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Use of Textured Vegetable Protein as Biosorbent for Removal of Heavy Metals from Industrial Wastewater

Mir Liyakat Farooq* Simarjot Kaur**

*Student at Department of Civil Engineering, RIMT University, Punjab India

**Assistant Professor, Department of Civil Engineering, RIMT University, Punjab India

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Abstract

The present paper discusses future scope for biosorption of industrial wastewater using textured vegetable protein (soya chunks). Industrial and humans activities produce and discharge wastes containing heavy metals into the water resources making them unavailable and threatening to human health. Conventional methods for the elimination of heavy metal ions such as chemical precipitation and membrane filtration are extremely expensive whilst treating large amounts of water, inefficient at low concentrations of metal (incomplete removal) and generate large quantities of sludge and other toxic substances that require careful disposal. Biosorption and bioaccumulation being eco-friendly alternatives have advantages over conventional methods. Abundant natural materials like microbial agro-wastes, biomass, and industrial by-products have been suggested as potential biosorbents for heavy metal elimination. Biosorption is influenced by various process parameters such as temperature, pH, concentration of metal ions, biosorbent dose, and speed of agitation. The biomass can be modified by chemical and physical treatment before use. The process can be made economical by regenerating and reusing the biosorbent after eliminating the heavy metals from wastewater. Various bioreactors can be used in biosorption for the removal of metal ions from large volumes of effluents or water.

Keywords:biosorption, heavy metal, isotherm, water, waste, pollution

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INTRODUCTION

Industrialization to a greater extent is responsible for the contamination of environment especially water where lakes and rivers are contaminated with a large number of toxic substances. Heavy metals are reaching hazardous levels when compared to other toxic substances. Their continuous release from industries leads to overconsumption and accumulation. As a result, people around the world are exposed to serious consequences of these heavy metals. Many industries (metallurgy, fertilizers, leather, aerospace, mining, photography, electroplating, pesticide, surface finishing, iron and steel, electrolysis, metal surface treating, energy and fuel production, electro-osmosis, and appliance manufacturing) discharge waste containing heavy metals either directly or indirectly into the water. Heavy toxic metals, which are of prime concern, are chromium (Cr), zinc (Zn), arsenic (As), cadmium (Cd), copper (Cu),), lead (Pb), mercury (Hg), nickel (Ni), and cobalt (Co). As these metals are non-biodegradable, they accumulate in the living organisms and lead to various diseases and disorders which ultimately threaten human life. They can cause ill health, even when present as very small traces.

Biosorption has emerged as a convenient option for the removal of heavy metal ions from effluents discharged from various industries which ultimately reach and pollute fresh water resources. This paper reports the application of biosorption using textured vegetable protein for the removal of metal ions from industrial effluents. The recent advances and future of the process are discussed.

MATERIALS AND METHODS

1. Materials

Soya chunks (textured vegetable protein) were taken from a local unit. Impurities were separated manually. Soya chunks are full of organic matter such as protein, cellulose, lignin etc. and rest mineral components such as phosphorus, calcium and trace elements. Soy is full of polyunsaturated fats, proteins and omega 3 fatty acids and sodium which make it a viable biosorbent.

Sampling

Wastewater samples were collected from Fill industries, SIDCO Electronic Complex, Rangreth, Srinagar. The collected samples were reserved in PET Bottles.

According to Environmental Quality Act 1974, standards of heavy metal effluent are shown in Table 1.

Table 1 Standard values for heavy metal effluents

Parameters	Standard Value (mg/l)
Nickel	0.2
Lead	0.1
Chromium	0.2
Arsenic	0.05
Cadmium	0.01
Mercury	0.005
Zinc	1.0
Copper	0.20

2. Preparation of Synthetic Solutions

Aqueous solution of lead (Pb) and chromium (Cr) were prepared in an 800 ml flask. Magnetic stirrer was used to dissolve the salts of heavy metals in distilled water completely. A solution (800 ml) was made and aqueous solution was then diluted with distilled water to obtain the Lead and Chromium synthetic solution. AR grade chemicals and distilled water were used for all the analysis carried out.

Preparation of pre-boiled textured vegetable protein.

The collected textured vegetable protein was dried under sun and impurities were separated manually. It was boiled with distilled water for 4.5 hours and was freed from colored compounds and filtered. The residual material so obtained was dried at 70 C in hot oven for 22 h, and then the material was grinded. The material was then stored in airtight plastic container for further use.

Phosphate treated textured vegetable proteinpreparation

Six-gram dried textured vegetable protein was treated with 100 ml of 1.0 M Potassium hydrogen sulphate for 20h. The mixture was washed and filtered several times with pure distilled water to remove the excess phosphate from the treated textured vegetable protein. The resultant bio-sorbent was finally dried at 85o C for 22 h and preserved at room temperature in a sealed plastic bottle. All the chemicals used were of analytical grade.

Formaldehyde treated textured vegetable protein preparation

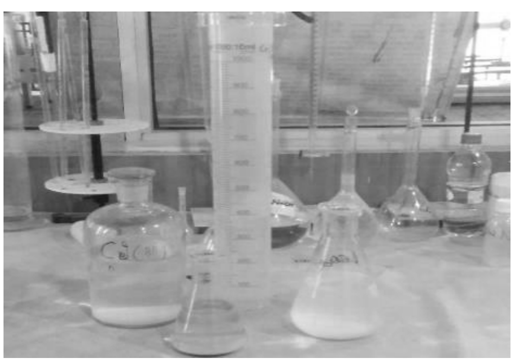
To immobilize the color and water-soluble substances,the soya chunks were treated with 1% formaldehyde in the ratio of 1:6 at room temperature (27±3 ◦C) for 22 h. The soya chunks were filtered and washed with distilled water to remove free formaldehyde and dried at 85 ◦C in a hot oven for 22 h. The resultant material was sieved through thesieves of 30 mesh size. The material was then stored in airtight plastic container for further use.

Adsorption Experiments

Various experiments were carried out at various bio-sorbent doses (1-2g) at stirring speed of 100rpm for a contact time of 4h. Fifty milliliters of the synthetic solution with initial concentration 1.3 mg/l of Cr was treated with 1 g and 2g of bio-sorbent. It was allowed to remain in contact with the bio-sorbent for 2.5 h. After that, the sample was filtered to remove solids present in the sample by using filter paper, glass funnel and beaker. Similarly following the same procedure two doses (1g and 2 g) of textured vegetable proteinis applied to 30 milliliters of wastewater.

Determination of Heavy metals by Atomic Absorption Spectrophotometer AAS

After treatment with bio-sorbent, heavy metals in the samples were determined by using AASfollowing the conditions described in AOAC. Selected elements included Chromium (Cr), Lead (Pb) and Nickel (Ni). The instrumental operating conditions for the elements under investigation are summarized in Table 3



Prepared synthetic solutions of heavy metals

Washed Soya Chunks (TVF)

Table 2: Specifications of Metal salts and their concentrations used for preparation of synthetic solution

Heavy Metal	Metal Salt used	Purity of Metal Salt (%)	Amount of Metal Salt used (g)	Volume of solution made (mL)	Conc. Of heavy metal in solution (mg/L)
Chromium	Chromium nitrate	99.4	200	800	1.20
Lead	Lead nitrate	99	200	800	25.40

Table 3. Conditions applied in determination of heavy metals

Elements	Wavelength (nm)	Current (mA)	Burner	Burner Height	Flame	Fuel gas pressure (kpa)	Oxidant pressure (kpa)
Ni	232	10	Standard	7.5	Ethyne	7	150
Cr	359	7.5	Standard	7.5	Ethyne	12	150
Pb	283	7.5	Standard	7.5	Ethyne	7	150

RESULTS AND DISCUSSION

The textured vegetable proteinapplied in two doses 1g and 2g to synthetic solutions of chromium and cadmium. By applying 1g dose, textured vegetable proteinhas reduced the concentration of chromium from 1.21 mg/l to 0.06 mg/l. Similarly, by applying 2g dose of textured vegetable proteinto chromium synthetic solution, the concentration has been reduced from 1.21 mg/l to 0.18mg/l. Concentration of nickel has been removed totally form initial concentration of 0.05 mg/l by applying 1g dose of textured vegetable proteinto waste water sample.

Textured vegetable protein has removed about 95% of chromium concentration from synthetic solution.By increasing the dose of textured vegetable proteinthe removal efficiency decreases, as by applying 2g dose the efficiency decreases by 10%

The bio-sorbent,textured vegetable proteinwas applied to waste water collected from Fill Industries for nickel removal also. The removal efficiency of the said biosorentfor nickel removal is 96% for 1g dose and 48% for 2g dose. It was found that the concentrations of Zn, Pb and Cr were decreased up to 59, 56 and 55 %, respectively.

Investigations conducted by various researchers to investigate the application of different organic biosorbents for the removal of heavy metals from wastewater support the results of present research work.

CONCLUSION

This study was undertaken to examine the adsorption of heavy metals on textured vegetable protein bio-sorbent whichexhibited high potential of removing all the studied heavy metals. Adsorption capacity of textured vegetable proteindecreases in the order of Ni>Cr. The adsorption was found to be strongly dependent on adsorbent dose, contact time and initial concentration of heavy metals. Textured vegetable proteinis more efficient in removing heavy metals from samples, but with increasing dose its efficiency decreases. Another aspect is availability of the Bio-sorbent. Textured vegetable proteinis easily and abundantly available.

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