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Preparation of Active Rodienticide via Exploitation of Aluminium Adsorption Vestiges from Aqueous Solutions

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Abstract:

This paper deals with the study the potential of Orange Peel Residue (OPR) (after extraction of pectin methylesterase (PME) enzyme and extraction of D-limonene acid) to remove aluminium (Al^{+3}) ions from simulated synthesis aqueous solutions (SSAS) through various operating parameters using adsorption technique in sorption unit. Results show that the removal efficiency were 92.84% for aluminium ions from (SSAS) and the removal efficiency decreased with increasing of initial concentration, pH and SSAS flow rate while the removal efficiency increased with increasing packing height of adsorbent material and feeding temperature. A mathematical model was proposed for an adsorption packed bed column with adsorbent media. Statistical model is also achieved to find an expression relates the overall operating parameters with the removal efficiency of aluminium in a general equation. The waste of OPR (remaining after adsorbed aluminium) were predestined to investigate the utilization of it in useful method. It can prepare a cheap rodenticide from these OPR waste without any further treatment. The results explain that the OPR adsorb aluminium ions showed a good behaviour as rodenticide. By this way it can perform different benefits which are: remove the aluminium ions polluted the water, get rid of agricultural waste OPR, in the same time, prepare a cheap and active rodenticide. It can discard more type of waste in a non-cost and eco-friendly method accessing to zero residue level (ZRL).

Key words: aluminium, orange peel, adsorption, residue wastewater and ZRL

1. INTRODUCTION

Aluminium is a silvery-white, soft, nonmagnetic, ductile metal and it is the third most abundant element in the earth's crust (~8%) after oxygen and silicon. It occurs in nature in combination with other elements such as oxygen, silicon and fluoride. It is hard to believe that aluminium was once more expensive than gold, through it precluded its isolation in pure form for a long time. Aluminium is present in more than 270 different minerals, has a high affinity for oxygen and its oxides and silicates are chemically stable. The chief ore of aluminium is bauxite **(Aly et. al., 2014)**. Only one non-radioactive aluminium isotope occurs naturally. There are eight instable isotopes **(Leentech, 2015)**. Aluminium and its alloys are commonly used in the construction of siding, aircrafts, motor vehicles and lightweight utensils because of its strength and light weight. Dissolving aluminium compounds with acids produces aluminium salts, which are used widely in water treatment applications to facilitate coagulation of pollutants such as sediments, nutrients, microbes and dissolved organic compounds **(Al-Muhtaseb, et. al., 2008)**. Aluminium salts are also widely used. Aluminium chloride (a common Lewis acid) is used in Friedel-Crafts acylation and alkylation reactions, aluminium chlorohydrate ($Al_2Cl(OH)_5$) is an attractive ingredient in many antiperspirants and methylaluminoxane is employed in the Zeigler-Natta polymerisation of olefins. Other use of aluminium salts in industrial and domestic products include antacids, food additives and vaccines **(Aly et. al., 2014)**. Therefore, numerous industrial effluents discharge aluminium into the environment. Typical examples are waste liquors discarded in the production of catalyst-supporting materials from clays; liquors from uranium mills using acid leach process; acid mine waters from iron and coal mines; waste solutions resulting from the extraction of copper from waste dumps at porphyry copper mining operations or from Bayer process **(Rodil et. al., 2004)**. Aluminium may be present in water through natural leaching from soil and rock or from the use of aluminium salts as coagulants in water treatment procedures **(Aly et. al., 2014)**. Although water treatment processes by coagulation depend on the precipitation of aluminium (along with impurities) at neutral conditions, residual amounts of dissolved aluminium always remain in the treated water **(Al-Muhtaseb, et. al., 2008)**. Aluminium is known to dissolve in water at acidic and basic conditions **(Al-Muhtaseb, et. al., 2008)**. Aluminium exists in three different forms in water: suspended aluminium, particulate aluminium and soluble aluminium. Aluminium speciation studies have indicated that raw waters have aluminium predominantly in particulate form while aluminium exists in the treated waters as soluble, chemically labile form which is bioavailable **(Aly et. al., 2014)**. The American Waste Water Association (AWWA) estimated that drinking water (including treated water) provides about 5% of overall aluminium in human diets. The Environmental Protection Agency (EPA) sets the secondary permissible standard for aluminium in drinking water as 0.05–0.20 mg/l. **(Al-Muhtaseb, et. al., 2008)**. Guideline value of 0.2 mg/l as total aluminium proposed by WHO (1998) is based mainly on aesthetic considerations, as excess aluminium results in discolouration of water. Generally, aluminium is measured as “total”, as the guideline requires this value **(Aly et. al., 2014)**. The total aluminium concentration in the human body is approximately 9 ppm (dry mass). In some organs, specifically the spleen, kidneys and lung, concentrations up to 100 ppm (dry mass) may be present. Daily aluminium intake is approximately 5 mg, of which only a small fraction is absorbed. This leads to relatively low acute toxicity. Absorption is about 10 µg per day. These amounts are considered harmless to humans. Large aluminium intake may negatively influence health. This was connected with nerve damage. Particularly people with kidney damage are susceptible to aluminium toxicity. There is a risk of allergies. Aluminium is probably mutagenic and carcinogenic. Furthermore, aluminium is a potential cause of Alzheimer's disease, Lou Gehrig's disease and other forms of senile dementia. It is still unclear if aluminium leads to these diseases or if it is that the diseases cause brain tissues to retain aluminium secondarily. Increased aluminium intake may also cause osteomalacia (vitamin D and calcium deficits). Aluminium intake mainly occurs through food and drinking water. Aluminium particles may cause functional lung disorder. Aluminium chloride may corrode the skin, irritate the mucous membranes in the eyes, and cause perspiration, shortness of breath and coughing. Alum increases blood clotting. Aluminium has been shown to be a neurotoxic compound if it is allowed to enter the bloodstream. Long-term exposure of patients to dialysis water containing aluminium may cause encephalopathy (defect of the brain) and/or bone mineralization disorders **(Al-Muhtaseb, et. al., 2008; Leentech, 2015)**. Aluminium may negatively affect terrestrial and aquatic life in different ways. Regular aluminium concentrations in groundwater are about 0.4 ppm, because it is present in soils as water insoluble hydroxide. At pH values below 4.5, solubility rapidly increases, causing aluminium concentrations to rise above 5 ppm. This may also occur at very high pH values. Dissolved Al^{3+} ions are toxic to **plants**; these affect roots and decrease phosphate intake. As was mentioned above, when pH values increase aluminium dissolves. This explains the correlation between acid rains and soil aluminium concentrations. Acid rain dissolves minerals in soils, and transports these to water sources. This may cause aluminium concentrations in rivers and lakes to rise. At increasing nitrate deposition the aluminium amount increases, whereas it decreases under large heather and agricultural surfaces. In forest soils it increases. Aluminium is toxic to **fish** in acidic, unbuffered waters starting at a concentration of 0.1 mg/L. **Phytoplankton** contains approximately 40-400 ppm aluminium (dry mass), which leads to a bio-concentration factor of 104-105 compared to seawater. Terrestrial organisms also contain some aluminium. Examples: mosquito larvae 7-33 ppm, springtails 36-424 ppm (dry mass). Together, pH values and aluminium concentrations determine larvae mortality. A number of LD_{50} values for rats are known for aluminium **(Leentech, 2015)**. The oral LD_{50} of aluminium nitrate, chloride, and sulfate in mice and rats ranges from 200 to 1000 mg of aluminium per kg of body weight **(WHO, 1997)**. The mechanism of toxicity is mainly based on enzyme inhibition **(Leentech, 2015)**. Therefore it is important to remove the aluminium from water before being used as drinking water **(Al-Muhtaseb, et. al., 2008)**. Water streams and groundwater containing metals in solution present considerable health and environmental hazards. In the case of aluminium, there are many processes such as precipitation, extraction, ion exchange, and other techniques used for the removal or recovery of aluminium from the vast supply contained in industrial and mine wastewater **(Rodil et. al., 2004)**. Extraction processes used for the removal of aluminium from aqueous solutions use different organic phases like kerosene, benzene, 1-octanol, and also different extracting agents like di-(2-ethylhexyl-) phosphoric acid, 2-ethylhexyl 2-ethylhexyl-phosphonic acid, phenylacetic acid, bis(1,1,3,3-tetramethylbutyl) phosphinic acid (MBP) and its sulfur analogues, alkyl phosphoric acids. A limitation of these methods is that residual organic solvent or expensive extractant remains as a contaminant in the treated wastewater. The removal of the extractant from the treated water adds to the costs of the process. Precipitation processes widely used to remove metal ions from aqueous solutions include the formation of hydroxides, carbonates, or sulfides. The disadvantages of most precipitation processes are the large consumption of precipitating agent and the difficulties found in the filtration of the sludge. The use of organic reactants to precipitate metals in solution has been limited by poor regeneration and the high cost of the organic precipitating agent **(Rodil et. al., 2004)**. Adsorption technique is one of the alternative, most commonly and efficacious methods in wastewater treatment and it represented the green chemistry direction to reduce the use of toxic and carcinogenic solvents in remediation processes of wastewater **(Abbas, 2014a)**. Recently, great attention has been paid to the adsorbents based on natural materials, such as rice husk which is used as adsorbent media for adsorption of many pollutants such as heavy metals **(Abbas et. al., 2012; Abbas et. al., 2013a; Abbas and Abbas (2013a), (2013b), (2013c) and (2013d); Abbas and Abbas 2014a)**, dyestuffs **(Abbas and Abbas 2014b)**, pesticides **(Abbas and Al-Madhhachi, 2015)**, phenols **(Abbas et. al. (2013b), (2013c))** non-organic toxins **(Abbas, 2014b)** and cesium as a radioactive waste **(Abbas, 2014a)**, banana peel for adsorption of cyanide **(Abbas et. al., 2014)** and thorium **(Abbas, 2013)** because it is available, very inexpensive and ability to remove different types of contaminants. Orange peel also can be used as a natural adsorbent like rice husk and banana peel in the same way, thus the orange peel usage will decrease the cost of wastewater treatment considerably and would represent practical benefit of agriculture waste residue in disposal toxic matter in save way **(Abbas, 2014c)**. The objective of this paper was to evaluate and determine the efficiency of orange peel residue (after extraction of pectin methylesterase (PME) enzyme and extraction of D-limonene acid) for recovering of aluminium from simulated synthetic aqueous solutions and exploit from the husk remaining in eco-friendly method accessing to zero residue level (ZRL).

2. EXPERIMENTAL WORK

2.1: Materials

2.1.1: *Orange peel residue* (*adsorbent media*)

Orange Peel Residue (OPR) were collected after extraction of extraction of pectin methylesterase (PME) enzyme and extraction of D-limonene acid from the Fresh Orange Peel (FOP) as described in **(Abbas, 2014c)**.

2.1.2: *Stock solutions*

In order to avoid interference with other elements in wastewater, the experiments in this study were carried out using simulated synthetic aqueous solution (SSAS) of different aluminium concentrations. 1000 mg/l stock solution of aluminiu was prepared by dissolving known weight of aluminium nitrate Al $(NO_3)_3.9H_2O$ in one litre of double distilled water, all solutions using in the experiments were prepared by diluting the stock solution with double distilled water to the desired concentrations for the experimental work of this investigation. The aluminium concentrations were measured using spectrophotometer method using spectrophotometer thermo – genesys 10 UV, USA.

2.2: Sorption unit

Fixed bed column of continuous mode experiments were conducted in order to test aluminium removal by treated SSAS of above aluminium at desired concentration with the various bed heights of the adsorbent media OPR using different flow rates of SSAS of aluminium at various pH. The pH value was adjusted using 0.1 N NaOH and 0.1 N HCl solutions where the flow direction is downward by gravity. The sorption unit consists of two glass container of SSAS of aluminium one for inlet and another for outlet each of (1 liter) capacity. Glass column has 2.54 cm ID and 150 cm height. The sorption column packed with adsorbent media to a height of (10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 cm) supported from the top and the bottom by glass hollow cylinder layer, each cylinder have (0.5 cm ID, 0.1 cm thickness and 1 cm long). Before starting the runs, the packed bed sorption column was rinsed by double distilled water down flow through the column. The OPR is packed in the column to the desired depth, and fed to it as slurry by mixing the media OPR with distilled water in order to avoid the formation of air bubbles inside the media. After the packed bed sorption column was accommodation and putting the required amount of adsorbent media, the adsorption process started by allowing the aluminium SSAS of required concentration and pH down flow through the sorption column from inlet container by gravity at a precise flow rate in experiment which is adjusted by the valve. To determination the best operational conditions, the experiments were carried out at a temperature between (20 –45°C), various pH values which are (1–8) and initial feed concentrations of SSAS of different aluminium which are between (1–100) mg/l and at different flow rates which are between (5–100) ml/min for aluminium initial feed concentration. Outlet samples in each experiment were collected every 10 minutes from the bottom of packed column and the unadsorbed concentration of aluminium in SSAS was analyzed by spectrophotometer.

3. MATHEMATICAL MODEL

Fixed bed dynamics are describing by a set of convection-diffusion equations, coupled with source terms due to adsorption and diffusion inside adsorbent particles. Inside the particle, molecules of adsorbate diffuse into the inner portions of particle via surface diffusion, pore diffusion, or both. The solution of these equations will give rise to the prediction of the needed concentration distribution. This investigation focuses on understanding the mechanism of both surface diffusion and pore diffusion. To formulate a generalized model corresponding to the dispersion flow, surface diffusion and pore diffusion mechanism, following assumptions are made:

1. The system operates under isothermal conditions.
2. The equilibrium of adsorption is described by Langmuir isotherm.
3. Intraparticle mass transport is due to Fickian diffusion, and it is characterized by the pore diffusion coefficient, D_p and the surface diffusion, D_s.
4. Mass transfer across the boundary layer surrounding the solid particles is characterized by the external-film mass transfer coefficient, k_f.
5. Film transfer resistance for mass transport from the mobile to the stationary phase.
6. Local adsorption equilibrium between the adsorbate adsorbed onto the adsorbent surface and the adsorbate in the intraparticle stagnation fluid.
7. Both surface and pore diffusion are included in the mass transport mechanism.
8. Axial dispersion.

3.1: Simulation Technique

Equations used in simulation technique represent a set of simultaneous, nonlinear, partial differential equations (PDEs) that can be solved numerically. The discretatization was applied to space coordinates (Z and r) to convert the PODs to a set of ordinary differential equations (ODEs). The resulting ODEs can be solved using an existing ODE solver provided by **(Abbas et. al. (2013b), (2013c))**.

4. RESULTS AND DISCUSSION

The ability of OPR to remove aluminium ions from SSAS in fixed bed column of continuous mode at various parameters which are pH's of SSAS of heavy metal ion (*pH*), height bed of adsorbent media (OPR) (*l*), flow rates of SSAS (*F*), SSAS temperature (T_{feed}) and time of treatment (*t*) was investigated. The experiments were achieved by varying all above parameters for different initial concentrations (C_o) of SSAS of aluminium. Thus, the results obtained are explained below.

4.1: Effect of Initial Concentration

The results showed that using OPR as an adsorbent material, the percent removal of aluminium ions was decreased when the initial concentration (C_o) of SSAS of aluminium ions was increased at constant other variables as shown in **Figures 1**. This can be explained by the fact that the initial concentration of aluminium ions had a restricted effect on aluminium ions removal capacity; simultaneously the adsorbent media had a limited number of active sites, which would have become saturated at a certain concentration. This was lead to increase in the number of aluminium ion molecules competing for the available functions groups on the surface of adsorbent material. Since the solution of lower concentration has a small amount of aluminium ions than the solution of higher concentration of it, so the percent removal was decreased with increasing initial concentration of aluminium ions. For adsorbent media, higher percent removal was 92.86 % for aluminium ions, at initial aluminium ion concentration of 1 mg/l, so adsorbent material was found to be efficient to aluminium ions removal from SSAS and wastewater.

4.2: Effect of pH

The results showed that using adsorbent material, the percent removal of Al^{+3} ions was decreased when the pH of SSAS of above heavy metal ions was increased at constant other variables, **Figures 2**. It is well recognized that the pH of the aqueous solution is an important parameter in affecting adsorption of heavy metal ions. High adsorption of Al^{+3} ions at low pH can be explained in both terms; the species of the metal and the adsorbent surface. For this case, at low pH, i.e. acidic conditions, the surface of the adsorbent OPR becomes highly protonated and favours adsorb of Al^{+3} ions in the anionic form. With increasing the pH of aqueous solution, the degree of protonation of the surface reduces gradually and hence adsorption is decreased. Furthermore, as pH increases there is competition between hydroxide ion (OH^-) and Al^{+3} ions, the former being the dominant species at higher pH values. The net positive surface potential of sorbent media decreases, resulting in a reduction the electrostatic attraction between the (*sorbent*) metal ion species and the (*sorbate*) adsorbent material surface OPR, with a consequent reduced sorption capacity which ultimately leads to decrease in percentage adsorption of metals ion **(Abbas, 2013; Abbas, 2014a)**.

4.3: Effect of Adsorbent Media Bed Height

The results elucidated that when the adsorbent media bed height was increased, the percent removal of all Al^{+3} ions was increased too at constant other variables as shown in **Figures 3**. The increased of bed height (*l*) meaning increased in the amount of adsorbent media, thus increasing the surface area of adsorbent material, hence increased the number of active sites in the adsorbent material surface i.e. increased the availability of binding sites for adsorption and consequently increase the Al^{+3} ions removal capacity on OPR. This lead to increase the ability of adsorbent media to adsorb greater amount of Al^{+3} ions from SSAS at different initial concentrations and ultimately the percent removal of Al^{+3}ions increased.

4.4: Effect of Flow Rate

The results illustrated that when the flow rate of SSAS of Al^{+3} ions was increased, the percent removal was decreased at constant other variables as shown in **Figures 4**. This may be due to the fact that when the flow of SSAS of Al^{+3} ions increasing, the velocity of solution in the column packed with the adsorbent media OPR was increasing too, so the solution spend shorter time than that spend in the column while at low flow rate, the SSAS of Al^{+3} ions resides in the column for a longer time, and therefore undergoes more treatment with the adsorbent media, thus the adsorbent media uptake low amount of Al^{+3}ions from SSAS of Al^{+3} ions for high flow rate, therefore the percent removal of Al^{+3} ions was decreased when the flow rate was increased.

4.5: Effect of Feed Temperature

The results demonstrated that when the temperature of feed which was SSAS of Al^{+3} ions was increased, the percent removal of heavy metal ions was increased too at constant other variables as shown in **Figures 5**. The effect of temperature is fairly common and increasing the mobility of the metal cation. Furthermore, increasing temperature may produce a swelling effect within the internal structure of the adsorbent media enabling Al^{+3} ions to penetrate further. It was indicated that Al^{+3} ions adsorption capacity increased with increasing feed temperature from 20 to 45°C. This effect may be due to the fact that at higher temperature an increase in active sites occurs due to bond rupture.

4.6: Effect of Treatment Time

The results demonstrated that when the treatment time of SSAS of Al^{+3} ions increased the percent removal of Al^{+3} ions increased too at constant other variables as shown in **Figures 6**. This may be due to the fact that when the time of treatment of SSAS of Al^{+3} ions increasing and the velocity of solution in the column packed with the adsorbent material was remaining constant, the solution spend longer time than that spend it when the time of treatment decreased, so the adsorbent material uptake more amount of Al^{+3} ions from SSAS, therefore the percent removal of Al^{+3} ions from SSAS of was increased.

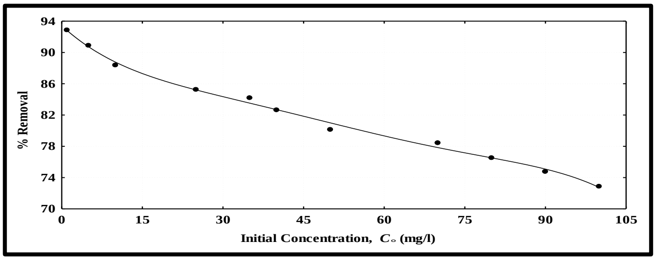

Figure 1: Effect of initial concentration ($C_\circ$) on the percent removal of Al^{+3} ions @ T_f =45°C, l = 1 m, pH=1, t=60 min. and F=5 ml/min.

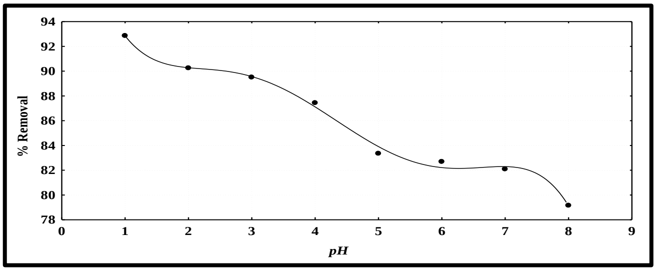

Figure 2: Effect of pH on the percent removal of Al^{+3} ions @ $C_\circ$= 1 mg/l, T_f =45°C, l = 1 m, t=60 min. and F=5 ml/min.

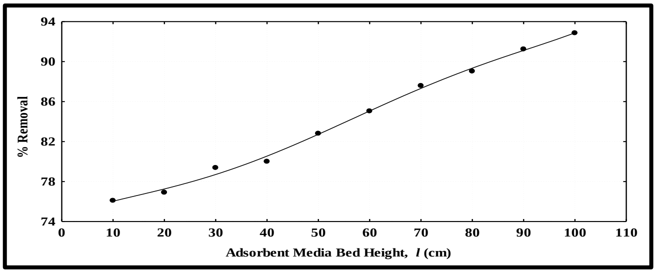

Figure 3: Effect of adsorbent media bed height (l) on the percent removal of Al^{+3} ions @ $C_\circ$= 1 mg/l, T_f =45°C, pH=1, t=60 min. and F=5 ml/min.

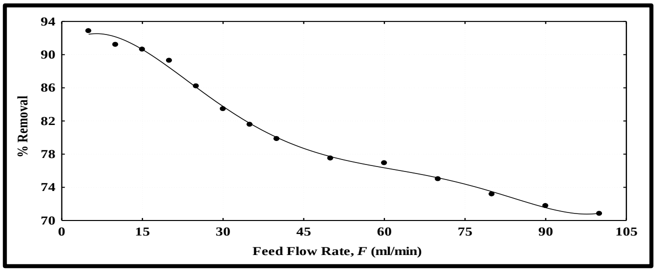

Figure 4: Effect of aqueous solution flow rate (F) on the percent removal of Al^{+3} ions @ $C_\circ$= 1 mg/l, T_f =45°C, pH =1, l = 1 m and t=60 min.

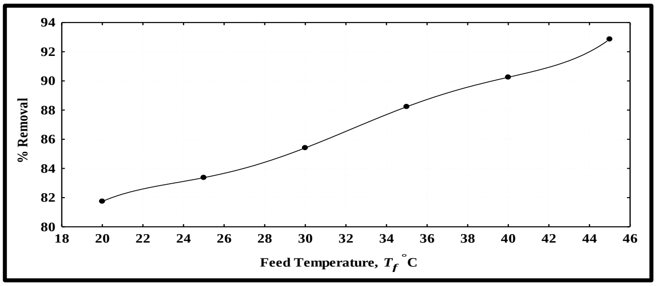

Figure 5: Effect of feed temperature (T_f) on the percent removal of Al^{+3} ions @ $C_\circ$= 1 mg/l, pH=1, l = 1 m, t=60 min. and F=5 ml/min.

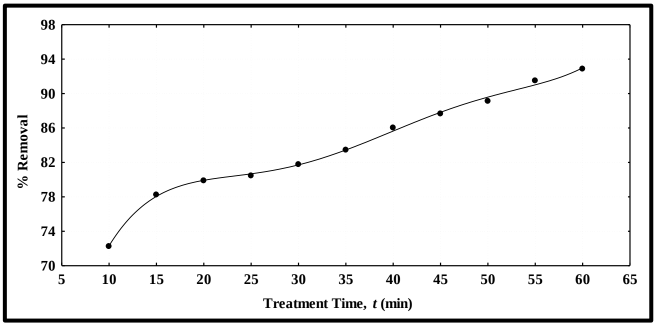

Figure 6: Effect of treatment time (t) on the percent removal of Al^{+3} ions @ $C_\circ$= 1 mg/l, T_f =45°C, pH=1, l = 1 m, and F=5 ml/min.

5. STATISTICAL MODEL

A statistical model was carried out on the experimental results obtained from this study. Regression Analysis and **π** Theorem was adopted to maintain a relation between the percent removal of Al^{+3} ions and the feed temperature, flow rate, pressure, pH of feed solution, initial concentration of Al^{+3} ion, adsorbent media bed height, treatment time and column diameter. These relations are shown in **equation 1**, which has a correlation coefficient (R^2) 0.9954.

$$\%\boldsymbol{R} = \mathbf{5.132} \times \mathbf{10^{-7}} \left(\frac{\boldsymbol{\rho_{sol}}}{\boldsymbol{C_\circ}}\right)^{0.2521} . \left(\frac{\boldsymbol{l}}{\boldsymbol{d}}\right)^{0.2185} . \left(\frac{\boldsymbol{T_f . C_{P_{sol}} . t}}{\boldsymbol{\vartheta}}\right)^{0.2205} . \left(\frac{\boldsymbol{K_{sol} . T_f}}{\boldsymbol{\gamma . u}}\right)^{0.2112} . (\boldsymbol{pH})^{0.0741} \qquad (1)$$

where:	$\%\boldsymbol{R}$	Percent Removal of Aluminium ions from SSAS
	$\boldsymbol{\rho_{sol}}$	Density of SSAS, (kg/m^3)
	$\boldsymbol{C_\circ}$	Initial Concentration of Aluminium , (kg/m^3)

l	Adsorbent Material Bed Height, (m)
d	Internal Diameter of Sorption Column, (m)
T_f	Feed Temperature, (K)
$C_{P_{sol}}$	Heat Capacity of SSAS, (kJ/kg. K)
t	Treatment Time, (s)
ϑ	kinematic viscosity of SSAS, (m^2/s)
K_{sol}	Thermal Conductivity of SSAS , (W/m. K)
γ	Surface Tension, (N/m)
u	Velocity of SSAS, (m/s)

6. UTILIZATION OF ORANGE PEEL AFTER USES

Huge amount of OPR was lingered after using it in removal of Al^{+3} ions from SSAS as illustrated above. The remaining waste of OPR after removal of aluminium ions from SSAS by adsorption process were collected, segregated and classified according to its contain of aluminium and utilization from these vestiges to prepare a simple and active rodenticide. Twenty groups (ten for male and ten for female) of an outbred multipurpose breed of albino rat which was Sprague dawley rats (*Rattus rattus*) were used in this test; each group has ten rats besides another animal control group to compare the results. Before the test is beginning, the rats were left for one week in clean and convenient cages and nurtured with normal feed to make sure that it's were not suffer from anything leading to death **(Ibrahim et. al., 2014; Abbas and Al-Madhhachi, 2015)**. The OPR waste were mixed with little amount of fruit to give sweet test and feed to the rats directly as rodenticide without any further treatment. The results were fate the rats in different periods and the lethal dose for aluminium was also calculated as shown in **Table 1**.

The inorganic pesticide, is one of the most important type of pesticide used in rodent control, and perhaps the most important components used in this field are aluminium, arsenic, barium, bismuth, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, nickel, tin, and zinc inorganic compounds. There are several ways to use these rodenticide in rodents places passing where the pesticide inter to the mouth of the rodent when its clean parts of their bodies, or through mixing with attractive materials to rodent like OPR or bread or vegetables pieces. Characterized compounds of this rodenticide being used successfully to combat rodent and where they are used as toxin infectious for their secured effectiveness, and severity of toxic, in addition to non-degradable and remain for a long time without changing their composition. There is more than one way to interpret the mechanical toxic effect of these elements compounds on rodents, which are:

1 – The compounds of these elements operate to prevent the phosphorylation process of Adenosine diphosphate (ADP) material in the process of oxidative phosphorylation and thus preventing the formation of Adenosine triphosphate ATP material necessary in the storage of energy required for the rodent.

2 – Theses compounds linked with many important enzymes required from the rodent body and discourage work, and these enzymes are dehydrogease, cytochrome oxidese, phosphatase where these inhibition process lead to an imbalance in the processes of chemical or biological eventually lead to the death of the rodent.

3 – The high concentrations of elements compounds lead to a deposition holistic and very fast for a protein in a living cell because it attack the sulphur bonds, which plays an important role in keeping the distinctive shape of the protein, it observed that the effect of these elements compounds are concentrated in the epithelium in the central gut of rodents.

4 – The low concentrations of these elements compounds leading to excessive drowsiness and lack of movement and the collapse of immune system and the failure of the ability to reproduce (infertility) of the rodent.

Table 1 LD_{50} (mg of Pesticide/kg of rat body) of Aluminium Calculated in this Study

LD_{50} for male (mg/kg)	LD_{50} for female (mg/kg)	Standard Dose (mg/kg)
324	270	200 to 1000 **(WHO, 1997)**

7. CONCLUSIONS

The following conclusions can be drawn:

1. OPR showed a good ability to remove aluminium from SSAS using fixed bed adsorption unit. So, it could be recommended for removal of heavy metal ions from treatment plant wastewater instead of other material like activated carbon because it is valid, cheaper, economical, easy and simplicity for using, and has a high ability to adsorb heavy metal ions, and can be used finally in another benefit uses.
2. Maximum removal of Al^{+3} ions were 92.86% at initial concentration of 1 mg/l.
3. The percentage removal of Al^{+3} ions was increased with decreeing pH, flow rate of SSAS and initial concentration of Al^{+3} ions while the percentage removal was increasing with increasing of treatment time and the height of adsorbent material OPR.
4. It can be prepared a good rodenticide for rodent control from the residual samples of OPR that adsorb the Al^{+3} ions above from SSAS.

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