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A Review on Native Plant Based Coagulants for Water Purification

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Abstract

Potable, wholesome water is only a basic entity but also basic right for every individual. Extensive and exhaustive studies have been taken up previously; unfortunately complete solutions for drinking water problem has not been achieved (or) are not been made available for most of the population. Nevertheless, every population/ community has been bestowed with age old practices for treatment of water. In the process of development these practices has been either forgot or neglected. Hence, there is a need to search for the native materials which can be used for water purification as these can provide technology near to the point of use that can be adapted by communities. In these lines, the present study has been focused on reviewing natural coagulants for water treatment owing to the disadvantages of chemical coagulants. International and National works on natural coagulants and their efficiency was discussed in detail. This study will not only through light on the traditional knowledge but also provide an insight of the available natural coagulants.

Key Words: Natural Coagulants, Water Treatment, Point of Use, Seeds.

INTRODUCTION

Water is a vital substance and of great importance in all natural and anthropogenic activities. It regenerates shape and oceans and seas, rivers, lakes and forests, becoming part of the identity of environments and landscapes and of paramount importance for the development of ecosystems and human life. While in the past it

has been considered an infinite good, but currently misuse, coupled with growing demand, has made reserves of fresh and clean water decrease (Telles and Costa, 2007).

Because of its ability to solubilize the pure water is not found in nature. Dissolved impurities comprise minerals, organic compounds and gases that alter the physical (turbidity, color, temperature, electrical conductivity), chemical (chemical and biological demand for oxygen, pH, alkalinity, total organic carbon) and biological characteristics of water, whose effect depends on the composition, concentration and chemical reactions between pollutants (Richter and Netto, 2003).

The quality of water that reaches the consumer is determined by parameters that establish the maximum concentration of substances contained in the product, which must be respected (DI Bernardo et al., 2002). In this context, water treatment is the removal of suspended and colloidal particles, organic matter, micro-organisms and other substances that are deleterious to health, seeking the lowest cost of deployment, operation and maintenance and reduced environmental impacts to the surrounding region (Libanius, 2008).

In India the majority population still lives in villages and small towns. These rural/tribal communities do not have access to public water supplies. This population obtains their water supply from unprotected sources such as open dug wells or small Streams and ponds which are polluted. The treatment of water in these areas has a unique problem. Therefore, there is an urgent need for development and widespread promotion of simple treatment techniques for rural/tribal areas.

This review attempts to provide collective information of indigenous coagulants for treating water as studied by assorted researchers from International to regional levels.

INTERNATIONAL LEVEL

Table below presents information of authors who have worked with various natural coagulants. Description below provides the process of use and efficiency of these coagulants.

S.No	Plant coagulant	Authors	Year	Plant Part Used
1	Moringa oleifera	Hassan, Musand, Burgstaller.	1986	Seeds
		Mohammad, Ahmad hussain Birima.	2001	
		J.Yusuf,Yuakubu,balarabe	2015	
		Mihael Lea.	2010	
		Md. Asrafuzzaman et al.,	2011	
		M. Madsen et al.,	1987	
		S.A Muyibi and C.A Okuofu	1995	
		C. R. Shultz et al.,	1984	

		S. Muyibi et al	2002	
		S. Muyibi et al	2003	
		S.A., Muyibi and L.M., Evison	1995	
		S. A. Muyibi etal.,	2003	
		S. Bhatia et al.,	2006	
2	Vigna anguiculata	Nancy josham,Mwaisumo,Marobha.	2008	Seeds
		Davis D.W. et al.,	1991	
		Marobhe N.J. et al.,	2007	
		Annika Blix	2011	
3	Parkinsonia aculeate	Francis, J.K.	2009	Seeds
		Annika Blix	2011	
		Marobhe et al.,	2007a	
		Marobhe et al.,	2007b	
		Marobhe N.J. et al.,	2013	
4	Opuntia spp.,	S. M. Miller et al.,	2008	Pods
		Y. C. Yang et al.,	2007	
5	Jatropha curcas	Pritchard,mkandawire,Edmdson,Neil,Kululanga.	2009	Seeds
6	Cicer arietinum, Dolichus lab-lab.	Md. Asrafuzzaman, A. N. M. Fakhruddin, and Md. Alamgir Hossain.	2011	Seeds
		ECR, Bangladesh.	1997	
		S. A.Unnisa et al.,	2010	
		Moa Megersa et al.,	2014	
7	Prosopis laevigata	Luis G. Torres, et al.,	2012	Seed gum(prosopis)
		C.-Y. Yin	2010	
		L. Chairez-Martínez et al.,	2008	
8	Opuntia Ficus indica	Luis G. Torres, et al.,	2012	Mucilage(ficus)
		C. Saenz et al.,	2004	
		J. D. Zhang et al.,	2006	
		P. Miretzly et al.,	2008	
		S. M. Miller et al.,	2008	
		E. R. Bandala et al.,	2012	
9	Cassia alata	Aweng E.R., et al.,	2012	Leaves
10	Arachis hypogea(peanut seeds)	Birima, A.H., Hammad, H. A., Desa, M.N.M., Muda, Z.C.	2012	Seeds
11	Water melon	Muhammad,I.M., Abdulsalam, S., Abdulkarim, A. and Bello, A.A.	2015	Seeds
12	Coccinia indica	Varsha Patale and Jay Pandya	2012	Mucilage
		Diaz A et al.,	1999	
		Nkurunziza et al	2009	
		Mishra et al	2004	
13	Mustard and Moringa	Bodlund I et al	2014	Seeds

14	Strychnos potatorum	C. R. Shultz and D. A. Okun	1984	Seeds
		Y. C. Yang et al.,	2007	
15	Opuntia dillenii	Alima et al.,	2003	Mucilage
		Sarah et al.,	2008	
		Moa Megersa et al.,	2014	
16	Trigonella foenum-graecum	Moa Megersa et al.,	2014	Seeds

Moringa oleifera (drum stick) seeds:

The seed kernels of *Moringa oleifera* contain significant quantities of a series of low molecular weight, water-soluble proteins which, in solution, carry an overall positive charge. The proteins are considered to act similarly to synthetic, positively charged polymer coagulants. When added to raw water the proteins bind to the predominantly negatively charged particulates that make raw waters turbid (silt, clay, bacteria etc.). Under proper agitation these bound particulates then grow in size to form the flocs, which may be left to settle by gravity or be removed by filtration (Maruti Prasad and Srinivasa Rao, 2013).

Moringa oleifera powder has been reported to have the capability of reducing low and high turbidity values in surface water (C. R. Shultz et al., 1984, R. Sanghi et al., 2006; M. Madsen etal., 1987; S.A Muyibi et al., 1995; S.A., Muyibi et al., 1995; S. Muyibi et al., 2002; S. A. Muyibi et al., 2003; S. Muyibi et al., 2003). *Moringa oleifera* was used as a natural coagulant in a full-scale treatment trial at the water treatment works in Malawi. Turbidity values as high as 270–380 NTU were reduced to around 04 NTU, which are within the WHO (2006) guideline value with the addition of the powder (S. Bhatia et al., 2006).

Kingdom: **Plantae**
(unranked): **Angiosperms**
(unranked): **Eudicots**
(unranked): **Rosids**
Order: **Brassicales**
Family: **Moringaceae**
Genus: ***Moringa***
Species: ***M. oleifera***

Vigna unguiculata:

Vigna unguiculata (eng. “cowpea”, swa. “choroko”) is an annual legume plant. It is well known in Tanzania as a food crop and for animal fodder. The flowers are mostly

self pollinating and give pods carrying the seeds. Vigna unguiculata can be used as a nitrogen fixing crop and for erosion control. It grows in warm and dry conditions, with temperatures
above zero. The crop is preferably grown well-drained, sandy loams or soils. Vigna unguiculata is drought resistant, which makes it an important crop in many underdeveloped parts of the world. Mature green seeds are normally harvested mechanically by some type of mobile viner (Davis et al, 1991).

The active agents of Vigna unguiculata are expected to be at least two different coagulating proteins with a molecular weight of about 6 kDa (Marobhe et al, 2007b) (Annika Blix, 2011).

Kingdom:	**Plantae**
(unranked):	**Angiosperms**
(unranked):	**Eudicots**
(unranked):	**Rosids**
Order:	**Fabales**
Family:	**Fabaceae**
Genus:	***Vigna***
Species:	***V. unguiculata***

Parkinsonia aculeate:
It is a short shrubby tree which can reach a height of 10 m. It belongs to the Fabaceae family. It has yellow fragrant flowers that are pollinated by bees and give fruits carrying one to several seeds. Parkinsonia aculeata will grow in many different soils, in everything from sand dunes, clay soils, strongly alkaline, chalky and mildly salty soils. It is heat resistant and can survive in dry areas with an annual rainfall of less than 300 mm. The tree produce two different type of seeds, about 25 % of them are soft and will germinate without pretreatment, the rest have hard seed shells and requires processing to germinate (transportation through water or animals)(Francis, 2009) (Annika Blix, 2011).

Laboratory studies have been conducted on effectiveness of crude extract of *P. aculeata* seeds has revealed that the seeds are effective polyelectrolyte coagulants for clarifying natural and synthetic turbid water (Marobhe et al., 2007a; Marobhe et al., 2007b). The coagulant protein from *P. aculeata* (PAP) seeds are cationic proteins that can be purified using simple technique that can be scaled up to purify coagulant proteins for treatment of water for drinking purpose in poor communities. It reduces the turbidity and most other pollutants in coagulated charco dam water samples to levels that comply with TDWQS. The turbidity removal efficiency of PAP and alum was very similar.(Marobhe N.J., 2013).

Kingdom:	**Plantae**
(unranked):	**Angiosperms**
(unranked):	**Eudicots**
(unranked):	**Rosids**
Order:	**Fabales**
Family:	**Fabaceae**
Genus:	***Parkinsonia***
Species:	***P. aculeata***

Jatropha curcas:
Jatropha curcas seed and press cake powder were used as coagulants against kaolin solution as the model wastewater. The Jatropha seed was found to be an effective coagulant with more than 96% of turbidity removal at pH 1-3 and pH 11-12. The highest turbidity removal was recorded at pH 3 using a dosage of 120 mg/L.

Kingdom:	**Plantae**
(unranked):	**Angiosperms**
(unranked):	**Eudicots**
(unranked):	**Rosids**
Order:	**Malpighiales**
Family:	**Euphorbiaceae**
Genus:	***Jatropha***
Species:	***J. curcas***

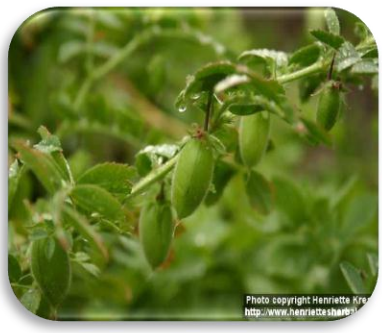
The flocs formed using Jatropha were observed to be bigger and to sediment faster when compared with flocs formed using alum. The turbidity removal was high (>98%) at all turbidities (100 NTU to 8000 NTU), suggesting its suitability for a wide range of industrial wastewater. The performance of Jatropha press cake after extraction of oil was also comparable to the fresh seed and alum at highly acidic and highly alkaline conditions. The addition of Jatropha did not significantly affect the pH of the kaolin samples after treatment and the sludge volume produced was less in comparison to alum. (Zurina et al 2011).

Cicer arietinum and Dolichos lablab:
Powder of Cicer arietinum (commercial name bashion) was bought from local market of Dhaka city. The grains of powder were maintained approximate size less than 600 µm to achieve solubilization of active ingredients in the seed. Mature seeds of Dolichos lablab were used in the study. After sun dry, external shells were removed and seed kernel were obtained. Using grinder, fine powder achieved from seed kernel.

Kingdom:	**Plantae**
(unranked):	**Angiosperms**
(unranked):	**Eudicots**
(unranked):	**Rosids**
Order:	**Fabales**
Family:	**Fabaceae**
Genus:	***Lablab***
Species:	***L. purpureus***

The results using Cicer arietinum for higher-, medium-, and lower-turbidity-range comply with the Bangladesh drinking standard and the WHO guidelines (ECR, Bangladesh, 1997; WHO, 2006). Cicer arietinum was found most effective for coagulation when the dose were 100 mg/L for high-, medium-, and lowturbidity water at a 3-min slow mixing time, 12 min slow mixing, and 30 min settling time. Cicer arietinum is cheap, easily cultivable, and available in Bangladesh. On the other hand naturally occurring coagulants are biodegradable and presumed safe for human health.

Kingdom:	**Plantae**
(unranked):	**Angiosperms**
(unranked):	**Eudicots**
(unranked):	**Rosids**
Order:	**Fabales**
Family:	**Fabaceae**
Genus:	***Cicer***
Species:	***C. arietinum***



A study was conducted using Dolichos lablab as natural coagulant for reduction of turbidity by Unnisa et al. (S. A. Unnisa et al., 2010), and the study showed that initial turbidities of 20 (low), 40 (medium), and 80 (high) NTUs mainly considerably decreased when the coagulant doses increased. Coagulation was the most effective at a dose of 200 mg/500 mL, when the coagulation activity of the Dolichos lablab seed extract was 65, 62, and 68% at a 60 min settling time. So the use of locally available materials like beans provides a better option for clean, safe water accessible to rural people. (Md. Asrafuzzaman et al., 2011).

Prosopis laevigata:

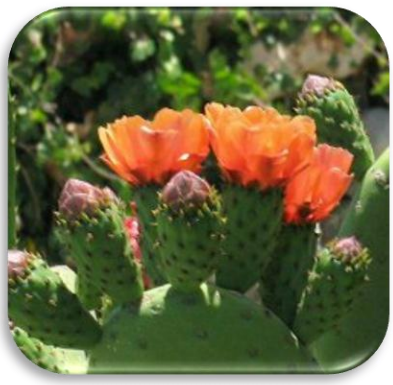
Prosopis laevigata (Humb. Et Bonpl. Ex Wild), also known as Prosopis dulcis, Mimosa rotundata, Neltuma laevigata and Acacia laevigata (among others), is a tree with maximum height of up to 13 m and a diameter of 0.8 m. The whole tree is used as a source of firewood and its pods are used as fodder for cattle (sheep and goats). The endosperm portion of the seed contains galactomannan gum, very similar to guar gum.

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Rosids
Order:Fabales
Family: Fabaceae
Genus: Prosopis
Species: P. laevigata

In order to differentiate the plant exudates and the gum contained inside the endosperm, this gum will be called seed gum. The Prosopis galactomannans share many characteristics with other related galactomannans such as locust bean, guar and tara gums (L. Chairez-Martínez et.al., 2008). These characteristics include its capabilities as thickening agents, the low surface tension of gum dispersions, the tendency to form gels alone or when combined with other gums (such as carrageenan, agar and xanthan gum). Finally, galactomannans can act as a coagulant-flocculant agent for treating wastewaters and waters for human consumption (C.-Y. Yin,2010).

Opuntia ficus-indica:
Opuntia ficus-indica is a cactaceae from arid and semiarid regions, in the form of shrub or tree up to 5 m tall, forming a sturdy trunk when aging. The use of Opuntia sp. as coagulant in water treatment has been reported by some authors (C. Saenz et al., 2004; J. D. Zhang et al., 2006). Besides, (P. Miretzly et al., 2008) have reported the use of Opuntia streptacantha as a low cost biosorbent for lead in water treatment.

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Core eudicots
Order: Caryophyllales
Family: Cactaceae
Genus: Opuntia
Subgenus: Opuntia
Species: O. ficus-indica



Though the use of Opuntia sp. mucilage (or the whole cladode dry powder) has been proposed as a coagulantflocculant agent, most of these works used real or simulated wastewaters (most of them simulated ones) where only changes in turbidity have proven the efficiency of Opuntia mucilage as coagulant-flocculant agent (J. D. Zhang et al., 2006, S. M. Miller et al., 2008). In another work (E. R. Bandala et al., 2012),

the whole cladode, dried and milled was used as a coagulant-flocculant agent with excellent results.

Cassia alata:
The plant leaves of Cassia alata was used to test coagulant rate and dose. The experiments were carried out with coagulant dosage of 0.5, 1.0, 1.5, 2.0, 2.5 and 3 mL/L with the intervals of 0.5 mL/L. The results have shown that Cassia alata leaves can remove turbidity up to 93.33% at the optimal dosage of 1.0 mL/L. In addition, the potential of Cassia alata leaves to remove other pollutants presence in the river water like suspended solids, ferrous, manganese and pH was also identified. On the other hand, the leaves of Cassia alata can remove suspended solids by 56.4% but no other parameters. (Aweng et al 2012).

Kingdom:	**Plantae**
(unranked):	**Angiosperms**
(unranked):	**Eudicots**
(unranked):	**Rosids**
Order:	**Fabales**
Family:	**Fabaceae**
Subfamily:	**Caesalpinioideae**
Tribe:	**Cassieae**
Subtribe:	**Cassiinae**
Genus:	**Senna**
Species:	***S. alata***

Peanut seeds:
Turbidity removal of 93.2% was obtained by using peanut seeds as coagulant by Birima et al., 2013. When they used the extract of peanut using NaCl i.e PC-NaCl by 6 mol/l NaCl solution, they achieved 92% turbidity removal with initial turbidity of 200NTU using only 20mg/l of the extract.

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Rosids
Order:Fabales
Family: Fabaceae
Subfamily: Faboideae
Tribe: Dalbergieae
Genus: Arachis
Species: *A. hypogaea*

On the other hand the extract with distilled water resulted in only 31.5% removal of turbidity. From this they implied that the protein associations inside the peanut seeds are responsible for coagulation activity. They also found that KNO_3, KCl, NH_4Cl and $NaNO_3$ solutions were also good solvents to extract the active coagulant component for peanut seeds; leading to improvement of coagulation activity; with no much difference from NaCl solution in terms of efficiency.

Watermelon seeds:
Watermelon seeds powder was used as coagulant for treating medium turbid water with dose of 0.1g/L at pH 7, stirring time of 8 minutes and mixing speed of 100rpm which resulted in optimum removal of turbidity within the standards of WHO. When blended with alum, it caused unfavorable changes in the pH of the treated water. However with 20% alum as coagulant aid, the best color and turbidity removal at acceptable pH was obtained, with residual turbidity of 0.89 NTU and residual colour of 15TCU at a pH of 6.50 (Muhammad et al., 2015).

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Rosids
Order:Cucurbitales
Family: Cucurbitaceae
Genus: Citrullus
Species: *C. lanatus*
Variety: lanatus

Coccinia indica:
Varsha Patale and Jay Pandya in 2012 worked with fruit extract of *C.indica* and reported that its mucilage has higher efficiency in removing high turbidity in comparison with low turbidity. Highest turbidity removal (94%) was obtained with very high i.e. 100 NTU initial turbidity whereas the lowest turbidity removal of 82% was observed with water containing initial turbidity of 10 NTU. Their observation also stated that coagulation efficiency of *C. indica* mucilage is dependent on initial turbidity of water samples, their results were in correlation with studies done by other researchers (Diaz et al., 1999; Nkurunziza et al., 2009 and Mishra et al., 2004).

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Rosids
Order: Cucurbitales
Family: Cucurbitaceae
Subfamily: Cucurbitoideae
Tribe: Benin caseae
Subtribe: Benincasinae
Genus: Coccinia

Mustard and Moringa seeds:
Extract of Mustard (large) and Moringa seed showed coagulation activity of 70% and 85% respectively after 90 min. interestingly, seed extracts from other Mustard varieties had shown coagulation activity after heat activation at 95^0C for 5 h. However, the coagulation activity of Mustard seed extract against turbid pond water was higher (60%) compared to Moringa seed extract (50%). The peptide sequence analysis of 6.5 and 9 kDa proteins from mustard seeds was found to be homologous to Moringa coagulant protein and napin3, respectively. (Bodlund et al 2014).

Kingdom:Plantae
Division:Magnoliophyta
Class: Magnoliopsida
Order:Brassicales
Family:Brassicaceae

Strychnus potatorum seeds:
Strychnus potatorum suspension and alum solution were used either independently or in combination with spiked turbid water prepared in the laboratory. Reduction in turbidity was dependent on the raw water. Effective doses of Strychnus potatorum were found to be 0.25 to 3.5 mg/L. At lower doses as said it acts as good coagulant and acts as coagulant aid for water with higher turbidity 1000-3000 NTU. Shelf life of the suspension and its efficacy in coagulation were also determined, where in the prepared solution of Strychnus potatorum was kept for 4 days in refrigerator. The removal efficiency of Strychnus potatorum solution was observed better on second day as compare to first and third day after preservation. (Vijayaraghavan et al., 2011).

Kingdom: **Plantae**
(unranked): **Angiosperms**
(unranked): **Eudicots**
(unranked): **Asterids**
Order: **Gentianales**
Family: **Loganiaceae**
Genus: ***Strychnos***

Natural coagulants of plant origin have been used for water purification for many centuries. *Strychnos potatorum* (Nirmali seeds) was used as a clarifier between the 14th and 15th centuries BC.

Shultz and Okun (Y. C. Yang et al., 2007) together with Sanghi et al., (R.P. Singh et al., 2000) reported that seeds of the Nirmali tree were used to clarify turbid river water about 4000 years ago in India.

Opuntia dillenii:
Opuntia dillenii is a natural coagulant from the *Cactaceae* family. The preliminary phytochemical Screening of the powder of this plant showed that it contains tanins, saponins and mucilages. Flocculation and coagulation tests showed that *Opuntia dillenii* can be used in highly turbid water treatment. The removal efficiency varied from 89% to 93% for the turbidity and suspended solids, and from 4% to 15% for the obvious color in water when we used the optimum values of this natural coagulant (1 mL to 10 mL). The successive addition of this natural coagulant and the lime, gave a better elimination of turbidity and suspended solids, and a good reduction for the color. The removal efficiency of the turbidity and suspended solids became more than 95% and the one of the color between 67% and 94% (Alima et al., 2013).

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Core eudicots
Order: Caryophyllales
Family: Cactaceae
Genus: **Opuntia**
Species: O. stricta

The predominant coagulation mechanism for Opuntia spp. is adsorption and bridging, whereby clay particles do not directly contact one another but are bound to a polymer-like material form (Sarah et al., 2008). They reported that the galacturonic acid can be a component which plays a role in turbidity reduction by Opuntia spp. and independently, arabinose, galactose, and rhamnose were displayed no coagulation activity; however, added in combination with galacturonic acid, these sugars were able to reduce turbidity between 30% and 50%. Galacturonic acid added independently was able to reduce turbidity by more than 50%. (Moa Megersa et al., 2014).

Trigonella foenum-graecum seeds:
Seed extracts of Trigonella foenum-graecum (T. foenum-graecum) and Cuminum cyminum (C. cyminum) were prepared using distilled water and NaCl (0.5 M and 1.0 M) solution. Only 1.0 M NaCl extract of T. foenum-graecum had coagulation capability and did not depend on pH values. Further it showed that natural coagulant obtained from T. foenum-graecum is temperature (up to 100^0C) and pH stable (pH 4.0 - 10.0). Extract of C. cyminum had very minimal (16 ± 2) coagulation property. The seed extract of T. foenum-graecum showed about 80% coagulation properties, where as the best known natural coagulants such as *Strychnos potatorum* and *Moringa oleifera*, and chemical coagulant such as $Al2(SO4)_3$ showed around 90%, 65% and 95% respectively, which are used as standards for the present study. When compared with pond water, T. foenum-graecum extract treated water shows decrease in alkalinity, turbidity, $KMnO_4$ demand and total coli-form. (Ramamurthy et al 2012).

Dominio: **Eukaryota**
Regno: **Plantae**
Divisione: **Magnoliophyta**
Classe: **Magnoliopsida**
Ordine: **Fabales**
Famiglia: **Fabaceae**
Sottofamiglia: **Faboideae**
Tribù: **Trifolieae**
Genere: **Trigonella**
Species: ***T. foenum-graecum***

From the above discussion, studies carried out by Indian authors are summarized in the below table.

S.No	Plant coagulant	Authors	Year	Plant Part Used
1	Moringa oleifera	Jadhav and Mahajan	2011	Seeds
2	Trigonella foenum-graecum.	Ramamurty, Maheswari, Selvaganapathy, Sujatha, Chinnaswamy.	2012	Seeds
3	Coccinia indica.	Varsha patale, Jay pandya.	2012	Fruit mucilage

		Nirmalarani, Jadhav	2011	
		Mishra et al.,	2004	
4	Moringa oleifera, Okra.	Godhani, Adiyecha, Viradhia, Jani, Joshi.	2014	Seeds
		Sunitha singh,Sonal choubey.	2014	
		Maruti Prasad and Srinivasa Rao	2013	
		Shwetha chouhan et al.,	2015	
		A.Sethupathy	2015	
		S.Sotheeswaran, Vikashni, M.Matulute	2011	
5	Strychnus potatorum	Selvi et al.,	2014	Seeds
		Vijayaraghavan et al.,	2011	
		Nirmalarani, Jadhav	2011	
		Singh et al.,	2000	
6	Vigna unguiculata	Shwetha chouhan, Gupta, Jyoti singh	2015	Seeds
7	Dolichus lab-lab	Unnisa, Deepthi, Mukkanti.	2010	Seeds

CONCLUSION

Present technologies of water treatment have been created on the foundation of traditional practices/ methods, which have been ignored off late. In this review we have presented natural coagulants whose availability is innate, their efficiency is also presented so that they can be considered for further study. It can be concluded that natural coagulants bring with them advantages of being, low cost, copious, native and efficient for treatment. Further studies in optimizing working parameter of the coagulants along with increasing shelf life will benefit research in this area.

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