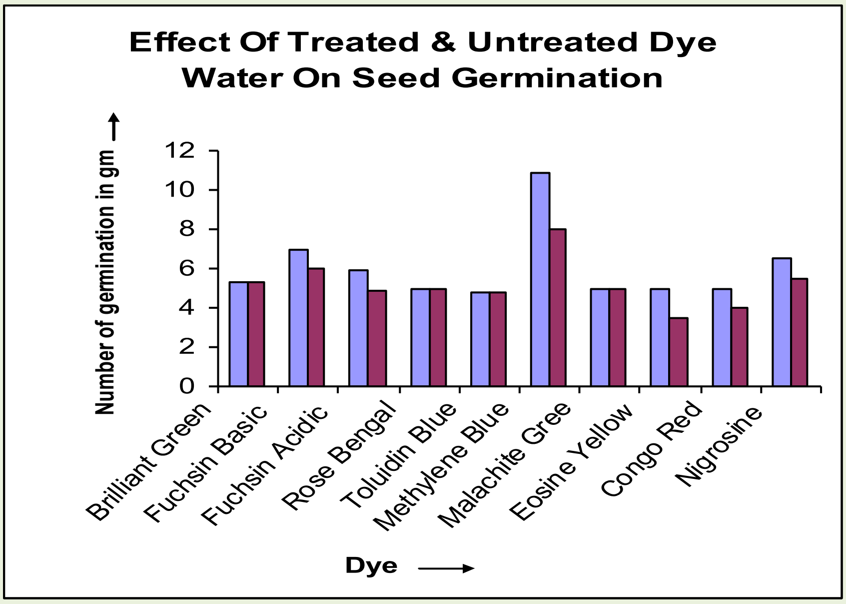
The data of table 2 and graph 2 are depicted in photograph 1

TABLE 2- SEED GERMINATION

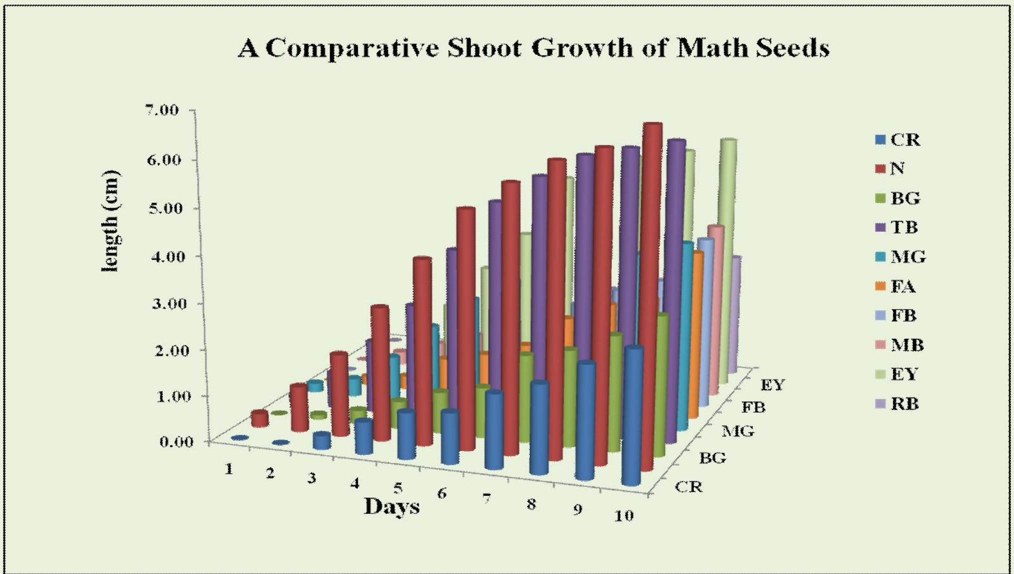
Dyes	Number of seed germinated	
	With treated dye solution (g)	With untreated dye solution (g)
Brilliant Green	5.3	5.3

Fuchsin Basic	7.0	6
Fuchsin Acidic	5.9	4.9
Rose Bengal	5.0	5.0
Toluidin Blue	4.8	4.8
Methylene Blue	10.9	8
Malachite Green	5.0	5.0
Eosine Yellow	5.0	3.5
Congo Red	5.0	4
Nigrosine	6.5	5.5

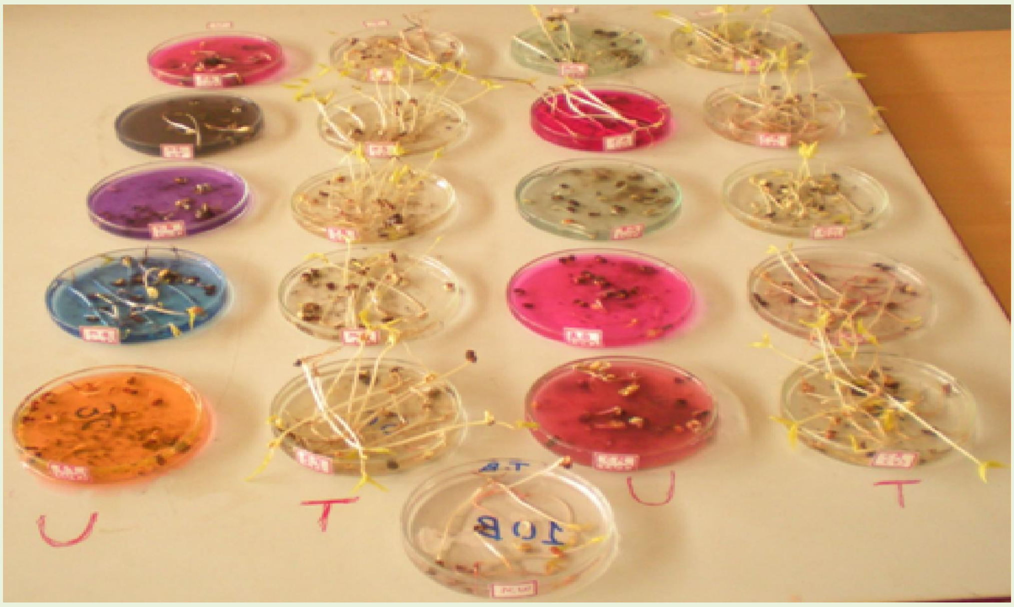
Graph 1- Comparison of Effect Treated and Untreated Dye water on Number of Seed Germination



Graph 2 A Comparative Shoot Growth of Math seeds



Photograph 1 Effect of treated and untreated dye water on the number Of seed germination



CONCLUSION:

Part-I Photo catalytic Bleaching of Dye

Photo induced 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 photo catalytic bleaching of dye using low cost semi conducting powder like zinc oxide may open new avenues for the treatment of waste water from dyeing, printing and textile industries. Not only this, the treated wastewater may be used for cooling, cleaning, waste land irrigation, etc., which is not possible otherwise with coloured water. Time is not far-off, when photo catalytic route will be firm footed as a promising technology in wastewater treatment.

Part-II: Germination study

- The photo catalytic bleaching of dye using low cost semi conducting powder like zinc oxide may open new avenues for the treatment of waste water from dyeing, printing and textile industries.
- The treated wastewater may be used for cooling, cleaning, waste land irrigation, etc., which is not possible otherwise with coloured water.
- Treated water resulted in increased growth of math seeds.

- Both weight and length of seeds were more in treated water as compared to natural water.

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