ISSN: 0974-5823 Vol. 7 No. 4 April, 2022

International Journal of Mechanical Engineering

Experimental Study of Removal ofChromium from Industrial Wastewater byUsing Cow Dung as Adsorbent

Rajeshkanna K[1], Arun Prasad J[2], SouthamirajanS[3], Nithyaprakash G[4]

[1]PG Student, Erode Sengunthar Engineering College, Perundurai, Erode

[2,4]Faculty, Erode Sengunthar Engineering College, Perundurai, Erode

[3]Faculty, Kongunadu College of Engineering & Technology, Thottiyam, Trichy

ABSTRACT

The presence of Industrial waste water contains high levels of heavy metals that may pollute the wateronce it is discharged to the nature. The heavy metals, Chromium (Cr) and Lead (Pb) are the most toxic substances.The main objective is to develop low cost absorption technologies to treat particularly Cr+ and Pb+ contaminatedwaste water. In this project, a naturally available material like cow dung is used to develop low cost absorption toremove the presence of Cr+ and Pb+ metals in waste water. The waste water samples collected from the industrial units, when tested under laboratory conditions exhibited a fixed pH value and Cr+ or Pb+ concentration. The naturallyobtained cow dung was collected, dried and burnt to ashes are used to remove the Cr+ and Pb+ presence by adsorbentmethod here. Detailed experimental studies with proposed low cost adsorption in treating the aqueous solution withvarying Cr+ or Pb+ concentration was carried out as part of the research study. The aqueous solution has been prepared. And unique concentration of Cr+ with pH values and activated ashes were added separately to the aqueoussolution with different dosages and varying contact periods.

Keywordschromium, quality index, cow dung, effluents, adsorbent

I. INTRODUCTION

Chromium and Lead are the world's most critical elements in the contaminated water from the industries resultedin ubiquitous pollutants on the environment due to its high solubility. In particular, Hexavalent chromium (Cr(VI)) and Lead are classified carcinogenic contaminant of significant concern, endangering our environment andhuman body through direct or indirect pathways. The most of the waste water primarily from the industrial tanningprocess results in water contaminated with Hexavalent chromium (Cr (VI)) and Lead dominantly. Historically ithas been used in a wide range of industrial applications including steel, pigments, wood preservatives,electroplating, metal finishing, dyes, leather tanning, textiles and chemical manufacture. Chromium is widely usedin alloys such as stainless steel, chrome plating and metal ceramics. Earlier, chromium plating was commonly usedto give steel a polished silvery mirror coating. Also, chromium is used (i) in metallurgical industry to impartcorrosion resistance and a shiny finish, (ii) in dye and paint industries, (iii) to produce synthetic rubies, (iv) as acatalyst in dyeing and in the tanning of leather, (v) to make moulds for the firing of bricks and (vi) Chromiumoxide (CrO2) is used to manufacture magnetic tape. In specific, Hexavalent chromium (Cr(VI)) is one of the world'smost strategic and critical materials having a wide range of uses in the metal and chemical industries. Due to thesevere toxicity of Cr(VI), the U.S. Environmental Protection Agency (USEPA) has set the maximum contaminantlevel (MCL) for Cr(VI) in domestic water supplies at 0.05 mg/L.

II. HEXAVALENT CHROMIUM

The efficiency of activated carbons prepared by various chemical activations in the removal of hexavalentchromium [Cr(VI)] was investigated in this present study. Chromium is usually found in industrial effluents such aselectroplating, leather tanning and textile industries. Chromium, in wastewater can exist both as Cr(III) and Cr(VI).However, in potable waters, Cr(VI) appears as the most stable species due to the aerobic conditions in the environment.The trivalent form is not considered toxic. On the other hand, the detrimental effects of hexavalent chromium tobiological systems and the environment have been well documented (Bagchi et al. 2002). Exposure to Cr(VI) beyondthe tolerance levels (0.05 mg/L) can have damaging effects on the human physiological, neurological and biologicalsystems. Several methods have been adopted for the removal of Cr(VI) from aqueous pase (Agarwal et al. 2006; Baeket al. 2007; Dragan et al. 2004; Kyzas et al. 2009; Muthukrishnan&Guha, 2008 and Yilmaz et al. 2008).

TABLE 1

GENERAL PROPERTIES

Sl. No.	Description	Value
1.	Appearance	Metallic gray
2	Atomic number (z)	82
3.	Group, period	Carbon group "14"
4.	Block	Period "6"
5.	Element category	Post-transition metal
6.	Standard atomic weight	207.2
7.	Electron configuration	[Xe] $4f^{14}$ $5d^{10}6s^{2}6p^{2}$

TABLE 2

OTHER PROPERTIES

Sl.No.	Description	Value
1.	Crystal structure	Face-centered cubic (fee)
2	Thermal expansion	28.9/um/(m.k) [at 25°c]
3.	Thermal conductivity	35.3 w/(m.k)
4.	Electrical resistivity	208 nΩ.m [at 25°c]
5.	Magnetic ordering	Diamagnetic
6.	Young's Modulus	16 GPa.
7.	Shear modulus	5.6 GPa
8.	Bulk modulus	46 Gpa
9.	Poission's ratio	0.44
10.	Mohrs hardness	1.5
11.	Brinell hardness	38-50 MPa
12.	CAS Number	7439-92-1

III. SCOPE

These include chemical reduction and precipitation, ion exchange, evaporation and concentration, electrolysis and electroplating, ion flotation, activated sludge process and carbon adsorption. Adsorptive removal of pollutants by activated carbon is found to be the most effective, particularly for the removal of metal ions at low concentrations.

IV. LITERATURE

In 2014 M. I. Alfa et al. had proposed the efficiency of the mesophilic biodigestion process in the stabilization and sanitization of cow dung and chickendroppings. Six (6) kg each of cow dung and chicken droppings were collected freshand free from impurities, pre-fermented, mixed with water in the ratio 1:1 w/v to formslurry, fed into the respective reactors and digested for 30 days at an average ambienttemperature of 30degree centigrade. The pH of the medium fluctuated between 6.5and 8.0. The analysis of the feedstock and effluent of the digesters showed that a totalsolids reduction of 75.3% and 60.1% were recorded for cow dung and chickendroppings while the reduction in total coliforms had about 95% and 70% respectivelyfor the dung and droppings. Microbial analysis of the bio fertilizer produced revealsboth aerobic and anaerobic organisms which include species of Pseudomonas,Klebsiella, Clostridium, Bacillus, Bacteroides, Salmonella, Penicillum andAspergillus. Escherichia coliandShigellaspp were removed while species ofSalmonella and Klebsiella were still presented in the digestate.

In 2014 P. Mullai et al. had proposed the presence of heavy metals in watersupplies and wastewater threatens the environment and the health of humans. Theadsorption of chromium (VI) onto cow dung ash, a bio-organic waste had beeninvestigated in a batch reactor under two different conditions, namely, initial metalion concentration and adsorbent dosages. For the five different initial metal ionconcentrations such as 500, 600, 800, 900, 1000 mg/L, the steady state values ofchromium removal efficiency were 100, 83.33, 88.09, 94.3 and 96 %, respectively,using 20 g of cow dung ash under shaking at the end of 3rdh. The equilibrium of theprocess was found to fit into the two well-known adsorption models, Freundlich andLangmuir. The results obtained in the previous study revealed the potentialapplication of the cow dung ash in the removal of metal ions from the aqueous solution.

In 2012 A. Ounnar et al. had proposed the anaerobic digestion offersan advantageous alternative to land filling, incineration and composting since it isconsidered as the most appropriate treatment solution. Indeed, the biogas naturallyproduced by the fermentation of organic waste into anaerobic digesters, containsbetween 40 and 60% of methane, which gives it fuel character and its valorizationallows energy conservation while protecting the environment by reducing thegreenhouse gases emission. The main aim of the literature explained to popularize thetechnique of organic waste bio mechanization or anaerobic digestion in order toproduce renewable energy and cleaner environment through the exploitation ofresearch results. The above process supported to the experimental results obtained inthe laboratory. The mesophilic anaerobic digestion of cow dung, into an experimentaldigester of 800 liters capacity, had produced 26.478 m3 of biogas for 77 days with anaverage optimal. These results are hopeful for the use of cattle wastes mass availablein Algeria, or even household wastes.

In 2010, Landrout et al. were the first people to measure the initial rates of Cr(III)oxidation on hydrous manganese oxide (HMO) at three different pH values (pH 2.5, 3,and 3.5), using a quick X-ray absorption fine structure spectroscopy (Q-XAFS) batchmethod and found out that the values of rate constants were independent of bothCr(III) and Mn(II) and mixing speed, suggesting that the reaction was “chemically”controlled and not dependent upon diffusion during the time period of measurements.In 1996, Sharma & Forster proposed totally different mechanism that the removal of Cr(VI) at low pH is governed by the active reduction reaction given by the followingequations and they noticed the increase in pH of the final solution. The effect of pH onthe adsorption of Cr(VI) is attributed to the interactions between ions in solution andcomplexes formed at the adsorbent surface. The Cr(VI) can form different species atdifferent pHs in aqueous solutions and the maximum adsorption of Cr(VI) on thevarious adsorbents was found at pH 2.0 and negligible at pH values over 8.0 (Mohanet al. 2005).

Vjayraghavan. K and Veoung. Sang Yun (2008) reviewed that the biosorptiontechnique used for removal of pollutants from water especially for non– degradable materials like metals and dyes. Various bio – materials are used for thisbiosorption like fungi, bacteria, algae, agricultural waste. To enhance biosorptioncapacity, biomass modifications through chemical methods were discussed, factorsinfluencing the biosorption also discussed.AjaeluChijiokeJhon et al., (2011) says that equilibrium and kinetics studies ofbiosorption of cadmium on Cassia Siamea Bark, to remove Cd (II) ions from aqueoussolutions. Batch equilibrium studies the highest Cd (II) ions removal yield wasachieved at pH 7.0, Adsorption capacity of Cdincreased from 2.48 to9.81 mg/g. the equilibrium experimental data better fitted the freundlich isotherm. Inkinetics model pseudo second order was the best of the kinetics model to successfullydescribe the biosorption.

V. METHODOLOGY

As the required materials for the experimental works has been collected from the various places mentioned in thematerial collection. The aqueous solution which used to do the experimental work has been prepared with variousdosage levels of 4, 6, 8 and 10 g/l was mentioned in the adsorbent preparation. In the preparation of aqueous solutionarea it has been explained in detailed manner how the aqueous solution was made with different pH level. As thetest material has been made prepared for the test and the preliminary test on aqueous solution and confirmatory teston aqueous solution was done to calculate the final concentration level with various pH levels. From the preliminaryand confirmatory tests the initial concentration of chromium in aqueous solution using spectrophotometer has beenmade out. Then the batch process has been carried out with all the parameters such as pH values, dosage level andcontact period and the final concentration of chromium in aqueous solution after completion of batch process usingspectrophotometer. From the results obtained from the above mentioned tests and results, the graph plotting andresult analysis has been made. By plotting the graphs and result analysis a detailed review has been made and clearconclusion has been presented.

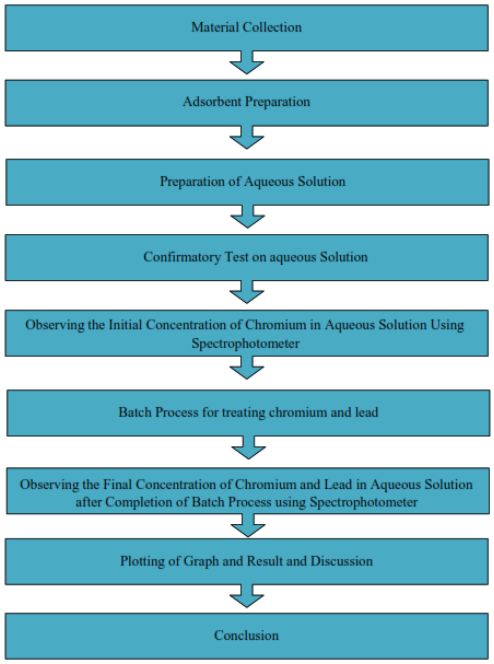

FIGURE 1

V. MATERIAL TEST

In this work, the aqueous solution is employed rather than the collected chromiumcontaminated waste water from the industry to study the influence of proposedactivated cow dung. The reason for the use of aqueous solution for this research studyis, the collected chromium contaminated waste water from the industry will haveonly a particular Crconcentration and pH value. A stock solution of Cr (VI) isprepared by dissolving 2.8287g of K2Cr2O7 in 1000ml of water. The prepared solutionis diluted as required to obtain standard solution. Initial concentration of preparedsolution is 1000ppm.

The dried cow dung is treated with concentrated H_2SO_4 in the ratio of 1:1 and kept inthe oven for 24h. Then the activated cow dung is washed with the distilled water toremove the free acids and dried for few hours. The Fig. 3.2 shows the raw cow dungas collected and the final activated powder material ready to be used as absorbent..

FIGURE 2

Cow dung Dried and powdered

FIGURE 3

ACTIVATED COW DUNG

V. RESULTS ANALYSIS

I. PRIMARY RESULTS

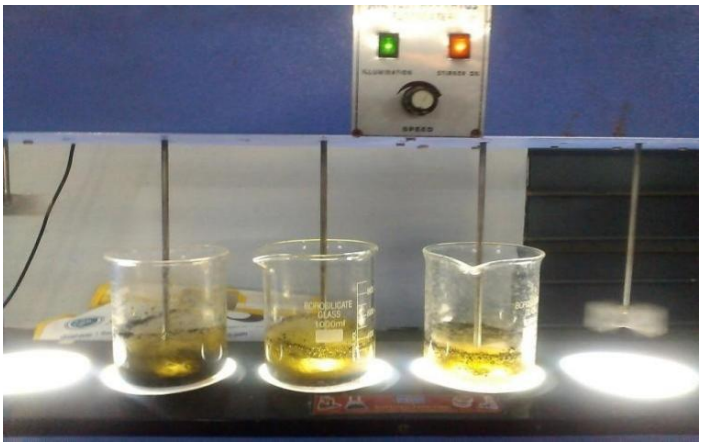

FIGURE 4

BATCH STUDIES

In this research study, the Spectrophotometer is used to evaluate the concentration of chromium present in the test sample. Spectrophotometer is an instrument used for detecting metals in solution. A spectrophotometer is an instrument that

measures the amount of photons (the intensity of light) absorbed after it passes through sample solution. With the spectrophotometer, the amount of a known chemical substance (concentrations) can also be determined by measuring the intensity of light detected. The batch experiments are carried out in 1000ml beaker by agitating a pre weighted amount of the adsorbent with 100ml of the aqueous Cr (VI) solution for a predetermined period on a flocculator. The adsorbent is separated with filter paper. The batch studies of the test sample in flocculator.

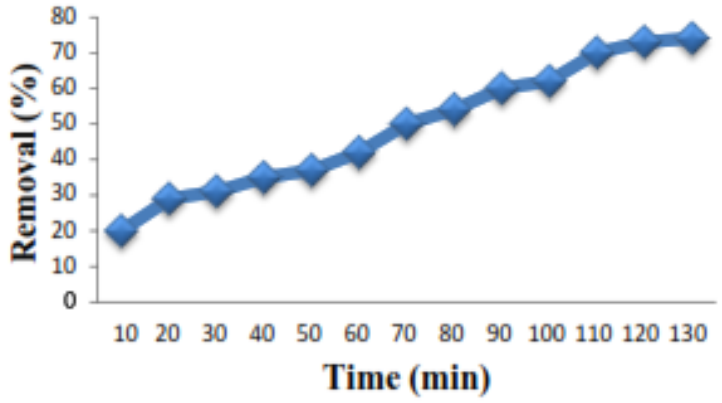

FIGURE 3

EFFECT OF CONTACT TIME ON ADSORPTION OF CR

All the parameters were kept constant. The results indicate that the Cr removal was increased from 20 – 74% industrial waste water contact time at 130 min. Thehighest % of removal of Cr 74%.This result shows contact time is one of the importantfactors for waste water treatment

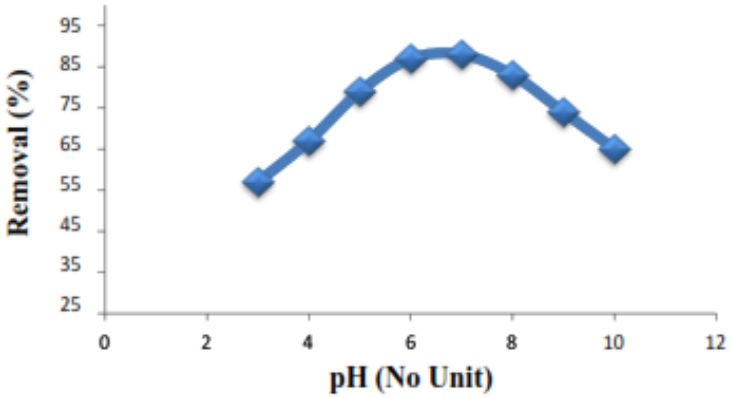

FIGURE 4

EFFECT OF PH ON ADSORPTION OF CR

The temperature dependence of the adsorption process is related to thermodynamic parameters. the temperature effect on removal of Cr using sweetpotato peel was studied with the range of 25 C. with the increase intemperature from 25o C to 50o C the percent removal of Cr was decreased. This graphsshows that the lower temperature favor of Cr ion. With temperature 25o C to 50o C removal81% and 90% of Cr from industrial waste water.

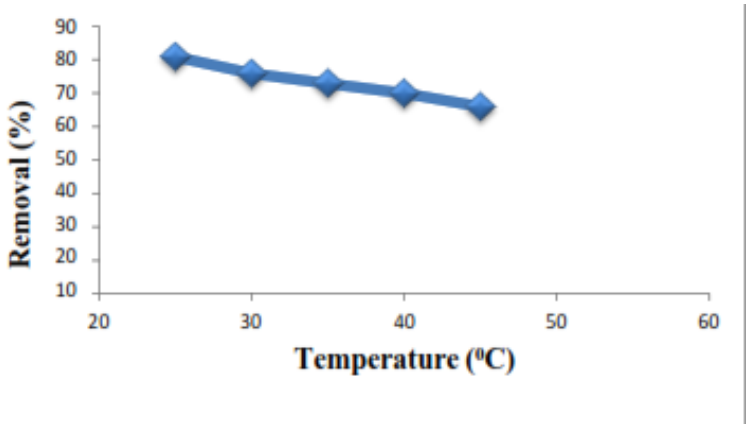

FIGURE 6

EFFECT OF TEMPERATURE ON ADSORPTION OF CR

VI. CONCLUSION

The present investigation is carried out to study the suitability of a adsorbent,Cow dung for the removal of heavy metal such as Cr from the Industrial wastewater. Influence of process parameters such as contact time, pH and Temperature wereat optimized for the removal efficiencies of the heavy metals were concerned. The optimum pH of solution of Cr removal were found to be 6.5 for Industrialwaste water. With the experimental investigation the optimum temperature was found to be25 C.The optimum contact time for adsorption of chromium found to be 130 min.

REFERENCES

[1] I. Urruzola, L. Serrano, R. L. Ponte, Á. D. Andres, and J. Labidi, "Obtaining ofeucalyptus microfibrils for adsorption of aromatic compounds in aqueous solution",Journal of chemical engineering, Vol. 229, pp. 42-49, 2013.

[2] J. Aravind, P. Kanmani, A. J. Devisri, S. Dhivyalakshmi and M. Raghavprasad,"Equilibrium and kinetic study on chromium (VI) removal from simulated wastewater using gooseberry seeds as a novel biosorbent", Journal of environmentalscience and technology, Vol. 1, No. 3, pp. 233-244, 2015.

[3] J. B. Dima, C. Sequeiros and N. E. Zaritzky, "Hexavalent chromium removal incontaminated water using reticulated chitosan micro/nanoparticles from seafoodprocessing wastes", Journal of Chemosphere, Vol. 141, pp. 100-111, 2015.

[4] B. Wionczyk, W. Apostoluk, W. A. Charewicz and Z. Adamski, "Recovery ofchromium (III) from wastes of uncolored chromium leathers, Part I. Kinetic studies onalkaline hydrolytic decomposition of the wastes", Journal of separation andpurification technology, Vol. 81, pp.223-236, 2011.

[5] E. Agrafioti, D. Kalderis and E. Diamadopoulos, "Arsenic and chromium removalfrom water using biochars derived from rice husk, organic solid wastes and sewagesludge", Journal of environmental management, Vol. 133, pp. 309-314, 2014.

[6] M. H. Dehghania, D. Sanaei, I. Ali, and A. Bhatnagar, "Removal of chromium (VI)from aqueous solution using treated waste newspaper as a low-cost adsorbent: Kineticmodeling and isotherm studies", Journal of molecular liquids, Vol. 215, pp. 671-679,2016.

[7] H. Singh and V. K. Rattan, "Comparison of Hexavalent Chromium Adsorption fromAqueous Solutions by Various Biowastes and Granulated Activated Carbon", Journalof indian chemical engineering, Vol. 56 No. 1, pp. 12-28, 2014.

[8] S. Pal, P. Dhanpal, J. L. Goswami and P. K. Tewari, "Feasibility study of novelsorbent for chromium sequestration and enhanced immobilization", Journal ofdesalination and water treatment, Vol. 38, pp. 215-221, 2012.

[9] M. Jaina, V. K. Garg and K. Kadirvelu, "Adsorption of hexavalent chromium fromaqueous medium onto carbonaceous adsorbents prepared from waste biomass", Journalof environmental management, Vol. 91, pp. 949- 957, 2010.

[10] N. S. Barot and H. K. Bagla, "Eco-friendly waste water treatment by cow dungpowder (Adsorption studies of Cr (III), Cr (VI) and Cd (II) using tracer technique)",Journal of desalination and water treatment, Vol. 38, No. 1-3, pp. 104-113, 2012.

[11] N. S. Barot and H. K. Bagla, "Studies on biosorption of Cr (VI) on a green resin:dry cow dung powder and tracer technique", Journal of chromium toxicity orbiosorption, pp. 1-10, 2012.

[12] T. D. Yavini, K. Silas, M. B. Grema and J. A. Luria, "Kinetic Study of AgriculturalWastes Conversion to Biogas using Cow Dung/Poultry Droppings as Inoculums",Journal of environmental science, toxicology and food technology, Vol. 8, pp. 46-51,2014.

[13] O. C. Ozor, M. V. Agah, K. I. Ogbu, A. U. Nnachi, O. E. Udu-ibiam and M. M.Agwu, "Biogas Production Using Cow Dung from Abakaliki Abattoir in South-EasternNigeria", Journal of scientific and technology, Vol. 3, No. 10, pp. 1-3, 2014.

[14] Oladejo, S. Oladipupo and B. F. Ayorinde, “Production of Bio Fertilizer from RiceWaste, Cow Dung and Timber Sawdust”, Journal of chemical, environmental &biological sciences, Vol.3, No. 2, pp.112-118, 2015.

[15] K. K. Gupta, K. R. Aneja and D. Rana, “Current status of cow dung as a bioresourcefor sustainable development”, Journal of bioresources and bioprocess technology, Vol.3, No. 1, pp. 1-11, 2016.

[16] V. Vinodhini, V. Anabarasu and D. Nilanjana, “Screening of natural wasteproducts for the removal of Cr (VI) ions from industrial effluents”, Journal of naturalproducts and resources, Vol. 1, No. 2, pp. 174-180, 2010.

[17] M. B. Ibrahim and W. L. Jimoh, “Remediation of Cr and Fe from aqueous solutionby natural adsorbents”, Journal of biological and chemical sciences, Vol. 5, No. 3, pp.915-922, 2011.