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A REVIEW ON: REMOVAL OF LEAD FROM WASTE WATER BY VARIOUS TECHNIQUES AND METHODS

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ABSTRACT

*Lead is one of the most dangerous compounds present on earth. The presence of thisparticular compound in waste water causes toxicity to environment and also to humanbeings. Various methods has been analysis on different ways to carry out the lead content from water like the use of activated charcoal, some natural and synthetic adsorbents, extraction from waste water ,ion exchange, various precipitation techniques has been analysed for removal of lead. There are few models like Langmuir and frend lich isotherm are used in these methods for removal of lead. Theremoval of lead is found to be a sum of adsorption induced by ion exchange and precipitation of lead hydroxide. The main sources of the lead are these heavyindustries, smoke from transportation both by natural and manmade activities are responsible. The various parameters that affect these methods are the pH concentration, time contact and metal ion concentration, and also its adsorption capacity. This review article presents the information about the removal of lead (**Pb)**and **(**Pb^{+2}**)** ions from various techniques and models from waste water.*

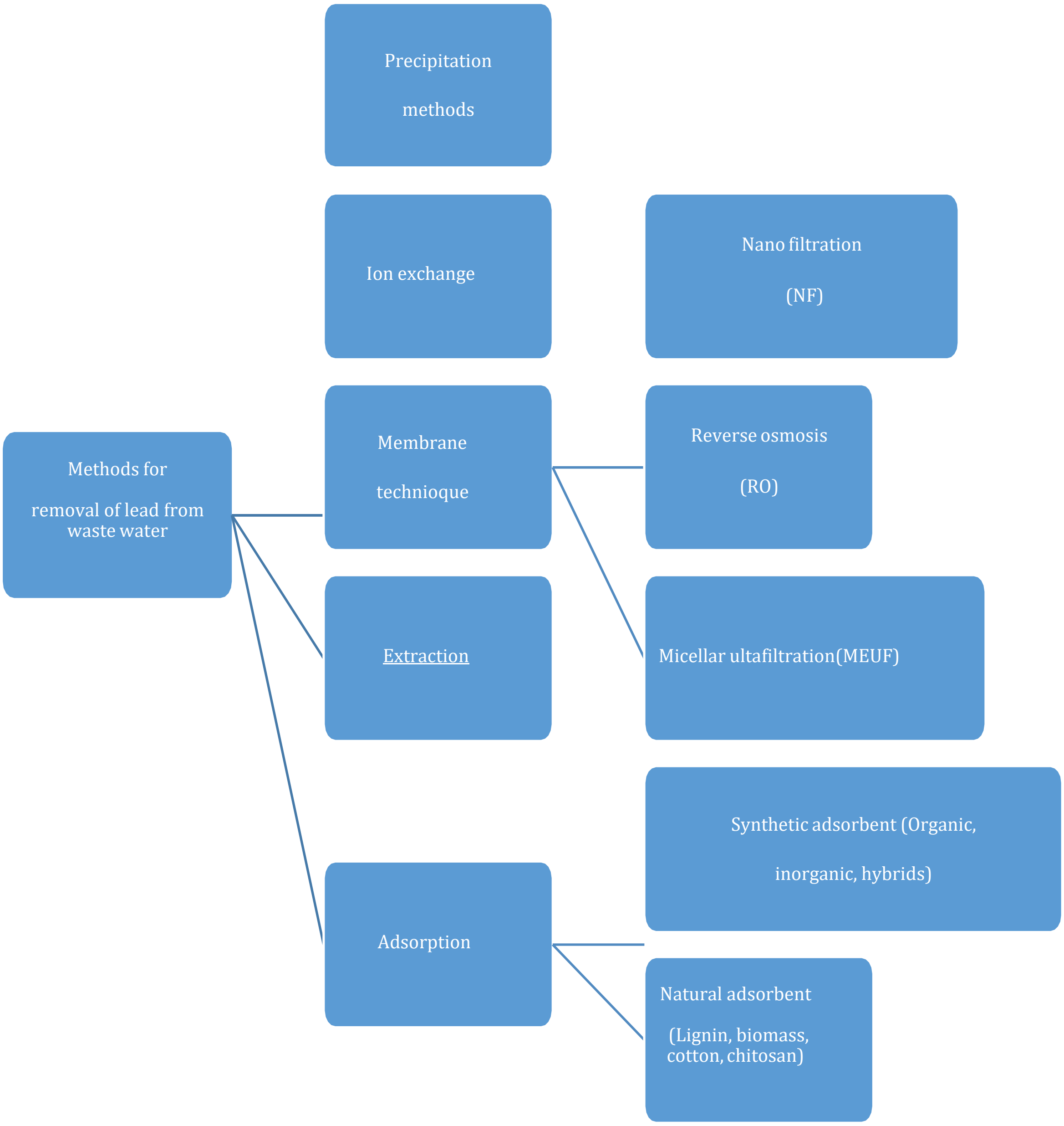
Keywords: *Waste Water, Lead, Techniques, biosorbents*

INTRODUCTION

Lead is a chemical element with the symbol **Pb** and atomic number 82. It is a heavy metal that is denser than most common materials. Lead is soft and malleable, and also has a relatively low melting point. When freshly cut, lead is silvery with a hint of blue, it tarnishes to a dull grey colour when exposed to air. Lead has the highest atomic number of any stable element and three of its isotopes are endpoints of major nuclear decay chains of heavier elements. In the late 19th century, lead's toxicity was recognized, and its use has since been phased out of many applications.However, many countries still allow the sale of products that expose humans to lead, including some types of paints and bullets. Lead enters the body via inhalation, ingestion, or skin absorption.[1]Almost all inhaled lead is absorbed into the body; for ingestion, the rate is 20–70%, with childrenabsorbing a higher percentage than adults. Lead can accumulate in soils, especially those with a high organic content, where it remains for hundreds to thousands of years. Environmental metals in wastewater are lead can compete with other metals found in and on plants surfaces potentially.The two main sources of heavy metals are natural and human. The natural factors include soil erosion, volcanic activities, urban run offs and aerosols particulate while the human factors include metal finishing and electroplating processes, mining extraction operations, textile industries and nuclear power. Inhibiting photosynthesis and at high enough concentrations, negatively affecting plant growth and survival. Apart from this, very high lead concentrations were found in houses with lead plumbing.[2]

DIFFERENT METHODOLOGY FOR REMOVAL OF LEAD

Kavak, D *et al* (2013) studied that the Chemical precipitation is the most common technology forthe removal of dissolved metals from industrial wastewater. In this study, the removal of Pb(II) from aqueous solutions by precipitation was investigated and factorial design was applied. The effects of three variables i.e. pH, mass of precipitating agent, and precipitation time on the removalof lead were evaluated. The significance of the effects was checked by analysis of variance withina 95% confidence level.[3]



Li *et al.*, (2015) studied that a green porous lignin-based sphere (PLS) had been fabricated by a feasible gelation-solidification method from lignosulfonate cross-linked with sodium alginate andepichlorohydrin. The prepared sphere was characterized by Fourier transform infrared spectrometry, scanning electron microscopy, mercury intrusion porosimetry, and thermo gravimetric analysis. The results demonstrated the PLS had a large amount of mesopores (d = 20.7 nm) with a high porosity of 87.66% and a total pore volume of 0.416 cm^3/g. Batch wiseadsorption experiments indicated the PLS possessed excellent adsorption efficiency (95.6 ± 3.5%)for lead ions at an initial concentration of 25.0 mg/L. The adsorption process could be well fitted by intra-particle diffusion model and Langmuir isotherm model.[5] Microbial metal carbonate precipitation may also be relevant to detoxification of contaminated process streams and effluentsas well as the production of novel carbonate biominerals and biorecovery of metals and radionuclides that form insoluble carbonates.[6] Wan, *et al.* (2016) researched in his study that to overcome the limits of graphene oxide (GO) as a novel sorbent for heavy metal removal (e.g., lowsorption selectivity and difficulty in solid-liquid separation), a nanocomposite (HMO@GO) with excellent settling ability (<2 min) was fabricated through in situ growing nanosized hydrated manganese oxide (HMO) (10.8 ± 4.1

nm) on GO. Cyclic sorption batches showed that 1 kg HMO@GO can treat at least 22 m^3Pb(II)-laden synthetic industrial drainage (5 mg L^{-1}Pb(II)) and40 m^3 drinking water (0.5 mg L^{-1}Pb(II)) to their corresponding limits (0.1 mg L^{-1} for wastewater and 10 µg L^{-1} for drinking water) enforced in China. Additionally, the exhausted HMO@GO canbe effectively regenerated using 0.3 M HCl for repeated uses.[7] The R^2 of the pseudo-second orderkinetics was 0.99857, which indicated the adsorption process was controlled by chemical reactions.[8] These results show that AP is a good adsorbent for heavy metals from aqueous solutionsand could be used as a purifier for water and wastewater.[9]

Sdiri*et al.,* (2016) reviewed that the natural clay minerals are an inherently colorless class of materials, which have long been known for their versatility as adsorbents due to their interchangecapacity, large catalytic support, great surface area, and low cost. Herein, they have reported the use of natural clay, collected from the Gabes area, southern Tunisia (Early Cretaceous) for selectively capturing of lead ions from aqueous environments. Our results showed that natural clay samples were mainly composed of silica, alumina, iron and magnesium oxides. Adsorption data showed that the studied clay samples preferably removed substantial amounts of lead ions from water. The removal efficiency of lead ions was about 86.4 mg/g of clay and followed pseudo- second-order kinetics. More than 95% of the total adsorptive capacity occurred within 30 min. Theprocess of adsorption was quite fast to be completed within a time frame of 60 min obeying pseudosecond order rate kinetics. 1.0 g sorbent was capable enough to adsorb 133.60 mg lead (qmax) withLangmuir isotherm model categorically illustrating the adsorption process. These results suggest the Early Cretaceous clays, Tunisia, turned out to be an effective natural adsorbent for capturing of lead ions from aqueous environment.[10]

Wen *et al.*, (2018) studied that the magnetic polyvingakohol (PVA) immobilized the endogenous bacterium Bacillus licheniformis with sodium alginate to get a novel biosorbent. The optimum preparation and adsorption conditions were studied. The whole adsorption process was well fit bythe pseudo-second order kinetic and it was also a Langmuir monolayer adsorption.[11] Bhat, *et al*(2015) studied that the removal of Pb(II) ions using γ-Alumina was investigated. γ-Alumina usedin the present study was prepared by gel combustion method. Experimental data was evaluated with isotherm models and non-linear type I model was well fitted on data. Statistically based experimental model such as Box–Behnken Method (BBM) was used to study the effect of variableson adsorption. Regeneration studies of the adsorbent were carried out and it was found that the adsorbent can be effectively regenerated upto 3 times with significant level of adsorption. The results suggest that γ-Alumina is effective adsorbent for the removal of lead.[12]

Badawi*et al.,*(2017) researched that Chitosan was reacted by tannic acid to obtain three modified chitosan biopolymer. Their chemical structures were characterized by FTIR and elemental analysis. The prepared biopolymers were used to adsorb Al(III) and Pb(II) metal ions from industrial wastewater. The factors affecting the adsorption process were biosorbent amount, initialconcentration of metal ion and pH of the medium. The adsorption efficiency increased considerably with the increase of the biosorbent amount and pH of the medium. The adsorption process of biosorbent on different metal ions was fitted by Freundlich adsorption model. The adsorption kinetics was followed Pseudo-second-order kinetic model. The adsorption process occurred according to diffusion mechanism which was confirmed by the interparticle diffusion model. The modified biopolymers were efficient biosorbents for removal of Pb(II) and Al(III) metal ions from the medium.[13]

"Adsorption of Lead by Bentonite Clay" removal of heavy metals from industrial waste water is a worldwide challenge. Inorganic pollutants are difficult to treat as they are non-biodegradable, hence they remain in nature. Such pollutant when enters the food cycle, affect human, plant, animallives and aquatic systems. Therefore, their removal becomes critical from the environmental pointof view. In this study lead is being used as a pollutant in water and unmodified bentonite clay is used as adsorbent material. The bentonite clay was characterized using technique XRD. The resultsof XRD show that montmorillonite is the main clay mineral. The applicability of the bentonite clayfrom Bhavnagar area for removal of lead from aqueous solution was tested using the batch process.Experimental data were fitted well to the Langmuir adsorption isotherm with maximum adsorption capacity of 26.3 mg/gram at correlation coefficient of 0.955. It was found that Langmuiradsorption model is fit well with experimental data. Successful application of bentonite clay fromBhavnagar area for removal of lead from aqueous solution greatly supports its field application.[14]

Thapak*et al.*,(2019) researched that the Indian Prime Minister Shri Narendra Modi focused more on clean and green India. On behalf of it an effective tea waste collected from Hotel RudrapratapTomar PuraniChhawani, Gwalior, MP, India. The objective of this work was to evaluate. Effect of Agitation Rateluate the potential of activated tea waste adsorbent for removal of Pb (II) ions from industrial waste water. The different experimental parameters such as; concentration, adsorbent dose, initial pH, temperature and contact time were carried out inexperimental setup. The initial Pb (II) concentrations were 10, 20 and 30 ppm in the experiment. The result shows maximum removal of lead ions at 5 pH, 120 sec contact time and 0.6 gm adsorbent at 25°C; is 98% respectively.[15]

Basu*et al.,*(2017)reviewed that the competency of cucumber peel (CP) was explored for adsorptionof lead. Optimum adsorption occurred at pH 5.0 and at incubation temperature of 30 °C. The process of adsorption was quite fast to be completed within a time frame of 60 min obeying pseudosecond order rate kinetics. 1.0 g sorbent was capable enough to adsorb 133.60 mg lead (q_{max}) with Langmuir isotherm model categorically illustrating the adsorption process. The biomass was characterized by different instrumental analyses like TGA, SEM, EDAX, XRD, FTIR and zeta potential measurement which additionally authenticated the sorption phenomenon. Post adsorptionelution of the loaded metal was successfully executed using HCl as eluant.[16]

Basu*et al.,*(2019) studied the depicts successful employment of fixed bed column bioreactor for adsorption of lead in continuous mode using lentil husk as sorbent. Design parameters considerablycontrolled the reactor performance, amongst which height of the fixed bed and flow rate were crucial in generating cleaner effluent. The column reactor was efficient enough to treat lead containing actual industrial effluents.[17] Fadzil*et al.,*(2016)reviewed that to evaluated the Pb(II) sorption capacities of two chemically modified biosorbents which are citric acid modified rubber leaf powder (CARL) and monosodium glutamate modified rubber leaf powder (MGRL). Differentcolumn parameters such as column adsorption capacity and 50% adsorbate breakthrough were calculated. It was found that the adsorption capacity and performance of MGRL was superior to CARL in both batch and fixed bed column studies.[18]

Aslan and Özçayan, (2019)observed that several organic and inorganic adsorbents are used for theseparation and purification processes of metal ions and removal of radionuclides from radioactiveand industrial wastes. In this study, calcium hydroxyapatite was prepared by phosphogypsum waste and its adsorption behavior towards lead-210 was evaluated. Results showed that the adsorption percentage of hydroxyapatite was found to be 95% on the optimum conditions.Additionally, the adsorption kinetic data were analyzed using pseudo-first order and pseudo- second order kinetic models. The results indicated that hydroxyapatite is an efficient adsorbent for the removal of lead-210 from aqueous media with good performance.[19] Awual, *et al*(2019) studiedthe importance of toxic contaminants treatments have become increasingly apparent due to the severe threat from anthropogenic pollution in water pollutants. For the remediation of water contamination, novel material is always welcome based on the sensitivity and selectivity.

Therefore, the solid design composite material is efficient and cost-effective promising materialfor selective Pb(II) ion detection and removal from wastewater.[20] Anwar, *et al.,*(2018) studied that,a facile and an eco-friendly manganese oxide nanoparticles dispersed in chitosan (CS-MnO_2)nanocomposite was synthesized. A chemical precipitation method was used for the productsynthesis. The product characterization was performed using various spectroscopic techniquessuch as X-ray scattering, scanning electron microscopy, Fourier transform infrared spectroscopy, thermogravimetric analysis and zeta potential which confirmed its successful formation. Colonyforming units method was used in the antibacterial studies which showed that the bio-nanocomposite had moderate antibacterial activity against the stated strains of bacteria.[21] Karim *et al.,*(2019) reviewed that the nanofibers membranes were fabricated by poly(vinylalcohol)/chitosan (PVA/Chi) using an electro-spun technique for selective and high adsorption oflead (Pb(II)) and cadmium (Cd(II)) ions based on the solution acidity. Thus, the PVA/Chi NFs areconsidered to be effective and promising materials for Pb(II) and Cd(II) ions from wastewaterswith high efficiency.[22]

Alghamdi*et al.,*(2019) reviewed this study thatpolypyrrole-based activated carbon was prepared by the carbonization ofpolypyrrole at 650 _C for 2 h in the presence of four-times the mass of KOH as a chemical activator. The adsorptioncharacteristics of PPyAC4 were examined through the adsorption of lead ions from aqueous solutions.The influence of various factors, including initial ion concentration, pH, contact time, and adsorbentdose, on the adsorption of Pb2+ was investigated to identify the optimum adsorption conditions. Theexperimental data fit well to the pseudo-second-order kinetic model (R2 = 0.9997) and the Freundlichisotherm equation (R2 = 0.9950), suggesting a chemisorption pathway. The adsorption capacity wasfound to increase withincreases in time and initial concentration, while it decreased with an increasein adsorbent dose. Additionally, the highest adsorption was attained at pH 5.5. The calculatedmaximum capacity, qm,determined from the Langmuir model was 50 mg/g.[23]

Jin*et al.,*(2019) researched that a kind of biomass that exists widely in plants, lignin shows much diversity as a functional material. In order to improve the adsorption ability, lignin was chemicallymodified by 5-sulfosalicylic acid and then used to adsorb methylene blue (MB) and Pb^{2+} from aqueous solutions. The proposed SSAL is low-cost, eco-friendly and highly efficient therefore a promising material for adsorptive removal of MB and Pb^{2+} from wastewater.[24] Shah *et. al.* ,2016 studied adsorption of lead (II) ions onto cassava starch 5-choloromethyl-8-hydroxyquinoline polymer (CSCMQ) was investigated with the variation in the parameters of pH, contact time, lead
(II) ions concentration, temperature and the adsorbent dose. The dynamical data fit well with the second-order kinetics model. The main operating conditions such as pH, concentration of Pb(II) ions and sorbent dose were also studied. Kinetic modelling has been studied and lead uptake capacity was calculated using the Langmuir, Freundlich and Dubinin–Kaganer–Radushkevich (DKR) models. The results indicate that CSCMQ could be employed as low-cost material for the adsorption of Pb(II) ions from aqueous medium.[25] Huang *et al.,*(2015)studied that the total of 167superfluous leads (mean [SD] lead duration 53 months; median 34 months) were removed duringthe 123 procedures. Forty-one percent of procedures were for lead malfunction. The procedural complete-success rate was higher for the removal of superfluous leads than for leads associated with infection (97% vs 92%; P = .05).[26] Tortora*et al.,*(2016) studied that the wastewaters from civiland industrial use, which contain high concentration of heavy metals, pose the problem for their correct disposal. The synthetic liquid contained 10-mg/L metal ions (Cr, Zn, Co, Ni), while SDS concentration varied from values above and below critical micellar concentration (CMC). The experiments were carried out at room temperature (25 °C). Results achieved showed that SDS wasable to bind metal ions, resulting in a strong increase of rejection coefficient, which reached highestvalues in case of SDS concentration below CMC, unexpectedly.[27]

Shahabuddin, S. *et al.*, (2018) studied that the present investigation demonstrates the successful and easy approach for the synthesis of magnetic amine-substituted SBA-15 nanocomposite for effective removal of lead (Pb^{2+}) ions via adsorption from aqueous environment. Experimental data was evaluated with isotherm models and non-linear type I model was well fitted on data. The effective parameters for adsorption process such as effect of pH, salt, adsorbent dosage, contact time, initial concentration and temperature were studied and optimized. The studies indicated thatat pH range of 6, the percentage removal of Pb(II) was found to be 96% at room temperature. TheFTIR spectroscopy and EDX results of the nanocomposites after the Pb(II) adsorption (MNPs/SBA-15-Met-Pb^{2+}) specified that adsorption occurred probably through electrostatic interaction between Pb(II) ions and N groups (amine & amide).[28] "Lead ion removal from water by hydroxyapatite nanostructures synthesized from egg sells with microwave irradiation SpringerLink" states that the Hydroxyapatite nanostructures were synthesized by microwave irradiation from egg shells.. The synthesized nanoadsorbent shows high adsorption capacities for removal of lead ion from water samples.[29] The conjugate adsorbent (CJA) was fabricated by functional ligand embedded onto the highly porous silica material for selective lead (Pb(II)) ion monitoring and removal from wastewater. Evidence of nanoscale lead hydroxide crystallization, induced by the lead(II)-NOCNF aggregated scaffold, was confirmed by FTIR, UV–visible spectroscopy, SEM/EDS, WAXD and TEM measurements.[30] Ge *et al.*, (2016) studied that an increased interest in development of natural polymer-based sorbent for clean-up of heavy metals in water has been seen due to their abundance, low-in cost, and eco-friendliness. The proposed LMS is eco-friendly, cost-effective and therefore a promising candidate for Pb(II) retention with effective adsorption and reusable abilities.[31]

Shi, *et al.*,(2018) researched, designed and synthesized a magnetic metal organic frameworks (MOFs) composite, Cu-MOFs/Fe3O4 as the adsorbent for removal of lead (Pb(II)) and malachite green (MG) in wastewater.The adsorption capacities were found to be 113.67 mg/g for MG and 219.00 mg/g for Pb^{2+}, respectively, which are significantly higher than reported materials. Adsorption isotherm, kinetics and recyclability of Cu-MOFs/Fe3O4 for removal of Pb(II) and MGwere then studied. Adsorption of Pb(II) and MG exhibited Freundlich adsorption isotherm model,with the adsorption kinetics of available second-order kinetic. Experimental data was evaluated with isotherm models and non-linear type I model was well fitted on data. Physical adsorption forMG and chemical adsorption for Pb(II) were confirmed by Dubinin-Radushkevich (D-R) isothermal adsorption model. The adsorption of Pb(II) and MG in real water samples were then studied. The Fe3O4/Cu-MOFs was found to be recyclable for removal of Pb(II) and MG, can be explored as the potential adsorbent for waste water treatment.[32]

Yap *et al.,* (2017)reviewed that the novel magnetic biochar (MB) has been successfully synthesizedby using the microwave technique, using discarded materials such as coconut shell (CS). The optimized conditions for the best novel magnetic biochar synthesis are at 800 W reaction power, 20 min reaction time, and 0.5 g (FeCl3:biomass) impregnation ratio. The detailed physical and chemical analyses of novel magnetic biochar were found to be in good agreement with the hypothesis. These newly produced magnetic biochars have high surface area of 834 m^2/g and thisleads to high efficiency in the removal of cadmium and lead from wastewater. The results revealed that magnetic biochar composite exhibited excellent ferromagnetic property with a saturation magnetization of 6 emu/g. Experimental data was evaluated with isotherm models and non-lineartype I model was well fitted on data. As for new invention, the magnetic biochar can be directly produced using microwaves heating by single stage of activation compared to the conventional method.[33]

"Novel conjugated hybrid material for efficient lead(II) capturing from contaminated wastewater",in 2019 studied that an efficient material is always welcoming for the water treatment due to the need of clean water to safe the human health. The conjugate adsorbent (CJA) was fabricated by functional ligand embedded onto the highly porous silica material for selective lead (Pb(II)) ion monitoring and removal from wastewater. The study was achieved not only investigating the beginning material but also the performing extrusion as novel conjugate material, this defining thematerial novelty of this study considers to the modern state-of-art. The adsorption was completelyfitted with the Langmuir adsorption as defining the monolayer coverage as expected of the homogeneous porosity of the CJA. The maximum adsorption was determined as high as 175.16 mg/g. In addition, the foreign ions were not affected in the Pb(II) adsorption by the CJA, and the adsorbent was regenerated using 0.20 M HCl for several cycles used without significant loss of the initial performance. Considering these advantages, the CJA demonstrated the potentiallow-cost material for competitive use in wastewater remediation, especially in the developing countries.[34]

Novais*et al.,*(2016) studied that the novel porous biomass fly ash-containing geopolymer monoliths were produced using a simple and flexible procedure. Geopolymers exhibiting distinct total porosities (ranging from 41.0 to 78.4%) and low apparent density (between 1.21 and 0.44 g/cm^3) were fabricated. Afterwards, the possibility of using these innovative materials as lead adsorbents under distinct conditions was evaluated. Results demonstrate that the geopolymers' porosity and the pH of the ion solution strongly affect the lead adsorption capacity. Lead adsorption by the geopolymer monoliths ranged between 0.95 and 6.34 mglead/ggeopolymer. More porous geopolymers presented better lead removal efficiency, while higher pH in the solution reduced their removal ability, since metal precipitation is enhanced.[35]

"Optimal ranges of variables for an effective adsorption of lead(II) by the agricultural waste pomelo (Citrus grandis) peels using Doehlert designs | Scientific Reports" studied that The capacity of pomelo peels' adsorption on lead(II) from aqueous solutions without modifications wasinvestigated and confirmed. Four variables in this study, pH, temperature, time and initial concentration of lead(II), significantly affected the adsorption rate of pomelo peels. The predictionmodel and optimal ranges of optimized variables were given by Doehlert designs, which made theselection of variables rapid, flexible and effortless to obtain an adsorption rate reaching 99.9% and20 mg/L for initial lead(II) concentration, 3 for pH, 50 °C for temperature and 210 min for time was a choice.The ability of pomelo peels to adsorb lead(II) from aqueous solutions was not interfered with the presence of calcium(II), magnesium(II), copper(II) and zinc(II). Pomelo peels had the potential to be utilized in the simultaneous adsorption of toxic heavy metal ions.[36]

Ng *et al.,* (2016)investigated that the technical feasibility of natural iron-rich sandy soil as a low- cost adsorbent for removal of lead from water was investigated. The soil, which had an iron contentof 3,719 mg/kg, was collected from Hulu Langat, Malaysia, and was used for adsorption studies without any surface modification through chemical treatment. The results showed that pH of the solution had the highest impact on the adsorption efficiency whereby adsorption efficiency of 97%could be achieved at pH 3.5–5. The experimental data were also checked for compliance with different kinetic models and adsorption isotherms. The adsorption process was found to be rapid monolayer chemisorption with adsorption capacity of 0.9–1.0 mg/g, as it fitted Langmuir isothermand followed pseudo-second-order kinetic model.[37]

Yan, *et al.,*(2017) studied that thechrome-tanned leather waste were activated with sodium hydroxide (NaOH) to prepare a porous adsorbent for lead (II) adsorption. The effects of various preparation parameters like the concentration of NaOH, the size of leather particles, the activation time and the activation temperature were studied. Under optimum preparation condition, the alkali-activated porous leather particles (AAPLP) were obtained after vacuum freeze-drying. AAPLP was characterized with BET, SEM, FT-IR, TG and XPS. It was found that the BET surface of AAPLP was twice more than unactivated leather waste. Additionally, it could be inferred that ion-exchange and complexation happened during the adsorption process between AAPLP and lead (II).The effects of solution pH, temperature and contact time on adsorption capacity of AAPLP for lead (II) have also been investigated. The experiment data was fitted well with Freundlich isotherm and followed pseudo-second-order kinetics. Meanwhile, the kinetic data was governed by intraparticle diffusion model and it was found that the adsorption process contained three stages[38]

Mahar *et al.,* (2019)researched that the Lead is one of the toxic elements in the environment havingnon-biodegradable behavior. On the other hand, the high contamination of lead in water is a major alarming threat to the world nowadays. In this study, PAN-based porous carbon nanofibers (p- CNFs) were used to adsorb the lead ions for both batch and continuous method. The synthesis was achieved by electrospinning and thermal treatment. The characterization of p-CNFs was achieved via FE-SEM, EDX, BET and Raman spectra. Furthermore, the adsorption capability for lead ions was examined using ICP-MS. The separation parameter, RL, values of less than 1.0 indicate that adsorption of Pb(II) on zeolite-NaX is favorable. The adsorption parameters such as pH of the solution, the mass of nanofibers, adsorption time and initial concentration of lead ions were optimized. The obtained results fitted well with the Langmuir model and the pseudo-second-ordermodel. The nanofibers showed high adsorption capability at neutral pH within 1 min. Therefore, the prepared p-CNFs can be recommended for lead ions removal up to its permissible limit in a continuous purification system for drinking water.[39]

Hoang *et al.*, (2019) studied that the feasibility of an integrated system comprising adsorption

andcrystallization in a pellet reactor to remove and recover lead from aquatic environment. The selective adsorption of Pb^{2+} over Ca^{2+} and Mg^{2+} was investigated using citric acid modified sugarcane bagasse (SCA) in batch and column systems. The separation parameter, RL, values of less than 1.0 indicate that adsorption of Pb(II) on zeolite-NaX is favorable. Selective separation of Pb^{2+} from the mixed solution was achieved at a molar ratio $3.22 < C_{o,batch Ca+Mg}/C_{o,batch Pb} <$
4.49 in batch mode while in a packed bed column, lead was selectively adsorbed by SCA up to a capacity of 0.767 mmol/g. In addition, synthetic lead wastewater with characteristics simulating the concentrate from desorption of saturated SCA was further treated in a fluidized bed denoted aspellet reactor. Lead (II) was quantitatively recovered at optimized conditions of pH 10, molar ratio $[CO_3^{2-}]$: $[Pb^{2+}] = 3:1$, superficial velocity 9.55 m/h, and initial lead concentration 2.43 mM. The well-controlled crystallization process of cerussite on the surface of grain sand in the pellet reactoris comparable with the chemical equilibrium speciation data obtained by Visual MINTEQ. Overall,the developed system comprising adsorption combined with a pellet reactor was found sufficient to remove and recover lead as $PbCO_3$ from wastewater.[40]

Seema *et al.,* (2018) studied that the Lead (Pb) pollution is our water system is a major concern, as this metal is toxic even at low concentration. This study aim to fabricate a bio-nanocomposite (cyclodextrin-polycaprolactone titanium dioxide) that will be used as an adsorbent for the removalof lead in aqueous waste. The conjugate adsorbent (CJA) was fabricated by functional ligand embedded onto the highly porous silica material for selective lead (Pb(II)) ion monitoring and removal from wastewater. In this study, titanium dioxide was synthesized via sol-gel technique then incorporated in a polymer blend (CD-PCL) via solution blending method. The resulting bio- nanocomposites were characterized using Scanning Electron Microscopy (SEM), transmission electron microscope (TEM) and Brunauer Emmett and Teller (BET). The separation parameter, RL, values of less than 1.0 indicate that adsorption of Pb(II) on zeolite-NaX is favorable. Maximumadsorption of lead obtained was 98% at pH 9.7, 10 ppm with 0.005 g dosage. Kinetic studies and adsorption isotherms were also investigated. The adsorption data fit Langmuir isotherm. Pb (II) obeyed pseudo-second order kinetics.[41]

Raikar*et al.,* (2015)reviewed thatthe use of rice husk in the removal of lead (II) from the aqueous solution. In this study, rice husk is used in four different forms, namely, natural un-activated form(RH), rice husk ash acquired after carbonizing rice husk without pretreatment (RHA), rice husk pretreated with phosphoric acid (PRH) and acetic acid (ARH) separately and then followed by carbonization. The separation parameter, RL, values of less than 1.0 indicate that adsorption of Pb(II) on zeolite-NaX is favorable. Through batch adsorption studies the effect of various parameters such as pH of the aqueous medium, contact time of agitation, adsorbate concentration,and adsorbent dosage were examined. The results obtained show that the adsorption of the metal ion is pH, contact time, adsorbent dosage and adsorbate concentration dependent. The maximum percentage removal of lead (II) ions is 93.36%, 94.8%, 96.72% and 99.35% with adsorbents RH, RHA, PRH and ARH, respectively. It is found that RH, RHA and PRH followed Freundlich isotherm model whereas ARH followed Langmuir isotherm model. Further, both RH and RHA follow pseudo-second order kinetics.[42]

Ravulapalli and Kunta, (2018) studied that the nitric acid activated carbon prepared from the seedsof Caryotaurens plant (ACSCU) and the calcium alginate beads doped with the active carbon (CABCU) are investigated as adsorbents for the removal of lead (II) ions from polluted water usingbatch methods of extraction. ByThe active carbon is characterized using XRD, FESEM, and FT- IR and the sorption mechanism is investigated using various isotherms and noted that the Freundlich model describes well the adsorption process. Thermodynamic parameters are analyzedand inferred that the adsorption is endothermic and spontaneous in nature. The kinetics ofadsorption is well defined by the pseudo-second-order model. The separation parameter, RL, values of less than 1.0 indicate that adsorption of Pb(II) on zeolite-NaX is favorable. The methodology developed is successfully applied to effluent samples collected at various industries.[43]

Pandey *et al.,* (2015) researched that the sorption of Pb(II) on zeolite-NaX was studied. Zeolites NaX is characterized by large surface area because of its highly porous nature. High surface area and ordered pore structure of zeolite-NaX result in adsorption of large quantities of adsorbate depending on adsorbate size, aperture size, temperature and surface acidity of zeolites. Therefore, equilibrium isotherms were obtained using batch study by varying operating parameters such as pH, initial concentration, temperature, adsorbent dosage and the contacttime. Experimental data was evaluated with isotherm models and non-linear type I model was well fitted on data. The separation parameter, RL, values of less than 1.0 indicate that adsorption of Pb(II) on zeolite-NaXis favorable. The estimated values of thermodynamic parameters indicate the exothermic nature ofadsorption of Pb(II) on zeolite-NaX. This study supports the view that zeolite-NaX could be an efficient adsorbent for removal of Pb(II) form aqueous solution.[44]

Bouabidi*et al.,*(2018) studied that the presence of high concentrations of toxic heavy metals such as lead Pb(II) in water is a major hazard to human health and may have a detrimental effect on theaquatic life and the environment. In this study, Steel-Making dust obtained from a local Steel Factory was utilized for the adsorption of lead Pb(II) from an aqueous solution.TheDubinin- Radushkevich model was found to best describe the experimental data for the adsorption of lead ions onto Ladle furnace and cyclone steel dust with high Akaike weight (wi) of 0.91 and 0.83, respectively. The optimum pH range was found to be around 4–5; working within this range prevents lead precipitation during the adsorption process. The maximum adsorption capacity for lead on Steel Dust as obtained from the Langmuir isotherm was 208.9 mg/g for the Ladle Furnacesteel dust, and 39.8 mg/g for the Cyclone steel dust. Overall, the Steel-Making dust gave a high efficiency for the reduction of lead concentration in the aqueous solutions and thus could be utilizedin industrial adsorption processes.[45]

Zou *et al.,*(2019) researched that the Rational design and directed synthesis of an adsorbent with superior selectivity is challenging but of utmost importance for the remediation of heavy metal- laden actual wastewater. In this work, a novel tannic acid (TA)-based adsorbent (TA@Zr) was synthesized by a simple coordination reaction. Adsorption isotherm experiments exhibited the TA@Zr had a high capacity for Pb^{2+} capture. Impressively, an outstanding selectivity with extremely high selective coefficient (40–170) can be achieved by the TA@Zr. Further, based on the results of XPS, DFT and batch adsorption experiments, it can be deduced that the phenolic hydroxyl groups on TA functioned as the dominant adsorption sites in which the hydroxyl groups'oxygen atoms coordinated with Pb^{2+} while hydrogen atoms of hydroxyl groups were replaced and released as hydrogen ions, thus extending a proton exchange mechanism for the selective adsorption of Pb^{2+} ions.[46]

Abdel -Aty*et al.,* (2013) studied that, the effects of mild air oxidation of a biochar produced by the Pyrovac Inc. pyrolysis process, on the adsorption of lead(II) from synthetic wastewater under batchexperimental conditions have been investigated. The adsorption experiments were performed under several conditions suggested by the response surface methodology, which allowed finding the optimal conditions, in order to maximize the adsorption capacity (Q(mgg−1)), as well as the extraction efficiency (E (%)). The optimal conditions of lead ions adsorption were as follows: pH = 5, agitation time = 300 min, adsorbent mass = 0.5 g (per 50 cm^3 of solution), and lead initial concentration = 100gm−3, resulted in an adsorption capacity of 7.9 mg g^{-1}.Results showed that mild air oxidation increased the equilibrium adsorption capacity of biochar from 2.5 to 44 mg g^{-1}. Oxidized biochar after equilibrium adsorption was submitted to SEM/EDX and XPS analysis. From SEM it was found that lead particles were distributed heterogeneously after adsorption.Thiswork suggests that the very simple process of mild air oxidation can be used instead of the usual costly chemical activation, in order to improve biochar cation exchange capacity.[47]

In 2017, Lawal *et. at.* studied the biosorption characteristics of Pb (II) ions from aqueous solutionusing black walnut (*Juglans nigra*) seed husk (WSH) biomass were investigated using batch adsorption techniques. The effects of pH, contact time, initial Pb (II) ion concentration, and temperature were studied. The Langmuir, Freundlich and Temkin isotherms were used to analyzethe equilibrium data. It was found that the adsorption of Pb (II) ions onto WSH was best describedby the Freundlich adsorption model. Biosorption kinetics data were tested using the pseudo-first order and pseudo-second order models, and it was observed that the kinetics data fitted the pseudo- second order model. Thermodynamic parameters such as standard Gibbs free energy change (ΔG^0), standard enthalpy change (ΔH^0) and standard entropy change (ΔS^0) were evaluated. The result showed that biosorption of Pb (II) ions onto WSH was spontaneous and endothermic in nature. The FTIR study showed that the following functional groups: O-H, C = O, C-O, C-H and N-H were involved in binding Pb (II) ions to the biomass.[48]

Abdel -Aty*et al.,*(2013) researched that thebiosorption of Cd(II) and Pb(II) from aqueous solutiononto the biomass of the blue green alga Anabaena sphaerica as a function of pH, biosorbentdosage,contact time, and initial metal ion concentrations. Freundlich, Langmuir, and Dubinin– Radushkevich(D–R) models were applied to describe the biosorption isotherm of both metals by A. Sphaericabiomass. The biosorption isotherms studies indicated that the biosorption of Cd(II) and Pb(II) followsthe Langmuir and Freundlish models. The maximum biosorption capacities (qmax) were 111.1and 121.95 mg/g, respectively, at the optimum conditions for each metal. Fromthe D–R isothermmodel, the mean free energy was calculated to be 11.7 and 14.3 kJ/mol indicatingthat the biosorptionmechanism of Cd(II) and Pb(II) by A. sphaerica was chemisorption. The FTIRanalysis for surfacefunction group of algal biomass revealed the existence of amino, carboxyl, hydroxyl, andcarbonyl groups, which are responsible for the biosorption of Cd(II) and Pb(II). Theresults suggestedthat the biomass of A. sphaerica is an extremely efficient biosorbent for the removal of Cd(II)and Pb(II) from aqueous solutions.[49]

Kanwal*et al.,* (2013) studied that the Polyaniline composites are gaining importance now-a-days for waste water treatment by adsorption. In this research work, novel composites of polyaniline with maize bran, wheat bran and rice bran have been synthesized, characterized and employed forbatch wise adsorption of Pb(II) from water. FT-IR technique was used for surface analysis of adsorbents. Various operational conditions of adsorption process like agitation time, pH, adsorbent dose, particle size of composites and temperature were optimized for isothermal and thermodynamical investigations. Maximum adsorption capacity values for polyaniline compositeswith maize bran, wheat bran and rice bran were 18.75, 28.93 and 30.11 mg/g of adsorbent, respectively.[50]

Awual,*et al.,*(2016)reviewed that a ligand doped conjugate adsorbent was prepared by indirect ligand immobilization onto the mesoporous silica for lead (Pb(II)) ions detection and adsorption from aqueous media. The conjugate adsorbent (CJA) was fabricated by functional ligand embedded onto the highly porous silica material for selective lead (Pb(II)) ion monitoring and removal from wastewater. The solution acidity played a key factor for sensitive Pb(II) ions detection. The adsorption isotherms of Pb(II) ions from aqueous solutions onto the adsorbent weremeasured, and the results showed that the Langmuir isotherm was found to be the best represent the measured adsorption data. The maximum adsorption capacity was determined to be 188.67 mg/g. The Pb(II) adsorption efficiency was not affected in the presence of co-existing ions.Moreover, this technique achieved residual Pb(II) concentration less than 10 µg/L, which is acceptable by water quality regulations. In addition, the conjugate adsorbent was regenerated by 0.10 M HCl treatment the Pb(II) ion adsorption efficiency was retained after nine adsorption- elution-regeneration cycles. The results suggested that conjugate adsorbent had the potential to become a promising technique for in situ Pb(II) contaminated groundwater remediation with naked-eye monitoring. Therefore, the ligand doped conjugate adsorbent is efficient and cost- effective potential materials for sensitive and selective Pb(II) detection and adsorption from aqueous solution.[51]

Ghasemzadeh et. al. (2017) used Nanoscale zero-valent iron (NZVI) particles which can effectively remove heavy metals from contaminated aqueous and solid media. It was accordingly hypothesized that it is possible to recycle and detoxify organic waste materials containing heavy metals using NZVI and NZVI fixed on quartz (QNZVI). Their objective was to investigate the effects of NZVI type, concentration (2% and 5%) and contact time on the removal of Pb from rawcompost, compost fermented with beet molasses, and leachate using a factorial design. The resultsindicated the significant reduction of DTPA- Pb and DTPA-Ni concentration, in all the organic compounds treated with NZVI and QNZVI (P= 0.01), compared with control. Increased concentration of NZVI in all treatments increased the rate of DTPA-Pb at 113.1% and 180% for Pb (NZVI at 2% and 5%). The reducing trend of extractable Pb in all the organic compounds wasthe same, quick reduction at the beginning, followed by a negligible rate. The highest reduction rates for Pb (at one hour) were equal to 72.93% respectively. NZVI at 2% was more efficient thanNZVI at 5%.[54]

Abdelwahab*et al.,*(2015) studied that the, cellulose acetate (CA) was modified by grafting with an equimolar binary mixture of acrylic acid (AA) and acrylamide (AAm) via radical polymerization technique using benzoyl peroxide as an initiator. The main operating conditions such as pH, concentration of Pb(II) ions and sorbent dose were also studied. Kinetic modelling has been studiedand lead uptake capacity was calculated using the Langmuir, Freundlich and Dubinin–Kaganer– Radushkevich (DKR) models. The maximum sorption capacity (qemax) for Pb ions was only 9.4 mg/g for unmodified CA, while, it was reached to 66.67 mg/g by using modified CA.Spectroscopic analysis (FTIR), SEM, EDX and XRD analysis were investigated for CA and modified CA before and after recovery of lead ions from wastewater.[55]

CONCLUSION

The present study shows the various methods of removal of lead metals or ions from waste water.It has become dangerous for environment day by day as many of man-made sources are growing rapidly, Recently various approach had been studied for removal of lead, but the best and the effective and rapid technique is seems to be the absorption by the both synthetic way by using polymers, metal oxides, and organic and inorganic hybrids and also the another technique is the adsorption by using natural adsorbents like lignin, biomass, cotton, chitosan, clays, zeolites. It hasbecome the alternative method for removal of lead and also it is low cost method. The overall studydescribes the usage of various methods those have less environmental impact also. Hence, all the factors mentioned above have to be taken into consideration by selecting the methods for lead removal by protecting the environment.

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