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Removal of Iron and Phosphorous from Contaminated Water Using Various Plant Leaf Powder

Naga Sai Anusha.K[1], Vennela.B[2], Vamsi.S[3], Vijaykumar.M[4], Naresh kumar.V[5], Dr. Subhashish[6]

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[1,2,3,4,5] *Graduate Student, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India*

([6]*Assistant Professor, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India*

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A B S T R A C T

Human and industrial activities produce and discharge wastes containing iron and phosphorous metals into the water resources making them polluted and threatening human health and ecosystem. Conventional methods for the removal of iron and phosphorous metal ions such as chemical precipitation and membrane filtration are more expensive when treating large amounts of water, inefficient at low concentrations of metal and generate large quantities of sludge and other toxic products that require careful disposal. Bio-sorption is eco-friendly alternatives. These methods have advantages over conventional methods because it has a lower cost, easily available and reused. The present work studies the feasibility use of neam leaf, custard apple leaf, sapodilla leaf, mango tree leaf, java palm leaf and guava leaf as a bio-sorbent in removal of iron and phosphorous from contaminated water. The removal efficiency 100% obtained from this work. The effects of different parameters like contact time, agitation speed, adsorbent dosage; pH and temperature are also studied. Also, the biomass can be modified by physical and chemical treatment before use. The process can be made economical by regenerating and reusing the bio-sorbent after removing the heavy metal.

Keywords: Removal, Iron, Phosphorus, Neem leaf powder, Custard leaf powder, Sapodilla leaf powder, Mango leaf powder, java plum leaf powder, Guava leaf powder

1. Introduction

Heavy metals in drinking water pose a threat to human health. Populations are exposed to heavy metals primarily through water consumption, but few heavy metals can bio-accumulate in the human body (e.g., in lipids and the gastrointestinal system) and may induce cancer and other risk. Heavy metals in drinking water, including the types and quantities of metals in drinking water, their sources, factors affecting their concentrations at exposure points, human exposure, potential risks, and their removal from drinking water. Many developing countries are faced with the challenge of reducing human exposure to heavy metals, mainly due to their limited economic capacities to use advanced technologies for heavy metal removal. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater. Thus removal of these heavy metals from waste water is required.

2. Effects on Water

Although there are many sources of water contamination, industrialization and urbanization are two of the culprits for the increased level of heavy metal water contamination. Heavy metals are transported by runoff from industries, municipalities and urban areas. Most of these metals end up accumulating in the soil and sediments of water bodies.

Heavy metals can be found in traces in water sources and still be very toxic and impose serious health problems to humans and other ecosystems. This is

* *Corresponding author*

E-mail address: anu.kotaru@gmail.com

because the toxicity level of a metal depends on factors such as the organisms which are exposed to it, its nature, its biological role and the period at which the organisms are exposed to the metal. Food chains and food webs symbolize the relationships amongst organisms. Therefore, the contamination of water by heavy metals actually affects all organisms. Humans, an example of organisms feeding at the highest level, are more prone to serious health problems because the concentrations of heavy metals increase in the food chain.

2.1 **Iron:**

Iron is a chemical element with symbol **Fe** (from Latin: ferrum). In its metallic state, iron is rare in the Earth's *crust*, limited to deposition by meteorites. Iron ores, by contrast, are among the most abundant in the Earth's crust, although extracting usable metal from them requires kilns or furnaces capable of reaching 1500 °C or higher, about 500 °C higher than what is enough to smelt copper.

The body of an adult human contains about 4 grams (0.005% body weight) of iron, mostly in haemoglobin and myoglobin.

Iron can exist in two forms, soluble ferrous iron (II) and insoluble Ferric iron (III). The presence of iron in water may be attributed to dissolution or rocks and minerals, acid mine drainage, landfill leachate sewage or industries wastes. Generally iron present in ferric state. The presence of iron at concentrations above 0.1 mg/L can cause damage to gills of fish. Free radicals generated on surface of gills will cause oxidation of tissue and leads to massive destruction of gill tissue and anemia. At the pH conditions in drinking water supply ferrous sulphate settle out as rust colored silt, such water tastes unpalatable and stain laundry and plumbing fixtures

2.2 Phosphorus:

Phosphorus plays a critical role in the development of ecosystems, agriculture, and industry, but also becomes a pollutant in water bodies. To meet increasing demands for phosphorus, more and more phosphate ore reserves are being exploited. However, current reserves will be depleted in 50–100 years.

2.3 Bio-sorbent:

Bio-sorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physico-chemical pathways of uptake Algae, bacteria and fungi and yeasts have proved to be potential metal **bio-sorbents**.

Sorption is a physical and chemical process by which one substance becomes attached to another. Specific cases of sorption are treated in the following articles:

Absorption – "the incorporation of a substance in one state into another of a different state" (e.g., liquids being absorbed by a solid or gases being absorbed by a liquid);

Adsorption – the physical adherence or bonding of ions and molecules onto the surface of another phase (e.g., reagents adsorbed to a solid catalyst surface);

Ion exchange - an exchange of ions between two electrolytes or between an electrolyte solution and a complex.

3. Type of Bio Sorbent Used

Guava: Guava is a sweet and delicious fruit cultivated in tropical climates. This seasonal fruit, scientifically known as *Psidiumguajava*, is round or pear-shaped. It is light green, yellow or maroon in colour when it ripens. It has white or maroon flesh, depending on its type, and has small hard seeds enveloped in its soft, sweet pulp.

The common types of guava include apple guava, yellow-fruited cherry guava, strawberry guava, and red apple guava. Guava is mostly eaten raw (when ripe or semi-ripe) or consumed in the form of juice, jams, and jellies.

This popular fruit is a powerhouse of nutrients. As per USDA's Food Data Central, guava is a good source of energy, dietary fiber, vitamins, and minerals. The guava fruit contains vitamin C, A, E, B-vitamins, as well as potassium, phosphorus, magnesium, calcium, sodium, and zinc.

Custard apple: Custard apple is a common name for a fruit, and the tree which bears it, *Annona reticulata*.

The fruits vary in shape, heart-shaped, spherical, oblong or irregular. The size ranges from 7 centimetres (2.8 in) to 12 centimetres (4.7 in), depending on the cultivar. When ripe, the fruit is brown or yellowish, with red highlights and a varying degree of reticulation, depending again on the variety. The flesh varies from juicy and very aromatic to hard with a repulsive taste. The flavor is sweet and pleasant, akin to the taste of 'traditional' custard.

Java plum: Black jamun is also known as jambhool, black plum or java plum. The black jamun tree is an evergreen tree which grows in tropical and sub-tropical regions globally. It is an important minor crop in India, where it grows abundantly. This plant is native to India, Bangladesh, Sri Lanka, Nepal, Pakistan and also Philippines and Indonesia.

It is scientifically known as Syzygiumcumini. The crop has migrated to places such as Florida, Trinidad-Tobago, some African countries as well.

All parts of this plant are used for curative reasons. The flesh of the fruits (or pulp), seeds, leaves, steam- bark etc.

The ripe fruits are dark purple to almost black in color with a sweet n sour taste. The fruit is green when raw, which then changes color from green to pink to purple and finally dark purple. It is a highly perishable fruit and hence should be bought and consumed fresh and immediately.Storing ripe fruits for more than a day is not recommended.

It has shown a wide range of medicinal uses traditionally and in alternative medicine. For example, it is believed to have positive effects on cough, asthma, diabetes, ulcers, diarrhea, inflammation, stomachache, pimples and ringworm.

Neem: Azadirachtaindica, 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, Sri Lanka, 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.

Sapodilla (sapota): Manilkarazapota, commonly known as sapodilla, sapota, chikoo, naseberry, or nispero is a long-lived, evergreen tree native to southern Mexico, Cent**Mango:**A **mango** is a juicy stone fruit (drupe) produced from numerous species of tropical trees belonging to the flowering plant genus *Mangifera*, cultivated mostly for their edible fruit.

Most of these species are found in nature as wild mangoes. The genus belongs to the cashew family Anacardiaceous. Mangoes are native to South Asia, from where the "common mango" or "Indian mango", *Mangiferaindica*, has been distributed worldwide to become one of the most widely cultivated fruits in the tropics. Other *Mangifera* species (e.g. horse mango, *Mangiferafoetida*) are grown on a more localized basis.

An example natural occurrence is in coastal Yucatán in the Petenes mangroves ecoregion, where it is a subdominant plant species. It was introduced to the Philippines during Spanish colonization. It is grown in large quantities in India, Pakistan, Thailand, Malaysia, Cambodia, Indonesia, Vietnam, Bangladesh and Mexico.

4. Materials and Methods

Bio-sorbent preparation:

The plants leaves are collected from their plants respectively.Clean the leaves with distilled water and acid, dried in sunlight for 6days then make a powder of those leaves and sieved in 63.5mm sieve, then prepare 100gm of powder each sample,then preserve the powder in air tight container.

Analysis of iron and phosphorus

For iron:

Rust iron is collected from corroded materials. This powder is added to distilled water 0.1gm per 1000ml of water. This sample is tested for iron by using iron test solution. This sample is again taken in conical flask as 100ml.Javaplum leaves powder is added to rust iron water in 6.1gm per 100ml of water sample, this sample is kept on horizontal shaker for 1hour.This treated water sample is filtered with whatman filter paper. The filter sample is tested for iron using iron test solutions.The colour of sample is checked with iron indicating table to ensure that the sample is free from iron.

For phosphorus:

Phosphoruschemical is purchased and is mixed in distilled water 10gm per 1000ml of water. This sample is tested for phosphorus by using phosphorus test solutions. This sample is taken conical flask as 100ml. Neem leaves powder is added to phosphorus chemical water in 2.8gm per 100ml of water sample, this sample is kept on horizontal shaker for 1hour. This treated water sample is filtered with whatman filter paper. This sample is tested for phosphorus using phosphorus test solutions. The sample is checked with phosphorus indicating table to ensure the sample is free from phosphorus.

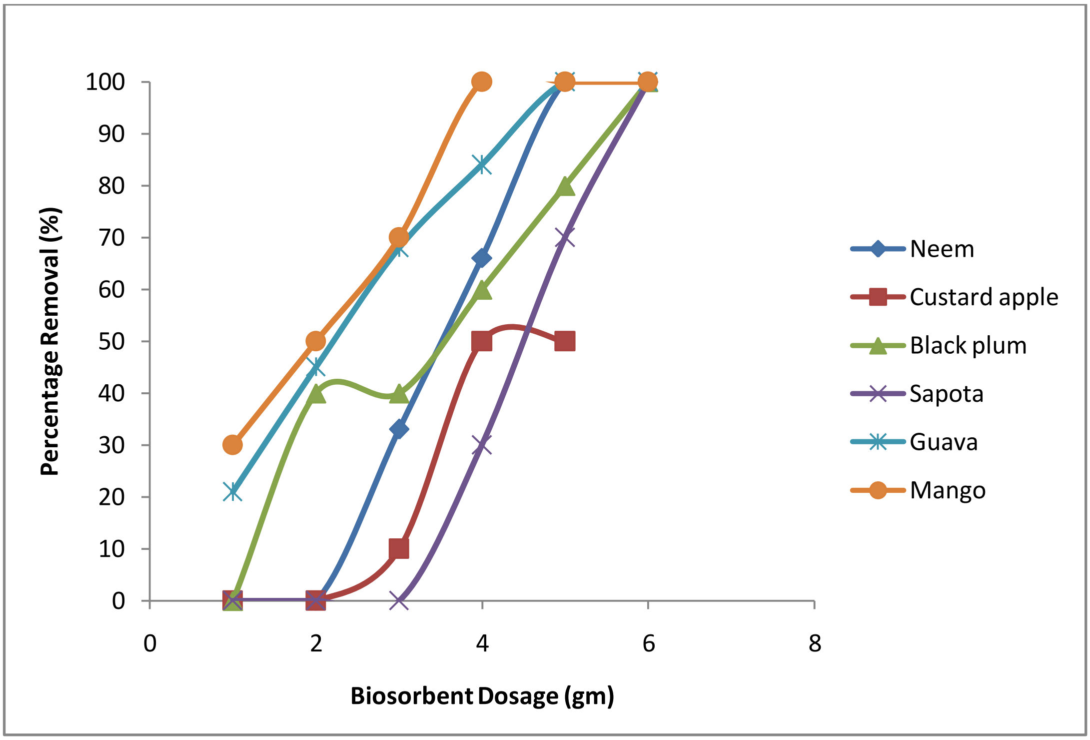
5. Results and Discussions

For iron:

The various materials used in removal iron from waste water

The removal efficiency for iron by using Neem and guava is has same results such as 5.8 gramsper litre has 100%. Javaplum and sapodilla also same results such as 100%efficiency at 6gmper litre of water the mango has 100% for 4gm per litre of water at low cost material and high adsorption capacity.

The custard apple only has 50% removal efficiency in removal of iron form waste water. The graph shows the removal efficiency various materials and its dosage and the tabular form also.



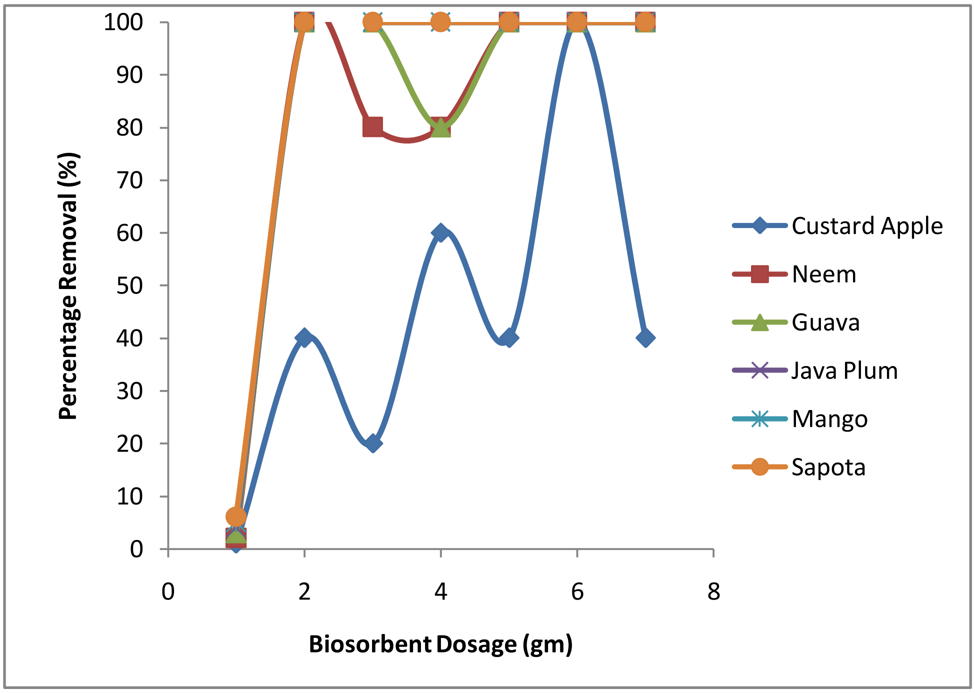
Graph 1: Bio-sorbent comparison graph

Bio-sorbent Dosage (g)	Neem (%)	Java Plum (%)	Guava (%)	Sapodilla (%)	Custard Apple (%)	Mango (%)
1	0	0	20	0	0	30
2	0	40	45	0	0	50
3	33.33	40	68.5	0	13	70
4	70	60	83	30	50	100
5	100	80	100	70	50	100
6	100	100	100	100	50	100

Tabular form:1

For phosphorus:

The removal efficiency of phosphorus by mango is 100% for dosage used for 1gm/lit, 2gm/lit, 3gm/lit, 4gm/lit, 5gm/lit, 6gm/lit has 100% respectively. The sapodilla, custard apple and java plum has same results such as 2gm/lit of water has 100% efficiency respectively. The Neem has varied form 1gm, 2gm and 3gm to 6gm has 20%,80% and 100% respectively. The graph shows the removal efficiency and dosage of material, the tabular form also.



Graph 2: Bio-sorbent comparison graph

Bio-sorbent Dosage (g)	Neem (%)	Java Plum (%)	Guava (%)	Sapodilla(%)	Custard Apple (%)	Mango (%)
1	20	40	60	40	40	100
2	80	100	80	100	100	100
3	100	100	80	100	100	100
4	100	100	100	100	100	100
5	100	100	100	100	100	100
6	100	100	100	100	100	100

Tabular form 2

6. Conclusion

The study shows that's the removal efficiency of waste water has varied form material to material. The contact time for iron and phosphorus 90minutes and 60minutes respectively. The materials have high adsorption capacity and low cost. The dosage 6gm/lit and 4gm/lit adsortion for iron and phosphorus respectively has 100% efficiency.

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