



## Heavy Metals Adsorptive Potentials of Synthesized Silver Nanoparticles from Orange Peels

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### ABSTRACT

Orange peels obtained from Zaria were used in the synthesis of silver nanoparticle and the formation of silver nanoparticles was found to be successful. Silver nanoparticles exhibits brown color in aqueous solution due to excitation. Batch adsorption was carried out and the isotherm model well fitted in this research was the Langmuir adsorption isotherm model the choice of the advocate was due to their adverse effect on human and the environment. This study shows that silver nanoparticles is a green material and can be synthesized at low cost and used for the removal of heavy metals in wastewater with economical advantage having no adverse effect on the environment and possessing antimicrobial activity. This study also revealed that factors such as pH, adsorbent dose and concentration has very high significant influence on the adsorption processes.

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### KEYWORDS

Biosorption, Synthesis, Nanoparticle, water, heavy metal

### INTRODUCTION

Among all water contaminants, heavy metals were found to be highly toxic and causes severe health problems in human and animals (Xiangtan *et al.*, 2012). Heavy are natural components of the earth crust and cannot be destroyed (Lentech, 2011). Contamination of water with toxic metal is becoming serious environmental and public health problems (Samanta *et al.*, 2016).

It is estimated that over 1.1 billion people lack supply of adequate drinking water (WHO, 2016) due to the rising cost of portable water, growing populations, and variety of climatic and environmental concerns (Muzammilet *et al.*, 2016). Various techniques currently used for heavy metal removal from contaminated water are: physico-chemical precipitation, reverse osmosis, ion exchange, solvent extraction

and adsorption (Sezginet *et al.*, 2013, Farghali, 2013). Nanotechnology has been considered effective in solving water problems related to quality and quantity, this can only be achieved through synthesis procedure of biological nature using plant extract that are considered safe and ecological sound for nanomaterial production as an alternative to conventional, physical and chemical method (Castro *et al.*, 2013). Using plant extract reduced the use of expensive chemicals, consume less energy, and generate less or nonhazardous chemical by products (Benakashaniet *et al.*, 2016). Nano particles has been used in water purification systems, medicinal devices, cosmetics, bioremediation, heavy metal and pesticide removal in water and soil (Rajeshkumar., 2016). In order to maintain a healthy living environment ways of



controlling pollution should be considered (Ibrahim, 2011). Khaydarovet *et al.*, (2010) used carbon nanoparticles for waste water treatment. Warner *et al.*, (2010) suggested a method for removal of contaminants from natural water using high performance super magnetic nanoparticles based heavy metal sorbents. Sezgin *et al.*, (2013) proposed synthesis, characterization and the heavy metal removal efficiency of (NiFe<sub>2</sub>O<sub>4</sub> and CuFe<sub>2</sub>O<sub>4</sub>) nanoparticles. Sumeshet *et al.*, (2011) used a practical silver nanoparticles based adsorbent for the removal of Hg<sup>2+</sup> from water. The result show that silver nanoparticles supported on alumina is an efficient system for the removal of mercuric ion from water. Annadurai *et al.*, (2002) study the removal of heavy metals from water using banana and orange peels. The results showed that both banana and orange peels are good adsorbent in the removal of heavy metals. This research is indispensable as the problem of contamination of water with toxic metal which has become serious environmental and public health issue could be resolved with this silver nanoparticle derived from orange peelstrog adsorption process.

## MATERIALS AND METHODS

### Preparation of Orange Peels

The method of Ainaet *et al.*, 2012 was used in extracting peels from orange fruits obtained from Zaria.

### Synthesis of Silver Nanoparticle

Aqueous solution of silver nitrate was taken into Erlenmeyer flask. Different amount of orange peels extract solution were added until colour turned to dark brown; the solution stirred for 35 min to form silver nanoparticles.

### Batch Experiments

This was carried out on laboratory scale to evaluate the effectiveness of silver nanoparticles for the removal of Lead and Chromium. Consistent with Garba, *et al.*, 2016, known amount of adsorbent (silver nanoparticles) was added to sample solutions; The pH of the solution were adjusted to the required pH with 0.1 M HCl or 0.1 M NaOH solutions. The reaction mixture was allowed for 2 h with continuous shaking and filtered using filter paper. The concentration of heavy metals in the filtrate was analyzed using atomic absorption spectrophotometer, AAS (VARIAN INSTRUMENT AA240FS) and the concentrations of the Cu (II), Pb (II) and Fe (II) ions remaining in the adsorbent phase ( $q_e$ , mg/g) were calculated using

$$q_e = \frac{(C_o - C_e)V}{m}$$

Where;  $q_e$  = metal ion uptake capacity (mg/g),

$C_o$  = initial concentration of metal ion in solution (mg/L)

$C_e$  = Final concentration of metal ion in solution (mg/L)

$m$  = mass of the biosorbent

(g)

$v$  = volume of solution (L)

## RESULTS

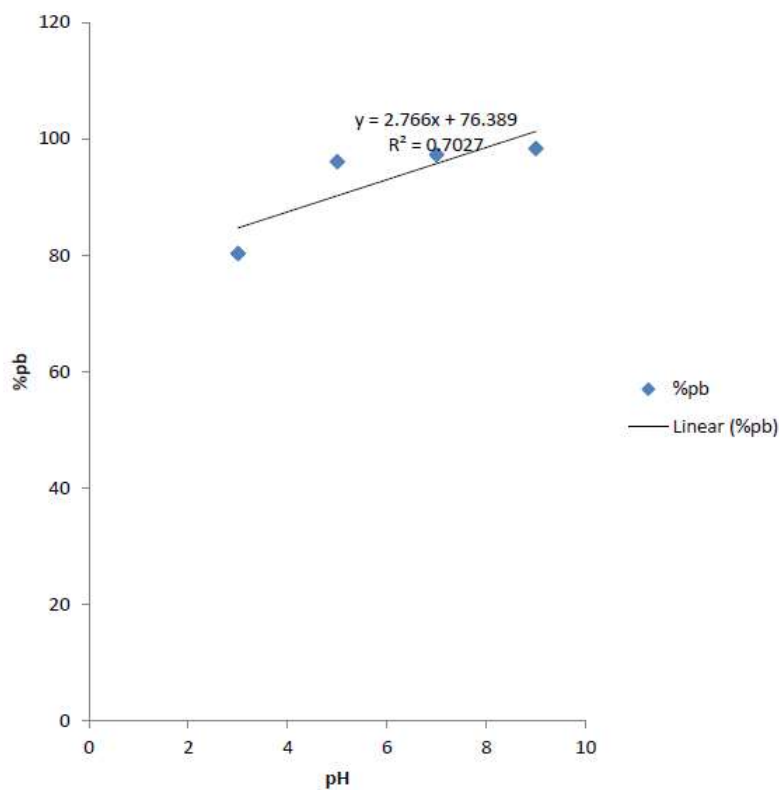


Figure 1: Effect of pH on Lead Removal

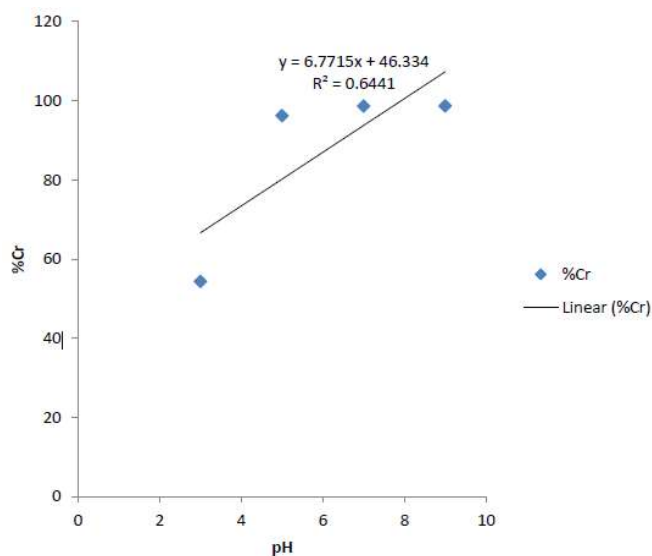


Figure 2: Effect of pH on Chromium Removal

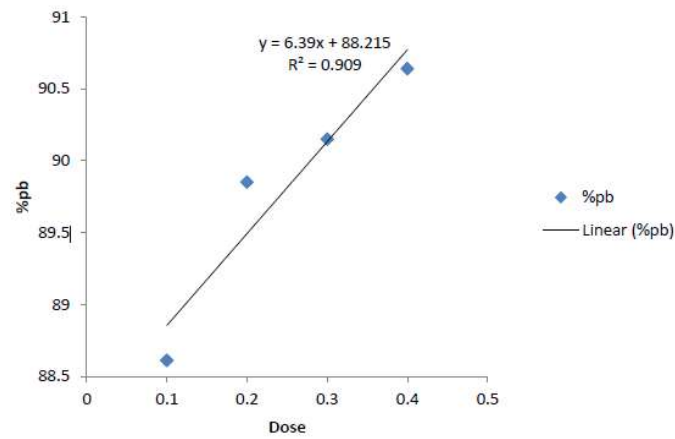


Figure 3: Effect of Adsorbent Dose on Lead Removal

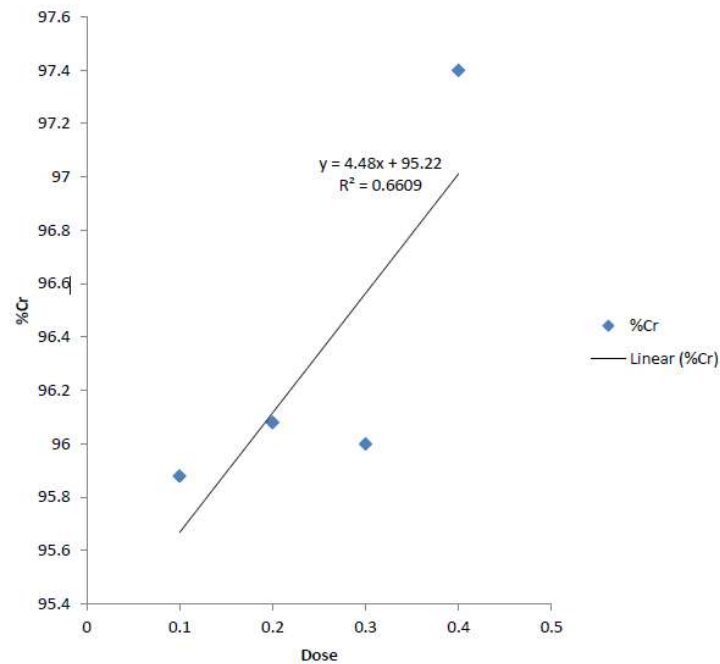


Figure 4: Effect of Adsorbent Dose on Chromium Removal

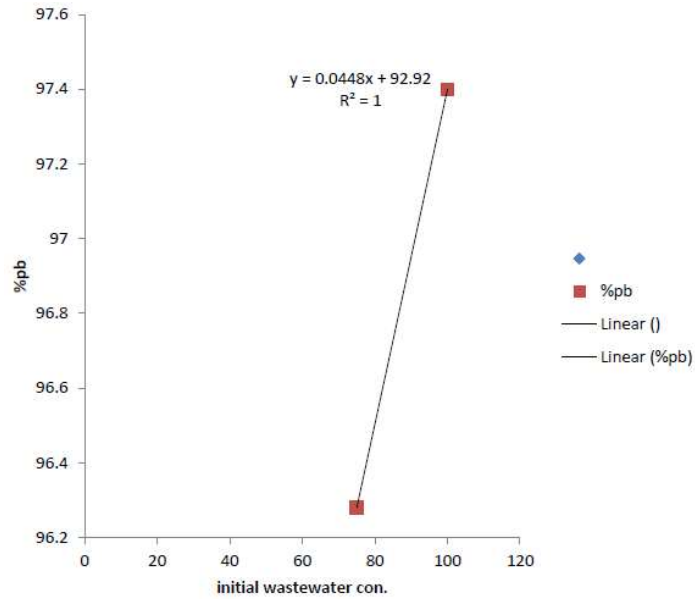


Figure 5: Effect of Initial wastewater on Lead Removal

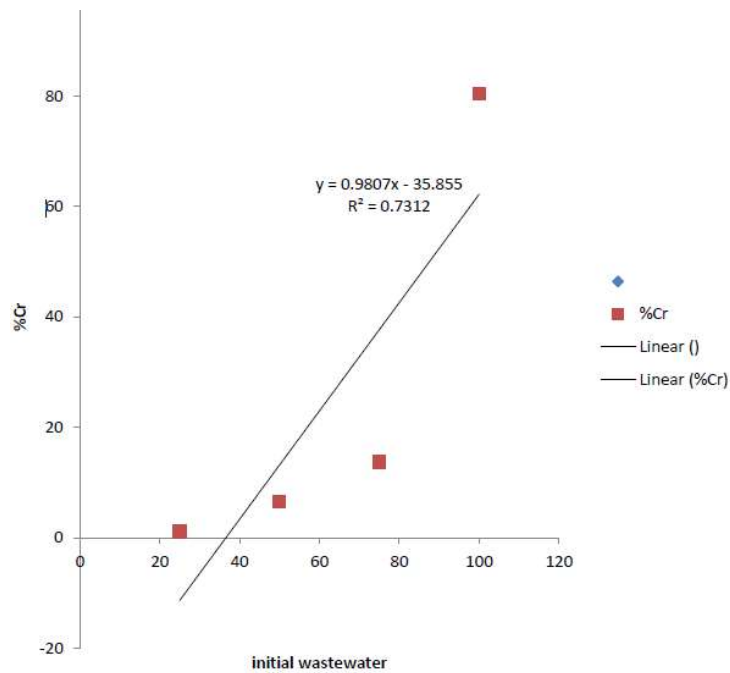
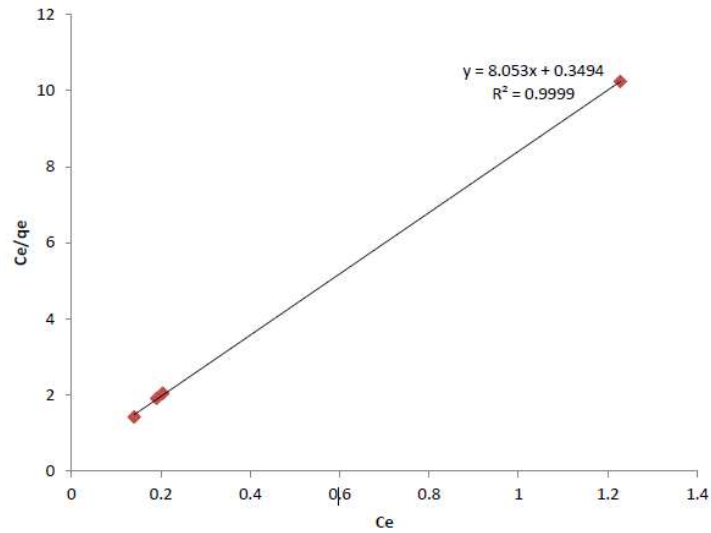
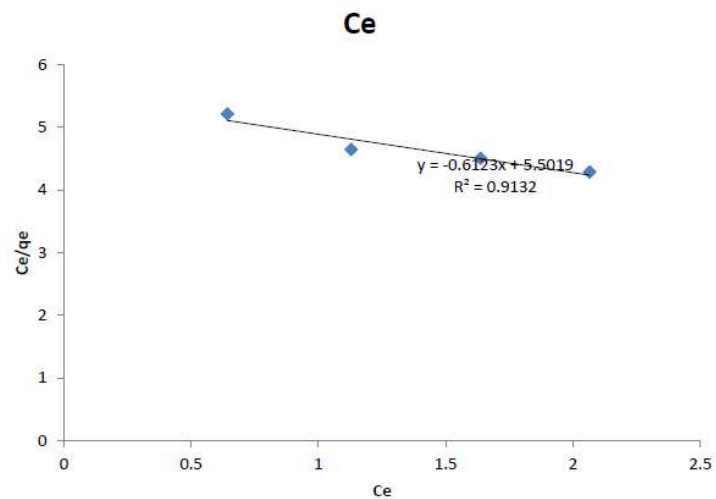


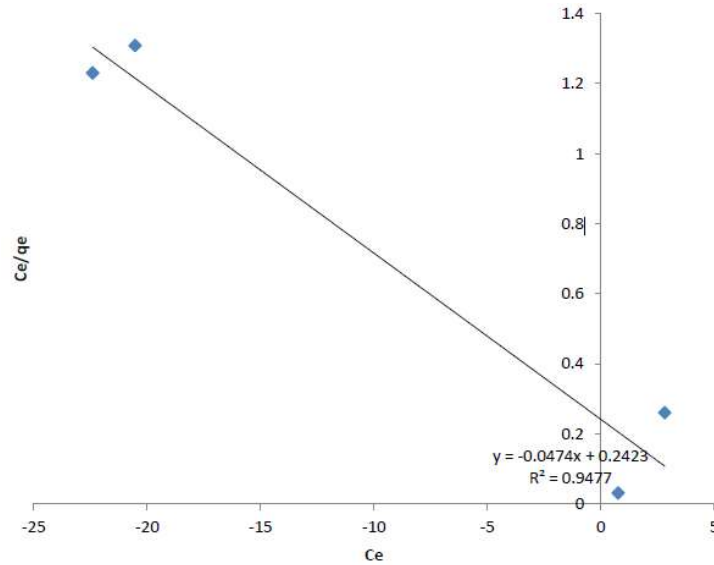
Figure 6: Effect of Initial wastewater on Chromium Removal



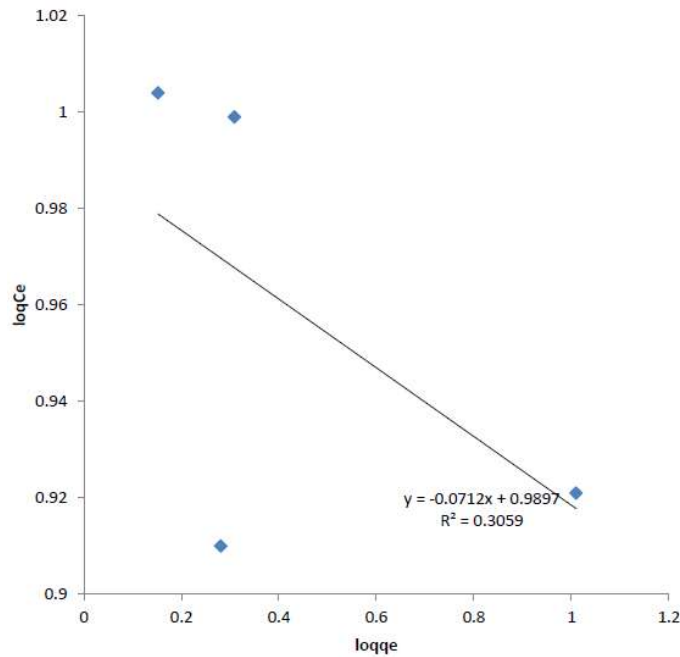
**Figure 7:** Langmuir Isotherm on effect of pH for Pb (II) ion adsorption onto Silver nanoparticles.



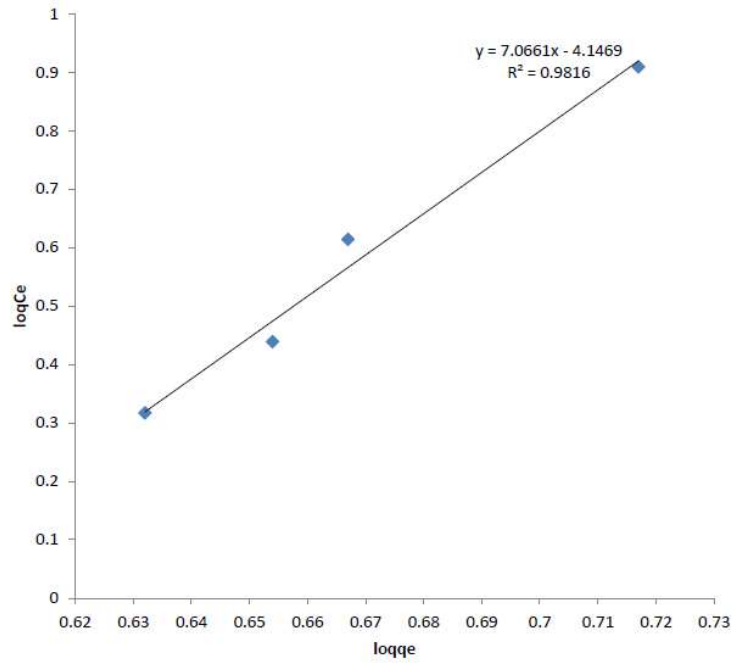
**Figure 8:** Langmuir Isotherm on effect of adsorbent dose for Pb (II) ion adsorption onto Silver nanoparticles



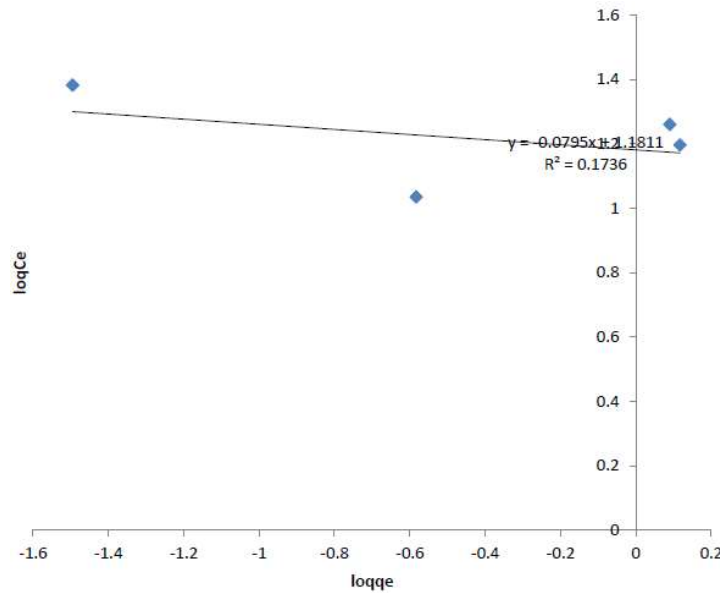
**Figure 9:** Langmuir Isotherm on effect of Initial wastewater for Pb (II) ion adsorption onto Silver nanoparticles



**Figure 10:** Freundlich Isotherm on effect of pH for Pb (II) ion adsorption onto Silver nanoparticles.

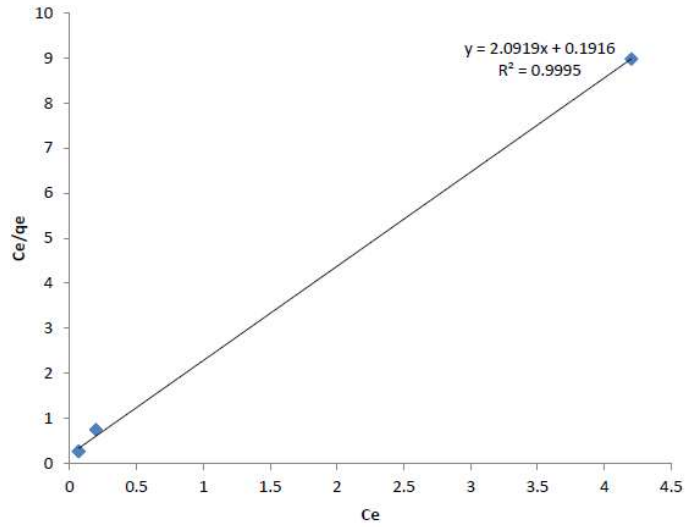


**Figure 11:** Freundlich Isotherm on effect of adsorbent dose for Pb (II) ion adsorption onto Silver nanoparticles

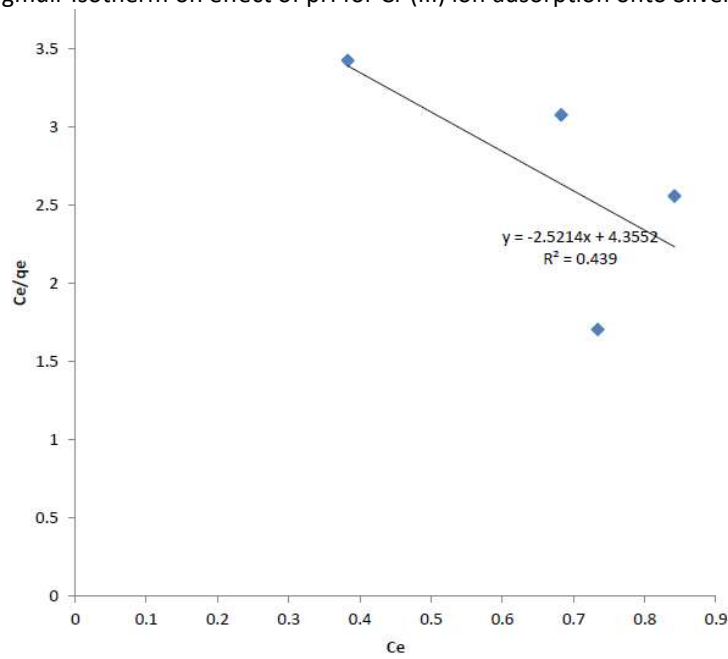


**Figure 12:** Freundlich Isotherm on effect of Initial wastewater for Pb (II) ion adsorption onto Silver nanoparticles.

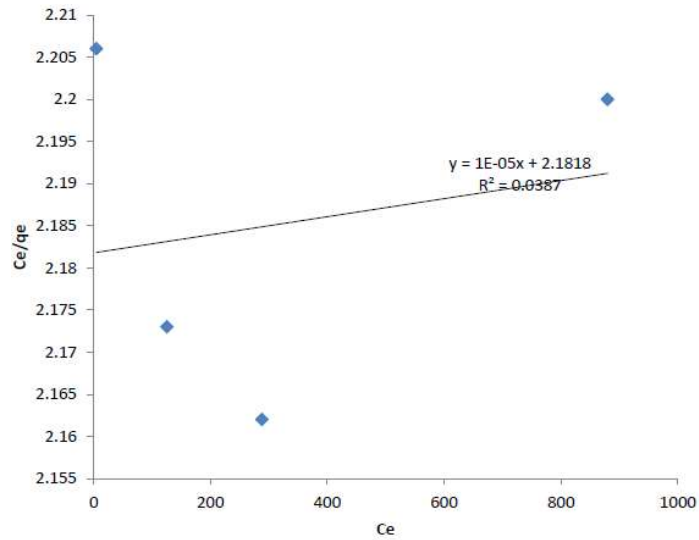




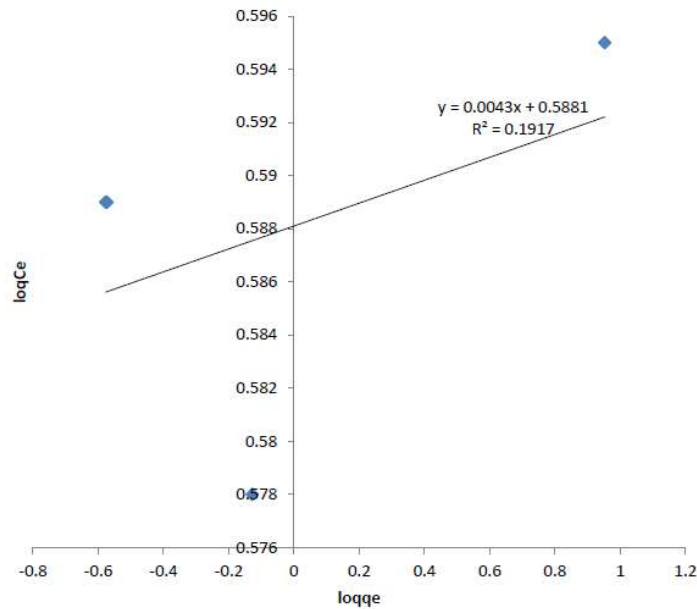
**Figure 13:** Langmuir Isotherm on effect of pH for Cr (III) ion adsorption onto Silver nanoparticles.



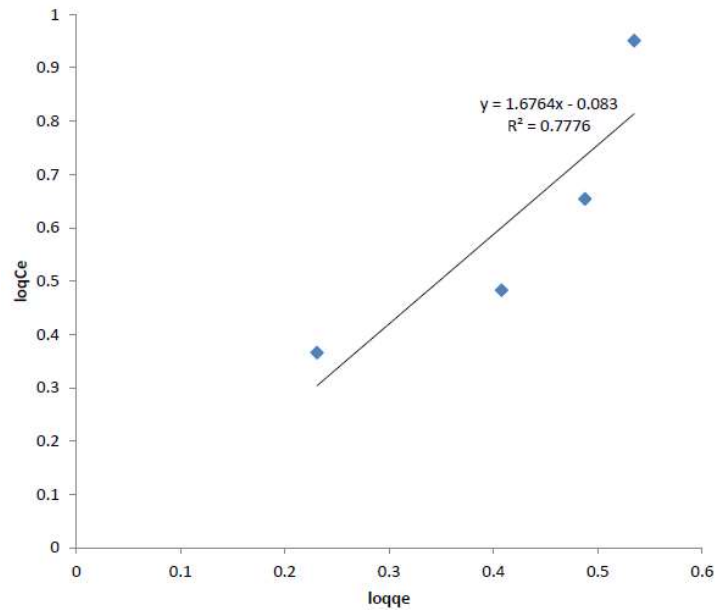
**Figure 14:** Langmuir Isotherm on effect of adsorbent dose for Cr (III) ion adsorption onto Silver nanoparticles.



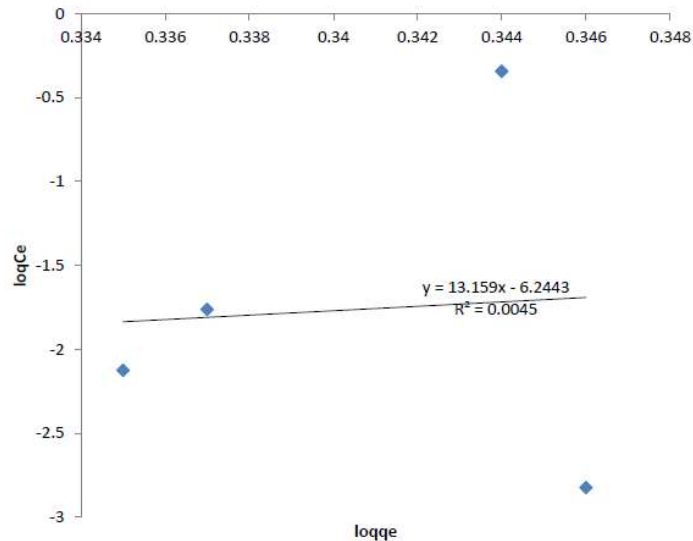
**Figure 15:** Langmuir Isotherm on effect of Initial wastewater for Cr (III) ion adsorption onto Silver nanoparticles.



**Figure 16:** Freundlich Isotherm on effect of pH for Cr (III) ion adsorption onto Silver nanoparticles.



**Figure 17:** Freundlich Isotherm on effect of adsorbent dose for Cr (III) ion adsorption onto Silver nanoparticles



**Figure 18:** Freundlich Isotherm on effect of Initial wastewater for Cr (III) ion adsorption onto Silver nanoparticles

## DISCUSSION

It is well known that silver nanoparticles exhibit brown color in aqueous solution due to excitation of surface plasmon vibration in silver

nanoparticles. These result agrees with the finding of Benakashaniet *al.*, (2016) and Al-qahatani (2017).



### **The Effect of pH**

The effect of pH solution on heavy metal removal onto silver nanoparticles at different values of pH ranging from (3-9) with no change in other parameters was found to be that the biosorption rate for lead and chromium were all parabolic, which shows that there exist an optimum range of pH value. The percentage removal of lead and chromium increases from 80.28 - 98.32 % for lead, while 54.33 - 98.66 % for chromium when the pH increases from 3-9. The sharpest increase in all heavy metals uptake was obtained at pH=9. This finding agrees with the result obtained by Al-qahatani (2017) and Abdel-latifet *al.*, (2010)

### **Effect of Adsorbent Dose**

The effect of adsorbent dose on heavy metal removal at different adsorbent dose ranging from 0.10 - 0.40 g. with other parameter constant showed that as the dosage of silver nanoparticles increases, there was increase in the heavy metals percentage removal. This is because there are many site of the surface of silver nanoparticles to correlate with heavy metals ions. The percentage removal of lead and chromium increased from 88.610 - 90.635 % for lead; 95.83 - and 92.88-96.46 % for chromium ions. An increase in the percentage removal of heavy metals occurs with corresponding increase in the amount of adsorbent which is line with Al-qahatani *et al* 2017 and Chine *et al.*, 2015.

### **Effect of Concentration**

The effect of concentration on heavy metal removal by silver nanoparticles at different concentration ranging from (25-100 mg/L) keeping other parameter constant revealed that the removal percentage increase with increase of concentration a similar report with that of Sankar *et al.*, (2015), Hassan and Abdulhussein (2015).

### **Langmuir Isotherm for Bio-sorption of Pb (II) Ions**

This depicts the capacity of the biosorbent to detoxify maximum amount of Pb (II) ions, indicating that the removal of Pb (II) ion by silver nanoparticles was favorable and correlation coefficient ( $R^2$ ) signifies that the experimental data fit into Langmuir adsorption isotherm (Elaigwuet *al.*, 2009; Al-Bayati and Ahmed, 2011).

### **Langmuir Isotherm for Bio-sorption of Cr (III) Ions**

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### **Freundlich Isotherm for Bio-sorption Pb (II) Ions**

This isotherm depicts that maximum amount of pb (II) ion was binded by silver nanoparticles with high biosorption intensity, the experimental data for Pb (II) ions biosorption using silver nanoparticles does not fit into the Freundlich isotherm (Gupta and Rastogi, 2008).

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### **CONCLUSION**

The formation of silver nanoparticles was found to be successful.



Silver nanoparticles exhibit brown color in aqueous solution due to excitation. This study shows that silver nanoparticles can be synthesized at low cost and used for the removal of heavy metals in wastewater with economical advantage having no adverse effect on the environment and possessing antimicrobial activity. Factors such as pH, adsorbent dose and concentration were found to show significant influence on the adsorption processes.

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