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REMOVAL OF IRON AND CHROMIUM FROM WASTE WATER USING NEEM AND TULSI LEAF POWDER AS FILTER BED

Grace K Mikhayel *Anitha K**
M. Tech Student, Department of Civil Engineering, Malabar College of Engineering and Technology
Desamangalam, Thrissur, Kerala – 679 532
Email– gracekmikhayel20@gmail.com
**Assistant Professor, Department of Civil Engineering, Malabar College of Engineering and Technology
Desamangalam, Thrissur, Kerala – 679 532

***Abstract*— It is well known fact that clean water is essential for healthy living. Adequate supply of fresh water is a basic need for all human beings on earth, yet it has been observed that millions of people world wise are deprived of this. Clean water use being a prime concern in many communities of developing communities. The quality and accessibility of drinking water are of great importance to human health. Drinking water may contain disease causing agents and toxic chemicals and to control the risks to public health, systematic water quality monitoring and surveillance are required.**

In this project I am try to develop a "Low cost water purification technique" using plastic bottles and locally available herbal materials like Neem leaf powder and Thulsi leaf powder. Main focus was removal of iron and chromium from pharmaceutical waste water. Filtration is the simplest and cheapest technique for the removal of metal components from waste water. The initial concentration of iron and chromium is 0.536 mg/L and 0.289 mg/L respectively. Neem with aluminium hydroxide is more efficient in removing iron content from waste water with efficiency of removal is 60.075%. Tulsi with aluminium hydroxide is more efficient in removing chromium from waste water with efficiency of removal is 93.77%. Thus it is below than the permissible limit and can be used for drinking and irrigation purpose

Keywords: Filtration, tulsi leaf powder, neem leaf powder, aluminium hydroxide, pharmaceutical waste water, iron, chromium.

I. INTRODUCTION

1.1 General

As a result of different human activities, world is facing serious threats of air, land and water pollutions. Water pollution in particular, has raised severe environmental impacts. In addition to the shortage of resources of water due to drought and misuse, production of large volumes of waste water has put a lot of pressure on the humankind. There are different kinds of water contaminants, among them inorganic pollutants are extremely harmful due to their high toxicity and non-biodegradability.

The accumulation of heavy metals certainly has adverse effects on aquatic flora and fauna and may constitute a public health problem where contaminated organisms are used for food. They can cause poisoning, initiate cancer and result in brain damage. In some of the rural areas, women use cotton cloth layers for water filtration. This method is very cheap, cost effective in removal of sediments or any suspended solids, but may be not completely suitable for drinking purpose. In some places people are using simple plastic bottles with open end, inside which a layer of bone char followed by a layer of sand and a layer of pebble on both sides of the bone char layer is being used through which water will be passed for filtration. This kind of filtration process is capable of removing sediment and microbes effectively from water. Also solar distillation and solar sterilization are the recent but convenient technologies developed as a low cost filtration process.

Ultimately the aim of development of any low cost water filtration model should be to operate with minimum energy, minimum maintenance, cost effective, environment friendly, implementable with ease and can be developed from local artisans.

Toxicity studies are very rare for various groups of chemicals such as pharmaceuticals, nanoparticles and industrial chemicals. Today pharmaceutical chemicals have been found in water sources, sewage water, soil, air etc. The heavy metals will cause some health problems while consuming the water which contain these chemicals. The removal of heavy metals from our environment especially industrial effluents is now shifting from the use of conventional adsorbents to the use of chemical precipitation. The presence of heavy metals in the environment is a major concern because of their toxicity, bio accumulating tendency, and threat to human life and the environment. The main objective of this research is to study the removal of heavy metals using natural adsorbents as filter media from pharmaceutical waste water. A number of conventional treatment technologies have been considered for treatment of wastewater contaminated with heavy metals. In order to remove toxic heavy metals from water systems, conventional methods have been used such as chemical precipitation, coagulation, ion exchange, solvent extraction and filtration, evaporation and membrane methods.

Sample for the project is to be collected from pharmaceutical industry. Quality of water affects our biological system and our surrounding is also affected. In this project removal of iron and chromium in the effluents of pharmaceutical industry. Heavy metal toxicity can result in damaged or reduced mental and central nervous function. Pharmaceutical effluents are wastes generated by pharmaceutical industries during the process of drug manufacturing. Their risk to human and environment are immense. The increase in demand for pharmaceuticals has resulted in a consequent increase in pharmaceutical manufacturing companies in the country and hence increased discharges from these industries constitute hazard to man and other living organisms in the environment because they contain toxic substances detrimental to health.

1.2 Scope of work

Scope of this work is the removal of iron and chromium using low cost and natural materials as filter materials.

1.3 Objective

The aim of this project is to study the removal efficiency of iron and chromium from pharmaceutical waste water using:

- **i.** Using tulsi lesf powder
- **ii.** Using tulsi and aluminium hydroxide
- **iii.** Using neem leaf powder
- **iv.** Using neem and aluminium hydroxide

II METHODOLOGY

Sand filtration is a frequently used very robust method to remove suspended solids from water. The filtration medium consists of a multiple layer of sand with a variety in size and specific gravity. 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. Powders of neem leaf and tulsi leaf are also filter material in assistance with sand and it is a good absorbent for metal as well

2.1 Materials used

The materials used in this project are:

2.1.1 Neem leaf

The scientific name of neem is Azadirachta indica, commonly known as neem, nimtree or Indian lilac is a tree in the mahogany family Meliaceae. It is one of two species in the genus Azadirachta, and is native to the Indian subcontinent, i.e. India, Nepal, Pakistan, Bangladesh, SriLanka,and Maldives It is typically grown in tropical and semi-tropical regions. Neem trees also grow in islands located in the southern part of Iran. Its fruits and seeds are the source of neem oil. Neem leaves are dried in India and placed in cupboards to prevent insects eating the clothes, and also in tins where rice is stored. Neem leaves are dried and burnt in the tropical regions to keep away mosquitoes. Here neem leaf powder was taken for removal of toxic element from water and it was collected from surrounding areas (kollam).

Fig: 2.1.1 Neem leaf

2.1.2 Tulsi leaf

The scientific name of tulsi is Ocimum Tenuiflorum,or OcimumSanctunn Linn. leaves are dropped in drinking water for purification and for medication. The leaves, seeds and root of this plant have been used in ayurvedic medicines. Chemical composition is highly complex, containing many nutrients and other biological active compounds. It can remove fluoride levels in drinking water. Recently it's used have been found in fighting fluorosis. It is collected from surrounding areas (kollam).

Fig: 2.1.2 Tulsi leaf

Studies have confirmed that RO systems remove unhealthy contaminants present in water. Unfortunately, along with removing unwanted chemicals, microbes and compounds, they also remove a significant portion of the minerals found in water, especially calcium and magnesium. These two elements are among the seven major dietary elements required by our body for stronger bones, teeth and normal muscular and nerve functions.

2.1.3 Aluminium hydroxide

Aluminium hydroxide Aluminium hydroxide, $Al(OH)_3$, is found in nature as the mineral gibbsite (also known as hydrargillite) and its three much rarer polymorphs: bayerite, doyleite, and nordstrandite. Aluminium hydroxide is amphoteric in nature, i.e., it has both basic and acidicproperties. Closely related are aluminium oxide hydroxide, AlO(OH), and aluminium oxide or alumina (Al_2O_3), the latter of which is also amphoteric. These compounds together are the major components of the aluminium ore bauxite

One of the major uses of aluminium hydroxide is as a feedstock for the manufacture of other aluminium compounds: speciality calcinedaluminas, aluminium sulfate, polyaluminium chloride, aluminium chloride, zeolites, sodium aluminate, activated alumina, and aluminium nitrate. Freshly precipitated aluminium hydroxide forms gels, which are the basis for the application of aluminium salts as flocculants in water purification. This gel crystallizes with time. Aluminium hydroxide gels can be dehydrated to form an amorphous aluminium hydroxide powder, which is readily soluble in acids. Aluminium hydroxide powder which has been heated to an elevated temperature under carefully controlled conditions is known as activated alumina and is used as a desiccant, as an adsorbent in gas purification, as a Claus catalyst support for water purification, and as an adsorbent for the catalyst during the manufacture of polyethylene by the Sclairtech process.

Fig: 2.1.3 Aluminium hydroxide

2.1.4 Plane sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. Sand is a non-renewable resource over human timescales, and sand suitable for making concrete is in high demand. Sand filters are used as a step in the water treatment process of water purification. Fine sand and gravel are naturally occurring glacial deposits high in silica content and low in soluble calcium, magnesium and iron compounds are very useful in sedimentation removal. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass. Here for the experimentation plane sand passing through 600 Micron is required and also it is collected from surrounding area (kollam).

Fig: 2.1.4 Plane sand

2.1.5 Pharmaceutical effluent

Pharmaceuticals are a large and diverse group of compounds designed to prevent, cure, and treat disease, and improve health. Significant fractions of the parent compound are excreted in un-metabolized form or as metabolites (active or inactive) into raw sewage and wastewater treatment systems. Pharmaceutical wastewater streams containing heavy metals are produced from different laboratories such as Toxicology and Food Toxicology Labs. Some examinations and chemical test and processes generate significant quantities of wastewaters containing heavy metals (such as cadmium, zinc, lead, chromium, nickel, iron, copper, silver, chromium and titanium). Heavy metals cause serious health effects, including reduced growth and development, cancer, organ damage, nervous system damage, and in extreme cases, death. Exposure to some metals, such as mercury and lead, may also cause development of autoimmunity, in which a person's immune system attacks its own cells. The conventional processes for removing heavy metals from wastewater include many processes such as chemical precipitation, flotation, adsorption, ion exchange, and electrochemical deposition. Chemical precipitation is the most widely used for heavy metal removal from inorganic effluent.

Fig: 2.1.5 Pharmaceutical waste water

The waste water is collected from Southern Pharmaceuticals, Kalady, Thrissur. 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.The characteristics of pharmaceutical waste water are tested and is listed below.

Table 2.1: Initial characteristics of waste water

CHARACTERISTICS	RANGE
Initial concentration of Iron	0.536 ppm
Initial concentration of Chromium	0.289 Mg/L
pH	7.46
DO	1.25 Mg/L
Turbidity	31.7 NTU
TDS	364 Mg/L
COD	592 Mg/L

2.2 Method adopted

For removal of metals from effluents herbal materials had been used in this experiment. Filtration is the method used for removing toxic metals from the industrial effluents in this project. The process of passing the water through the beds of granular material is known as filtration. To remove or to reduce remaining impurities and to produce potable and palatable water.

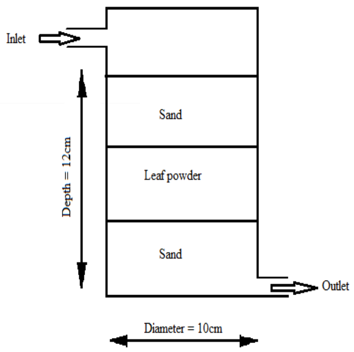


Fig: 2.2 Experimental setup

2.2.1 Water quality

The following four categories are used to describe drinking water quality:

- *Physical:* physical characteristics relate to the quality of water for domestic use. They include colour, turbidity, temperature and in particular, taste and odour.
- *Chemical:* Chemical characteristics of waters are sometimes evidenced by their observed reactions, such as the comparative performance of hard and soft waters in laundering. Most often, differences are not visible. However, in some cases, such as the oxidation of iron, the reactions result in highly objectionable colour.
- *Microbiological:* Microbiological agents are very important in their relation to public health and may also be significant in modifying the physical and chemical characteristics of water.
- *Radiological:* Radiological factors must be considered in areas where there is a possibility that the water may have come in contact with radioactive substances. The radioactivity of the water is of public health concern in these cases.

Table 2.2.1(a): standards and potential health effects of the contaminants regulated under the SDWA

Contaminant	Maximum contaminant level goal mg/L	Maximum contaminant level mg/L	Potential health effects
Arsenic	Zero	0.010	Dermal, nervous system effects, cancer
Bromate	Zero	0.010	Kidney effects, nervous system effects and hearing loss
Cadmium	0.005	0.005	Kidney effects
Chromium (total)	0.1	0.1	Liver, kidney, circulatory system effects
Copper	1.3	TT	Gastrointestinal effects
Cyanide	0.2	0.2	Thyroid, central nervous system effects.
Fluoride	4	4	Skeletal fluorosis
Lead	Zero	TT	Cancer, kidney, central and peripheral nervous system effects
Iron	Nil	0.3	Mutation in the gene, hemochromatosis

Table 2.2.1(b): Recommended limits for constituents in reclaimed water for irrigation. (Adapted from Rowe and Abdel-Magid, 1995)

Constituent	Long-term use (mg/L)	Short-term use (mg/L)	Remarks
Aluminum (Al)	5.0	20.0	Can cause nonproductivity in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity.
Cadmium (Cd)	0.01	0.05	Toxic to beans, beets, and turnips at concentrations as low as 0.1mg/L in nutrient solution. Conservative limits recommended.
Chromium (Cr)	0.1	1.0	Not generally recognized as essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants.
Iron (Fe)	5.0	20.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum.
Lead (Pb)	5.0	10.0	Inhibit plant cell growth at very high concentrations.
Nickel (Ni)	0.2	2.0	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Zinc (Zn)	2.0	10.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils.

2.2.2 Instrument used

Atomic absorption spectrophotometer:

Atomic absorption spectroscopy (AAS) is a spectro analytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. In analytical chemistry the technique is used for determining the concentration of a particular element (the analyte) in a sample to be analyzed. AAS can be used to determine over 70 different elements in solution, or directly in solid samples via electrothermal vaporization, and is used in pharmacology, biophysics and toxicology research. Atomic absorption spectroscopy was first used as an analytical technique, and the underlying principles were established in the second half of the 19th century by Robert Wilhelm Bunsen and Gustav Robert Kirchhoff. The modern form of AAS was largely developed during the 1950s by a team of Australian chemists. Atomic absorption spectrometry has many uses in different areas of chemistry such as clinical analysis of metals in biological fluids and tissues such as whole blood, plasma, urine, saliva, brain tissue, liver, hair, muscle tissue, semen, in some pharmaceutical manufacturing processes, minute quantities of a catalyst that remain in the final drug product, and analyzing water for its metal content. The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. It requires standards with known analyte content to establish the relation between the measured absorbance and the analyte concentration and relies therefore on the Beer-Lambert Law.

Fig: 2.2.2 Atomic Absorption Spectrophotometer

In order to analyze a sample for its atomic constituents, it has to be atomized. The atomizers most commonly used nowadays are flames and electrothermal (graphite tube) atomizers. The atoms should then be irradiated by optical radiation, and the radiation source could be an element-specific line radiation source or a continuum radiation source. The radiation then passes through a monochromator in order to separate the element-specific radiation from any other radiation emitted by the radiation source, which is finally measured by a detector.

2.3 Methodology

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar. Four types of filtration are used for this project.

1. Filtration with Tulsi leaf powder
2. Filtration with Neem leaf powder
3. Filtration with Tulsi and aluminium hydroxide
4. Filtration with neem and aluminium hydroxide

2.3.1 Tulsi leaf powder

Tulsi leaf powder and 600 micron sand was taken. Top and bottom layer is sand and in between the sand layer tulsi leaf powder is placed. Effluent is passed through this filter bed and filtrate was collected in a beaker then it is filtered through a Whatman filter paper. The rate of filtration was calculated and final concentration of iron and chromium was measured with AAS (Atomic Absorption Spectrophotometer) and the removal efficiency can be calculated by using the formula;

Fig: 2.3.1(a): Tulsi leaf powder

Fig: 2.3.1(b): After filtration using tulsi leaf

2.3.2 Neem leaf powder

Neem leaf powder and 600 Micro sand was used. Neem leaf powder is used as an intermediate filter bed in between sand layer. Effluent is passed through this filter bed and filtrate was collected in a beaker then it is filtered through a Whatmans filter paper. The rate of filtration was calculated and final concentration of iron and chromium was measured with AAS (Atomic Absorption Spectrophotometer) and the removal efficiency can be calculated by using the formula;

Fig: 2.3.2(a) Neem leaf powder

Fig: 2.3.2(b) after filtration using neem leaf

2.3.3 Aluminium hydroxide

Aluminium hydroxide is mixed with neem leaf powder and tulsi leaf powder in 1:10 proportion and is used as an intermediate filter bed. Effluent is passed through this filter bed and filtrate was collected in a beaker then it is filtered through a Whatmans filter paper. The rate of filtration was calculated and final concentration of iron and chromium was measured with AAS (Atomic Absorption Spectrophotometer) and the removal efficiency can be calculated by using the formula;

III RESULT AND DISCUSSION

Filtration is used for the removal of metal ions from this waste water. Filtration is an effective and low cost method for metal removal from waste water. Tulsi leaf powder, neem leaf powder, combination of aluminium hydroxide with these two powders separately and sand are used as filter media. Initially characteristics and metal concentration of waste water is determined. Then after filtration the metal concentrations are determined using atomic absorption spectrophotometer and its results are mentioned in table 4.1, table 4.2.1 and table 4.2.2. Tsssssshe flow rate is maintained as 0.5L/hr.

3.1 Characteristics of waste water

Table 3.1: Initial characteristics of waste water

CHARACTERISTICS	RANGE
Initial concentration of Iron	0.536 ppm
Initial concentration of Chromium	0.289 Mg/L
pH	7.46
DO	1.25 Mg/L
Turbidity	31.7 NTU
TDS	364 Mg/L
COD	592 Mg/L

3.2 Efficiency of removal of iron and chromium

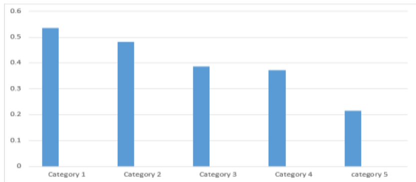
3.2.1 Efficiency of removal of iron

Table 3.2.1: Efficiency of removal of iron

Filter media	Concentration of iron (Mg/L)	Removal efficiency of iron (%)
Tulsi leaf powder	0.481	10.2611
Neem leaf powder	0.387	27.798
Tulsi with aluminium hydroxide	0.372	30.597
Neem with aluminium hydroxide	0.214	60.075

Without using aluminium hydroxide neem leaf shows greater removal efficiency of iron from waste water than tulsi leaf. But using aluminium hydroxide with leaf powders, neem with aluminium hydroxide shows much more removal efficiency than other three and it is shown in the graph 3.2.1(b). Thus neem leaf with or without aluminium hydroxide can be used as a good filter media for the removal of iron from waste water than tulsi leaf.

Graph 3.2.1(a): Concentration of iron in various filtered solution



Category 1: Initial iron concentration

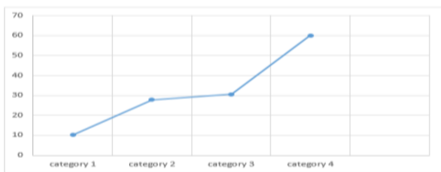
Category 2: Using tulsi leaf powder

Category 3: Using neem leaf powder

Category 4: Using tulsi leaf powder and aluminium hydroxide

Category 5: Using neem leaf powder and aluminium hydroxide

Graph 3.2.1(b): efficiency of removal of iron content



Category 1: using tulsi leaf powder

Category 2: using neem leaf powder

Category 3: using tulsi leaf powder with aluminium hydroxide

Category 4: using neem leaf powder with aluminium hydroxideAuthors and Affiliations

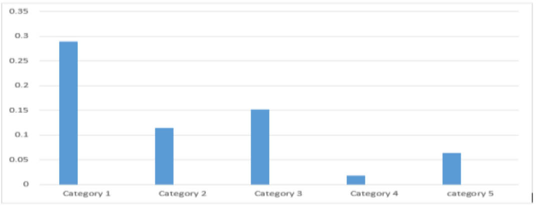
3.2.2 Efficiency of removal of chromium

Table 3.2.2: Efficiency of removal of chromium

Filter media	Concentration of chromium (Mg/L)	Removal efficiency of chromium (%)
Tulsi leaf powder	0.114	60.554
Neem leaf powder	0.152	47.405
Tulsi leaf with (Ctrl) n hydroxide	0.018	93.772
Neem leaf with aluminium hydroxide	0.064	77.855

Tulsi leaf alone is more efficient than neem leaf for the removal of chromium having removal efficiency 60.554%. Also tulsi leaf with aluminium hydroxide have greater removal efficiency than other three materials used and its efficiency is 93.77%, which is graphically shown in graph 4.2.2(b).

Graph 3.2.2(a): Concentration of chromium in various filtered solution



Category 1: Initial iron concentration

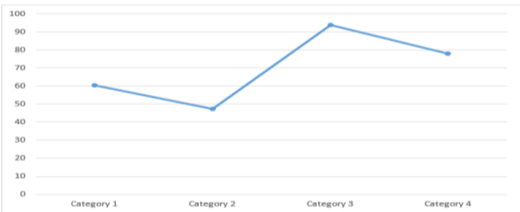
Category 2: Using tulsi leaf powder

Category 3: Using neem leaf powder

Category 4: Using tulsi leaf powder and aluminium hydroxide

Category 5: Using neem leaf powder and aluminium hydroxide

Graph 3.2.2(b): efficiency of removal of chromium content



Category 1: using tulsi leaf powder

Category 2: using neem leaf powder

Category 3: using tulsi leaf powder with aluminium hydroxide

Category 4: using neem leaf powder with aluminium hydroxide

IV CONCLUSIONS

Several techniques are used for the removal of metal concentration from waste water. Some of them are iron exchange, membrane process, ultrafiltration, filtration, electrochemical method, adsorption etc. Among these techniques filtration is the simplest and cheapest technique for the removal of metal components. Sand being the cheapest adsorbing surface is very effective in removal of dissolved metal component for effluent. The only demerit is subsequent development of bacterial layer due to rigorous use and again back washing is needed. Neem leaf powder, tulsi leaf powder, aluminium hydroxide and sand is used for filtration. The waste water used for this project is pharmaceutical waste water and it is collected from Southern pharmaceuticals at Kalady, Thrissur. The initial concentration of iron and chromium is 0.536 mg/L and 0.289 mg/L respectively. Its pH is 7.6, thus which is basic in nature. The filtration rate is about 0.5L/hr. The result showing that neem with aluminium hydroxide is more efficient in removing iron content from waste water with efficiency of removal is 60.075% and without aluminium hydroxide neem have more removal efficiency (27.798%) than tulsi alone (10.261%). Also concentration of iron after filtration is 0.214 using neem with aluminium hydroxide. As per standards this is below than permissible value, thus it is safe for drinking purpose and also for irrigation. Tulsi with aluminium hydroxide is more efficient in removing chromium from waste water with efficiency of removal is 93.77%. Thus it is below than the permissible limit and can be used for drinking and irrigation purpose. So concluding that tulsi with aluminium hydroxide is efficient for chromium removal and neem with aluminium hydroxide is more efficient for the removal of iron from pharmaceutical waste water. Thus it can be used for drnking and irrigation purpose.

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