Review Article

A REVIEW ON THE UTILIZATION OF ORGANIC ADSORBENTS FOR THE REMOVAL OF TOXIC METALS FROM WASTE WATER

ABSTRACT

In the world of explosive population growth rate, water is essential requirement for all the living being. Enormous numbers of population around the world are lacking of potable water. Lack of water is even due to unethical usage of watercausing scarcity. As the industrialization and urbanization rapidly increases need of water, at the same time waste water from various industries containing toxic metals is been disposed of to the water bodies with poor treatment technics adopted leading to water pollution in turn affects the surface and subsurface water leading to serious health issues of public. At present, treatment of water in the economical process is very important.So the various natural adsorbentswere used for the treatment of water. Many of the studies have given the good methods for the economical treatment of the toxic wastes giving scope to the new techniques.

Keywords: *Potable Water, Toxic Metals, Adsorbents*

1.0 INTRODUCTION

Environmental pollution is presently one of the major important issues due to undesirable effects of industrialization, urbanization, population growth and human attitude towards the environment. At present, environmental protection is the main need of the society. In India, the environmental pollution has become a cause of concern at various levels. Due to lack of sewage treatment plants, generally untreated sewage effluents are released either on agricultural land for irrigation or disposed of to nearby water bodies.Toxic metals are chemical elements like arsenic, iron, chromium, cadmium, lead, cobalt, nickel and mercury which are having specific gravity multiple times the specific gravity of water and arepoisonous even at low concentrations. These toxic metals are from electroplating industry, electronic goods manufacturing industry, battery industry and so on.

As these industries disposes untreated or poorly treated waste water containing toxic metals to the water bodies which in turn affect the human health those who are consuming it causing serious carcinogenic health effects. In this paper an attempt is made to study the effort done by the various researchers those who have made an attempt to treat the toxic waste water by using natural adsorbents and the results are discussed. As the natural adsorbents are easily available, they have been utilized to treat the waste water containing toxic metals by many researchers.

Table No.1 Maximum Contamination Level Standards for Toxic Metals [MCL]

Toxic Metal	MCL (mg/L)
Arsenic	0.050
Cadmium	0.01
Chromium	0.05
Copper	0.25
Nickel	0.20
Zinc	0.80
Lead	0.006
Mercury	0.00003

Toxic metals contamination has been recognized as a major environmental concern because of their high solubility in the aquatic environments and toxic metals can be absorbed by the living organisms too. Toxic metals have a great tendency to bio-accumulate and end up as permanent additionto the environment and cause serious health effect.

2.0 OBJECTIVES AND SCOPE

To study the work done by the various researchers to remove the toxicity in the water polluted by the industrial effluents.This study is very much helpful to find the research gap in this important area and propose the new materials /methods to treat the water in an economical way. Study focuses on the various natural adsorbents which are helpful in removal of toxic metals from

various industrial waste water. As the adsorbents are available in large quantity, it is economical for the treatment process as compared to artificial and other treatment techniques.As the adsorbents used are organic in nature, recovery of the adsorbents after treatment can be done easily and they can be biodegraded later.

3.0 LITERATURE REVIEW

Chun Yang Yin et al., (2008), In this study, palm shell activated carbon was impregnated with polyethyleneimine (PEI) and the effect of impregnation on batch adsorption of Ni^{2+}, Cd^{2+}or Pb^{2+} as well as the equilibrium behavior of adsorption of metal ions on PEI- impregnated AC were investigated. In the single metal adsorption capacities of Ni^{2+} or Cd^{2+}except for Pb^{2+}, where its adsorption capacities were reduced by 16.67% and 19.55% for initial solution pH of 3 and 5 respectively.

Goran D. Vukovi et al., (2009) studied the functionalization of multi-walled carbon nanotubes (MWCNTs) by ethylenediamine, via chemical modification of carboxyl groups, using O-(7-aza benzotriazol-1-yl)-N,N,N',N'- tetra methyl uroniumhexafluoro phosphate. The resulting materials were characterized by different techniques, such as FTIR, TGA and elemental analysis. Biocompatibility studies showed that the functionalized MWCNTs, at concentrations between 1 and 50_gmL−1, were not cytotoxic for the fibroblast L929 cell line. In batch tests, the influences of solution pH, contact time, initial metal ion concentration and temperature on the sorption of Cd^{2+} ions onto raw-MWCNTs (raw-multi-walled carbon nanotubes), oxidized MWCNTs (o-MWCNT) and ethylenediamine-functionalized MWCNTs (e-MWCNT) were studied. The adsorption of Cd^{2+} ions by o-MWCNT and e-MWCNT was strongly pH dependent. The time dependent Cd^{2+} sorption onto raw-MWCNT, o-MWCNT and e-MWCNT can be described by a pseudo-second-order kinetic model. The Langmuir isotherm model agrees well with the equilibrium experimental data. The maximum capacity was obtained for e-MWCNT, 25.7mgg−1, at 45^0C. The thermodynamic parameters were also deduced for the adsorption of Cd^{2+} ions on raw-MWCNT, o-MWCNT and e-MWCNT and the results showed that the adsorption was spontaneous and endothermic.

Mihaela Mureseanu et al., (2012) it is stated that Metallothioneins (MTs) are low-molecular weight proteins (1–10 kDa), which are known to bind selectively metal ions such as Zn or Cd in metal–thiolate clusters. The present work describes the preparation of copper–metallothionein (Cu–MT) and its immobilization by covalent grafting on mesoporous silica for the selective uptake and recovery of Cu^{2+} from water. The mesoporous silica used (SiDav) features 10 nm pore size suitable to accommodate Cu–MT (6 nm size) and 200 lm particle size adequate for flow processes. For the covalent coupling, SiDav was first functionalized with aminopropyl (SiDav–NH_2) or glycidoxypropyl (SiDav–Gly) functions before to react with Cu–MT. After decomplexation of Cu, the resulting MT–SiDav–NH_2 and MT–SiDav–Gly materials were used to adsorb Cu^{2+} from aqueous solutions in the presence of various competing cations. The adsorption capacity of the hybrid biocomplexant silica materials was studied in batch and in column for flow process. Starting from a solution containing 2 mm of four cations, the maximum adsorption capacity under flow (1 mL/min, pH 6) was obtained for MT–SiDav–NH_2 with a high selectivity for Cu^{2+}: Cu^{2+} (0.210 mmol g_1)_Cd^{2+} (0.009 mmol g_1) > Zn^{2+} (0.005 mmol g_1) > Pb^{2+} (0.003 mmol g_1). Furthermore, adsorbed Cu^{2+} ions were quantitatively recovered by simply eluting the column with HCl. This column was also successfully used to preconcentrate Cu^{2+} contained in different water samples as tap or mineral waters for an easier analysis of Cu traces.

MohdRafatullah et al., (2012) did a study on Meranti wood, an inexpensive material, utilized as an adsorbent for the removal of Cadmium (II) from aqueous solutions. Various physicochemical parameters such as equilibrium contact time, solution pH, initial metal ion concentration and adsorbent dosage level were studied. Langmuir, Freundlich, Dubinin-Radushkevich (D-R) and Temkin isotherms were used to analyze the equilibrium data at different temperatures. The experimental data fitted well with the Langmuir adsorption isotherm, indicating the monolayer adsorption of the cadmium (II). The thermodynamics of cadmium (II) adsorption on meranti wood indicates its spontaneous and exothermic nature. Kinetic studies showed that the adsorption followed a pseudo-second-order kinetic model.

Ihsanullah et al.,(2015) stated that the scarcity of water, especially in arid and semi-arid regions of the world is exerting great pressure on resources and establishing more need to provide good quality water for human and other consumptions. Water recovery/recycle/reuse has proven to be effective and successful in creating a new and reliable water supply. Accordingly, attention is being paid to the effective treatment of alternative sources of water (apart from fresh water) such as seawater, storm water, wastewater (e.g. treated sewage water), and industrial wastewater. In this paper the result obtained was the equilibrium time required for Pb^{2+}adsorption is 60, 50 and 20 min for the initial concentration of 30, 20 and 10 mg/L respectively. The desorption of lead ions reaches from 0% to 100% quickly, when the pH was reduced from 5.4 to 2.

Adarsh S et al., (2020) has done for diary wastewater treatment using low cost adsorbent. The orange peels are adsorbent used in the Study, the effect of pH, time of contact, adsorbent dosage in removal of contaminants present in diary wastewater is evaluated. Experiments were conducted for different dosages using water bath shaker with slow mixing contact time. Results have shown that the pH is reduced from 8.4 to 6.2, The BOD & COD removal is observed to be 70.79% & 74.58% respectively. Turbidity and sulphates removal is observed to be 35.53% and 47.61% respectively. There is a superficial increase in the chloride and total suspended solids level by 36.47% and 80.66% respectively. Total dissolved solids removal is observed to be 86.86 %.

Awwal Musa et al., (2020) evaluated the contaminant removal efficiency of an improvised charcoal filter. The filter had four layers with 6.3mm, 2.0mm, 1.18 mm size, and powdered charcoal was used for the filtration process. The water sample was

collected from river Challawa from the region believed to have the highest concentration of contaminants. The physicochemical and bacteriological characteristics of the water sample before and after filtration were determined and evaluated. Although testing for coliform bacteria in the samples before and after filtration read positive, the charcoal filter showed very high turbidity removal efficiency (i.e. up to 98%) after a seven-number repeated filtration runs. It also showed high odor, hardness, and chloride removal efficiencies. However, an increase in conductivity was observed in the filtered samples which may be correlated to the ability of charcoal to enrich the water with elements like sodium and potassium. In addition to these the pH value of the sample before filtration was acidic (i.e. 5.7) but increased to 7.7 after filtration which is suitable for drinking water. Hence, it is recommended here that charcoal filters can be used to produce high-quality water.

ShameedaNk, RanaRahman (2020), stated that the textile industry is considered to have one of the most polluting wastewater effluents in the world, with regards to volume and composition, and large quantities of dye used for coloring fabrics are present in the effluent. Most wastewater treatment facilities apply the well established and efficient activated sludge process to decrease chemical oxygen demand (COD) in the wastewater. Microbial fuel cell is an emerging approach for treat wastewater and also generating electricity. Textile industrial wastewater is highly polluted. So, Textile wastewater requires most sophisticated and expensive methods for treatment. Textile wastewater was diluted to get different concentrations from 790 mg COD/L to 1350mg COD/L and this was given as feed to microbes present in MFC. The COD removal efficiency increased with the increase in feed concentration. The maximum COD removal of 77.03% was achieved at the feed concentration of 1350 mg COD/L. MFC produced a maximum current of 4.8 mA and power density of 16.8 mW/m^2

4.0 DISCUSSIONS

From the dairy waste water results showed that the pH is reduced from 8.4 to 6.2, The BOD & COD removal is observed to be 70.79% & 74.58% respectively. Turbidity and sulphates removal is observed to be 35.53% and 47.61% respectively. There is a superficial increase in the chloride and total suspended solids level by 36.47% and 80.66% respectively. Total dissolved solids The concept of utilizing Orange peels has proved to optimize the quantity of waste in dairy wastewater and an effective, Economical & a sustainable method to treat the dairy wastewater.In the other study PEI (polyethyleneimine) impregnation evidently increased the single metal adsorption capacities of Ni^{2+} or Cd^{2+}except for Pb^{2+}, where its adsorption capacities were reduced by 16.67% and 19.55% for initial solution pH of 3 and 5 respectively. This suggested that PEI-impregnated AC could be used for selective separation of Pb^{2+}ions from other metal ions. The adsorption data of all the metal ions on both virgin and PEI-impregnated AC for both initial solution pH of 3 and 5 generally fitted the Langmuir and Redlich-Peterson isotherms considerably better than the Freundlich isotherm.The charcoal filters used had four layers with size varied from 6.3, 2.0, 1.18 mm, and powdered charcoal responsible for the filtration process. The water sample was collected from river Challawa has the larger concentration of contaminants. Physical and chemical characteristics and testing for coliform is also done before and after filtration. After the test the charcoal filter shows 98% removal efficiency after many trials and also removed odor, hardness, chloride and also studied that in addition pH value of the sample increased from 5.7 to 7.7 after filtration.Textile wastewater was diluted to get different concentrations from 790 mg COD/L to 1350mg COD/L and this was given as feed to microbes present in MFC. The COD removal efficiency increased with the increase in feed concentration. The maximum COD removal of 77.03% was achieved at the feed concentration of 1350 mg COD/L. MFC produced a maximum current of 4.8 mA and power density of 16.8 mW/m^2.The monolayer adsorption capacity of meranti wood for cadmium (II) was found to be 175.43, 163.93 and 153.84 mg/g at 30, 40, and 50^0C, respectively. The results indicated that the meranti wood could be an alternative for more costly adsorbents used for cadmium (II) removal.

As per the above reference papers it is observed that various researchers have used various natural adsorbents which are efficient enough in removing the different toxic metals under different circumstances like variation in adsorbent dosage, contact time, pH variation, thickness of filter bed which affects the removal efficiency of toxic metals from the waste water.

5.0 CONCLUSIONS

From the above study following conclusions may be derived

- Various studies have been conducted on various natural organic adsorbents and achieved a good efficiency in removing the various toxic metals with help of natural adsorbents.
- As the natural adsorbents are easily and cheaply available and can be economically utilized for removal of toxic metals discharged into the water bodies which affect the health of human beings those who consume the water which is contaminated with toxic metals.
- The percentage of removal efficiency depends on various factors like variation in adsorbent dosage, contact time, pH variation, and thickness of filter bed.
- Some studies show even removal of physical and chemical characteristics of water by using adsorbents.
- By using the natural adsorbents as a filter media, coliform bacteria can also be efficiently removed from the waste water.

REFERENCES

1.Chun Yang Yin, Mohamed KheireddineAroua, Wan MohdAshri Wan Daud, "*Enhanced Adsorption of Metal Ions onto Polyethyleneimine-Impregnated Palm Shell Activated Carbon: Equilibrium Studies*", Water Air Soil Pollution, 192:337–348, 2008.

2. Goran D. Vukovi´c, Aleksandar D. Marinkovi´c, Miodrag ˇ Coli´c, Mirjana Đ. Risti ´c, RadoslavAleksi´c, Aleksandra A. Peri´c-Gruji´c, Petar S. Uskokovi´c, "*Removal of cadmium from aqueous solutions by oxidized and ethylenediamine-functionalized multi-walled carbon nanotubes*", Chemical Engineering Journal, 157, 238–248, 2010.

3. MihaelaMureseanu, NicoletaCioatera, Ion Trandafir, Irina Georgescu, François Fajula, Anne Galarneau, "*Selective Cu^{2+} adsorption and recovery from contaminated water using mesoporous hybrid silica bio-adsorbents*", Microporous and Mesoporous Materials, 146, 141–150, 2011,

4. MohdRafatullah , Othman Sulaiman, RokiahHashim, Anees Ahmad, "*Removal of cadmium (II) from aqueous solutions by adsorption using meranti wood*", Wood Science Technology, 46:221–241, 2012.

5. Ihsanullah, Aamir Abbas, Adnan M. Al-Amer, TaharLaoui, Mohammed J. Al-Marri, Mustafa S. Nasser, MajedaKhraisheh, Muataz Ali Atieh, *"Heavy metal removal from aqueous solution by advanced carbon nanotubes: Critical review of adsorption applications*", Separation and Purification Technology, 157, 141–161, 2016.

6. Adarsh S, Manasa M P, Sheshaprakash M N, ChandanBalu, "*Dairy Wastewater Treatment using Orange Peels as an Adsorbent*", International Research Journal of Engineering and Technology, VOLUME: 07, JUNE 2020

7. Awwal Musa, SaniSaleh, Kasim Mohammed, Yahaya Hassan Labaran, "*Evaluation of Potential Use of Charcoal as a Filter Material in Water Treatment",* International Research Journal of Engineering and Technology, Volume: 07 Issue: 05, May 2020.

8. Shameeda NK, RanaRahman, "*Microbial Fuel Cell an Alternative for Treatment of Textile Wastewater*", International Research Journal of Engineering and Technology, Volume: 07 Issue: 04, Apr 2020.