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CYANIDE REMOVAL FROM WASTEWATER BY USING BANANA PEEL

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ABSTRACT

This investigation is related to study the potential of Banana peel (BP) on the cyanide ion pollutant removal from wastewater using different design parameters by adsorption process at different design parameters. Results elucidate that the maximum removal efficiency was 95.65 % for cyanide ion from simulated synthetic aquatic solution (SSAS) and this efficiency was decreased with increasing initial concentration and flow rate while increased with increasing pH, absorbance material bed height and feeding temperature. Statistical model is achieved to find an expression combined all operating parameters with the removal efficiency for cyanide ion used in this paper in a general equation. The samples of BP remaining after using it in the removal of cyanide ion above from aqueous solutions aforementioned were predestined to investigate the utilization of it in useful method. One of these methods is used BP as a rodenticide directly without any pretreatment. The results show a good behaviour as rodenticide. By this way we can possess different benefits which are: remove the toxic cyanide ion polluted aqueous solution, get rid of agricultural waste BP, in the same time, and produce a rodenticide from remaining BP.

Keywords: Banana peel, Cyanide ion, Aqueous solutions, Adsorption, Residue, Wastewater.

1. INTRODUCTION

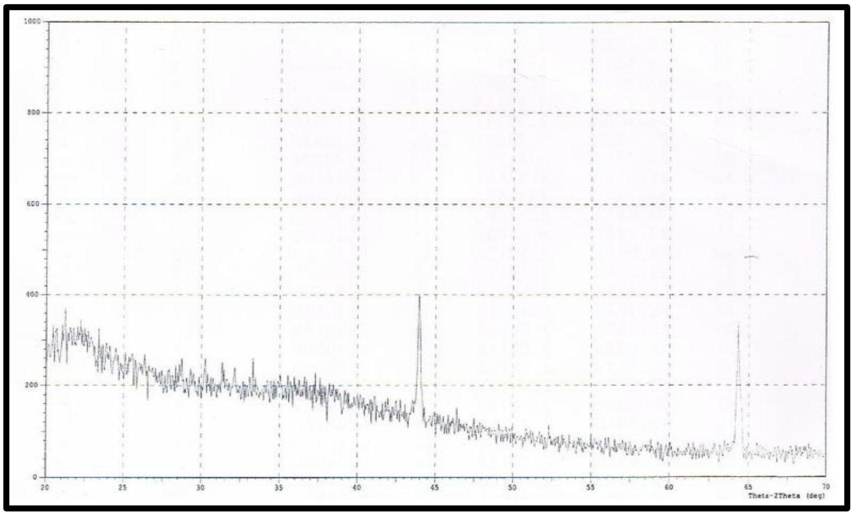
In spite of the fact that cyanide ion itself is benefit industrial substance, but it is undesirable polluted wastewater, because have been found to be fetid to the watery environment. The unfavorable types of cyanide are hydrogen cynide and cynide ion [1]. Cyanides are used extensively in metal finishing processes and heat treatment of steel, and are a significant constituent of wastes from coke oven and blast furnace operations, therefor, electroplating industries are the most Industrial sources of undesirable forms of cyanide ion wastewater [2]. Therefore the industrial wastewater treatment assayer need permanent analytical methods for a best understanding of the conflicting cyanide complexes that may be confronted [3]. As an environmentally protective measure, the Environmental Protection Agency (EPA) has placed rigorous limitations on the permitted cyanide concentrations levels in industrial wastewater effluent streams. The toxic effects of cyanide are so momentous to cause nerve damage and thyroid glands malfunctioning and established toxicity level so low (<0.1mg/l) [4]. Effectually removal of cyanide ion from wastewater by current methods are used like, adsorption and biodegradation [5]. The adsorption process is a well-founded and efficacious mechanism for curing municipal and industrial effluents [6]. These two techniques are considerable methods for treatment of wastewater tolerate cyanide complexes, operated either separately or simultaneously, but the choosing of the better treatment method is based on the benefit, cost and concentration of cyanide ion in wastewater [7].

Activated carbon which has been the most adsorbent matter used however it is relatively expensive, other specific examples of materials which are used as adsorbents include both the naturally occurring materials such as the minerals, zeolites of different types, clays and synthetic materials which include Al_2O_3, SiO_2 [8]. Various agricultural by-products such as walnut waste, maize cobs, peanut shell, cassava waste, wheat bran, maize husk, coconut shell, bagasse, and banana peel are also utilized in the removal of heavy metals and toxic materials from wastewater [9]. The aim of this investigation is to study the possibility of using banana peel for removing cyanide ion from aqueous solution, and benefit from the banana peel residue in eco-friendly method.

2. EXPRIMENTAL WORK

2.1. Materials

Figure-1. X-Ray Diffraction of Banana Peel



2.1.1. Adsorbent Material

Banana peel (BP): Mature yellow banana peel was compiled from the markets in Baghdad city. The collected BP was excess washing three times with boiled double distilled water for removing impurities, dust and other filth particles that may be stucked to the BP. The washed BP was cut into (0.5-1 cm) small pieces then dried for 24 hours at 50°C. The surface area of BP was determined by BET method (Brunauer - Emmett - Teller nitrogen adsorption technique). X-ray diffraction (XRD) of BP was presented in Figure 1.

2.1.2. Stock Solutions

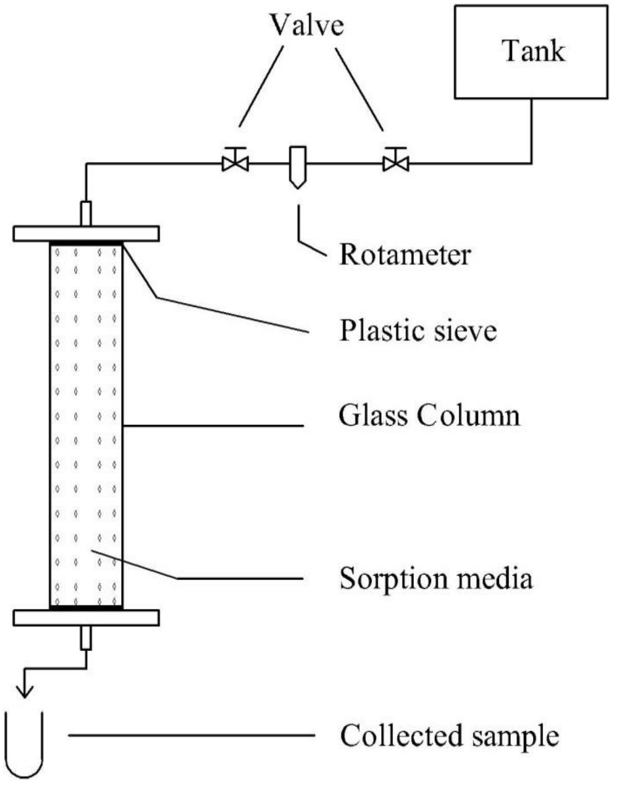
In order to avoid interference with other elements in wastewater, the experiments in this study were carried out using simulated synthetic aqueous solution (SSAS) of different cyanide ion concentrations. 1000 mg/l stock solution of cyanide ion was prepared by dissolving known weight of sodium cyanide (NaCN) in one liter 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 cyanide ion concentrations were measured using spectrophotometer thermo – genesys 10 UV, USA.

2.1.3 Adsorption Unit

Fixed bed column of continuous mode experiments is conducted in order to test cyanide ion removal by treated SSAS of above cyanide ion each one alone at desired concentration with the various bed heights of the adsorbent media BP using different flow rates of SSAS of cyanide ion at various pH. The pH value was modified using solutions of 0.1 N HCl and0.1 N NaOH. A schematic representation of the sorption unit is shown in Figure 2 where the flow direction is downward by gravity. The sorption unit consists of two glass container of SSAS of cyanide ion one for inlet and another for outlet each of (1 liter) capacity. Glass column has 2.54 cm ID and 150 cm height. The heights of adsorbent media at adsorption packed bed were (10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 cm) separated from the top and the bottom by two layers of hollow cylinder glass, (0.5 cm ID, 0.1 cm thickness and 1 cm long). Before starting the experiments, the adsorption column was washed with down flow double distilled water.

The BP is packed in the column to the desired depth, and fed to it as slurry by mixing the media BP 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 cyanide ion 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 as shown in Figure 2. To determination the best operational conditions, the experiments were carried out at a temperature between (20 –55°C), various pH values which are (1–8) and initial feed concentrations of SSAS of different cyanide ion which are between (1–100) mg/l each one alone and at different flow rates which are between (5–100) ml/min for cyanide ion initial feed concentration. Outlet samples after treatment in each experiment were collected every 10 minutes from the bottom of packed column and the unadsorbed concentration of cyanide ion in SSAS was analyzed by spectrophotometer.

Figure-2. The laboratory adsorption setup



3. RESULTS AND DISCUSSION

The ability of BP to remove cyanide ion from SSAS in fixed bed column of continuous mode at various parameters which are pH's of SSAS of cyanide ion (*pH*), height bed of adsorbent media BP (*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 cyanide ion. Thus, the gained results are dissected as follow.

3.1. Initial Concentration Effect

The results showed that using adsorbent material, the percent removal of cyanide ion was decreased when the initial concentration (C_o) of SSAS of cyanide ion was increased at constant other variables as shown in Figure 3. This can be explained by the fact that the initial concentration of cyanide ion had a restricted effect on cyanide ion 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 the increase in the number of cyanide 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 cyanide ion than the solution of higher concentration of it, so the percent removal was decreased with increasing initial concentration of cyanide ion. BP, maximum percent removal were 95.65 % for cyanide ion at initial cyanide ion concentration of 1 mg/l, so adsorbent material was found to be efficient to cyanide ion removal from SSAS and wastewater.

3.2. pH Effect

The results showed that using adsorbent material (BP), the percent removal of cyanide ion was increased when the pH of SSAS of cyanide ion increased too, at constant other variables as shown in Figure 4. This growing in removal efficiency can be elucidated as follows: the pH of the solution enfluence the adsorbent surface charge and the ionization degree with speciation of different pollutants. The effect pH was very less pronounced in adsorption but had a marked effect on the stability of cyanide ion. HCN presents at low values of pH which is a weak acid and highly soluble in water. This tendency to water at low pH inhibits the adsorption onto BP adsorbent. Also at a higher pH the de-protonation on BP surface provides functional groups, for chemisorption, on its surface that can undergo ion exchange type of interaction with cyanide ions. In the alkaline pH free cyanide is existed mostly in neutral HCN form. Equilibrium adsorption between BP and cyanide indicates that extent of adsorption is not dependant on pH in ranges of 7-10. Thus, the optimum pH for removal of cyanide and phenol from combined effluent is 8 [10].

3.3. Adsorbent Media Bed Height Effect

The results elucidated that when the adsorbent media bed height was increased, the percent removal of cyanide ion was increased too at constant other variables as shown in Figure 5. The increased of bed height (*l*) meaning increased in the amount of adsorbent media BP, 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 cyanide ion removal capacity on BP. This lead to increase the ability of adsorbent media to adsorb greater amount of cyanide ion from SSAS at different initial concentrations and ultimately the percent removal of cyanide ion increased.

3.4. Flow Rate Effect

The results illustrated that when the flow rate of SSAS of cyanide ion was increased, the percent removal of cyanide ion was decreased at constant other variables as shown in Figure 6. This may be due to the fact that when the flow of SSAS of cyanide ion increasing, the velocity of solution in the column packed with the adsorbent media BP was increasing too, so the solution spend shorter time than that spend in the column while at low flow rate, the SSAS of cyanide ion 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 cyanide ion from SSAS of cyanide ion for high flow rate, therefore the percent removal of cyanide ion was decreased when the flow rate was increased.

3.5. Feed Temperature Effect

The results demonstrated that when the temperature of feed which was SSAS of cyanide ion was increased, the percent removal of cyanide ion was increased too at constant other variables as shown in Figure 7. The effect of temperature is completely widespread and rising the mobility of the acidic ion. Furthermore, increasing temperatures may produce a swelling effect within the internal structure of the adsorbent media enabling cyanide ion ions to penetrate further. It was indicated that cyanide ion adsorption capacity increased with increasing feed temperature from 5 to 55°C. This effect lead to increasing in active sites that may be due to the bond rupture which take place when rise the feeding temperature.

3.6. Treatment Time Effect

The results demonstrated that when the treatment time of SSAS of cyanide ion increased the percent removal of cyanide ion increased at constant other variables as shown in Figure 8. This may be due to the fact that when the time of treatment of SSAS of cyanide ion increasing and the velocity of SSAS 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 cyanide ion from SSAS, therefore the percent removal of cyanide ion from SSAS was increased.

4. STATISTICAL MODEL

the experimental results obtained from this study were modeled in statistical model. Regression Analysis and $\boldsymbol{\pi}$ Theorem was adopted to maintain a relation between the percent removal of cyanide ion and the feed temperature, flow rate, pressure, pH of feed solution, initial concentration of cyanide ion, adsorbent media BP bed height, treatment time and column diameter. These relations are shown in equation 1 below, which has a correlation coefficient (R^2) 0.989.

$$\%R = \mathbf{1.4281} \times \mathbf{10^{-2}} \left(\frac{T_f \,.P\,.l\,.C_{P_{sol}}\,.t}{F\,.d\,.C_\circ\,.g}\right)^{\mathbf{0.472}} (\boldsymbol{pH})^{\mathbf{0.153}} \qquad \ldots(\mathbf{1})$$

where:

$\%\boldsymbol{R}$	Percent Removal of Cyanide ion from SSAS
$\boldsymbol{T_f}$	Feed Temperature, (K)
$\boldsymbol{P}$	Pressure, (Pa)
$\boldsymbol{l}$	Adsorbent Material Bed Height, (m)
$\boldsymbol{C_{P_{sol}}}$	Heat Capacity of Aqueous Solution, (J/g. K)
$\boldsymbol{F}$	Aqueous Solution Flow Rate, (m^3/s)
$\boldsymbol{d}$	Internal Diameter of Sorption Column, (m)
$\boldsymbol{C_\circ}$	Initial Concentration of Cyanide ion, (g/m^3)
$\boldsymbol{t}$	Treatment Time, (s)
$\boldsymbol{g}$	Acceleration of Gravity, (m/s^2)

Figure-3. Effect of initial concentration ($C_{\circ}$) on the percent removal of cyanide ion @ T_f =55°C, l = 1 m, pH=8, t=60 min. and F=5 ml/min.

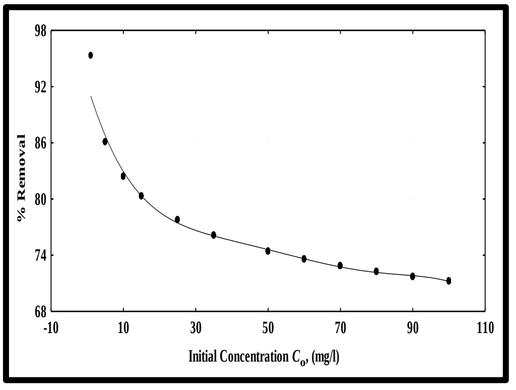


Figure-4. Effect of pH on the percent removal of cyanide ion @ $C_{\circ}$= 1 mg/l, T_f =55°C, l = 1 m, t=60 min. and F=5 ml/min.

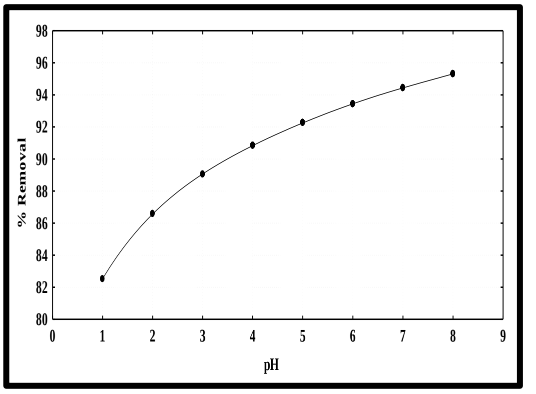


Figure-5. Effect of adsorbent media bed height (l) on the percent removal of cyanide ion @ $C_{\circ}$= 1 mg/l, pH=8, T_f =55°C, t=60 min. and F=5 ml/min.

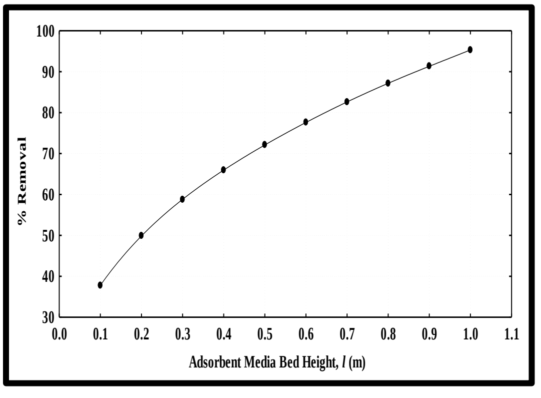


Figure-6. Effect of SSAS flow rate (F) on the percent removal of cyanide ion @ $C_{\circ}$= 1 mg/l, pH=8, T_f =55°C, l = 1 m and t=60 min.

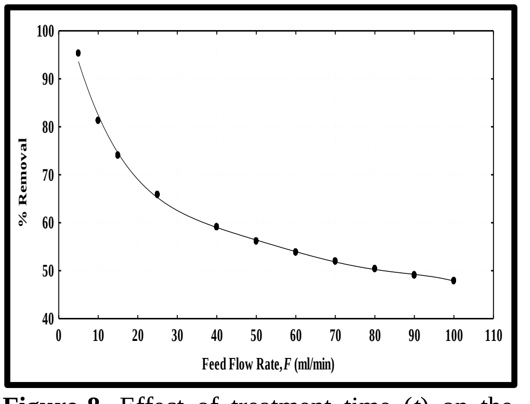


Figure-7. Effect of feed temperature (T_f) on the percent removal of cyanide ion @ $C_{\circ}$= 1 mg/l, pH=8, l = 1 m, t=60 min. and F=5 ml/min.

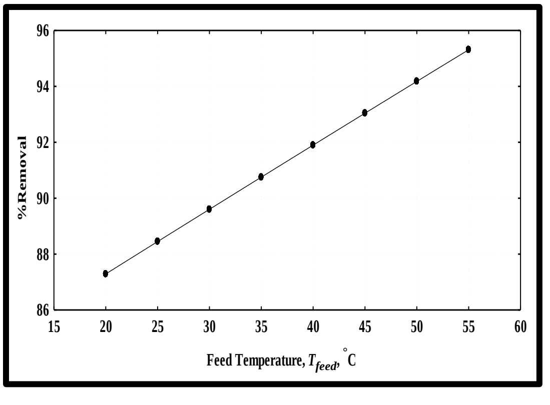
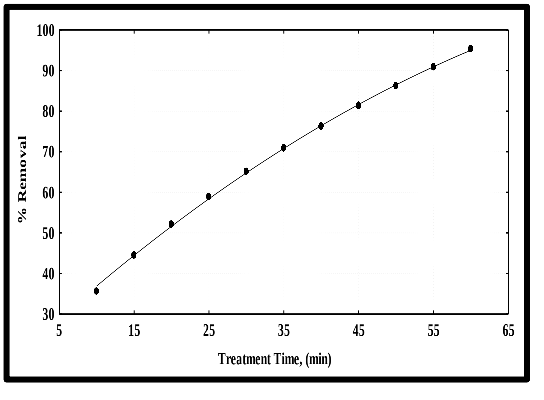


Figure-8. Effect of treatment time (t) on the percent removal of cyanide ion @ $C_{\circ}$= 1 mg/l, T_f =55°C, pH=8, l = 1 m, and F=5 ml/min.



5. UTILIZATION OF BANANA PEEL AFTER USES

Huge amount of banana peel was lingered after using it in removal of cyanide ion from SSAS as explained above. Utilization from banana peel uses can be achieved as follows.

5.1. Employment of Used Banana Peel as a Rodenticide

BP waste which were adsorbed cyanide ions from SSAS at different operating conditions were segregated and classified according to it's contain of cyanide ion and utilization from these remaining samples as a rodenticide without any treatment. The samples give different ratios of cyanide ion to BP. The ratios were ranged between (0.1 to 1 wt %) for. Before the treated BP wastes with the cyanide ion take to the rats, the rats were left for one week and nurtured with normal feed to make sure that it's were not suffer from anything leading to death. After that the rats nurtured with treated BP wastes with cyanide ion, the results were fate the rats in a different periods as shown in Table 1.

The inorganic pesticide (toxin) is one of the most important types of pesticide used in rodent control, and perhaps the most important components used in this field are inorganic cyanide compounds. There are several ways to use these pesticides, which can be used by spraying the vegetative plants, 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 banana peel 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 inorganic cyanide compounds 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 – Inorganic cyanide compounds linked with many important enzymes required from the rodent body and discourage work, where these enzymes inhibition the 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 inorganic cyanide 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.

Table-1. Hours lead to kill rat when it nurtured with treated banana peel

Heavy metal ions (CN^-) to banana peel ratio (wt%)									
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
120	100	96	72	44	36	28	16	10	7

6. CONCLUSIONS

The following conclusions can be obtained:

1. BP showed a good ability to remove cyanide ion from SSAS using fixed bed adsorption unit. So, it could be recommended for removal of cyanide ion from wastewater instead of other

material because it is valid, cheaper, economical, easy and simplicity for using, and has a high ability to adsorb cyanide ion, can be used several times by costly regeneration method and can be used finally in another benefit uses.

2. higher removal of cyanide ion was 95.65% at initial cyanide ion concentration of 1 mg/l.
3. The percentage removal of cyanide ion was increased with decreeing flow rate of SSAS, and initial concentration of cyanide ion while the percentage removal was increasing with increasing of pH, treatment time and the height of adsorbent material BP.
4. It can be prepared a good rodenticide from the residual samples of banana peel that adsorb cyanide ion from aqueous solution. So, remove the hazards waste in economic and eco-friendly method.

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