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Treatment of Industrial Wastewater by using Banana Peels and Fish Scales

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Abstract: ***Environmental pollution by toxic heavy metal contamination due to rapid industrialization is a challenging problem for maintaining the quality and hygiene of water. The discharges of industrial effluents into aquatic environment cause a potential threat to the aquatic life as well as human health, which is a matter of great concern due to their toxic nature and adverse effect. Techniques used to remove heavy metal are namely physical, chemical and biological treatment. Biosorption is a recent eco-friendly technique which gained importance in this decade. The process of Biosorption has many attractive features compared to the conventional method. The present study investigates that successful use of eco-friendly adsorbents Banana peels and Fish scales. Banana peel which is a discarded fruit waste and Fish scales which are readily available waste in the market were used to prepare environment benign bio-adsorbent for the adsorption of impurities from aqueous solution. Banana peels and fish scales were washed, dried and ground to 150-200 µm and to 160 µm respectively, before being used for treatment of pharmaceutical waste water. The combination of both these biosorbent was used for treatment of waste water with different proportion of adsorbents, variation of pH and contact time. It is found that the maximum efficiency of removal of heavy metal is 60% and 70%respectively.***

Keywords: Banana Peel, Bio-adsorbent, Fish Scale, Industrial Effluents, Wastewater Treatment.

1. Introduction

India is a developing country with an increasing population density. In order to develop its economy, India requires establishment of new industries. Due to unplanned industrial growth, much of the land and nearby water bodies are polluted by indiscriminate dumping of solid and liquid wastes generated by these units. Increase in the levels of metal ions and organic pollutants in the environment are either due to absence of laws for various industries to treat their wastes or if there are laws, there is no strict enforcement by the Ministry of Environment and other regulatory authorities in India. Land contaminated by heavy metals is increasingly becoming an environmental, health, economic and planning issue in the India.

Eco-toxicity due to polluted water sources affect on living organisms has become a main concern for the last few decades. Due to rapid industrialization and substantial urbanization, the waste effluents get discharge directly in river water causing pollution to environment [1]. Heavy metals are an important class of environmental pollutants. With the onset of fast developing industries and energy stations, metal wastes are getting discharged into the environment in many ways. There have been many instances when heavy metal toxicity has led to mass deaths. Removal of heavy metal ions from effluents can be achieved by various methods. The existing technologies for waste water treatment have major problems.

Costs involved in the construction of waste water treatment plants are un-economical, it consumes lot of space, and commercially they are unattractive and have disposal problems. The technologies are divided into three types namely biological, chemical and physical. There were many merits and demerits caused due to high cost and disposal problems. The technologies like electro floatation, electro kinetic coagulation, and coagulation combined with floatation and filtration, conventional oxidation methods by oxidizing agents, irradiation and electro chemical processes are the technologies which fall under chemical methods. These chemical technologies are having many disposal problems. Ion exchange and membrane technologies are very costly. So there was a need for some alternative method which can overcome all these problems and treat the waste water in an appropriate way.

Biosorption is the ability of biological materials to accumulate heavy metals from wastewater through physical-chemical pathways of uptake [2]. The main advantage of Biosorption is that it gives the significant amount of energy saving from a more efficient wastewater treatment system operating for fewer hours; it is economically attractive because waste biomass is inexpensive and widely available [3]. In bio-adsorption, removal of metal ions helps in the effective usage of bio-waste as metals stick on to the surface of biological components.

Full scale Biosorption process requires the biological materials which have high metal binding capabilities and specific heavy metal selectivity. Biosorption also offers low operating cost, minimization of chemical and biological sludge, and no additional nutrient requirements [4]. Different bioadsorbent have been used for removal of heavy metals. Some of them include rice straw, sea-weed, wood and bark, tea-waste, maize-corn cob, sugarcane bagasse, tamarind hull, sawdust, rice husk, sunflower stem, etc. [5]. Out of the wide range of adsorbents, banana peel seems to be good adsorbent and can be used as valuable material for cleaning of water. Bioadsorbent prepared from banana peels has been reported for the removal of chromium, cadmium and copper ions from aqueous solution [6]. Also the fish scales are used as the bioadsorbent for removal of copper, chromium, zinc and iron

from waste water [7]. More amounts of these scales are being generated from fish markets everyday and are thrown away as it is. This study reveals about the importance of using an environmental pollution free approach, Banana peels and Fish scales for the removal of heavy metal ions from waste water.

2. Materials and Methods

2.1 Biomass Preparation

Fresh banana peels were collected from domestic wastes, as its availability and transportation was easy. Banana peel contains lipids (1.7%), proteins (0.9%), crude fiber (31%) and carbohydrates (59%). The various minerals present are potassium (78.10 mg/g), manganese (76.20 mg/g), sodium (24.30 mg/g), calcium (19.20 mg/g) and iron (0.61 mg/g). The peels were washed several times with tap water and followed by distilled water. The washed material then cut in to small pieces and allowed to dry in a hot air oven at 80˚C for 24 hours. The moisture content was lost from it and the color change was observed from yellow to brownish black. The dried material was finely ground and screened through the sieves of cut size of 150-212µm.

Figure 1: Banana peels

Figure 2: Banana peels powder As Adsorbent

In a similar manner, fish scales were collected from the local fish market of city. These fish scales are made up of *keratin* protein which are also present in hair, thorn and nail. Mature fish scales were washed repeatedly with water to remove adhering dust and soluble impurities from their surface. The fish scales were allowed to dry in sunlight for 2 days. The scales were kept in an oven at 70˚C till the fish scales become crispy. The dried scales were then converted into size of 150-212 µm by grinding in mechanical grinder.

Figure 3: Fish Scales

Figure 4: Fish Scales powder As Adsorbent

2.2 Sampling

Sampling was done using standard method from a pharmaceutical industry situated in the Mahad MIDC. Samples were collected from industrial outlet in plastic bottles and then preserved at 4˚C.

2.3 Pretreatment of Adsorbent

For Chemical pretreatment of Fish Scales -10 gm of sample was soaked in 150 ml of 0.1M HCL, H_2SO_4, H_3PO_3, NaOH, $Ca(OH)_2$ and $Al(OH_3)$ for 2 hours in rotary shaker in 100 rpm at room temperature. The fish scales were filtered and washed with deionised water. Resulting biomass were used for the Biosorption study.

2.4 Batch Studies

The experiments were carried out in the batch mode for the measurement of adsorption capabilities. Waste water sample 500ml each was kept with 1.0gm of fish scale and banana peel, powdered as an adsorbent, in orbital shaker at 150 to 180 rpm at 25˚C. Then the separation of bioadsorbent and solution was carried out by filtration with Whatman Filter Paper No.42 and the filtrate stored in sample cans for determine the metal ion concentration using Atomic Absorption Spectrophotometer (AAS). An experiment is carried out by different concentration of dosage for incubation time 24 hours. Heavy metal ions were estimated before and after addition of powdered adsorbents.

A.Study of Adsorbent Dosages

The effect of adsorbent doses on the equilibrium adsorption of heavy metal ions were investigated with banana peel and

fish scale of 1, 2, 5 g in three set of 500 ml wastewater . The Erlenmeyers were shaken for 24 hours with 120 rpm at room temperature. The water samples were then filtered and analyzed in terms of metal ions by AAS.

B. Study of pH

The effect of pH for metal adsorption onto banana peel and fish scale were investigated with 1gm of banana peel and fish scale in 500 ml water sample with adjusted pH between 3 to 8 using either 1N H_2SO_4 or NaOH solution. The Erlenmeyers were shaken for 24 hours with 120 rpm at room temperature.

C. Study of Contact Time

The effect of contact time on adsorption of metal ions was examined with different time (0, 6, 12 hr) and speed (150 rpm) with 1gm banana peel and fish scale and with the combination of both adsorbents in 500 ml water sample.

2.5 Adsorption Isotherms

The adsorption experiments were carried out by batch method. Percentage of removal of metal ion calculated by following equation:

$$\text{Removal \%} = (C0 - C) / C0 \times 100 \quad (1)$$

Where C0 is the initial concentration of metal ions (mg L-1) in the wastewater sample and C is the final concentration of metal ions (mg L-1) after addition of adsorbent. The amount of heavy metal adsorbed onto biosorbent (qe, mg g-1) was calculated using the Eq. 2. These data were evaluated by Langmuir and Freundlich adsorption isotherm equations, two equilibrium isotherm models usually used to interpret the efficiency of metal sorption

$$qe\ (mg\ g\text{-}1) = (C0 - C) \times V/M \quad (2)$$

Where V is the volume of solution (L) in contact with the biosorbent and M is the mass (g) of the biosorbent. The equilibrium of the biosorption process is often described by fitting the experimental points with models usually used for the representation of isotherm adsorption equilibrium. The two widely accepted and linearised equilibrium adsorption isotherm models for single solute system are given by the following:

$$q = \text{Langmuir}\ \frac{q_{max}\ b\ C_{eq}}{1 + b\ C_{eq}}$$

Where, q is milligrams of metal accumulated per gram of the biosorbent material; C_{eq} is the metal residual concentration in solution; q_{max} is the maximum specific uptake corresponding to the site saturation and b is the ratio of adsorption and desorption rates. This is a theoretical model for monolayer adsorption.

Another empirical model for monolayer adsorption is,

$$q = KF\ Ceq^{1/n}\ \text{Freundlich}$$

Where, KF and n are constants. These models can be applied at a constant pH.

3 Results and Discussion

A. Effect of Biosorbent Dosages

Various dosage of the prepared banana peels and fish scales bioadsorbent used to treat the industrial wastewater. The parameters such as Zinc, Iron have been change with the increase in the bioadsorbent dosage. The effects of adsorbent dosage were varied from 1 to 3 gm for banana peel and fish scale individually and mixture of both. Hence 3 mg was found to be the optimum dosage in treating the wastewater for Banana peels adsorbent. The plots of langmuir isotherms Ceq/q vs Ceq show that all the adsorbents followed the Langmuir isotherm with respect to the metal ions.

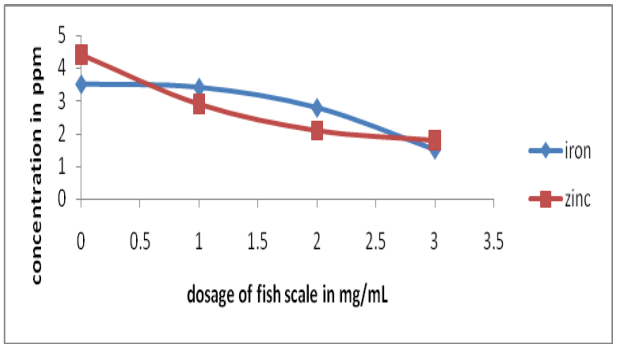

Figure 5: Removal of metal concentration using Fish Scale with various dosages

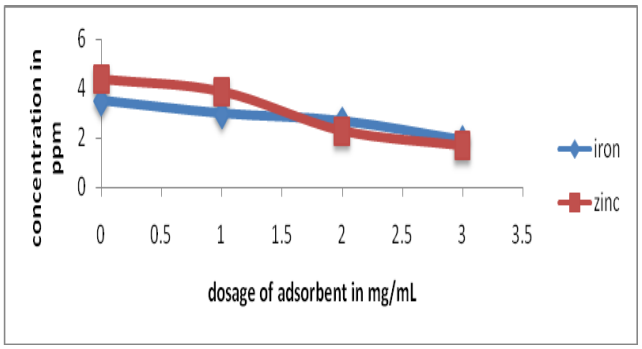

Figure 6: Removal of metal concentration using Banana peels with various dosages

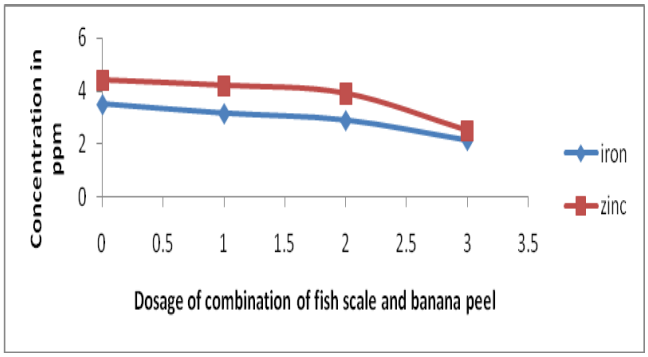

Figure 7: Removal metal concentration using combination of Banana peel and Fish scale adsorbent with proportion 1:1

B. Effect of pH

To study the effect of pH on adsorption, experiments were carried out in the pH range 3–8 for Zinc and Iron. Fig. 3 shows that the removal of metal ions was increased with

increasing initial pH of metal ion solution and maximum value was reached at pH 8 for Zinc and Iron. The plots of langmuir isotherms Ceq/q vs Ceq show that all the adsorbents followed the Langmuir isotherm with respect to the metal ions.

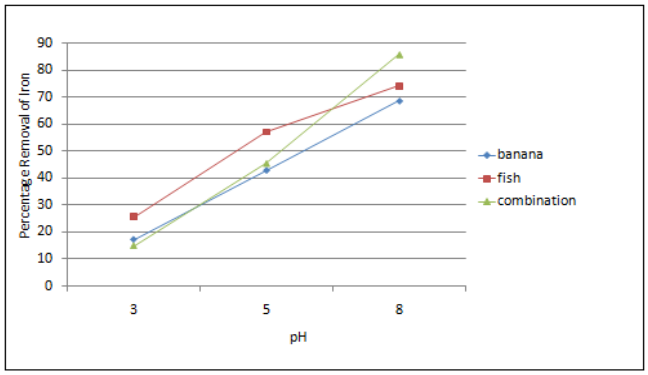

Figure 8: Removal of Iron concentration (mg/l) with pH

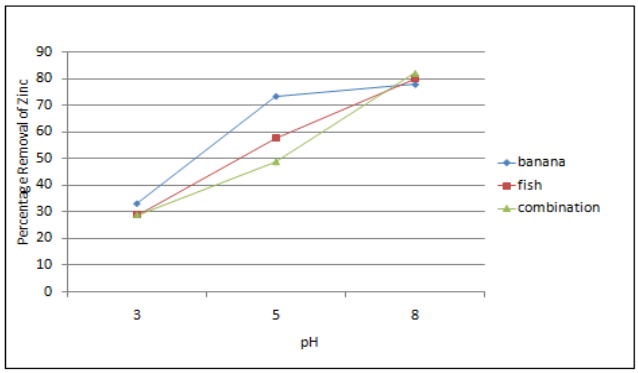

Figure 9: Removal of Zinc concentration (mg/l) with pH

C. Effect of Contact Time

Influence of contact time on adsorption of heavy metal on Banana peel and fish scale were investigated in the range of 0–12 hour. Maximum rate of removal occurred within 6 hours of contact time thereafter removal rate became slow and after 12 hour of contact time no change was observed for Zinc (81%) and Iron (74%), which established that the system has reached the equilibrium point. The plots of langmuir isotherms Ceq/q vs Ceq show that all the adsorbents followed the Langmuir isotherm with respect to the metal ions.

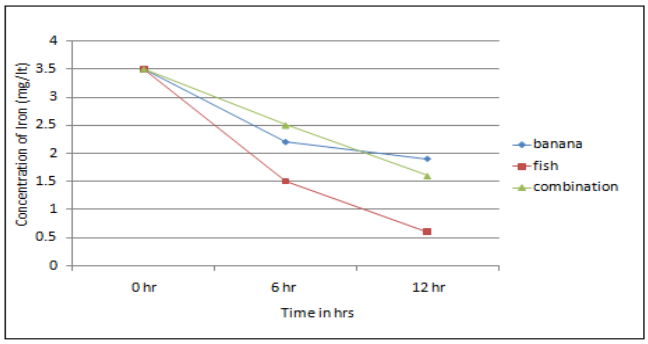

Figure 10: Removal of Iron concentration (mg/l) With time (hr)

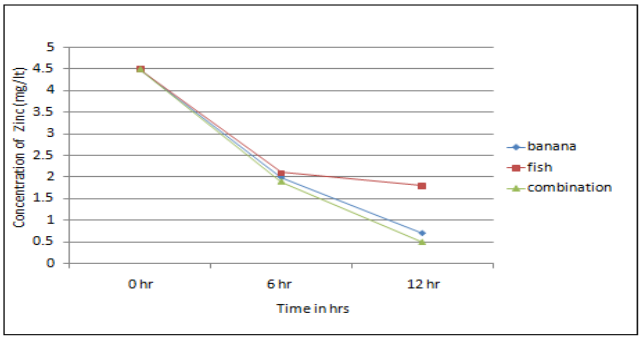

Figure 11: Removal of Zinc concentration (mg/l) With time (hr)

Study suggests that use of bioadsorbent shows promising approach towards the purification process of wastewater at various parameters. Along with bringing the properties as pH, TDS, COD, BOD etc. towards the desirable limit, it has been found quite effective for the removal of Iron and Zinc.

The surface activity of banana peels is mainly due to the presence of carboxyl, hydroxyl and amide groups at its surface due to which it is able to chelate with various metals and help in their removal. In the presence of various metal ions, a competition is there among them for the coordination sites present on the surface of adsorbent. High surface area of banana peels adds to the property and makes it an excellent and economic adsorbent than fish scale, for water purification process. Varying contact time and different pH of wastewater with adsorbent used in treatment was found to be efficient to different extents towards various parameters, so it is a subject to further study so as to optimize the process.

4 Conclusion

The present work explores a new approach of development in the field of purification of water through minimal energy input, less labour and low investment, also proves to be biodegradable and effective compared to synthetic adsorbent and chemicals. Adsorption tends to increase with contact time. At first the increase in adsorption is very rapid as there are lots of free sites for the adsorption to take place. Thus it can be concluded that Banana peels and Fish Scales, which are discarded waste materials and are in abundance in the local market, can be used for the removal of heavy metal from waste water. Efficiency of removal of heavy metal concentration is more with banana peel and then with fish scale. Mixture of both the adsorbents gives more efficiency. The bio-adsorbents once used could be re-used through desorption methods for a certain period of time and this could be employed commercially in the future.

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