Ghanshyam. International Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 5, Issue 1, (Part-6) January 2015, pp. 72-78

RESEARCH ARTICLE

OPEN ACCESS

Removal of Hexavalent Chromium from Synthetic Waste water through Adsorption

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ABSTRACT

The hexavalent chromium maycauseserioushealthproblemsandalsoresultenvironmental deterioration. In the present study, the removal of hexavalent chromium from synthetic wastewater using commercially available activated carbon has been carried out under variable experimental conditions. The experiments have been performed for variable pH, contact time and activated carbon dosage. The results show that the removal of hexavalent chromium has greatly been affected by all three parameters. Assessing theresults for higher adsorbent dosages at optimum pН value of 2, it mav be deduced that in a minimum time of 30 minutes, more than 95% chromium is efficiently removed from the solution. Hence suggested that at aminimumtimeofcontactof30on the basis of this result it may be minutes should be provided to obtain removal percentages of greater than 85%. The adsorption data obtained experimenta llyhasbeenanalyzedusingtwoadsorptionisotherm methods which include Langmuir and Freundlich at varied conditions of pH which show better fitting isotherm models.

Keywords: hexavalent chromium, synthetic wastewater, activated carbon, adsorption

I. INTRODUCTION

Adsorption is a process which occurs when a gas or liquid solute accumulates on thesurface of a solid or a liquid (adsorbent), forming a molecular or atomic film (theadsorbate).Adsorption is а consequence of surface energy. In a bulk material, all the bondingrequirements(bethey ionic, covalent metallic)oftheconstituent or atoms of the material are fulfilled by other atoms in the material. However, atoms on the surface of the adsorbent are not wh ollysurroundedbyotheradsorbentatomsandthereforec anattract adsorbate. Adsorptionisarelativelylowcostprocess.Adsorptionhascertainadvantages over other conventional methods such as it results in a lower quantity ofchemicalandbiologicalsludge, highefficiency, regen erationofadsorbentsandpossibility of metal recovery. Adsorption is commonly used technique for the removalof metal ions from various industrial effluents. Adsorbents which have been alreadyused for heavy metal removal are activated carbon, zeolites, agricultural waste product such as water hyacinth, sunflower and coconut coir pith etc. Y. Orhan et al. (1993) carried out removal of heavy metals from wastewater usingadsorbents such as waste tea, Turkish coffee, exhausted coffee, nut and walnutshells.Sharma and Forster (1994) tested sawdust, sugar bagasse, cane beet pulp and maize cobwhich are organic was tes as potential adsorbentsforhexavalent chromium removal. Selvi et al. (2001) used activated carbon prepared from coconut tree sawdustwhich was used as an adsorbent for the removal of Chromium from its aqueoussolution. Garg et al. (2004) have performed similar experiments

withcommerciallyavailablecoconutbasedactivatedcar bontocompare the results. Acharya et al. (2009) studied the adsorption of chromium (VI) on activated carbonprepared from *Tamarind wood* with zinc chloride activation. Anirudhan and Sreekumari (2011) have used activated carbon (AC) derived fromwaste

coconutbuttons(CB)intheirstudyasasuitableadsorben tfortheremoval of heavy metal ions such as Pb (II), Hg (II) and Cu (II) from industrial effluentsthrough batch adsorption process. However, Arulkumar et al. (2012) investigated the rapid removal of chromium ions fromaqueous solutions using prawn shell activated carbon (PSAC). Li et al. (2013) graphene functionalised oxide withmagneticcyclodextrinchitosanfortheremovalofc hromiumfrom industrial effluent in their batch studies. In the present study, the removal of hexavalent chromium from synthetic wastewater using commercially available activated carbon has been carried out under variable experimental conditions.

II. METHODOLOGY

2.1 SYNTHETICWASTEWATER

Depending on the availability of the various reagents and apparatus to be used

Ghanshyam. International Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 5, Issue 1, (Part-6) January 2015, pp. 72-78

fordeterminationofheavymetalsinthesyntheticwaste water,Chromiummetalhasbeentaken as the metal of choice for removal using activated carbon as an adsorbent.Colorimetricmethod()hasbeenemployedfo rthedeterminationofchromiumintheprepared

wastewater samples. The syntheticwastewater having hexavalent chromiumhas been prepared bydissolvingthesaltpotassiumdichromate(K2Cr2O7) indistilledwaterinordertopreparestocksolution(500pp m)following

Standard Methods for the Examination of Water and Was

tewater,20thEdition.

2.2 STANDARDCALIBRATIONCURVE The work

The working standardsof0.1,0.2,0.4,0.5,0.6,0.8,1.0ppmchromiums olutionshave beenpreparedusing 500 ppm standard solution in beakers along with a blank. Thereafter, five drops of *ortho-phosphoric acid* have been added to each beaker for color development. Fig. 1 shows standardcalibrationcurve used in the present study.



Fig.1: Standard calibration curve

2.3 EXPERIMENTALPROCEDURE

Synthetic wastewater solutions of 100 mL been prepared in batches using the have stocksolution and each of the solutions had a chromium concentration of 10 ppm. The pHof the solutions has been adjusted to the desired value specified range of within the 2 to 7using1NH2SO4and0.1NNaOH.Thesesolutionswere transferredto250mLconicalflasks. The solutions were then dosed with the desired weight of the adsorbent ranging from 0.2 to 1.2 g/L. The adsorbent dosed solutionshave been then placed in a mechanical shaker and a git at edataspeedof150rpm,decidedon the basis of the most prevalent value of agitation speed from several researchstudies. The shaker has been stopped after every 30-minutes of contact time and 5 mL sampleshave been taken from each conical flask. The samples have been then filtered using

Whatman'sfilterpaper.Centrifugationofcollectedsam pleshasalsobeen doneintheinitialbatchesofthe research and results of concentration identical to that of filtration. The samples have been then examined for reduction in concentration of chromium afteradsorption by correlating with the calibration curve within stipulated time intervals of 30, 60, 90, 120, 150 and 180 minutes. Minimum of three samples have been tested for asingle result and the average results have been noted. The reaction kinetics for eachbatchhasbeenestablishedindividually. The adsorp tionhasalsobeenexaminedandcorrelatedbyusingisoth erms.

2.4 ADSORPTIONISOTHERMS

Isotherms relative to constant pH values have been prepared in order to provide thedescriptionoftheinteractionofadsorbateandadsorb entsurfaces and to optimize the use of adsorbents for removal of adsorbates from aqueous solutions. Langmuir and Freundlich isotherms have been developed by plotting C_e/q_e versus C_e or $1/q_e$ versus $1/C_e$ for the former and $log q_e$ versus $log C_e$ for the

latter. Thevalueof R_L inLangmuirisotherm indicates the type of Langmuir isotherm to be either irreversible (R_L = 0) or favourable ($0 < R_L < 1$) or linear (R_L = 1) or unfavourable ($R_L > 1$). The value of n (1 < n < 3) in the Freundlich isotherm indicates that the adsorption of chromium on theadsorbentisfavorable.

III. RESULTS AND DISCUSSION

The experimental results clearly show that percentageremovalefficiency of hexavalent chromium increases with decrease in pH.

Fig.2clearlydepictstheincreaseinthepercentageremov alefficiencyofchromiummetalfromthesyntheticwaste waterasthetimeprogressesatallconditionsof pHand an activated carbon dosage of 0.2 g/L. It can be observed that at the pHvalue of 2, the percentage removal increases from 50.5% to 61% within a duration

of3hours.ForthepHvalueof3,anincreaseintheremoval efficiencyfrom45%to51%can be observed. At the pH value of 4, percentage removal can be seen to rise from37%to43%overatimeperiodof180minutes.ForthehigherpHvalues,althoughthepercenta ge removal is not significant but it is seen to show an increasing trend andrises from 11% to 14%, 5% to 10% and 3% to 8% for the pH values of 5, 6 and 7respectively overthecontactperiodof3hours.



Fig. 2:RemovalEfficiencies with Variable pH, Contact Time and Constant Dose 0.2 g/L

Fig.

3clearlydepictstheincreaseinthepercentageremovalef ficiencyofchromiummetalfromthesyntheticwastewat erasthetimeprogressesatallconditionsof pH and an activated carbon dosage of 0.4 g/L. It can be observed that at the pHvalue of 2, the percentage removal increases from 68% to 81% within a duration of180-minutes. For the pH value of 3, an increase in the removal efficiency from 57.5%to 65.5% can be observed. At the pH value of 4, percentage removal can be seen torise from 45% to 48.5% over a time period of 180-minutes. For the higher pH values, although the percentage removalis not significan tbut it is seen to show an increasing trend and rises from 25% to 30%, 14% to 19% and 10% to 13% for the pH values of 5,6 and 7 respectively over the contact period of 3 hours.



Fig. 3:Removal Efficiencies with Variable pH, Contact Time and Constant Dose 0.4 g/L

Fig.

4clearlydepictstheincreaseinthepercentageremovalef ficiencyofchromiummetalfromthesyntheticwastewat erasthetimeprogressesatallconditionsof pH and an activated carbon dosage of 0.8 g/L. It can be observed that at the pHvalue of 2, the percentage removal increases from 82.5% to 95% within a duration of 3 hours. For the pH value of 3, an increase in the removal efficiency from 72% to84.5% canbeobserved. AtthepHvalueof4, percentage removal can be seen torise from 49% to 62% over a time period of 180-minutes. For the higher pH values, although the percentage removal is not significan tbut it is seen to show an increasing trend and rises from 47% to 53%, 34% to 38% and 6% to 18% for the pH values of 5,6 and 7 respectively over the contact period of 3 hours.



ISSN: 2248-9622, Vol. 5, Issue 1, (Part-6) January 2015, pp. 72-78

Fig. 4:Removal Efficiencies with Variable pH, Contact Time and Constant Dose 0.8 g/L

LangmuirAdsorptionIsotherm

Fig. 5 and Table 1 depicttheLangmuirisothermplotandparametersrespectively atthepHvalueof2.



Table 1:LangmuirIsotherm parametersatapHvalueof2

SLOPE	INTERCEPT	QMAX	KL	RL	R ²
0.272266	0.2881587	3.672882	0.944846707	0.095708	0.953414

Freundlich Isotherm

Fig. 7andT a ble 2 illustratetheFreundlichisothermandparameters, respectivelyatthepHvalueof 2.



Fig. 7:Freu ndlich Isothermat pH 2

Table2:Fi	reundlichIsothern	nparametersata	pHvalue	of2

SLOPE	INTERCEPT	1/n	Kf	R ²	Ν
0.442519	0.2037393	0.442519	1.598598282	0.993702	2.259788

From the isotherms, it is clear that Freundlichads or ption is otherm has a higher coefficient of regression and is there by a better fit.

IV. CONCLUSIONS

Itisconcludedthatfor the pH value of 2, maximum adsorption occurs and the removal efficiency is seento increase from 50.5% to 61% over a time interval of 120 minutes for an activatedcarbondosageof0.2g/L.Similarly,fordosages of0.4,0.6,0.8,1.0and1.2g/Lan

increaseof13%,9.5%,12.5%,9% and 7.5% can be obser vedrespectively, when the contact period is increased from 30 to 180 minutes at the pH of 2. Assessing theresults for higher adsorbent dosages at optimum pН value of 2, it may be deduced that in a minimum time of 30 minutes, more than 95% chromiumis efficiently removed from the solution. Hence on the basis of this result it may be suggested that at aminimumtimeofcontactof30*minutes* should be provided to obtain removal percentag esofgreaterthan85%.

Theadsorptiondataobtainedexperimentallyhasbeenan alyzedusingtwoadsorptionisotherm methods which include Langmuir and Freundlich at varied conditions of pH.The better fitting isotherm model has been selected on the basis of the coefficient of regression. R^2 .

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