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RESEARCH ARTICLE

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# EFFECT OF ENZYME DOSAGE AND DEINKING EFFICIENCY OF RECYCLED PULP BY USING ENZYMATIC DEINKING METHOD

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**ABSTRACT**

The demand of paper has been continuously increasing at a pace much faster than the availability of fibers from the natural source. Recycling of waste paper, after its intendment use, has been found to be more economical and eco-friendly. Without recycling, the fiber supply from the world's natural sources shall not be sufficient to keep up with the demand. Recycling efficiency can be increased further by choosing Enzymatic de-inking technology. The reuse of the paper fiber is essentially independent on their proper processing and deinking. Only after the ink has been removed from the fibers, the fibers can once again be used to make a good paper.

The potential of using enzymes in deinking of wastepaper has been investigated and proven successful using xylanase enzymes. The scope of this work is to give economic and pollution control process with increased brightness of waste paper. The enzymatic deinking process reduces the amount of chemicals added it also reduces the BOD and COD in the waste water. The collected data predict well the general trend and its magnitude of the experimentally measured brightness, opacity, burst strength and burst factor. The increased enzyme dosages affect significantly the brightness.

**Keywords**: recycled pulp, Enzyme dosage, Enzymatic deinking,



## INTRODUCTION

The enzymatic deinking technology will be helpful for small scale industries to compete with the brightness of waste paper recycling in large scale industries. This method also improves the quality of the product in an effective manner.

This enzymatic deinking method will result in the minimal amount of BOD and COD content in the effluent water compared to conventional chemical deinking. The various advantages of enzymatic deinking methods include decreasing availability of conventional raw materials, lower energy requirements, decrease the average ink particle size and destroy fiber-toner concentration, improving ink removal effectiveness, improved technology for reuse of secondary fibers and to obtain better quality products.

J. Behin et al., studied the effect of alkyl chain in alcohol deinking of recycled fibers by flotation process. In which combination of chemical

and mechanical forces was done to remove the ink particles from the fibers. The mechanical force is usually supplied by a pulper where the paper is beaten into its constituent fibers. C.K. Lee et al. used the enzymatic deinking of laser printed office waste papers. The protocol for the enzymatic deinking of laser printed waste papers on a laboratory scale using cellulase (C) and hemicellulase (H) of Aspergillus niger (Amano) was developed as an effective method for paper recycling. A maximum deinking efficiency of almost 73% by the enzyme combination of C:H was obtained using the deinking conditions of pulping consistency of 1.0% (w/v) with the pulping time of 1.0 min, temperature of 50 °C, pH 3.5.

Avtar Singh et al. reported the paper entitled "An eco friendly cost effective enzymatic methodology for deinking of school waste paper" and provided the results with an enzyme dose of 15.0 IU xylanase and 3.0 IU pectinase per gram of pulp was sufficient for ink removal. Performance of enzymes at alkaline conditions showed their suitability for paper industries. Enzymatic plus chemical deinking approach decreased the requirement of chemicals to nearly 50%.This combined methodology resulted in decrease of 20.15% and 22.64% in BOD and COD of effluents. This deinking approach also improved the various physical properties.

In our study the raw materials used were the papers of Note book (NB), White record (WRD) NO.1 quality, Export quality. Map printing (MP), Map litho (ML), Cream wove (SCW) , White writing (WW) and White printing(WP) these are some of the industrial grade qualities in which we tried enzymatic Deinking method to increase the brightness of the paper in an economical manner.

**Materials and Methods**

From the literature survey, among the various methods of deinking process, the enzymatic deinking methods have been chosen because of their future scope in the improvement of brightness. A xylanase enzymes producing bacterial strain was purchased from (MTCC), Institute of Microbial Technology (IMTECH), Chandigarh. The micro organisms purchased were enterobacter aerogenes (MTCC111), enterobacter gergoviae (MTCC621), enterobacter cloacae (MTCC509). Xylan, were purchased from sigma chemicals. All other chemicals used were of commercial grade. School waste paper which consisted of a mixture of used good quality register pages, white record, Export quality, NO1 quality, ice cups without coating and rough quality register pages.

**Incubation and Enzymatic Assay:**

The nutrient broth is prepared by dissolving instant medium (Beef Extract, Yeast Extract, Peptone, NaCl per liter of water). The nutrient broth is transferred into the conical flask. After the broth is sterilized, microbes were added and maintained in the incubator at 37 °C. Xylanase activity was assayed using 1% birchwood xylan as the substrate. Xylan was dissolved in 50 mM Glycine-NaOH buffer (pH 9.0). The reaction mixture containing 10 µg of the enzyme and 2.5 mg of the substrate was incubated for 10 min at 100°C in an incubator. The amount of the reducing sugars liberated was estimated following the 3,5- dinitrosalicylic acid (DNS) method. Xylose was used as a standard. The absorbance of reference sample (substrate solution incubated without enzyme and diluted enzyme solution in buffer) was deduced from the absorbance of the test sample. One unit of xylanase activity was expressed as µmol of reducing sugars (xylose equivalent) released in 1 min under the above conditions**.**

First we performed a 30% cut of ammonium sulphate. Slowly added the solid ammonium sulphate to a final concentration of 30% (179 g/L of solution) and stirred at room temp for 15 min. Centrifuge is done in 10 ml tubes at max speed for 15 min. Then we go for 70% cut of ammonium sulphate. The supernatant solution is separated from the pellet. The supernatant from the first step is measured and performed to a 70% of ammonium sulphate precipitation by adding 273 g of solid ammonium sulphate / L of supernatant solution. Stirred and centrifuged as above and the pellet is collected. Brightness and Opacity were tested for the sample.

**RESULTS AND DISCUSSION**

In the present work, the deinkability of different paper pulps is evaluated. The tested pulps are representative of different printing methods. The selection of the optimal enzyme concentration is important since excessive enzymes may be corrosive to the fibers and thus affected the strength of the paper and its quality. There was no significant difference in deinking efficiency with the enzyme concentration in the range of 0.5%. For 1% concentration of enzyme there is decrease in optical and strength properties. The results clearly indicated that since the pulp was an insoluble substrate, the rate of reaction would, therefore, not be directly proportional to the enzyme amount or concentration.

**Determination of deinking efficiency**

Deinking efficiency was expressed based on the brightness of the paper. The hand sheets were prepared based on the method by the Technical Association of the Pulp and Paper Industry (TAPPI), TAPPI Test Method T218 om91 for reflectance testing of pulp (Buchner Funnel Procedure).Hand sheets were conditioned under controlled conditions as described in TAPPI Test Methods (TAPPI T402) before the deinked papers were evaluated for its brightness. The paper brightness (%) was determined by the method of TAPPI T452 (Brightness of pulp, paper and paper Board) (directional Reflectance at 457nm) using brightness and opacity tester.

The enzyme dosage was carried out after pulping stage the various qualities of paper were tested at various pH levels.

**Effect of enzyme concentration on pulp (enzyme dosage 0.5%)**

At pH 9 the result shows that there is increase in brightness compared to chemical and conventional deinking process there is no significant difference on results. Time taken for enzymatic reaction is 1 hr, but compared to chemicals used and cost effective this process is effective. The highest deinking efficiency was observed with Map litho quality at 0.5% concentration of enzyme dosage, but the lowest efficiency was obtained with white printing quality.

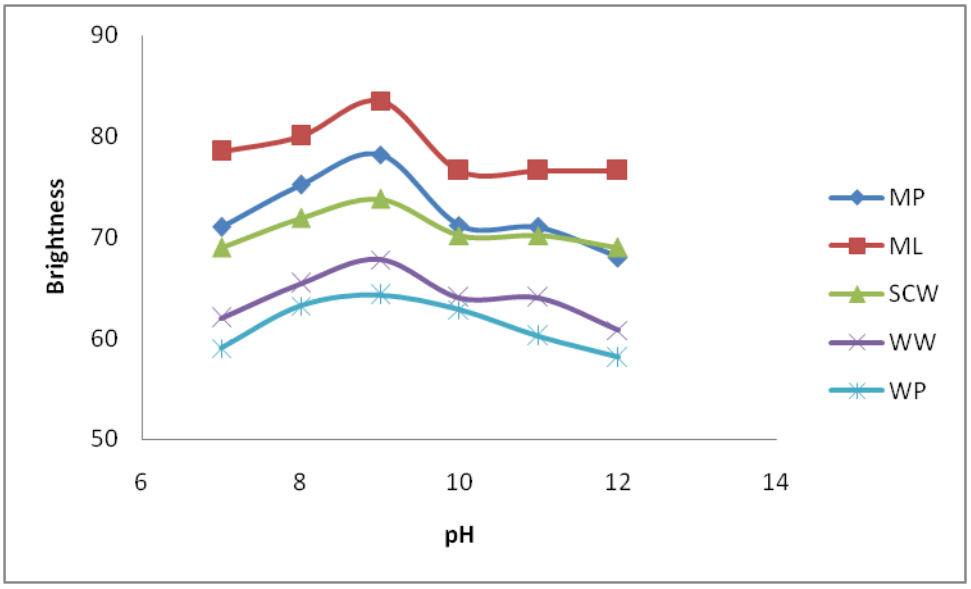


**Figure 1: pH Vs Brightness for various pulp with 0.5 enzyme concentration**

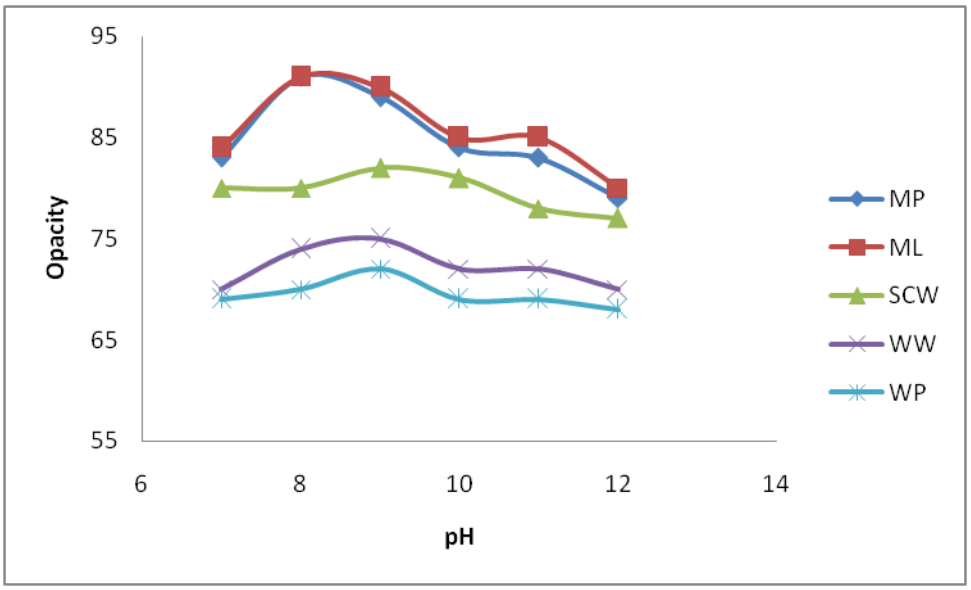


**Figure 2: pH Vs Opacity for various pulp with 0.5 enzyme concentration**

**Effect of enzyme concentration on pulp (enzyme dosage 1.0%)**

The enzyme dosage of 1.0% concentration affects the effectiveness of optical and strength properties because of irreversible reaction there is decrease in brightness, opacity and bursting strength the pulp was also evaluated at various pH levels. Time taken for enzymatic reaction is 1 hr. The result is given in a below figure.

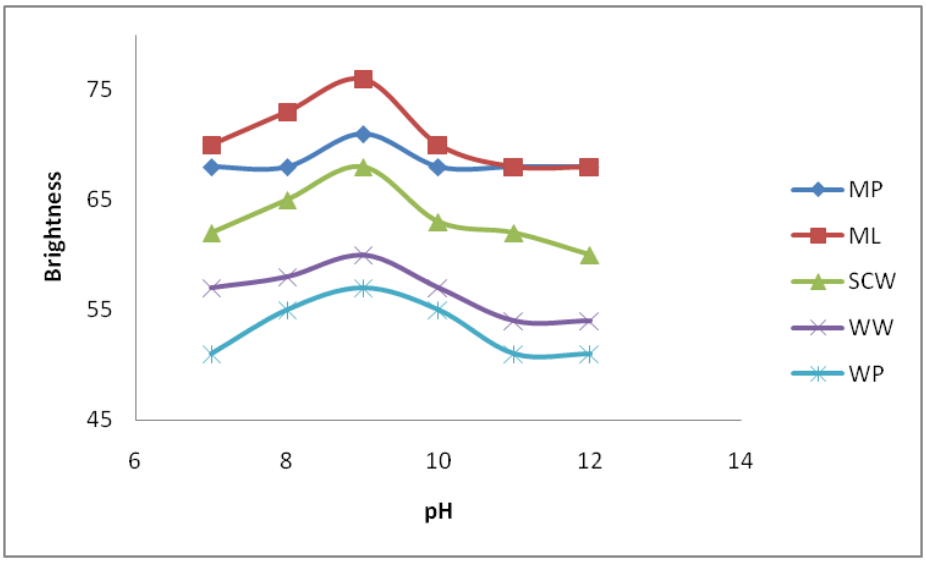


**Figure 3: pH Vs Brightness for various pulp with 1% enzyme concentration**

According to this study, the use of enzymes is a possible and competitive strategy to deink recycled pulps. However, a thorough enzyme selection and the optimization of the process are needed in order to accomplish a good quality final product. Different pulps may react differently to similar deinking protocols, either enzymatic or chemical. The enzymatic process effectiveness depends more critically on the furnish characteristics than the chemical one. Considering the wide variability on the industrial wastepaper supplies, this is probably the most important disadvantage of this methodology. The enzyme effectiveness was obtained at pH level 9, although enzymes favour ink

removal, their action significantly affects the paper strength properties. The effect of COD and BOD also been decreased on enzymatic deinking.. In all the quality 1% concentration of enzyme dosage gives reduced brightness because of its reversible reaction. However, the enzymatic process resulted in both positive and deleterious effects on the mechanical properties of deinked paper. The enzymatic deinking process the BOD, COD in the effluent water gives a pollution control process.

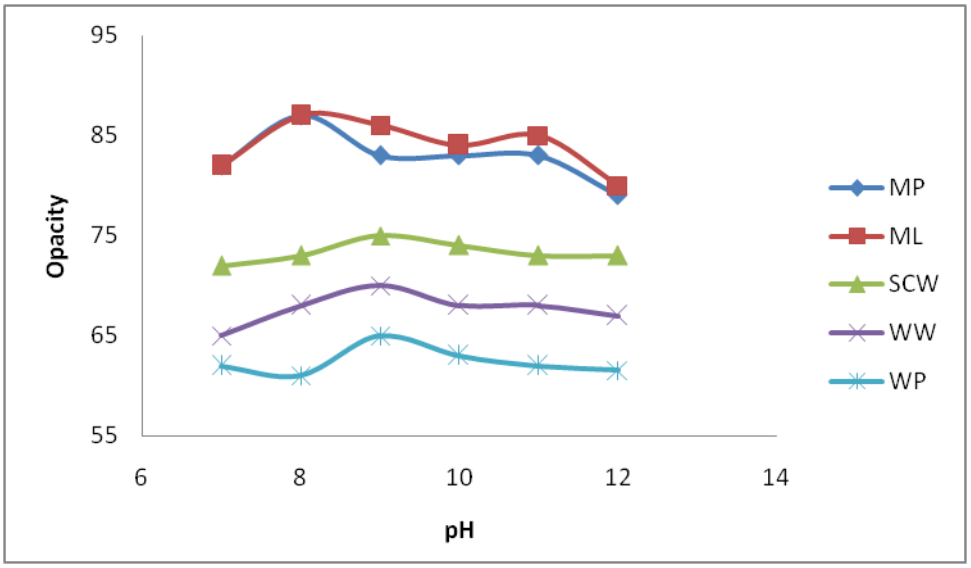


**Figure 4: pH Vs Opacity for various pulp with 1% enzyme concentration**

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