

RICE HUSKS AS A BIOSORBENT AGENT FOR Pb^{2+} IONS FROM CONTAMINATED AQUEOUS SOLUTIONS : A REVIEW

Mohammed Nsaif Abbas^{1*}, Suad Turkey Ali² and Rajaa S. Abass²

¹Department of Environmental Engineering, College of Engineering, Mustansiriyah University, Baghdad, Iraq.

²Al-Ma'moon University College, Baghdad, Iraq.

*e-mail: mohammed.nsaif.abbas@uomustansiriyah.edu.iq

(Received 30 August 2019, Accepted 5 December 2019)

ABSTRACT : Lead element and its compounds is one of the main substances disposed hugely by many industries such as electroplating, batteries and pesticides as well as the emissions of burning process of the fuel containing lead ions by various transport vehicles, small generators and others. As a result of its wide use, it causes an undeniable source to contaminate all components of environment, especially aquatic ecosystems. The most important feature of this dangerous element is the possibility of accumulation in the tissues of living organisms. Moreover the continuous and persistent exposure to lead is considered a major cause of diseases associated with kidney failure, brain and liver damage and diseases of the nervous system. Therefore, it should be removed from contaminated water as soon as possible and with the highest conceivable percentage. There are many methods of removing lead element from aqueous solutions including electrocoagulation, membrane filtration, ion exchange, chemical precipitation, extraction, adsorption, biological methods, etc. All the above methods differ in their usability, efficiency, residual waste and the economic cost necessary to apply them, but all these methods have advantages and disadvantages. Either it is a costly or less efficient method, or requires special units or primary treatments, or produces harmful wastes that require further treatment after completion. In contrast, adsorption technology by activated carbon and other adsorption media emerge as one of the most promising methods that have proven to be highly efficient in treating a lot of wastewater contaminated with toxic and hazardous waste types. It is an easy technology compared to other methods and does not require special units in addition to economic and can be repeated many times before the regeneration process. However, due to the constraints associated with this technique, which is represented by the high cost of activated carbon production and the loss of an amount ranging between 8-15% of its weight with each regeneration process and accumulation of pollutants on the surfaces of the adsorbents led to search for other alternatives to make the process economical and efficient approach. In the last two decades, industrial and agricultural wastes have attracted the attention due to their availability, efficiency, low cost, negligible toxicity and as a useful way to get rid of these environmentally harmful wastes. They have been used either as an adsorbent material or as raw materials for preparation of activated carbon. In order to treat the residual toxic residues, the concept of zero residue level (ZRL) has been introduced, which includes the exploitation of these toxic residues in a useful, economical and eco-friendly method. This article is related to review a number of papers that have used rice husks as adsorption media for lead from aqueous solutions and wastewater.

Key words : Adsorption, lead, rice husks, aqueous solutions, pollution.

INTRODUCTION

Lead is one of the elements known to human from ancient times and is found naturally in the Earth's crust (Jaishankar *et al*, 2014). It is used in many industries such as mining, smelting metals and manufacturing some types of paint (Tchounwou *et al*, 2012). Lead compounds are still used as an additive to improve the properties of gasoline and raise its octane number (Amine and Barakat, 2019). It accounts for more than three-quarters of the world's lead consumption for the manufacture of lead-acid batteries for cars, and is also used in several other products, for example dyes, paints, welding, stained glass, crystal utensils, military ammunition, glazed ceramics,

jewelry and toys, as well as being a major or secondary component in some traditional cosmetics and pharmaceuticals (Snow, 2012). Drinking water may contain Lead if transported by pipes made from lead or connected to each other by lead welding (Renner, 2010). Excessive use of this element and its compounds has resulted in widespread pollution of the environment (Tiwari *et al*, 2013). Past and other activities are important sources of contamination of this toxic metal as a result of the water or gas residues containing lead compounds, through which human exposure to damage and cause major public health problems in many regions of the world (Abbas and Abbas, 2013a). Lead is a cumulative toxic

substance that affects many organs of the body and is damaged (Wani *et al*, 2015). Once lead enters the human body, it is distributed in organs such as the brain, kidneys, liver and bones (Assi *et al*, 2016). The body stores lead in teeth and bones where it accumulates over time and usually assessed human exposure to lead by measuring the level of lead in its blood (WHO, 2019). It is worth mentioning that lead is the only heavy element that does not come out of the body tissues if it enters easily and requires a very long time but on the contrary accumulates in them (Morkunas *et al*, 2018). The lead stored in the bones and teeth can be massed again and the bloodstream is carried out during pregnancy, putting the fetus at risk as well (Wani *et al*, 2015). Exposure of pregnant women to high levels of lead can result in miscarriage, stillbirth, premature birth, low birth weight, and minor abnormalities (Kumar, 2018). Young children are particularly exposed to risk of toxic lead effects and may suffer serious and lasting adverse effects on their health, particularly those affecting brain development and the nervous system and there is no known level of lead exposure is considered safe (WHO, 2019). Lead also causes long-term damage to adults, including an increased risk of high blood pressure, joint and muscle pain, kidney failure, memory or concentration difficulties and mood disorders (Assi *et al*, 2016).

Methods of removing lead from contaminated water

Water pollution with heavy metals is a serious environmental problem (Abbas and Abbas, 2013b). Increased use of heavy metals in recent decades has resulted in the influx of heavy metals into natural water sources (Abbas and Abbas, 2013c). This contamination with toxic heavy elements has spread not only to surface water, but can contaminate the ground water through the small amounts that leak out via the soil after rain and snow fall, so the ground water contains different toxic metals (Abbas *et al*, 2019a). The severity of these toxic metals results from their negative effects on human health and the ecosystem surrounding it (Abd Ali *et al*, 2018). Most heavy metals are substances that accumulate in the tissues of organisms (Ali *et al*, 2020). These metals are mostly copper, lead, cobalt, cadmium, manganese, chromium, arsenic and most of these elements are toxic and carcinogenic. Sources of pollution with heavy metals also include various industries such as batteries, fertilizers, mining, various electronic industries, metal plating and dyes, also illegal landfills and radioactive waste (Alalwan *et al*, 2018). Several treatments and methods have been developed for the dispose of polluting heavy metals including chemical precipitation coagulation-flocculation (Pang *et al*, 2011), electrophoresis (Elmofty, 2011),

(Kavak, 2013), adsorption (Abbas and Abbas, 2013a), solvent extraction (Baba and Adekola, 2013), reverse osmosis (Thaçi and Gashi, 2015), ion exchange (Lalmi *et al*, 2018), membrane (Khulbe and Matsuura, 2018) and ultrafiltration (Yaqub and Lee, 2019). It has been found that the use of some of these techniques is of limited benefit because it requires high cost or its efficiency is not good in removing heavy metals (Abbas and Abbas, 2014), *i.e.*, it does not give a solution to the problems of the environment, but it has been proven that adsorption and ion exchange is one of the best methods in removing toxic materials and heavy metals from bilge water (Abbas *et al*, 2019b). Recently, this task has become the main concern of many international organizations concerned with the protection of the environment, especially in the industrialized countries where many laws, legislations and controls have been put in place for various industries (Abbas and Alalwan, 2019), which led many researchers to find solutions to solve this problem (Alalwan *et al*, 2019). Significant development in adsorption applications has led to the need to provide new adsorbents for use in special applications, to be of low economic cost and requires laboratory studies on them to determine the factors affecting them and their adsorption behavior (Abbas and Abbas, 2013d). Adsorption is one of the most important techniques in the present and one of the best ways to remove heavy elements from contaminated water and there are many studies in this field (Abbas, 2015). The goal of this paper is reviewed the use of rice husks as a type of agricultural waste widely used in the treatment of lead-contaminated aqueous solutions as a heavy metal with adsorption technology.

Adsorption of lead from contaminated water using rice husks

Rice husks have been widely used for adsorption of heavy metals and lead chiefly. This review includes a sequent chronological historical recitation of research on the remediation of Pb^{+2} ions from contaminated wastewater via adsorption technology using rice husks.

Khalid *et al* (1998) was studied Lead removal by rice husks with four types of strong acids which were nitric acid (HNO_3), hydrochloric acid (HCl), sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) each one alone. Adsorption experiments were performed in a unit of batch mode at different operational conditions of strong acid concentrations, pH of the solution, agitation time, amount of rice husks, temperature and different initial concentrations of lead. The results showed that lead adsorption was inversely related to the concentrations of all strong acids and at optimum conditions, the adsorption lead capacity was 0.004g of lead per g of rice husks.

Also show the adsorption process follows Freundlich isotherm within a certain range of pollutant concentrations. From calculating the thermodynamic factors of the process (ΔG° , ΔS° and ΔH°), the researchers concluded that the lead adsorption process was spontaneous, exothermic and high randomness process.

The ability of tartaric acid-modified rice husks to adsorb lead and copper ions was investigated by Kim (2001). Raw rice husks were treated with tartaric acid ($C_4H_6O_6$) at a concentration of 1.2 M for 10 minutes and heated to 180°C. To determine the adsorption behavior of modified rice husks, the researcher carried out adsorption experiments in a batch system and continuous system under various experimental conditions using simulated aqueous solutions polluted by lead ions. The operating conditions studied were temperature of polluted solutions, pH, initial concentration of Pb^{+2} and Cu^{+2} , agitation speed, rice husk dose, particle size, contact time, flowrate, packed bed height, adsorption desorption cycles, chelators, competitive cations and semiconductor. Batch results show that the adsorption was exothermic process and highly depended on pH, also illustrate that the percentage removal was directly proportion with adsorbent dose and agitation speed but it was decreased in case of chelators and competitive cations existence. The Langmuir isotherm model was fitted the results best than other models, while the adsorption process reaches to equilibrium in one hour according to kinetic study. Moreover, the continuous study achieved by packed column shows that the breakthrough was depended on height of bed, flowrate, initial concentration of pollutants. Finally, the sorption-desorption test exhibits that the lead can be extracted from the adsorbent using a 0.1 M of HCl acid solution and the column can be used five times before loses its efficiency.

Rice husks, carbon prepared based on rice husks as raw material (RHC), peat and commercial activated carbon to adsorb lead, iron, cadmium, chromium, nickel, zinc and manganese ions from simulated aqueous solutions were evaluated by Dos Santos *et al* (2006). Adsorption experiments were achieved out using aqueous solutions prepared under certain conditions from the effluent from the acid discharge of a coal mine in the Criciúma region (State of Santa Catarina, Brazil) and nearby industrial areas. The metal contents were measured using total reflection X-ray fluorescence (TXRF) spectroscopy while the adsorption capacity was determined by Langmuir isotherm model. Effluent toxicity test was performed with *Daphnia magna* in acute test in 24 and 48 h according to ASTM 8711. The results show that the peat was the

highest efficiency to remove lead followed by rice husk, commercial rice husk, finally RHC.

Abdel-Ghani *et al* (2007) studied the remediation of toxic lead ions from wastewater by adsorption using several available and low-cost materials such as rice husks, maize cobs and sawdust. For this purpose, simulated aqueous solutions contaminated by lead were prepared and adsorption experiments were conducted at room temperature and by a batch system using a reciprocating shaker. The FTIR analysis of rice husks was carried out and its spectrum included four intense bonds at 3379.1, 2920, 1604 and 1076.2 cm^{-1} , which is attributed to the hydroxyl groups and the natural chemical water. The initial concentration of lead, pH and treatment time were the operational factors investigated in this study while the agitation speed remained constant at 225 rpm while the non-adsorbed concentration of lead in the solution was specified by inductively coupled plasma analysis (ICP-OES). The obtained results showed that the removal efficiency of lead using rice husks was higher than that of other materials (maize cobs and sawdust) and that the pH, contact time and amount of adsorbent were directly proportional to the percentage removal while the concentration of lead was inversely proportional. The results also showed that the equilibrium time of adsorption was 120 minutes, adsorption capacity at equilibrium fitted with Temkin model more than Freundlich and Langmuir isotherm models.

Ordinary rice husks have been used by Wang and Lin (2008) for preparing of rice husk ash (RHA) by washing it with distilled water three times, dried at 105°C for 24 hours and then burned at 500°C in a box furnace. The resulting RHA was utilized as sorbent media for Pb^{+2} ions from in vitro and prepared contaminated solutions of lead using lead nitrate ($Pb(NO_3)_2 \cdot 3H_2O$). The laboratory unit used was of batch pattern and the design factors studied were the amount of RHA, pH, agitation speed and temperature of adsorption. The obtained results exhibit that the removal percentage was decreased with decreasing the amount of adsorbent, agitation speed and temperature while it increased with decreasing the initial concentration of lead and pH of aqueous solutions. The highest percent removal was 99.75% gained at a temperature of 30°C and agitation speed of 120 rpm, the amount of rice husk ash 20 g/L, pH of 4.2 and an initial concentration of 100 mg/L with contact time of 3 hours. Adsorption kinetics data indicated that the adsorption process of lead was physiologically controlled and that the pseudo-second-order rate equation appropriately explained the overall adsorption process as well as finding an experimental relationship relate the adsorption of Pb^{+2}

and contact time.

Biosorption of rice straws, bagasse, eucalyptus bark, black gram husk, and wheat bran of divalent lead ions was studied by Mukhtar-ul-Hassan *et al* (2009). In this study, the laboratory aqueous solutions were prepared using solid lead metal, not from one of the lead salts as followed. 1000 mg of solid metal was dissolved in 2.5 ml of diluted nitric acid to prepare the stock solution of a concentration (1000 µg/ml). From this solution, the main solutions of lead were their concentrations were in the range of 10-70 µg/ml and lead concentrations were measured using Atomic Absorption Spectroscopy (AAS). Rice husks and other adsorption media were tested for adsorption efficiency in a continuous laboratory system (flash column) after acid treatment using (HNO_3 , H_2SO_4 and $\text{C}_6\text{H}_8\text{O}_7$), alkali using (NaOH , KOH and NH_4OH) and using volatile organic solvents such as (CCl_4 , n-hexane, 50% V/V ethyl alcohol and methyl alcohol, acetone and ethyl acetate), while the operational conditions used in this study were initial concentration of lead and mesh size. The relation between the percentage of adsorption and the size of the adsorbent, the concentration of concentrations was a direct relationship where the removal rate increases with increasing these two factors as shown by the experimental results. The results showed that the adsorbents treated with NaOH as a base gave the best removal efficiency of 99.5%, while the best lead removal percentage for acid treated was approximately 88% using nitric acid whereas the effect of volatile organic solvents was very close between acetone, hexane and carbon tetrachloride followed by the rest solvents with lower removal efficiency. The isotherm calculation showed that adsorption of these media follows the model of Freundlich and Langmuir isotherm with a correlation coefficient of 0.95 and 0.94, respectively.

Due to its low cost as a plant waste, rice husks have been applied as one of the cheap alternatives to conventional water treatment methods. Rice husks was used as an adsorbent material for removing lead ions by El-Said (2010) and the result of treatment was compared with rice husk ash (RHA) prepared via burning local rice husks (as one of the rice mill waste) in 600°C in electric furnace for 3 hours. To realize this purpose, adsorption experiments were carried out from aqueous solutions (prepared by dissolving 1.59 g of lead nitrate in liters of distilled water twice) in a batch unit and using different operating conditions represented by pH, equilibrium time, amount of rice husk, lead concentration and particle size and variable numerical ranges. The results of this study showed the possibility of rice husks and RHA to recover lead from contaminated aqueous solutions with a

percentage of 87.75% and 95.75% at equilibrium time of 1 hour and 40 minutes, respectively. The results also indicated that the lead removal percentage was increased by increasing the acid function between 1-5 and then starting to decrease, while the effect of the lead initial concentration was inverse, where the highest removal percentage was at 20 mg/L and then gradually decreased until it stabilized at approximately 80 mg/L. The amount of adsorbent and particle size was related directly with the lead removal percentage, where the highest removal was achieved at 2 g/l and 0.35 mmesh particle size. Kinetic studies carried out confirmed that the best model for describing the results obtained was the pseudo-second order model, which record the highest correlation coefficient. The Langmuir isotherm model was the best represented model to isotherm and also by correlation coefficient.

Brazilian rice husks produced from the Boa Vista fields used by researchers (Vieira *et al*, 2011) in their study on the evaluation of different adsorption modes for lead and copper remediation by rice husk ash (RHA). The husks were initially prepared by crushing, sieving, sorting by size and then calcined by 500°C for one hour. Adsorption susceptibility has been tested in two types units, continuous and batch modes at constant operating conditions. At the end of the experimental period, the samples are withdrawn, centrifuged and the concentration of heavy metals was determined using an atomic absorption spectrometry (AAS). Batch experiments were conducted at temperature of 25°C, agitation speed 225 rpm, initial concentration of lead and copper 100 mg/L and the amount of adsorbent was 0.1 g/L. As for the continuous tests were carried out using different flow rates of contaminated aqueous solutions in a 5.5-inch glass column and a 0.5-inch inner diameter in which a packing of rice husks was placed at the same length of the column and in contact with distilled water for two hours before the experiment starts. The obtained results showed that the highest adsorbed amount was 0.053 mmol/g at 1000 min equilibrium time and 0.057 mmol/g at 600 min equilibrium time for lead and copper, respectively, in other words, the lead removal percentage was 94% and copper 33%. The highest adsorption removal using continuous unit was 33.33% at the lowest flow rate of 2 mL/min and 22.22% at 4 mL/min for lead and copper, respectively. While the adsorption quantity of the two adsorbent elements was 0.05 mmol/g, which is approximately the same results obtained in the batch unit. The results of the dual metals using the batch mode indicated that the removal percentage of lead was 37%, copper was 18%, and the equilibrium time was the same for the two

elements, which was 1000 minutes.

Aliyah (2012) investigates the effectiveness of tartaric acid-modified rice husks as an adsorbent for lead ions from aqueous solutions manufactured using batch unit. The main operating conditions used in this study were the contact time, pH and the amount of modified rice husks as an adsorbent ranged from (5-70) minutes, (2-6), (0.5-3) g respectively, while the initial concentration of lead was 400 mg/L. Detection of the lead ions concentration in aqueous solutions achieved using Atomic Absorption Spectrometer (AAS). The results showed that the lead removal percentage was directly proportional to the variables used and it was 71% at 70 minutes time, 86% at 6 pH and 80% at 4 g of treated rice husks.

Iraqi rice husks (IRH) with its usual form were tested by Abbas and Abbas (2013) for lead removal efficiency and other eight heavy metals without any further treatment using continuous adsorption unit of packed bed. Lead nitrate ($Pb(NO_3)_2 \cdot 2H_2O$) was used to prepare experimental solutions and the concentration of lead was determined using spectrophotometer. The operational parameters used were the initial concentration of lead metal, pH, flowrate of aqueous solutions, the height of column packing, the treatment time and temperature. The results indicated that IRH could adsorb heavy metals in general and lead in particular. The removal efficiency of lead was reached to 97.05% with the possibility of reusing the same husks after drying them for five times. After the completion of the treatment process, the polluted husks were sorted according to the amount of heavy metal loaded. With regard to the IRH loaded with lead, it's used as a rodenticide was studied directly without further treatment. This type of pesticide has proved highly potent in killing rodents relative to the toxic lead loaded. By this way, the researchers introduced a new concept in waste treatment, namely the zero residue level (ZRL).

Batch type adsorption unit was used by Prabha and Udayashankara (2014) to identify the effect of some different operational conditions on the adsorption of lead using groundnut shell and rice husks. The operational conditions used were pH, amount of husks, contact time, initial concentration of lead. Lead solutions were prepared using lead nitrate and the concentrations were determined using inductively coupled plasma (ICP). The results showed that the removal efficiency increases in acidic medium and decreases with increasing the concentration of lead ions in the solution. Moreover, 9 g of rice husk had the ability to remove 97.11% of the lead in solution of 100 mg/L at an acidic function of 7 and a treating time of 2 hours. The study also indicated that the kinetics of lead adsorption by rice husks is subject to pseudo second

order model with an optimal correlation coefficient unprecedented in previous research ($R^2 = 1$).

Upendra and Jyotikusum (2015) compared the using of ordinary rice husks (DWRH) with that treated with sodium carbonate (SCRH) as an effective, low-cost and environmentally friendly adsorption media to remove lead ions from simulated contaminated solutions in a adsorption unit of batch-type. Several operational factors affecting the adsorption process were studied, such as pH, contact time, lead concentration in solution and amount of adsorbent. This study achieved a lead removal rate of 80% using DWRH and 98.2% using SCRH. The results also showed conformity with the Freundlich and Langmuir isotherm models and the adsorption rate corresponded to the pseudo second order. Analysis of the results mathematically showed that the kinetics of the adsorption process were subject to rate controlling step.

The batch and continuous fluidization system were used to investigate the ability of rice husks to adsorb lead, cadmium and chromium by Al-Baidhani and Al-Salihy (2016). Firstly, rice husks were prepared by crushing, sieving, and then stored in plastic bags according to their particle size. After that the husks were washed and dried in the sun for 12 hours then kept in desiccators until use. Some physical tests were conducted for the rice husks such as bulk density, solid density base dry and surface area which their values were of 219.7 and 1480 $kg.m^3$ and 97.5 m^2/g , respectively. Different lead solutions were prepared using lead nitrate ($Pb(NO_3)_2 \cdot 2H_2O$) while the atomic absorption spectrophotometer (AAS) was used to measure lead concentrations. Adsorption experiments were performed for solutions had a concentration of 25 mg/L of lead in the shaker at a constant agitation speed of 150 rpm for 3 hours at laboratory temperature (25 ± 5 °C). The acidic value was maintained at 6 with NaOH solution and HCl. Different amounts of rice husks (0.25 - 3.0) grams were tested to determine the best removal percentage, while the particle size of the husks used ranged from (0.6-1.2) mm. The results of the batch experiments showed that the highest removal efficiency of Pb^{+2} , Cd^{+2} and Cr^{+6} ions was 90%, 97.96% and 80%, respectively. These results was achieved at the amount of 3 grams of rice husks, while the fluidized bed unit was used to study the removal of cadmium from aqueous solutions only.

Physico-chemical properties of Nigerian rice husks form Makurdi, Benue State-Nigeria were measured by Ahile *et al* (2017). It was found to be had pH, attrition, ash content, moisture content, bulk density, and Iodine number of 6.13, 42%, 23%, 5%, 0.5 mg/L, 55.5 mg/L, respectively. These husks were prepared by sequential

processes in order to evaluate their ability for sorption of lead ions from aqueous solutions using batch unit. The method of preparation included washing with distilled water at room temperature and then dried in oven at 105°C for 24 hours before being grinded and sieved to obtain Fine powder. The final rice husk was activated by ammonium chloride and then carbonized at 650°C for 25 minutes in a muffle furnace then washed several times until the obtained acidic solution was between 6-7 and finally kept in plastic bags until used. The design parameters used in this study were the initial concentration of lead, pH of solution, amount of adsorbed husks and contact time which varied in ranges (4-20) mg/L, (2-12), (1-5) g and (20-60) minutes, respectively. The highest removal efficiency of lead ions using activated husks was 81.50%, 84.45%, 92.44% and 99.60% in experiments of contact time, initial concentration, adsorbent amount and pH, respectively. The isotherm study indicated that the results were matching Langmuir isotherm with a correlation coefficient of $R^2 = 0.9082$, whereas the correlation coefficient obtained of Freundlich isotherm was $R^2 = 0.8664$.

Rice straws obtained from Shuangliu County near Sichuan University, Chengdu, China have been used by Tan *et al* (2018) as a raw material for the preparation of magnesium oxide (MnO_x)-coated biochar in three-stages. The first stage involved preparing the straw by washing with tap water then by distilled water, drying it at 80°C overnight and sieving it by 0.154 mm sieve. The next step was pyrolysis the dried straws at 420°C for 4 hours before coated in the last step with magnesium oxide via mixing it with a solution of potassium permanganate (KMnO_4) at a ratio 0.316: 1 (straw: permanganate). After SEM-EDS, XPS and FTIR tests of the prepared material (MnO_x -coated rice straw biochar) were performed to determine its characteristic properties; it was used as an adsorbent material and was applied to remove lead ions from aqueous solutions previously prepared using lead nitrate. The adsorption unit used was batch type and operational variables were pH, initial concentration and contact time. The results showed that the MnO_x -coated rice straw biochar achieved higher removal percentage than the ordinary biochar and the adsorption capacity was 0.9707 mmol/g and 0.5547 mmol/g for coated rice straw biochar and ordinary biochar, respectively. The results also showed that the adsorption isotherm and kinetics were corresponded to Langmuir model and pseudo second order rate, respectively.

Hasan *et al* (2019) studied the synthesis of fibrous silica KCC-1 from rice husks as raw material and compared the properties of the manufactured material

with the properties of the normal material (fibrous silica KCC-1) before being tested in removing lead ions from aqueous solutions using batch unit. The highest removal percentage was 75% and achieved at optimum conditions, which had an initial concentration of 322.06 mg/l, adsorbent amount 2.4 g/l and treatment time 117 minutes. The experimental results indicated that the adsorption kinetics followed the pseudo second order model and that the closest isotherm to represent the results is the Langmuir model with correlation coefficient ($R_2 = 0.9950$) and ($R_2 = 0.9934$), respectively.

CONCLUSION

As a result of its specifications and moderate surface area and being one of the agricultural waste produced annually in large quantities in the world, rice husk is becoming the first and most important material for researchers to consider not only in the field of water treatment, but also in the field of energy, catalysts and sustainable engineering. This review article reveals that rice husks, due to their availability and negligible toxicity have attracted attention over the past two decades for use as an adsorbent to remove lead and other heavy metals from contaminated aqueous solutions and waste water. It has been used as adsorption medium either directly or activated with acid or base materials or as a feedstock to prepare adsorption materials such as activated carbon, activated charcoal or silica.

The results show that rice husks are highly efficient in treating lead-contaminated water in batch and continuous units and at both high and low concentrations of lead. In addition to the above, this sequential historical review indicated a clear difference in the results of the mentioned papers. The results indicated that the removal percentage of lead ions from the aqueous solutions ranged between 75-99%. This may be attributed to the different conditions in which the experiments were conducted or the time they were conducted or because of the accuracy and modernity of the measuring devices used. However, all studies indicated that the adsorption kinetic of lead ion removal was subjected to pseudo-second order and that it followed the Langmuir isotherm with high correlation coefficients.

The residue of rice husks become toxic and hazardous residue after adsorption process due to the accumulation of lead on its surface. Except what the paper of Abbas and Abbas (2013), put forward about the exploitation ability of these residues in the concept of zero residue level (ZRL), it is noted that the papers reviewed in general did not deal with or suggest methods or manners for the disposal of leaded rice husks residues. The researcher

just suffices by determining the removal efficiency, adsorption capacity, adsorption kinetics and appropriate isotherm.

Therefore, this review attempts to highlight the disposing possibility of more than one type of wastes in one method. Also, it seeks to develop the use of unvaluable, available and economically agricultural residues as an adsorbent for toxic substance widely and to study their use as soil and air treatment materials. On the other hand, deepening studies related to the development the utilization techniques of these materials after compilation the adsorption process for the safe and economic disposal of residual toxic waste.

REFERENCES

- Abbas M N and Abbas F S (2013a) Utilization of Iraqi Rice Husk in the Removal of Heavy Metals from Wastewater. *Res. J. Environ. and Earth Sci.* **5**(7), 370-380.
- Abbas M N and Abbas F S, (2013b) Iraqi Rice Husk Potency to Eliminate Toxic Metals from Aqueous Solutions and Utilization from Process Residues. *Adv. Environ. Biol.* **7**(2), 308-319,
- Abbas M N and Abbas F S (2013c) The Predisposition of Iraqi Rice Husk to Remove Heavy Metals from Aqueous Solutions and Capitalized from Waste Residue. *Res. J. Appl. Sci. Eng. and Tech.* **6**, 4237-4246,
- Abbas M N and Abbas F S (2013d) The Feasibility of Rice Husk to Remove Minerals from Water by Adsorption and Avail from Wastes. *WSEAS Transactions On Environment and Development* **9**(4), 301-313.
- Abbas M N and Abbas F S (2014) Application of Rice Husk to Remove Humic Acid from Aqueous Solutions and Profiting from Waste Leftover. *WSEAS Transactions on Biol. Biomed.* **11**, 62-69,
- Abbas M N (2015) Phosphorus removal from wastewater using rice husk and subsequent utilization of the waste residue. *Desalination and Water Treatment* **55**(4), 970-977. <https://doi.org/10.1080/19443994.2014.922494>
- Abbas M N and Alalwan H A (2019) Catalytic Oxidative and Adsorptive Desulfurization of Heavy Naphtha Fraction. *Korean J. Chem. Engineering* **12**(2), 283-288. November. DOI: 10.9713/kcer.2019.57.2.283.
- Abbas M N, Al-Madhachi A T and Esmal S A (2019) Quantifying soil erodibility parameters due to wastewater chemicals. *Int. J. Hydrol. Sci. and Tech.* **9**(5), 550-568. DOI: 10.1504/IJHST.2019.10016884.
- Abbas M N, Al-Hermizy S M M, Abudi Z N and Ibrahim T A (2019) Phenol Biosorption from Polluted Aqueous Solutions by *Ulva lactuca* Alga using Batch Mode Unit. *J. Ecol. Eng.* **20**(6), 225-235. DOI: <https://doi.org/10.12911/22998993/109460>
- Abd Ali I K, Ibrahim T A, Farhan A D and Abbas M N (2018) Study of the effect of pesticide 2,4-D on the histological structure of the lungs in the albino mice (*Mus musculus*). *J. Pharmaceut. Sci. Res.* **10**(6), 1418-1421.
- Abdel-Ghani N T, Hefny M and El-Chaghaby G A F (2007) Removal of lead from aqueous solution using low cost abundantly available adsorbents. *Int. J. Environ. Sci. Tech.* **4**(1), 67-73, <https://doi.org/10.1007/BF03325963>
- Ahile U J, Ama S O, Mchihi M M, Oteikwu M O, Nyom P N and Utange P I (2017) Removal of Pb^{2+} from Aqueous Solution Using Rice Husk as an Adsorbent. *FUW Trends in Sci. Tech. J.* **2**(2), 886 – 889.
- Alalwan H A, Abbas M N, Abudi Z N and Alminshid A H (2018) Adsorption of thallium ion (Tl^{+3}) from aqueous solutions by rice husk in a fixed-bed column: Experiment and prediction of breakthrough curves. *Environ. Tech. Innov.* **12**, 1-13. <https://doi.org/10.1016/j.eti.2018.07.001>
- Alalwan H A, Abbas M N and Alminshid A H (2019) Uptake of Cyanide Compounds from Aqueous Solutions by Lemon Peel with Utilising the Residue Absorbents as Rodenticide. *Indian Chem. Engineer* <https://doi.org/10.1080/00194506.2019.1623091>
- Al-Baidhani J H and Al-Salihi S T (2016) Removal of Heavy Metals from Aqueous Solution by Using Low Cost Rice Husk in Batch and Continuous Fluidized Experiments. *Int. J. Chem. Eng. Appl.* **7**(1), 6-10. February. DOI: 10.7763/IJCEA.2016.V7.532
- Ali S T, Qadir H T, Moufak S K, Al-Badri M A M and Abbas M N (2020) A Statistical Study to Determine the Factors of Vitamin D Deficiency in Men the City Of Baghdad as a Model. *Ind. J. Forensic Med. & Toxicol.* (in press).
- Aliyah N A B (2012) Adsorption of Lead Using Rice Husks. *Bachelor Thesis*, Faculty of Chemical Engineering, Universiti Malaysia Pahang. January. http://umpir.ump.edu.my/id/eprint/3621/1/CD6389_NURUL_AKMA_BINTI_ALIYAH.pdf
- Amine M and Barakat Y (2019) Properties of gasoline-ethanol-methanol ternary fuel blend compared with ethanol-gasoline and methanol-gasoline fuel blends. *Egypt. J. Petroleum*, (in press), 14 September. <https://doi.org/10.1016/j.ejpe.2019.08.006>
- Assi M A, Hezmee M N, Haron A W, Sabri M Y and Rajion M A (2016) The detrimental effects of lead on human and animal health. *Vet. World* **9**(6), 660-671. doi:10.14202/vetworld.2016.660-671.
- Baba A A and Adekola F A (2013) Solvent extraction of Pb(II) and Zn(II) from a Nigerian galena ore leach liquor by tributylphosphate and bis(2,4,4-trimethylpentyl) phosphinic acid. *J. King Saud University – Science*, **25**(4), 297-305, October. <https://doi.org/10.1016/j.jksus.2013.07.003>
- Dos Santos J H Z, Lattuada R M and Peralba M C R (2006) Peat, Rice Husk and Rice Rusk Carbon as Lowcost Adsorbents in Metals Sorption from Synthetic Acid Drenage of Mine Effluents. *Brazilian Synchrotron Light Laboratory*, Activity report 2006. LNLS.
- Elmofty S E (2011) Use of electrophoresis technique to study removal of toxic metal ions from waste water by adsorption on mineral surface. *WIT Trans. on Ecol. and the Enviro.* **145**, 747-757. DOI:10.2495/wrm110671
- El-Said A G (2010) Biosorption of Pb(II) Ions from Aqueous Solutions Onto Rice Husk and its Ash. *J. Am. Sci.* **6**(10), 143-150. January. https://www.jofamericanscience.org/journals/am-sci/am0610/17_3030am0610_143_150.pdf
- Hasan R, Chong C C, Bukhari S N, Jusoh R and Setiabudi H D (2019) Effective removal of Pb(II) by low-cost fibrous silica KCC-1 synthesized from silica-rich rice husk ash. *J. Ind. and Eng. Chem.* **75**, 262-270. 25 July. <https://doi.org/10.1016/j.jiec.2019.03.034>
- Jaishankar M, Tseten T, Anbalagan N, Mathew B B and Beeregowda K N (2014) Toxicity, mechanism and health effects of some heavy metals. *Interdisc. Toxicol.* **7**(2), 60-72. doi: 10.2478/intox-

2014-0009

- Kavak D (2013) Removal of lead from aqueous solutions by precipitation: statistical analysis and modeling. *Desalination and Water Treatment* **51**(7-9), 1720-1726. <https://doi.org/10.1080/19443994.2012.714652>
- Khalid N, Ahmad S, Kiani S N and Ahmed J (1998) Removal of Lead from Aqueous Solutions Using Rice Husk. *Separation Sci. and Tech.* **33**(15), 2349-2362. <http://dx.doi.org/10.1080/01496399808545279>
- Khulbe K C and Matsuura T (2018) Removal of heavy metals and pollutants by membrane adsorption techniques. *Appl. Water Sci.* **8**(19), 1-30. <https://doi.org/10.1007/s13201-018-0661-6>
- Kim W K (2001) Removal of Copper and Lead from Aqueous Solution by Tartaric Acid Modified Rice Husk. *MSc. Thesis*, The Faculty of Science and Environmental Studies, Universiti Putra Malaysia.
- Kumar S (2018) Occupational and Environmental Exposure to Lead and Reproductive Health Impairment: An Overview. *Ind. J. Occup. and Environ. Med.* **22**(3), 128-137. doi:10.4103/ijoom.IJOEM_126_18
- Lalmi A, Bouhidel K-E, Sahraoui B and Anfif C el-H (2018) Removal of lead from polluted waters using ion exchange resin with $\text{Ca}(\text{NO}_3)_2$ for elution. *Hydrometallurgy* **178**, 287-293.
- Morkunas I, WoŹniak A, Mai V C, Rucińska-Sobkowiak R and Jeandet P (2018) The Role of Heavy Metals in Plant Response to Biotic Stress. *Molecules* (Basel, Switzerland) **23**(9), 1-30. doi:10.3390/molecules23092320
- Mukhtar-Ul-Hassan, Khalid H N, Batool N, Ahmad D, Khatoon S, Fatima H B and Farooq R (2009) Biosorption of Aqueous Lead (II) on Rice Straws (*Oryza sativa*) by Flash Column Process. *World Appl. Sci. J.* **7**(10), 1263-1268.
- Pang Y L, Abdullah A Z and Bhatia S (2011) Review on sonochemical methods in the presence of catalysts and chemical additives for treatment of organic pollutants in wastewater. *Desalination* **277**(1-3), 1-14..
- Prabha R T and Udayashankara T H (2014) Removal of heavy metal from synthetic wastewater using Rice husk and Groundnut shell as adsorbents. *J. Environ. Sci, Toxicol. Food Tech.* **8**(7), 26-34.
- Renner R (2010) Exposure on tap: drinking water as an overlooked source of lead. *Environ. Hlth Perspect.* **118**(2), A68-A72. doi:10.1289/ehp.118-a68
- Snow B D (2012) Living with Lead: an Environmental History of Idaho's Coeur D'alenes, 1885-2011. *Ph.D. Dissertation*, Montana State University, Bozeman, Montana
- Tan G, Wu Y, Liu Y and Xiao D (2018) Removal of Pb(II) ions from aqueous solution by manganese oxide coated rice straw biochar –A low-cost and highly effective sorbent. *J. Taiwan Inst. of Chem. Engineers* **84**, 85-92. March. <https://doi.org/10.1016/j.jtice.2017.12.031>
- Tchounwou P B, Yedjou C G, Patlolla A K and Sutton D J (2012) Heavy Metals Toxicity and the Environment. *Experientia Supplementum* **101**, 133-64. doi:10.1007/978-3-7643-8340-4_6.
- Thaçi B S and Gashi S T (2015) The Heterogeneous Reverse Osmosis Membranes Based Separation of Fluorides with Fly Ash Pretreatment. *Acta Physica Polonica A* **128**(2-B), B-62 –B-66. Special issue of the International Conference on Computational and Experimental Science and Engineering (ICCESEN 2014)
- Tiwari S, Tripathi I P and Tiwari H (2013) Effects of Lead on Environment. *Int. J. Emerg. Res. in Manag. & Tech.* **2**(6), 1-5.
- Upendra K and Jyotikusum A (2015) Removal of Pb(II) from Wastewater by Rice Husk. *Res. J. Chem. Environ.* **19**(2), 30-38.
- Vieira M G A, Almeida Neto A F, Silva M G C, Carneiro C N and Melo Filho A A (2011) Influence of the system on adsorption of Pb(II) and Cu(II) by rice husks ash: Kinetic study. *Chem. Engineering Transac.* **24**, 1213-1218. April 20. <https://doi.org/10.3303/CET1124203>
- Wang L-H and Lin C-I (2008) Adsorption of Lead (II) Ion from Aqueous Solution Using Rice Hull Ash. *Ind. Eng. Chem. Res.* **47**(14), 4891-4897. <https://doi.org/10.1021/ie071521z>
- Wani A L, Ara A and Usmani J A (2015) Lead toxicity: a review. *Interdisciplinary Toxicology* **8**(2), 55-64. doi:10.1515/intox-2015-0009
- World Health Organization (WHO) (2019) Lead poisoning and health. 23 August. <https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health>
- Yaqub M and Lee S H (2019) Heavy metals removal from aqueous solution through micellar enhanced ultrafiltration: A review. *Environ. Engineering Res.* **24**(3), 363-375. DOI: <https://doi.org/10.4491/eer.2018.249>