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Development of indigenous Bio-coagulant for Turbidity Removal

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Abstract: Coagulants are widely used for the removal of turbidity in the form of suspended and colloidal material. Aluminum and ferric salts are cheap and the most widely used coagulants in water and wastewater treatment all over the world. In recent years the development of plant based natural coagulants have been more focused by researchers because of less production of after treatment sludge, biodegradability and health friendly nature. Natural coagulants have been developed from Nirmali seed, maize, mesquite bean, Cactus latifaria, Cassia angustifolia seed, chestnut, acorn and leguminous species.

At present nearly 0.1 million tonnes of date pits per annum are disposed off having no use, which is causing the environmental pollution in the shape of solid waste. The date pit is treated and converted into natural coagulant, which can be used as a green alternative to the inorganic coagulants. In the present research work Bio-coagulant is prepared from date pits, which were dried, ground and sieved and physically treated. Various factors including turbidity concentration, dose of crude extract, mixing time, mixing speed and pH were investigated. The highest removal efficiency was observed as 86% when pH was 13 and crude extract dose was 1ml/L. The efficiency graph uniformly increased as pH range increased. Further study is needed to enhance its uses and remaining parameters can be investigated such as COD removal, temperature, in order to increase applicability.

Keywords: Bio-Coagulation, Turbidity Removal, Date pit extracts, Protein Content

1. INTRODUCTION

The drinking water production through various raw water cradles needs use of coagulant in the coagulation step for turbidity removal in the form of colloidal or suspended particles. Several coagulants are broadly used for drinking water treatment. The coagulants can be divided into organic polymer (polydactyl amide derivatives) and inorganic coagulants (salts of aluminum and ferric). Salts of Aluminum have the potential application for industrial or Drinking water treatment all over the world because of its cheapness and wide availability. Unfortunately it has many harmful effects on human health like severe trembling, Neurotoxic, and Carcinogenic Diseases (Evert Nieboer *et al.* 1995). Due to presence of residual monomers and neurotoxic and carcinogenic property (Mallevialle *et al.* 1984) the synthetic polymer has been unsuitable in water treatment.

Without any distinction of status or standard the drinking of safe water is the primary right of every people living on the globe. The majority of Pakistani nation is using the river water for drinking purpose and other domestic uses. The rivers are to be contaminated by many natural and anthropogenic actions of communities like as discharge of domestic and industrial wastewater in the running canals and rivers without any mandatory preventive actions, bio- deaths and Floods etc. There are various contaminants which pollutes the river water.

The plant oriented bio-coagulants usage in water treatment is not a new idea but it has been practiced from the centuries in traditional way at the rural communities of tropical countries (lie *et al.* 2001). The trend is now to be shifted to prepare the bio-coagulants from many seeds just because of their enviro-friendly nature and less after treatment sludge production. The researchers have been worked on this issue and have got remarkable results to replace the alum salts which have hazardous effects of human body. The following seeds have been optimized such as Moringaoliefra, Chestnut, Acorn, Chitosan, Cactus and Beans etc. (Scibian 2009.

However, the MoringaOliefra seed has been rising instantly in the field of water treatment as bio-coagulant. In the present research work the bio-coagulant was produced from the seed of dates. The different operational factors like as dosage of coagulant, mixing speed, mixing time (Time period of each coagulation experiment), pH, and synthetic turbid water concentrations were optimized. The coagulant was also compared with other natural coagulants including MoringaOliefra, chestnut, Acorn and Chitosan from

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literature review for the effectiveness optimization of prepared bio-coagulant.

2. SCOPE OF THE WORK

Recent study has verified that coagulants made from inorganic polymers are not completely safe for the human body, on the other hand the bio-coagulant which can be obtained from natural plants are very health friendly and nontoxic nature.

Certain researches have been carried out research on natural coagulants production which can be produced or extracted from plants or animal tissues, such as from Chestnut, MoringaOliefra, and Acorn. According to World date producer countries list the Pakistan is placed at fourth rank. Nearly 622,000 tonnes of dates are produced annually. Date palm seed which is also known as date pit or kernel is the 15% of the date fruit's total weight (Hussein *et al.*1998).

At present nearly 0.1 milliontonnes of date pits per annum are disposed off having no use, which is causing the environmental pollution in the shape of solid waste. The date pit is treated and converted into Bio-coagulant, which can be used as an alternative to the inorganic coagulant. Date pits are safe for use and contains many minerals i.e. (K, P, Na, Ca, Mg, Fe, Zn and Cu), (Al-Whaibi *et al* 1985) and carbohydrate which are favourable for human body. It is more effective and economic for our country to use this waste material as a Bio-coagulant for water treatment.By the development of this indigenous material (Bio-coagulant) revenue will be generated, and it will create new areas of research and development.

3. MATERIAL AND METHODS

The date pit is treated and converted into natural coagulant, which can be used as an alternative to the inorganic coagulant. Various researchers have extracted natural coagulants from MoringaOliefra, Chestnut, Cactus latifaria, Nirmali, maize and other organic matters.

In the present work coagulant is extracted from date pits by physical treatment method. The second phase involves the optimization of various operating parameters such as coagulant dose (volume of bio-coagulant per litre of Turbid water), synthetic turbid water concentration (NTU), mixing speed (RPM), mixing time and pH. The protein content in the crude extract was also determined by Kjeldahl Method to compare with other Bio-coagulants.

3.1 **Preparation of Crude Extract**

Seed extract was prepared in laboratory by doing various unit operations on it such as washing, drying, grinding, mixing and filtration etc.Date pits were collected from the different parts of District Sukkur and Khairpur Mir's. The Date pit commonly known as (kernel, seed or stones) was washed with the distilled water in order to remove unwanted material and to make it more useful. The washed date pits were heated at 120ºC to remove moisture content present in the seeds after washing and to facilitate grinding and other operations. The dried date pits were ground to fine powder for easy extraction of coagulating active components; this operation was carried out by using the Brown crusher and laboratory ball mill. All groundmaterial was sieved through 40 mesh or 0.4 mm sieve and the fraction with particles size less than 0.4 mm were used to prepare the crude extract (Bio-coagulant). By sieving step the material of homogenized, equal and small size was achieved which enhanced the extraction. The ground material was kept in the Refrigerator by putting it into an air tight glass jar, for increasing its preservation time.

3.1.1**Preparation of crude extracts**

50g of ground powder was kept for extraction of coagulating active components from the seed powder and mixed in one litre of distilled water and agitated through magnetic stirrer for a period of 10 minutes at a constant speed. The agitated solution of powder was filtered through rug filter paper by the mechanism of gravitational filtration to obtain the crude extract. The filtered solution called coagulating active components, was kept at a cool temperature for its preservation.

3.2 Preparation of Synthetic Turbid Water

Synthetic turbid water of different concentrations was produced by adding 2.5 to 12 ml of stock solution of kaolin (Hydrated Aluminum silicate) into one litre of distilled water. 2.5 ml of kaolin were added to prepare the 17.5 NTU water, 35 NTU water was produced by adding 5 ml of stock solution of kaolin, 8 ml of kaolin solution were added for making 50 NTU water, 70 NTU water was prepared by mixing 10 ml of stock solution and in same way the last sample of turbid water of 90 NTU was prepared by adding 12 ml of kaolin stock solution. The procedure given by Okuda *et al.* (2001a) was used to choose the central point in the range of investigated initial water turbidities.

3.3 Coagulation Test

All Coagulation experiments were examined by using jar test technique. At a constant room temperature of 28ºC the 300 ml of turbid water from each sample was collected and treated in a 600 ml beaker through stirrer for one minute at 200 RPM after that the RPM was reduced to different stages to optimize and the mixing speed and mixing time. Using same technique to get maximum efficiency via variation of mixing speed

and time sample was left for sedimentation purpose for one hour. The residual turbidity was measured after one hour of sedimentation and the sample was collected from the top of the beaker and kept into turbidity meter to check its removal percentage. The same process was also applied without coagulant addition and that turbidity was supposed as $-T_B$ and with coagulant residual turbidity was denoted by T_S and the coagulation activity of bio-coagulant was calculated as follows:

Coagulation activity (%) = $(T_B-T_S).100/T_B$
T_B = Turbidity of water without coagulant addition
T_S = Turbidity of water with coagulant addition

3.4Analytical Methods:

According to the MEBAK 1997 and APHA 1995; the crude extracts were examined for the protein content and total Kjeldahl nitrogen.

4 RESULTS AND DISCUSSION

The coagulation and flocculation are the two main processes followed for treatment or purification of water. In which commonly the impurities are being removed either in the form of suspended, colloidal or tiny silica particles by using coagulants, which is not possible to separate from water by simple sedimentation. In last ten years the production of natural coagulants has been done by many researchers from different plant based components, including chestnut, Nirmali, Maize, Mosquito bean, Acorn, MoringaOliefera, Cactus, and different Leguminous specieswhich had showed remarkable efficiency while they used to treat turbid water. The present study is concentrated on production of bio-coagulant from date palm seed, through physical treatment and some unit operation like as washing, de-moisturizing, crushing, grinding, and sieving. The protein contents were also investigated for crude extract which was produced from ground date pits.

4.1 Optimization of Operating Parameters

Evaluation of bio-coagulants necessary includes coagulation experiments and many parameters have an influence on coagulation process, like nature of coagulant, composition of coagulant, coagulant dose, initial water turbidity, and pH etc.

4.1.1 Coagulant Dose (Crude Extract)

Dosage of coagulant is very important factor for the coagulation activity.

It is believed that the coagulation activity is dependent of dose and cations present in water (Okuda 2001)**.**The influence of dose of date pit crude extract on coagulation activity was investigated in following experiments.

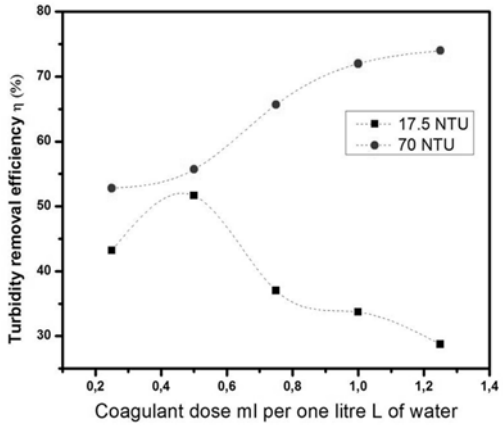


Fig. 1: Optimization of Coagulant Dose

The synthetic turbid water having 17.5 NTU and 70 NTU were treated with different doses of crude extract from 0.25 ml, 0.5 ml, 0.75ml, 1ml and 1.25 ml as shown in **(Fig. 1)**. The efficiency was achieved 52 % to 65% at 0.25 ml to 0.75 ml of coagulant dose. But the efficiency at 1 ml and 1.25 ml were higher than the all above doses and it was also observed that the efficiency gradient of 1 ml and 1.25 was slight, so optimized dose was supposed as 1.0 ml per litre of turbid water which is very resemblance with the study of Chestnut (Sciban *et al.* 2009). Dosage of 1 ml showed maximum coagulation activity up to 72 % and as compared with 0.25 ml to 0.75 ml it had more ability to mix easily with the turbid water and make more flocks of agglomerates, the agglomerates were attracted and settle down by gravity, by making water more transparent. As we give the more settling time than the efficiency will also be increased. Although the optimized dose were less efficient in lower turbidities (17.5 and 35 NTU) but in higher turbidity i.e. 50, 70 and 90 NTU the dose was observed most efficient 65%, 72% and 77% respectively, and got high removal efficiency resemblance with Chestnut up to 77% (Marina 2009). Simply it was observed that as the concentration of turbidity increased than the turbidity removal efficiency of optimum dose was also increased up to certain limit. The highest removal efficiency was observed when crude extract dose was 1ml/L which is recommended by other researcher for chestnut study (Marina 2009),remaining samples were tested by same dose.

4.1.2 Optimization of Mixing Time

After coagulant dosage the mixing time is also main factor which can affect the coagulation activity, so to overcome on this factor five different time intervals were studied to get optimum mixing time for coagulation experiment i.e. 20,25,30,35 and 40 min with a constant difference of 5 min between each point.

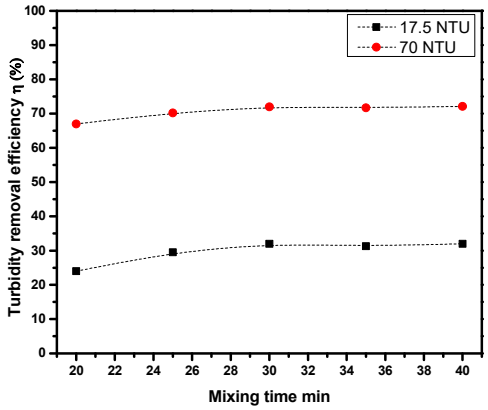


Fig. 2: Optimization of mixing time

It was observed that from 20 min to 30 min the efficiency was raising and obtained the turbidity removal up to 72% but after 30 min it was stimulated as a straight line or with a very minute increasing in coagulation efficiency slope. The recommended optimized time was observed as 30 min and was set as optimum for remaining experiments. The synthetic turbid water of 70 NTU was treated with optimum dose at a different time periods and observed a notable change in coagulation activity while conducting the coagulation experiments. The experiments of 20 min and 25 min were observed as increasing point towards the maximum efficiency which was instigated at 30 min and turbidity removal was 72%. When the mixing time was examined above than the 30 min than it was grown as straight line because the maximum floc production was achieved at 30 min and after that the floc started to dismantle or behaved like a free particle that's why the efficiency remained static. The optimum mixing time was investigated to check effectiveness on variable turbidity concentrations.

4.1.3 **Optimization of Mixing Speed (RPM)**

The mixing speed of agitator is also an important factor while coagulation is takes place so this factor was also investigated during study and found some minute observations in efficiency graph. The different speeds (RPM) were tested to get optimum speed of agitator for experiments and it was observedas 80 RPM, because the speeds below and above than 80 RPM were not much efficient in coagulation as shown in **(Fig. 3)**. It was observed from the Fig.3 that the optimum mixing speed is 80 (RPM) because maximum turbidity removal efficiency of 72% is achieved.

The mixing speed had much interference in production of flocs during coagulation because the weight and thickness of floc may be disturbed by the speed of agitator's blade or impeller.

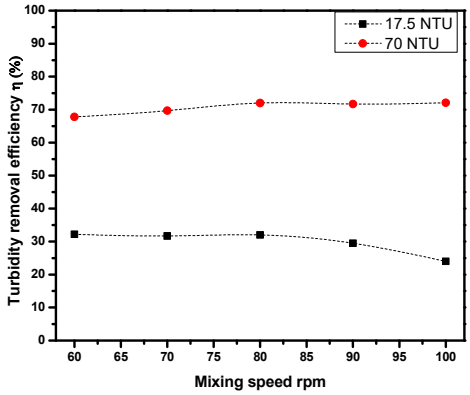


Fig.3: Optimization of mixing speed (RPM)

Many studies have investigated this factor because its effectiveness on coagulation efficiency.

4.1.4 **Optimization of pH**

The pH is very important parameter regarding coagulation process. So that finally the effect of pH was investigated to check the optimum pH ranges for highest efficiency. When pH was changed from throughout the scale the different results were obtained and shown in **(Fig. 4)**. The coagulation efficiency was observed much higher in basic range than the acidic nature of turbid water. When experiments were taken place the 86 % result achieved at pH 13 which is maximum value in basic medium and 39.2% was achieved at pH 2 which is lowest efficiency of natural coagulant. The remaining experiments were taken for all the pH ranges and observed as the pH range increased then the turbidity removal efficiency also increases; it means this natural coagulant is most efficient in basic nature (i.e. from pH-7 to pH-14) of turbid water. The experiments gave less result to the acidic range however better results to basic range of pH.Although in basic range the efficiency graph raised towards maximum value and the optimum result was atpH-13 (86%). Proteins becomes fully charged in strong basic medium, the free particles pulled by fully charged proteins and formed agglomerates and those agglomerates were attracted and settle down by gravity. The pH-13 was observed as optimum pH after getting maximum efficiency results.

4.2 Effectiveness of Optimized Parameters

After optimization of all parameters the effectiveness was checked at optimized conditions.When the synthetic turbid water having 17.5 NTU, 35 NTU, 50 NTU, 70 NTU and 90 NTU was treated with optimum dose of 1 ml/L, optimum mixing time of 30 min and optimum mixing speed of 80 RPM, the efficiency was 33.7%, 60%, 65.6%, 72% and 77% respectively.

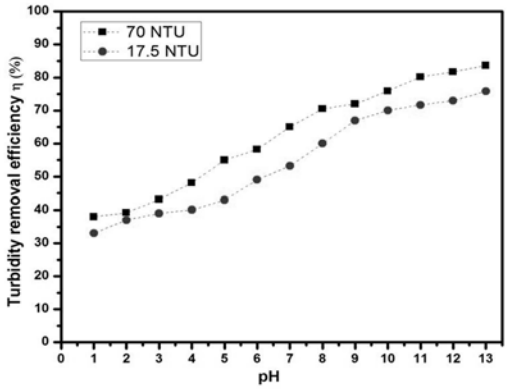


Fig.4: Optimization of pH.

Optimized dose was supposed as 1.0 ml per litre of turbid water which was also supported by the study of (Sciban *et al.* 2009).

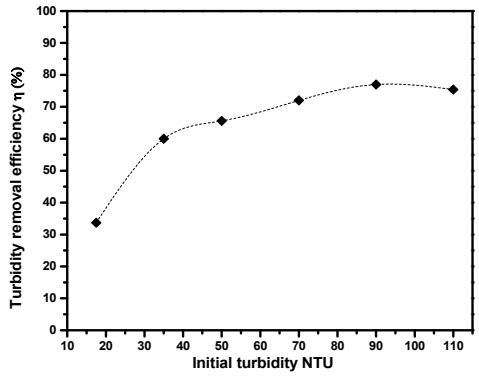


Fig.5: Effectiveness of Optimized Parameters

4.3 Investigation of Protein Content in Crude Extract

4.3.1 Protein content

Proteins are coagulation active components in plant extracts (Ndabigengesere *et al.,* 1995, Ghebremichael *et al.* 2005, 2006) that's why the protein content test was investigated to check the presence of protein in date palm seed. The results of crude material to water ratio (50 grams/liter of water) contained protein as shown in **(Fig.6)**. The crude extract of date pit (130 mg/l) reported higher protein content more than Q. rubba (120 mg/l) and near to Q.robur (150 mg/l). It proved that the biocoagulant from date pit can be produced, itcan give some valuable uses in our daily life and help to replacealum usage in water treatment.Which has been notified as unsafe for health in terms of long time drinking. Through the production of this bio coagulant revenue will be generated and it canopen new areas of research and development and also help to stabilize our Country's economy.

4.3.2 Extraction of Protein

The distilled water or brine solution may be used to extract the proteins from plant seed. Higher extraction efficiency can be achieved by dissolving ground seed into brine solution.canDifferent seeds have different extraction efficiency as Aesculus Hyppocastanum (44.6%), Castanea sativa (54.4%) Q. robur (32.5%), Quercusrubra (32.4%) and Quercuscerris (38.5%) as shown in **(Fig 6).** Date pit (46.3%) had the highest extraction efficiency when compared to other seeds.

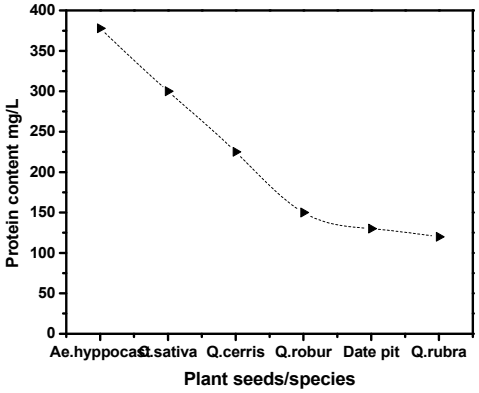


Fig.6: Protein concentration in crude extract

5. CONCLUSON

The purpose of this study was to investigate the ability of bio-coagulant extracted from date pit for turbid water treatment, the experiments confirmed the positive coagulation properties of the investigated natural coagulant developed from the date pit. This natural coagulant is biodegradable and does not cause any harmful effects on human being. The extract from seed was the most efficient expressing the highest coagulating activities about 40% to 86% respectively, in both low and medium investigated water turbidities. The environmental friendly, health safe natural coagulant may be produced from date palm seed for water treatment and it has prominent chances to replace the alum or other inorganic coagulants. The highest efficiency was observed as 86% when turbid water was treated with 1ml/L (1ml of bio-coagulant solution per 1litre of turbid water)at pH-13. The efficiency graph was observed continuously increasing when pH range was increased. The government should take some serious steps towards the production of these enviro-friendly, health safe and economical natural coagulants on commercial scale. The natural coagulant may be extracted by some advanced technologies like extraction through different solutions which have more ability to extract coagulating active components from date pit. The extracted solution may be more concentrated to make more efficient, because in this process the

efficiency depends on the existence of coagulating active components. Further study can enhance its uses and remaining parameters can be optimized such as total organic content (TOC) existence, temperature, etc. should be optimized in order to extend the applications of Bio-coagulant.

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