Heavy Metal Removal (Pb & Cu) From Waste Water Using Pumpkin And Egg Shell Along With Chitosan As Filter Media

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Abstract

Sand filters are the most commonly used filter for water treatment. Filtration helps in reducing color, turbidity, odour and some pathogenic bacteria. Sand is one of the most exploited natural resource. Waste water generated at homes is rarely treated, causing environmental distress. Utilization of house hold waste materials such as egg shell waste, vegetable wastes such as pumpkin wastes etc is a partial solution to environmental problems. This project aims at designing a sustainable waste water filter that can be used for domestic and industrial purpose which helps in the removal of heavy metals such as lead and copper. This involves the comparative study of efficiency of filtration using egg shell waste and pumpkin wastes as a substitute for sand as filter media. The waste water is passed through the designed sustainable filtration technique and it is analyzed for physical and chemical characteristics. The use of chitosan which is widely known for its absorbent property has been proved to improve the efficiency of the filter unit by combining it with egg shell and pumpkin. The use of Chitosan when blended with locally available waste materials was found to increase the efficiency of filtration unit.

Keywords: Filtration, Sustinable Filtration, Heavy Metal Removal, Chitosan, Egg Shell, Pumpkin

1 INTRODUCTION

Water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from water. The goal is to produce water fit for a specific purpose. Most water is disinfected for human consumption (drinking water), but water purification may also be designed for a variety of other purposes, including fulfilling the requirements of medical, pharmacological, chemical and industrial applications. The methods used include physical processes such as filtration, sedimentation, and distillation; biological processes such as slow sand filters or biologically active carbon; chemical processes such as flocculation and chlorination and the use of electromagnetic radiation such as ultraviolet light. Purifying water may reduce the concentration of particulate matter including heavy metals, suspended particles, parasites, bacteria, algae, viruses, fungi, as well as reducing the concentration of a range of dissolved and particulate matter

Filtration is a common but effective technology for drinking water treatment and often it is cost effective in comparison with other advanced method. Different filter materials are used such as sand, gravel, charcoal, straw, stone etc. Chitosan is also used as filter material in assistance with sand and it is a good absorbent for metal as well. (Bushra A Giadh et.al, 2016)

Our environment is continually exposed to pollution by organic and inorganic compounds such as pesticides and metals. Heavy metals enter the water through a variety of sources, such as atmospheric deposition, mining, industry and agriculture. Because of the world's growing population and resource demands, the rate at which these compounds enter our environment has been on an upward trend. These metals can bioaccumulate, so scientists are motivated to develop purification and extraction methods using a variety of techniques . Some of these techniques have been successful but are expensive or have detrimental effects on the environment. This justifies the need to investigate additional methods for the filtration of waste water. So sustainable filtration methods are developed.

The filter materials used in this project are pumpkin, egg shell and chitosan. Sand is a most exploited material so here in this project we are replacing sand with a most suitable sustainable filter media with high heavy metal

removal efficiency. Chitosan is a white, hard, elastic, nitrogenous polysaccharide found in the exoskeleton as well as in the internal structure of invertebrates. The waste of these natural polymers is a major source of surface pollution in coastal areas. The production of Chitosan from crustacean shells obtained as a food industry waste is economically feasible. It can also kill microorganisms as well. It is biodegradable and is harmless in the human body. Chitosan also can be used as an absorbent in drinking water due to its structure and chemical properties. It has been used to remove mercury and fluoride in drinking waters.(Talukdar M.I et.al, 2014)

Eggshell membrane (ESM) contains many surface functional groups, including amines, amides and carboxylic groups. The team modified ESM with polyethyleneimine (PEI), which has known metal chelation properties, and they tested the resulting bioabsorbent for its ability to remove heavy metals from water. The properties of Pumpkin which are responsible for removal of heavy metal is high cellulose content and presence of carboxylic acid in pumpkin.

There are currently thousands of types of water filters on the market with the ability to purify water contaminated indifferent ways. However, most of these filtering methods are too expensive. Sustainable technologies are innovative, simple, and incorporate combinations of basic science and local waste materials to create usable and efficient filters.

The objective of this project to investigate the efficiency of filter by the replacement of sand with household wastes such as egg shell and pumpkin, investigate the efficiency of filter materials blended with Chitosan.

2. MATERIALS AND METHODS

The waste water used in the experiment was collected from a pharmaceutical industry in Thrissur. Latitude and longitude is 10.485860, 76.266242. The waste water was collected from raw effluent sump.

Materials: The materials used for the project are -

i. Chitosan
ii. Egg shell waste
iii. Pumpkin
iv. Sand and Gravel

Water Sample collection and preservation : Plastic container of 500 ml and 250 ml were used for sampling purpose . For the avoidance of further contamination and changes in parameter, sample were collected and stored in airtight sample bottle in refrigerator to maintain the temperature around 4 to 6ºC. (Talukdar et al,2014)

2.1 Preperation Of Filter Media

2.1.1 Eggshell

Around 20 eggshells were collected from daily kitchen waste rand washed with normal tap water followed by distilled water (using latex gloves to avoid contamination). The eggshells were left to dry on blotting paper to absorb excess water and were then subjected to the hot air oven at 50°C for 2 days. Once completely dried we pulverized and shred eggshells to fine particles using mortar and pestle followed by a mixer, later we sieved the pulverized adsorbent to obtained a homogenous size (Mrilalini et al, 2015)

2.1.2 Pumpkin

2 small size pumpkins were taken washed thoroughly. After removing stems, seeds, and inner membranes pumpkin was sectioned into small sizes, air dried then subjected to the hot air oven at 50°C for 2 days then they were pulverized into fine powder and were sieved to obtain uniform particle size. (Maitri et Al., 2017)

2.1.3 Chitosan

The shell of shrimp were collected from a Matsyafed outlet in the city and washed thoroughly. Then shells were washed with distilled water and dried. Then it is powdered.

2.1.4 Sand and Gravel

River sand was collected from Sasthamangalam (latitude and longitude;8.508815, 76.970292) and was sieved through 0.6micron IS sieve. Crushed gravel of size 4.75mm is used and it was also collected from Sasthamangalam

2.2 Experimental Setup

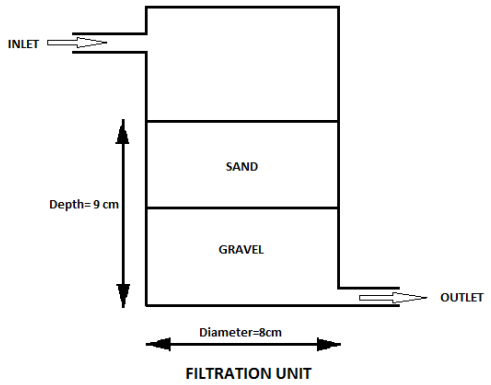

Fig 2.1 Cross section of Filtration unit

We replace sand with different filter media. The filter was designed as a slow sand filter to

treat about 1000 ml of sample per hour. Assuming rate of filtration as 200 L/hr/m^2 of filter area, the diameter was obtained as 8 cm. The filter unit consists of circular pipes at top and bottom of the compartment, one for the influent and other one for effluent. The optimum depth for the filter media is found out using sand and gravel and then sand is replaced with filter materials (pumpkin, egg shell and chitosan)

Fig 2.2 Filtration Unit

2.3 Procedure

The efficiency of filter media can be found out by the following three steps-

1. Optimisation of depth of filter media using sand and gravel
2. Optimisation of filter media using pumpkin and egg shell
3. Optimisation of filter media blended with Chitosan

2.3.1 Optimization Of Depth:

The water is poured into the filter media consisting of different configurations of sand and gravel through an inlet pipe. The rate of flow is maintained at 1L/hr. The filtered water flows downwards through different filter media to the lower compartment and then the effluent passes out through a pipe fitted in the lower compartment. The effluent is tested for its various characteristics to determine the efficiency and the optimum configuration. The filter is designed after testing the efficiencies of water obtained from different filter media configurations as described below:

Configuration 1: The filter media consists of full gravel.

Configuration 2: The filter media consists of 33% sand and 67% gravel. The influent was fed into the tank at a constant flow rate and the efficiency of the effluent was studied.

Configuration 3: The filter media consists of 50% sand and 50% gravel. The influent (domestic waste water) was fed into the filter at a constant flow rate and the efficiency of the effluent was studied.

Configuration 4: The filter media consists of 67% sand and 33% gravel. The influent was fed into the tank at a constant flow rate and the efficiency of effluent water was studied.

Configuration 5: The filter media consists of with full sand.

2.3.2 OPTIMIZATION OF FILTER MEDIA:

The sand layer in the filter is now replaced with powdered Egg shells and pumpkin separately .The influent water was fed in. The rate of flow is maintained at 1L/hr. The efficiency of effluent was studied. The influent was fed into the tank at a constant flow rate as used for optimum configuration design and the efficiency of the effluent was studied.(Pradip Kumar Dutta et.al,2004)

2.3.2.1.Pumpkin powder

The pumpkin powder is used plainly at first. The influent is fed and passed through the pumpkin powder and sand and gravel layer. The rate of flow is maintained at 1L/hr. The characteristics studied are turbidity, BOD, total solids, pH, lead content and copper content. The pumpkin powder is then mixed with same amount of Chitosan and the filtration is carried out, followed by the study of characteristics. The removal efficiency is observed to be greater for the filter media blended with Chitosan

2.3.2.2 Egg Shell Waste

The egg shell is used plainly at first. The influent is fed and passed through the egg shell waste and gravel layer. The rate of flow is maintained at 1L/hr. The characteristics studied are turbidity, BOD, total solids, pH, lead content and copper content. The egg shell waste is then mixed with 25g of Chitosan and the filtration is carried out, followed by the study of characteristics. The removal efficiency is observed to be greater for the filter media blended with Chitosan.

3. RESULTS AND DISCUSSIONS

3.1 Optimization Of Depth

The optimum depth of the filter media is obtained after studying the characteristics of the influent and the characteristics of effluent obtained from various configurations of sand and gravel. The results are as shown below:

Table 3.1 Characteristics of initial effluent

Odour	Foul smell
Ph	7.78
Turbidity	46.7 NTU
BOD	561mg/L
Total Solids	395 mg/L
Lead	0.93ppm
Copper	0.136ppm

Table 3.2 Removal efficiency for configuration with different percentage of sand

SAND (%) / PROPERTIES	0	33	50	67	100
Turbidity Removal efficiency (%)	66.34	94.57	96.81	91.06	96
BOD removal efficiency (%)	26.2	70.05	85.56	75.93	42.78
Total solids removal efficiency (%)	43.29	80.17	82.73	68.35	68.2

The configuration with 50% sand and 50% gravel was observed to be the most efficient and is chosen as the optimal configuration. Thus the thickness of each filter media to be used in the filter is decided as 3cm each that is 3cm thick gravel layer and above that 3cm thick layer of pumpkin powder, eggshell powder and chitosan blended with these two.

3.2 Optimization Of Filter Media Using Waste Materials

Table 3.3 Properties of effluent after filtration using pumpkin with and without Chitosan

Properties	**Without Chitosan**	**Blended with Chitosan**
Ph	7.79	8.86
Turbidity	228NTU	201NTU
BOD	392mg/L	343mg/L
Total solids	1832mg/L	1623mg/L
Lead	0.644ppm	0.303ppm
Copper	0.097ppm	0.0425ppm

Table 3.4 Properties of effluent after filtration using egg shell waste with and without Chitosan

Properties	**Without Chitosan**	**Blended with Chitosan**
pH	7.92	8.67
Turbidity	213NTU	190NTU
BOD	266mg/L	242mg/L
Total solids	1386mg/L	1050mg/L
Lead	0.56ppm	0.002ppm
Copper	0.068ppm	0.008ppm

Chitosan serves an important role in filtration. Along with sand filtration Chitosan can remove more unwanted particles in water than the sand filtration(which can remove up to 97.8% lead content, 94.11% copper content). There was an improvement in the floc size when Chitosan was used as a coagulant aid in conjunction with pumpkin and chitosan as compared to either Chitosan or waste materials alone. Poor performance was obtained when waste materials were added simultaneously. The use of Chitosan blended with eggshell as coagulant aid in filtration process decreased lead content and copper content, pH, BOD,Total solids and the residual turbidity.

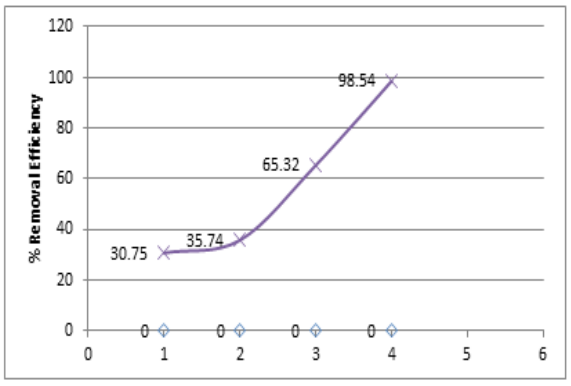

Fig 3.1 Removal efficiency of lead using pumpkin(1), egg shell(2), pumpkin with chitosan(3) and egg shell with chitosan(4) respectively

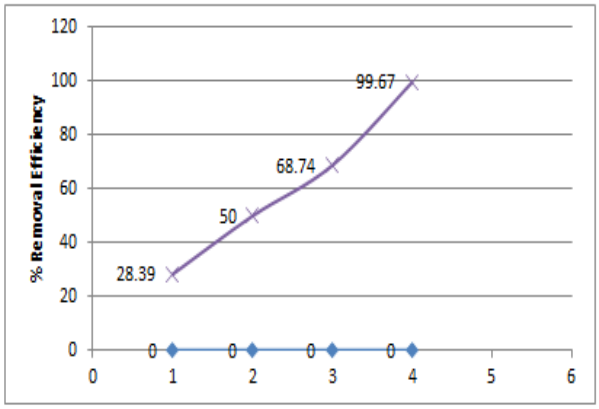

Fig 4.4 Removal efficiency of copper using pumpkin(1), egg shell(2), pumpkin with chitosan(3) and egg shell with chitosan(4) respectively

Table 4.5 General Standards of waste water effluents to be discharged on Inland surface water and properties of effluent after treatment with egg shell

Characteristic of effluent waste water	**Effluent of filter with eggshell along with chitosan as filter media**	**Tolerance limit** (Source-Environment protection Rules ,1986)
Lead	0.002ppm	0.1ppm
Copper	0.018ppm	3ppm

Optimum filter media: The optimum filter media was observed to be egg shell powder blended with Chitosan. The effluent can be discharged into inland surface water.

4. CONCLUSIONS

When filter with egg shell powder blended with Chitosan is used, the removal efficiency of lead, copper are 97.8%, 94.11%.It can be concluded that egg shell powder blended with Chitosan can be used as a replacement for sand in filter media. The effluent from filtration unit with eggshell powder blended with Chitosan can be discharged into inland surface water.

Eggshell membrane (ESM) contains many surface functional groups, including amines, amides and carboxylic groups. The team modified ESM with polyethyleneimine (PEI), which has known metal chelation propertiesis the reason for its ability to remove heavy metals from water

A sustainable water filter of this kind is easily adaptable. It requires no electrical energy, low operating costs, high rate of heavy metal removal efficiency, high reduction of BOD and solids, moderate area requirement are its advantages.

REFERENCES

[1] Heavy Metal Extraction from Industrial Waste-Water A Comparative Study Maitri M. Raval, Dipen Dhodi, Jinal A. Jariwala, Diksha Patel, Prof. Soumita Bid (IJIRSET May 2017)

[2] "Heavy Metal Removal from Wastewater Using Low Cost Adsorbents" AshutoshTripathi and Manju Rawat Ranjan(JBRBD,2015)

[3] Bushra A Giadhand Basim Y Al-khafaji. (2016). "The possibility of wastewater Treatment by some selective Filtrations", *International Journal of Recent Scientific Research* ,vol. 7, Issue, 1, pp. 8312-8316

[4] EPA: Environment Protection Agency. (2004). "Guidelines for water reuse", Washington DC: USA: US Agency forinternational Development, 2004; EPA /625/R-04/ 108, 18

[5] Madhukar M., Dayananda H.S., Chethan G., Dwithiya C., Chaithara K. R., Sajini B, Sandeep. (2012). "Performance Evaluation of Sand and Chitosan as Dual Filter Media", *International Journal of Engineering Science and Technology* (IJEST), 4(1), pp 349-352

[6] [6] Metcalf and Eddy Inc. (2003)."Wastewater Engineering Treatment and Reuse", McGrawHill, ISBN-10:0071241403.

[7] Pradip Kumar Dutta, V.S Tripathi. (2004). "Chitin and Chitosan: Chemistry, Properties and applications", *Journal of scientific and industrial research*, vol 63, pp 20-31.

[8] Talukdar M.I, Hasnine M.T. (2014). "Application of Chitosan based filtration technique for removal of heavy metals from surface water", *International research journal of environmental sciences*,vol 3(3),pp5-10.

[9] UmiAisahAsli, Nora Sikin Othman, AziatalNizaSadikin. et al. (2015)." Removal of oilywaste water using Chitosan filled filter media", *Journal Technology sciences and Engineering*,vol74:7,pp 111-115.

[10] Identification of optimum filter media configuration to improve the treatment efficinacy of pebble matrix filters N. S. Miguntanna1, C. P. G. Jayalath1, C. Kariyawasam1, H. A. K. C. Perera1, S. M. Sriwarnasinghe1, W. M. R. I. Wijerathna (SAITM Research Symposium on Engineering Advancements 2013)

[11] Application of Chitosan-Based Filtration Technique for Removal of Heavy Metals from Surface Water, Talukdar M.I. and Hasnine M.T.International Research Journal of Environment Sciences

[12] https://www.lenntech.com/processes/heavy/heavy-metals/heavy-metals.htm#ixzz59yxCPZwF