Banana Peel as Removal Agent for Sulfide from Sulfur Springs Water

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Abstract

Banana peel which consider as fruit waste has been tested for the removal of total sulfide from spring water in Heet area, Iraq. The chemical composition of peels was investigated. The results show that the composition consists of Sodium ,Potassium, Calcium ,Manganese and Phosphate and concentrations of these contents were 18.2mg/g, 62mg/g,15.4mg/g ,48mg/g and 0.37 mg/g , respectively. The alkalinity of peels was 5.2 mg/g and the moisture content was 5.8 % . The treatment efficiency was studied as a function of the retention time and concentration of sulfide ion .The maximum sorption for sulfide was found to be 97% and it was nearly effective as activated carbon. As a result of the removal process , the concentrations of some common anions ,cations and heavy metals (Mg^{+2},Ca^{+2}, Na^{+},SO_4^{-2},Cl^{-},PO_4^{-2}, Cr, Fe, Ni, Cu and Zn) decreased ,the concentrations of K^{+} and Mn increased . Increasing of concentrations of K+ and Mn is attributed to their high content in the banana peels. A slight increase in pH of the treated water (6.5 - 7.5). This study revealed that the treatment of water using the banana peel is most effective for removal of hydrogen sulfide from sulfur spring water.

Keywords: Sulfide removal, banana peel, sorbent, peel mineral content ,sulfur, spring water

1. Introduction

Hydrogen sulfide contents in the environment, generally, have been studied due to its high toxicity, effect on health, it was also a common cause of industrial injury such direct corrosion of metals and indirect corrosion of metals and concrete (McCrty 1974). Many methods were tabulated for sulfide contamination control ,the common methods for sulfide removal are physiochemical processes, which involve direct aeration or adding of oxidizing agent ,precipitating agent, and masking agent (Alleala and Ahmed 1984). The removal efficiency of a lab-scale biofilter for eliminating hydrogen sulfide has been modeled. The results demonstrate that is possible to totally remove the hydrogen sulfide from the biogas (Ibarra-Berstegi et al. 2007). Hydrogen sulfide was removed by means of chemical adsorption in an iron-chelated solution catalyzed by Fe/EDTA, which converts Hydrogen sulfide into elemental sulfur (Horikawa et al. 2004). New publication describes a successful treatment of Hydrogen sulfide by applying bio filtration to hot gas effluent at high temperatures (700° C) using a microbial community obtained from a hot spring (Datta et al. 2007).The solid ferrites sludge can be used to remove hydrogen sulfide from gas stream, each gram of ferrite was able to retain 0.274 gm H_2S (Barrado et al. 2001), however these methods are associated several disadvantages. Sorption using plant waste material (if it is available) is impending alternative to chemical methods for ions removal from water system (Meunier, et al. 2003; Pangnaneli, et al. 2003).These methods were reported in literature as low cost methods for water treatment. Removal of As(III) and As(V) from aqueous solutions by waste material and Crab shells (Rahman et al. 2007; Hui Niue, et al. 2007), cupper (II) by fly ash (Kpanday, et al. 1985), Lead(II) by sorption on peat (Ho and Mckay 1999; Ho et al. 2001), removal and recovery of Cadmium(II) by low coast adsorbent (Periasamy and Namasivayam 1984), removal of phenol by fly ash (Hairbabu, et al. 1993) and Chlophenols by bituminous shale (Tutem, et al. 1998). Heavy Metals (Cu, Pb and Zn) had been also removed from the aqueous solution by activated Carbons prepared from Coconut Shell and Seed Shell of the Palm Tree that activated chemically by phosphoric acid (Gueu, et al. 2006). Memon et al. (2008) used banana peels for removal Cr(III) from industrial waste water. Ashraf et al. (2011) applied banana peels for removal heavy metals (Pb, Cu, Zn and Ni). Banana peels were used for extraction of copper and lead from river water and preconcentration of metal ions (Castro et al. 2011). The banana peel based biosorbent was evaluated for adsorptive removal of CU(II) from water and its desorption capability (Hossain et al. 2012a). Banana peels were used by Hossain et al. (2012b) as bioadsorbent for removal of copper from water.

Most of the ground water sources in Heet city (Fig.1) are springs water of high sulfide concentration. The existence of Hydrogen sulfide in the ground water of Heet and surrounding areas is attributed to the oil field

water, where some brine water associated with petroleum, may contain several hundred mg/L of dissolved Hydrogen sulfide (Him 1970) , due to anaerobic oxidation reduction processes (Hussien and Gharbie 2010).
The main aim of this research was to use banana peels as bioadsorbent for removal sulfide from springs water in Heet city, Iraq.

2. Material and Methods

2.1. Chemicals

All chemicals used in the present study were of analytical grade and were purchased from Fluka, BDH. A stock standard solution of sulfide ion was prepared by dissolving appropriate amounts of sodium sulfide, sulfide antioxidant buffer was used too.

2.2. Sampling

The coordinate of the ground water spring that represent the ground water in the area were determined with GPS (33 38 21.6) N and (042 48 53.5) E, (Figure .1). Water samples were collected in polyethylene washed with diluted Nitric acid and kept in cool place for testing.

2.3. Preparation of sorbent

For Banana peel preparation, Slices of banana peels were cut into small pieces and were washed thoroughly with de-ionized water to remove physically adsorbed contamination, and then oven dried at 100^0Cfor a period of 8 hours. The dried peels was ground and sieved through 4000 µm sieve (Memon, ea al. 2008) and kept in desiccators for further study. In one liter flask a suitable amount of the deride peel was conditioned by mixing with distilled water, then water decanted and the solution was transferred on small batches to a (18 cm) separation column. Another separation column was prepared using commercial activated carbon for comparison study.

2.4. Sorption behavior of water on banana peel separation column

The sorption behavior of sulfide on the banana peel surface was investigated using sulfide standard solutions (5, 25, 50,100,250) mg/l .The standard solutions has been passed at flow rate 2 ml/ minutes on banana peel column and on an activated carbon column for comparison study, Table 1.
The sorption of sulfide as function of time was investigated at room temperature using 50 gm adsorbent and 1000 ml adsorbate solution. The standard sulfide solution (250) mg/l was passed at flow rate 2 ml/ minutes through a column of banana peel and on an activated carbon column .The eluent was examined for sulfide concentration directly and after 15, 30, 60,120 minutes retention time.
An analytical study has been investigated to check banana peels tendency for sulfide removal from fresh spring waters in Heet city. The study involves the interference effect of common anions and cations under the condition of study. Fresh Spring water sample was passed through the separation columns (banana peel column and activated carbon column) and the eluted water was collected and tested for pH, Ca, Mg, Na & K by flame photometric methods, Chloride ion with Fe (III) thiocyanate method at 455 nm, sulfate ion with Barium -sulfate turbidity method at 450 nm, sulfide at 660 nm, phosphate with Vanadomolymbdate method at 470 nm (Mendham 1989). Phoenix_986 Atomic absorption spectrophotometer (AAS) was used to determine the concentration of metals studied in Banana peel and spring water samples (Mn, Fe, Cr, Ni, Zn and Cu). The results compared with that of untreated water.

2.5.Chemical analysis

Slices of the dried banana peels (70^0C for 72 hours) were crushed, and passed through mesh sieve 120 mesh sieve (125 µm) and 0.5 gm was analyzed for chemical constituent following the procedure of kjeldahel digestion with H2SO4 ,HCLO4 , HNO3 (10:4:1), (Jakson 1958).

3. Results and conclusion

Generally different techniques have been used for hydrogen sulfide gas removal from spring waters. This study aims at finding new methods to treat the water of sulfur spring to get rid of the major polluting materials for public use. The treatment process depends on using banana's peels as low coast sorbent for sulfide from the spring water in Heet city. The spring water is rich with chloride, sulfide, sodium, calcium, tar and erupting stifling gases (Hussien and Gharbie 2010)
The treatment process depends on using banana peels as low coast sorbent for sulfide. The chemical composition, phosphate, alkalinity and moisture content of the banana peels were investigated. The concentrations (mg/g) of sodium, Potassium, calcium, manganese, were found to be 18.2, 62, 15.4 and 48 respectively. Phosphate concentration was 0.37 mg/g, the alkalinity was 5.2 mg/g and moisture content was 5.8 %. The banana peel has the highest content of Potassium and this agreed with literatures (Anhwange et al. 2009), Table 2.
The concentration of hydrogen sulfide gas in the water samples of the spring exceeds the cutoff concentration (Laboutka 1974). The existence of hydrogen sulfide in the ground water of the studied area (Heet) is attributed to

the oil field water where some brine water associated with petroleum, may contain several hundred mg\l of dissolved hydrogen sulfide (Him 1970). The main source of hydrogen sulfide gas which has distinct smell and poisonous effect on man health, is reduction of sulfate by sulfate reducing bacteria according to the following reaction (Zobell 1963).

$$CaSO_4 + C_nH_{2n+2} \rightarrow CaS + CO_2 + 2H_2O$$
$$CaS + CO_2 + 2H_2O \rightarrow H_2S + Ca(HCO_3)_2$$

3.1. Mechanism of sorption

This study was conducted to assess the efficiency of sulfide elimination and its relation with the sulfide concentration and the time of contact. The sorption of sulfide as function of time was investigated at room temperature. A series of sulfide standard solution (5, 25, and 50,100,250) mg/l has been passed at flow rate 2 ml/ minutes on banana peel column and on activated carbon column for sulfide removal, Table 1. The results showed the high efficiency of banana peel column for sulfide sorption (94.4%-98.5%) at low sulfide concentration (5-25 mg/l) and (99.5% -99.8) at high sulfide concentration (100-250 mg/l). The study of sorption mechanism by panama peels indicates the similarity to activated carbon sorption mechanism. The recent literatures about the thermodynamics of sorption by banana peels shows that the positive value of ΔH indicated the endothermic sorption process while the negative value of ΔG indicated spontaneous nature (Memon et al. 2008) and the energy value obtained from the isotherms indicated that the sorption of physical nature (Memon et al. 2008).

The banana peels has large surface area (measured by BET method) about 13 m^2/g (Memon et al., 2008). gives good evidence that there are large number of absorption site have the ability for removal of sulfide ion from aqueous solution at room temperature over a wide range of sulfide concentration (0-250 mg\l).The banana peels has approximately the same efficiency of sulfide sorption comparing with commercial activated carbon. A standard sulfide solution (250) mg/l was passed through a column of banana peel and the eluent was examined for sulfide concentration directly and after 15, 30, 60,120 minutes retention time. The sorption was very fast and the maximum sulfide removal 99.79% was achieved after 15 minutes retention time with very little increase in sorption at 2 hours (99.87%). The results showed that the removal process was affected by time of contact and the result was compared with activated carbon.(99.89% at 15 minutes and 99.95% after 2 hours, Table 3.

3.2. Multiple use of banana peel

In order to check the reusability of Banana Peel as economical sorbent for sulfide , it has been subjected to several loading experiments. The eluent spring water was tested for sulfide concentration directly ,and after 1,2,3,4,5 liter volume of the spring water. The capacity of the sorbent was found to be constant with variation of 1-1.8% after 3 times of one liter volume of the spring water repeated use.

3.3. Interferences effect

An analytical study has been investigated to check banana peels tendency for sulfide removal from fresh spring waters in Heet city. The study involves the interference effect of common anions and cations and heavy metals under the condition of study. Fresh Spring water sample was passed through the separation columns (banana peel column and activated carbon column) and the eluted water was collected and tested for, Ca, Mg, Na & K , Chloride ion , sulfate ion, sulfide, phosphate, in addition to heavy metals (Cr, Mn, Fe, Ni, Cu and Zn).

The study has shown excellent results in spring water treatment and the treatment results has explored the suitability of banana peel for sulfide removal from water spring in the presence of different cations and anions in high concentration. Sulfide content of main sulfur spring in Heet was 236 mg/l before treatment, the treatment with banana peels helps in eliminating sulfide concentration to 0.58 mg/l with treatment efficiency of 99.7%, comparing with treatment efficiency of 99.87% by activated carbon, Figure 2.

There was a noticeable decrease in the treated water content of the studied anion and cations. The efficiency of sulfate and chloride removal on banana peel was 70% and 40% compared to that of activated carbon 94% and 70.7 % , Figures. 3 and 4.The phosphate ion removal was undetectable (2.7%) as in the case of commercial activated carbon (60%), Figure 5.

The efficiency of Na, Mg and Ca removal was 43%, 34% and 20%, respectively, by banana peels while it was 41% , 19% and 22% respectively. The treated water by the two methods has a concentration more than the standard limit of Na (> 200 mg/l), Mg (> 50 mg/l) and Ca (> 200mg/l)due to high content of the three elements in the untreated spring water , Figures 6,7and 8. The high concentration of potassium in the peels of banana (62 mg/g) has affected the potassium content in the treated water causing a concentration increase of potassium after the treatment with banana peels (345 to 852 mg/l), Figure 9.

There was a noticeable decrease in the concentration of the trace elements in the treated water below the standard limits where the treatment efficiency sometimes reaches 98% as in chrome (Figure 10) and iron 96% (Figure 12), copper 38.7% (Figure 14) and zinc 33. % (Figure 15).The efficiency of nickel removal was 60% but don't reach the standard limits (Ni > 0.2 mg/l) due to high Ni concentration in spring water, although it was more effective than commercial activated carbon, Figure 13. There was a noticeable increase in Manganese

concentration when treated with banana peels column on contrast to that of activated carbon column, Figure 11. The increase in manganese concentration was due to the high content of Manganese (48 mg/g) in banana peel, Table 2. The treated water has a manganese concentration exceeds the standard limits (Mn > 0.1 mg/l).
The pH of the spring water before treatment was slightly acidic (pH =6.5). There was slight increase in the pH of the treated water with banana peel (6.5 to 7.5), Figure 16, due to carbonate content of the banana peel (5.2mg\g) ,Table 2. Regardless of this increase, the pH was within the specific limit (6.5-8.5), (WHO 2006).
The previous studies employed the banana peels as biosorbent for removal heavy metals from water (eg. Ashraf et al. 2011; Castro et al. 2011; Hossain et al. 2012a). This study was the first attempt to use banana peels for removal sulfide from water.

4. Conclusions

From a results of this study , we conclude that the banana peels can be used as low cost ,fast ,and selective sorbent for sulfide at wide concentration range, in addition to its role in improvement of some physical and chemical properties of spring water.

5. References

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Table 1. The sulfide concentration effect on the efficiency of banana peels in sulfide sorption comparing with activated carbon.

Standard sulphide solution	treatment by banana peels	treatment by activated carbon
5 (mg\l)	0.28 (mg\l)	0.12 (mg\l)
25(mg\l)	0.37(mg\l)	0.19 (mg\l)
50(mg\l)	0.39(mg\l)	0.25 (mg\l)
100(mg\l)	0.47(mg\l)	0.30 (mg\l)
250(mg\l)	0.52(mg\l)	0.42 (mg\l)

Table 2. The chemical analysis of banana peels

Test	Concentration mg\g
Na	18.2
K	62
Ca	15.4
Mn	48
PO_4	0.37
Alkalinity	5.2
moisture	5.8%

Table 3. The retention time effect on the efficiency of banana peels in sulfide sorption comparing with activated carbon using standard sulfide solution (250) mg/l.

Time (minutes)	treatment by banana peels	treatment by activated carbon
Direct elution	0.54 (mg\l)	0.32 (mg\l)
15	0.51 (mg\l)	0.27 (mg\l)
30	0.48 (mg\l)	0.21 (mg\l)
60	0.39 (mg\l)	0.19 (mg\l)
120	0.31 (mg\l)	0.11 (mg\l)

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Figure 1. Location map of the study area.

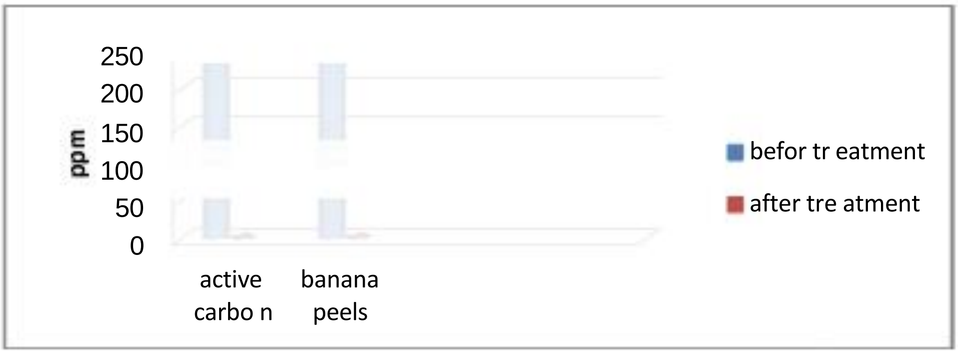

Figure 2. Total sulfide treatment by banana peels comparing with active carbon.

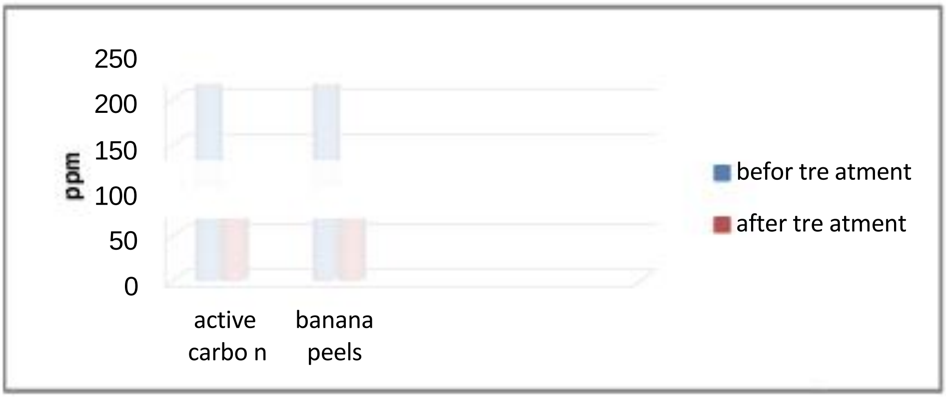

Figure 3. Total sulfate treatment by banana peels comparing with active carbon.

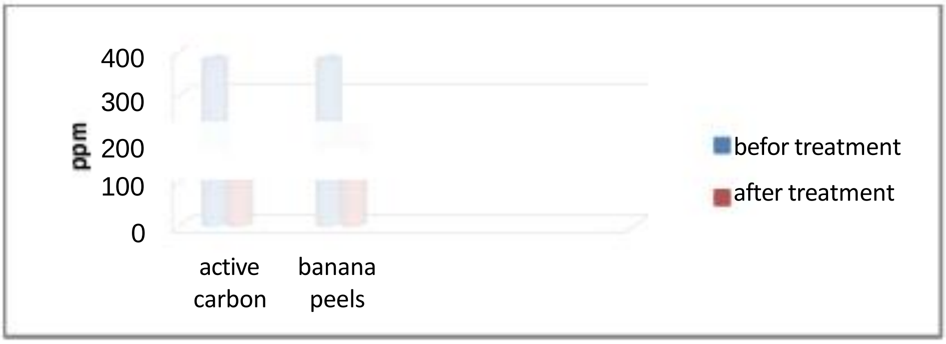

Figure 4. Total chloride treatment by banana peels comparing with active carbon.

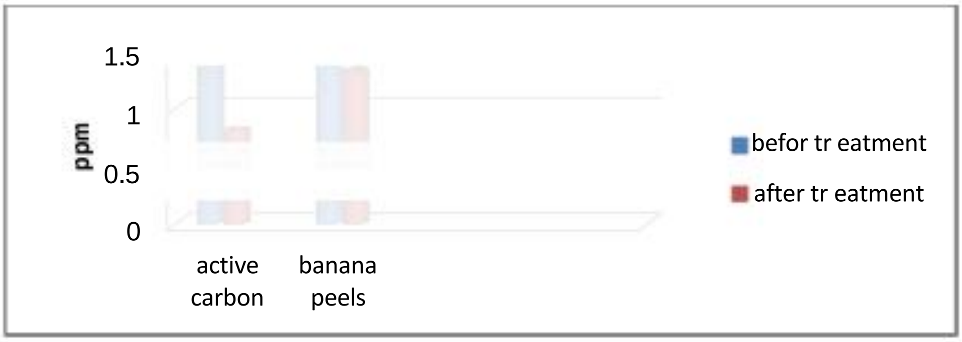

Figure 5. Total phosphate treatment by banana peels comparing with active carbon.

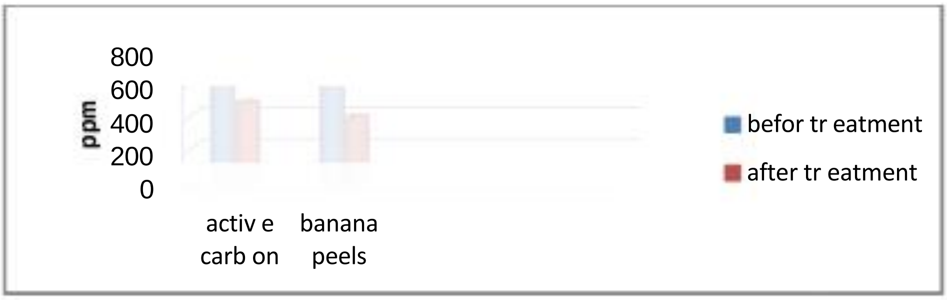

Figure 6. Total Magnesium treatment by banana peels comparing with active carbon.

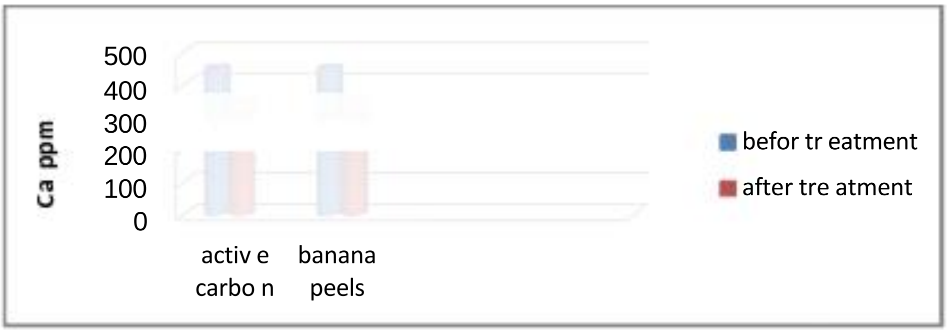

Figure 7. Total calcium treatment by banana peels comparing with active carbon.

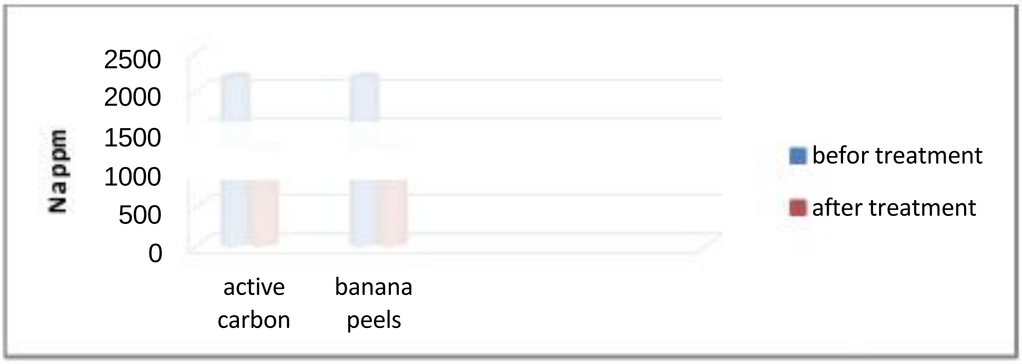

Figure 8. Total sodium treatment by banana peels comparing with active carbon.

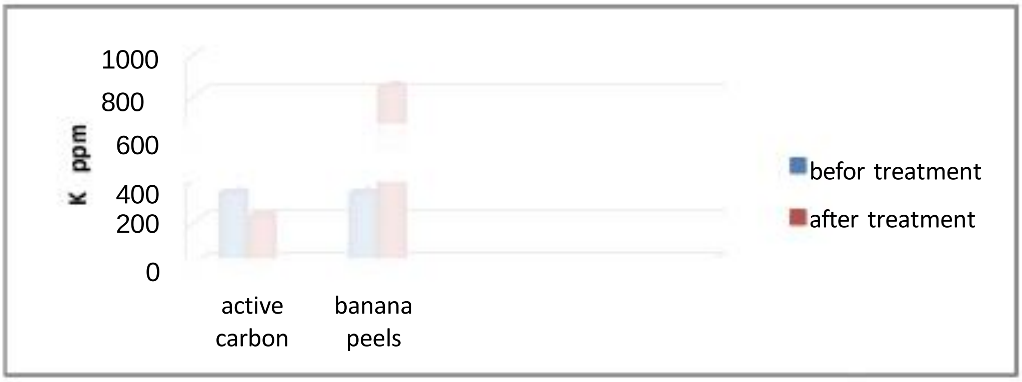

Figure 9. Total Potassium treatment by banana peels comparing with active carbon.

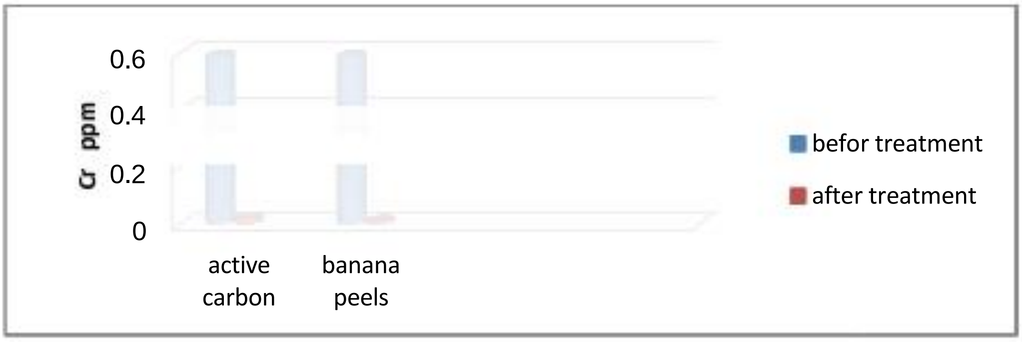

Figure10. Chromium treatment by banana peels comparing with active carbon.

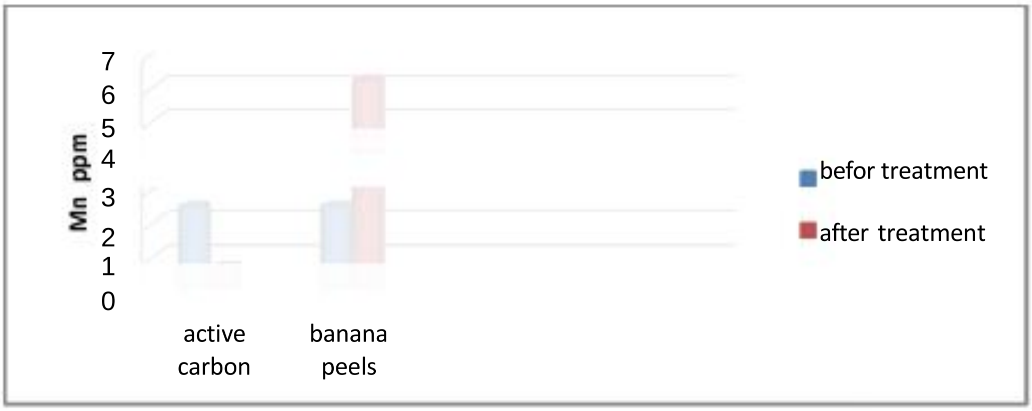

Figure 11. Manganese treatment by banana peels comparing with active carbon.

Figure 12. Iron treatment by banana peels comparing with active carb on.

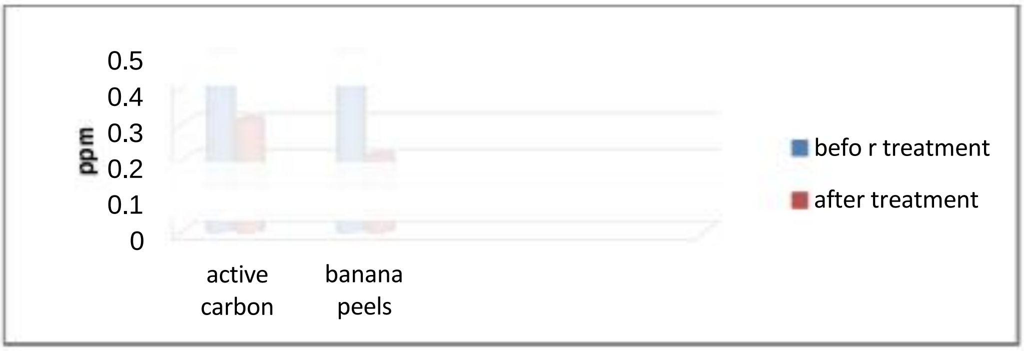

Figure 13. - Nickel treatment by banana peels comparing with active carbon.

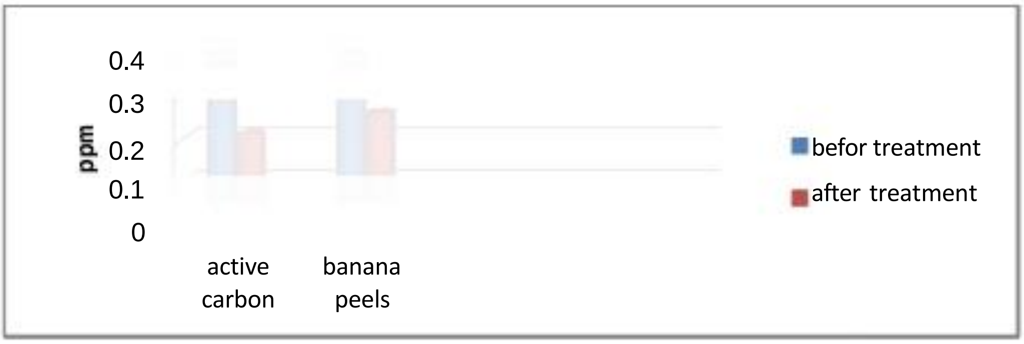

Figure 14. Cupper treatment by banana peels comparing with active carbon.

Figure 15. Zinc treatment by banana peels comparing with active carb on.

Figure 16. pH change after treatment by banana peels comparing with active carbon.