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An Adsorption Study of Cr (III) and Fe (II) on Khaya Senegalansis Leaves (Mahogany)

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Abstract: *An environmental friendly method for adsorption of Cr (III) and Fe (II) has been investigated using Khaya senegalensis leaves. The effect of pH on adsorption of the studied analyte has been investigated. The result of the study indicated a maximum adsorption of 81% for Cr (III) at pH6. And maximum adsorption of 80% for Fe (II) at pH4. The target analytes were determined by wagtech photometer 7100.*

1. INTRODUCTION

Chromium and Iron are continuously released into natural environment due to industrial activities, weathering of rocks and soils, combustion of fossil fuels, agricultural activities, atmospheric emission, and mining activities. Speciation analysis of trace amounts of chromium ions has become an important topic in environmental and biological science. It is well known that the toxicological and biological properties of most elements depend upon their chemical forms. Therefore, the knowledge on the speciation of chromium is of particular necessity. Chromium is widely used in various industries, such as plating, tanning, paint and pigment production, and metallurgy, which possibly contaminate the environment. Chromium (III) compounds are one of the essential trace nutrients in human bodies and play an important role in the metabolism of glucose and certain lipids, whereas chromium (VI) compound are toxic and carcinogenic. The United State Environmental Protection Agency (USEPA) has regulated the permissible limit of 0.1 mgl^{-1} of total Chromium in drinking water. In Japan, the maximum tolerable concentration of Chromium in waste water is 0.5 and 0.05 $mgl^{-1}$for total chromium. The element Chromium occurs in natural samples in two relatively stable valence states, i.e. in the form of Cr(III) and Cr(VI) species, which exert quit different effects on biological system. In fact, while Cr (III) is an essential component having an important role in the glucose, lipid and protein metabolism, Cr (VI) has a definitely adverse impact on living organism. Cr (VI) can easily penetrate the cell wall and exert itself. The importance of Chromium speciation in plants may be illustrated by the fact that, to maintain good health, humans require an adequate daily intake of nutrients, including essential trace elements such as chromium, cobalt, copper, iodine, iron, manganese, molybdenum, selenium, zinc and several other micro-elements found mostly in vegetables. It is therefore essential to ascertain in which form Chromium is present in plant tissues as well as the extent of their accumulation, because plant derived Chromium containing food materials, primarily from vegetable crops, provide a major portion of the daily Chromium intake. Another example of the importance of Cr (VI) speciation is connected with the possibility of its presence in medicinal plants.

Since one of the routes of Chromium incorporation into the human body is by ingestion, several analytical methods have been developed in order to separate and determine Cr(III) and Cr(VI) species in water samples. The concentration of Chromium in natural water is very low, in order of a few μgl^{-1}, therefore powerful techniques are required but of those currently available only a few show sufficient detection power. Despite the fact that iron is the second most abundant metal in the earth crust, iron deficiency is the world's common cause of anemia. When it comes to life, iron is more precious than gold. The body hoards the element so effectively that over millions of years of evolution, humans have developed no physiological means of iron extraction. Iron adsorption is the sole mechanism by which iron stores are physiologically manipulated. The average adult stores about 1 to 3 grams of iron in his or her body. An exquisite balance between dietary uptake and loss maintains this balance. About 1 mg of iron is lost each day through sloughing of cell from skin and mucosal surfaces, including the lining of the gastrointestinal tract [1].

In northern Nigeria the Hausa and the Fulani tribes utilize Khaya senegalensis (Mahogany) ethnomedicinally as a remedy for several human and animals ailments [2].The plants *Khaya senegalensis* is given different names by different tribes. Hausa people called *Khaya Senegalensis* as Mahogany, Yoruba people said Oganwa and Igbo people said Ono. *Khaya senegalensis* is a savanna tree, easily recognized by its round evergreen crown dark shinning foliage capsules. A tree of *Khaya senegalensis* is 30m high and 3m width with dance crown and short bole covered with dark scaly bark. The leaves with 3-4 (exceptionally 5) pairs of leaflets, 5-10cm long by 2.5–5cm broad, more or less elliptic, round obtuse or shortly

acuminate at apex, stalk of leaf let 4mm long. It has attracted worldwide attention for its high quality timber production.

The leaves and stem-back of Khaya senegalensis (Mahogany) has been used in Adamawa state in Northern Nigeria in the form of decoction and concoctions for the cure of mucous, diarrhea, sypHilis pyrexia, Malaria fever [3]. The application of herbs to treat disease is almost universal among non industrialized societies. This might be because pharmaceutical drugs are expensive to be bought. In fact, world Health Organization (WHO) estimates that 80% of the world population presently use herbal medicine for some aspects of primary health care. Among those of few herbal remedies demonstrated positive effect on humans, many refer to animal model experiments or invitro assays. Because of this strong dependent on plants, a large number of studies have been concluded on traditional medicine usage of plants and some often showed scientific rationale or resulted in the isolation of bioactive compounds for direct use in medicine. However, stills very little are known about African traditional medicine when compared to European and Asian system [4]. The majority of works have been focused on laboratory studies using plants extracts prepared by scientists after collecting plant materials themselves.

Khaya senegalensis is a multipurpose African timber species. The development of clonal propagation could improve plantation establishment, which is currently impeded mahogany shoot borer. To examine its potential for clonal propagation, the effect of cutting length, leaf area, stock plant maturation, auxin and smoke solution treatment were investigated. Leafy cutting rooted well (up to 80%) compare to leafless cutting (0%). Cutting taken from seedling rooted well (at least 95%) but cuttings obtained from older trees rooted poorly (5% maximum). The rooting ability of cuttings collected from older trees was improved (16% maximum) by pollarding. Auxin application enhanced root length and the number of roots while smoker solution did not improved cuttings rooting ability. These results medicate that juvenile khaya senegalensis is enable to clonal propagation, but further work is required to improve the root cuttings from mature trees [5].

These metals are needed in every small quantity for the proper functioning of the system for both plants and animals. But if released into the biosphere in large quantity, they undergo a cyclical process through biotic and abiotic means, and are converted into toxic substances that can affect the ecosystem. In view of the above, the qualification of trace metals at very low concentrations is becoming the requirement of environmental assessment studies.

The commonly used analytical technique for trace metal analysis in environmental samples includes:- FAAS; coprecipitation of heavy metals with erbium hydroxide for their flame atomic absorption spectrometric determinations in environmental samples, use of chelating resins and inductively coupled plasma mass spectrometry for simultaneous determinations of trace and major elements in small volumes of saline water samples.

Nowadays, the potentialities of biological materials including algae, plant leaves and root tissues, bacteria, fungi and yeast as adsorbents of metals in aqueous solution have been extensively explored. Basically the accumulation of metals by biological materials is called biosorption. Biosorption can be broadly categorized into two parts: (a)biosorptive (passive) uptake by the use of non living biomass, and (b) bio accumulation by applying living cells [6].

The mechanisms of cell surface sorption are independent of cell metabolism; they are based upon physicochemical interactions between metal functional (polysacchandes, lipids and proteins) of the cell wall [7] speciation of Cr (III) and Cr (VI) in waters using immobilized mass and determination by ICP-MS and FAAS. But, on the contrary bioaccumulation is an intracellular metal accumulation process which involves metal binding on intercellular compounds, intercellular precipitation and methylation depends on the cell metabolism; it can be inhibited by metabolic Inhibitors such as low temperature and lack of energy sources.

In this study, the possibility of using KhayaSenegalensis leaves as a biosorbent was explored. From literature scanning we were made to believe that no studies have in the past been conducted on adsorption of Fe (II) and Cr (III) on Khaya Senegalensis leaves.

The Botanical description of Khaya senegalensis is given as follows:

- Common name:– African mahogany, Benin mahogany, Dry zone mahogany, Senegal mahogany
  Botanical name: *khaya senegalensis*
  Family: *melieceace (Neem family)*
  Synonyms: *swieteria senegalensis*

Significance Of The Study

The research work is important in several reasons:

Firstly, the research work is important in terms of determining the level of Chromium and Iron on Mahogany leaves (Khaya Senegalensis)

Secondly, it will provide comprehensive information to students who might wish to further the research process.

Thirdly, this research work will lead to further in-depth research on the determination of levels of chromium and Iron on mahogany leaves.

Lastly, the research work will serve as a contribution to knowledge in the area of determining Chromium & Iron on

Mahogany leaves (Khaya Senegalensis), in this regard it will be useful for other researchers who might want to carryout research in related areas.

Aim and Objectives

This research is aimed at investigating the adsorption of Chromium (III) and Iron (II) on leaves powder of Mahogany (Khaya Senegalensis).

The main objective of the study is to explore the possibility of Chromium (III) and Iron (II) adsorption on Khaya Senegalensis leaves (Mahogany).

Botany, Description And Distribution Of Khaya Senegalensis Khaya senegalensis is a large and study tree of meliaceae family. Also named Senegal mahogany, it is a forestry species well known and exploited by Africans. It pinnate leaves, glabrous with 6 and 12 alternate or opposite ellipticcaloblong leaflets. At the flowering, Khaya senegalensis twigs curry at their end panicles of small while flowers consisting of successive whorls of four floral parts. Its fruits are capsules with thick and woody seed coat. These capsules are dehiscent and have four valves that allow to sell the flat seeds closely applied against each other.

Chemical Composition of Khaya Senegalensisomposition of Khaya S

The determination of chemical composition of Khaya senegalensis has a long history that began on 19th century with convention who revealed in a macerated bark, non-nitrogenous piero–resin which hecailcedrin, some coloring substances, sulphate of lime, chloride of lime, phosphate of lime, gum, starch, wax and very small amount of full. A century later, [8] found in the leave of khaya seneganelensis, 2% sucrose, saponin and better principle obtained with varying yields 0.90% in the bark of the trunk [4].

Biochemical And Tissue Effect Of Khaya Senegalensis Extracts

Studies from various backgrounds have shown that organs extracts of Khaya senegalensis induce signification changes in blood biochemical parameters [3] after a physiochemical study, indicated that the extracted oil from the seeds of this plant is rich in bioactive substances that induce prophylactic and therapeutic effects.

Toxicological Risks

According to [9] the aqueous extract of leaves of Khaya senegalensis is not toxic. Indeed at the end of a study conducted by them on rate in Nigeria; these authors reported that the extract is greater than 3000 mg kg^{-1}body weight. Long treatments also cause elevation of serum creatinine and blood urea which reflects renal dysfunction.

A rick acute toxicity of aqueous and ethanolic extracts of leaves of khaya senegalensis have been suspected in [5]. These authors assessed the sensitivity of chironomid leaves to aqueous and ethanolic extracts of the plant in aquatic environment. The result indicated the aqueous and ethanolic extracts were 1.39g/l and 1.20g/l respectively and a deformity of mouthpart, change in body coloration, packing of certain body segments with black particles.

2. EXPERIMENTAL

Materials

- Wagtech photometer 7100 modal
- Centrifuge machine TDL 50B
- 3505 JENWAY pH Meter

Reagents

- Ferrous Chloride ($FeCl_2$)
- Chromium Chloride ($CrCl_3$)
- Hydrochloric acid (HCl)
- SulpHuric acid (H_2SO_4)
- Ammonia solution (NH_3)

Standard stock solutions containing (1.000g/l) of Cr (III) and Fe(II) were prepared separately by dissolving $CrCl_3$. $6H_2O$ (LOBA CHEMIE PVT LTD, Mumbai 400005. India) and $FeCl_2$ (B.D.H. Chemical LTD, Poole England) in 2% HCl and 20% H_2SO_4.

Preperation of Adsorbent

The fresh leaves of Khaya senegalensis (Mahogany) were collected from Khaya senegalensis tree. It was dried in room temperature and grounded into powder by motar and pestle and then stored for future use as adsorbent.

3. PROCEDURE

(i) Sample solution containing 2µg /l of the analytes iron (II) and chromium (III) were prepared by appropriate of these stock solution with distilled water and then adjusted to the desired pH value (1-6) with 1.0 mol/l ammonia solution or hydrochloric acid before use.

(ii) 0.5g of khayas senegalensis leaves powder was place into a test tube containing 10ml of the pH adjusted(1- 6) sample solution of the analytes.

(iii) The test tube were centrifuged at 500 rpm for 10 minutes and 5ml of the supernatant was pipette into separate clean test tubes for determinate respectively.

(iv) One H.R iron tablet was added into each supernatant obtained from (iii) above and kept to stand for a minute to allow full colour formation.

(v) An appropriate wavelength of the analytes were selected on a wagtech photometer and the sample were inserted in to the photometer separately and the result were recorded respectively.

(vi) The above procedure was repeated for blank determination without the analytes. During the process of the data analysis, all values obtained were corrected by subtracting the values of procedural blank.

4. RESULTS AND DISCUSSION

Results

Table 1: pH and sample solution (supernatant) of Fe(II)

pH	Mean ± SD μgl^{-1}
1	2.02 ± 1.43
2	2.34 ± 1.66
3	2.74 ± 2.08
4	3.21 ± 2.27
5	3.21 ± 2.27
6	2.85 ± 1.96

Table 2: pH and the solution without leaves powder (Blank) of Fe (II)

pH range	Mean ± SD μgl^{-1}
1	2.71 ± 1.91
2	3.02 ± 2.13
3	3.51 ± 2.48
4	3.61 ± 2.54
5	3.62 ± 2.55
6	3.52 ± 2.48

Table 3: Effect of pH on adsorption of the Fe (II) on Khaya senegalensis leaves (Mahogany)

pH	Blank solution minus analyte in µgl-1	Adsorption in µgl-1
1	2.71-2.02	0.69
2	3.02-2.34	0.68
3	3.51-2.84	0.67
4	3.61-3.21	0.40
5	3.62-3.21	0.41
6	3.52-2.85	0.66

5. CALCULATIONS

The original sample used was 2ppm therefore to calculate % record after adsorption according to the pH.

$$pH_1 = \frac{0.69}{2} x\,100 = 35\%, \quad pH_2 = \frac{0.68}{2} x\,100 = 34\%,$$

$$pH_{3\backslash} = \frac{0.67}{2} x\,100 = 33\%, pH_4 = \frac{0.40}{2} x\,100 = 20\%,$$

$$pH_5 = \frac{0.41}{2} x\,100 = 21\%, pH_6 = \frac{0.66}{2} x\,100 = 33\%,$$

Table 4: Adsorption of Fe (II)

pH	Adsorption (%)
1	(100-35) = 65
2	(100-34) = 66
3	(100-33) = 67
4	(100-20) = 80
5	(100-21) = 79
6	(100-33) = 67

Table 5: Effect of pH on adsorption percentage (%) fo Iron (II) on khaya Senegalensis leaves (Mahogany).

pH range (x)	Adsorption (%)
1	65
2	66
3	67
4	80
5	79
6	67

Effect of pH on adsorption of iron

Effect of pH on adsorption of Fe (II) on Khaya senegalensis leaves has been studied. The pH of the sample solution containing 2µg / l of the analyte was adjusted to a pH range of (1-6) by adding 1.0 mol / l NH_3 solution or HCl. Fig.1 represents the effect of pH on adsorption of the target analyte on khaya senegalensis leaf powder. As could be seen, the maximum adsorption (80%) was obtained at pH4. Hence pH4 was adopted for all subsequent studies.

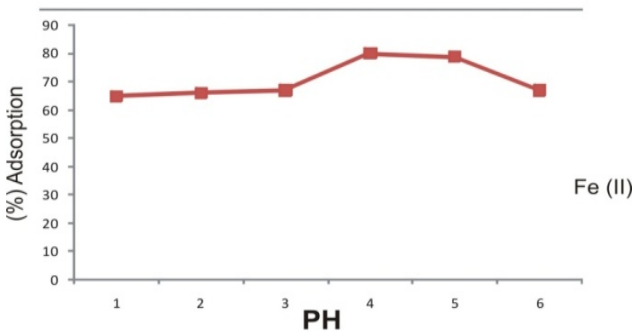

Fig. 1: Effect of pH on percentage (%) adsorption of Fe (II)

Table 6: pH and sample solution (supernatant) of chromium (III)

pH range	Mean ± SD µgl-1
1	1.64 ± 1.16
2	1.94 ± 1.37
3	2.41 ± 1.70
4	2.82 ± 1.99
5	2.81 ± 1.98
6	2.43 ± 1.55

Table 7: pH and the solution without leaves powder (Blank) of Cr (III)

pH range	Mean ± SD µgl-1
1	2.11 ± 1.49
2	2.64 ± 1.88
3	3.30 ± 2.33
4	3.33 ± 2.35
5	3.32 ± 2.34
6	2.81 ± 3.94

Table 8: Effect of pH on adsorption of Chromium (III) on khaya senegalensis leaves (Mahogany).

pH range	Blank solution minus analyte in µgl-1	Adsorption in µgl-1
1	2.11-1.64	0.47
2	2.64-1.94	0.70
3	3.30-2.41	0.89
4	3.33-2.82	0.51
5	3.32-2.81	0.51
6	2.81-2.43	0.38

6. CALCULATIONS

The original sample used was 2ppm therefore to calculate % record after adsorption according to the pH range.

$$pH_1 = \frac{0.47}{2} x\,100 = 24\%, \quad pH_2 = \frac{0.70}{2} x\,100 = 35\%,$$

$$pH_{3\backslash} = \frac{0.89}{2} x\,100 = 45\%, \; pH_4 = \frac{0.51}{2} x\,100 = 26\%,$$

$$pH_5 = \frac{0.51}{2} x\,100 = 26\%, \; pH_6 = \frac{0.38}{2} x\,100 = 19\%,$$

Table 9: Adsorption of Cr (III)

pH range	Adsorption (%)
1	(100-24) = 76
2	(100-35) =65
3	(100-45) = 55
4	(100-26) = 74
5	(100-26) = 74
6	(100-19) = 81

Table 10: Effect of pH on adsorption percentage (%) of Chromium (III) on Khaya senegalensis leaves (Mahogany).

pH range (x)	Adsorption (%)
1	76
2	65
3	55
4	74
5	74
6	81

Effect of* pH *on adsortion of chromium (III)

Based on the experiment conducted, the result indicated that the maximum adsorption of 81% was obtained at pH6. Hence the pH for adsorption of Cr III using supernatant is pH6. From the above table 10, plots a graph of pH range-x (axis) against adsorption (%)-y (axis).

The effect of pH on adsorption of Cr (III) on khaya senegalensis leaves has been investigated. The pH of the sample solution containing 2µg/l of the target analyte was adjusted to a pH range of (1-6) by adding 1.0 mol / l NH_3 solution or HCl. Figure 2 represents the effect of pH on adsorption of Cr(III) on khaya senegalensis leaf powder. As could be seen, maximum adsorption of (81%) was obtained at pH6 was selected as the optimum pH6 for all subsequent studies.

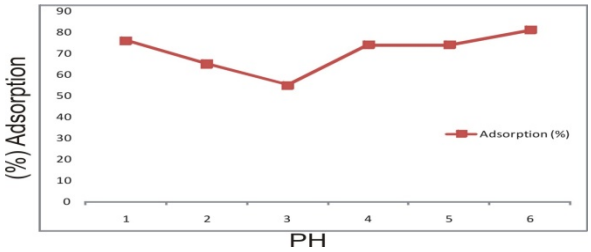

Fig. 2: The effect of pH on adsorption of Cr(III) on khaya senegalensis (Mahogany)

7. CONCLUSION

An environmental friendly, inexpensive bio-sorbent of khaya senegalensis leaves (Mahogany) for the adsorption of Cr (III) and Fe(II) has been developed.

A maximum adsorption of about 81% for Cr (III) at pH6 and a maximum adsorption of 80% for Fe (II) at pH4 were obtained respectively. Although the adsorption was quantitative up to 90% but this may be attributed amount of adsorbent.

Hence, further studies need to be conducted on the following parameters:- Amount of sorbent, type of eluent and its concentration, sample volume co-existing ions etc.

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