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Turbidity removal from surface water by natural coagulants and its potential application

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A B S T R A C T

The Natural coagulant Vigna mungo, Zea mays were used to remove the turbidity from synthetic wastewater . Vigna mungo, Zea mays are ancient crop and having high proteins and nutrients. Chemical coagulants used it induce Alzheimer's, Carcinogenic and neurotoxic health effects. This is alternative method for turbidity removal in synthetic wastewater. In this study Vigna mungo, Zea mays, Allium cepa ash, waste tea powder ash, Phyllanthus niruri ash used for turbidity removal. Vigna mungo seeds extract have highest percentage (90%) turbidity removal compared to Zea mays (76%). Microwave and ultrasonic assisted both methods are very efficient; 87% of turbidity removal achieved for Vigna mungo; 70% for Zea mays. Allium cepa peel ash, Waste tea powder ash, Phyllanthus niruri ash approximately almost above 95% of turbidity removal achieved. The various optimized parameters were studied and results are discussed. Natural coagulants are eco-friendly method for turbidity removal because the sludge disposal is very easy. The sludge it can be used as biocompost or biofertilizer.

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INTRODUCTION

Water scarcity has become a major problem in the world. The village pond surface water making it necessary to treat the water before use in households [1]. Oxygen, turbidity and pH are important quantities for ecosystem studies and physics biology couplings and their fluctuations reveal the possible influence of environmental factors such as tides of turbulence [2]. Various conventional methods such as precipitation, adsorption, coagulation, flotation, ion exchange, membrane filtration and biological and electrolytic method have been utilized to remove turbidity from water [3]. Electrocoagulation technique has been used for the treatment of textile wastewater, aluminium and iron electrodes are used to remove the COD and turbidity. The main efficacy of the technique was followed depending on the electrode material in terms of water treatment, current efficiency of the dissolution, cell voltage, energy consumption to reach the same COD or Turbidity was evaluated [4]. Turbidity removal performance varied according to the following order of humic-kaolin synthetic water $AlCl_3$ >PAC>$Al_2(SO_4)_3$ was reported by Li et al. [5]. Effects of polydimethyl diallylammonium chloride on coagulation behaviors of different from aluminium based coagulants impurity removal efficiency were investigated in coagulation-ultrafiltration hybrid process [6]. Aluminium sulphate used in water treatment turbidity removal it induce Alzheimer's disease. However, high concentration of aluminium causing several problems, increasing water turbidity leads to the formation of aluminium precipitation. Another drawback of these hydrolyzing metal coagulants is the production of huge amount of sludge which is non-biodegradable and causes disposal problems and requires treatment of the sludge [7]. Although the chemical coagulants are well known their use is associated with high costs and environmental drawbacks. Whereas the synthetic organic polymer such as acrylamide have neurotoxic and carcinogenic effects [8, 9]. Polyacrylamide–based materials are also frequently used; however, the possible release of monomers is now considered harmful because they can enters the food chain, causing potential health impacts [10]. The coagulation performance of some new coagulants were prepared by adding different amount of carbon nanotubes to the polyaluminium chloride. In the coagulation process the removal for hyaluronan, is an

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anionic molecules may be caused by two mechanisms, one is adsorption of CNTs and the other is coagulation process was evaluated [11]. The application of coagulation/flocculation process is applied in water, wastewater treatment to remove turbidity from drinking water [12]. The alternative proposed were the use of natural coagulants for pretreatment by several researchers [13-17]. In previous studies various plant material such as Moringa oleifera [18] the coagulation-flocculation process using Moringa oleifera seeds after oil extraction was reported [19]. Moringa oleifera is readily available in many tropical countries, farmers used to treat high turbid water for irrigation was reported [20]. Strychnos potatorum [12] Nirmali seed extracts are anionic polyelectrolyte's that destabilize the particle in water by means of inter-particle bridging was also investigated [10] on Phaseolus vulgaris [2], rice starch [17], fava bean [21], Starch [22], Plantago ovato [23]. World health organization recommended ≤ 2 NTU for drinking water quality. The present study reported technically-supported, economically-feasible and environmentally friendly method to remove water turbidity from synthetic wastewater. Vigna mungo, Zea mays seed ancient crop and having high nutrients value. These seeds are food grade nature contains no oil and non-toxic. It is having coagulating active proteins used to remove the turbidity from surface water. It is also having proteins and other nutrients are increased the organic matter of the water. Another major disadvantage is associated stored for several days it produce bad smell. Another problem also hypothesized that defattening of the seed could increase the efficiency in treatment of turbid water. The mechanism of coagulation is adsorption and charge neutralization of colloidal particles, similar to the main mechanism of the Moringa oleifera. Allium cepa peel ash, Phyllanthus niruri ash, waste tea powder ash were used to remove the turbidity and the results are presented. Natural coagulants are in general used as point of use technology in less developed communities since they are relatively cost effective compared to chemical coagulants and easily biodegradable. Natural coagulants are sustainable environmental technology to remove turbidity from synthetic wastewater.

MATERIAL AND METHODS

Preparation of Natural coagulants powder

Sample 1: *Vigna mungo* powder
Sample 2: *Zea mays* powder
Sample 3: *Allium cepa* peel ash
Sample 4: *Phyllanthus niruri* leaf ash
Sample 5: Waste tea powder ash

Preparation of Synthetic turbid water

Synthetic turbid water was prepared by adding 10g of Kaolin in 1L of distilled water these solution was stock solution. Before the coagulation experiments different initial turbidities 250, 500,750, 1000, 1250 NTU were prepared from stock solution. The initial pH in the synthetic turbid water was adjusted to 0.01M NaOH and 0.01M HCl.

Coagulation test

Coagulation activity of each coagulant was determined by the jar test. 300mL synthetic turbid water was filled into the beakers and mixed at 800rpm at constant room temperature. Then different dosages of coagulants were added into the beakers and mixed for 120min.Then the suspensions were left for sedimentation. After 5hours of sedimentation the clarified samples were collected from top of the beakers and residual turbidity was measured, if filtration is needed filter the suspensions.

Coagulation activity % = $(T_B-T_S).100/ T_B$

Synopsis of Jar test and ultrasonic and microwave assisted turbidity measurements

500mL of synthetic turbid water known turbidity was taken in a beaker and particular dosage of coagulant stirred for 90min at 800rpm. Then slow agitation was programmed for duration of 10min. After 1hour sedimentation turbidity was measured by Nephelometer. NTU values of zero and 40 were used for calibration primary standard solution. Turbidity sample was taken from the centre of the beaker and turbidity was measured. 300mL of synthetic turbid water was taken in a beaker adding corresponding amount of coagulant put in microwave oven 20min. After 5hours sedimentation turbidity was measured. Similar procedure also used for ultrasonic assisted method.

RESULTS AND DISCUSSION

Effect of pH and Coagulant dosage on 0.5M V.M.NaCl, 0.5M Z.M.NaCl

In order to determine effect of coagulant dosage on turbidity removal different initial turbidities 100, 250, 500, 750, 1000NTU were prepared from synthetic turbid water. The extract of *Vigna mungo, Zea mays* was used for turbidity removal is shown in Fig. 1. *Vigna mungo* 0.5M NaCl extract have greater performance of turbidity removal of synthetic turbid water compared to Zea mays. 5, 10, 15, 20, 25mL of 0.5M V.M.NaCl, 0.5M Z.M.NaCl extract added to 300mL of synthetic turbid water 500 NTU and stirred for magnetic stirrer 800rpm at neutral pH. Then settle the sample for 90min settling time. The highest percentage of turbidity removal obtained V.M. 0.5M NaCl 87%. All the experiments were carried out at neutral pH. The percentage of turbidity removal decreased increasing the pH of synthetic wastewater. *Vigna mungo, Zea mays* NaCl extract presence of NaCl

in water it does not affect the coagulation activity because NaCl is used to remove the turbidity. *Vigna mungo* and *Zea mays* crop seeds contains protein and having different electrical charges and various particle size. At basic pH leads to decrease in cationic form. Turbidity water having negatively charged particle, electrostatic attraction between the water and coagulant becomes weak at basic pH. Turbidity reduction takes place via coagulation mechanism similar to *Moringa oleifera*. 0.5M NaCl without coagulant added no effect on turbidity removal was noted. Further experiments were conducted at pH 7.

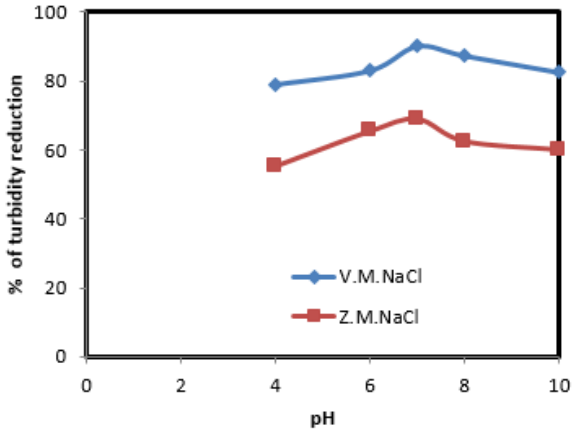

Figure 1. Effect of pH(Various pH, Adsorbent dosage-25mL,Initial concentration-500NTU)

Effects of Microwave and Ultrasonic assisted extraction method on 0.5M V.M.NaCl, 0.5M Z.M.NaCl

In microwave assisted method 300mL of synthetic turbid water from 100 to 500NTU was taken in 500mL beaker and adding optimum dosage of coagulant (20mL/L) put it in microwave oven at neutral pH. Microwave assisted extraction method 20min time was fixed, longer the treatment of coagulant denaturation of coagulant takes place less turbidity removal was achieved. Ultrasonic assisted extraction method sonic waves are homogeneous synthetic wastewater and coagulant. In this method 100mL synthetic wastewater adding 5mL/L of coagulant dosage, fix the sonication time 10 min. Prolonged treatment of sonication destroyed the protein presents in coagulants. Both methods after 3hours settling time turbidity were measured. Maximum percentage of turbidity reduction achieved in microwave assisted Vigna mungo (M.V.M) 93%, Microwave assisted Zea mays (M.Z.M) 74.3%, Ultrasonic assisted Vigna mungo (U.V.M) 88.2% and ultrasonic assisted Zea mays (U.Z.M) 70% at 500 NTU is shown in Fig. 2.

Settling Column Test

The main theme of settling column test is find out optimum dosage of coagulants used for experiments. All the experiments duplicate was run. The settling column test was carried out no coagulant added in one beaker

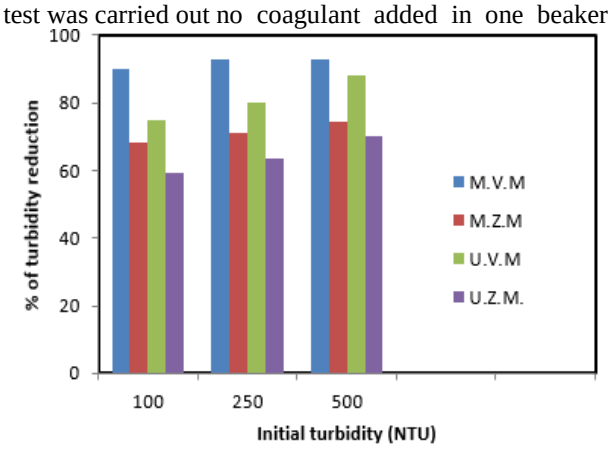

Figure 2. Microwave and ultrasonic assisted extraction method (initial concentration 100 to 500NTU, pH - 7,adsorbent dosage 25mL)

(blank) and five different types of coagulants such as Vigna mungo, Zea mays, Allium cepa peel ash, waste tea powder ash, Phyllanthus niruri ash were taken in corresponding dosage. The efficacy of maximum percentage of turbidity removal in Vigna mungo 12h settling time in initial turbidity of 100NTU, 250NTU, 500NTU removal efficiency was 56, 69 and 78% respectively. The maximum turbidity removal obtained Zea mays 12hours settling time in initial turbidity of 100, 250 and 500NTU removal efficiency are as 45, 56 and 70%, respectively. The maximum turbidity removal efficiency obtained for Allium cepa peel ash at 6h settling time in initial turbidity of 100, 250 and 500NTU removal efficiency are as 90, 93 and 96%, respectively. Waste tea powder ash, Phyllanthus niruri ash both are approximately similar percentage of turbidity removal efficiency compared to Allium cepa peel ash. Initial turbidity of synthetic wastewater 100, 250, 500NTU removal efficiency were as 87, 91 and 95%, respectively. Allium cepa peel, waste tea powder and Phyllanthus niruri activated carbon did not remove the turbidity from synthetic wastewater. Maximum turbidity removal efficiency of different coagulants is shown in Table 1. It can be observed that all ash coagulants exhibit similar behavior except Vigna mungo, zea mays powder coagulants. Ash coagulants which was found as the most efficient between them.

Effect of Settling Time

The efficacy of settling time in turbidity removal was increasing the settling time the percentage of turbidity removal efficiency increased. The maximum percentage of turbidity removal 500NTU synthetic wastewater (300mL) for the 0.3g coagulant dose occurred at a time of 12h.Then increasing the settling time of synthetic wastewater equilibrium is attained. Allium cepa peel ash, Phyllanthus niruri ash and waste tea powder ash 0.2g

added 6hours contact time. Fig. 3 shows that the percentage of turbidity removal in Vigna mungo 70%, Zea mays 50%, Allium cepa peel ash 98.5% ,waste tea powder ash 97.3%, Phyllanthus niruri is 97% of turbidity reduction takes place. Ash coagulant to remove the turbidity of synthetic wastewater at short time compared to Vigna mungo and Zea mays.

Table 1.

Coagulants	Dose used(mg/L)	%Turbidity reduction 100NTU	%Turbidity reduction 250NTU	%Turbidity reduction 500NTU
Vigna mungo	0.1	43.2	53.0	45.8
	0.2	60.0	57.3	56.3
	0.3	67.2	63.5	68.0
	0.4	73.9	71.6	75.7
Zea mays	0.1	30.0	33.8	35.4
	0.2	33.4	37.2	42.2
	0.3	38.0	39.0	45.5
	0.4	42.2	47.0	50.8
Allium cepa peel ash	0.1	69.8	73.2	75.0
	0.2	83.5	78.0	88.3
	0.3	89.6	85.3	93.0
	0.4	95.5	97.8	98.3
Tea powder ash	0.1	83.0	77.8	85.2
	0.2	86.5	86.5	87.0
	0.3	87.0	90.3	93.4
	0.4	90.3	96.8	97.3
Phyllanthus niruri ash	0.1	77.7	89.0	87.5
	0.2	83.4	93.5	89.0
	0.3	87.5	95.2	94.6
	0.4	93.2	96.0	98.7

Effect of Initial Concentration

Regarding turbidity removal from synthetic raw water from 100 to 1000NTU Vigna mungo, Zea mays NaCl extract, most efficient turbidity removal compared to raw powder. In order to compare the efficiency of turbidity removal in different initial concentration, maximum turbidity removal attained at highly turbid water at neutral pH. Maximum percentage of turbidity removal achieved in 20mL of Vigna mungo 0.5M NaCl extract 87% for 7hours settling time. Zea mays 0.5M NaCl extract 69% of optimum turbidity removal was achieved. Initial concentration increases the corresponding amount of coagulant dosage were needed. After 500NTU slightly decreasing turbidity removal efficiency is shown in Fig. 4.

Effect of Combined coagulant

In order to compare the turbidity removal efficiency of natural coagulants such as Vigna mungo and Zea mays mixed with aluminium sulphate 3:1 ratio increasing the performance of turbidity removal from synthetic raw water. Aluminium sulphate 0.2g optimum dosage was mixed with 100 to 500 NTU initial turbidities stirred for 1h, 400rpm at neutral pH. Maximum turbidity removal efficiency occurs 99% but the major drawback of this study excess amount of alum present in water it leads to Alzheimer's diseases and other health effects. The mixed coagulant have better turbidity removal efficiency compared to raw powder. A 93% of turbidity removal efficiency occurs at mixed Vigna mungo, 85.3% for Zea mays were observed is shown in Fig. 5.

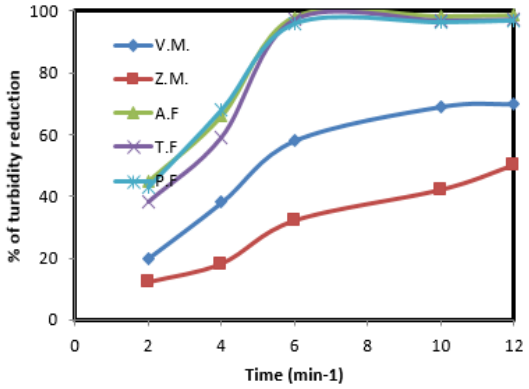

Figure 3. Effect of Time (Various time, Adsorbent dosage Vigna mungo, Zea mays-0.3g, other coagulants -0.2g, pH-7)

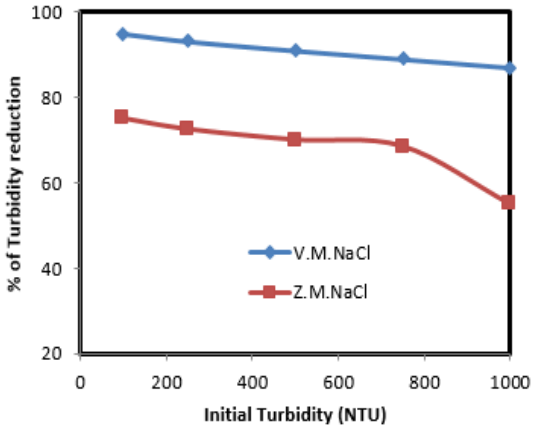

Figure 4. Effect of initial concentration (pH-7, Initial concentration 100 to 1000NTU, Stirring speed 400rpm,adsorbent dosage-25mL)

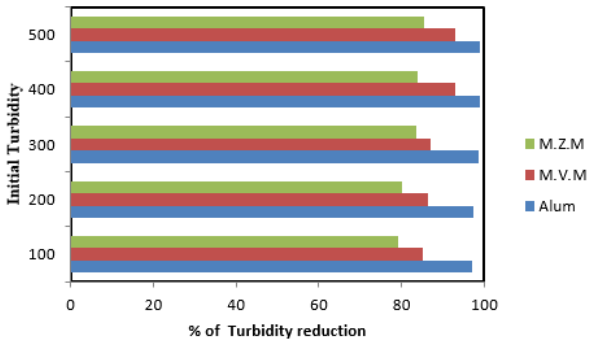

Figure 5. Effect of Combined coagulant (Alum dosage-0.2g, Mixed coagulant 3:1, pH-7)

Impact Assessment to The Society and Description of The Problem

In present possibilities of these study natural coagulants used in water treatment it is environmental friendly method. The applicability of natural coagulants it is easily applied in rural areas. It produces lesser volume of sludge due to biodegradable nature of sludge. After treatment of sludge is used as biocompost/biofertilizer, additional cost benefits include the avoidance of specific equipment. Natural coagulants such as Vigna mungo, Zea mays are used in water treatment it produce the smell. It is applicable only small scale process. The sludge produced bacterial contamination of the treated water proper disposal is required. Protein presents in the Vigna mungo, Zea mays leading to increase the chemical oxygen demand and organic matter of the treated water. Future studies purified protein extract is used doesn't increase the Chemical oxygen demand.

CONCLUSION

The main conclusions that can be withdrawn from this study aimed to investigate natural coagulant were used to investigate the turbidity from synthetic raw water. More efficient treatment was achieved in turbidity removal from highly turbid synthetic raw water. Based on laboratory experiments it was found that natural coagulants was effective in reducing by 70 to 97% in synthetic and surface water samples. Natural coagulants used in this study are readily available in many tropical countries. The decreasing order of highest percentage turbidity removal achieved Allium cepa peel ash, waste tea powder, Phyllanthus niruri, Vigna mungo, Zea mays. All parameters carried out at neutral pH.

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Persian Abstract

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