JPIChE 51 (1) 2023: 1-10

Journal of Pakistan Institute of Chemical Engineers

journal homepage: www.piche.org.pk/journal

DOI: https://doi.org/10.54693/piche.05111

Removal of Heavy Metals from Wastewater of Textile Industry using Polymeric Nano-Adsorbent

W. Ali[1], H.M. Masood[1], K. Shahzad[2], M. Imran[1], N. Ali[1,], A. Naveed[1]*

Submitted: 16/09/2022, Accepted: 13/12/2022, Online: 14/03/2023

Abstract

Abstract--Wastewater of textile industry having impurities and heavy metal ions cause problems in human society that can endanger the human health through food chain. Adsorption of heavy metal ions before draining makes wastewater safe for aquatic life and human health. Now a day's adsorption of heavy metal through polymeric Nano adsorbent is the emerging technology which is more efficient than conventional adsorbents like activated carbon. The pH 9.0 gave maximum 96% sorption of Co at 1.0 g/L adsorbent dosage, due to increased electrostatic force of attraction produced by the negative charge at the surface of sorbent which is favorable for adsorbing cationic species. In the beginning of 15 minutes retention time, metal ions adsorption was faster due to availability of more number of adsorptive sites but further increase of retention time decreased the sorption due to partial desorption that may occur due to the charge density and diameter of hydrated ions. Similarly in case of Cu, the maximum sorption was 95% at 7.0 pH using 1.0 g/L adsorbent dosage.

Keywords: Heavy metal ion, Wastewater of textile industry, Effect of operating parameters, SEM, XRD & FTIR analysis

1. Introduction:

China has a large textile sector due to huge amount of foreign investment, advanced technology, low cast labor force. China has 1st position in US market with 36% share of US textile importers and 29% share of European Union total textile imports in the world. Textile industry of India is oldest and biggest industry of India. It is on 2nd number after China [1, 2]The textile Industry of India contributes 14% of industrial production, and earns 17% of its total exports. India is on 1st number in Jute production, 2nd in Silk production, 3rd in cotton, and 5th big country in synthetic fiber production [3]. Pakistan also has a huge sector of textile industry, 40% manpower of industrial sector is working in textile industry, whereas the 63% contribution in total export. Pakistan is the 4th big country in the world in cotton production, on 3rd number in spinning after China and India, provides 5% of spinning capacity in the world [4-6].

A huge amount of water is required in textile industry for wet processing per day. It is estimated that, on average, almost 100 liter of wastewater is produced to manufacture only 1 kg of textile goods [7]. The main steps of wet processing are, sizing, desizing, scouring, bleaching, mercerizing, dyeing, printing & finishing. On discharging these effluents into the rivers, river's soil adsorbed the heavy metals and other chemicals traces, and it also expose to the environment by evaporation. Various dyestuffs used in textile mills are major sources of heavy metals which cause high amount of total suspended solids (TSS) and total dissolved solids (TDS) in water. The amount of

[1]*Department of Chemical Engineering & Technology, NFC Institute of Engineering & Fertilizer Research, Faisalabad, Pakistan*

[2] *Institute of Chemical Engineering and Technology, University of the Punjab, Lahore.*

*Corresponding author: najafawan@hotmail.com

suspended solids increases due to increased amount of heavy metals in water. The most important parameter for the quality of water is dissolved oxygen (DO). The low level of DO makes water body uninhabitable to grill-breathing aquatic organism. The chemicals in effluents may be react and their products became more toxic to the environment [8]. In the presence of organic material and hydrogen sulphate (HS) is formed in the condition of limited oxygen. The presence of heavy metals (HMs) creates the serious issues on environmental hazards. Those rivers attributed to textile industries have high concentration of heavy metals. Textile dyes have high MW, complex chemical structure, and low biodegradability which make textile industries effluent more harmful to the environment. Textile effluents direct displace to the sewage networks by the biological treatment processes. Biological treatment processes are disturbed by the direct displacement of textile effluents into sewage networks. Heavy disease burden is increasing due to these effluents in special those areas which are attributed to these industries, and it could be one of the reasons for the shorter expectancy of life in country about 61.4 years for both male and female. Some of the chemicals in these effluents are carcinogenic and while others are poisonous depending upon dose and exposure duration [9]. Aquatic life has danger at free concentration of 10-50 μg/L NH_3. Azo dyes discharged to water system from dyeing factories have shown damage to the ecosystem. Textile effluents are one of the significant causes of environmental degradation and human illness. 40% globally used colorants contain chlorine which is a known carcinogen.

The field of science that discusses the materials at nanoscale is called nanoscience. The bigger size of materials has different properties as compared to Nano-sized material. Nano technology is used for the formation of different materials using control integration & manipulations of several types of atoms and molecules. Nano technology applications have been increased from past decades to find the most efficient and cost effective methods and materials for the treatment of wastewater and water purification. Nano chemicals are more suitable and advantageous to their bigger counter parts due to their small size, better reactivity, most accuracy, and the main environment friendly techniques. Wastewater having organic & inorganic pollutants can be removed from carbon nano-sorbents [6]. Activated carbons are mostly used in carbon based nano-sorbent category due to high adsorption capacity & thermal stability. The organic matter can absorbed Benzene and Toluene which could make it harmful, so the removal of these materials should be done to make effluents environment friendly. The removal of heavy metal ions is done effectively with granular activated carbon (GAC). The maximum amount that can be adsorbed by GAC for Benzene (350-450 mg/g) and Toluene (650 mg/g) was checked [10]. GAC has been checked as efficient adsorbent for the removal of Mercury, Nickel, Cobalt, Cadmium, Lead, and Chromium [11]. Iron, Manganese, Titanium, and Tungsten oxides are mostly used for as metal oxide adsorbents for the removal of HMs. The main benefit of metal oxide is their functionality due to their metal oxide which makes it more specific for the desired pollutant that has to be removing. Iron oxide Nano-sorbent removes pollutant from wastewater using its magnetic properties to separate the pollutants from water [12]. Organic dyes can be removed more efficiently through Nano tungsten oxide. Reactive yellow dyes have been removed efficiently using zinc-aluminum Nano-sorbent. Non-metallic oxide also has been used successfully for removal of organic pollutants [13, 14]. Zeolite is also one of good option for the removal of pollutants from wastewater (ww) due to its high surface area and the major one due to its ion exchange capacity which make it more suitable for wastewater (ww) treatment. Zeolite can be made commercially and are also present naturally. Chabazite & clinoptilolite zeolites were used for the adsorption of lead and cadmium. Due to high surface area and porosity zeolite give 98% removal efficiency from wastewater [15, 16]. Nanotechnology used for the removal of pollutants is the most efficient technique among all others conventional and advanced treatment methods of wastewater (ww). Nanoscale research is more favorable for wastewater (ww) treatment due to its feasibility, cost effective, and environment friendly properties. Nanomaterial are subjected to structural variation which made material more suitable for removing heavy metal through large surface area and high reactivity due to functional group attached in back bone [17]. Researcher has studied deep penetration also the advantageous factor to enhance the removal efficiency. Membrane technology using

nano-chemicals can remove pollutants on bulk scale more easily without reducing quality of removal efficiency. Colloid of nanoparticles can be made during mixing with aqueous solution or wastewater (ww) and quantum size effect can also be observed. Nano particles have small sizes which lead to energy conservation and economical [18]. Mansour et al. (2016) reported carbon capture that was collected from the exhaust gases of a power plant. The goal of study was to modify the power plant for CO_2 adsorption, experimental investigation applying adsorption technique. A numerical model was prepared to simulate the separation process & optimize the system for CO_2 adsorption. It was suggested that this model could be used as economic method for capturing g the carbon prior to combustion by just few changes to operating plant. Total capture of CO_2 was 15% by wt & 85% by wt N_2 using 0.20 m adsorption bed and 1.3 bar pressure. The CO_2 adsorbed at ninth cycle was 0.27 g, material reduction was reduced after ninth cycle due to establishing steady state. It was suggested that there is still need more advancement in operations and to find out the more efficient material for the adsorption of CO_2 and to reduce the unburnt carbon and evolution of greenhouse gases which is a global problem and should be controlled [19]. Ali et al. (2016) performed experimentation for removal of Congo red dyes from textile w/w. Adsorption data was analyzed by Langmuir model. The most removal of pollutants batch parameters were at initial concentration 150µg/L, contact time 25 min, pH 7.0, dosage 0.5 g/L and 25 °C temperature. The adsorption method was speedy, environment friendly and cost effective. It was observed after the experimentation that synthesized iron carbide nanoparticles (ICNPs) performed efficiently for the removal of dye. The maximum removal efficiency of dye was 90%. The removal of dye is cost effective and it can be adsorbed from any source of water [20]. Marzbali et al. (2017); used algae for the removal of Direct Yellow-12 from textile wastewater. It was studied in batch system. Spirulina algae was analyzed by and characterized by FTIR, BET & AFM. It was nano-sized and mesoporous material which was used for the elimination of DY 12 from textile wastewater. DY12 adsorption by spirulina was examined by pseudo-second order model. The maximum value to which adsorbent can adsorb was 714 mg g-1, which was the highest among previous work according to author. The work was based on physical adsorption using natural algae in crushed form to nanosize for the adsorption of dye contaminants. A controlled adsorption rate was managed by different techniques. Langmuir model showed the maximum adsorption of dye molecule which proved algae as an efficient adsorbent for the removal of dye pollutants. The pore size of adsorbent was large enough to capture the dye pollutant and it was confirmed after testing pore size of adsorbent which make sure the adsorption of DY12 through algae using as adsorbent. It was notices after experimentation that by increasing adsorbent dosage removal of dye pollutant increases, but giving too much adsorbent dosage adsorption ratio decreases. According to pH effect, it was noticed after doing experiments from 3-10 pH value. The maximum pollutants of dye were removed in acidic pH zone. Increasing pH did not show more adsorption of dye pollutants [21]. Shimaa et al. (2016) performed experimentation using Nano conducting polymer adsorbent for the removal of organic pollutants. Nano-composite of polyaniline was prepared by chemical polymerization method in the presence of different Nano oxides SiO_2, TiO_2, and Fe_3O_4. All prepared PANI composites were used as adsorbents for the removal of dye [22]. Xinliang Jin et al. (2011); prepared a unique organic-inorganic adsorbent for the displacement of HM ions and organic pollutants in textile wastewater. The removal of Pb^{+2} was up to 122 mg/g which was more than 97%. The adsorption of phenol was 7.2 mg/g. The blend of organic material with inorganic material made a hybrid adsorbent which increased the adsorption power and capturing affinity to phenol from wastewater. The maximum pollutants of phenol were removed in basic pH zone value at 9.0. This adsorbent can be used efficiently for the removal of phenol pollutants from w/w on commercial scale due to cost effectiveness and high adsorption power. The adsorption efficiency was verified by Langmuir model [23]. Kaynar et al. (2016); did experimentation for the removal of thorium (IV). Silicone adsorbent was prepared with nano size for the removal of ion. Silica is used for different purposes in different fields. Nanoparticles of silica were synthesized by sol-gel technique for efficiently removal of thorium ion. The surface morphology was enhanced to increase the adsorption behavior. The maximum amount of thorium that adsorbed on the surface of adsorbent was 189.3 mg/g. It was noticed that adsorption behavior

was bitterly explained by Freundlich adsorption model. Model showed that adsorption is a process which takes heat from surroundings and reduces the temperature of surrounding and increases the temperature of tested area system. It was suggested that adsorbent was cost effective and could be used on commercial scale. Adsorbent had another advantage that it had special affinity to metal ions due to non-metal silica base compound [24]. Salem et al. (2016); designed normal and modified zeolite based adsorbents. The adsorbent surface area was enhanced by the dust that was removed from kiln of cement industry. The maximum amount of lead that was removed from wastewater using this adsorbent was 92 mg/g.a comparison was made between the adsorption behavior of dust and nano zeolite adsorbent. It was suggested that dust of cement kiln industry can be used as low cast adsorbent with greater efficiency removal of metal ion [25].

Adsorbent dosage, pH and retention time are major parameters of adsorption process. Many authors have studied the effect of these operating parameters in adsorption process, some of the studies have been summarized here after. Most of the researches [15, 26, 27] have reported optimum adsorbent dosage is in range of 1-3 g/L. depending upon the specialty of adsorbate and adsorbent, the optimum adsorbent dosage varies.

Goher et al. (2015); studied the removal of Al, Fe, & Mn ions from industrial waste using GAC and amberlite IR-120H. There was performed a number of experiments to find out the parameters that could show the maximum removal percentage of metal ions. Adsorbent dosage was taken from 0.2 - 0.8, 1.2, 2, and 3 g/L after making pH 5.0 of lab made wastewater. The optimum removal yield of heavy metal (HM) ions was 98.2% & 98.65% for Al, 98.30% & 98.43% for Fe, 78.60% and 96.67% for Mn was gained at the dosage of 2.0 g/L using GAC & AIR-120 H. It was seen as the dosage of adsorbent was increased, there was no lineated increasing behavior in adsorption of HM ions. It was checked by experimentation that adsorption increases directly with adsorbent dosage at initial level, but as the dosage was increased further the adsorption yield decreases that may be due to cluster formation of adsorbent which reduces the removal efficiency of metal ions. Agglomeration also takes place which reduces adsorption yield significantly because the some little bit desorption behavior starts with the formation of agglomeration [28]. Kharman et al. (2016); studied the dosage effect of CNC of adsorption of Cr+6 ion. The amount of adsorbent that was used 0.25 - 3.25 g/L. It was noticed after experimentation based on physical adsorption mechanism removal of Cr+6 was increasing to starting dosage of adsorbent but then it goes to decreasing due to cluster formation of adsorbent particles [29].

Goher et al. (2015); used GAC & AIR120H for the sake of adsorbent and studied pH effect. Experimentation was performed for pH 2 8. The ionization of adsorbent particles takes place at different pH values in different ways. Ionization of adsorbent influences on the adsorption behavior significantly. It was noticed that adsorption was increased gradually by increasing pH value. The optimum removal of Fe was at pH 2.0 by giving 62.34%, Mn removal just 27.41% which was low at initial level but increased with increasing pH value 7.0. The removal of Mn was reached up to 95.65%. Al & Fe did not show significant removal percentage due to saturation that was established on pH 5.0 [28]. Kharman et al. (2016); had seen during experimentation that Cr+6showed precipitation on pH lower than 6 which reduces the adsorption yield of Cr^{+6} ion because it lead to desorption of metal ion. It was noticed that higher pH values was not favorable for the adsorption of Cr+6 ion that may be due to deprotonating which reduce the affinity of metal ion to the adsorbent and removal of Cr+6 ion decreases [29].

Goher et al. (2015); studied the behavior trend by giving different Retention times to the sample that used for the removal of Fe, Al, & Mn ions. The sequence of time for oscillation was 2, 5, 10, 2, 30, and 60 minutes respectively using GAC & AIR-120 H as adsorbents. It was noticed that adsorption took good trend in initial oscillation time but on further increasing retention time the removal percentage of HM ion was reduced due to establishing somehow desorption process. If sample of wastewater had given too much time with sufficient adsorbent dosage then the functional groups of adsorbent's adsorptive sites failed to hold the metal ion for over long time and then they desorbed the metal ion [28]. Kharman et al. (2016); gave retention time from 30 130 minutes to check the adsorption of Cr+6 ion using CNC and chitosan adsorbent. Similarly his finding was also somehow same with. It was notices that the adsorption behavior at initial stage from 30 40 minutes was increasing but then it goes to equilibrium and no more

further increased amount of adsorption yield was being noticed. It may be due to the presence of free adsorptive sites at the start but with increasing time the concentration of metal ion fills the adsorptive sites completely which does not show further significant increase in adsorption yield [29].

2. Material and Methods:

2.1. Materials:

Amberlite XAD 7HP & wastewater from Fateh Textile Industry Pvt. Limited Faisalabad Pakistan is used for experiments for adsorption of Cu & Co.

2.2. Experimental Setup:

The experimental apparatus consists of an electric stirrer, weight balance, pH meter, glass beaker. An electric stirrer was made at lab scale having speed from 50 - 100 rpm, with electric power of 3-5 ampere. Weight balance (made Sartorius Company) which can measure from 0.001 gm to 300 gm accurately. A digital pH meter (HANNA Company) which has maximum level from pH 4 -10, Universal Indicator (Merck Company, Germany) was also used to assure and cross check the pH.

The experimentation was started using JJ-1 Mechanical Stirrer which consists of controlling speedo meter & Timer. Lab scale mechanical stirrer was developed by using sewing machine motor having specification; operated at 12 V DC, using 0.7 Ampere current, 35watt power & 500 3000 rpm with a 50 60 Hz frequency. Motor is connected with a stainless steel rod of 10 inch length, at the bottom end of rod a small piece of stirring piece with 2 hands is assembled.

Agitation by JJ-1 Mechanical Stirrer at 2000 rpm

Figure 1: Experimental Set up

2.3. Experimental Procedure:

Textile wastewater sample was collected from Fateh Textile Industry (Pvt.) Ltd, Faisalabad-Pakistan from various places up to 2 weeks regularly and collected 30 Liter sample in a plastic cane. Sample of collected wastewater was taken under the process of sedimentation to settle down the sludge and suspended solids. Sedimentation process was taken for overnight. Next day the sample was filtered through textile arc & nd 90T having mesh of 270 per square inches. All impurities that can be seen through naked eye including suspended solids and sludge in wastewater were removed firstly through sedimentation and then by filtration. After collecting the sample was took in a glass beaker, then made the desired pH. After making pH put it under electric stirrer by giving required time according to experimental schedule. Then sample was filtered by arc & nd 90T. After filtration sample saved in 250 ml plastic bottle by covering its top with polyethylene sheet and then closed by its cap to make it air tight.

A sample of 250 ml taken from collected stock wastewater and tested from High-tech Lab University of Agriculture Faisalabad-Pakistan for the identification of heavy metals. The metals were detected from the sample after testing from instrument (made Hitachi Polarized Zeeman AAS, Z-8200 Japan).

3. Results And Discussion:

3.1 Analysis of Waste Water:

Table 1. Heavy Metals Detected from Textile wastewater

Sr #	Name of Metal	Symbol	Conc (mg/L)	EPA Standard (mg/L)	NEQS Standard (Pakistan) (mg/L)
01	Calcium	Ca	99.5	-	-
02	Manganese	Mn	-	-	-
03	Iron	Fe	14.4	2.0	2.0
04	Cobalt	Co	15.0	0.05	-
05	Copper	Cu	12.0	0.05	1.0
06	Zinc	Zn	3.5	-	5.0
07	Cadmium	Cd	-	-	0.1
08	Lead	Pb	1.5	0.1	0.5

After taking these results, Co & Cu were taken for further testing with nano material.

Experiments were performed to determine the effect of adsorbent dosage, pH and retention time for stirring. Forty five experiments were done with Fateh Textile mill wastewater. It was found that maximum 96% adsorption of Co was obtained at 1.0 g/L adsorbent dosage at 9.0 pH for 15 minutes retention time, and maximum adsorption of Cu was 95% that was gained at 1.0 g/L adsorbent dosage, 7.0 pH and 30 minutes retention time.

3.2. Effect of Adsorbent Dosage

A number of experiments were performed using adsorbent dosage of 1.0, 2.0 and 3.0 g/L of test solution at pH 4.0, 7.0 and 9.0. The maximum removal of 96% and 89% for Co, 95% and 86% for Cu was obtained at 1.0 g/L of Amber lite XAD7HP. Graph 1 and 2 show that a 1.0 g/L

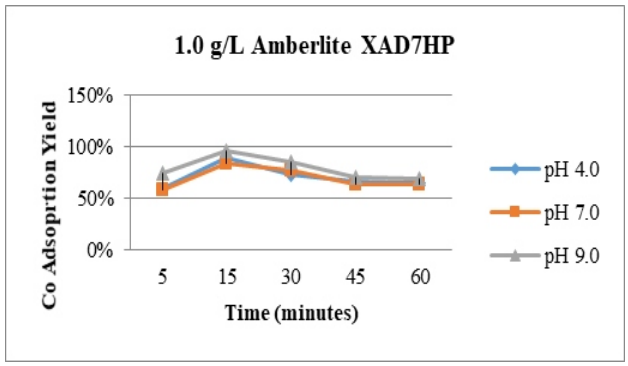

Figure 2. Co-Adsorption Yield% at 1.0 g/L Adsorbent Dosage

Dosage was sufficient for the optimum removal of Co and Cu. Every metal have different affinity and attraction to the adsorbent, which can be seen that Co adsorption is more at the start as compare to Cu which may be due their charge density and size of nuclear radius. 1.0 g/L dosage pf Amber lite XAD 7HP in neutral pH zone again gets more adsorption which shows that is suitable for the removal of Co. adsorbent dosage in basic pH zone becomes favorable for the adsorption of Co. The adsorption of Co rises to maximum value 96% and which then on giving more retention time goes to decreases up to 85% and then more reduces to 69%. The basic zone does not proof as a good sign for the adsorption of Cu which remains at 73% from initial time and then goes to 95% up to 30 minutes, but then giving more retention time slightly decreases up to 79% by giving maximum time interval of 60 minutes.

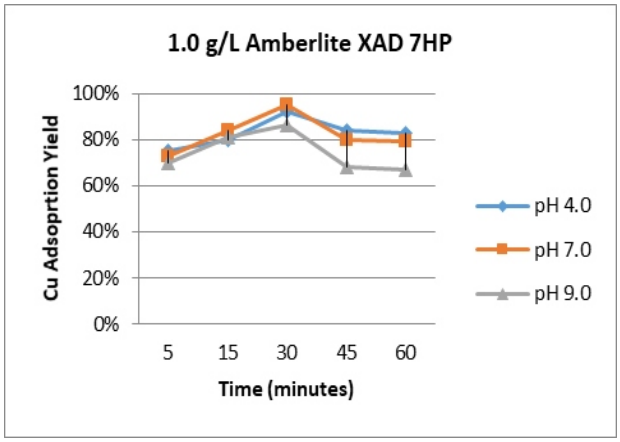

Figure 3: Cu Adsorption Yield% at 1.0 g/L Adsorbent Dosage

Increasing adsorbent dosage did not show more efficiency and getting good results. Initially at 2.0 g/L dosage, in Graph 3 & 4 adsorption of Co was same in acidic pH zone but further on

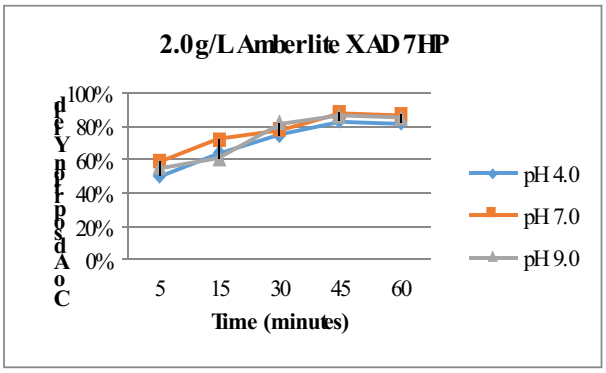

Figure 4: Co Adsorption Yield% at 2.0 g/L Adsorbent Dosage

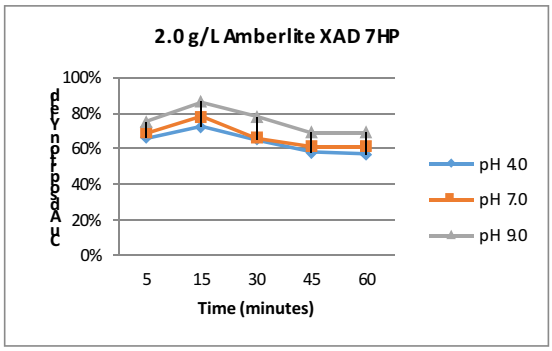

Figure 5: Cu Adsorption Yield% at 2.0 g/L

Adsorbent Dosage 3.0 g/L dosage of Amber lite, Graph 5 & 6 did not show maximum adsorption result which could may be due to the cluster formation of adsorbent molecules which reduced metal capture and adsorption. In neutral pH zone the adsorption of Co was in start 75% at 5 minutes retention time and then further giving more retention time did not give significant increase in removal percentage, while on the other hand the adsorption of Cu was also not optimum at 3.0 g/L dosage. The adsorption of Cu was 79% at start in 15 minutes retention time which then further decreased to 62%.

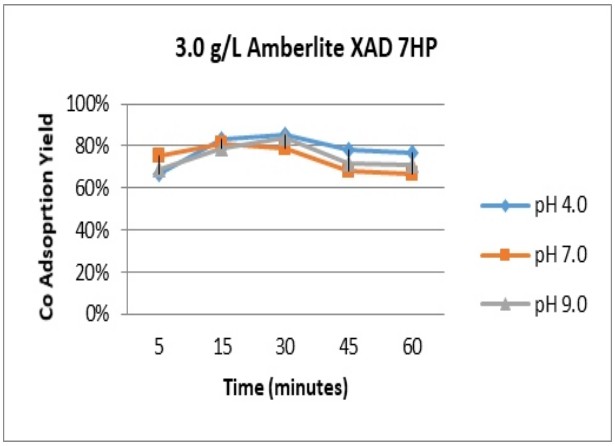

Figure 6: Cu Adsorption Yield% at 3.0 g/L Adsorbent Dosage

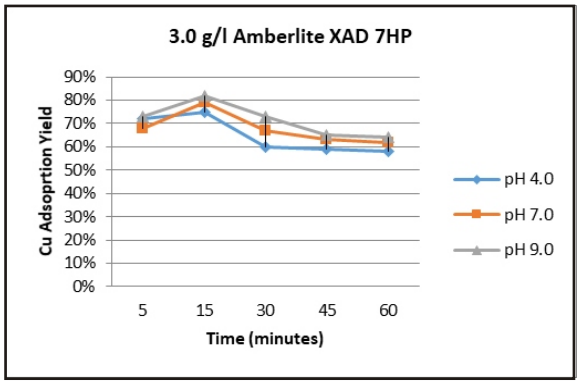

Figure 7: Cu Adsorption Yield% at 3.0 g/L Adsorbent Dosage

A further increased amount of adsorbent dosage had not significant effect on the removal of Co and Cu. This observation was confirmed by [29] for heavy metal removal of Al, Fe, Mn from industrial wastes by using GAC on and Amber lite IR-120H as an adsorbent. More dosage causes agglomeration which is a factor the reduction of adsorption yield. The distance between particles of adsorbent decreases which reduces the easily capturing of metal ion? As the number of particles of adsorbent increases a resistance is created to outer most layers of the adsorbent molecules which do not allow the binding sites to attract the metal ion towards itself. Another problem that is created by overdosing of adsorbent is the intersection of active sites of the adsorbent which also causes desorption or less adsorption behavior that can be seen at 3.0 g/L dosage.

3.3. Effect of pH:

It was noted that adsorption of HM ion was not significantly more in low pH zone which may be due to fight between hydrogen ion and metal ion during ionization. The other factor is that metal ion and hydrogen ion have the same charge which make a dispute between the metal ion and hydrogen ion during adsorption process [29]. Increasing pH creates an electrostatic force of attraction that causes favorable condition for the adsorption of metal ion. There was another problem with increasing pH that the metal ion did not remain stable for the adsorption process. They show precipitation behavior and make complex molecules by combining with other molecules or ions which make it difficult to carry for the adsorbent. The pH effects on the adsorption at a certain level then it further increase in pH value causes the reverse process of adsorption which results in low yield. Precipitation of metal ion was also noticed by kharman during his experimental work for the adsorption of chromium ion.

3.4 Effect of Retention Time:

Applying 15 minutes retention time, Graph 1 & 2, the maximum adsorption of Co was 96% at 1.0 g/L dosage of adsorbent in basic pH 9.0 zones. The second most optimum value for the same time period was 89% which was gained at 1.0 g/L dosage in acidic pH 4.0. The maximum adsorption for Cu in this time period was 86% that was obtained using 2.0 g/L adsorbent dosage and basic pH 9.0. The second most optimum value was 80% obtained using 1.0 g/L adsorbent dosage for pH 4.0. The

reason behind the more adsorption of Co against Cu is due to charge density. The Co has more charge density as compare to Cu which has greater affinity to the adsorbent as compare to Cu. The second reason behind more adsorption of Co is the difference in the size of ionic radius. The ionic radius of Co is 60 pm while Cu having 73 pm. Co ion is more easy to trap by the adsorbent due to shorter ionic radius as compare to Cu, and its goes to equilibrium earlier than Cu. Increasing retention time above certain value did not show increase in adsorption behavior.

Conclusions:

Adsorbent dosage was found to be the significant parameter that effects the percentage removal of heavy metal ions, it was found that the maximum removal of heavy metal ions was taken at 1.0 g/L adsorbent dosage at room temperature, if the adsorbent is further increased the sorption of heavy metal ion decreases due to agglomeration which causes screening effect, and consequent reduction in inter-particle distance. The pH has large effect on the sorption yield, at higher pH 9.0 sorption yields was maximum due to increased electrostatic force of attraction produced by the negative charge at the surface of adsorbent which is favorable for adsorbing cationic species. The adsorption of metal ions was faster at beginning to 15 minutes retention time due to the accessibility of more number of adsorptive sites. Further increased of retention time decreases the sorptions due to partial desorption that may occur due to the charge density and diameter of hydrated actions. The Nano particles after the filtration process can also be reused or regenerated.

Nano-adsorbent, such as CNTs, nanomaterial, or nanometal oxides, and other organic sorbents are used successfully in the removal of heavy metal ions in wastewater, it still remains several problems, and wastewater treatment on a large scale is the essential one. As the nanotechnology developed, the development of new efficient adsorption material is requisite and will continue infinitely, the future of nanomaterial's in removal heavy metal ions in wastewater treatment is fairly bright.

References:

1. M. Morshed and A. J. B. T. T. Guha, "Production of Biogas from Textile Sludge by Anaerobic Digestion, a Sustainable Ecofriendly Sludge Management Method," 2014.
2. Z. Wang, M. Xue, K. Huang, and Z. Liu, "Textile dyeing wastewater treatment," in Advances in treating textile effluent: IntechOpen, 2011.
3. K. Rajaganesh, N. Sumedha, and B. J. I. S. R. J. Ameer, "Characterization of textile dye effluent from Komarapalayam, Namakkal district, Tamilnadu, India," vol. 4, pp. 2230-7850, 2014.
4. S. Nosheen, H. Nawaz, and K.-U. J. I. J. A. B. Rehman, "Physicochemical characterization of effluents of local textile industries of Faisalabad-Pakistan," vol. 2, pp. 232-233, 2000.
5. S. Hyder, A. J. M. U. R. J. o. E. Bari, and Technology, "Characterization and study of correlations among major pollution parameters in textile wastewater," vol. 30, pp. 577-582, 2011.
6. D. Saba Sadiq, A. Yasar, and M. Zakria, "CLEAN AND LOW COST TECHNIQUES FOR TEXTILE DYE BATH EFFLUENT TREATMENT."
7. H. J. J. S. e. Koslowski, "Dictionary of man-made fibers," 2000.
8. P. J. E. I. Soldán, "Toxic risk of surface water pollutionsix years of experience," vol. 28, pp. 677-682, 2003.
9. G. Tamburlini, O. S. v. Ehrenstein, R. Bertollini, and W. H. Organization, "Children's health and environment: a review of evidence: a joint report from the European Environment Agency and the WHO Regional Office for Europe," 2002.
10. K. Kadirvelu, K. Thamaraiselvi, and C. J. B. t. Namasivayam, "Removal of heavy metals from industrial wastewaters by adsorption onto activated carbon prepared from an agricultural solid waste," vol. 76, pp. 63-65,

2001.

11. M. Kobya, E. Demirbas, E. Senturk, and M. J. B. t. Ince, "Adsorption of heavy metal ions from aqueous solutions by activated carbon prepared from apricot stone," vol. 96, pp. 1518-1521, 2005.
12. L.H. Luo, Q.M. Feng, W. Q. Wang, and B. L. Zhang, "Fe3O4/Rectorite composite: preparation, characterization and absorption properties from contaminant contained in aqueous solution," in Advanced Materials Research, pp. 592-598.
13. H. Abdolmohammad-Zadeh, E. Ghorbani, and Z. Talleb, "Zincâ "aluminum layered double hydroxide as a nano-sorbent for removal of Reactive Yellow 84 dye from textile wastewater effluents," Journal of the Iranian Chemical Society, vol. 10, pp. 1103-1112.
14. W. Yantasee, R. D. Rutledge, W. Chouyyok, V. Sukwarotwat, G. Orr, C. L. Warner, M. G. Warner, G. E. Fryxell, R. J. Wiacek, and C. Timchalk, "Functionalized nanoporous silica for the removal of heavy metals from biological systems: adsorption and application," ACS applied materials & interfaces, vol. 2, pp. 2749-2758.
15. M. Pansini, C. Colella, and M. De Gennaro, "Chromium removal from water by ion exchange using zeolite," Desalination, vol. 83, pp. 145-157, 1991.
16. T. Masciangioli and W.-X. Zhang, "Peer reviewed: environmental technologies at the nanoscale," ACS Publications, 2003.
17. G. L. Hornyak, H. F. Tibbals, J. Dutta, and J. J. Moore, Introduction to nanoscience and nanotechnology: CRC press, 2008.
18. J. Riu, A. Maroto, and F. X. Rius, "Nanosensors in environmental analysis," Talanta, vol. 69, pp. 288-301, 2006.
19. R. Ben-Mansour, M.A. Habib, O. E. Bamidele, M. Basha, N. A. A. Qasem, A. Peedikakkal, T. Laoui, and M. Ali, "Carbon capture by physical adsorption: materials, experimental investigations and numerical modeling and simulations "a review," Applied Energy, vol. 161, pp. 225-255.
20. I. Ali, Z.A. Al-Othman, and A. Alwarthan, "Molecular uptake of congo red dye from water on iron composite nano particles," Journal of Molecular Liquids, vol. 224, pp. 171-176.
21. M.H. Marzbali, A.A. Mir, M. Pazoki, R. Pourjamshidian, and M. Tabeshnia, "Removal of direct yellow 12 from aqueous solution by adsorption onto spirulina algae as a high-efficiency adsorbent," Journal of environmental chemical engineering, vol. 5, pp. 1946-1956.
22. S.M. Ali, K.M. Emran, and A.L.L. Al-Oufi, "Adsorption of organic pollutants by nano-conducting polymers composites: Effect of the supporting nano-oxide type," Journal of Molecular Liquids, vol. 233, pp. 89-99.
23. X. Jin, C. Yu, Y. Li, Y. Qi, L. Yang, G. Zhao, and H. Hu, "Preparation of novel nano-adsorbent based on organicâ "inorganic hybrid and their adsorption for heavy metals and organic pollutants presented in water environment," Journal of hazardous materials, vol. 186, pp. 1672-1680.
24. A.H. Kaynar, I. Å abikoÄŸlu, S. A. a. Kaynar, and M. Eral, "Modeling of thorium (IV) ions adsorption onto a novel adsorbent material silicon dioxide nano-balls using response surface methodology," Applied Radiation and Isotopes, vol. 115, pp. 280-288.
25. L. Rafati, M. H. Ehrampoush, A. A. Rafati, M. Mokhtari, and A. H. Mahvi, "Modeling of adsorption kinetic and equilibrium isotherms of naproxen onto functionalized nano-clay composite adsorbent," Journal of Molecular Liquids, vol. 224, pp. 832-841.
26. X. Ma, Y. Wang, M. Gao, H. Xu, and G. Li, "A novel strategy to prepare ZnO/PbS heterostructured functional nanocomposite utilizing the surface adsorption property of ZnO nanosheets," Catalysis Today, vol. 158, pp. 459-463.
27. C.-Y. Cao, Z.-M. Cui, C.-Q. Chen, W.-G. Song, and W. Cai, "Ceria hollow nanospheres produced by a template-free microwave-

assisted hydrothermal method for heavy metal ion removal and catalysis," The Journal of Physical Chemistry C, vol. 114, pp. 9865-9870.

28. M. E. Goher, A. M. Hassan, I. A. Abdel-Moniem, A. H. Fahmy, M. H. Abdo, and S. M. El-sayed, "Removal of aluminum, iron and manganese ions from industrial wastes using granular activated carbon and Amberlite IR-120H," The Egyptian Journal of Aquatic Research, vol. 41, pp. 155-164.
29. H. T. Kahraman, "Development of an adsorbent via chitosan nano-organoclay assembly to remove hexavalent chromium from wastewater," International journal of biological macromolecules, vol. 94, pp. 202-209.