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Review Paper on Removal of Heavy Metal Ions from Waste Water Using Adsorption Process

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Abstract:

Nowadays toxicity of heavy metal ions is a serious issue, which causes health problem . The large industries mainly chemical industries discharge these heavy metal ions in the form of chemicals directly into the water of river, lake, sea . They cause health issues for living beings specially flaura and fauna which survies into the water. So, it is compulsory to remove that toxic metal ions to illuminate the health risk of living beings and plant as well. There are lots of techniques present to remove that heavy metal ions like ion-exchange, chemical precipitation, coagulation-flocculation & flotation, adsorption, membrane filtration. Among all of the process, adsorption is the best suitable method for illumination of toxicity of heavy metal ions from industrial waste water effluent. Here adsorption performs a useful method for removal process with lots of advantages because this is the low cost method with eco-friendly in nature.

Keywords- Industrial Waste Water, Reliability, Adsorption, Removal Techniques, Adsorbent

Introduction-

Water pollution is the major cocern nowadays and it also affects the health of living organism. The excessive use of chemicals which present in the contaminated water are directly flow into the rivers which endanger the life of aquatic organism as well as human beings [1]. Recently, researchers have target towards removal process of various unwanted pollutants in which biodegradable waste, phosphates, heavy metals, heat, dyes, toxic chemical, fluoride, sediment, radioactive pollutants, hazardous chemical and personal products [2].When these pollutants are directly subjected into the water causes lots of diseases to human health and kills many aquatic organism. So, it is very necessary to remove that pollutants from contaminated water and make pollutation free [3]. There are various techniques which are used for the sepration of pollutants from the contaminated water and that techniques are adsorption, oxidation, coagulation, ion-exchange, bio-remediation ,nano-filtration, solvent,-extraction, reverse-osmosis [4]. Among all of the above techniques adsorption is choosen for the best removal process from the waste water effluent because adsorption is low cost process, easy removal as well as recovery rate, most efficient technique because of its easy operation, high efficiency and the operation perform is sludge free [5]. If we talk about the adsorption process then we have concern about the properties of adsorbent because it play major role in adsorption , a good adsorbent for removal of heavy metal ions must possesses these characteristic like high adsorption capacity, pore volume and size, large surface area , compatibility, cost effectiveness, mechanical stability , environment friendly, high selectively, ease of regeneration, simple processing [6]. Lots of adsorbent present which work effectively in which carbon nanotube increases the removal rate and gives good result in adsorption process. The mechanism of carbon nanotube in adsorption process is mainly the interaction of functional group which present at the surface of carbon nanotube with heavy metal ions which present in the contaminated water. As shown in the below **figure 1** [7]. If the surface area will be larger then result in greater the number of reducing group and hence more pollutants attracts on the surface and give better result of adsorption.

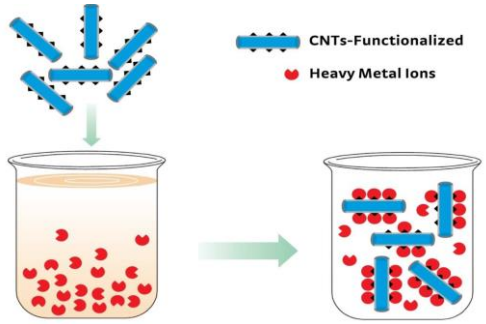


Figure 1 – Sepration of heavy metal ions from waste water using CNT

Case Studies

1.*Removal of toxic metal ions through carbon nanotube adsorbent*- In this case study we know how carbon nanotube works efficiently in removing heavy metal ions from industrial waste water [8]. There are lots of low cost

adsorbent like rubber tire [9] , multi-walled carbon nanotube [10], Nano-particle [11-14] .But these adsorbents have low efficiency. So, carbon nanotubes has found the highly potential adsorbent because of its superior quality like opto-electronic, mechanical properties, unique structure, physical properties, semiconductor, chemical properties, electronic properties [15-20]. There are two division of CNTs (a) Single-walled carbon nanotube (b) Multi-walled carbon nanotube [21] as shown in **figure 2**

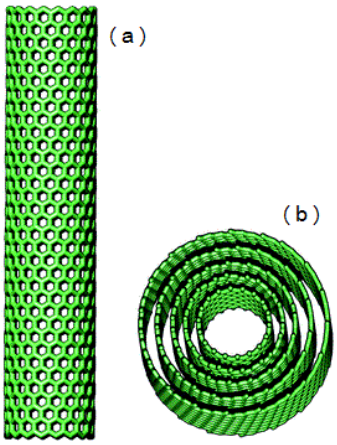


Figure 2 Diagram of (a) Single-walled carbon nanotube (b) Multi-walled carbon nanotube

Carbon nanotube is efficient adsorbent in removing heavy metal ions from contaminated water and that toxic metal ions are Ni^{2+}, Cu^{2+} , Co^{2+} ,Cr^{3+} ,Cr^{6+} , Hg^{2+}, Cd^{2+}, Sr^{2+}, Pb^{2+} , Zn^{2+},As^{3+},Eu^{3+} ,U^{6+},Th^{4+},As^{5+} [22-34]. The functional group present on the surface CNTs are –OH, -COOH, -C=O these provide large amount of activated site which increase the removing capacity [35].

From the experiment researcher found pH is greater than 7 in removal in removal of Fe from contaminated water through multi-walled carbon nanotube [36]. In the presence of poly acrylic acid the pH is observe that greater than 8 in illumination of Ni^{2+} ions [37]. In carbon nanotube, adsorption capacity depends upon the size of the adsorbing particles hich present on the surface [38]. Here is a flow diagram of purification of water using carbon nanotube as shown below **fig 3.**

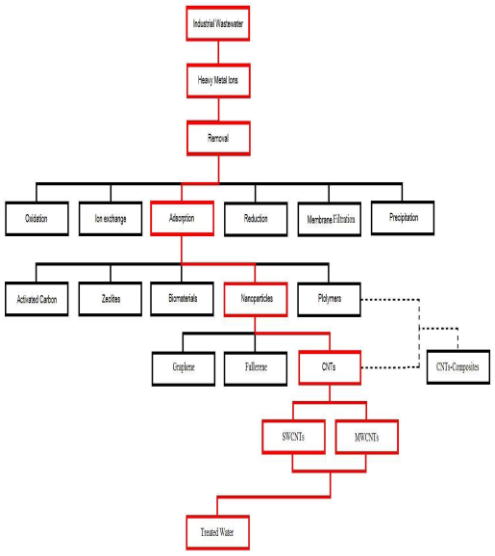


Figure 3- This flow diagram indicates , different process and various adsorbent is used for the illumination of heavy metal ions from waste water effluent. Red box indicates that carbon nanotube is used for removal of toxic ions.

2. Treating waste water through low-cost adsorbent- To overcome the problem of organic or inorganic pollutants there are several conventional and unconventional method adopted to remove that heavy metal ions from the waste water and make that polluted water pollution free, As we know that heavy metals are very harmful and cause lots of disease which are given below **table 1.** And that heavy metal comes from chemical company, paper factory, tanneries, battery manufacturing company [39-42]. Continue flowing harmful chemicals into water may pollute the quality of water as well create a lot of health problems of human life and aquatic organism [43] .

S. No	Heavy Metals	Health Hazard	Permissible Limit (mg/L)	References
01.	Arsenic (As)	kidney cancer, nausea, skin diseases, Muscular weakness, lung bladder.	0.009-0.01	[44]
02.	Cobalt (Co)	thyroid, heart disease,Asthma,allergy, Carcinogenic, liver damage.	0.09-0.1	[45]
03.	Cadmium(cd)	renal disorder, emphysema, kidney Disease, human carcinogen.	0.0029-0.003	[46]
04.	Copper(Cu)	Insomnia, liver disease, Wilson Disease.	2.3-2.5	[47]
05.	Chromium(Cr)	Vomating, headache, lung-tumor Diarrhea, carcinogenic, nausea.	0.04-0.05	[48]
06.	Manganese (Mn)	memory loss, parlcinson disease	0.4-0.5	[49]
07.	Mercury(Hg)	paralysis, rheumatoid-arthritis, Neurological disorder, anorexia.	0.0009-0.001	[50]

08.	Nickel(Ni)	chronic-asthma, dermatitis, lung cancer Nausea, coughing.	1.0-2.0	[51]
09.	Zinc(Zn)	neurological disorder, dehydeation, Depression, anaemia, lethargy.	4.0-5.0	[52]
10.	Lead(Pb)	Anorexia, damage of nervous system, Brain fail, vomiting, anaemia, circulatory Disease.	0.04-0.05	[53]
11.	Iron(Fe)	Depression, Tinnitus, headache, constipation Gastrointestinal problem, nails damage.	1.0-2.0	[54]

Table 1. According to WHO, various disease affects Human health with these heavy metal ions.

To remove these heavy metal ions there are some conventional process for treating waste water effluent and illuminating the harmful heavy metal ions from waste water as shown in **figure 4.**

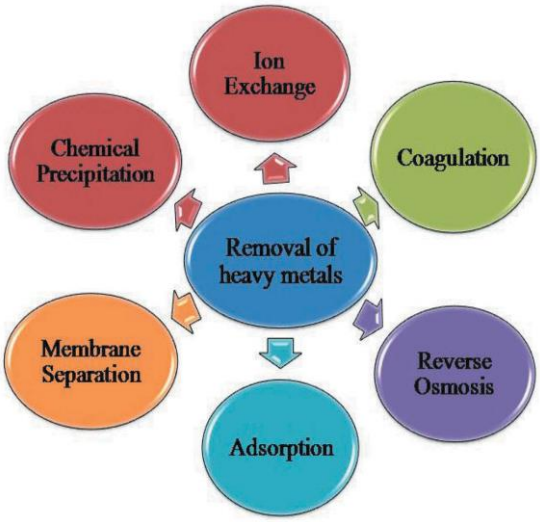


Figure 4. Heavy metal ions illuminate through conventional process

The survey gives result that a lot of low cost adsorbent like animal wastes, industrial wastes and agriculture wastes are used in removing toxic metal ions from the industrial waste water. Different type of functional group is present on the outer surface of the adsorbent which contribute important part in adsorbing that unwanted particles from aqueous solution [55].

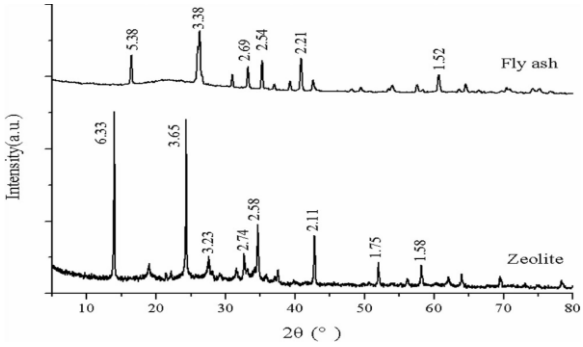
3. Adsorbent as bio adsorbent (activated carbon) in adsorption for removing heavy metal ions- A bio-adsorbent is prepared when Fe_3O_4 and modified sulton is placed on the surface of activated carbon [56]. For making low-cost this activated carbon is made from the pistachio shell (agriculture waste). The study of the magnetic behaviour, structure of adsorbent, morphology of the prepared activated carbon by vibrating sample magnetometer (VSM) [57], thermal gravimetric analysis (TGA) [58], transmission electron microscopy (TEM) [59], Fourier transform infrared spectroscopy (FT-IR) [60]. Under assisted –ultrasound and with the help of Langmuir adsorption isotherm [61] the tendency of adsorbent to remove these heavy metals cd(II), pb(II) and As(III) is studied. The limit of cd(II), pb(II), As(III) is adsorbed 119.03 , 146.99 , 151.50 mg g^{-1} respectively and ultrasonic time is recorded 10 mins. A good adsorbent comes under these quality like it is recyclability, easily availability, low cost, eco-friendly for removing toxic metal ions from aqueous solution. The new technology which is use in nowadays for removing heavy metal ions from contaminated sources is ultrasound radiation which is very effective technology [62].

4. Using synthesized zeolite as a adsorbent to remove toxic metal ions from contaminated sources- From coal fly-ash zeolite is synthesized and which is useful in removal process of heavy metals like $Ni^{2+,}$ $Pb^{2+,}$ $Cu^{2+,}$ Mn^{2+} and Cd^{2+} from contaminated water [63].

Graphs of characteristic in between zeolite and fly-ash

(a) X-Ray Diffraction graph of fly-ash and adsorbent zeolite are shown in **fig 5.**

Fig5



(b) FTIR- Spectrum of fly-ash and zeolite are shown in **fig 6.**

Fig 6

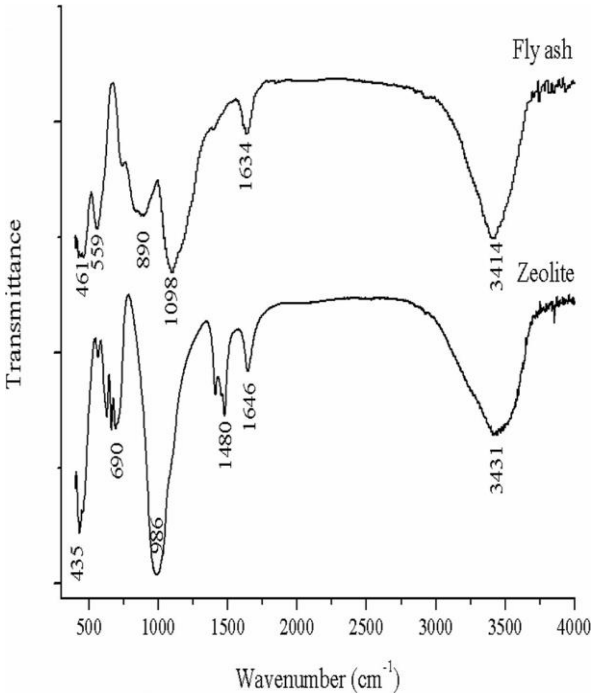


Fig 6. Fourier transform infrared spectroscopy of fly-ash and zeolite

The pH of solution and cations will affects the removing efficiency of the toxic ions .the increasing capacity of cations are as follow Al^{3+}> Mg^{2+} < NH_4^+> Ca^{2+} > Na^+[64]. According to Langmuir model the metals are arrange with maximum adsorbing tendency Cd^{2+}, Mn^{2+}, Pb^{2+}, Ni^{2+}, Cu^{2+} are 52.11, 30.39, 65.70, 34.39, 56.05 mg g^{-1} [65]. Zeolite is verified tested in removal of heavy metal ions from waste water. So, result comes that synthesized zeolite which comes from coal fly-ash is successfully in removing of heavy metal ions from aqueous solutions [66].

Result and conclusion

Due to increasing industrialization day by day there is also increase of use of heavy metal and this create a dangerous environment problem [67]. Heavy metal gives lots of dangerous health problem of human beings as well as aquatic organism. So, it is very necessary to illuminate that heavy metals (Pb^{2+}, Cd^{2+}, Hg^{2+}, Mn^{2+}, Cu^{2+}, Co^{2+}, Ni^{2+}, Zn^{2+}) from the aqueous solution and make river, lake, sea pollution free [68]. Different kind of conventional and unconventional methods are available there are some conventional process are reverse osmosis, ion-exchange, membrane filtration, chemical precipitation, adsorption, coagulation process are useful for removing of heavy metal ions [69]. Among all of the above process adsorption method is found more useful process. Excluding adsorption process all have more disadvantage . So, adsorption is more useful method. Even at low concentration adsorption is more effective for illuminating toxic metal ions from waste water [70]. For more efficient result we can use activated carbon but due to consideration of economy we cannot go in extensively usages of this adsorbent [71]. If we look forward on low-cost adsorbent there is lots of benefit like it is high adsorbing capacity, abundance, renewability, easy separation, low cost [72]. Here we can see that a lot of low-cost adsorbent variety present like agriculture waste, industrial waste and animal waste in the removing of toxic metal ions from waste water effluent. Mostly all the adsorbent possess the phenol group, carboxyl group, hydroxyl group on the surface of the adsorbent [73] , which we simply called functional group , it activates the adsorbing capacity of adsorbent.

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