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Utilization of Natural Coagulant for Chromium (VI) and Cadmium Removal from aqueous Solution

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Abstract: ***Heavy metal contamination in water is now a major environmental issue because of its toxicity and effects. Forremoval of heavy metals various treatments are given to water such as reverse osmosis, solvent extraction, chemical oxidation etc. but these are expensive. In present work, Coagulation process is used for removal of Hexavalent Chromium and Cadmium from aqueous solution using natural coagulants. The potential of pumpkin seed (Cucurbita pepo) and soybean (Glycine max) is investigated to remove Cr (VI) and Cd (II).Protein present in seeds is main constituent for removal. Batch scale experiments are carried out and various experimental parameters such as pH, Coagulant dose, Stirring rate, Initial metal concentration and Coagulation time. The optimum pH for maximum uptake of Cr was at 6 and for Cd was at 7.As per results the removal efficiency for Cr(VI) using soybean and pumpkin seed are found about 90.2% and 92.2% respectively .The removal efficiency for Cd(II) using soybean and pumpkin seed are found about93.5% and 93.3 % respectively.***

Keywords: Coagulation, Natural coagulant, Heavy metal, Soybean, Pumpkin seed

1. Introduction

Water pollution is growing now a days as a result of rapid industrialization. Water contamination is a major issue world is facing today. The main source of heavy metals in water are industries and mines. Agricultural waste and household waste discharges are also responsible for heavy metal contamination. Chromium and Cadmium are highly toxic and hazardous among 59 elements classified as heavy metals. There are various treatment methods to remove these heavy metals such as solvent extraction, reverse osmosis, ion exchange, chemicaloxidation, fluidized bed reactor, chemical precipitation, coagulationetc. [7]. Drawback of these methods are that, these are expensive, required expensive chemicals and doesn't remove heavy metals completely. As per USEPA the permissible limit of Cr (VI) and Cd in drinking water are 0.05ppm and 0.005ppm respectively.

In this study Soybean and Pumpkin seed are used as natural coagulant to remove Cr (VI) and Cd (II) from water with coagulation process. The main objective of this study is to give cost effective and eco-friendly method to remove heavy metals from water. As coagulants are natural will have no adverse effects on consumption of treated water with these natural coagulant. In soybean seed the main constituent for removal of heavy metal is proteins which act as polyelectrolyte. It contains 36.49gm of protein and other constituents such as carbohydrates, calcium, iron, phosphorus, magnesium, potassium, sodium and zinc, amino acid and functional groups. In Pumpkin seed contains 33.92gm of protein. It also contains minerals, sterols and fatty acids. Protein binds with metal ion and destroy them in water. They form complexes with metal ion.Metal ion removes from water with specific mechanism of adsorption. In case of seeds used as coagulant, the removal of heavy metal ions occurs due to adsorption and charge neutralization or adsorption and interparticle bridging [14]. It gives alternative option to those treatment methods which produce chemical sludge which is again creates major problem of its disposal. So by use of natural coagulants secondary pollution will not produce.

2. Materials and Methods

2.1 Preparation of synthetic samples

Cadmium sulphate ($3CdSO_4$, $8H_2O$) was used to prepare stock solution of Cd (II) and Potassium dichromate ($K_2Cr_2O_7$) was used to prepare stock solution of Cr(VI) in distilled water. Standard working solutions of Cr(VI) and Cd were prepared by diluting aliquots from stock solution in distilled water as per requirement. pH was adjust by using 0.1N hydrochloric acid (HCl) and 0.1N sodium hydroxide (NaOH) as per requirement. The chemicals used in this study were of analytical grade. Chromium was estimated using 1, 5-Diphenylcarbazide method UV-Visible Double beam spectrophotometer at 540 nm wavelength. Cadmium also estimated with UV-Visible double beam spectrophotometer using Alizarin Red S. at 422nm wavelength. For determining the concentration of both heavy metals, first a calibration curve should be plotted. This is done by preparing known standards and then measuring their absorbance.

2.2 Preparation of coagulants

Soybean and pumpkin seed were collected from local market of Nagpur, India. Seeds are washed with distilled water to remove the dirt. Then these washed seeds are dried in oven for 3 days at 100°C to remove the moisture from seeds. After drying, seeds are grind to powder and sieved through 600µm sieve. Thus coagulants were prepared and stored in airtight container. Before performing the experiments no additional treatment is given to coagulants.

2.3 Coagulant activity test

The study of coagulation using natural coagulants was performed in jar test apparatus having six beakers. The coagulation experiments were done for both Chromium and Cadmium using soybean and pumpkin seed powder as coagulant. A standard Jar test was performed with 100 rpm for 1 min for rapid mixing and 30 rpm for slow mixing for 15 min and allowed to settle for 60 min.After settlement sample was pipette out from 2cm below from surface of sample and filtered it through whatman filter paper No.1 In first step, Dose was fixed for maximum removal of Cr (VI) and Cd (II) using both materials. In second step effect of other parameters that is pH, coagulation time, stirring rate, initial metal concentration was studied.

3. Result and Discussion

3.1 Chromium

3.1.1 Effect of coagulant dose on Cr (VI) removal rate

Coagulant dosage plays an important role in coagulation process.The effect of coagulant dose on removal of Cr(VI) was studied by making six synthetic samples of concentration of 0.5mg/L for Cr (VI) metal ion.The coagulants are added in six samples with varying dose of 2, 4, 6, 8, 10,12g/L. As shown in fig.4 it is observed that as dose increases removal of metal ion also increases. This may be found due to increase in surface area for adsorption and increasing functional groups. ForCr(VI), soybean powder has given maximum removal efficiency of 90.2% at dose of 8g/L. Pumpkin seed has given maximum removal efficiency at 12g/L but the dose was fixed 6g/L as it will produce less sludge.

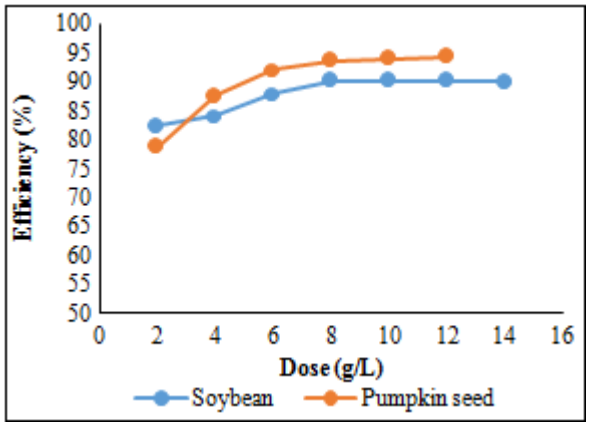

Figure 4: Effect of coagulant dosage on Cr(VI) removal of metal concentration of 0.5mg/L at pH of 6

3.1.2 Effect of pH on Cr(VI) removal rate

The effect of pH on removal efficiency of Cr(VI) was investigated with initial Cr (VI) concentration of 0.5 mg/L with coagulant dose of 8g/L for soybean seed and 6g/L for pumpkin seed. The removal of chromium is pH dependent. The effect was studied at pH range of 4, 5, 6…10.

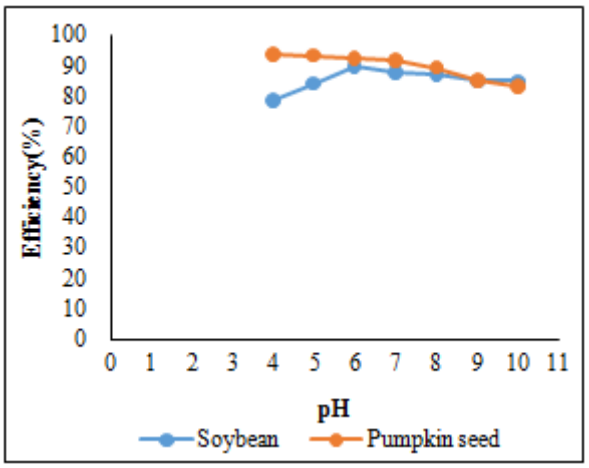

Figure 5: Effect of pH on Cr (VI) removal of metal concentration of 0.5mg/L with coagulant dose of 8g/L and 6g/L of Soybean and Pumpkin seed respectively

From figure 5, it is observed that in case of soybean, as pH increases removal of Cr (VI) decreases.The maximum removal was found to be 90% at pH 6.But in case of pumpkin seed removal increased upto pH 7 then it decreased and maximum removal was found at pH 7.

3.1.3 Effect of Initial metal concentration on Cr (VI) removal

The effect on removal of Cr(VI) was studied by preparing synthetic samples of concentration OF Cr (VI) ranges from 0.2, 0.4, 0.5, 0.6, 0.8 and 1mg/L. Dose of soybean of 8g/L and dose of pumpkin seed of 6g/L was mixed in each sample. The pH was not adjust for experiments. The experiments with soybean was done at pH 6 and with pumpkin seed at pH 7.

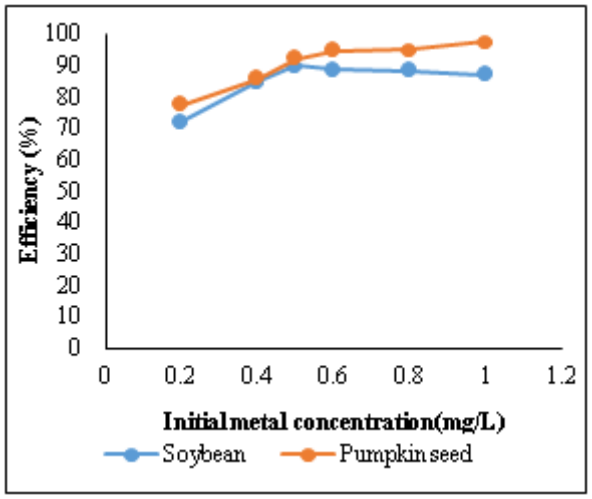

Figure 6: Effect of initial metal concentration on Cr(VI) removal with dose of 8 and 6g/L for soybean and pumpkin seed resp. at pH of 6 for soybean and 7 for pumpkin seed

From Figure 6, in case of soybean, it is observed that when initial concentration of chromium increased removal also increased upto 0.5 but after that it decreased as concentration increased. At concentration of 0.5mg/L removal was found maximum that is 90%.However in case of pumpkin seed it is observed that as concentration of metal increased removal efficiency also increased.

Maximum efficiency of 97.83% was found at concentration of 1mg/L.

3.1.4 Effect of Coagulation time on Cr (VI) removal

To evaluate, the effect of coagulation time on Cr (VI) removal, coagulation experiments were performed with coagulation time changes from 1,2,4,6 and 8 min.

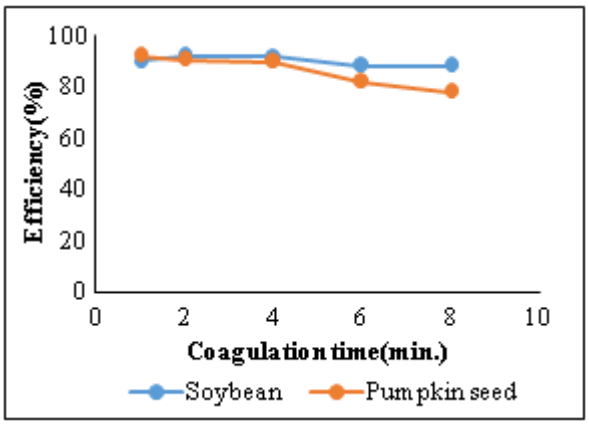

Figure 7: Effect of coagulation time on Cr (VI) removal with dose of 8g/L of soybean and 6g/L of pumpkin seed and 0.5mg/L concentration of Cr (VI)

As demonstrated in figure 7, it is evident that at time of 2min.Cr(VI) can be removed rapidly in case of soybean and efficiency was found 92%.However in case of pumpkin seed maximum removal of 92.2% was found at 1min.So it can be concluded that when coagulation time increases removal get decreases. This may happened because when time increased the small flocs get break down and adsorbed ions desorbed them in water.

3.1.5 Effect of stirring rate on removal of Cr (VI)

To evaluate the effect of stirring rate on removal of Cr(VI) was studied by varying agitation speed ranges from 15,30,45,60 rpm.As from figure 8, it is observed that as stirring rate increased the removal decreased .This may be due to breaking of flocs at higher stirring rate. At stirring rate of 30 rpm the removal efficiency found maximum about 90.2% and 92.2% using soybean and pumpkin seed respectively.

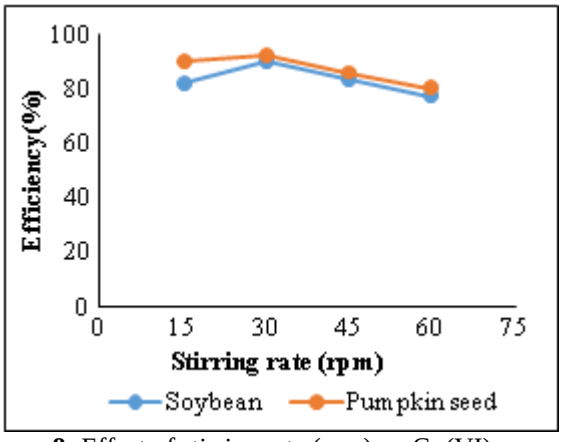

Figure 8: Effect of stirring rate (rpm) on Cr (VI) removal with coagulation time 1min. for 0.5 mg/L concentration of Cr(VI) and dose of soybean and pumpkin seed are 8g/L and 6g/L respectively.

3.2 Cadmium

3.2.1 Effect of coagulant dose on Cd (II) removal rate

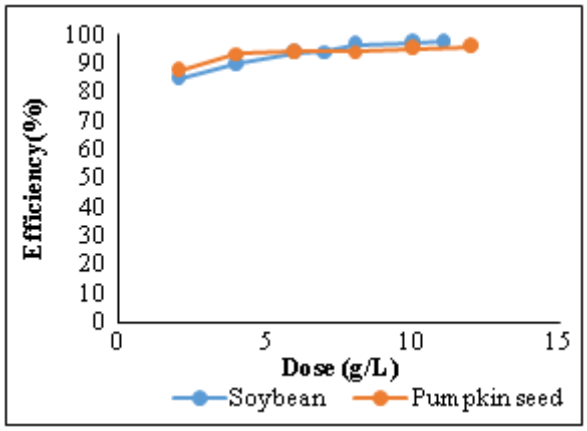

Figure 9: Effect of coagulant dosage on Cd (II) removal of metal concentration of 1mg/L at pH of 7.

To study the effect of dosage on Cd (II) removal and to know the optimum dose of coagulants synthetic samples were prepared of 1mg/L of Cd (II) metal ion concentration. As shown in graph of dose against removal efficiency it is observed that as dose is increased removal also increased for both materials. In case of soybean maximum removal was found 97.4% at 11g/L but 6g/L was taken as optimum dose. However in case of pumpkin seed maximum removal found 95.9% at 12g/L but in this case 4g/L dose was considered as optimum dose.

3.2.2Effect of pH on Cd (II) removal rate

In the study of pH batch experiments were carried out for pH ranges from 4 to 10.pH was adjust using 0.1N HCl acid and 0.1N NaOH solution. In case of soybean maximum removal found at pH 7 and then it goes on decreasing but not much fluctuation in removal. As shown in Fig. 10 the state of equilibrium was found in the range 6 to 8.In case of pumpkin seed pH found decreased from 4 to 10 and higher removal efficiency found at pH 4.it can be say that in acidic pH removal was good than in alkaline pH.

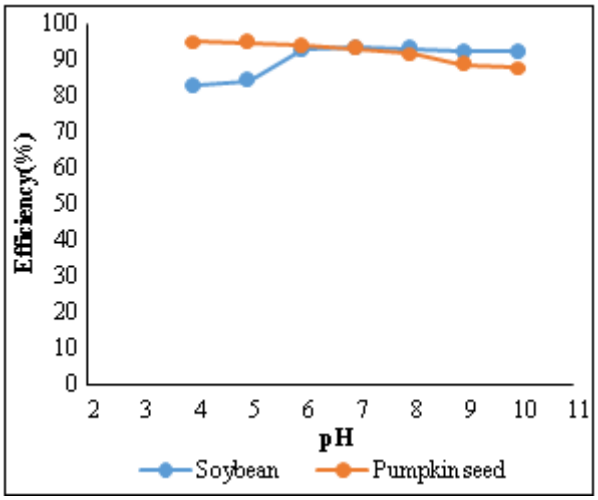

Figure 10: Effect of pH on Cd (II) removal of metal concentration of 1mg/L with coagulant dose of 6 g/L and 4g/L of Soybean and Pumpkin seed respectively at pH 7 and coagulation time of 1min.

3.2.3 Effect of Initial metal concentration on Cd (II) removal rate

The effect of initial metal concentration was studied for the metal concentration in the range of 0.5, 1, 2, 3, 4,5mg/L.As demonstrated in graph, removal by using soybean seed was found maximum that is 93.5% at 1 mg/L and after that again increase in concentration removal rate of cadmium decreases. Pumpkin seed has given maximum removal efficiency of 94% at concentration of 0.5mg/L.As initial concentration of ion increased removal capacity of pumpkin seed decreased.

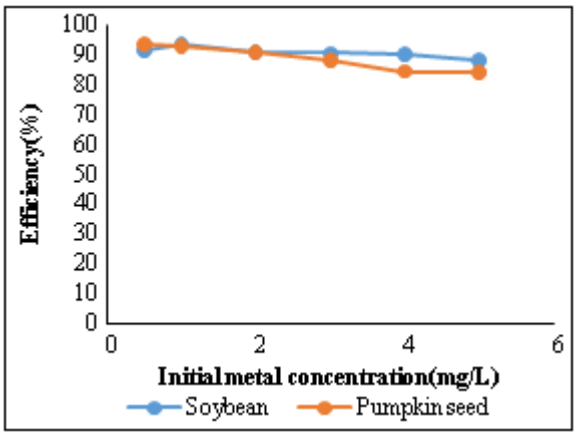

Figure 11: Effect of Initial metal concentration on Cd (II) removal with coagulant dose of 6 g/L and 4g/L of Soybean and Pumpkin seed respectively at pH 7 and coagulation time 1 min

3.2.4 Effect of coagulation time on Cd (II) removal

In this experiment, effect of coagulation time on Cd (II) removal was investigated with concentration of 1mg/L and coagulation time varying in the range from 1, 2,4,6,8 min with no adjustment in pH.

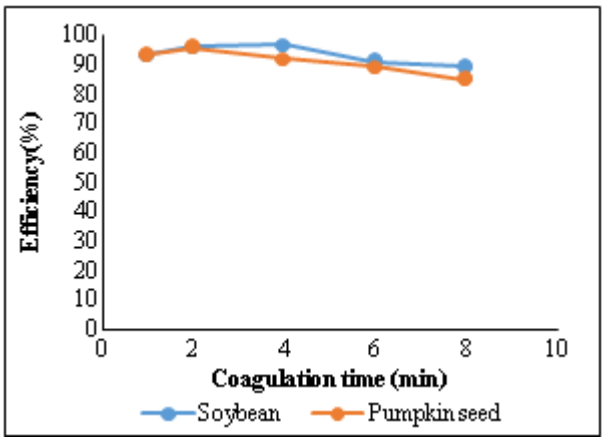

Figure 12: Effect of coagulation time on Cd (II) removal with coagulant dose of 6 g/L and 4g/L of Soybean and Pumpkin seed respectively at pH 7 and coagulation time 1 min.

Fig. 12 shows that the determination of optimum coagulation time for Cd(II) removal rate was carried out at 1 to 8 min.It was known that coagulation time affects the removal rate, when the coagulation time was 4.0 min, the removal rate was maximum about 97% for soybean seed and 96% for pumpkin seed at time 2min.When coagulation time is short, coagulant and metal ion doesn't get sufficient time to bind each other and process of adsorption bridging and charge neutralization occurs less. However when coagulation time is long, then small flocs may break and adsorbed metal ion again release into water. So it was found that at 6 and 8 min removal get decreased.

3.2.5 Effect of Stirring rate (rpm) on Cd (II) removal rate

To evaluate the effect of stirring rate on removal of Cr (VI) was studied by varying agitation speed ranges from 15,30,45,60 rpm.As from figure 8, it is observed that as stirring rate increased the removal decreased .This may be due to breaking of flocs at higher stirring rate. At stirring rate of 30 rpm the removal efficiency found maximum about 90.2% and 92.2% using soybean and pumpkin seed respectively.

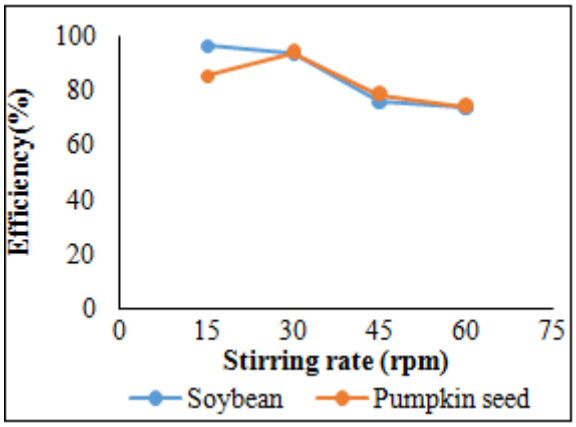

Figure 12: Effect of coagulation time on Cd (II) removal,coagulant dose of 6 g/L and 4g/L of Soybean and Pumpkin seed respectively at pH 7 and coagulation time 1 min

4. Conclusion

In this study, the coagulation test for removing Cr (VI) and Cd (II) have been researched. Other influencing parameters such as pH, coagulation time, initial metal concentration, stirring rate and dose of coagulant was investigated. Maximum removal of Cr(VI) was found about 90.2% at dose of 8g/L with initial concentration of 0.5mg/L at pH 6 using soybean as a coagulant. Removal of Cr (VI) using pumpkin seed as coagulant was found about 92.2% at dose of 6g/L. Cd (II) removal with initial concentration of 1mg/L using soybean seed was found 93.5% with dose of 6g/L at pH 7.In case of Cd (II) removal using pumpkin seed was found 93.3% with dose of 4g/L. From this study it can be concluded that for removal of Cr (VI) and Cd (II) from water, seed as natural coagulant found efficient. It gives eco-friendly and cost effective method to treat the water contaminated with these heavy metals. This study proved that both soybean and pumpkin seed have high potential to be used as low cost natural coagulant to remove Cr (VI) and Cd (VI) from water. Further study can be attempted to increase the removal capacity of coagulants by modifying coagulants, so existing results will be enhanced.

References

[1] Amruta D.Parkhi et al., Adsorption of Copper from Aqueous Solution Using Mango Seed Powder, Int. Journal of Engineering Research and Applications, Vol. 4, Issue 4, (2014) pp.75-77
[2] Arjum Virupakshi et al., Treatment of Tannery Wastewater Using Natural Coagulants, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 8, (2013), pp. 4061-4068
[3] G. Vijayaraghavan, Application of Plant based Coagulants for Waste Water Treatment,IJAERS, Vol. I, Issue I, (2011), pp. 88-92
[4] Government of India Ministry of Water Resources Central Water Commission, Status of Trace and Toxic Metals in Indian Rivers, (2014)
[5] Janet g. Hering et al.,Arsenic removal from drinking water during coagulation, Journal of Environmental Engineering, Vol. 123, No. 8, (1997), pp. 800-807
[6] Khairia M.Al-Qahtani, Assessment and Treatment some of the Local Seeds then used in Removal of Heavy Metals, Journal of American Science, (2015), pp. 198-203
[7] Kiran Pakhle et al., Adsorption Studies on Waste of VegetableMethi (Fenugreek) For Removal of Heavy Metal Ions fromAqueous Solution, J. Chem. Bio. Phy. Sci. Sec. D, February 2016 – April 2016, Vol. 6, No.2, pp. 312-320.
[8] Ravikumar K et al., Heavy Metal Removal from Water using Moringa oleifera Seed Coagulant and Double Filtration, International Journal of Scientific & Engineering Research, Vol. 4, No. 5,(2013), pp. 10-13
[9] Ravikumar K et al., Fluoride Removal from Water using Moringaoleifera Seed Coagulation and Double Filtration, International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August 2013,pp.
[10] Shaleesha A Stanley et al., Comparative Analysis of Cost Effective Bio sorbents in the Removal of Chromium and Iron from Aqueous Solution,Advanced Bio Tech., Vol.12, Issue 12 l (2013), pp. 1-5
[11] S. M. Sajidu et al.,Removal of lead, iron and cadmium ions by means of polyelectrolytes of the Moringa Oleifera whole seed kernel, WIT Transactions on Ecology and the Environment, Vol 80, (2005), pp. 251-258
[12] S.V.Maruti et al., Influence of Plant-Based Coagulants in Waste Water Treatment, IJLTEMAS, Vol. 5, Issue III, (2016), pp. 45-48
[13] Vikashni Nand et al., Water Purification using Moringa Oleifera and Other Locally Available Seeds in Fiji for Heavy Metal Removal,International Journal of Applied Science and Technology, Vol. 2, No. 5, (2012),pp. 125-129
[14] U. Hashim et al., Plant seeds-potential alternative as natural coagulant to treat water for turbidity, Journal of Applied Sciences Research, 9(2),(2013) pp. 1067-1073