



Original Research Article

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Effective removal of phenol red dye using biochar derived from *Zea mays*

S. Malini, R. Baskar, C. Loganath*, V. Ravi Krishna, A. Ravindranath, K. Gopinath,
M. Senthil Kumar

Department of Biotechnology, Karpaga Vinayaga College of Engineering Technology, GST Road, Chinna Kolambakkam,
Palayanoor, Chengalpattu - 603 308, Madhuranthagam, Tamil Nadu, India

*Corresponding author; e-mail: clognath@gmail.com

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Abstract

In this study the investigation had been to evaluate the effectiveness of *Zea mays* seeds as a natural adsorbent to the removal of phenol red dye from the waste water. Jar test is a pilot scale laboratory test that stimulates coagulation and flocculation with differing chemical doses. The purpose of this test is to estimate the minimum coagulant dose required to achieve certain water quality goals. Flocculation or coagulation is fundamental in every water treatment process and it is a propaedeutic step for sedimentation, filtration and disinfection before distributing water for residential and industrial use. The jar test is used to determine the proper chemical dosage required for good coagulation and flocculation of water. The phenol red dye is available at the maximum peak at 570 nm wavelength in wastewater. The percentage of phenol red dye eliminated was 90.81%. The SEM coupled with energy-dispersive X-ray spectroscopy were subsequently used to quantitatively and qualitatively determine the content of the biomass before and after treatment.

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Introduction

Coagulants are essential in purifying raw water for drinking water safety for consumers. Commonly, aluminium sulphate, a chemical coagulant, is used for water treatment. However, for long-term usage, chemical coagulants can be considered toxic and harmful to the environment (Emelie et al., 2008) which can create severe health issues if consumed. Coagulation and flocculation processes are widely used in water and wastewater treatment. Its main objective is to remove suspended colloidal particles and to reduce turbidity in water body (Dong et al., 2012). The process usually takes place in a chemical

reactor in which the influent water or wastewater enter the basin and it is mix with coagulant agents using a mechanical mixer, followed by sedimentation process to move the particulate through gravity settling (Chang Weon Kim, 2013). There are many types of coagulants available. Jar testing is a method of simulating a full-scale water treatment process, providing system operators a reasonable idea of the way a treatment chemical will behave and operate with a particular type of raw water (Shon et al., 2012). Because it mimics full-scale operation, system operators can use jar testing to help determine which treatment chemical will work best with their system's raw water.

This module on the jar test is intended to give the operator those skills necessary to actually determine proper chemical dosages and mixing times for proper coagulation and flocculation of water (Zeng, 2004). The Jar Test helps water treatment plant lab operators avoid overfeeding or overdosing, especially with coagulants saving resources and optimizing processes. Solutions for Jar Test are robust products with strong resistance to chemical and mechanical corrosion. The illuminated back panel enables simple and clear floc observation and evaluation leading to maximized reproducibility. The most often used are the chemical-based coagulants such as alum and ferric salts. However, the use of these chemical coagulants resulted in many downsides such as harmful voluminous sludge production. There are also coagulants derived from plant-based materials known as natural coagulant (Seung-Woo Han, 2001).

Natural coagulants are safe and eco-friendly. It can be extracted from plant, microorganisms and animals. Some of the plants are able to be a coagulant because they are able to conduct some of the coagulation mechanisms which are neutralizing the charge in colloidal particles and per-form polymer bridging (Bhende and Jadhav, 2012). The natural plant-based coagulant can be a substitute for a sustainable solution in the water treatment coagulation process. This research aimed to determine the efficiency of plant-based materials as coagulants in water treatment. *Zea mays* seeds were chosen as natural coagulants in this investigation since they are both locally available plant-based materials. Here, this research aims to study the ability of *Zea mays* seed as plant-based coagulants in enhancing the effluent quality of the wastewater treatment plant (Jasmin Mertens, 2011).

For obtaining a long term sustainable solution, strategic planning of the system is very essential. A strategic planning study gives the opportunity to take a broader view and to address the problems identified. Only a systematic approach of strategic planning can achieve on a long term basis. Aluminium and iron salts are mostly used as coagulation reagents. Recent studies (Ngabiengengesere & Narasiah, 1998; Katayon et al., 2005) have indicated a number of serious drawbacks linked to the use of aluminium salts such as Alzheimer's disease associated with high aluminium residuals in treated water. In addition, the use of alum salts is inappropriate chemicals and low availability of chemical coagulants. This study deals with natural and synthetic coagulants. This will not have any side effects

in the treated water. The natural and synthetic coagulants are much economical when compared to the current method which is under practice and also has a higher efficiency. Present study is eco-friendly and does not deteriorate the environment. A jar test experiment was used to assess the capacity of *Zea mays* as natural coagulants. The phenol red dye is used in coagulation process. Phenol red is a highly water-soluble textile dye belonging to the class of triphenylmethane dyes.

Materials and methods

The methodologies for this study are discussed under the chapter. Different methods were adopted for the preparation of stock solutions for natural and synthetic coagulants.

Preparation of stock solution

The equipment used for jar test experiments was a Jake and Kunkel jar test apparatus with 4 beakers of 1.0 L capacity each. Each beaker was filled with 500 ml of test water with identical turbidity. Different volumes of coagulant reagent were added to 4 beakers 0.3 g of phenol red dye were added to the first beaker, 0.5 g of phenol red dye was added in second beaker, 1.0 g of phenol red dye were added in third beaker 1.5 g of phenol red dye were added in fourth beaker. Mixing of the coagulant with water was provided by flash mixing during approximately 30 min with propellers set at 120 rpm followed by slow mixing at 40 rpm during approximately 17 min. Then the propellers were stopped and the content of the jars left to settle for approximately 20 min. After sedimentation, samples were taken for water quality determination. For each coagulant and turbidity level, three identical jar tests were performed same in order to obtain statistically reliable results. However, some of the parameters were only measured during one of these in four jar tests and/or in the jar with the optimal dosage, the 0.5 g of dye in beaker is shown the changes in the process. If the optimal dosage was not found in the jar test, a new test with new dosage was carried out until the optimum was found in the jar test.

Natural coagulants used

The application of natural materials for clarifying turbid waters of rivers is an ancient and home-based practice in tropical developing countries where these natural materials act as primary coagulants.

Description of natural coagulants maize

Maize with scientific name *Zea mays*, is a species of corn, native to North America. The seeds from corn are extracted and are crushed and dried under the sun. After perfect removal of water content from the crushed seeds, the seeds are further crushed into powder and are sieved. Particles which pass through 75 micron sieve are collected and are used for the study. Particular amount of the crushed maize seed is added to the stock solution and are studied under different criteria. The *Zea mays* seed is absorbed the unwanted sample in the water with phenol red dye. Phenol red dye is used in wastewater discharge from the industries must be properly treated. The results comprise turbidity removal by 92% *Zea mays*, the chemical oxygen demand (COD) of 95% reduction rate using *Zea mays* seed. The biochemical oxygen demand (BOD) for 88% removal by *Zea mays* seed, a total suspended solids (TSS) of 100% reduction rate using mixed *Zea mays* seed for the effluent sample. Thus, it can be recognized that maize seeds can be an alternative solution to replace the chemical coagulants in the treatment systems N Kasmuri *et al.* (2023).

Coagulation method

The stock solution prepared by using foundry sand was used for the study of coagulation performance of natural coagulants. The initial turbidity of the stock solution is first noted before adding the coagulants. The natural material to be added as a coagulant was added to the stock solution. About 500 mg was added to the stock solution. The stirring is done with the help of a Jar Test Apparatus. The initially the stirring speed of about 80rpm is set for about 5 min. Further to get proper mixing the stirring was set at a slower speed of about 40 rpm. The slower stirring was maintained for 25 min. After this process the settling time of about one hour was allowed. The settling was influenced only by gravity and was left.

Preparation of stock solution

The sample of 0.3 g and phenol red dye was added to 500 ml of distilled water and 0.5 g of sample and phenol red dye was added in 500 ml of distilled water. One gram of sample and phenol red dye was added to 500 ml of distilled water. The sample (1.5 g) and phenol red dye was added to 500 ml of distilled water. This is mixed with the help of the Jar Test apparatus.

Initially the mixture is stirred at a higher speed of 80 rpm for 30 min. Further to get a perfect mixture it is stirred at a slower speed of 40 rpm for 20 min. The turbidity was noted with the help of a turbidity meter. Turbidity of the freshly prepared stock solution is studied as a function of time for about 24 h. Turbidity was noted for every hour. Under the conclusions of the study the standard stock solution was taken for the study of coagulation efficiency of synthetic coagulants.

Sampling method

Domestic waste water accumulated in a pond was collected for the study. Samples were collected from the pond such that the sample exhibits the property the property of the whole pond without exhibiting property of a particular area of the pond. Sampling was done in such an effective way. The pond shown above is the pond from which the domestic waste water was collected. Samples were collected from seven different positions in the pond. This is done to exhibit the whole property of the pond. The seven different positions were around the pond. Considerable amount of samples were collected from each position. The samples were mixed together and are used for the treatment process.

Results and discussion

The natural coagulants were added to the stock solution in four various quantities so as to estimate the optimum coagulant dosage required. As the coagulants were added and thoroughly mixed the coagulation takes place. The natural coagulant was added clog the agglomerated materials and enhances the settling of the agglomerated particles. Thus the coagulation efficiencies of various natural materials were studied. Most of the materials failed to act as a coagulant whereas *Zea mays* seed had higher efficiency of turbidity removal. The coagulation observed was intensely rapid (Fig. 1). The settling of the agglomerated particles took place very quick after the initial precipitation occurred. The precipitation occurred was due to the neutralization of synthetic coagulant. During precipitation the agglomerated particles tend to settle along with the precipitation as the synthetic coagulant are thoroughly mixed in the mixture. The settled floc was taken and studied under a Scanning Electron Microscope (SEM). The floc which was collected from the bottom of the beaker after complete settlement had been witnessed. They were separated carefully as the clear solution above had to be used for various other tests.

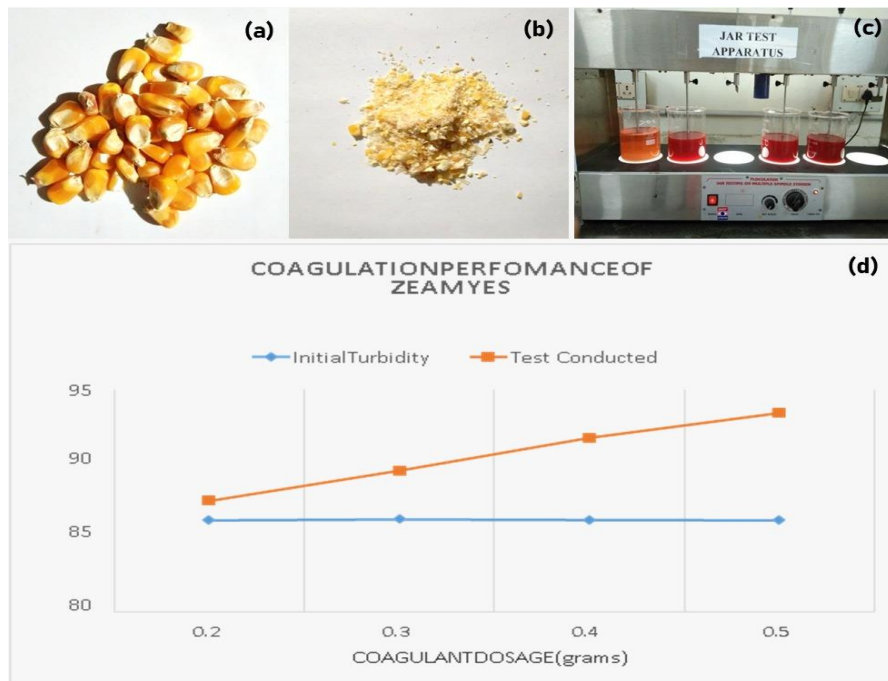


Fig. 1: (a) *Zea mays* seeds, (b) *Zea mays* seeds powder, (c) Jar test and (d) Coagulation performance.

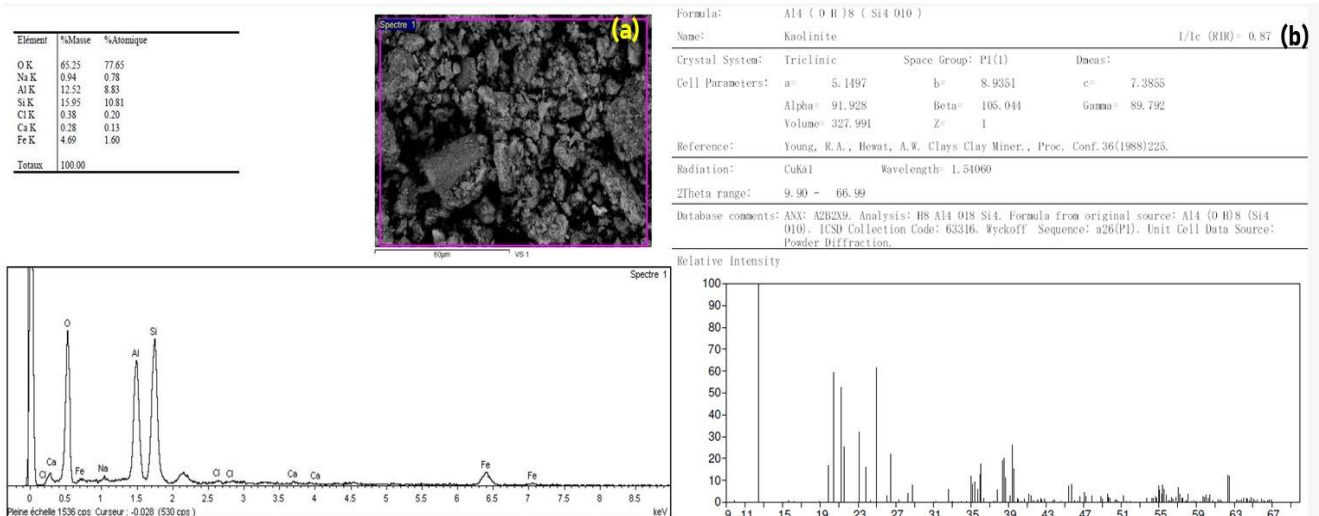


Fig. 2: SEM analysis of settled floc.

The above image is the SEM analysis of the settled floc of kaolin stock solution which clearly explains the morphology and percentage mass of the residual components in the floc. The morphology of the floc of Kaolin + Fe coagulant is heterogeneous in nature. The graph shown is generated by the Scanning Electron Microscope which shows the percentage mass of the various components in the floc when it is incident by an electron beam (Fig. 2).

Conclusions

The variation in the flow with respect to time of the bed shows the bed exhaustion from time to time. As the bed exhausts the quality of the treated water also withers. So the bed could be used when it discharges water with better efficiency or at least well than the initial water supplied to the bed. The bed we provided was efficient up to a period of 2 h. The bed had to be totally replaced

for better treatment. Dye was diluted under different dilutions and the absorbance was studied under a photo calorimeter. With this study done in the dye a standard graph could be plot and the treated water's efficiency can be easily studied. By this study the column treatment efficiency was studied to be 31.5%

Conflict of interest statement

Authors declare that they have no conflict of interest.

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